



Tamil Nadu Generation and Distribution Corporation Ltd.

2 X 660 MW Udangudi Supercritical Thermal Power Project - Stage - 1

TENDER ENQUIRY DOCUMENT FOR EPC CONTRACT

[BID Specification No. SE/C/UP/EE/E/OT No. 01/2015-16]

VOLUME - II SECTION - 1 GENERAL TECHNICAL SPECIFICATION

FICHTNER Consulting Engineers (India) Private Limited
Chennai, India



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**VOLUME – II****SECTION 1****GENERAL TECHNICAL SPECIFICATION****1.0.0 GENERAL PLANT DESCRIPTION****1.1.0 Intent of specification**

TANGEDCO (Owner) is involved in setting up a 2 x 660 MW Udangudi Supercritical Thermal Power Project (Stage I) in Udangudi, Tuticorin District, Tamil Nadu State, India. TANGEDCO has also plans to expand the Power Plant to additional 4 x 660 MW during Stage II.

The Stage I of the project shall have a configuration of two (2) Supercritical Units of 660 MW each with a total capacity of 1320 MW.

The Project shall consist of two (2) Pulverized coal fired supercritical steam generator each connected to an individual steam turbine generator complete with all the required auxiliaries and the balance of plant. The design power output of the each unit shall be 660MW at 100% TMCR condition.

TANGEDCO wishes to construct the plant through the Engineering, Procurement and Construction (EPC) route through a Turnkey Contractor who would be responsible for all major aspects of the installation; from detailed design, project management, procurement, construction, manufacturing, shop testing, packaging & transportation from manufacturers works to site, unloading, storage, erection, pre-commissioning and commissioning, performance testing and handing over. The Turnkey Contractor would control the work of all subcontractors including those providing civil, mechanical, electrical and Instrumentation & Control services.

This technical specification is intended to specify the minimum requirement for the complete plant.

This section explains General scope of supply & services, Limits of supply, Provisions by the owner, General plant design & layout requirements, Quality & testing requirements, Spare parts, Documentation and Environmental requirements.

The scope of this Tender Specification for the 2 x 660 MW coal based supercritical thermal power project including all mechanical, electrical, controls & instrumentation and civil/structural/ architectural works as specified herein covers design, engineering, procurement, manufacture, inspection and testing at manufacturer's works, supply, packing & forwarding, transport and delivery at project site, unloading, storage and in plant transportation at site, erection, painting, supervision, pre-commissioning, testing, successful commissioning, performance testing, Guarantee testing and handing over, of all equipments and facilities, forming a part of the power project, which are deemed to be part of Contractor's scope on EPC basis. Statutory and local approval required for the work to be executed including payment of fees upto the handing over of the plant is in contractor's scope. Transport and erection insurance is also in contractor's scope.

The detailed scope of supply and services are indicated in this section as well as in the following sections of Volume II.

Section 2.0	Detailed Technical Specification – Mechanical
Section 3.0	Detailed Technical Specification – Electrical



Section 4.0	Detailed Technical Specification – Control & Instrumentation
Section 5.0	Detailed Technical Specification – Civil, Structural And Architectural Works
Section 6.0	Technical Schedules
Section 7.0	Tender Drawings

1.2.0 Plant Components and Major Equipment

The EPC Contract for the proposed Thermal Power Project with support facilities envisages two Units with each Unit comprising of one (1) Pulverized Coal fired Supercritical Steam Generators and one (1) Steam turbines complete with needed integral facilities, but not be limited to the following:

Mechanical

1. Pulverized Coal fired Supercritical Steam Generator and Auxiliaries including Electro static precipitator
2. Steam Turbine & Auxiliaries
3. Auxiliary Boiler.
4. Condenser system
5. Feed water heating system
6. Power cycle pumps and accessories
7. Condensate system
8. Condensate polishing unit and chemical feed system
9. Plant cooling water system & Auxiliary cooling water system
10. Equipment cooling water (CCW/DMCW)system
11. Fuel oil handling system
12. Coal handling system (Excluding external coal handling system)
13. Ash handling system including ash pond and ash water recovery system
14. Mill reject handling system
15. Seawater intake and outfall system
16. Plant Water Treatment, Waste water & Chemical Treatment System
17. Fire Protection System
18. Compressed air system
19. Air conditioning and ventilation system
20. Hydrogen generation plant
21. Cranes and Hoist
22. Piping, Valves, specialties, fittings, supports etc.
23. Thermal Insulation
24. Workshop, road weigh bridge, chemical laboratory and stores
25. Sewage treatment plant
26. Electro chlorination and gas chlorination system
27. Mandatory spares
28. Start up and commissioning spares
29. 3 years Operation and maintenance spares
30. Special Tools and tackles for erection & maintenance
31. Fire tenders
32. Solar PV Plants on Roof Tops. The Solar Photo Voltaic (PV) installation on Rooftop of various buildings in the SG Package of Thermal Power Plant shall be carried out preferably on shadow free area in such a way that the generation is maximized on each building Rooftop suitable for installation of Solar PV power plants. The final solar plant capacity shall be as per detailed approved engineering design of each of the buildings.
33. Ambulance and Fire Jeep

Any other Mechanical systems as required to complete the project shall be included.



Electrical

1. Generators and its auxiliaries
2. Excitation system for generators
3. Neutral grounding equipment for generators
4. Surge arrester and voltage transformer cubicle for generators
5. Isolated phase busduct for generators
6. Protection panel for generator and transformers
7. Control panel for generators
8. Generator circuit breakers
9. Generator transformers
10. Spare Generator transformer
11. Bus reactors
12. Unit transformers
13. Station transformers
14. Standby maintenance transformer
15. 400 kV gas insulated indoor switchyard (GIS) including all control, metering & protection panels, substation automation system, communication system etc.
16. 400 kV outdoor equipment for GIS switchyard (Such as GIS busduct, SF6 Air Bushing, lightning arrester, CVT, wave trap etc.)
17. Switchyard Optical fiber communication system equipment at power plant switchyard end of transmission lines.
18. 11kV and 6.6kV segregated phase busduct
19. Neutral grounding resistors for 11 kV system
20. Neutral grounding resistors for 6.6 kV system
21. Unit auxiliary transformers
22. Station auxiliary transformers
23. Auxiliary transformers for CHP, AHP, Seawater intake etc.
24. Dry type LV service transformers
25. 33 kV switchgear
26. 11 kV switchgear
27. 6.6 kV Switchgear
28. 33kV, 11kV and 6.6kV VCB Isolation Panels
29. Bus transfer panels
30. Electrical monitoring system (EMS)
31. Integrated energy management system (IEMS)
32. Tariff metering panels
33. 415 V switchgear
34. DC distribution boards (220 V, 48 V & 24 V)
35. 415 V Non segregated phase busduct
36. Batteries and Chargers (220 V, 48 V & 24 V)
37. Uninterrupted power supply system (UPS)
38. Diesel generator set
39. 33 kV, 11 kV & 6.6 kV HT Power cables
40. LT Power and control cables
41. Trailing cables
42. Cable trays, Bolted (Unistrut) type supports, fittings and accessories
43. Cabling accessoires (cable glands, lugs, ferrules, terminations, joints, clamps etc.)
44. Fire stop sealing system for cable penetrations
45. Illumination system
46. HT Motors
47. LT Motors
48. DC Motors
49. Electric actuators with integral starters
50. Passenger cum goods elevators
51. Rack & Pinion type elevators
52. Telephone system
53. Public address system
54. Wireless paging system



55. Electrical lab equipment
56. Construction power supply system
57. Earthing system
58. Lightning protection system
59. Variable frequency drive system
60. Electrical equipment for ESP
61. Work stations, large video screen, Multi function printers, laptops etc.
62. Furniture for all workstations and printers
63. Test bench, Steel Almirah, Storage Cabinets and Furniture for all Lab equipment
64. Safety items
65. Mandatory spares
66. Start up and commissioning spares
67. Special Tools and tackles for erection & maintenance

Any other electrical system as required to complete the project shall be included.

Control & Instrumentation System

1. Plant Distributed Control System
2. PLC based control systems for plant utility systems such as ESP etc(Refer Section 4)
3. Relay based local control system
4. SG integral including Burner Management System (BMS), Secondary Air Damper Control, Soot blowing system, Mill gravimetric feeder control and Boiler tube leakage system
5. Turbine Protection System (TPS)
6. TG integral including Automatic Turbine Run-up System (ATRS), Turbine Stress Evaluator (TSE), Electro Hydraulic Governing System (EHTC), Automatic Turbine Testing System (ATT), and Turbine Supervisory Instrumentation (TSI)
7. Vibration monitoring and analysis system
8. GPS / Master & slave clock system
9. Large video screen for operation and monitoring
10. Sequence of events recording system integral to DCS
11. HART Management systems (HMS)
12. Performance analysis, Diagnosis and optimization (PADO)
13. Management Information system (MIS)
14. Station LAN
15. Unit control panel for limited backup manual safe shutdown operation
16. Standalone hardwired annunciation system mounted in the UCP
17. Furnace flame monitoring and analysis system for each unit
18. Auxiliary power supply system and complete distribution for I&C equipment
19. Smart soot blower system complete with all hardware, software and interfaces shall be independent for each unit
20. SWAS (Steam and water analysis system)
21. SEMS (Stack emission monitoring system) and flue gas measurement system
22. All field Instruments and sensors including pipe mounted items and accessories within battery limits
23. All final control elements like control valves, de-superheaters, control dampers and actuators etc within battery limits
24. Gas Analysers for each unit
25. All junction boxes, transmitter racks, cubicles, enclosures, local panels, marshalling panels, pneumatic and process hook up hardware and other erection materials and accessories including Earthing system (separate electronic and frame earth) including cables
26. Complete Instrumentation, control, compensating, special cables, pre-fabricated cable, fibre optic cable etc.,
27. Ambient air quality monitoring system (AAQMS)
28. Instrument Lab
29. Plant security and surveillance system (PSS)
30. Mandatory spares



31. Start up and commissioning spares
32. 3 years Operation and maintenance spares
33. Special Tools and tackles for erection & maintenance
34. All other I&C items, works and services detailed elsewhere

Any other control & instrumentation system as required to complete the project shall be included.

Civil Structural & Architectural Work

The Scope will cover but not limited to Architectural, Civil and Structural works of the following buildings / structure / systems / facilities.

1. Topographic survey
2. Geotechnical Investigation
3. Site Development Work
 - Site clearance works
 - Site grading
 - Fencing
 - Approach road to the main entry of the plant from State Highway
 - Plant road network including patrol roads, approach roads to all the buildings / structures / services.
 - Plant storm water drainage system for the entire plant, sump, pump houses, drainage channels, drainage pump house, etc.
 - Boundary walls
 - Security Gate Complex
 - Watch Towers
 - Storm Water Diversion Channels
4. Construction Enabling Works
 - Site office
 - Site Store Complex
 - Temporary Workshop and Garage
 - Fabrication Yard
 - Quality Control Laboratory
 - Fuel Storage Area
 - Staff Welfare Facilities
5. Main Power House building consisting of TG bay, Electrical bay, including its substructures with STG, Boiler Feed pumps and all other major / minor equipment foundations, service and maintenance bays.
6. Central Control room building
7. Mill and Bunker building with steel coal bins including sub-structures with foundations and mill foundations, mill reject handling system with mill reject silo.
8. Foundations for Steam generator (Boiler) supporting structures and its auxiliaries along with boiler elevator foundation and interconnection to bunker building and power house building.
9. Foundations for ESP structures and its auxiliaries along with fans, duct supports, etc., including sub-structure.
10. ESP switchgear & Control Room building
11. Boiler Area Paving
12. Transformer yard civil works including transformer foundations, reactor foundation, oil soak pits, burnt oil pit/oil separating pits, cable ducts, cable trenches with covers, fire protection walls, roads, drainage, fencing, oil drainage to sump pit and oil recovery, jacking pads, transformer rail tracks (upto maintenance bay of Power House Building) along with foundation, oil test lab and Transformer Oil Filter Plant Building, etc.
13. Switchyard comprising of indoor Gas Insulated Switchgear (GIS) building, Switchyard control building and outdoor equipment such as towers, gantries, lighting poles,



- lightning masts, equipment support etc. cable trenches, fencing, internal roads, drains, etc.
14. Civil, structural and architectural works for Coal handling systems.
 15. Civil, structural and architectural works for Ash handling systems
 16. Civil, structural and architectural works for Fuel handling Area including Fuel Oil pump house
 17. Cooling Water channel, CW fore bay, CW piping etc.
 18. CW pump house
 19. Chemical House and Chlorination Building
 20. CW Inlet and Outlet Conduits
 21. Civil, structural and architectural works for Desalination and Water Treatment Plant
 22. Pipe and cable racks, pipe pedestals etc.
 23. Effluent treatment plant
 24. Sewage network and treatment plant.
 25. Miscellaneous Plant Buildings
 - Plant Air Compressor Building and Air Washer Room
 - DG House
 - Chemical / Hazardous Store
 - Hydrogen Generation Building
 - Maintenance Office Cum Stores
 26. Non-Plant Buildings
 - Service Building
 - Weigh Bridge and Control Room
 - Workshop
 - Fire Station
 - Administration Building
 - Canteens and Dormitory
 - Dispensary
 - Parking
 - Bank Extension Counter and Post Office
 27. Other Structures and Facilities
 - Condensate storage tank foundation
 - Pipe Trenches & Duct Banks
 - Service Water Overhead Tank
 - Horticulture and Landscaping Works and Green Belt Development
 - Rain Water Harvesting
 28. Sea water intake system and outfall system including related Bathymetric survey and land / marine geotechnical investigations
 29. Reinforced concrete chimney
 30. Natural draught cooling towers.
 31. Ash pond
 32. Paving

Any other buildings, structures and works necessary and not specifically mentioned here but required for construction, operation and maintenance of the power plant for system engineering conforming to other sections of this tender document are deemed to be included in the scope of the Contractor.



2.0.0 LIMITS OF SUPPLY/ TERMINAL POINT (TP)

2.1.0 Mechanical

Sl.No.	Description	Terminal Point	Remarks
1	Seawater Intake System		
a)	Sea water supply	Terminal point at Stage-II intake channel after desilting basin. The Stage –II channel shall be provided with blanked wall. During detailed engineering interface with stage II shall be reviewed and finalized by the owner.	After the desilting basin bay, the intake channel shall be divided into two (one for present 2 x 660 MW and another for future 2 x 660 MW).
b)	Desal make up	Terminal point for interconnection of Stage I with Stage-II shall be provided with valve and blind flange near the sea water intake pump house.	
c)	CT makeup	Terminal point for interconnection of Stage I with Stage-II shall be provided with valve and blind flange near the sea water intake pump house.	
d)	Sludge disposal from desilting basin	At sea	Necessary pumping and piping from desilting basin up to sea shall be provided by EPC Contractor.
2	Seawater Outfall System		
a)	Sea water outfall piping	No terminal point	The outfall tank shall be provided with provisions for receiving the Stage II CT blowdown water and desal reject water. Conveyor deck front required for the erection of the outfall pipes will be available in 24 months from the date of the ordering. Sea water outfall piping Load for designing Conveyor deck shall be provided within 6 months from the date of the ordering by contractor.
3	Water Treatment Plant		
a)	Service water distribution piping for all buildings within EPC scope	No terminal point	



Sl.No.	Description	Terminal Point	Remarks
b)	Service water supply for Port	Service Water for Port shall be terminated at one point at the Plant boundary in the seawater piping corridor	Water at 10m ³ /h (25m ³ /day) at 2 bar at the terminal points shall be provided. The location will be finalized during detailed engineering stage. Booster pump and distribution piping outside the Plant boundary shall be in port's scope.
c)	Service water supply for Township	One no. pipe with isolation valve and blind flange shall be provided at the bottom of the tank for the following for service water application. At the bottom of the overhead tank, space required for the 1W+1S pumps for colony service water application shall be provided.	Electrical Feeder provision required for the pumps shall be considered in Stage I. Capacity will be informed during detailed engineering.
d)	Service water supply for buildings/ facilities within EPC scope	No terminal point	
e)	Potable water supply for Township (Drinking water quality)	One no. pipe with isolation valve and blind flange shall be provided at the bottom of the tank for the following for potable water application. At the bottom of the overhead tank, space required for the 1W+1S pumps for colony potable service water application shall be provided.	Electrical Feeder provision required for the pumps shall be considered in Stage I. Capacity will be informed during detailed engineering.
f)	Potable water supply for Port (Drinking water quality)	Potable Water (drinking water quality) for Port shall be terminated at one point at Plant boundary in the seawater piping corridor (near the ECHS conveyor terminal point)	Water at 5m ³ /h (1m ³ /day) at 2 bar shall be at the terminal points shall be provided. The location will be finalized during detailed engineering stage. Booster pump and distribution piping outside the Plant boundary shall be in port's scope.
g)	Potable water distribution piping for all buildings within EPC scope	No terminal point	
h)	All bulk chemicals supplied through road tankers.	At road tanker outlet flange by Owner	Length of the unloading hoses (from the road tanker to unloading



Sl.No.	Description	Terminal Point	Remarks
			pumps) shall be minimum 10.0 meters is included in the Scope of Contractor
i)	Pre-Treatment Plant Clarifier Sludge	No terminal point	shall be pumped to Ash pond
j)	Effluent Treatment Plant Clarifier sludge	No terminal point	shall be pumped to Ash pond
k)	Ash water recovery system Clarifier Sludge	No terminal point	shall be pumped to Ash pond
	Cooling Tower Sludge pump discharge	No terminal point	shall be pumped to Ash pond
4	Electro-Chlorination System	Stage	
a)	All bulk chemicals supplied through road tankers.	At road tanker outlet flange by Owner	
b)	Chlorination piping	No terminal points for Stage I.	
5	Effluent Treatment Plant (ETP)		
a)	Treated waste water from ETP	Treated water shall be stored in Central Monitoring Basin (CMB) of Contractor. Necessary pumping system for recycling shall be provided by Contractor.	Treated water shall be reused for CHP dust suppression, Horticulture etc. For horticulture EPC Contractor shall terminate the treated water at plant boundary one each on the eastern, western, northern and southern sides. The pumping system shall be designed for use of treated water through sprinkler for the entire green belt of the Plant. The sprinkler system shall be provided by the EPC contractor.
b)	Sewage from the port	Sewage from port will be terminated at the STP plant by port contractor.	The quantity (10m3/day) from port shall also be included in designing the STP.
c)	Sewage disposal	No terminal point. Treated waste water from STP shall be transferred to horticulture.	



Sl.No.	Description	Terminal Point	Remarks
d)	Waste Oil	Waste oil collection tank / pit near oil water separator. Contractor shall provide portable pump for filling up waste oil tanker / barrel.	Portable pump will be in EPC contractor scope.
e)	Equipment / piping maintenance drains	Shall be terminated through drain manifold header upto nearest drain trench/pit	
6	Fire Protection System	Terminal point for Stage-II shall be provided with gate valve and blind flange.	Locations will be finalized during detailed engineering. Fire protection system for External coal conveyor outside plant boundary shall be excluded from EPC contractor scope.
7	Compressed Air System		
a)	Instrument air for plant	No terminal point	
b)	Service air for plant	No terminal point	
8	Air Conditioning & Ventilation System	No terminal point	
9	Fuel Oil System		
a)	HFO unloading system	At HFO road tanker outlet. Quick couplings shall be in the scope of Contractor	
b)	HSD unloading system	At HSD road tanker outlet. Quick couplings shall be in the scope of Contractor	
c)	Auxiliary Steam for HFO road tankers	At HFO road tanker heater outlet. Quick couplings shall be in the scope of Contractor	
10	Coal Handling System		
a)	Coal from Port in JNT-1	The terminal point for the Coal Handling Plant will be from the surge hopper outlet provided in the JNT-1. Four chutes with flanged connection shall be provided) Companion flange is in owner's scope.	The main Structures of JNT1 will be provided by the Port Contractor. Design and civil & structural requirement for BCN-1A/1B, CSU, DFDSS, handling arrangement inside JNT-1 is in contractor scope. All provision, space required for the BCN-1A/1B, DFDSS, CSU, handling arrangement will be provided in JNT-1 by the owner. Floor required for the vibrating feeder, rod gate, rack and pinion



Sl.No.	Description	Terminal Point	Remarks
			gate is in owner's scope. Monorail for the contractor's handling arrangement shall be provided by owner. All foundation bolts, insert plate are in contractor's scope. Fire fighting system, dust extraction/suppression system for the owner's conveyor (Inside the plant boundary including JNT-1) is in contractor's scope. Loads in JNT-1 shall be provided within 6 months (from the ordering date) by the contractor to owner.
b)	Coal feeding at JNT-7 for stage -II	The terminal point for the Coal Handling Plant will be from the discharge pulley of reversible belt feeder along with the head frame (provision for fixing the future chute).	Loads of the stage –II shall be taken care in the design of this JNT. Feeding chute upto the stage-II conveyor shall be in contractor's scope. Contractor shall consider future conveyors in the same floor of BCN 10A/B, provided all the layout and maintenance requirements are satisfied. If not separate floors for future conveyors shall be provided by the contractor based on the layout requirement. Floor of the future conveyors shall be elevated as per specification requirement. JNT -7 Loads on JNT shall be provided within 6 months (from the ordering date) by the owner. Insert plate and other foundation bolts required for the future conveyors to be supplied by the owner. Contractor to note that



Sl.No.	Description	Terminal Point	Remarks
			the tap points for the service water, service air, DFDSS for future conveyors to be provided in the junction tower.
c)	Coal feeding at JNT-3 for stage -II		Loads of the stage –II shall be taken care in the design of this JNT. Required floor for the stage –II shall be provided by contractor. Feeding chute upto the stage-II conveyor shall be in contractor' scope. Loads on JNT shall be provided within 6 months (from the ordering date) by the owner.
d)	Coal feeding at JNT-4 for stage -II		Loads of the stage –II shall be taken care in the design of this JNT. Feeding chute upto the stage-II conveyor shall be in contractor' scope. Contractor to note that there shall be a floor for yard conveyor feeding on to the conveyors. BCN-7A/7B placed on the ground floor. In addition to this, additional floors for future conveyors shall be provided by the contractor based on layout requirement. Loads on JNT shall be provided within 6 months (from the ordering date) by the owner. Insert plate and other foundation bolts required for the future conveyors in JNT- 4 to be supplied by the owner. Contractor to note that the tap points for the service water, service air, DFDSS for future conveyors to be provided in the junction



Sl.No.	Description	Terminal Point	Remarks
			tower by the contractor.
e)	Coal bunker emptying chute	Suitable arrangement to directly unload from each coal bunker to trucks through bunker emptying chute.	
11	Mill Reject System		
a)	Mill Reject disposal	Upto sector gate outlet (including telescopic chute) of mill reject storage silos.	
12	Ash Handling System		
a)	Fly Ash disposal in open trucks – Dry mode	Bottom flange of Ash unloader including ash conditioner suitable to dispose the ash into trucks	
b)	Fly Ash disposal in closed Trucks – Dry mode.	Bottom flange of Ash unloader including telescopic spout suitable to dispose the ash into trucks	
c)	Fly Ash–Wet mode	To discharge into ash pond at various location including garlanding of ash pond. Ash pond shall be in Contractor's scope	Ash pond shall be in Contractor's scope
d)	Bottom Ash –Wet mode	To discharge into ash pond at various location including garlanding of ash pond. Ash pond shall be in Contractor's scope	
13	Cranes & Hoists	No terminal point	
14	Chimney	No terminal point	
15	CPU Regeneration System	No terminal point	
a)	All bulk chemicals supplied through road tankers for CPU Regeneration System	Terminal point is at road tanker outlet flange, road tankers are provided by Owner.	
b)	CPU Regeneration waste water & acid, alkali drains	No terminal point	Wastes shall be treated and reused

**Notes**

- a. All high pressure, flash tank vents shall be terminated at safe elevation (i.e) 1.5 m above the building / steam generator roofs.
- b. Steam Generator roof drains shall be terminated at the catch pits in ground floor

2.2.0 Electrical

Sl.No.	Description	Terminal Point	Remarks
a)	400kV GIS Switchyard / Power evacuation	The proposed power plant shall be provided with 400kV GIS Switchyard with four (4) numbers of outgoing line feeders. The generated power shall be evacuated to the State grid / PGCIL through these outgoing line feeders provided. The terminal point for outgoing line feeders will be at the Switchyard gantries. Power Evacuation beyond the Line feeder gantry of switchyard and integration with the grid will be done by the Owner. In respect of OPGW: The EPC contractor has to supply, Erection, Testing and Commissioning of related equipments from Switchyard gantry to Switchyard control building (supply included Fiber optic cables, Multiplexer and other related equipments etc.,)	
b)	External coal handling system	The External Coal Handling system (ECHS) power requirement is about 25 MVA. EPC contractor has to provide 2Nos. of 33kV feeders at Sea Water intake pump house as per Tender SLD drg No. 10-1115112-E-201.	
c)	Telephone system for External coal handling system	Public address system cable, at Signal junction box located at power station CHP control room or Administrative Building..	
d)	Construction Power Supply	33 kV supply shall be provided by the TANGEDCO at one point in proposed power plant, near boundary.	

**2.3.0 Instrumentation and control**

Sl. No.	Description	Terminal Points	Remarks
1.	Remote Modem connectivity for DCS maintenance	Contractor to provide remote Modem at DCS end.=. Terminal point at Remote Modem.	
2.	External coal handling plant interface	Provision shall be made available at the ICHS end for the following 1. DCS IOs for the interface of ECHS equipments 2. Time synchronization signal for extension to ECHS control system	

2.4.0 Civil

Sl.No.	Description	Terminal Point	Remarks
1.0	Storm water drains		
a	Storm water drains -final discharge	Complete storm water drain system will be in the scope of EPC package.	
b	Drains from Owner's non-plant buildings (those which are not in EPC contractor scope)	At 1 m distance from each Non Plant building (those which are not in EPC contractor scope) terminating at the garland drain around the building. Interconnection to main storm water network is in EPC scope.	
2.0	Approach Roads		
	Plant Approach Roads	Upto State Highway	
3.0	Construction Water		
a	Construction Water	Shall be arranged by EPC Contractor	

Note: In this specification if there is any contradiction between two or more clauses in stating a requirement, then the Bidder shall bring out to notice such contradictions and get it cleared during the bidding stage itself. If contractor brings to notice of the same in later stage after the award of contract then the final decision about that requirement shall lie with the Owner which the contractor shall comply.

2.5.0 Conditions at limits of supply

The equipment design requirements at the limits of supply are described in the detailed technical specifications, in addition to those indicated below.

Coal Supply

Coal will be received through ship at the captive jetty. The quality of coal received is furnished at Annex – 1.1 of this specification



Ash handling system

To meet the ash removal requirement of the power plant, ash pond shall be constructed by constructing dykes.

The ash pond shall be located within the power plant site. Reference may be made to the plot plan, and other tender drawings.

For ash pond, the required area of the land will be about 120 acres considering the bund height of 25m for both fly and bottom ash above finished ground level. The dykes shall be impervious to seepages etc., and also be able to resist erosion. The ash pond design and construction shall meet the MoEF, CPCB and TNPCB requirements.

Fuel oil supply

The Heavy Fuel oil (HFO) and High Speed Diesel (HSD) will be transported by road tankers. The oil unloading facilities to be provided by the Contractor which has to accommodate the required no. of road tankers as specified in fuel oil system specification. The fuel oil analysis is furnished at Annex – 1.2 of this specification.



3.0.0 GENERAL SCOPE OF SUPPLY AND SERVICES

The scope of supply and services covered by this EPC enquiry document shall be complete from site clearing to project take over by the Owner including all supplies and services. The Contractor's scope of supply and services shall include those listed under **Clause 1.2.0 of this section**, as well as those listed below and shall not be limited to the following:

1. Design, Engineering, Procurement, Testing at Manufacturer's Works, painting, packing, forwarding and Supply of all equipment, plants and facilities within the limits of supply and for connection at the boundary limits, as specified in the relevant detailed technical specification for the completion of the power project on an EPC basis including Special Tools & Tackles, startup/Commissioning spares, Mandatory Spares etc.,
2. Intermediate site storage, transport to erection area, Receipt of material at site including unloading from carriers at site, handling, storage & preservation at site and intra site transport. The electrical equipment such as switchgear, motors etc., shall be stored in a covered shed. The electronic item such as PLC panels, DCS panels ,cards shall be stored in an A/c storage shed.
3. Inspection, testing, cleaning, painting, marking, etc. at the EPC contractors and/or sub-contractors workshops, delivery and transportation to the site, including insurance, unloading, etc
4. Overall Project management, project control, quality assurance, site management and coordination for all technical matters, interconnections, connection to off-site facilities, scheduling, contractual matters and obligations, etc. with suppliers, sub-suppliers, subcontractors, vendors, the Owner, authorities as required on a EPC basis for the implementation, construction and putting into commercial operation of the whole project under the overall and sole responsibility of the EPC contractor.
5. Complete civil, structural and architectural engineering including, topographic survey and Geo-technical investigation and design and carry out all necessary civil and construction works at site as specified. To carry out soil resistivity test for designing of plant earthing system.
6. Supply of all information, documents, calculations, drawings, reports, etc. which are required for Owner's approval and to obtain all necessary permits, clearances, from the Government authority.
7. Apply for all permits and get the authorities approval for all actions, which require approval or permit from local government and statutory authorities. All fees shall be paid by the Contractor upto the handing over of plant
8. Supply of all consumable materials required for construction, erection, testing and commissioning, reliability run, performance guarantee test, taking over of the plant. Fuel required for these trials / test of the plant will be Owner's scope. Supply of HSD for emergency DG Set till 'Take Over' by the Owner will be in Contractor's scope.
9. Provision of all labour, necessary erection equipment, temporary site facilities, temporary connections to power supply, water supply, etc. for erection and commissioning required for the fulfillment of the Contractor's duties in connection with the works and for completion of the entire project in time.
10. Provision of all accommodation, transport, canteen facility, social facilities, etc. for the Contractor's personnel employed at site. Labour accommodation at site shall not be allowed.



11. Co-ordination with other agencies including with the Owner at the plant interconnections (interfaces)
12. Cleaning and application of corrosion protection during erection as required by the Owner and apply final & touch up painting in accordance with the specification.
13. Carry out commissioning, testing, trial operation, reliability run and performance guarantee test of the systems / equipments / plant including civil, structural & architectural works specified and upto handing over of the plant to the Owner requirements and approval and in compliance with the requirements of this specification.
14. Installation and removal of temporary piping and equipment for carrying out oil flushing, Alkali boil out and Steam blowing operation.
15. Removal of surplus materials, scraps out of fabrication yard, temporary infrastructures, subsequent cleaning up and handing over of plant to the owner.
16. Provision of supply of all documents required and specified including AS BUILT drawings.
17. Training services for the Owner's operation and maintenance Personnel.
18. Supply and Installation of Proven and latest air quality monitoring system at the strategic locations of the plant to monitor and comply with norms of various statutory bodies.
19. All safety practices as per industry practice with the involvement of the "Company" and furnishing the report.
20. Any other supplies and services in connection with or related to the works so far as the necessity for providing the same is specified in or reasonably to be inferred from the contract and/or required for the completion of the power project.
21. The Contractor shall accept full responsibility for the completeness and for the faultless working of equipment and the plant as a whole. These shall be executed on the basis of proven design principles and in accordance with the state-of-the-art in such a manner that the purpose to be served by the plant is fulfilled in every respect and a maximum of operational dependability and efficiency are assured. Standardization of equipment, materials etc. as well as of buildings shall be employed in the design. Care shall be taken to ensure safe operation as well as simplicity of assembling and dismantling of all parts of the plant.

22. Satisfactory conclusion of the Contract:-

By accepting the Contract, the Contractor shall be deemed to accept the obligation of supplying everything necessary for the purpose mentioned above, regardless of any omission in the specification or on the drawings.

More detailed scope of supply and service is described under this section and the relevant chapter of the detailed technical specification.

23. Scope of Engineering Services:-

The engineering services of the Contract refer to the complete basic and detail engineering of all equipment and equipment systems, Providing engineering drawings, data, instruction manuals, as built drawings and other information for the Owner's review, approval and records. 3D walkthrough model of the plant, buildings



and associated software shall be included in the scope of the Contractor and the same shall be furnished before getting the final approval of the drawings.

The Contractor shall be responsible for all licensing applications. All fees is in contractor's scope.

24. Required approval, coordination, permission from different agency for the Conveyors, electrical system and pipes crossing the National Highway is in contractor's scope. This includes road cutting required for the pipes.
25. Transport Insurance.
26. Safety, security of materials, gate management.
27. Fire fighting system during construction
28. Medical facility during construction
29. Security requirement for this project shall be engaged by the contractor.
30. All services shall be performed by the Contractor to obtain the required permits to commence the works and operate the Plant, including but not limited to:
 - Clarifications with authorities
 - Participation in all clarification meetings
 - Boiler operation permission by independent authority
 - All other services as required.

3.1.0 Common Equipment and Services

The following supplies and services are to be included in the Contractor's scope

- Plant Hand Book contains the design and performance data of various plant, equipment, systems, covering complete supply package including single line diagram.
- All necessary co-ordination with other contractors on site for erection, testing and commissioning of equipment and accessories.
- Making available of all testing and commissioning equipment.
- All necessary pipelines, warm up system, vents, drains, valves, actuators, required for commissioning, operation and preservation in standstill.
- All temporary installations required for tie-in measures including post weld heat treatment complete, inner cleaning, etc.
- All temporary pipe work as required during connection measures
- All support structures, hangers, supports etc.
- All base frames, mounting plates, grouted in parts, rag bolts, covers, etc.
- All required steel parts embedded in concrete
- All couplings and coupling guards for electric motors and other drives
- All lifting equipment (crane, hoist, lift etc.) required for maintenance
- Required safety equipment, pressure relief valves, etc.
- All thermal (Hot and Cold) and noise insulation including cladding as well as any other noise attenuation measures
- Stairways, ladders, platforms, galleries and walkways to all plant components, including escape routes as necessary, pipe cross overs,
- All necessary steel structures, stairs, ladders and platforms including weather protection
- All required ventilation and / or air conditioning equipment as specified and as required for safe operation of mechanical and electrical equipment, to be supplied



- All necessary corrosion protection measures for plant components and equipment stored or mounted on site up to the time of "Handing Over".
- Complete primer and top coatings conforming to color code, to be agreed with the Owner/Owner's Engineer
- Noise abatements measures to comply with noise pollution control requirement
- Complete labelling of all plant components according to the Owners system in English and also in local language for notices etc.
- All fire protection measures
- Initial filling of Lubricants and further makeup, chemicals, consumables upto trial operation shall be covered under the scope of EPC contractor. Refilling / makeup of lubricants, chemicals shall be covered under the scope of EPC contractor upto 3 months after trail operation.
- Provision of all connections and temporary pipe work for steam blowing of the steam pipelines
- Flushing of all other pipelines including disposal of the effluents; protection with wood and/or plastic at all instrumentation and appendages to be installed during construction
- Chemical cleaning and Steam blowing of piping
- All standard accessories and auxiliary equipment which normally form part of the scope of supplies
- All tests, inspections and works acceptances as well as all certificates and reports of these
- Cleaning of all filters/strainers before "Handing Over" of the relevant Unit
- Valve trims for purging and subsequent exchange
- Removal of any unused material from site
- Soil investigations
- Any necessary surveying works
- Earthworks, drainage, excavation and refilling works
- Roads and pavement
- Concrete and reinforced concrete works, masonry and earthing
- Water proofing works for pressing and non-pressing water
- Roofing (non asbestos)
- Plumbing
- Facade works/glazing works; non asbestos
- Non-load bearing walls/installation partitions/dry construction works
- Metalwork and blacksmith work/raised flooring/doors and gates/sheet metalwork
- Flooring work
- Corrosion protection for underground/ over ground RCC and steel structures
- Crane way works
- Potable water, service water and waste water, sewage water, storm water (permanent and during construction), etc.
- Housekeeping during construction (at least once a week total)
- Transport of all dumping material to dump locations (at least once a week)

Any other supplies & service which are not covered above, but are required for the effective completion of the project.

4.0.0 PROVISIONS BY THE OWNER

Following are the provisions / supplies by the Owner:

- Land within the property line limits as indicated in the plot plan.
- TANGEDCO will provide power supply for construction power at one location near boundary, on chargeable basis at commercial tariff rate. HT tariff VI commercial as per TNERC norms will be levied as per the usage. Further caution deposit and statutory levies as per TNERC / TANGEDCO will be applicable. The power at 33 kV level shall be terminated at pole. The contractor shall receive the same and establish 33 kV Construction Power Substation and distribute 33 kV supply to various distribution substations in the plant and further step down to 415 V supply to provide construction power for various locations. The Owner may not be able to guarantee on the reliability of the power supply and it is the responsibility of the contractor to make alternative arrangement during not availability of power supply. The Owner shall not be responsible for the delay in the project execution due to non-availability of power supply. Required number of Diesel generators shall be arranged & utilized by the contractor for the construction power requirement, if the Owner's power supply is temporarily unavailable.
- Contractor shall arrange construction water.
- 400 kV Transmission lines
- Any requirements of LDC to be provided at 400kV receiving end substations (outside power project)
- All utilities/services up to the limits of supply and conditions of supply as specified in above section.
- Captive Jetty and its related facilities for receiving coal
- External Coal Handling System up to Junction tower-1. Complete Junction tower-1 is in Owner's scope except of the equipments/requirements mentioned in the specification.
- Township / Colony

**5.0.0 SITE CONDITION****5.1.0 Location and existing Infrastructure**

The plant location details are as follows:

Country	: India
State	: Tamil Nadu
Administrative district	: Thoothukudi
Next big cities to site	: Thoothukudi (approx.45 kms from site)
Road access	: East Coast Road – State high way (176)
Nearest Railway Station	: Thiruchendur (approx.12 kms from site)
Nearest Airport	: Vagaikulam (approx.60 kms from site)
Nearest Harbour	: Tuticorin (approx.45 kms from site)

The proposed power project will be located at Udangudi in Tamil Nadu. The proposed power project site is located at about 45km South of Thoothukudi. The proposed marine facilities for the power project will be built on the coast adjoining the power project. The site is accessible by well developed roads.

The town of Tuticorin has all infrastructural facilities and has number of Industries. Tuticorin is well connected by both state highways, National highways and has direct rail link with State Capital Chennai.

5.1.1 Soil Profile

A Preliminary soil investigation report and topographical survey has been carried out by Owner. The results are furnished in a separate annexure.

The Detailed geotechnical Investigation and Setting out survey will be performed by the EPC contractor, and will be the basis for the detailed engineering for the project. The geotechnical report shall contain recommendations for foundation design during detailed engineering.

5.1.2 Seismic intensity

Seismic Intensity	:	As per IS : 1893 Latest
Zone	:	II
Intensity	:	As per IS:1893-Latest

5.1.3 Tide Levels

The recorded tide levels with respect to the Chart Datum (CD) near the identified intake point are as follows:

Mean high water-Spring	CD + 0.99 m
Mean high Water-Neap	CD + 0.71 m
Mean low Water-Neap	CD + 0.55 m
Mean low water-Spring	CD + 0.29m
Mean sea level	CD + 0.64 m
Highest High Tide Level	CD+ 1.026 m
Lowest Low Tide Level	CD + 0.110 m

**5.2.0 Meteorological conditions****Ambient Air Temperature**

Maximum dry bulb temperature	:	41 °C
Minimum dry bulb temperature	:	17 °C

Relative humidity

Mean Maximum humidity (Summer)	:	84%
Mean Minimum humidity (Summer)	:	62%
Maximum humidity (Monsoon)	:	97%
Minimum humidity (Monsoon)	:	45%

Rainfall

Annual rainfall (Maximum)	:	718.2 mm
Annual Rain fall (Minimum)	:	384.1 mm
Twenty four (24) Hour max	:	138.2 mm

High Flood Level

High Flood Level for site	:	RL 2.450 m

Wind

Mean Wind Speed (max)	:	20.6 km/h
Wind direction	:	North, North East, North West, East

The details given are arbitrary and may vary. The contractor should collect the actual data from the Meteorological Department pertaining to the site location and design the plant accordingly.

Meteorological data corresponding to Tuticorin observatory station shall be adopted. These data can be collected from Regional Meteorological Centre, India Meteorological Dept, 50, College Road, Chennai – 600 006.

5.3.0 Design Requirements related to site conditions**5.3.1 Design Ambient Data****Rainfall data:**

The maximum rainfall in a year to be considered for design is 718.2 mm. 24 hours maximum to be considered is 138.2 mm. Area drainage study as required is in Contractor's scope of work.

Wind data

Wind loads to be considered for design of structures shall be based on the design wind speeds arrived at based on IS : 875 (Part -3) – Latest Edition. The parameters for calculation of design wind speed as per IS : 875 (Part -3) – Latest Edition are elaborated under Volume II, Section 5 of Detailed Technical Specification - Civil.



5.3.2 Seismic Data

Seismic loads to be considered for design of structures shall be as per as per IS : 1893. Seismic design criteria are elaborated under Volume - II, Section 5 of Detailed Technical Specification- Civil.

**6.0.0 PLANT LAYOUT & SITE PREPARATION WORKS****6.1.0 Plant Site****6.1.1 Plot Plan of Site**

In developing the site layout, a system approach shall be adopted with a view to ensure that all the subsystems comprising the power project are optimally laid out both from the view point of capital cost as well as running costs.

A suggestive Plot Plan is enclosed as Dwg.No 00-1112140-G-001 considering the existing plant facility, fuel receipt and electrical system hook-up. However, the Contractor shall propose a layout arrangement which will be subjected to approval of the Owner.

The development work consists primarily of clearing the site, grading the site to appropriate levels keeping in view the planning for storm water drainage and green belt.

Coordinate system shall be N-S / E-W and shall be in meters. Elevations shall be in meters with Finished Ground Floor Level of Power House building taken as EL 0.000. Paved level in boiler area shall be at EL (-) 0.200.

6.1.2 Earthworks & Site Grading

Finished grade level (FGL) shall be RL (+) 3.300 m above MSL.

Site will be handed over to the contractor in the present condition. Existing levels are available in the contour drawing. Balance site filling shall be done by the contractor and the filling material to be identified by the Contractor.

Necessary additional filling / cutting shall be done by the Contractor. Finished Floor Level of Power House Building shall be 500 mm above FGL.

Earthwork in excavation including rock quarrying/blasting if required, identifying borrow pits, transportation of soil from borrow pits, backfilling, disposal of excavated soil to designated areas within and outside the plant boundary etc.

Necessary grading/leveling required for the construction shall be done by the Contractor. The area shall be suitably cut and filled to suit the layout requirement if required.

6.1.3 Roads, Fencing and Compound Wall

Approach roads to the plant site shall be provided to access from existing road network. (SH-176) Roads as required inside plant boundary shall be provided. The layout concept of roads is shown in plot plan. The main plant roads shall be of double lane and the peripheral roads along the Compound wall shall be of single lane. Motorable Security road along the boundary shall be provided. Clear distance of 1 m shall be provided all along the boundary, thus the compound wall shall be 1m inside from the boundary.

Switchyard, Transformer area and fuel oil storage area, hydrogen generation area shall be fenced off using chain link fencing.

6.2.0 Layout of power project area**6.2.1 General**

The power project shall comprise of Power block area, balance of plant area (together called Plant Area) and non-plant building area. Layout / Plot Plan shall be developed such that the non-plant building area can be directly accessed from the Public road. The Plant



Area shall be fully separated from the non-plant building area by proper fencing and gate shall be provided for controlled entry of vehicles and personnel to the Plant Area.

The following factors shall be considered in developing the plant layout.

- a) The layout of this Station shall be compact so as to optimize use of land, materials and minimize system losses.
- b) Due consideration shall be given for the wind direction while deciding on the relative location of Natural Draft Cooling tower and switchyard to minimize the moisture drift towards the switchyard.
- c) Adequate space shall be provided for unloading and maintenance purposes in Turbine - Generator (TG) area. Requisite lay down area shall be provided for each unit on TG floor and same shall be approachable with electric overhead travelling (EOT) crane.
- d) Adequate fire escape staircases shall be provided in power house building with fire doors at each landing.
- e) Adequate no. of staircases for each unit/ module and access through elevator shall be provided for the TG building.
- f) Adequate number of permanent stores and open paved yard shall be provided as per requirement of the Station for storage of spares and materials etc.
- g) The safety requirements as per the Factories Act, Indian Electricity Rules and other applicable codes/standards etc. shall be observed while developing the layout.
- h) Steel storage yard and pre-assembly yard required for storing and assembling of plant equipments during construction phase and later this space will converted into green belt during the operational phase.
- i) Adequate provision shall be made in regard to space and access in order to carry out the maintenance of various equipment. Adequate maintenance facilities shall be provided as required, for assembly, disassembly, handling during maintenance and alignment work of all important equipments and auxiliaries viz: dampers, steam turbine casing (inner and outer), diaphragm glands, steam valves, journal/thrust bearings, turbine rotors, generator rotor, end rings, shaft seals, generator bearings, hydrogen coolers, condenser water box, condenser cooling water line inlet and outlet motor operate butter fly valves, vacuum pumps, CEPs and BFP cartridges, BFP drive motor, turbine oil coolers, pumps, fans, air pre heaters, boiler circulation pumps, coal mill, coal feeder etc.
- j) Lay down space for all the equipments shall be considered and lifting and handling equipments shall be extended upto the laydown space
- k) Crisis Management scheme and Emergency Management scheme shall be provided. This is related to plant and personnel safety during construction and operation in relation to layout features, operational features and accidents. The details shall be discussed and finalized during engineering stage.

6.2.2 Power Block Area

The following building / structures & equipment shall be located within power block.

- Steam Generator area
- Steam Turbine Generator Hall
- Control & switchgear building



- Power Cycle Pipe Rack & Cable Gallery
- Transformer yard area

The suggested General Arrangement concept of Power Blocks is shown in Plot plan. Contractor shall develop an optimized Layout of the Power Blocks to suit the configuration and equipment offered.

Clear walk ways of minimum 1.5 m width at all the levels shall be provided in the main plant building. For interconnection with service building, walk way of about 3.5 m width shall be provided along the row of main plant building. Adequate fire escape staircases shall be provided in main plant building with fire doors at each landing.

For EOT crane maintenance, through walkway shall be provided along both rails at crane girder level. Approach to the crane through rung ladders shall be provided at least at two places.

Plant Main road to the power house building from the main gate shall be considering turning radius required for heavy multi axle trucks.

Steam turbine, generator, Lube oil system, CEP, and other equipments located in the turbine hall shall be accessible by the EOT cranes for their handling during maintenance and overhauling. For all other equipment/ components located in the main plant building, suitable handling arrangement viz. cranes/ chain pulley blocks/monorail hoists etc. as required shall be provided for the maintenance and overhauling. Wherever special handling procedures are to be followed, the same shall be described in a separate document.

Floor drains shall be provided at all floors and drain discharge pipes shall be properly sized taking into account the fire water sprinkler system wherever provided.

MDBFP to be located in 0.0m in BC bay. The Turbine repair bay area shall be sized for minimum of 20 m x 30 m

TG maintenance room and tool room shall be provided in TG operating floor.

Partition wall shall be shown between the CW pit and CEP pit. Required access facility shall be provided. Level based Sump pumps (1W+1S) shall be provided in each pit.

Office Block of 75 sq.m and guard room of 10 sq.m will be located adjacent to Silo Utility Building at silo area. 140 sq.m of maintenance area provided for ash handling system in addition to maintenance bay in each ash handling building.

6.2.2.1 SG area

The lay down area shall be provided on any one side of each SG, which would facilitate easy access for erection and maintenance. Equipments located outdoor shall be provided with covered roof /canopy.

Maintenance room for boiler, Mills and Fans shall be provided.

Coal bunker bay shall preferably be located away from the TG building to avoid the dust nuisance. In case bunker bay is located adjacent to TG area, suitable isolation arrangement shall be provided.

A clear walkway of 1200mm (min) shall be ensured between the mills / its foundation / mill reject vessel edge and inner face of mill bay column. Maintenance space shall provided on either side of Mill bay.



In the SG area, facility of crane/ chain pulley block/ monorail hoist etc. shall be provided along with provision of space for maintenance/ overhauling of equipment such as handling of coils of economizer, motors etc.

Space outside the ESP casing before ID fans for provision of one no. of additional Field in each pass in the ESP shall be provided.

Interconnecting walkways between SG and TG building shall be provided at TG operating floor level and at deaerator floor level. Walkways at various levels shall also be provided for interconnection between steam generator and bunker bay.

If the fuel with high Sulphur content is used, then FGD plant will have to be installed as per the norms. The space for FGD plant shall also include requirement of Waster Water Treatment required for FGD plant effluent. The mechanical, electrical and control & instrumentation design for the plant shall consider provision for the future installation of FGD.

6.2.2.2 Steam Turbine & Generator Hall

Adequate space for maintenance of steam turbine/generator and condenser shall be provided in the layout. Requisite lay down area shall be provided for each unit on TG floor and same shall be approachable with Electric Overhead Travelling (EOT) crane. One transverse bay with adequate space shall be provided for each Unit in TG building for unloading and maintenance purposes. TG EOT crane is required to handle the heaviest component other than the generator stator.

Generator stator shall be lifted using the strand jack method or portable crane.

The crane rails of the turbine hall shall be at sufficient elevation with adequate clearance from the crane main hook to the operating floor level. Preferably, EOT Crane access shall be made available for all STG Hall equipment. In case certain items do not have EOT Crane access, suitable permanent handling facilities shall be provided for them.

The operating floor for the STG shall be at suitable elevation level. The vertical CEP's, shall be located adjacent to the condenser.

Preferably Closed cooling water pumps, PHE, Vacuum pumps shall be kept in the ground floor.

Facility shall be provided for handling of condenser water box to enable maintenance and withdrawal of condenser tubes. Rolling shutter(s) along with extended platform shall be provided to facilitate condenser tube withdrawal.

Electrical bays shall be provided in TG building for each unit to house switchgear room, cable spreader room, battery room. Switchgear room shall accommodate HT switchgear, LT switchgear, dry type transformers etc. for the main plant electrical system. Each switchgear room shall have cable spreader room below the switchgear. Minimum floor height of the cable spreader room shall be 3.5m.

Corridor for transportation and lifting of Generator Stator outside "A" row column all along TG building shall be considered.

Required load and clear path for the platform to link Stage I & II, TG building shall be considered in the end of Stage-I TG building.



6.2.2.3 Control & Switchgear Building

The control and switchgear building shall be a separate building suitably located adjacent to the TG hall, between two boilers, considering ease of cable routing and interconnection. Below ground basement rooms shall not be considered.

The control and switchgear building shall house the Central control room and control equipment room, electrical switchgear room, relay panel room, UPS room, cable spreader room, battery rooms and air-conditioning system room as well as certain O & M Offices.

The Central control room shall house the DCS and other electrical control panels

The electrical switchgear room shall be located in the control and switchgear building at sufficient elevation, above the cable spreader room. Minimum floor height of the cable spreader room shall be 3.5m.

6.2.2.4 Transformer Yard Area

All power transformers shall be located outdoor.

Generator transformers, Unit transformer, station transformer, standby maintenance transformer, Unit auxiliary transformers, station auxiliary transformer and ECHS Auxiliary Transformers shall be located in transformer yard. LT dry type transformers shall be located indoor.

Layout of facilities and equipment shall allow removal of generator transformers, Unit transformer, station transformer, standby maintenance transformer, Unit auxiliary transformers and station auxiliary transformers without disturbing structure, equipment, piping, cabling, bus ducts etc. routed in the area. Suitable rail track and associated facilities like jacking pads, anchor blocks etc. shall be provided in the transformer yard to facilitate the movement of transformers upto road and further in to maintenance bay of turbine building.

6.2.3 Balance of Plant Area

Control Rooms, Electrical switchgear Rooms, Pump houses and any other functionally required buildings shall be included in the Contractor's scope.

The Cooling Towers (CT) and CW/ACW pumps shall be suitably located considering buried cooling water conduits to and from the power blocks and the CT make-up water piping. The pumps shall be located in the CW pump house at CT weir end & cooling water from the CT will enter the CW sump through a fore bay.

The emergency DG sets shall be located in the transformer yard in a separate building.

The Effluent Treatment plant shall be suitably located considering the source of effluent generation and the point of effluent disposal at the plant boundary and shall ensure conformance to the local environment regulations. Floor wash waste from areas as specified in Volume II, Section 2.14 under Waste water treatment system needs to be considered for treatment in oil water separator.

Space for Ash pond and Bottom ash / Fly ash disposal and evacuation shall be considered.

Facilities for Fuel oil receiving, handling and storage shall be considered.

The interconnection pipe work between plant utilities and power block equipment shall be routed through pipe racks / sleepers, pipe trenches or buried. The CW/ACW water conduits shall be laid below ground and buried. Trestles/Pipe rack to be provided for routing of cables, pipes etc. shall have a clear height at road crossings so as to clear the



road spaces, approach to maintenance bays of different equipment. A walkway of 750mm width (minimum) with hand rails and toe guards shall be provided all along length of the trestle for maintenance of cables and pipes. Ladders for approach to these platforms shall be provided near roads, passage ways.

Valves shall be located in accessible positions. All piping shall be routed at a clear height of minimum 2.5 m from the nearest access level for clear man movement. Best engineering practices shall be adopted for keeping the minimum clear working space around equipment and clear headroom within main structures and cable trays etc.

All Hydrant, Spray and foam system pipe mains/pipes shall be routed aboveground on top of the concrete pedestals at regular intervals. In main plant area and coal (yard) stock pile area pipelines shall be routed in RCC pipe trenches filled with sand and covered with pre-cast RCC removable covers. Pipe trenches crossing through road or rail shall be through hume pipes.

Space for pipe racks and pipe pedestals shall be considered while planning the layout.

Seawater intake and outfall piping and corridor for routing the same shall be considered.

The seawater intake pump house shall be provided with one(1) no of Diesel Engine driven vertical turbine pump of capacity 410 m³/hr for supplying fire water to the coal stockpile area ring main header for fighting large coal stockpile fire. The material of construction for the pumps, piping and valves shall be rated for seawater duty.

All BOP pump house shall have a tool room with racks and maintenance room of each (5 X 5 meters) in addition to control room.

Major external functional system are so oriented that any maintenance work as well as subsequent construction work can be carried out without any interference and/or hindrance to the operational units.

All facilities of the units are to be laid out in close proximity to each other to the extent practicable so as to accommodate all facilities efficiently within the plant boundary.

The layout shall also facilitate communication of men and materials between the various facilities both during initial construction and also during subsequent operation and maintenance.

Adequate space as required by the Owner for operator's rest room, tool room and pantries shall be included in all buildings/operating area.

All pumps shall be located in covered building. Proper ventilation shall be provided.

All pumps other than the drain sump pumps shall be located above ground.

Debris filter shall be located above ground with covered shed outside the TG building.

Vacuum pumps for ash evacuation shall be located near the first field of ESP. Vacuum pumps shall be located inside proper building.

Fabrication yard and laydown area shall also be developed as green belt.

All oil pits and floor wash pit shall be provided with cover slab.

FO pumps shall be placed above the ground and the tanks shall be suitably elevated so as to have minimum dead stock.



6.2.4 Consideration for Future Unit:

Necessary space shall be provided in the layout for interconnection of Stage I infrastructure with that of Stage II.

Where Stage II equipment are to be located in Stage I buildings, necessary space, power supply and other provisions shall be incorporated in the building for easy construction, installation and maintenance of such Stage II equipment.

For facilitating the connection of future GT bay to switchyard, contractor shall develop only the layout and submit as required by the Owner. Whereas the scope of supply and erection of future GT line bay to switchyard is not in the scope of contractor.

6.2.5 Layout of other facilities

6.2.5.1 Hazardous areas, fire protection provisions

Hazardous areas

The Contractor shall take full account of any special requirements concerning the nature, handling and storage of all fuel oils, and chemicals etc., and provide plant, equipment, buildings and other services accordingly, including all facilities to ensure the safety of the operating and maintenance personnel.

The Contractor shall provide drawings to define all the hazardous zones taking account of all sources of hazards under normal and abnormal operating conditions, (regardless of whether or not these areas are specifically listed in the specification). The zoning philosophy shall be subject to the approval of the Owner / Engineer.

In particular, equipment directly concerned with plant which may give rise to a hazardous situation shall be designed to requirements with electrical connection safety barriers or intrinsically safe equipment. Where required by the Owner / Engineer, certification shall be provided to confirm the suitability of the equipment and devices.

The Contractor shall be responsible for ensuring that all electrical equipment installed in any hazardous zone is designed and tested to suit the relevant zone classification and shall be to the approval of the Owner. Cables shall not be laid in trenches with fuel pipe work.

Fire protection provisions

Unless otherwise specified or agreed with the Owner, the following design principles should be observed as minimum fire prevention requirements:

Pipeline insulation and the infills of cable and pipeline wall penetrations are to be of non-combustible material.

All pipelines or vessels with internal temperatures of more than 180 °C shall be so arranged as to avoid any contact with flammable liquids if fuel or lube oil lines should leak. Sufficient physical separation shall be ensured.

Particular care should be taken to eliminate any risk of hot pipeline-insulating material becoming impregnated with flammable liquids in the case of fuel or lube oil line leakage. The insulation is to be covered in its entirety, with an oil resistant sheet, over which the cladding is to be fitted.

Cable and pipeline ducts must be so arranged and sealed as to avoid any risk of flooding with, lube oil or any other flammable liquid. In addition to sealing the cable and pipeline ducts, the cable basements must be completely sealed against leakage from above as well, in order to preclude the ingress of lube oil or other flammable liquids.



Covered floor ducts must be easily accessible for inspection and cleaning.

All parts of plant and equipment are to be arranged so that no corners or pits that would be difficult to inspect and clean and in which flammable matter could collect are formed.

Fuel preheating temperatures should be limited to a margin of at least 10 K below the fuel flash point.

Lubricating oil lines in the turbine-generator lube oil system are not to be connected with compression-type joints but rather with welded or screwed-type points.

Non-combustible materials which do not release noxious or toxic fumes must be used for wall and ceiling paneling, for floor covering, and for cubicles and cabinets.



7.0.0 GENERAL PLANT DESIGN REQUIREMENTS

7.1.0 General

The design of the coal based thermal power plant and associated auxiliaries shall generally conform to the following requirements and shall be new and unused.

The plant shall be constructed considering prudent engineering practices and optimal utilization of resources. These shall be complete and include all the equipment and systems necessary to ensure high level of reliability, availability, efficiency, safety and maintainability over their lifetime. It is also necessary to consider various precautions to safeguard the operating and maintenance personnel

The Plants and Electric Lines shall be suitable for full range of ambient and other environmental conditions as prevailing at site. The design of the power plant shall ensure that the plant can, in the state of normal operation, adapt itself to load, frequency, power factor, ambient variations within the allowable range of design

The auxiliary systems and plant facilities shall be designed for serving the whole power plant with adequate redundancy. Secondary system component shall be designed generally for 100% redundancy in order to achieve high reliability and availability of the power plant.

The life span to be considered for the design of equipment and component selection shall be at least **40 years**. The civil structures shall be designed for a design life of 50 years.

The various parts and systems of the power plant shall be designed to achieve the object of providing integrated and coordinated power plant operations. For the design of the power plant, it is necessary not only to consider the requirements of operation, but also, by suitably planning the layout, the convenience for inspection, cleaning, maintenance and repair are ensured.

The various parts or components or assemblies of equipment and systems shall be of proven materials with well established physical and chemical properties appropriate to the service as intended. It is required that the equipment shall be of a rustproof, moisture proof and waterproof type to ensure continuous trouble free operation

All materials, components and equipment shall be tested at all stages of procurement, manufacturing, erection, commissioning as per comprehensive Quality Assurance Programme to be agreed mutually between the Owner and the equipment supplier.

In the design of the power plant and selection of equipment, the specific requirements of this project and likely occurrences of abnormal operating conditions have to be taken into consideration to ensure that the power plant can, under these circumstances, operate continuously, safely and with high efficiency. The selection of materials shall be suited to local conditions.

Equipment installed outdoors shall be capable to operate in all-weather conditions and withstand the work site environment. For equipment in operation or in standby that may be influenced by direct sunshine, shelter or cover shall be provided.

The equipment must operate without vibrations that may affect its operation, that of other machinery or of civil works under every condition.

Corresponding parts throughout shall be made to gauge and be interchangeable wherever possible. In case required, the supplier shall provide the necessary references for all kinds of equipment.



All equipment performing similar duties shall be of the same type and manufacture in order to limit the stock of spare parts required and maintain uniformity of plant and equipment to be installed.

The Station shall comply with all applicable environmental stipulations of Ministry of Environment and Forests (MOEF) in regard to ambient air quality, gaseous emissions, liquid effluent discharges, solid waste disposal and any other stipulation of the Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) in this regard. TANGEDCO have applied for the MOEF clearance with 100% imported coal and it will be given to contractor during the detailed engineering stage. Contractor has to fulfill the requirement of the MOEF without any cost implication. TANGEDCO have already obtained the Environmental & CRZ clearance for coal jetty, coal conveyor and seawater intake and outfall system and the approval letter is attached in Volume III – Attachments to Tender Documents. Contractor shall fulfill the MOEF CRZ clearance requirements as applicable for his scope of work.

Areas where a potential flammable atmosphere may exist shall be classified in accordance with the provisions of latest version of relevant IS. Certified equipment shall be used in the designated hazardous areas. To the extent practicable, equipment requiring operator's attention and/or electrical equipment shall not be installed in hazardous areas.

The equipment should be adequately protected against environmental elements, such as humidity, dust etc., and the influences that other equipment may have, such as heat radiation, induced vibrations, etc. The supply shall include protective cabinets for parts exposed to the open air or sensitive parts requiring such protection.

As the plant site in the coastal area, the environment is likely to be corrosive and the materials of construction for all exposed metal/ concrete surfaces shall be so chosen as to withstand the corrosive environment. Also suitable weather protection shall be provided to all exposed surfaces. Suitable anti-corrosive measures shall be provided for under-ground piping where the same is absolutely necessary.

All stand-by auxiliaries shall be designed for auto start up, on failure of running auxiliaries with minimum time delay and without runback on unit load.

All heavy parts of the plant must be provided with some convenient arrangement for aligning and for handling during erection and overhaul. Any item of plant required to be stripped or lifted during period of maintenance and weighing one tonne or more shall be marked with its approximate weight.

7.2.0 Standards and Codes of Practice

All equipment, systems and works covered under these specifications shall be in accordance with all the latest applicable statutes, regulations, codes and standard specified as well as all such standards, statutes, regulations and safety codes applicable in the locality where the equipment will be installed. Contractors may familiarize themselves with all such requirements before preparation of bids. Complete design including pressure parts, piping, valves and fittings shall meet or exceed all the requirements of the latest versions of Indian Boiler Regulations (IBR), Indian Standards / ASME codes.

The design, construction and testing of all equipment, facilities, components and systems shall be in accordance with latest version of relevant standards and codes issued by Bureau of Indian Standards (BIS) and/or reputed international standards and codes. A non-exhaustive list of reputed international standards is given below:

- a) American National Standards Institute (ANSI)
- b) American Petroleum Institute (API)

- c) American Society of Mechanical Engineers (ASME)
- d) American Society of Testing and Materials (ASTM)
- e) American Water Works Association (AWWA)
- f) American Welding Society (AWS)
- g) British Standards (BS)
- h) Cooling Technology Institute (CTI)
- i) Deutsches Institute for Normung (DIN), Germany
- j) Gosstandart of Russia (GOST) standards
- k) Heat Exchange Institute (HEI), USA
- l) Hydraulic Institute Standards (HIS), USA
- m) International Electro-technical Commission (IEC)
- n) Institute of Electrical and Electronics Engineers (IEEE)
- o) International Organisation for Standardisation (ISO)
- p) Japanese Industrial Standards (JIS)
- q) National Electric Code (NEC), USA
- r) National Electrical Manufacturers Association (NEMA), USA
- s) Central Electricity Authority (Construction of Electrical Plants & Electric Lines) Notification of 20 th August 2010
- t) National Fire Protection Association (NFPA), USA
- u) Occupational Safety & Health Administration (OSHA)
- v) Tubular Exchanger Manufacturers Association (TEMA), USA
- w) VDE association for Electrical, Electronic and Information Technologies (VDE), Germany

Other international Standards, equivalent or superior to the above Standards can also be adopted. However, in the event of any conflict between the requirements of the international standards or codes and the requirements of the BIS standards or codes, the latter shall prevail. In the event of any conflict between the requirements of equivalent codes and standards, and the requirements of IBR, the latter shall govern unless specified elsewhere in the specifications

The Plants and Electric Lines shall also be designed to comply with the requirements stipulated in

- a) Central Electricity Authority (Installation and Operation of Meters) Regulations.
- b) Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations



- c) Central Electricity Authority (Measures relating to Safety and Electricity Supply), Regulations as and when these are notified by the Authority.
- d) Central Electricity Authority (Safety Requirements for Construction, Operation and Maintenance of Electrical Plants and Electric Lines) Regulations as and when these are notified by the Authority.
- e) Central Electricity Authority (Grid Standards) Regulations as and when these are notified by the Authority.
- f) Central Electricity Authority (Technical standards for Construction of Electrical Power Plants and Electric Lines) Regulations 2010
- g) Indian Electricity Grid Code issued by Central Electricity Regulatory Commission (CERC) and
- h) Applicable State Grid Code issued by appropriate Regulatory Commission

All material and equipment supplied and all work carried out as well as calculation sheets, drawings, quality and class of equipment, methods of inspection, constructional peculiarities of equipment and parts and acceptances of partial plants, as far as these are beyond the special requirements of the specifications, shall comply in every respect with the technical codes of the above listed codes and Standards

It shall be the responsibility of the Contractor to take all approvals required and get the boiler registered under the IBR. In all other cases where IBR does not govern, IS/ASME, Japanese, American, British, German or other international standards established to be equivalent or superior to IS/ASME shall be acceptable with the approval of the Owner at the time of detailed engineering..

Where there are no standards or regulations, or the standard is not sufficient to meet the need of design and supply, for such items relating to the power project, the Contractor shall carry out the design, manufacture, supply and installation on the basis of good engineering practice with Owner's approval.

During the period of Contract execution, if any standards change, the Contractor shall be responsible to notify the Owner and provide the basis for the prospect that it would not cause the lowering of quality, performance and service life of the power plant due to alteration of the standard. Upon mutual agreement, the amended standard can then be followed.

Further requirements about applicable standards and codes are specified in the detailed technical specifications.

7.3.0 Plant Operational Requirements

- i) The unit shall give Maximum Continuous Rating (MCR) under the following conditions:
 - Maximum cooling water temperature
 - Worst fuel quality stipulated for the unit
 - Grid frequency variation of (-) 5% to (+) 3% (47.5 Hz to 51.5 Hz)

The Unit shall be designed for continuous operation under VWO condition.

The unit shall be capable of base load operation. However, the unit shall also be capable of regular load cycling and two-shift operation. The steam turbine shall be designed for a minimum of 4000 hot starts, 1000 warm starts and 150 cold starts during its life.



- ii) The steam flow through steam turbine under valves wide open (VWO) condition shall correspond to 105% of steam flow corresponding to MCR output.
- iii) The unit shall be designed for constant pressure and sliding pressure operation. The unit shall be designed to operate at constant pressure from zero to 40% rated load, sliding pressure mode from 40% to rated load. The throttle reserve shall be adjustable to minimum 0% for pure sliding pressure mode of operation. Unit shall also be capable to operate in modified sliding pressure mode of operation.
- iv) The design shall cover adequate provision for quick start up and loading of the unit to full load at a fast rate. The unit shall have minimum rate of loading or unloading of 3% per minute above the control load (i.e. 50% MCR).
- v) The unit shall be capable of automatically coming down to house load and continue to operate at this load in the event of sudden external load throw off.
- vi) Unit shall be designed to give maximum possible efficiency for the fuel stipulated and other site specific conditions.
- vii) The unit shall operate continuously with HP Heater out of service with max. specified cooling water temp, 3% make up and normal aux. steam requirement being tapped from CRH line. The power output of the unit under this operating condition shall commensurate with Steam Generator capacity as specified above.
- viii) HP-LP bypass operation under rated steam conditions with Bypass valve open to full capacity of the HP-LP Bypass system (i.e 60% of the BMCR flow) and turbine on house load.
- ix) The equipments and auxiliaries shall be suitable for continuous operation in the frequency range of 47.5 Hz to 51.5 Hz. All the auxiliary equipment and the drive motors shall be capable of delivering satisfactorily their rated output continuously for voltage variation, frequency variation and combined voltage & frequency variation as indicated else where in the specification

All the equipments and auxiliaries should be designed to cater to the above operating conditions with adequate margin as per standard practice prevailing in the fossil fired power plants.

x) Mode of Operation

The plant shall be designed for an availability of more than 90%.

Plant Operation and Service Life

Load Ramps

The Facility shall be capable of the following normal and emergency ramp rates for sliding pressure operation.

	Normal	Emergency
Sliding pressure	3% / min	5% / min

**Start Up:**

The facility shall meet the following maximum required start up times from the initial conditions

Cold Start : 7 hrs from lighting the burners to full load
Warm Start : 4 hrs from lighting the burners to full load with start-up bypass system
Hot Start : 1.5 hrs from lighting the burners to full load.

Low Load Operation

The facility shall provide safe and stable long-term operation with the controls in full automatic mode without any supplemental oil firing in the range of 40% to 100% of unit load.

The unit and the auxiliaries shall be designed for maximum reliability and availability; operability and maintainability. The Contractor shall specifically state the design features incorporated to achieve the high degree of reliability and availability.

7.4.0 Vibration

Vibration shall be reduced to the minimum as far as possible to well with in the limit of the standard where it cannot be completely eliminated. Amplitude and frequency limitation in the design and supporting structure shall be considered.

Special care shall be taken to avoid operating equipment making resonance with foundations, packing, duct, platform, piping or other components.

Unless otherwise stated or agreed by the Owner each rotating machine has to comply with the requirements for designation as 'good' stipulated by ISO /ASME std for the respective group of machinery. If the vibration is higher than stipulated as 'satisfactory' the Owner has the right to reject the corresponding equipment, subject to the conditions specified elsewhere.

7.5.0 Noise levels

The plant shall be designed and constructed to reduce the operating noise level as much as possible and when the plant is operating at all loads, the noise pressure levels specified in Section 18-Environmental Requirements shall not be exceeded.

- (a) Noise level at the Station boundary shall not exceed the Ambient Air Quality Standard in respect of noise as notified by MOE&F and any other stipulation of the state PCB and central PCB in this regard.
- (b) Noise level for the continuously operating equipment shall not be more than 85 dBA at a distance of 1 metre and at a height of 1.5 metre from any equipment. For short term exposure, noise levels shall not exceed the limits as stipulated in the Occupational Safety & Health Administration (OSHA) Standard.
- (c) The noise level in the offices and the control room shall not more than 50 dB(A).
- (d) Equipment/ machines shall be provided with acoustic enclosures, wherever required so as not to exceed the permissible noise limits.

7.6.0 Units of Measurement

For all the technical tables and diagrams, calculation results, drawings, test data and scales adopted in the design and provided for the power plant, the standard international

unit system (SI) as per International Standardization Organization (ISO) shall be uniformly employed.

SI system shall be employed for all the first-class plant layout and arrangement drawings of equipment made especially for the project. In spite of the employment of British Standard in the layout or drawings and single item standard drawings made with other measuring units, the principal dimensions and demarcation points on these drawings shall also be converted into SI system to be directly marked onto them.

7.7.0 Safety

Special importance shall be assigned to all aspects related with the safety of personnel operating, assembling and maintaining the equipment, including other persons who are likely to come in contact with same.

The possibilities of human failure must be foreseen. Provisions shall be taken to avoid damage caused by human error, or to ensure that such damage both to persons as well as to the equipment is the least possible.

Rotating or any other moving part of the machinery, hot parts or any part that may cause accident to the staff must be adequately protected, in accordance with the safest method known.

Areas where a potential flammable atmosphere may exist shall be classified in accordance with the provisions of latest version of relevant IS. Certified equipment shall be used in the designated hazardous areas. To the extent practicable, equipment requiring operator's attention and/or electrical equipment shall not be installed in hazardous areas.

Insulation along with aluminum cladding shall be provided for all the equipment/surfaces (excluding coal pulverisers) having skin temperature more than 60°C considering wind velocity of 0.25 m/sec. (0.5 m/sec where the heat loss is not the criteria)

Bright paints used will be agreed upon with the Owner to protect personnel, so that anything representing a potential danger will stand out: such as elements in movement, suspended hot, with electric tension, etc.

It should be possible to carry out frequent maintenance operations required by the equipment without interrupting its operation and without danger to the personnel.

Access stairs to the equipment must be safe, with anti-skid rungs and handrail. Normal circulation areas of the equipment shall be protected to keep personnel from falling or shall be surrounded by strong guardrails, platforms should have kicking plates to keep loose objects placed on the floor from dropping off, entrances and large openings in the equipment shall be provided with lids or doors affixed in such a way as to open them also from the inside.

Every equipment or parts of equipment that must operate under certain conditions of maximum pressure, temperature, speed, position etc., should have devices to keep such limits from being exceeded and, if necessary, to stop the operation of the machine (Safety valves, limit switches, thermal switches, etc.).

For protection against the possible failure of the above devices, additional safety elements shall be provided such as stroke limiting stops, diaphragms, bolts, etc. and/or links or other dimensioned rupture elements so that in case of failure, when exceeding extreme operating conditions, additional safety is provided to the equipment.

Inside air and gas ducts, ladders have to be installed for inspection of dampers, venturies, etc.



In designing an area where combustible gases are likely to accumulate, due consideration shall be given to provide safety measures to allow the gas to continuously diffuse or leak off to prevent explosion. The electric equipment in those areas shall be of the fireproof and explosion proof type. Suitable grounding shall be provided on the casing of electrical apparatus which might be energized.

Draining of water and venting of steam shall be performed with respect to the safe mode of discharge, and is not allowed to be carried out at or near the places where people exit and at the exit of the plant.

7.8.0 Fire Protection and Precautions

The Contractor shall adopt necessary methods to minimize fire hazards.

The fire protection system shall in general follow the recommendation of Tariff Advisory Committee of India and the system and equipment shall meet with their approval.

The design of power plant shall include a complete set of composite fire monitoring, protection, and fighting system to identify, isolate, and distinguish fires as well as minimizing potential fire hazards.

A warning alarm for the power plant and alarm for evacuation shall be provided. The alarm is to be audible in the normal working areas of personnel. The selection of the alarming device shall be such that it is audible about the normal background noise of the plant. Visual alarm shall be provided in addition to audio alarms in high noise areas.

During the construction phase of power plant, the Contractor adopts advanced and safe working practices and a set of guidelines to keep the site in a clean condition to reduce the possibility of fire. The basic guiding ideology is to adopt two methods: fire prevention and fire control shall adopt to improve conditions in designing the layout, to reduce potential fire danger, ensure the safety of personnel, ensure the safety of the important and main equipment of the power plant.

Use fire proof or fire resistant materials, ensuring that, isolating combustible material is not used or stored in possible fire source area of the power plant.

The end connection type of hydrant shall fit in with local fire brigade requirements to ensure the manual device in power plant to be compatible with the fire control device of local fire brigade.

7.9.0 Signs

Safety colors, safety symbols and safety signs must comply in construction, geometrical form, color and meaning with the ISO Recommendation 507 of the ISO committee TC 80 'Safety Colors'. All signs should give the identification number. All signs shall be in the English language.

The signs should be of a material which is weather-resistant and of sufficient durability for the conditions prevailing on site. Indian regulations and codes are to be considered.

The positions for the signs must be chosen so that they are within the field of vision of the persons to whom they apply. The signs should be permanently attached. Temporarily dangerous areas (e.g. construction sites, assembly areas) may also be marked by movable signs. The safety signs must be mounted or installed in such a manner that there is no possibility of misunderstanding.

All Necessary Traffic signs, Information sign, Emergency sign, Mandatory signs, Warning sign, Prohibition sign viz No Smoking, No Entry, Do Not Start, etc., shall be provided at appropriate area in the entire power project area.

7.10.0 Package, Storage and Store House

The Contractor should provide all the specifications and instructions for the self purchased and fabricated equipment during the planning period of the Contract. These specifications should include the cleanliness and maintenance requirements of materials during fabrication and the protection measures for the equipment from damage during transportation. Loss of materials during storage should be avoided before installation. The instruction should be worked out especially to suit the particular work site program.

All materials and equipment should be packaged according to the typical environmental conditions during storage. In case of severe conditions, these materials and equipment should be packaged carefully by taking a full and appropriate preventive measure to protect from any damage or wear.

The Contractor and his appointed Subcontractor for installation should guarantee jointly that a good supplementary storage will be carried out within the equipment site controlled by them.

Three classes for storehouse are described as follows:

Storehouse class A items: Special measures are taken to protect the stored goods and the temperature, humidity, are controlled within a specified range.

Storehouse class B items: Goods are stored with temperature uncontrolled.

Storehouse class C items: It is an outdoor storage with a drainage system on the ground.

For storehouses of class A and B they should be fireproof, heat resisting, waterproof and well ventilated. They should not be wet and should be provided with good drainage system and preferably with a brick laying or concrete ground. For storehouses of class C, they should not be wet and should be well drained, preferably with a brick laying or crushed stone ground, should be protected from rainfall, salt corrosion, ash and other adverse conditions with a temporary cover or tent if possible

Component surfaces should not be contacted directly with the ground or ground laying material. There should be a layer of oilcloth or wax or other similar materials between the machine surface and ground surface.

All components shall be inspected for their painting, storing, sealing etc. and any damage or wear should be repaired during acceptance and storage periodically. The inspection interval is determined by the component function, applied protection measure and storehouse class.

Many components are provided with a drying agent or sealed in a coverage (polyethylene or insulating cover) containing drying agent. The drying condition shall be inspected during storage in an interval of every 4 weeks.

7.11.0 Painting, Insulation, Anti-dewling

Anti corrosive coatings and painting shall be carried out as a pre-treatment to all equipment and parts. The paint system used should coordinate with the painted objects and surrounding conditions of project.

Anti corrosive coatings and painting shall comply with ISO 12944 classification C5M for all equipments and structural steel which are outside the plant boundary and ISO 12944 classification C4 for all equipments and structural steel which are inside the plant boundary

In multi-layer painting system, different painting layers should be selected to make the painting coordinate. If multi-layer painting system is used, various painting layers should have distinct colors so that the later layer can be distinguished from the former one.



After the equipment or apparatus finished preliminary or full painting, it can be supplied to field. After the installation is finished, ground coat must be painted.

Entire painting procedure should be supplied in order to repair the injures of painting coat after the equipment is delivered to field.

Color strip indication system should be used for pipes. These strips should be painted on the joint of pipes, entrance, valves of pipe. This pipe without outside protection layer should be marked by some color in whole length.

The principal color of field equipment should be determined by the Owner and Contractor during execution stage.

The specified requirements shall be applied to the whole equipment and facilities of the Power project Contract.



8.0.0 LANGUAGE TO BE USED

English shall be used as the general Contract language. English translations shall be provided for any code and standards not in English language.

Name plates of equipment and instrument scale, etc. shall be marked in English as required for start-up, testing and training etc.

Documents for training shall be provided in English.



9.0.0 QUALITY ASSURANCE, SHOP INSPECTION AND TESTING

9.1.0 General

This section contains general requirements for inspection of material, parts, equipment and workmanship of the plant during manufacture, assembling to demonstrate compliance with specification, codes and standards to ensure overall reliability of plant operation and performance.

The Owner and/or authorized Representatives shall, at any time, be allowed free and ready access to the Contractor's premises and those of his suppliers as well as to the site installation and the Contractor has to make the plant items available for the purpose of inspecting the specified equipment components and obtaining information as to the progress of the work. Failure on the part of the Owner, at this or any other time, to discover or reject materials or work which do not meet specified requirements shall not be deemed an acceptance thereof nor a waiver of defects therein.

The approval of the Owner shall not prejudice the right to reject equipment if it does not give complete satisfaction in service.

The cost of travel expenses, boarding and lodging expenses of the inspection have to be borne by the EPC contractor. This includes inspection in India and foreign countries.

9.2.0 Scope

All materials, components and equipments covered under this specification shall be tested at all stages of procurement, manufacturing, erection, commissioning as per a comprehensive quality assurance programme. The requirements of minimum quality plans to be followed by the Contractor in respect of various equipment are specified in detailed technical specification. The Contractor shall draw his own quality plans in line with these requirements and his standard practices and implement such programme after approval by the Owner.

Manufacturing quality plan shall detail out, for all the components and equipments, various tests/inspection to be carried out as per the requirements of this specification and standards mentioned therein and quality practices and procedures followed by Contractor's quality control organization, the relevant reference document and standards, acceptance norms and inspection documents raised etc. during all stages of material procurement, manufacture, assembly and final testing/performance testing. The detailed manufacturer's quality assurance plan shall be subject to approval after award of contract.

The Contractor has primary responsibility for ensuring the quality of items of equipment supplied under the contract and remains accountable when manufacture or erection is subcontracted. It is therefore a requirement of the specification that work is only subcontracted to companies with effective quality control organizations and that the Contractor monitors the performance of these by the attendance at tests of experienced inspectors employed by the Contractor. The Contractor shall, at the appropriate time, prove that his material and / or equipment comply with all the requirements of this Section, such proof being the successful completion of tests and inspections. Routine test and type test certificates shall be submitted for each item of equipment, wherever applicable.

All materials, components and equipment supplied under the contract shall be subject to inspection by the Owner, his representative, Inspectors of Boilers (India) or his authorized Agency or any other Inspector of the Government, should they so require during manufacture, erection and after completion. The necessary inspection charges of the authorized agency of Inspection of Boilers (India) shall be borne by the contractor. The inspection and tests shall include but shall not be limited to the requirements of this section of the specification. Further requirements to be applied are specified in the detailed specification.



The Contractor along with quality plan, shall also furnish copies of the reference documents/plant standards/acceptance norms/test and inspection procedure etc. referred by him in quality plans. These quality plans and reference documents/standards etc. will be subject to Owner's approval after award of contract.

No materials/equipment shall be dispatched from the manufacturer's works before the same is either accepted subsequent to pre-dispatch final inspection including verification of records of all previous tests/inspections by the Owner's Engineer /authorized representatives, or such pre-dispatch final inspection is waived by the Owner and dispatch is authorized after review of test reports.

All materials used or supplied shall be accompanied by valid and approved material certificates and test and inspection reports duly approved by the Owner. These certificates and reports shall indicate the acceptable identification number of the material they proposed to certify. The material certified shall also have the identification details stamped on it.

All material used for equipment construction including castings and forgings etc. shall be of tested quality as per relevant codes/standards. Details of results of the test conducted to determine the mechanical properties, chemical analysis and details of heat treatment procedures recommended and actually followed shall be recorded on certificates and time temperature chart. Tests shall be carried out as per applicable material standards and/or agreed details.

All welding shall be carried out as per welding procedure drawn and qualified in accordance with requirements of ASME Section IX. Welding procedures shall be submitted to the Owner for approval prior to carrying out qualification test in the presence of Owner's representative.

All welders/welding operators employed on any part of the contract either in the Supplier's works or at site or elsewhere shall be qualified as per ASME Section-IX.

Test results of qualification tests and specimen testing shall be furnished to the Owner for approval. However, wherever required by the Owner, tests shall be conducted in presence of Owner's Engineer/ authorized representative.

All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.

All the sub-vendors proposed by the Contractor for procurement of major bought out items including castings, forgings, pumps, heat exchangers, semi finished and finished components/equipment-(list of which shall be drawn up by the Contractor along with his offer and finalized with the Owner) shall be subject to Owner's approval.

The type and extent of inspection of items shall be in accordance with the relevant International/Indian Standards/Indian Boiler Regulations and other standards approved by the Owner, supplemented or amended by the requirements of this section of the specification or as specified elsewhere in the Specification.

9.3.0 Inspection Program and Test Notifications

Before manufacture commences and not later than 45 days after award of contract, the Contractor shall submit an outline of his proposed inspection program, which shall include all major stages during manufacturing. The inspection and test program shall include for the various items the designation No., name of equipment, part of equipment, the kind of test, test standard, company which carries out the test, place, date and witnesses by the Contractor, third party or Owner's Representative. The detailed manufacturer's quality assurance plan shall be subject to approval after award of contract



The Owner will return a copy of the Contractor's proposed inspection program indicating those inspection stages for which notification is required. Notification shall be by Fax or email in a format to be agreed and shall be sent prior to the intended test in accordance with 'General Conditions of Contract'. If the Owner intends to be represented at the test he will provide at least 24 hours' notice and if his representative does not attend on the notified date, the test may proceed unless an alternative date has been requested by the Owner.

9.4.0 Test Certificate Documentation

The results of all tests shall be certified by the manufacturer, Contractor or independent agency as appropriate.

Document files containing material certificates, welding procedures, test report etc. shall be compiled for each item of plant and shall be suitably identified (including equipment classification reference) and bound.

Three copies of each document file containing inspection reports and certificates of site erection testing activities of a particular item of plant or system shall be supplied to the Owner prior to commissioning.

Copies of the performance and acceptance test reports shall be prepared and distributed as specified in Clause 'Performance and acceptance test data and reports' of this Section. All documentation as required by IBR shall also be prepared and submitted.

9.5.0 Codes and Standards

9.5.1 General

The type and extent of inspection shall generally be in accordance with that specified in the standard used for design and construction of the item of equipment supplemented or amended by the requirements of this section of the specification. The Contractor should provide the copy of relevant codes and standard to the Owner if requires by the owner.

9.5.2 Reference to Codes and Standards

Reference to special codes and standards, where designated either directly or as "relevant", is intended to provide a measure of performance, safety, in-shop and on-site testing, and methods of construction and/or installation which must be equaled or exceeded in order to be considered acceptable for use under this specification. If more than a single degree of quality or accuracy is permitted within the scope of particular code or standard, the highest quality shall be applicable and the degree of accuracy commensurate with the intended function shall be selected, but with the understanding that the final decision will be made by the Owner.

In all instances, the finally accepted applicable code or standard shall be the version last published.

9.5.3 Alternative Standards

Where no appropriate standard is available, tests shall be conducted in accordance with the manufacturer's standard practice, subject to the approval of the Owner.

In such cases the Contractor shall submit to the Owner, complete data and a suggested procedure for the testing to be performed. Commencement of manufacture before receipt of the Owner's approval shall be at the Contractor's risk.



If the proposed procedures are accepted, the Contractor shall provide the Owner with four additional copies in English before any test is performed.

9.5.4 Derating Standards

The Contractor's attention is drawn to the climatic conditions in the site area. Derating factors shall apply in accordance with the relevant and approved standards if not specified in the contract documents.

9.6.0 Services prior to and During Inspection and Testing

In accordance with and in addition to specified standards the Contractor shall submit procedures for material testing, manufacture, quality control and performance testing right from the procurement phase of raw materials to the finished product. Manufacture commenced before receipt of the Owner's approval of material specifications and testing procedures shall be at the Contractor's risk.

No inspection shall be valid unless the Contractor and manufacturer are in possession of relevant approved drawings and procedures for the item to be tested. The Contractor on request shall supply the Owner's representative with a copy of drawings and procedures at the time of the test.

All instruments and apparatus required for the inspection or used for the performance of tests shall be subject to the approval of the Owner at his discretion and shall be calibrated to an agreed standard in approved laboratories. The cost of making such calibrations shall be borne by the Contractor in all cases.

If the Contractor wishes to apply for a concession in respect of a departure from an approved procedure or standard, this shall be made in writing with full information substantiating the technical acceptability of the proposed change. The Owner's decision shall be final. Concessions granted shall not absolve the Contractor from any of his responsibilities under the Contract.

9.7.0 Testing During Manufacturing

The minimum testing requirement for mechanical, electrical and C&I items to be conducted at manufacturer's works are specified under respective sections.

**10.0.0 EQUIPMENT ERECTION, SITE TESTING, COMMISSIONING AND RELIABILITY TEST**

This section generally covers the standards, scope of works, documentation, scope of installation, testing and commissioning of various requirements to be adhered to during the execution of the mechanical, electrical & instrumentation works.

Works shall be performed in accordance with this technical specification and various other drawings and schedules submitted and approved by the Owner during the execution and the instructions from Engineer-in-charge or his authorized representatives during the progress of the work. All consumables required for the job shall be ensured by the contractor. Contractor has to draw the water from the sea. After treatment, water shall be used for the different application. Electrical power for testing, commissioning, reliability test and performance guarantee test shall be availed from startup power (400kV grid) at free of cost. Necessary arrangements for available startup power under bidder's scope. All necessary equipments & instruments required to carry out the works, recalibration of the instruments required during loop checking and commissioning shall be done by the contractor.

Field quality plans shall be submitted and shall detail out for all the equipments, the quality practices and procedure etc. to be followed by the Contractor's site quality control organization during various stages of site activities including receipt of materials/equipments at site, preservation and storage, pre-assembly, erection, pre-commissioning and commissioning. The Contractor shall provide all necessary means for execution of inspection and testing, according to the requirements.

10.1.0 Erection**10.1.1 General**

Erection work shall be carried out in the manner and sequence as may be directed by Contractors supervisory Engineers and the Owner.

All existing structures, piping, conduits, equipment and facilities, if any, shall be protected by the Contractor against damage during erection. Any damage caused by Contractor shall be rectified at his cost to the satisfaction of the Owner.

As erection proceeds each assembled part before being boxed up with a view to erecting it finally, shall be inspected and approved by the concerned supervisor. Should any defect be found out during such inspection, the Contractor shall make it good as per directives from Owner.

All materials such as electrodes, gaskets, bolts, nuts etc., shall be of reputed make and conforming to relevant Indian Standards. Prior approval of Owner will have to be obtained before commencement of work. Manufacturer's test certificate shall have to be provided when called for.

Contractor shall furnish all instruments, isotopes, films etc. for conducting radiography and equip himself fully. Necessary operators of all testing equipment shall be provided by the Contractor. Dark room facilities with air conditioners for storing and processing radiography films and equipment, as necessary, shall have to be arranged by the Contractor. The radiography shall be done on any weld (including welds for repair) only after final heat treatment.

The equipment shall be placed on respective support, leveled and aligned with precision measuring instruments, checked for proper clearance between moving and stationary parts wherever applicable.

The installation of motors shall be carried out along with driven equipment in accordance with manufacturer's instructions and/or as directed by the Owner.



Wherever the scope includes control panels, all connections in control panels shall be completed, checked and adjusted to ensure safety and satisfactory operation of the equipment.

Particular attention shall be given towards removal of buckles and other forms of distortion.

Holes in plate work to assist in erection should be avoided.

Misalignment in vertical joints shall not exceed 10% of plate thickness or 1.0 mm, or whichever is larger.

Misalignment in horizontal joints shall not exceed 15% of upper plate thickness with a maximum of 2 mm for plate thickness above 8 mm and a maximum of 1.0 mm for plate thickness less than 8 mm.

Welding sequence shall be adopted in such a way so as to minimise distortion due to weld shrinkage and shall be got approved from the Owner prior to commencement of work.

Welding shall not be carried out on wet surfaces and shall be protected from high winds.

10.1.2 Erection Program and notification

The Contractor shall furnish a detailed erection programme taking into consideration the constraints likely to be encountered during various phases of work including interfacing with the existing plant. This erection programme shall be strictly adhered. The Contractor shall take appropriate steps as directed by the Owner to make up for any slippage from this erection programme and no additional compensation shall be allowed on this account.

Before erection commences and not later than three months before start of erection, the Contractor shall submit the proposed erection test program and the commissioning test program with all proposed erection and commissioning tests and checks. Together with the test programs the proposed test procedures have to be submitted.

The test programs should consider:

- that the sequence and duration of the proposed activities are logical, realistic and in accordance with safety and permit regulations in force
- that the commissioning of any item of plant would not interrupt the normal operation of the existing plant.
- that allowance for training the Owner's operation personnel during this period has been made.

The Contractor has to take care that the test programs are maintained by the erection organization during erection and commissioning.

The Contractor has to mark all stages, which are subject to the Owner's acceptance and has to notify at least two week's in advance when such inspection for acceptance becomes due.

10.1.3 Supervision during Erection

The Contractor shall provide at proper time the necessary supervisory Engineers, Supervisors and other supervisory personnel duly qualified and in sufficient number for transportation, handling, unloading, storage, erection, pre-commissioning and post commissioning etc., startup, testing and trial operation of plants and equipment.



The Contractor shall keep a competent representative who will be resident Engineer-in-charge and shall remain as In-charge of Contractor's work site and also remain answerable to the Owner for all activities of the Contractor at site. Before his placement at site, the Contractor shall submit his bio-data to the Owner for his approval.

The resident Engineer-in-charge shall supervise the work of all men of the Contractor working at site. He shall work in complete harmony and co-operation with Owner. All statutory rules and labour laws prevailing in the area must be observed by the Contractor. All safety measures against occurrence of accidents must be taken effectively. Resident Engineer-in-charge shall not be withdrawn without written permission of the Owner. If any of the Contractor's personnel was found unsuitable for the job, the Contractor shall remove him forthwith and a suitable replacement shall be posted to site within a reasonable time. No compensation for withdrawing of unsuitable or unqualified person(s) from site or for posting suitable person(s) to site at any stage of the project shall be allowed by the Owner.

10.1.4 Sequence of Erection Work

All packing cases and packages shall be opened in presence of the Owner or his authorized representative.

Each material after stripping from boxes or received loose, shall be carefully inspected, checked with shipping list and identified with erection drawing if necessary. Any short supply and/or damaged part shall be reported forthwith to the Owner in writing. The Contractor shall be completely responsible to make all necessary arrangements, application and follow procedure to process claim on underwriters, obtain replacement repair/rectify and modify as required on all such damaged/defective/lost equipment and material at no extra cost to the Owner in order to execute the work to satisfaction of the Owner within the stipulated contract time. Once the materials are inspected, the same shall be preserved properly and adequately protected from theft and deterioration or damage by rain, storm, dust, water, tampering by casual visitors or workers. The Contractor shall prepare and maintain stores, ledgers and bin cards for all materials in his custody.

Carrying out all repairs to damages that might have suffered during transit and in subsequent storage and modifications and rectification work and replacement of all lost parts, are under the Contractor's scope.

Nails and packing strips should be pulled out with suitable appliances and kept separately in container and not thrown away at random. All timber of packing cases shall have to be sorted out and stored properly at a suitable place as directed by the Owner. From time to time packing materials, timber, nails and strips shall be delivered back to the Owner or otherwise disposed of as directed by the Owner. All timber and packing materials shall remain the property of the Owner.

10.1.5 Safety Regulations

Contractor should follow all the safety regulations / norms as imposed by the Law/Authority/factory inspectorate /owner. When going to or from place of work in the plant only the prescribed walkways, paths or cross-overs shall be used. Rail-road crossing warnings shall be needed.

Crawling on, over or under movable equipment shall generally be prohibited.

For overhead work, proper signs shall be placed below and, when conditions justify, a watchman shall be stationed to warn employees in the vicinity.

Work on or about crane runways shall not be undertaken without the Owner's permission. Whenever it is necessary to do any work on or above the crane runways, the Contractor shall furnish a flag man stationed on the floor.



Only scaffolds which meet the requirements of any governing laws shall be used in the project.

Work in area of electric wires and cables shall generally be avoided.

All burning and welding equipment shall conform to, and be used in accordance with, regulations governing such equipment. No burning or welding shall be done at any place on the site until location where such work is to be done is approved.

Adequate fire protection shall be available before proceeding the work.

All warning signs shall be observed.

Contractor shall require his employees to wear hard hats at all times when they are inside the plant area.

Goggles shall be worn whenever there is a possibility of flying particles or splashing of corrosive fluid.

When working around corrosive environment workmen shall wear gloves, goggles and protective shoes.

When ladders are the means of access to a platform, they shall be firmly secured top and bottom and the ladder rails shall extend at least one meter above the top landing. When a ladder cannot be secured, a man shall be stationed at the base.

Safety belts shall be used by men working in high places when no hand rails or other guards are in place.

All accidents resulting in injury shall be reported to the Owner promptly. Owner's safety rules, regulations and directives shall be followed and reports thereon shall be submitted as and when required.

10.1.6 Female workers

Female workers shall not be allowed to work beyond 6 PM.

10.1.7 Proper Treatment of Injured

Contractor shall ensure that proper treatment of injuries is immediately available either as such or in the form of constantly available transportation to a source of such treatment.

Contractor shall ensure that stretchers are available near all areas in which their men are working and that the location of stretchers are well marked.

Contractor shall be solely responsible for the dissemination of all safety regulations including those written here, those promulgated by the Owner and those dictated by good practice, and shall ensure that all his employees and those of his Sub-Contractors are conversant with same.

10.1.8 Inspection

After completion of erection and/or installations and before start-up the equipment and all its appurtenances shall be thoroughly cleaned and then, inspected in the presence of the Owner for correctness, soundness and completeness of installation and acceptability for start-up.



All works to be carried out by the Contractor shall be subject to inspection by the Owner as applicable. The work shall be carried out as per applicable specifications, codes of practice, drawings and instructions of Owner. The Contractor shall provide necessary facilities, instruments, personnel etc., for carrying out the inspection as above and shall comply with the instructions given.

A check list in triplicate will be furnished for the approval of Owner wherein all items to be checked and necessary instructions will be listed. Inspection and checking shall strictly follow this check list. On completion of the joint inspection and checking two (2) copies of the check list will have to be handed over to the Owner. The check lists after checking will have to be jointly signed by the Contractor's supervisor and the Owner to ensure that all inspection and checking have been properly carried out. However, such endorsement shall not relieve the Contractor from the responsibility in ensuring proper erection and cleaning.

During inspection all clearance, alignment and important measurements and adjustments as may be directed shall be noted by the Contractor for future reference and guidance. Two (2) copies of such notes shall be delivered to the Owner.

All reports of radiographic examination in a format approved by the Owner shall be submitted to the Owner for his approval and records.

10.1.9 Cleaning

The Contractor shall observe strict cleanliness during execution of the work and shall be in possession of vacuum cleaner for cleaning the internals of machinery under installation. They shall check that all the finished surfaces are greased and covered.

Before boxing up, the Contractor shall examine carefully to ensure that no foreign material, such as welding rod ends, welding beads, metal chips, rope, working tools, etc., has been left inside any equipment.

In the case of motors, the following procedure shall be observed

- a. Checking and cleaning of bearings and charging / filling of lubricants, wherever necessary.
- b. Cleaning of core and winding, drying out and cornicing the winding and measurement of air gap for motor assembled at site.

Wherever the scope includes control panels, all withdrawable components shall be taken out and internals shall be cleaned with vacuum cleaner.

10.2.0 Testing and Commissioning

10.2.1 Erection Test

Following the satisfactory completion of inspection, checking and cleaning of a unit, the plant will be placed in test run. During this period, all adjustments and repairs as required shall be made by the Contractor. Protocol shall be made and signature has to be obtained from Owner/ Contractor. On completion of satisfactory test run, the plant will be placed under trial operation.

Prior to trial operation of any equipment the following shall be checked:

During erection all required erection tests as well as final erection checks of the mechanical completion of the systems and part thereof have to be performed.

After successful mechanical completion Mechanical Completion Certificates will be issued.



The activities necessary for mechanical completion shall include but not be limited to following testing:

- Visual inspection after unloading at site
- Checking of completion of relevant systems
- Proper installation of the drive and equipment on the foundation
- Proper alignment of drive and the driven equipment
- Proper connection of supports, hangers, piping, valves, instruments and other fittings.
- Freeness of the rotors of drive and equipment
- Healthiness of lube oil system, changing and filling as necessary.
- Safety audit
- Testing of site welds (non-destructive examinations)
- Pressure/leak/tightness test
- Pipe line and equipment flushing and cleaning
- Chemical protection of piping systems
- Checking of coating
- Testing of cranes and hoists
- Safety signs and warning signs
- Completion of buildings and civil works
- Test of ventilating and air-conditioning units

10.2.2 Pre-Commissioning Testing

After alignment of all equipment, alignment tests shall be carried out by the Contractor to check leveling, clearance, eccentricity etc. Measurements will be witnessed and acceptance will be certified by the Owner.

Hydro testing shall be conducted for the entire system/equipment after installation at required pressure. All necessary blanking arrangements for hydro testing shall be furnished by the Contractor. All necessary test pump/temporary piping etc., shall be supplied by the Contractor.

Preconditions for the commissioning are the issue of the Mechanical Completion Certificate and the availability of the accepted commissioning program and the Contractor's commissioning procedures. The Pre-commissioning Checks cover the functional tests of the individual items and their alarm and tripping systems. Following tests shall be included:

10.2.2.1 Mechanical equipment

- Individual pre-commissioning runs of all rotating equipment such as pumps, compressors, dosing equipment etc.
- functional tests of the mechanical equipment
- Testing and adjustment of safety devices.

10.2.2.2 Chemical Cleaning of Piping Systems and Equipments

It is intended to chemically clean the following piping system:

- Boiler feed discharge piping
- Main condensate piping
- Extraction steam piping
- Other miscellaneous piping

The following equipments which form a part of the above system shall also be included in the cleaning operation.



- Deaerator
- Gland steam condenser
- Drain cooler

Before introducing chemicals, all the piping systems and equipment listed above shall be water flushed. Water flushing will be followed by alkaline cleaning, acid cleaning and passivation or by EDTA (Ethylene Diamene Tetra Acid) and passivation.

However, the Contractor shall submit along with the offer his usual procedures and practices for chemical cleaning of the piping and equipment specified. The Contractor shall submit all schematics, write up, details of chemicals to be used etc. and detailed procedures he intends to follow. These schematics and procedures shall be subject to the approval of the Owner.

Pre- cleaning procedure:

Prior to starting any phase of cleaning operation the following procedures shall be ensured:

Installation of all temporary piping, valves, pumps and equipments as required for the flushing and chemical cleaning operations. Temporary piping shall be routed at floor level as far as possible and secured in place to prevent movement/ vibration beyond acceptable limits.

Installation of the instruments as required to ensure satisfactory monitoring and control of the cleaning process. The Contractor shall also determine and arrange locations for sampling of the cleaning solution during cleaning.

By passing all regulation/control valves coming in the cleaning circuit or installation of temporary spool pieces.

Installation of special end covers and temporary suction strainers, for boiler feed pumps and condensate pumps. Pump internals shall not be installed.

Installation of plastic seal in the condenser neck to protect the turbine from alkaline fumes.

Blocking and securing of all spring hangers in the steam lines which may be flooded during the cleaning operation.

Hand cleaning of the interiors of all vessels which are included in the cleaning operation.

General cleaning procedures:

- a) Seal water lines to pump shall be flushed by the permanent arrangement provided for the same.
- b) Where pipeline terminate in spray headers, these headers shall be inspected after each phase of the cleaning operation and cleaned if necessary.
- c) All strainers shall be observed closely during the cleaning operation by reading differential pressure gauges, and shall be cleaned when the differential pressure exceeds a predetermined value.
- d) All high points, vents shall be opened periodically to ensure full system flow.
- e) Upon completion of each stage of cleaning, the waste products shall be drained and transferred to the waste treatment basins. The Contractor shall then supply and add the necessary chemicals to the basin to neutralize all waste solutions and rinses



generated by the cleaning process, and arrange for its disposal to an area to be indicated by the Owner/Engineer.

- f) Strict safety precautions shall be exercised at all times during the chemical cleaning and during storage and handling of the chemicals. The Contractor shall ensure provision of all protective clothing, apparatus and equipment along with necessary first aid kits as required for handling the chemical and for carrying out the cleaning operation.

10.2.2.3 Steam Blowing of Piping Systems

- i) Steam blowing shall include engineering, supply and installation of all temporary piping, valves, fittings including quick actuating valves (for puffing purposes), supports, blanking plates, spools, target plates, instruments, controls and all other accessories and services required to complete the cleaning process as specified herein
- ii) The detailed schemes and procedure for steam blowing operations shall be prepared and furnished by the contractor and discussed and finalized during the detailed engineering stage.
- iii) Steam blowing shall also include reinstatement of cleaned piping systems; and dismantling/removal of all temporary piping, equipment and materials from site. All temporary piping, valves, equipment and materials shall be taken back by the contractor upon satisfactory completion of cleaning, and shall be removed from the Owner's premises.
- iv) Engineering involved regarding temporary piping shall include the following:
 - a) Selection of temporary piping including disturbance factor calculation.
 - b) Preparation of layout of temporary piping and performing stress analysis as per ANSI B 31.1.
 - c) Selection of temporary hangers and supports as required.
- v) The following piping systems shall be cleaned through steam blowing operation.
 - a) Main steam, HRH, CRH, HP bypass & LP bypass piping
 - b) Auxiliary steam piping including TG gland sealing lines.
- vi) Steam blowing shall be carried out for removal of particles (rust, scales, weld splatter etc.) from various piping systems to avoid damage to turbine bladings. Cleanliness of system shall be checked by means of test plates made of steel, which will be installed in the centre line of the piping system.
- vii) Cleaning shall be achieved by steam purging i.e. by blowing of steam through the piping such that the momentum of flow is greater than that of steam flow during normal operation of unit (at TMCR). The disturbance factor during steam blowing (ratio of momentum of flow during purge to that during TMCR) shall be more than 1.4.
- viii) The blow off shall be done with steam, which is exhausted through adequately sized, open-ended temporary piping. Temporary piping and motor operated valves shall be installed for steam blowing operation. Pressure shall be built up in the boiler and the piping warmed before release of steam by quick opening of motor operated valve located on temporary piping. The cycle shall be repeated until steam from the blow out pipe is determined to be clean.



- ix) If the flow nozzles and control valves etc. have already been erected these shall be removed and replaced by spool pieces before steam blowing. The removed flow nozzle and control valves etc. shall be put back after steam blowing.
- x) The motor operated valves used for steam blowing shall have special characteristics like minimum loss of pressure, resistance to wear during severe working conditions (high velocity and carryover of water and solid particles), quick opening time, minimum effort on electric actuator etc.
- xi) The steam blowing termination criteria shall be as under:
 - a) Acceptable target plate condition
 - b) Measured disturbance factor (DF) more than 1.4

The required values to calculate actual DF will be measured at site. The criteria for acceptable target plate condition shall be finalised during detailed engineering.

10.2.2.4 Electrical equipment

The following checks and test measurements shall be made during erection and pre-commissioning (as appropriate) in accordance with agreed standards:

- Screwed connections for correct assembly
- Terminals and terminal connections for correct assembly;
- Checking of earthing connections and testing of earthing resistances
- Measurement of insulation values
- Fire proof partitioning
- Marking, inscription, provision of designation plates
- Voltage checks
- Polarity checks in the case of D.C. voltages
- Fuses, over current trips, short-circuit trips, time settings, relay settings
- Transformer oil levels
- Safety signs and warning signs
- Setting indicators, revertive (check-back) signals to the central control room etc.
- Checks on wiring and cabling for conformity with the constructional circuit-drawings and plans
- High-voltage tests
- Trip tests
- Functional test on equipment.
- Tests on the transformers
- During installation: checking of complete delivery, checking of core earthing and insulation of active part from tank, H.V. sample tests of transformer oil in accordance with IEC, or equivalent Standards.
- During the Tests on Commissioning: checking of satisfactory operation. Tests on the generator main busbar:
- Checking for perfect electrical and mechanical correctness and for the air-tightness of individual main connections system.
- Tests on the earthing and lightning protection system
- Acceptance tests and measurements of the earthing installations in accordance with IEC or IS standards.
- Tests on the lighting system:

- Proof of the minimum new value of lighting densities, checking of correct operation both electrically and mechanically.

10.2.2.5 Control and instrumentation equipment

Site related test for Control & Instrumentation equipment and Calibration tests of instrumentation loop checking, functional testing of control equipment, interlocks, protection inputs, etc. are covered under Volume II, Section 4 Detail Technical Specification for Control & Instrumentation.

10.3.0 Commissioning

A precondition of the commissioning is the successful completion of the pre-commissioning checks of all items of the whole system. Commissioning basically consists of

- Commissioning Tests
- Trial Operation which also includes in it a Reliability Run and PPA tests.

10.3.1 Commissioning Tests

Commissioning tests shall be performed in accordance with the procedure contained in the commissioning program approved by the Owner for individual equipment/system and as a plant. Commissioning test shall also include Redundancy and automatic fall back by simulation of fault conditions

On completion of each commissioning activity to the satisfaction of the Owner/ Owner's Engineer, the commissioning schedule shall be signed and dated by the Contractor and countersigned by the Owner and Owner's Engineer.

Commissioning test shall prove that the plant is prepared and adjusted to ensure the correct functioning of the individual components and of the complete plant.

After successful completion of the commissioning tests "Authorization to Trial Operation" shall be signed.

The Commissioning test shall cover at least following tests:

- Protection tests
- operation of protection devices including the following as a minimum
 - Fire protection
 - SG protection
 - Steam turbine protection
 - Generator protection
 - Transformer protection
- Auxiliaries.
- Method of alarm/trip condition reset for subsequent starting
- Fire protection systems operation
- isolation procedures method of isolation of plant equipment for safe shut-down and maintenance procedures including as a minimum
- HV station and unit supplies
- LV supplies
- Protection systems/settings, in accordance with agreed design and the requirements of the transmission system
- Start-up tests
- Normal automatic start to preset load
- Staged automatic including start to synchronous speed, manual synchronizing (including synchro-check), automatic synchronizing, manual and automatic loading
- Starting with stand-by auxiliaries

- Operation of all auxiliaries
- Verification of start up times and loading rates of power units and steam generators at various downtime conditions
- Power unit(s), to test partial and full load rejection to demonstrate
- Full load rejection tests to measure transient maximum speed and steady state speed at normal governor droop setting
- Method of resynchronism to be demonstrated
- Turbine bypass operation capability
- Operating stability when operated in the full range of load conditions with load variations by increasing or decreasing the electric load
- Demonstration of the capabilities of the Power Units to operate at rated voltage and frequency, at power factors and reactive conditions between 0.85 (lag) and 0.95 (lead)
- start-up tests of the Plant equipment, facilities and systems including checking of automatic change-over of standby facilities
- Verification of vibration and noise emission guarantees
- Environmental monitoring equipment, water quality monitoring equipment, functioning tests and verification of guarantees
- Verification of active power response and voltage control response according to the requirements specified in the network connection conditions
- Demonstration of proper controlling, monitoring and recording according to the requirements of the grid code
- Verification of completeness of scope of supply
- Verification of 24 hours uninterrupted MCR operation

10.4.0 Trial Operation

After successful completion of commissioning test and after relevant test protocols have been accepted by the Owner, the Contractor shall be allowed to prepare the Plant Units for trial operation. The plant will be started up and loaded. During this loading operation all the controls and protections shall be finally set.

After the plant is loaded to the maximum capability rating and the contractor is fully satisfied with its performance he shall offer the unit for Trial Operation by communicating the same to the Owner in writing. After receipt of such communication the plant will be on trial operation. The trial operation shall be for a period of Thirty days (30) days continuously at rated full load/part load as made available by the owner for a duration mutually agreed between the contractor & owner to demonstrate the following

- Sustained capability of the plant
- Reliability of the equipment and auxiliaries
- Adequacy of the various auxiliaries, ancillaries & systems and controls.
- Capability of each equipment of the plant to correctly perform the functions for which it is specified.
- Safety requirements
- Standby system availability

This trial operation shall be undertaken jointly with the owner. As a part of the trial operation reliability run of the plant shall be conducted.

10.5.0 Reliability Run

Reliability run shall be undertaken jointly with the Owner as a part of the trial operation and within the trial operation period. Reliability run shall be conducted for Fifteen (15) days uninterrupted at a load not less than 95% of the capacity of the plant at prevailing ambient conditions.

In the event of interruptions to the reliability test run, for which the Contractor is responsible, the length of the reliability test run can be extended by a period equal to the



total duration of the interruptions. If such an interruption lasts more than 24 hours, the reliability test run shall be restarted, after repairing the defect. The reliability test run may be interrupted on a maximum of three occasions only.

During the Reliability run, the plant shall be in continuous operation at full load at rated capacity or maximum load to be provided by the Owner for a continuous period of seventy two (72) hrs and no interruption is allowed during this period.

**11.0.0 PLANT PERFORMANCE TEST AND GUARANTEES****11.1.0 Guarantee Test**

The Contractor shall provide guaranteed performance for the complete works/systems and the values guaranteed shall be binding on him. The Contractor shall conduct performance test as described in contract document and prove the guarantees.

Performance guarantee parameters shall be as per the individual items of Performance Guarantee as indicated in the Section 6, "Technical Schedules". The applicable values of liquidated damages factors for non- fulfillment of guaranteed performances are indicated under commercial conditions of Contract. The parameters indicated under 'Correction' shall be guaranteed by the Contractor during the performance tests and if the parameters are not attained during the performance tests, Contractor shall make all efforts to achieve the parameters.

11.2.0 Objective of the test

Performance guarantee shall be provided for operation at contract specific site reference conditions as specified and the guaranteed performance parameters of the plant shall be proved by the Contractor during the test. Should the results of these tests show any deficiency from the guaranteed value, the Contractor shall modify the equipment as required at no extra cost to enable it to meet the guarantee

11.3.0 Test Documents

The procedure for carrying out the above tests shall be submitted to the Owner for approval six (6) months in advance. The procedure shall highlight the anticipated date for the test, arrangement and form of the tests.

The procedure shall include the following for each test or group of tests:

1. The sequence of the tests to be conducted.
2. The time duration of each test
3. The number of test runs
4. A list of instruments that will be used for each test. The list shall define which instruments are (a) special test instruments, (b) certified, (c) to be calibrated before and after each test to identify the drift which is to be used for applying corrections to the calibration which is estimated based on the average of the pretest and post-test calibrations (d) check instruments, (e) station supply instruments (f) Schematic diagram showing all test points and cross referenced to the instrument list and (g) method of data logging. Data logging thro' satellite communication is not permitted.
5. All formulae, calculations, conversion factors, curves, correction curves etc., to be used in the conducting of the tests and the calculations of the test results. All such items shall be to a accuracy level of four decimals.
6. Sample test reports to data sheets and all specific result sheet forms that will be used for the test.
7. Written procedure and description of conducting the test.

In the event of the plant (or portions of plant) failing to give the required performance, further tests which may be considered necessary by the Owner, shall be carried out in a similar manner. The entire cost of the repeated test shall be borne by the Contractor.



For each of the Performance & Guarantee Tests, the Contractor shall evaluate the test figures and within Two months of the completion of the relevant test, shall submit to the Owner for approval, four (4) copies of the Test Report containing a complete analysis of the test results.

The Contractor shall prepare test reports for each performance test in which the methods followed, instrument readings, graphs, observations, final results obtained etc., shall be recorded.

Contractor shall examine and sign the reports and certificates of all tests. The Owner shall review and comment on all test protocol and procedures, reports and certificates. Written evidence of the test data shall be issued by Contractor who shall also perform the necessary calculations. The basic information and figures to be used for the tests shall be compiled by Contractor.

For the checkout turnover packages, Performance tests, Contractor shall prepare reports. The reports shall contain a summary of any tests and certifications as well as results, recorder charts, observations and comments derived from the testing and turnover procedure as applicable. Six copies of the reports signed by Contractor and accompanied by all the corresponding detailed testing reports shall be delivered to the Owner's office on Site. Six (6) copies of each test report shall be delivered to the Owner.

11.4.0 Testing Method

The testing shall be carried out as per PTC.

11.5.0 Measurements

The following measurement has to be taken during performance and guarantee test.

11.5.1 Output

- Gross Turbine cycle heat rate in Kcal/kwhr
- Gross Power Output in MW
- Auxiliary power consumption in kW
- Boiler Efficiency in %

All the plant, equipment and systems covered under this specification shall perform continuously without exceeding the noise level over the entire range of output and operating frequency.

Noise level measurement shall be carried out using applicable and internationally acceptable standards. The measurement shall be carried out with a calibrated integrated sound level meter meeting the requirement of IEC 651 or BS 5969 or IS 9779.

Sound pressure shall be measured all around the equipment at a distance of 1.0 m horizontally from the nearest surface of any equipment/machine and at a height of 1.5 m above the floor level in elevation.

A minimum of 6 points around each equipment shall be covered for measurement. Additional measurement points shall be considered based on the applicable standards and the size of the equipment. The measurement shall be done with slow response on the A-weighting scale. The average of A-weighted sound pressure level measurements expressed in decibels to a reference of 0.0002 micro bar shall not exceed 85 dBA.

Corrections for background noise shall be considered in line with the applicable standards. All the necessary data for determining these corrections in line with the applicable standards shall be collected during the tests.



The noise level at the plant boundary wall on all sides

- Emission level

11.5.2 Contract Specific Site Reference Conditions

The plant performance guarantees to be provided during Performance Test shall be based on the following condition.

a) Ambient conditions:

- Altitude - Finished Ground Level (FGL) refer clause 6.0.0
- Ambient dry bulb temperature - 32.0°C.
- Relative humidity - 65%.

e) Feed water make up - 0%

f) Fuel - Coal and fuel oil according to the analysis data given in Annex 1.1 and Annex 1.2 of this specification.

g) CW Temperature - 33°C

j) The desalination plant is operational under full load, and all normal steam consumers on line.

11.6.0 Specific Conditions of Testing Method

The correction method stated in PTC shall be applied to correct the performance parameters measured and corrected as per the above stated method Tolerances are applied over these corrected performance parameters in such case.

11.7.0 Test Uncertainties

The guaranteed performance parameters shall be without any tolerance values and all margins required for instrument inaccuracies and other uncertainties shall be deemed to have been included in the guaranteed figures.

11.8.0 Correction Curves & Tolerance

The correction curves shall be submitted along with the Bid.

11.9.0 Conditions for Gross Electrical Output

The Gross electrical output is referenced to the outgoing terminals of the Generators excluding excitation power and involves the total generated output.

11.10.0 Measuring Equipment

All test instrumentation and test equipment shall be provided by the Contractor. All the instruments shall be calibrated by a certified body before and after the tests Instruments need to be calibrated before and after the test to identify the drift which is to be used for applying corrections to the calibration which is estimated based on the average of the pretest and post-test calibrations. The calibration certificates shall be submitted to the Owner prior to the tests. The calibration certificates shall be considered valid for a period of not more than six (6) months from the date of its calibration or as per the guidelines of NABL accredited Calibration agency.



The anticipated points of measurement together with necessary isolation during the tests shall be indicated by the Contractor.

11.11.0 Functional Guarantees

Functional Guarantees fall under following categories (Refer, Volume-II, Section-6, Schedule-1 for Functional Guarantees).

11.11.1 General

The term "Performance Guarantees" wherever appears in the technical specification shall have the same meaning and shall be synonymous to "Functional Guarantees". Similarly the term "Performance Tests" wherever appears in the technical specification shall have the same meaning and shall be synonymous to "Guarantee Test(s)".

11.11.2 Performance Guarantees / Performance Tests

11.11.2.1 General Requirements

- i) The Contractor shall guarantee that the equipment offered shall meet the ratings and performance requirements stipulated for various equipment covered in the specifications.
- ii) The guaranteed performance parameters furnished by the Bidder in his offer, shall be without any tolerance values whatsoever. All margins required for instrument inaccuracies and other uncertainties shall be deemed to have been included in the guaranteed figures.
- iii) The Contractor shall conduct performance test and demonstrate all the guarantees covered herein under Category I, II & III. The various tests which are to be carried out during performance guarantee tests are listed in this Sub-section. The guarantee tests shall be conducted by the Contractor at site in presence of Owner on each unit individually.
- iv) All costs associated with the tests including cost associated with the supply, calibration, installation and removal of the test instrumentation shall be included in the contract price.
- v) The performance tests shall be performed using only the normal number of Owner supplied operating staff. Contractor, vendor or other subcontractor personnel shall be used only for instructional purposes or data collection. At all times during the Performance Tests the emissions and effluents from the Plant shall not exceed the Guaranteed Emission and Effluent Limits.
- vi) It shall be responsibility of the Contractor to make the plant ready for the performance guarantee tests.

vii) Test Instrumentation, Flow Measurement and their Calibration

All instruments required for performance testing shall be of the type and accuracy required by the code and prior to the test, the Contractor shall get these instruments calibrated in an independent test Institute approved by the Owner. All test instrumentation required for performance tests shall be supplied by the Contractor and shall be retained by him upon satisfactory completion of all such tests at site. All calibration procedures and standards shall be subject to the approval of the Owner. The protecting tubes, pressure connections and other test connections required for conducting guarantee test shall conform to the relevant codes.



Tools and tackles, thermowells (both screwed and welded) instruments/devices including flow devices, matching flanges, impulse piping & valves etc. and any special equipment, required for the successful completion of the tests, shall be provided by the contractor free of cost.

- viii) The P&G test procedures shall be submitted for equipments/ system & subsystem under Contractor's scope for all Guarantees under category I, II & III as mentioned below, as per latest International codes / standard including correction curves, meeting the specification requirements along with sample calculations & detailed activity plan of preparation (including test instrumentation), conductance and evaluation of Guarantees.
- ix) The contractor shall submit for Owner's approval the detailed Performance Test procedure containing the following:
 - (a) Object of the test
 - (b) Various guaranteed parameters & tests as per contract.
 - (c) Method of conductance of test and test code.
 - (d) Duration of test, frequency of readings & number of test runs.
 - (e) Method of calculation.
 - (f) Correction calculations & curves.
 - (g) Instrument list consisting of range, accuracy, least count, and location of instruments.
 - (h) Scheme showing measuring points.
 - (i) Sample calculation
 - (j) Acceptance criteria.
 - (k) Any other information required for conducting the test.

The Performance test shall be carried out as per the agreed procedure.

x) Test Reports

After the conductance of Performance test, the Contractor shall submit the test evaluation report of Performance test results to Owner promptly but not later than one month from the date of conductance of Performance test. Preliminary test reports shall be submitted to the Owner after completing each test run. Six (6) hard copies and two (2) soft copies on CD-ROM of each test report of final conducted test on each equipment/plant/system shall be submitted to Owner for approval.

- xi) The performance guarantee test will be carried out within three months after the successful completion of Initial Operation of facilities or as per the time frame specified for a particular equipment/ plant/ system in the Technical specifications. Delay in conductance of the test beyond this period will not be normally permitted by the OWNER. In the event of OWNER agreeing to conductance of such tests after three months, for reasons not attributable to the OWNER, as assessed by the Owner, no factor for ageing shall be considered for computing performance of the equipment.
- xii) Performance Guarantee Tests on the equipments/systems not covered in this Subsection shall be carried out as per the procedure/test codes specified in respective detailed section.
- xiii) If, the Functional Guarantees are not met, either in whole or in part, the Owner may, at its sole discretion, provide the Contractor notice, setting forth particulars of such defects or failure. The Contractor shall, forthwith upon receipt of such notice, at its cost and expense, make such changes, modifications and/or additions to the Plant and Equipment or any component thereof, as may be necessary to meet the Functional Guarantees. The Contractor shall notify the Owner upon completion of the necessary replacement, changes, modifications and/or additions, shall request



the Owner to facilitate the repetition of the Guarantee Tests until the Functional Guarantees have been met. If, the Functional Guarantees are not attained either in the whole or in part, even after the expiry of any additional time granted by the Owner (after carrying out necessary changes, modifications, and/or additions), the Owner may, at its sole discretion, exercise anyone of the following options:

- (i) For Category-I Guarantees-Performance Guarantees under Penalty.

Reject the equipment / system / plant and recover from the Contractor the payments already made, if the level of tested Functional Guarantees is beyond the acceptable shortfall limits as per clause 23.0, Section 4, Volume 1;

(or)

Accept the equipment / system / plant with penalty as per clause 23.0, Section 4, Volume 1, if the level of tested Functional Guarantees is within the acceptable shortfall limits. The penalty for shortfall in performance shall be levied separately for each unit. The penalty values and acceptable shortfall limits are applicable for per unit basis except for total auxiliary power consumption (as total auxiliary power consumption shall be guaranteed for the two units). The penalty shall be pro-rated for the fractional parts of the deficiencies. The performance guarantees coming under this category shall be called 'Category-I' Guarantees.

- (ii) For Category-II Guarantees – Performance Guarantee under Rejection

Reject the equipment / system/ plant and recover from the Contractor the payments already made. The performance guarantees under this category shall be called 'Category-II' Guarantees. Conformance to the performance requirements under Category-II is mandatory.

- (iii) For Category-III Guarantees - Performance Guarantee under Compulsory Correction

Reject the equipment /system / plant and recover from the Contractor the payments already made.

(or)

Accept the equipment/system after assessing the deficiency in respect of the various ratings, performance parameters and capabilities and recover from the contract price an amount equivalent to the damages as determined by the Owner. Such damages shall, however be limited to the cost of replacement of the equipment(s) / system(s), replacement of which shall remove the deficiency so as to achieve the guaranteed performance. These parameters/capacities shall be termed as Category-III Guarantees

11.11.3 Guarantees Under Category-I – (Performance Guarantees Under Penalty)

The Performance Guarantees which attract penalty are as follows:

11.11.3.1 Gross Turbine Cycle Heat Rate

Minimum Gross Turbine cycle heat rate at 100% TMCR after subtracting excitation power and power of TG integral auxiliaries with following conditions:

1. Cycle make-up : 0% makeup
2. Cooling water inlet temperature of 33 deg.C
3. TDBFP's in operation



4. Generator power factor of 0.85

(Gross Turbine cycle heat rate at 100% TMCR condition shall be guaranteed after accounting for pressure drop in main steam piping, Reheater system and all extraction steam piping from steam turbine to feed water heaters & deaerator)

Turbine Cycle Heat Rate shall be calculated as follows & indicated in all computed heat balance diagrams :

$$\text{HEAT RATE} = \frac{M1 (H1-h1) + M2 (H3-H2) + Mis (h1-his) + Mir (H3 -hir)}{Pg}$$

The expression "Mis (h1-his)" in the numerator of the formula is not applicable if spray water to superheater is completely internal to the boiler (i.e. tapped from a location downstream of economizer inlet).

Where,

- M1 - Quantity of live steam entering the turbine stop valve including any live steam supplied to valve stems, or glands etc. in Kg/hr.
- M2 - Quantity of steam from turbine to reheater in Kg/hr.
- Mir - Quantity of desuperheating water flowing into reheater system for regulation of steam temperature in Kg/hr.
- Mis - Superheater desuperheating spray flow in Kg/hr.
- H1 - Enthalpy in kcal/kg of live steam.
- H2 - Enthalpy in kcal/kg of steam to reheat.
- H3 - Enthalpy in kcal/kg of reheated steam.
- h1 - Enthalpy of feed water in kcal/kg at the downstream of the junction of feed flow and bypass flow of HP heaters.
- hir - Enthalpy of desuperheating water flowing into reheat system in Kcal/Kg.
- his - Enthalpy of superheater desuperheating spray water in Kcal/Kg.
- Pg - Unit output after deducting the power consumption by auxiliaries as listed below and the same shall be 693MW, and 660MW respectively for 105%, and 100% TMCR unit load:
 - (a) Power taken by Excitation system (KW) including transformer losses, as applicable for various guarantee points, in case of static excitation system is offered. (The transformer losses at various points shall be based on factory test to be conducted).
 - (b) Power required for ventilation of oil and control fluid tanks, if ventilating fans are separately driven (KW).
 - (c) Power required for lubrication, if lubricating pumps are separately driven (KW).
 - (d) Power required for control fluid pumps, if control fluid pumps are separately driven (KW).
 - (e) Power required for hydrogen, seal oil auxiliaries, if separately driven (KW).



- (f) Power required for stator water cooling system, if cooling pumps are driven separately (KW).
- (g) Power required for motors, heaters etc. of any other auxiliary service for the turbine generator (KW).

It may be noted that the heat balance diagrams and guarantees shall be furnished considering zero spray water quantity for superheater and reheater spray. During Performance Guarantee Testing, in case water is required for superheater and/or reheater temperature control, the contractor shall be entitled to heat rate correction as per correction curves to be submitted by him with his offer.

11.11.3.2 Steam Generator Efficiency

Steam Generator Efficiency with following conditions:

- 100% TMCR
- Firing design coal
- On Gross Calorific value (GCV) basis
- At 32 deg C DBT and 65% RH ambient air conditions
- Excess air at economizer outlet (at 100% TMCR load) 20% (min.)
- Corrected flue gas temperature at air preheater outlet (at 100% TMCR) 125 °C or as predicted by the Bidder whichever is higher
- Unburnt fuel at all guaranteed efficiency load i.e. 1.0% (min.)

Bidder/Contractor to note that no credit shall be given in the bid evaluation or in the evaluation of the results of the guarantee tests for performance predictions/ guarantees etc. if the values considered by the Bidder/Contractor for parameters indicated at e), f) & g) above are lower than those specified above.

Major Requirements/ Method of Steam Generator Efficiency Tests

i.	Test Code	As per PTC 4 / B S EN12952-15,2003 (by loss method)
ii.	Test Loads	105% TMCR (VWO unit Load)
.		100% TMCR (660 MW unit Load)
iii.	Test Conditions	Boiler operating with rated excess air, coal fineness and firing design coal.
iv.	Ambient air condition	Dry bulb temperature and Relative humidity shall be same as the design parameters specified for steam generator. The reference air temperature for the efficiency guarantee/ testing shall be taken as the temperature of air (as the design temperature of air) entering PA and FD fans.
v.	No. of readings	Two sets of consistent readings for each of test loads. Average of the test efficiencies based on above two readings for each load shall be considered for guaranteed efficiency.
vi.	Correction to tested efficiency shall be applicable for variation in following parameter only :	
a)	Ambient air temperature.	
b)	Relative humidity of ambient air.	
c)	Hydrogen in coal.	



d)	Moisture in coal.
e)	GCV of coal.
f)	Percentage of ash in coal.
xiii.	The number, location, type and accuracy of the test grade thermocouples and pressure gauges shall be to Owner's approval
xiv.	The Steam Generator efficiency testing shall be carried out with any combination of mills in operation to Owner's choice, with fineness of pulverized coal not exceeding 70% through 200 mesh.
xv.	Steam generator efficiency shall be with guaranteed or actual air heater leakages, whichever is higher.

The guaranteed steam efficiency shall be without any heat credit.

11.11.3.3 Gross Continuous TG Power Output

Gross continuous TG power output at 100% TMCR after subtracting excitation power and power of TG integral auxiliaries with following conditions:

1. Cycle make-up : 0 % makeup
2. Cooling water inlet temperature of 33 Deg C.
3. Generator power factor of 0.85

11.11.3.4 Total Auxiliary Power Consumption

Refer, Volume-II, Section-6, Schedule-2 for guaranteed auxiliary power consumption

TOTAL AUXILIARY POWER CONSUMPTION FOR THE PLANT (1320 MW) AT 100% TMCR CONDITION AFTER SUBTRACTING EXCITATION POWER AND POWER OF TG INTEGRAL AUXILIARIES WITH FOLLOWING CONDITIONS:

1. Cycle make-up: 0% makeup
2. Cooling water inlet temperature of 33 deg.C
3. TDBFP's in operation
4. Generator power factor of 0.85

The unit auxiliary power consumption shall be calculated using the following relationship.

$$Pa = Pu + TL$$

Pa = Guaranteed Auxiliary Power Consumption.

Pu = Power consumed by the auxiliaries of the unit under test.

TL = Losses of the transformers supplied by bidder based on works test reports. While guaranteeing the auxiliary power consumption the bidder shall necessarily include all continuously operating unit auxiliaries. The auxiliaries to be considered shall include but not be limited to the following:

UNIT AUXILIARIES (TO BE CONSIDERED FOR CALCULATING PU)

1) TURBINE GENERATOR AND AUXILIARIES

- a) Booster pumps for TDBFP
- b) TDBFP lube. Oil pumps
- c) Electric oil heater of TDBFP lube. Oil pumps
- d) Oil purifiers of TDBFP including feed and discharge pumps
- e) MDBFP Auxiliary Oil pump
- f) Condensate Extraction Pumps (CEP).
- g) Oil pumps for HP & LP bypass system
- h) Condenser air evacuation equipment (Vacuum pumps)



- i) Condenser online tube cleaning pumps
- j) LP drain condensate pump (if applicable)
- k) Chemical Dosing pumps
- l) Any Other Items (Contractor to list any other continuously running equipment)

Bidder shall note that the above shall not include the power consumption of the turbine generator integral auxiliaries which are included in TG output as specified in the Annex-2 clause no. 3.1.3.

2) STEAM GENERATOR AND AUXILIARIES

- a) Primary Air (PA) Fans including its lube oil pumps.
- b) Coal Feeders c) Seal air fans
- d) Coal mills including its lube oil pumps.
- e) Forced Draft (FD) Fans including its lube oil pumps.
- f) Regenerative Air Preheater including its lube oil pumps.
- g) Electrostatic precipitators (ESP)
- h) Induced Draft (ID) Fans including its lube oil pumps.
- i) Boiler circulation pumps
- j) Pressurising pumps of fuel oil system
- k) Scanner air fans
- l) Electrical Heat Tracing (if applicable)
- m) Any Other Items (Contractor to list any other continuously running equipment)

3) BALANCE OF PLANT - UNITISED SYSTEMS

- a) Main Cooling Water pumps
- b) Auxiliary cooling water booster pumps (ACW)
- c) Closed cooling water pumps (DMCW)
- d) Hotwell make up pumps e) DM transfer pumps
- f) Any Other Items (Contractor to list any other continuously running equipment)

4) BALANCE OF PLANT-COMMON SYSTEMS

	Coal Handling System – Maximum of the mentioned flow path in the specification	0.6
	Ash handling system	
i.	Bottom Ash Evacuation System	1.0
ii.	Fly Ash Evacuation System	0.7
iii.	Bottom ash disposal System	1.0
iv.	Fly Ash disposal System	1.0
v.	Recovery water system	1.0
	Mill Reject system	0.5
	Fuel oil system	
i.	Fuel oil unloading system	0.1
ii.	Fuel oil forwarding system	0.1
	Seawater intake system	1.0
	Seawater outfall system	1.0
	Pre-treatment plant	0.9
	Desalination plant (SWRO, BWRO, DM Plant)	0.9
	Chlorination Plant	0.9



	Auxiliary water system	0.9
	Effluent treatment plant	0.5
	Air conditioning system	1.0
	Ventilation system	1.0
	Compressed air system	0.75
	Plant lighting	0.6
	STP	0.5
	Hydrogeneration Plant	0.6
	Fire fighting system	0.4
	Any Other Items (Contractor to list any other continuously running equipment)	
	1	
	2	
	3	

5) ELECTRICAL SYSTEM

Total auxiliary power consumption of the following Electrical Systems at 100 % TMCR

- a) Generator Transformer losses (at rated Load Condition)
- b) Unit auxiliary transformer losses (at rated load conditions)
- c) Station transformer losses (at Unit rated load conditions)
- d) Losses in all other transformers (at rated load conditions)
- e) Losses in Bus ducts (at rated load conditions)
 - Isolated Phase Bus Duct
 - Phase segregated busduct
- f) UPS power consumption (at rated load condition)
- g) DC System power consumption (at rated load condition)
- h) Any Other Items (Contractor to list any other continuously running equipment)

11.11.3.5 Transformer Losses

Transformer losses (at rated capacity transformers (UAT, ST, GT & service transformer individually)

- a. Iron loss
- b. Copper loss
- c. Cooler Pump / fan loss

11.11.4 Guarantees Under Category-II – (Performance Guarantee Under Rejection)

The performance guarantees, conformance to which are mandatory are as follows:

A NOx Emission

Contractor shall guarantee that maximum total NOx emission from the unit shall not be more than 260 grams of NOx (from thermal as well as fuel) per giga joule of heat input to



the boiler during the entire operating range of steam generator for the range of coals specified.

The emission shall be measured during steam generating capacity test. The bidder shall furnish the methodology of measurement and demonstration of variations w.r.t. load upto 50% of total load.

B Particulate Emission

- a) Particulate emission at Electrostatic precipitator outlet at BMCR condition while firing design coal and any one field in each pass out of service.
- b) Particulate emission at Electrostatic precipitator outlet at BMCR condition while firing worst coal and any one field in each pass out of service.

C Noise Level

- a) Far field noise level measured at any point at plant boundary

D Effluent at outlet of CMB

- a) pH
- b) Residual chlorine
- c) TDS
- d) TSS

E Sea water outfall

- a) pH
- b) TDS
- c) TSS
- d) Temperature

11.11.5 Guarantees Under Category-III – (Performance Guarantee Under Compulsory Correction)

The parameters/capabilities to be demonstrated for various systems/equipment shall include but not be limited to the following:

11.11.5.1 Noise

All the plant, equipment and systems covered under this specification shall perform continuously without exceeding the noise level over the entire range of output and operating frequency specified in the technical specifications.

Noise level measurement shall be carried out using applicable and internationally acceptable standards. The measurement shall be carried out with a calibrated integrating sound level meter meeting the requirement of IEC 651 or BS 5969 or IS 9779.

Sound pressure shall be measured all around the equipment at a distance of 1.0 m horizontally from the nearest surface of any equipment/ machine and at a height of 1.5 m above the floor level in elevation.

A minimum of 6 points around each equipment shall be covered for measurement. Additional measurement points shall be considered based on the applicable standards and the size of the equipment. The measurement shall be done with slow response on the A weighting scale. The average of A-weighted sound pressure level measurements



expressed in decibels to a reference of 0.0002 micro bar shall not exceed the guaranteed value. Corrections for background noise shall be considered in line with the applicable standards. All the necessary data for determining these corrections, in line with the applicable standards, shall be collected during the tests.

11.11.5.2 Steam Generator & Auxiliaries

1. Steam Generating Capacity

Steam generating capacity in T/hr of steam at rated steam parameters at superheater outlet & rated steam temperature at reheater outlet (with any combination of mills working as per Owner's discretion) with the coal being fired from within the range specified at the following conditions with heaters out of service condition

- a) BMCR condition
- b) TMCR conditions
- c) TMCR with all HP with all HP heaters out of service condition.

2. The total attemperation water flow quantity for super heater steam temperature control T/hr

- a) 100% TMCR condition while firing design Coal
- b) 100% TMCR condition while firing Worst Coal
- c) 80% TMCR condition under sliding pressure operation while firing design Coal d) 80% TMCR condition under sliding pressure operation while firing worst Coal

3. The total attemperation water flow quantity for reheater steam temperature control with rated excess air

- a) 100% TMCR condition while firing design Coal
- b) 100% TMCR condition while firing Worst Coal
- c) 80% TMCR condition under sliding pressure operation while firing design Coal
- d) 80% TMCR condition under sliding pressure operation while firing worst Coal

It shall also be demonstrated that the RH temperature is maintained at the rated value without any spray water requirement under normal operating conditions (100% TMCR)

4. The super heater steam temperature at the high pressure (HP) turbine inlet under the following conditions(°C)

- a) Range of Coal specified
- b) Steam Generator load 60% TMCR to 100% BMCR under sliding pressure Operation

5. The reheat steam temperature at the intermediate pressure (IP) turbine inlet under the following conditions (°C):

- a) Range of coal specified
- b) Steam Generator load 60% TMCR to 100% BMCR under sliding pressure operation

**6. Steam temperature imbalance**

It shall be demonstrated at SH and RH outlets (in case of more than one outlet) that the temperature imbalance between the outlets does not exceed 10°C under all loads including transients.

7. Furnace exit gas temperature (FEGT)

It shall be demonstrated that maximum furnace exit gas temperature (FEGT) shall be as specified. A comprehensive thermal performance test (TPT) shall be conducted for this purpose on one unit only. FEGT shall be demonstrated through such TPT by indirect measurement.

8. Minimum stable load on the Steam Generator without oil support under the following condition (%):

- a) Range of coal specified
- b) Both Load ramp-up & ramp down
- c) Any combination of mills in operation.

It shall be guaranteed that oil support for flame stabilisation shall not be required beyond 30% of BMCR load when firing the coals from the range identified. It shall be demonstrated that with any combination of mills/adjacent mills in service (to Owner's choice), the steam generator does not require any oil firing for stable and efficient boiler operation at and above 30% BMCR loads.

9. Coal consumption at 100% BMCR, and 100% TMCR for design coal and worst coal based on the following (T/h)

- a) Ambient air temperature 32°C
- b) Relative Humidity 65%

10. Coal Mills

- i) Capacity, efficiency and power consumption of each mill while firing design coal and worst coal (tph) at:
 - New Condition
 - at 50% wear life
 - at worn out condition

Performance testing shall be done on coal mills toward establishing its guaranteed capacity specified at the rated fineness, applying corrections for the variation in coal characteristics i.e., HGI (Hardgrove Grindability Index) and total moisture.

Capacity demonstration test shall be carried out for the following conditions:

- a. Capacity output of one coal pulveriser (of Owner's choice) of each Steam Generator shall be demonstrated for establishing its capacity at 100% mill loading, at rated pulverized coal fineness with specified design coal with new set of grinding elements.
- b. Capacity output shall also be demonstrated on four coal pulverisers (of Owner's choice) of each Steam Generator, not less than the 90% of guaranteed value of a) above, at 100% mill loading with the originally installed grinding elements in nearly worn-out condition or at the end of guaranteed wear life of grinding elements, whichever is earlier.



Capacity test as mentioned at a & b above shall be demonstrated at the following conditions occurring simultaneously during testing:

Rated pulverised coal fineness	(a) not less than 70% through 200 mesh and (b) not less than 98% through 50 mesh screen
Test Coal	Any available coal from the specified range

In case the guaranteed capacity of coal pulverisers as stated above are successfully demonstrated, remaining coal pulverisers of corresponding steam generator will also be considered to have successfully met the above capacity guarantee requirement. However, in the event of any of the coal pulverisers not meeting the guarantee test, all the coal pulverisers of corresponding steam generator will have to be tested to demonstrate guaranteed capacity.

During the demonstration of the pulverizer capacity output, manufacturer's operating instructions will be followed and pulverizer will be operated with the specified range of coals without any such readjustment that requires a shutdown of the pulverizer or reduction of the load and/or any replacement of any pulverizer wear parts. For the purpose of testing to demonstrate the capacity, if HGI (grindability) and total moisture vary from those given in coal characteristics, the above pulverizer measured capacity shall be corrected using the capacity correction curves furnished by the Contractor and approved by the Owner. HGI versus coal pulverizer capacity curve shall be furnished for HGI variation upto a value above which the capacity remain constant.

- ii) Loading of each mill when steam generator operating at 100% BMCR and 100% TMCR condition while firing design coal and worst coal
- iii) Coal fineness for the range of coal specified
 - Through 200 mesh screen
 - Through 50 mesh screen
- iv) Life of mill wear parts warranty

The Contractor shall warrant the wear life of all wear parts of the coal pulverizer when grinding the specified range of coal(s). Pulverizer wear parts are defined as those parts of the pulverizer which are in contact with coal or coal dust and are likely to wear out during the operation of the pulverizer. The guarantee/warranty shall be demonstrated on each pulverizer during the Guarantee Trial Period (GTP).

Minimum Guaranteed Life for various coal pulverizer wear parts shall be as indicated.

The wear parts shall be considered to have passed their warranted operating life when they have successfully demonstrated their capability to meet the full load rated capacity of the pulverizer (as per requirements of Technical Specification) during the guaranteed life of the wear part. No weld buildup or reversing of grinding elements will be permitted for achieving the guaranteed wear life.

11. Primary Air fans

- a) Capacity(m³/h)
- b) Head developed(mWC)
- c) Fan efficiency(%)
- d) Power consumption (kW)
- e) Margins envisaged on capacity and head

**12. Forced Draft Fans**

- a) Capacity(m³/h)
- b) Head developed(mWC)
- c) Fan Efficiency(%)
- d) Power consumption (kW)
- e) margins envisaged on capacity and head

13. Induced Draft Fans

- a) Capacity(m³/h)
- b) Head developed (mWC)
- c) Fan efficiency(%)
- d) Power consumption (kW)
- e) Margins envisaged on capacity and head

14. Seal Air Fans

- a) Capacity (m³/h)
- b) Head developed (mWC)
- c) Fan Efficiency (%)
- d) Power consumption (kW)
- e) margins envisaged on capacity and head

15. Fuel Oil Firing System

- a) Percentage load for which High Speed Diesel (HSD) firing system is designed (% BMCR)
- b) Percentage load for which Heavy Fuel Oil (HFO) firing system is designed (% BMCR)

16. Air Pre-heater leakage

It shall be demonstrated that the air-heater air-in-leakage and maximum drift in air leakage do not exceed the guaranteed value or specified value (whichever is lower) of Technical specifications. Above requirement needs to be complied with recirculation of flue gas from downstream of ESP.

17. Run back capabilities

The automatic runback capability of the unit (boiler-turbine-generator) on loss of critical auxiliary equipment (such as tripping of one ID/FD/PA fan/ air heater etc.) shall be demonstrated ensuring smooth and stable runback operation.

18. CO emission at 100% TMCR at rated excess air for specified range of coal.

19. Flue gas temperature at APH outlet (maximum) while firing design coal at 100% TMCR without considering air leakage.(°C)

20. Unburnt carbon in bottom ash while firing design coal at 100% TMCR(%)

21. Unburnt carbon in fly ash while firing design coal at 100% TMCR(%)

22. Total unburnt carbon loss while firing design coal at 100% TMCR (%)

23. Surface temperature of thermal insulation with ambient temperature of 45 °C at surface velocity of 0.25 m/s. (°C)



24. Electrostatic Precipitator

The performance/acceptance tests shall be carried out in accordance with method-17 of EPA (Environmental Protection Agency of USA) code ASME PTC.

The particulate emission from ESP shall not be more than 50 mg/Nm³ under guarantee point condition at TMCR load with design coal firing. The corresponding ESP efficiency shall be worked out.

The ESP air in leakage shall not be more than 1% of total gas flow at ESP inlet at the guarantee point condition and shall be demonstrated.

The maximum pressure drop through the ESP at the guarantee point flow condition shall not exceed 25 mm WC, which shall be demonstrated.

The gas distribution in the various stream and fields shall be demonstrated.

METHOD OF COMPUTING TEST EFFICIENCY OF ESP

1. The performance test on electrostatic precipitator will commence after a minimum period of three thousand (3000) hours of continuous operation after completion of initial operation. During the interval between the commencement of initial operation and the commencement of performance test only routine maintenance shall be carried out. No physical or chemical cleaning of ESP shall be permitted during this period or immediately before the conductance of the performance tests.
2. The test efficiency shall be based on the overall performance of the electrostatic precipitator over a mutually agreed period of operation under the conditions given in this specification and allowing the normal operation of the unit including rapping and normal soot blowing and/or when fuel oil is being fired in the igniters and/or warm up guns.

The overall test efficiency and test temperature/inlet dust burden for one set of ESP passes (stream) serving one Steam Generator shall be worked out as follows:

- a) Vm (guarantee point test flow) shall be the total of inlet gas flows to the all the gas streams at the time of test.
- b) Test inlet dust burden (Di) shall be weighted mean of the inlet dust burdens for the individual streams i.e.:

$$D_i = \frac{(V_{m1} \times D_{i1}) + (V_{m2} \times D_{i2}) + (V_{m3} \times D_{i3}) + (V_{m4} \times D_{i4}) + (V_{m5} \times D_{i5}) + (V_{m6} \times D_{i6})}{(V_{m1} + V_{m2} + V_{m3} + V_{m4} + V_{m5} + V_{m6})}$$

Where suffix 1, 2, 3, 4, 5 & 6 represent the six gas stream.

Similarly the test outlet dust burden (Do) will be calculated based on outlet gas flow

- c) The weighted test inlet gas temperature (Ti) shall also be worked out in a similar manner i.e.

$$T_i = \frac{(T_{i1} \times V_{m1}) + (T_{i2} \times V_{m2}) + (T_{i3} \times V_{m3}) + (T_{i4} \times V_{m4}) + (T_{i5} \times V_{m5}) + (T_{i6} \times V_{m6})}{(V_{m1} + V_{m2} + V_{m3} + V_{m4} + V_{m5} + V_{m6})}$$



- d) The measured test efficiency shall be

$$EM = \frac{D_i - D_o}{D_i} \times 100(\%)$$

- e) The corrections for the variation in flue gas flow, inlet dust burden and ESP inlet flue gas temp. shall be based on the above computed test values and the procedure indicated in the next para.

Note: 5th & 6th gas stream if applicable

- 3 At the time of performance testing if the inlet flue gas conditions are not consistent with the specified conditions, due to variation in coal characteristics from the design coal and boiler operating conditions the precipitator performance conforming to this specification, shall be determined using performance curves and correction factors accepted at the time of award of contract. However, the test efficiency shall be corrected to the guarantee point conditions in the following manner:

1. $E_c = 1 - e^{-Z}$

Where E_c = Corrected test efficiency to guarantee point conditions.

$$Z = C \cdot \ln \left(\frac{1 - E_g}{1 - E_m} \right)$$

and $C = \frac{1}{C_a \cdot C_b \cdot C_c \text{ etc.}}$

C_a, C_b, C_c are Correction factors for flue gas at temperature, ESP inlet dust loading & sulphur based on correction curves furnished by the Bidder and approved by the Owner

- 2 $E_g = 1 - e^{-Y}$

$$\text{Where } Y = (V_m/V_g)^{0.5} \ln(1 - E_m)$$

E_g = Measured test efficiency corrected to the specified guarantee point flow.

V_g = Specified Guarantee point gas flow (m³/sec).

V_m = Measured gas flow (m³/sec) E_m = Measured test efficiency

$\ln$ = Logarithm, natural base

The correction curves should be realistic for expected range of operation and variation in characteristics specified.

The test efficiency shall be the average of at least two corrected test efficiencies.

4. The Performance tests shall be carried out in accordance with method-17 of EPA (Environmental Protection Agency of USA) code. The details of the test shall, however be mutually agreed upon between the Owner and the Bidder.

11.11.5.3 Steam Turbine & Auxiliaries

1. Gross power output at 100% TMCR and VWO condition after subtracting excitation power and TG integral auxiliaries with following conditions(MW):



- i) Cycle make-up : 1% make-up
 - ii) Cooling water inlet temperature of 33°C
 - iii) Generator power factor -0.85
2. Gross power output after subtracting excitation power and TG integral auxiliaries with following conditions(MW):
 - i) Cycle make-up : 1% makeup
 - ii) Cooling water inlet temperature of 33 Deg.C
 - iii) Generator power factor -0.85 iv) All HP heaters out of services.
3. Gross power output after subtracting excitation power and TG integral auxiliaries with following conditions (MW):
 - i) Cycle make-up : 1% makeup
 - ii) Cooling water inlet temperature of 33 Deg.C
 - iii) Generator power factor -0.85
 - iv) At 47.5 Hz to 51.5 Hz
4. Continuous TG output

Continuous TG output of 693 MW unit load (i.e. 105% of rated load) under rated steam conditions after subtracting excitation power and TG integral auxiliaries

 - i) Cycle make-up : 1% makeup
 - ii) Cooling water inlet temperature of 33 Deg.C
 - iii) Generator power factor -0.85 iv) At 47.5 Hz to 51.5 Hz
5. Turbine cycle heat rate at 100% TMCR after subtracting excitation power and TG integral auxiliaries with following conditions (MW):
 - i) Cycle make-up : 1% makeup
 - ii) Cooling water inlet temperature of 33 Deg.C
 - iii) Generator power factor -0.85

Note: The condenser pressure measurement while conducting the guarantee tests shall be measured at 300 mm above the top row of condenser tubes.

6. Turbine-generator set capability

The steam turbine generator shall be capable of delivering at generator terminals the output as indicated in the heat balances under the following conditions: Continuous TG output of 100% TMCR under rated steam conditions at 89 mm Hg (a) worst condenser pressure with 1% make up. While conducting this test, the condenser pressure measurement shall be done at 300 mm above the top row of condenser tubes.

The automatic runback capability of the unit (boiler-turbine-generator) on loss of critical auxiliary equipment (such as tripping of one BFP/CEP etc.) shall be demonstrated ensuring smooth and stable runback operation

7. Upon sudden total loss of all external loads units will not trip on over speed but shall continue to be in operation to supply power for plant auxiliary load (house load).
8. Run Back capabilities of the SG and STG upon loss of critical auxiliary equipment, shall ensure smooth and stable run back operation.
9. Variable pressure operating range (% TMCR)



10. Condenser

- a) Total pressure drop in condenser tube side with design cooling water flow and temperature (mWC)
- b) Total cooling water temperature rise in condenser with design cooling water flow and CW inlet temperature of 33 deg.C under the following condition.
 - i) Unit operating at 100% TMCR condition (°C)
 - ii) Unit operating at VWO condition (°C)
 - iii) Unit operating with all HP Heaters out condition and generating 100% TMCR power output (°C)
 - iv) Unit operating under house load and HP & LP bypass operating at rated capacity. (°C)
- c) Re-cooled water temperature at Outlet of cooling tower based on the following design conditions:
 - i) Rated Cooling Water Flow (m³/h)
 - ii) Design Ambient Wet Bulb Temperature (°C)
 - iii) Design Inlet Wet Bulb Temperature (°C)
 - iv) Design Relative Humidity(%)
 - v) Design Cooling Range(°C)
- d) Condenser pressure

Condenser pressure in mm Hg (abs) measured at 300 mm above the top row of condenser tubes under VWO conditions, 1% make up, design CW temperature and CW flow.

The condenser vacuum shall be measured with a vacuum grid utilizing ASME basket tips.

Temperature of condensate, at outlet of condenser, shall not be less than saturation temperature corresponding to the condenser pressure at all loads.

Air leakage in the condenser under full load condition shall not exceed more than 50% of design value taken for sizing the condenser air evacuation system.

When one half of the condenser is isolated, condenser shall be capable of taking at least 60% TG load under TMCR conditions.

The capacity of each vacuum pump in free dry air under standard conditions at a condenser pressure of 25.4 mm Hg (abs) and sub cooled to 4.17°C below the temperature corresponding to absolute suction pressure shall not be less than 30 SCFM. Correction curves for establishing the capacity at site conditions shall also be furnished.

The air and vapour mixture from air cooling zone of condenser shall be 4.17°C below the saturation temperature corresponding to 25.4 mm Hg (a) suction pressure. Correction curves for establishing the same at site conditions shall also be furnished.

PERFORMANCE TEST FOR THE CONDENSERS

- (i) Performance test for design condenser pressure shall be conducted in accordance with latest edition of ASME PTC-12.2.



- (ii) Condenser pressure will be measured at 300 mm above the top row of tubes under VWO conditions, 1% make-up and design C.W. flow & design temperature. The condenser pressure shall be measured with a vacuum grid utilizing ASME basket tips. The grid is fitted at 300 mm above top row of condenser tubes.
- (iii) Tube plug margin of 5%, as per design condition, shall be considered for condenser performance calculation at design condition.
- (iv) If tube side fouling resistance for actual test condition is not measured as per methodology given in PTC 12.2, the tube cleanliness factor corresponding to the same shall be appropriately assessed considering the aspect of actual tube cleaning prior to conducting the test

11. Condensate Extraction Pump (CEP)

- a) Rated capacity (m^3/h)
- b) Rated Total Dynamic Head (TDH) (mWC)
- c) Pump efficiency(%)

12. Booster pump of CEP (If applicable)

- a) Rated capacity (m^3/h)
- b) Rated Total Dynamic Head (TDH) (mWC)
- c) Pump efficiency (%)

13. Condensate Polishing Unit (CPU)

- a) Effluent quality of outlet of each vessel at its rated design flow and design service length between two regenerations
- b) Chemical consumption for regeneration
- c) Pressure drop across the polisher service vessel, as specified, in clean and dirty condition of resin at rated design flow. d) Condensate water quality.

14. Feed Water Heaters

- a) Pressure drop on the tube side of the individual LP heaters (Maximum) (mWC)
- b) Pressure drop on the tube side of the individual HP heaters (maximum)(mWC)

15. Deaerator

The following parameters shall be demonstrated:

- a) TTDs and DCAs of feed water heaters shall be demonstrated as per guaranteed heat balance diagram for 100% TMCR condition.
- b) Outlet temperature from final feed water heater(s)
- c) Dissolved O₂ content in Deaerator effluent at deaerator outlet without chemical dosing at all loads, not to exceed 0.005 CC/litre determined as per ASTM-D-888 – Reference method-A or Indigo Carmine method.
- d) Difference between saturation temperature of steam entering the deaerator and temperature of feed water leaving the deaerator shall be demonstrated as per guaranteed heat balance diagram for 100% TMCR condition.
- e) Continuous and efficient operation and performance of feed heating plant without undue noise and vibrations at all loads and duty conditions

16. Boiler Feed Water Pump (BFP)

- a) Rated capacity (m^3/h)
- b) Rated Total Dynamic Head (TDH) (mWC)
- c) Pump efficiency (%)



17. Booster pump of BFP

- a) Rated capacity (m^3/h)
- b) Rated Total Dynamic Head (TDH) (mWC)
- c) Pump efficiency (%)

18. Equipment cooling water system

- (i) Capacity, head & power consumption of all the pumps with the respective job (own) motors to be demonstrated at shop. For the pumps which are included under "Unit Auxiliaries for calculation of Pu" as defined elsewhere the power consumption value (at rated duty point) during shop testing shall be considered for computation.
- (ii) Vibration, parallel operation and noise level of all the pumps at the rated duty point shall be demonstrated at site
- (iii) Design heat load of plate type heat exchangers and Inlet & Outlet temperatures of the Plate type heat exchangers on the primary and secondary side to be demonstrated at site. Pressure drop across the Plate type heat exchanger on the primary & secondary water circuit to be demonstrated at site.

19. Condenser On Load Tube Cleaning System

Life of sponge rubber balls and number of balls lost during 1000 hours of plant operation shall be as indicated by Bidder in the offer and accepted by the Owner.

20. HP & LP Bypass System Capability

The HP & LP bypass system should satisfy the following functional requirements under automatic interlock action. It should come into operation automatically under the following conditions:

- a) Generator circuit breaker opening
- b) HP & LP stop valves closing due to turbine tripping
- c) Sudden reduction in demand to house load

Under all above conditions, while passing the required steam flows as per the relevant heat balances, the condenser should be able to swallow the entire steam without increasing the exhaust hood temperature and condenser pressure beyond the maximum permissible values. The same shall be demonstrated.

21. Power Cycle Pumps

Satisfactory operation of BFPs and CEPs without undue noise and vibration while operating in isolation or in parallel with other pumps shall be demonstrated at site.

22. Power Cycle Piping

Actual hanger readings under cold and hot condition (at rated parameters) to match with those of design cold and hot hanger readings for MS/CRH/HRH/HP & LP bypass piping system

11.11.5.4 **Generator**

- a) Generator Maximum Continuous Rating (MVA)
- b) Generator Efficiency (minimum) (%)
- c) Hydrogen Make-up per day (m^3/day)

**d) Excitation system**

Capacity of excitation transformer for static excitation (kVA) ii) Total loss of excitation transformer (kW) iii) Total loss of static excitation system (kW) iv) Total loss of brushless excitation system (kW)

11.11.5.5 Unit Start-Up Time (From Light-Up to Synchronization) (Minutes)

- a) Cold start-up : >72 hours
- b) Warm start-up : 10-72 hours
- c) Hot start-up : <10 hours d) Very hot start-up : <1.5 hours

11.11.5.6 Unit Ramp-up / Ramp Down Rates (% Per Minute)

- a) <50% TMCR
- b) 50%-100% TMCR
- c) Rate of change of load and sudden load change withstand capability

11.11.5.7 Step Load Change**11.11.5.8 Balance of Plant (BOP) Equipment****1. Coal Handling Plant System**

- a) Number of hours of CHP operation
- b) Guaranteed parameters of each equipment indicated below
 - i) Belt conveyors (tph)
 - ii) Crushers (tph)
 - iii) Screens (tph)
 - iv) Screen efficiency (%)
 - v) Stacker cum reclaimer (t/h)
 - vi) Belt feeder
 - vii) Vibrating feeder
- c) Maximum moisture in coal up to which crusher & screen will be capable of handling (%)
- d) Water requirement for dust suppression system (m³/h)
- e) Dust emission at each of the dust extraction system (mg/Nm³)
- f) Belt weigh scale (±)
- g) Capacity, head and power consumption of all the pumps shall be guaranteed. Vibration and noise level of all the pumps at the rated duty point shall be demonstrated at site
- h) Power consumption of all equipment shall be guaranteed. Vibration and noise level of all the equipment at the rated duty point shall be demonstrated at site

2. Ash Handling Plant

Conveying capacity / Evacuation time a) Bottom ash evacuation system

- i) Capacity of Scraper chain conveyors (tph)



ii) Capacity of clinker grinder (tph)

Fly ash evacuation system

i) Evacuation time per 8 h shift from fly ash hopper to fly ash silo (h) ii) Evacuation system capacity (tph) iv) Capacity of recovery water system (m³/h)

Sea water requirement

i) Max water requirement in a 8 h shift for ash disposal (m³/h)
ii) Required sea water in 8 h shift basis as make-up for AHS sea water tank (m³/h)

Desal water requirement

i) Max water requirement in a 8 h shift (m³/h)
ii) Required water in 8 h shift basis as make-up for AHS clarified water tank (m³/h)

Capacity, head and power consumption of all the pumps shall be guaranteed. Vibration and noise level of all the pumps at the rated duty point shall be demonstrated at site.

Power consumption of all equipment shall be guaranteed. Vibration and noise level of all the equipment at the rated duty point shall be demonstrated at site

3. Water System

Capacity, head and power consumption of all the pumps shall be guaranteed. Vibration and noise level of all the pumps at the rated duty point shall be demonstrated at site

- Seawater intake pumps – Desalination feed
- Seawater intake pumps – Cooling Tower make-up
- Condenser cooling water pumps
- Auxiliary cooling water pumps
- Cycle make-up pumps
- Other Miscellaneous Pumps

- a) Service water pumps
- b) CHP dust suppression plant feed pump
- c) DM water transfer pump
- d) Potable water transfer pump
- e) Ash water make-up transfer pump f) APH/ESP wash pump
- g) DMCW make-up pump
- h) Boiler initial filling pump i) Any other pumps

- Clarifier (per unit) – capacity (m³/h)
- Pressure sand filters – capacity (m³/h)
- Desalination plant – Capacity (m³/h)
- BWRO – capacity (m³/h)
- DM plant net output (m³/h)
- Mixed Bed OBR (m³)
- Water quality at PT Plant outlet

- a) Clarifier outlet turbidity (NTU)
- b) Pressure sand filter turbidity (NTU)
- c) Ultra filter outlet (SDI)

- Water quality at SWRO outlet (upon completion of three years from COD without replacement of membrane)



- a) Permeate conductivity @ 27 deg.C (Micro mho/cm)
- b) Permeate conductivity @33 deg. C (Micro mho/cm)
- c) Permeate TDS (ppm)
- Water quality at BWRO outlet upon completion of three years from COD without replacement of membrane
- a) Permeate conductivity @ 27 deg C (Micro mho/cm)
- b) Permeate conductivity @ 33 deg C(Micro mho/cm)
- c) Permeate TDS (ppm)
- Water Quality at Mixed Bed Unit outlet
- a) Conductivity @ 25 deg C (Micro mho/cm)
- b) Total Silica (ppb) c) pH
- Water Quality at DM Storage Tank outlet
- a) Conductivity @ 25 Deg.C (Micro mho/cm)
- b) Total Silica (ppb)
- Water quality at Potable Water outlet
- a) TDS (ppm)
- b) pH
- c) Boron (ppm)

4. Chemical Consumption for Water Treatment (KG/DAY)

- a) Contractor to list the chemicals type and quantities used
- b) Pre-treatment plant
- c) Desalination plant
- d) DM Plant

5. Chlorination Plant

Capacity (kgh)

6. Fuel Oil System (HFO/HSD (TPH)

- a) Unloading period (h)
 - HFO unloading period for 10 road tankers simultaneously with one standby pump
 - HSD unloading period for 5 road tankers simultaneously with one standby pump
- b) Capacity, head and power consumption of all the pumps shall be guaranteed. Vibration and noise level of all the pumps at the rated duty point shall be demonstrated at site

7. Fire Fighting System

Capacity, head and power consumption of all the pumps shall be guaranteed. Vibration and noise level of all the pumps at the rated duty point shall be demonstrated at site

- a) Fire water pumps – Hydrant system
- b) Fire water pumps – spray system



- c) Fire water booster pumps d) Foam system -pumps

8. Compressed Air System

- a) Free air delivery at site conditions per each compressor (Nm^3/min)
- b) Power consumption at site rated parameters per each compressor (kW)
- c) Max. capacity of each air dryer at min working pressure and max. temp at after cooler outlet (Nm^3/min)
- d) Parallel operation of air compressor shall be demonstrated at site.
- e) Pressure drop across Air Drying Plant, Capacity and outlet dew point of each air drying plant shall be demonstrated at site.
- f) Vibration level and noise level of each air compressor, blowers and any other rotating equipments of each air drying plant shall be demonstrated at site.

9. Passenger & Goods Elevators

Carrying capacity (kg)

10. Cranes & Hoists

Capacity and operating speed shall be guaranteed for the following cranes shall be guaranteed

- a) Turbine Building Main EOT Crane (AB bay)
 - i) Safe Working Load (T)
 - ii) Operating speed (meters per minute)
 - Hoisting
 - Long Travel
 - Cross Travel
- b) Turbine Building BFP EOT Crane (BC bay)
 - i) Safe Working Load (T)
 - ii) Operating speed (meters per minute)
 - Hoisting
 - Long Travel
 - Cross Travel
- c) CW Pump house EOT crane
 - i) Safe Working Load (T)
 - ii) Operating speed (meters per minute)
 - Hoisting
 - Long Travel
 - Cross Travel
- d) Seawater intake pump house EOT crane
 - i) Safe Working Load (T)
 - ii) Operating speed (meters per minute)
 - Hoisting
 - Long Travel
 - Cross Travel
- e) Any other area requiring Cranes and hoists



11. Mill Reject System

- a) Conveying capacity(tph)
- b) Compressor capacity / numbers (Nm³/min)

Continuous effective discharge and conveying at the rated capacity of the mill rejects without spillage or blockage in the system shall be demonstrated.

12. Air Conditioning System

Capacity and auxiliary power consumption of all equipment and inside room conditions shall be guaranteed for the following areas

- a) Main Control room in TG Building
- b) Control room in following aux buildings.
- c) ESP control building
- d) Switchyard control building
- e) DM plant control room
- f) Coal handling control building
- g) Ash handling control building
- h) Service building Floor wise:
- i) Any other area requiring air conditioning

13. Ventilation System

Capacity and auxiliary power consumption of all equipment shall be guaranteed for the following areas

- a) TG Hall
- b) Switchgear room in TG building
- c) Cable spreader room in TG building
- d) SWAS room in TG building
- e) Switchgear room in ESP building
- f) Cable spreader room in ESP building
- g) DG set room
- h) Air compressor house
- i) Battery room
- j) Switchgear room
- k) Cable spreader room
- l) Filtered water pump house
- m) CW pump house
- n) Chemical house
- o) Fire water booster pump house
- p) Fuel oil pump house
- q) AC plant room
- r) Chlorination room & associated areas
- s) Any other area requiring ventilation

14. Road Weigh Bridge

- a) Weighing capacity (T)
- b) Platform size (mxm)
- c) Accuracy(%) e) Load cell

15. Hydrogen Generation Plant

- i) Capacity & discharge pressure of hydrogen gas compressors at its rated duty point with its job (own) motor shall be demonstrated and proved at shop.



- ii) Parallel operation of two streams shall be demonstrated at site. Purity level and moisture content of Hydrogen shall be demonstrated at site. iii) Hydrogen generation plant capacity (stream wise) shall be demonstrated at site.

16. **As Applicable and/Or As Specified In The Technical Specification In Mechanical Subsection.**

17. **Electrical System**

As applicable and/or as specified in the technical specification in electrical Subsection.

18. **Control and Instrumentation System Requirements**

Performance guarantee tests for closed loop control system shall be carried out at site to verify the integrated performance of the total plant C&I and to verify as to whether all the important parameters remain within stipulated permissible limits under all the operating conditions. In case during this tests or otherwise it is observed that the behavior/response of Contractor's system (drives actuators/ valves etc.) is not satisfactory/acts as a limitation/restriction in achieving the permissible limits, the contractor shall carry out all required modifications rectification etc., in his system whatsoever so that the permissible limits can be achieved. He shall also depute his experts for associating in the above tests and also for carrying out the necessary modifications, rectification etc.

Further the Performance guarantee tests shall be as applicable and/or as specified in the technical specification in Control & Instrumentation subsection.

19. **Automatic On-Line Turbine Testing (ATT) System**

On-load testing of turbine protective equipment without disturbing normal operation and keeping all protective functions operative during the test

20. As applicable and/or as specified in the technical specification in control & instrumentation subsection.

11.11.6 Turbine Generator Performance/ Acceptance Test

1. Performance test for the turbine generator set will be conducted in accordance with the latest edition of ASME PTC-6. Such test shall be binding on the parties to the contract to determine compliance with the guaranteed heat balance conditions at 693 MW (105% TMCR) MW and 660 MW (100% TMCR) unit outputs corresponding to the conditions stipulated in the specification. Power consumed by the auxiliaries mentioned under in the Sub-section which is to be deducted from electrical power generated, shall be measured during the performance / Acceptance Test. Wherever the measurement is not possible, design values of power consumption by an auxiliary shall be considered.
2. The essential mandatory requirements for instruments, methods and precautions to be employed shall be in accordance with the requirements specified in the respective codes. All the necessary instruments (in duplicate) required for the tests shall be furnished by the contractor so as to meet the accuracies specified in the codes. Any advanced class instrument system such as those using electronic devices or mass flow technique shall be arranged by the contractor, if required. For determination of primary flow to the turbine, a calibrated low Beta-ratio throat-tap nozzle assembly including required machined straight lengths meeting the requirement of ASME PTC-6 shall be provided. The test procedures, Calibration Standards, Calibration procedures etc., shall be subject to Owner's approval. All the instruments including the flow nozzle shall be calibrated by the contractor before and after the test, in a reputed



international institute as approved by the Owner. However, post test calibration of flow nozzle shall not be mandatory. These calibrations shall be performed in the presence of the Owner. All calibrations shall be made available prior to the test and calibration certificates in original submitted to Owner at least 15 days before conductance of the test for Owner's approval.

The instruments shall be sealed after calibration by calibrating lab. The percentage calibration error/deviation should not be more than accuracy class of the instrument. Calibration low beta ratio throat tap nozzle assembly including flow straightner, upstream and down stream machined straight lengths, for main condensate flow measurements shall be as per ASME PTC6.

Secondary flow devices shall be calibrated flow nozzle / orifice plate as per ASME PTC 19.5.

3. Corrections to the test results for steam turbine shall be applied as per the correction curves listed in technical specification. When the system is properly isolated for a performance test, the unaccounted for leakages should not be more than 0.1% of the design throttle flow at that load. To achieve the above value of unaccounted for leakages, the Bidder shall prepare the unit during pretest available shutdown. However, during the test, if it is found that the unaccounted for leakage is more than 0.1% of design throttle flow at that load, then heat rate will be increased by an amount equal to half the difference between actual unaccounted for leakage expressed as percentage of design throttle flow at that load and 0.1% (allowed by the code).
4. The performance guarantee test will be carried out after successful completion of initial operation. Ageing allowance will be given during evaluation of PG test results and hence guaranteed heat rates shall be increased by the amount calculated as per the formula given in Cl. No. 3.07, Sub-Section-3 of ASME-PTC-6 Report 1985 (Reaffirmed 1991). Period of ageing shall be considered from the date of successful completion of initial operation to the date of conductance of PG test, In calculating the above factor any period(s) during which the turbine has not been in operation at a stretch for more than a week shall not be considered.
5. The tests shall be arranged in a manner that the OWNER's operation is not disrupted Duplicate test runs shall be performed at 693 MW and 660 MW unit loads. The results of corrected heat rate shall agree within 0.25%. If they differ by more than 0.25%, third test shall be run at the same point. The corrected result of any one of the three test runs, which deviates from the corrected averaged result of all the runs by more than 0.25%, shall be eliminated; otherwise the results of all the three tests runs shall be accepted.
6. During Performance/ Acceptance test, following tests shall be carried out for T.G. set with test grade instruments as per ASME code.
 - (i) Guarantee Turbine Cycle Heat rate test at 693MW (105% rated load) corresponding to the heat balance diagram specified in tender specification
 - (ii) Guarantee Turbine Cycle Heat rate test at 660MW corresponding to the heat balance diagram specified in tender specification
 - (iii) Guarantee Output test of 693 MW (105% rated load) corresponding to the heat balance diagram specified in tender specification
 - (iv) Maximum continuous output corresponding to both strings of HP heaters out of operation, under rated steam conditions at a condenser pressure of 77 mm Hg (abs) and 1% makeup.

11.12.0 Total Auxiliary Power Consumption of the plant

Refer, Volume-II, Section-1, GTS Clause no: 11.11.3.4 & Volume-II, Section-6, Schedule-2 for guaranteed Total auxiliary power consumption



The Contractor has to guarantee the power consumption and losses of all auxiliaries and ancillaries plant equipment which is required for the operation of the power generation units at rated output (100% load)

The Contractor shall list the auxiliary power consumption and/or losses separately for each equipment item or system and provide correction curves for variation in ambient conditions

11.13.0 Consumables

Contractors shall specify the major consumables (such as chemicals for waste water treatment plant, etc.) and their consumption. Contractor will be required to guarantee the consumption specified.

11.14.0 Make-up water

Contractor shall specify the amount of make-up water required at TMCR and the conditions being the basis for his calculation. Contractor will be required to guarantee the amount.

11.15.0 Waster water quality

Contractor shall guarantee the waste-water quality as per TNPCB/ CPCB norms.

11.16.0 Vibrations

Contractor shall guarantee that the vibration levels as stipulated elsewhere in this specification will not be exceeded under any operating condition.

11.17.0 Plant Availability Guarantee

Contractor shall guarantee the availability of the plant as a whole to be demonstrated during the Warranty period. The availability shall be minimum 90%. Plant availability shall be calculated with reference to 100% TMCR and full 1 year operating period. Planned and forced outages as well as capacity deratings done due to plant problems shall be considered. Outages and deratings due to dispatch conditions will not be considered in availability calculations (i.e. it will be considered that the plant is fully available during such dispatch conditions). Outages and deratings due to reasons not attributable to the EPC contractor will be considered as fully available in availability calculations.

11.18.0 Other Guarantees

Other guarantees as required have been indicated in the respective technical specifications



12.0.0 CLEANING, PROTECTIVE COATING AND PAINTING

12.1.0 General

This section covers the general requirements related to the cleaning protective coating and painting of equipment, components and system. Painting and protective coatings shall comply with the requirement of this section as well as Vol-II Section 2-25 Painting. The components and/or equipment shall be mechanically and /or chemically cleaned during the following stages of the Contract.

- Cleaning in workshop
- Cleaning before painting and/or corrosion protection (application of prime coat)
- Cleaning before erection and during installation.

Cleaning of fabricated component items shall be carried out after fabrication and final heat treatment or welding at manufacturer's works or at site, as appropriate.

For cleaning in workshop and before painting mechanical cleaning as opposed to alternative chemical cleaning is the preferred method for works cleaning except where this is precluded by design or access considerations.

Machined surfaces shall be protected during the cleaning operations.

In the event of the surfaces not being cleaned to the Owner's satisfaction, such parts of the cleaning procedures or agreed alternatives as are deemed necessary to overcome the deficiencies shall be carried out at the supplier's sole expense.

For reclining small areas, hand cleaning by wire brushing may be permitted. Wire brushes used on austenitic steel bristles.

Austenitic stainless steels, copper and aluminium alloys, cast iron, bimetallic and metallic/plastic items, and components fabricated by spot welding or riveting shall not be chemically cleaned. All weld areas shall be suitably stress relieved before chemical cleaning.

The paint manufacturer's instruction shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

- a) Proper storage to avoid exposure as well as extremes of temperature.
- b) Surface preparation prior to painting.
- c) Mixing and thinning
- d) Application of paints and the recommended limit on time intervals between coats.
- e) Shelf life for storage.

Any painting work (including surface preparation) on piping or equipment shall be commenced only after the system tests have been completed and clearance for taking up painting work is given by the Engineer, who may, however, at his discretion authorise in writing, the taking up of surface preparation or painting work in any specific location, even prior to completion of system test.

12.2.0 Equipment

All tools, brushes, rollers, spray guns, blast material, hand power tools for cleaning and all equipment, scaffolding materials, shot/sand blasting equipment & air compressors etc. shall be arranged by the contractor at the site in sufficient quantity at his own cost. He shall arrange at his own cost, for suitable paint thickness measuring instrument like Elkometers acceptable to the Engineer (with calibration facilities).



Mechanical mixing shall be used for paint mixing operations in case of two pack systems except that the Engineer may allow the hand mixing of small quantities at his discretion.

All the surface preparation, protective coating, painting of steel, structures; equipments shall be suitable for prevailing site condition and particular care shall be taken for site near to or at Coastal and Marine environment condition. Contractor shall submit the surface preparation, Protective coating and painting specification for the owner's approval.

12.3.0 Mechanical Cleaning at Manufacturer's Works

Refer Volume – II, Section 2-25 Cleaning, Protective Coating and Painting.

12.4.0 Protection at Manufacturer's Works

Refer Volume – II, Section 2-25 Cleaning, Protective Coating and Painting.

12.5.0 Weather Conditions

Refer Volume – II, Section 2-25 Cleaning, Protective Coating and Painting.

12.6.0 Surface Preparation

Refer Volume – II, Section 2-25 Cleaning, Protective Coating and Painting.

12.7.0 Rub Down and Touch up of Primer

Refer Volume – II, Section 2-25 Cleaning, Protective Coating and Painting.

12.8.0 Application

Health and safety of work

The supplier has to check all painting work to be carried out according to the specification of the paint supplier further to all relevant prescriptions and regulations concerning the health and safety of work.

The paint supplier has to present a written specification including at least the flash point of the paints, ventilation requirements, handling precautions such as inhalation, eye and skin protection, and first aid procedure, storage requirements, spill or leak procedure, fire precaution, waste disposal.

12.9.0 Safety Requirements

Protection of the blast cleaner operator's eyes and respiratory system should be given prime consideration in any open blast cleaning operation. Airfed helmets, respiratory filters, air conditioned hoods etc. should be provided in sufficient number to the blast cleaning operators to avoid the harmful effect of blast cleaning abrasives. Also, an automatic shut-off device which will shut-off the air supply to the blasting machine should be installed which will prevent the dangerous whipping of an operating blast hose if an operator becomes disabled.

Contractor shall take all safety precautions and shall follow all the safety requirement as imposed by the owner during execution of work.

12.10.0 Dry Film Thickness (DFT)

Refer Volume – II, Section 2-25 Cleaning, Protective Coating and Painting.



12.11.0 Protective Coatings and Paint Systems

The type and number of protective coats for any item requiring painting are to be furnished by the contractor as per the paint manufacturer's recommendation for owner's approval.

12.12.0 Colour Code for Piping

The colour code scheme is intended for identification of the individual group of the pipeline. The system of colour coding consists of a ground colour and colour bands superimposed on it. The colour coding for the identification of pipelines should comply with the standard and shall submit for owner's approval.

12.13.0 Galvanizing

Refer Volume – II, Section 2-25 Cleaning, Protective Coating and Painting.

12.14.0 Sprayed Metal Coatings

Refer Volume – II, Section 2-25 Cleaning, Protective Coating and Painting.

12.15.0 Inspection and Testing

Refer Volume – II, Section 2-25 Cleaning, Protective Coating and Painting.

12.16.0 Guarantee

Refer Volume – II, Section 2-25 Cleaning, Protective Coating and Painting.



13.0.0 SPARE PARTS, WEAR AND TEAR PARTS

Spares for the total plant of shall be divided into three categories namely:

- (a) Start-up and Commissioning Spares
- (b) Mandatory spares
- (c) Operation & Maintenance (O & M) Spares

Start-up and Commissioning Spares

Start-up and Commissioning spares are those which would be required during plant or equipment testing, start-up and commissioning. All spares used until the plant is finally handed over by the Contractor to the Owner come under this category. All start-up and commissioning spares as required shall be provided by the Contractor without any additional cost to the Owner. The list and details of start-up and commissioning spares shall be furnished by Contractor prior to award of Contract.

Contractor shall be responsible for the ready and timely availability for all the start-up and commissioning spares as required during various stages of testing, cleaning and commissioning upto handing over of each system of the plant.

Mandatory Spares

The mandatory spares required for the plant are identified and listed in **Annex 1.4** of this specification. Contractor shall review the list of spares specified and finalise the same based on the equipment and system proposed by the Contractor. The Contractor shall include the unit cost of the spares in the quoted price.

Operation and maintenance spares

The contractor shall provide, based on his own experience of the performance of his equipment, in the form of a schedule given in bid documents, the complete list of operation and maintenance spares for three (3) years operation of the equipment covered under the proposal. In the list of operation and maintenance spares parts, the Contractor shall identify the unit-wise population of each of items recommended and anticipated normal life of the spares.

The spare parts must be able to replace the original part completely and have the same technical specifications in quality, material, inspection and mechanical aspects.

Contractors shall supply all measurement testing data of any spare part supplied, if applicable.

All spare parts supplied shall be packed and stored for a 5 years reservation based on the local climatic conditions. Small spare parts shall be packed and sealed by transparent plastic bags and drying agents will be used if necessary. Every spare parts shall have operation instructions and design marks of the factory when it is supplied.

When multiple spare parts are packed in one packing box or container, the general indication to the spare parts outside the packing boxes or containers shall include a detailed list. All packing boxes, containers, and other such tanks shall be marked properly and numbered clearly. All electrical equipment including switches, fuse connection easy melting and other similar apparatus shall be protected and insulated.

The identification of all spare parts shall be in the English language.

Spare parts shall be supplied 6 months before start of acceptance test of the respective unit.



Wear and tear parts, to be replaced by the Owner at his own cost, shall be marked separately.

Contractor's operation and maintenance spares required spare part list shall be confirmed during detail design.

Contractor shall identify in the spare parts list, the items having a delivery time of more than 3 months



14.0.0 TOOLS, TACKLES & EQUIPMENT

Maintenance and repair tools including all special tools and tackles required unit for the operation, maintenance, inspection and repair of the individual main equipment and auxiliary equipment shall be supplied by the Contractors in sufficient quantity to equip the shift personnel, maintenance personnel and workshop craftsman for commissioning, testing, calibration, modification and maintenance of the unit. List of such special tools, tackles and equipment shall be submitted in the EPC bid.

The special tools and equipment for maintenance and repair shall be delivered by the Contractor in lockable steel boxes and they shall be marked in an approved manner for identification purposes and a corresponding tool chart shall be supplied with the steel boxes.

The following tools and appliances shall be supplied under this Contract for use by the Owner:

- a) two sets of special tools and gauges required for the maintenance of the Plant
- b) One set of special lifting and handling tackles / appliances required for the maintenance of the Plant.

The tools, tackles and appliances supplied in general, shall not be used for erection purposes by the Contractor and shall be handed over in brand new condition. Damaged tools, tackles, and appliances shall be replaced before handing over.

The exception to this is the special lifting gear which may be used provided that when it is handed over to the Owner it has not been subjected to more than normal wear and is still fully suitable for its intended use.

Each set of tools, gauges and appliances under category (a) above shall be suitably arranged in fitted boxes of mild steel construction, the number of boxes being determined in relation to the layout of the plant and equipment in question.

If the weight of any box and its contents should be such that it cannot conveniently be carried, it shall be supported on steerable rubber-tyred wheels.

Each cabinet and box shall be painted, fitted with a lock and clearly marked in white letters with the name of the item of equipment for which the tools and appliances contained are intended.

Suitable storage racks shall be provided for all portable lifting tackle supplied under this contract.

Suitable lifting lugs, ears or ring bolts, or tapped holes for lifting rings shall be provided on all equipment items where the weight exceeds 15 kg.

All lifting tackle shall be stamped with a unique identification number and safe working load. A test certificate from an approved Authority shall be supplied for each item of lifting tackle.

The Contractor shall provide a schedule of all lifting tackle and tools and appliances being supplied, for the approval of the Owner's Engineer.

The Contractor shall provide all runway beams, trolleys, mobile ladders, fork lifts, collapsible maintenance platforms, lifting blocks, special slings etc. necessary for the safe and efficient handling and maintenance of the works. Particular attention shall be paid to handling of equipment located at higher elevations

The tools and appliances with the appropriate storage racks, cabinets and boxes shall be handed over to the Owner at the time of Taking Over of the complete Plant.



15.0.0 CONSUMABLES

15.1.0 Lubricants and greases

All lubricants proposed for the Plant operation shall be suitable for all operating and environmental conditions that will be met on site.

All oils and greases shall where possible be readily available in India.

The number of oils and greases shall be kept to a minimum. For each type and grade of lubricant recommended the contractor shall list at least three equivalent lubricants manufactured by alternative companies.

In case of imported oils, lubricants and other consumables, the contractor shall indicate the indigenous equivalents to enable the Owner to arrange subsequent fills. Preference should be given to indigenous oils and lubricants during first filling itself. Short shelf life items if any may be supplied in a phased manner keeping in view of their actual use.

The Contractor shall supply the first fill of lubricants for the Plant, and shall provide at the Completion Certificate sufficient lubricants and greases necessary for the efficient operation and maintenance of the Plant at full load 24 hours per day for a period as specified under scope of supply.

15.2.0 Chemicals and other consumables

Contract includes the supply (by the Contractor) of all chemicals, reagents, resins, and other consumables required for testing, commissioning and setting to work of each section of the Works.

The Contractor shall provide all chemicals and other consumables required for the efficient operation and maintenance of the plant at full load 24 hours per day for a period as specified under scope of supply and services.

The Contractor shall prepare a list of these consumables giving quantities necessary for each section of the works and the recommended suppliers.



16.0.0 APPROVED SUB-VENDOR / MAKES

The makes of all the equipment/ instruments under this specification shall be subject to Owner's approval in the event of order. Contractor shall furnish a list of makes/ sub-vendors/ sub-contractors along with his bid. Owner reserves the right to accept/ reject any make or sub-vendor or add new makes/ sub-vendors for the project, after award of contract. Approval, rejection or addition of makes shall not have any cost implication to the Owner after award of contract.

**17.0.0 DOCUMENTATION****17.1.0 Format of Documentation**

All engineering documents and drawings shall be of international "A" series sizes, that is, A0, A1, A2, A3 and A4.

One set of CD containing all the drawings in Auto CAD shall also be supplied in addition to hard copies. Soft copy of all documents shall be supplied in a CD in PDF format.

Grouped documents shall be provided by size A4, with the inclusion of bigger size drawings which, however, have to be folded as Size A4.

17.2.0 Numbering and Identification of Documents

All the drawings shall be identified through a common way of numbering in accordance with the requirement of contracting. The numbering system of drawings and documents proposed by the Contractor shall be in compliance with the plant identification system and to be agreed with the Owner. Apart from this, some drawings may also be numbered in the way which the contractor or subcontractors are used to do. But, there shall be a common title block on all published drawings which include the following contents:

- Owner
- Owner's Engineer
- Project
- Contractor
- System
- Drawing No.
- Sheet No
- Revision No.

The measuring units and dimensions marked on the project engineering drawings shall be of SI system conforming to ISO 80000-1.

English words shall be used as descriptions on drawings.

In case dimensions are not marked in conformity with the scale of drawings and any dimension on the drawing does not conform to those dimensions and sizes measured through certain scale, the actual marked dimensions shall be applicable.

For revision of drawings, the revised part shall be clearly and definitely shown on the drawing. For revision of documents which have been grouped together, a brief description shall be a perpendicular line with the margin of the revised copy closely following it.

17.3.0 Provision for Documents

Generally, copies of drawings or documents containing trade secret and drawings with patented nature need not be provided.

However, to know whether the Contractor has performed its obligations, the Owner has the right to examine those drawings within the Contractor's working scope.

The Contractor shall meet the Owner's reasonable demands to files and do the following to satisfy the Owner:

- Contractor will work according to the requirements specified in the contract.
- Contractor's working has been arranged properly and developed according to the plan.



- The quality control system is reliable.
- After receiving all documents necessary for power plant operation and maintenance, Contractor shall supply equipment and systems.
- Having received all necessary documents for Contractor to perform its legal obligations or other relevant responsibilities.

17.4.0 Owner's Responsibilities

The Owner agrees that the Contract will be concluded in accordance with the EPC method of building the power project. It is the Contractor's duty to ensure that design standards and conditions meet the requirements and that the power project shall operate safely and reliably and with high efficiency, having the same performance as stipulated and guaranteed.

The Owner will examine, check and approve the drawings and documents with the aim of ensuring all these drawings and documents meet the demands and duties written in the documents. The Contractor shall have an active and cooperation working relationship with the Owner. If there is a disagreement over an issue, Owner and Contractor shall work together to reach some conclusion through mutual consultations.

If drawings and documents have been supplied to the Owner, the Contractor may not delay further design, waiting for the Owner's opinion. The Owner will arrange the time for submitting opinion and examination results for delivered documents. If the Owner finds that the Contractor cannot meet the contract requirements, the Contractor has the duty to modify the design and drawings to meet the Contract demand.



18.0.0 PLANT AND EQUIPMENT IDENTIFICATION, LABELLING

18.1.0 Plant and Equipment Identification

The Contractor shall propose and apply a common identification system preferably **KKS numbering** for the whole plant equipment, facilities and systems showing the name and number of each item and its respective drawing number etc. to fully identify the plant. The structure of the designations shall be developed in such a way that the symbols used can be handled by electronic data processing equipment. The identification system must be used by all subcontractors, vendors, etc., and shall be a proven system for power plant application. Each item of plant shall be separately designed with a reference number, which shall be used consistently on the drawings, in the documents and on the catalogues as well as on the equipment items themselves.

18.2.0 Labelling

Name plates which are to be firmly fixed on all the equipment, buildings and structures shall be provided. For equipment of small size, these are to be fixed on the piping or structure adjacent to the equipment. The contents of nameplate are to include the designation and principal parameters of the equipment.

The nameplate within the field shall be made of a high temperature - resistant metallic sheets, with designation permanently engraved on them. Indoor installed equipments (e.g., panels, cabinets, switchgear, etc.) shall also be labelled by appropriate name plate.

The form, size, base colour and colour of contents of the name plates and prompting plates will be agreed between the Contractor and the Owner. It shall be possible for these to be readily seen by the operator. The designation of warning tags shall be different from that of other tags.

**19.0.0 CONTRACT DRAWINGS, DOCUMENTS FOR APPROVAL, LIAISON MEETINGS****19.1.0 General**

The Owner reserves the right to ask the Contractor to submit copies of drawings and other documents for approval to his Head Office or to the Office of his Representatives. If the Owner or his Representatives are satisfied with the drawing, one copy will be returned to the Contractor marked with an 'Approved' stamp. If the Owner or his Representatives are not satisfied with the drawing, one copy stamped 'Reviewed and Returned with Comments' will be returned to the Contractor with comments marked thereon and the drawing shall be revised and re-submitted for approval.

The purpose of having drawings checked and approved by the Owner is to assist the Contractor in interpreting the Technical Specification so as to eliminate mistakes in the equipment or material actually shipped to the site of the work. The formal approval given to the Contractor is to be considered as in conformity with this purpose and in no manner shall be construed so as to release the Contractor from any liability or responsibility for proper design, fabrication or compliance with the Contract Documents.

Equipment drawings shall clearly indicate the general arrangement of the equipment to be furnished, give principal dimensions, and show sufficient details required for a complete power station.

While submitting drawings for approval, including any prepared by a Sub-Contractor, the Contractor shall certify that he has fully examined such drawings and that they comply with the requirements of the Contract.

If any item, equipment or work shown in the drawings does not completely comply with the requirements of the Specification or any other requirement of the Contract Document, the Contractor is obliged to clearly inform the Owner and his Representatives of the differences giving full explanations and reasons for such changes.

For the purpose of this Clause, the term "drawing" shall include design calculations, equipment specifications, diagrams, schedules, performance curves etc.

Approval of a drawing by the Owner or his Representatives will imply that:

- a) Arrangement and layout drawings and key diagrams have been examined and appear to be in accordance with the basic design concept of the project and meet the requirements of the Specification.
- b) Other drawings of components and equipment have only been examined in relation to compatibility of the items and equipment with the Specification and in respect of interconnection with other items and equipment.
- c) Any approval given by the Owner or his Representatives shall in no way relieve the Contractor of his responsibility under the Contract.

The Owner will not normally require to receive copies of detailed manufacturing drawings but the Contractor shall make these available if requested to do so.

The Contractor shall ensure that drawings are submitted in due time to permit amendments to be made and the drawings re-submitted for approval without delaying the scheduled deliveries or the guaranteed completion dates according to the Contract. Execution of work shall be taken up after the drawings are cleared by the Owner.

If, during the Contract period, the Contractor is required to modify the size of any buildings, foundations etc. from that shown on his Tender drawings to accommodate the finally

approved arrangement of the Work (with due allowance for access, laydown, maintenance etc), then such modification shall be deemed to be included in the scope of the Contract.

Requirements about the format of drawings and documents, the provision for documents and the Owner's responsibilities with regard to documentation are specified in relevant section of this volume.

The Contractor shall be responsible for any discrepancies, errors or omissions in the drawings and other particulars supplied by him, whether such drawings and particulars have been approved by the Owner and his Representatives or not.

19.2.0 Documentation by Contractor

The drawings to be submitted by the Contractor for approval shall cover the complete Scope of Contract work as defined by the Contract Specification and shall generally include, but not be limited to, the following:

19.2.1 Drawings & Documents to be submitted along with the proposal

(A) General (applicable for all discipline)

- Completely filled in technical schedules & other schedules for all equipments as enclosed with the Tender specification.
- Flow Diagrams and P&ID (Process and Instrumentation drawings) indicating Instruments and the destination / functionality of the signals Plot plan
- Plot plan and General arrangement drawing with section for major building viz Power house building, SG, CW pump house, BFP building, switch yard etc., showing maintenance area
- Quality Assurance and plan
- Master Document List (MDL) for Mechanical, Electrical, Civil and C&I with schedule of submission
- Description of options and alternatives offered
- Complete description of the plant offered including description of the process and the equipment
- General descriptions of individual systems and descriptions of operation including description of start-up, shutdown and emergency shutdown procedures,. Also behavior of boiler/steam generator and, turbine, etc. under transient conditions.
- Project specific Safety Plan shall be submitted for approval of owner.
- Training program and schedule for training of Owner's personnel
- Space requirement for construction site and equipment
- Maintenance proposal (for SG and STG)
- List of spares
- List of Special tools and Tackles
- Inspection intervals (major/minor)for six years along with the spares to be replaced during the above inspections. Contractor shall provide the cost of such spares on yearly basis.
- Contractor shall enter into a long term spare supply agreement with the OEM, and agree to transfer the same faithfully to the owner upon COD. Contractor shall commit to facilitate further negotiations on the spares with the OEMs directly by the owner.

(B) Mechanical

- Heat and Mass balance diagram same for 100% TMCR condition (0% and 1.0 % makeup), VWO condition (0% and 1.0 % makeup), 60% TMCR (Constant and Sliding pressure operation), All HP heaters out condition, Auxiliary steam condition and house load operation with HP-LP bypass in operation,
- Start up curve for cold, warm and hot condition
- Installation references where 660 MW Supercritical units with proposed main steam and reheat steam parameters are in operation.
- Experience list for supply and installation plants of similar capacity supercritical Units and performance certificate of the plants indicating the availability and plant load factor from the date of COD.
- Steam Generator, Steam Turbine Manufacturer's and Generator Manufacturer's experience list for the offered Capacity
- Deed of Joint Undertaking shall be executed by Contractor with following manufacturers
 - Steam Generator
 - Steam Turbine and
 - Generator manufacturer

The above shall be submitted clearly indicating the validity of the agreement and role and responsibilities among them

- Details of Technical Collaboration of the Steam Generator, Steam Turbine, Generator manufacturers with technology Supplier and role of the technology supplier for this project.
- Experience details of engineering consultant being engaged for detailed engineering of complete BTG and Balance of Plant. Deed of Joint Undertaking with engineering consultant including its validity and identifying the role and responsibilities of Contractor and engineering consultant shall be submitted
- Project Implementation Schedule and Methodology of project execution.
- Also refer the respective section-2 for the list of drawing/documents.

(C) Electrical

- Technical description of electrical system
- Technical schedules duly filled in
- Single line diagram for power project including switchyard
- Ratings of all major equipment
- List of make/vendors
- GA drawing for all the major equipment such as Generator, transformers, GCB, HT switchboards, GIS equipment.
- Description of Generator Cooling System, Excitation System & AVR
- Characteristic curves of Generator
- GIS Switchyard layout.
- Type test certificates for Generator, Generator transformer, GCB, GIS, HT switchboard.
- Description & Catalogues of all Electrical equipment

(D) Control & Instrumentation

- DCS / PLC architecture drawing (also indicating interconnection of different offsite C&I System) highlighting system features and capabilities
- Plant Control and operational philosophy
- Process description / functional write – up for all open loop and closed loop controls.
- Technical data Sheets of each hardware / instrument/control system/software offered with complete bill of materials and related detailed technical literature, etc.
- Functional specification for Plant DCS, STG control system with technical catalogues.
- Details of other C&I System offered for offsite plants.
- Write-up, scheme, technical details etc. of Continuous Emission Monitoring (CEM), Vibration monitoring and analysis system, Steam & Water Analysis System (SWAS), GPS /Master slave clock system etc.
- Details on all C&I items including CCTV, AAQMS, lab Instruments, Flue gas analysers and Field Instruments
- List of softwares (latest version) and hardware with confirmation certificate.
- Codes and applicable standards followed for the project.
- SER / Annunciation system configuration details including capacity, time stamping etc.
- List of vendors for instrument.
- Reference list with capacity of plant, year of commissioning and control system implemented along with minimum two user certificate for the DCS system configuration offered.
- GA diagram of the major equipments such control panel, control room console etc
- Evidence that the offered DCS system is upgradable and evolutionary in both hardware and software

(E) Others

- Overall project implementation with key dates and milestones for major plants design, construction, erection, commissioning, trial operation and testing up to provisional takeover of the complete power project.
- Reference lists for delivery and installation of plants of similar type and size
- Layout of temporary site facilities, buildings, structures, installations

(F) Maintenance

For, steam turbine, steam generator, generator and the total scope of supply maintenance and overhaul charts should be submitted with this bid. Both major and minor plant outages for inspection and/or routine maintenance should be shown on the chart, together with the nature of the work to be undertaken and the expected duration of the outage. This information should also include all the auxiliary plant to be supplied under the Contract.

Any other drawing or document which are not covered above but required to the effective commissioning of the project.

19.2.2 Drawings & Documents to be submitted after Award of Contract

The documents required for design, construction, installation, operation and maintenance of the entire plant shall be submitted by the Contractor in good time so as to permit the plant as a whole to be constructed in compliance with the specified time table.

Only the most important documents are listed below. The list and approval category of the doc/drawings shall be agreed sufficiently in advance before award of relevant order, so that corrections and amendments desired by the Owner as well as resubmission of the



documents will not result in any delays with respect to the guaranteed time table. The Owner reserves the right to request from the Contractor additional drawings, documents, etc. as may be required for proper understanding and definition of the design and engineering of the Plant.

(A) General

- Re-Submission of all the technical data furnished during pre award contract stage.
- Complete filled-in technical schedule.- For approval
- Plot plan - For approval
- General arrangement drawings /Equipment layout of all equipments along with sections indicating the unloading & maintenance area. - For approval
- Design basis for all the systems and major equipment sizing calculation - For approval
- P&ID (Process and Instrumentation drawings) indicating Instruments and the interlocks for all the systems - For approval
- Monthly progress report
- L2 network
- Quality plan for approval
- Prequalification document for different Vendors for Owner's approval.
- Equipment Testing procedure for approval
- Complete list of documents with proposed submission schedule
- Vendor Engineering document
- Data sheets, General arrangement drawing, material of construction, performance curves for approval for major items
- Painting & surface preparation procedure
- Technical specification

B) Mechanical

List of documents required to be submitted by the Contractor are listed in respective sub-sections of Section-2.

(C) Electrical

List of documents required to be submitted by the Contractor are listed in respective sub-sections of Section-3.

(D) Control & Instrumentation

- Control system configuration drawing for Plant DCS, STG and local PLC.
- DCS / PLC / Local control system / Vibration monitoring & analysis system functional specification covering both the hardware and software details along with the data sheets and technical catalogues.
- DCS / PLC IO allocation details, System loading details, controller grouping details.
- Details of the C&I System in offsite plants.
- Interconnection Diagram of DCS showing all hardware details.
- Design philosophy of C&I systems.
- Analog control schemes, Logic & protection diagrams for the entire I&C system along with the write-up/functional description.
- Start-up and shutdown logics with procedures and write-ups
- Data sheets, Specifications and catalogues of field instruments, analyzers, lab instruments, and associated accessories
- Flow element sizing calculations and dimensional drawings.



- Control valve & Safety Relief Valve sizing calculations and dimensional drawings.
- Plant graphics, alarms, various displays, logs and reports with menu and format.
- Analog & binary drive list for the entire system
- Complete Instrument Schedule, DCS I/O list, (Software & hardware) Annunciation list, SOE list, Hardware list for safe shut down, Flow element schedule, Control valve schedule, JB schedule, Rack schedule etc.
- Cable schedule, Interconnection & wiring schematics for the I&C systems offered.
- Detail wiring diagrams of all panel desk, control consoles, system cabinets etc.
- Instrument loop schematics.
- Final BOQ for the I&C system with the bought item vendor list.
- Calibration test & quality assurance test procedure and test certificates.
- Pre-FAT, FAT(Factory Acceptance Test), SAT (Site Acceptance Test) procedure
- Instrument installation & Hook-up diagrams showing all erection hardware.
- Tapping point details.
- Instrumentation Layouts such as, Control room layouts, Electronic Equipment room layout, CEM room layout, SWAS room layout.
- Drawings such as JB/ Rack/ Tray /Instrument location drawing etc.
- C&I power distribution scheme including UPS supply etc.
- Instrument air distribution scheme.
- Electronic Earthing schemes
- DCS vendor drawings/documents.
- Grouping philosophy of control loops in controllers.
- Marshalling / cabling philosophy.
- Write up and scheme on I&C power supply arrangement
- Lists of maintenance and calibration test,
- Outline general arrangement / Internal general arrangement drawing for all the I&C equipments drawing for all the I&C equipments.
- Detail dimensional drawings of various equipment, components / sub-assemblies
- Cable Spreader room details /false flooring details of CCR.
- Spare parts list, Laboratory Instrument list, test & calibration report, special tools & tackle list
- Operation and maintenance manuals for all the I&C equipments and systems.
- All the above drawings as applicable for the mechanical packages
- All other lists and drawings as required

(E) Civil

- General site plan of the entire site showing all buildings and installations, traffic routes and landscaping etc.
- Architectural arrangement drawings, design layouts and itemized drawings (plans and sections) to scale 1:100 of all buildings and plants
- Views of all sides of all buildings, scale 1:100
- Architectural drawings of each floor (plants, sections) including all necessary detail drawings, scale 1:50
- Arrangement drawings of the external plants of the site as a whole (existing, planned) with all supply and disposal facilities, roads and vehicle access and maneuvering areas, sewers, channels and culverts etc.
- Detailed constructive description of the each building with regard to the structural design (structural systems, foundations etc.)



- Detailed specification of the buildings including information on interior decoration, materials and qualities for execution
- Detailed construction drawings of all corresponding civil / structural / Architectural works including buildings, foundations, roads, trenches, cable ducts and services, etc.
- Structural design calculations for all buildings and foundations including equipment foundation. For rotating and vibratory equipment, dynamic analysis calculations shall also be submitted.
- Sectional elevations and roof plan
- False floors/systems
- Underground services and ducts with equipment appertaining to the services
- Layout of roads
- Plant drains layout
- Principal details and sections for traffic areas, especially for ramps and retaining walls
- Layouts for external works showing plants and fencing etc.
- Schematic details for plumbing
- Foundations and other underground concrete works for the transformer area.

(F) Others

- Testing report for approval
- Declaration of conformance with statutory regulations
- Operation & Maintenance manual
- Training program
- As-built-documentation including drawings of all equipment
- Complete bill of materials of the plant with expected life of major items along with break up price.
- Welding procedure (for workshop and site)
- Lubrication list and Schedule
- Site Quality plan
- Erection and Commissioning procedure

Any other drawing or document which are not covered above but required to the effective commissioning of the project.

19.3.0 Time scheduling, based on CPM

- Overall time schedule for design, manufacture, supply, assembly and commissioning broken down for the principal plant components and all construction works, stating dates for completion of any preparatory work from others which may be necessary
- Detailed erection, installation and commissioning schedule

The Contractor shall ensure that the final draft of all schedules, lists or data sheets / equipment are produced to a uniform format irrespective of whether the source of the above schedules, lists and data sheets is in the main Contractor or a Sub-contractor of the main Contractor. All documents shall carry a uniform numbering system.

All Contractor's drawings which are found to be incorrect during the construction period or which require changes owing to site constraints, shall be corrected by the Contractor to an "as built" condition to reflect any necessary changes.

The stipulations and requirements specified elsewhere in the specification shall also be followed with respect to preparation and submission of drawings.



Apart from those documents named in the various sections of the Specification, the Contractor has to submit as minimum requirement the drawings summarized in the above clause to the Owner or his representatives within the periods specified in months, starting from the "Commencement Date" according to the Definitions of the Contract. The delivery time as far as not specified, shall be proposed by the Contractor in his Tender in accordance with his overall implementation schedule and will be defined finally during Contract negotiations.

19.4.0 Liasion Meetings

The liasion meetings shall be organised by the contractor (once in 15 days during design period and once in 15 days during construction period) in accordance with stipulations specified elsewhere in the specification.

Contractor shall supply all documents required in the appropriated number as requested by the Owner.

19.5.0 Distribution of documents

The source, distribution, no. of copies etc shall be as per the following document distribution schedule.

Document Distribution Schedule - After Placement of Order

Sl.No.	Document	Total Copies	Distribution		
			Owner		Consultant
			HQ	SITE	
1.	PERT Network, work schedules, Bar charts, Layout drawings in 2D & 3 D of all building, plant, pump house, control room etc	12	4	6	2
2.	Data, drawings, documents, write-ups, calculation				
	- Preliminary	12	5	5	2
	- Revised	12	4	6	2
3.	Approved drawings, documents etc.	12	4	6	2
4.	Instruction manuals for erection and O&M	12	5	6	1
5.	As built drawings including O &M manual				
	- Hard Copy	12	5	6	1
	- Soft Copy	5	2	2	1

19.6.0 Manuals

19.6.1 General

The Contractor shall provide the manuals in a timely manner to enable the Owner / Engineer to review and comments and request changes as necessary.



Payments will be withheld for non-compliance or for late delivery of the drawings, procedures and manuals. In particular the Contractor shall be held responsible for consequential damage to the plant where such damage is due to late delivery of the O&M manual resulting in non-familiarity of the operating technique.

The Contractor shall also note that while all documents, procedures and manuals shall be in the English language including that of the sub vender of the contractor, it is particularly important that the O&M manuals be in clear concise English.

All manuals shall be divided by systems or sections and cross-indexed as necessary.

19.6.2 Certification Manual

This manual shall contain the approved works certification documentation for all plant equipment and services as specified in the relevant codes and standards and in this specification and the Contractors Quality Manual. This manual shall also include all material tests certificates. Certificates and test procedures shall be specific to the plant supplied.

19.6.3 Design Manual

This manual shall contain all the design calculations and all equipment and system data sheets and design criteria required under the Contract.

19.6.4 Construction Manual

This shall include a comprehensive record of as built site construction tests and records. Again the manual(s) shall be compiled in separate parts to reflect the plant and services supplied.

19.6.5 Commissioning Manual

This manual shall include all the records, certificates and test results arising from the agreed pre-commissioning and commissioning procedures carried out on site. The performance tests and guarantee test results shall also be included. There is a particular requirement that all commissioned plant/equipment values be recorded in this manual and subsequently incorporated into the O&M manuals.

19.6.6 Operating and Maintenance (O&M) Manuals

The Contractor shall provide the O&M Manual properly bound, within the time specified, to enable the Owner's staff to become fully acquainted with the operation, adjustment and maintenance of the entire plant. The manuals shall contain full and explicit instructions in respect of the operation of the plant under all operating conditions and the maintenance routines and requirements to be established to maintain the plant in optimum performance. These instructions shall be in the English language and be as comprehensive as possible and the form in which they are to be set out shall be agreed with the Owner / Engineer. The instructions may be divided as appropriate into individual sections and sub-sections as necessary. All section and sub-sections shall be clearly indexed and cross-referenced as required for clarity.

The instructions shall be tailored to suit the specific requirements of the Operations and Maintenance functions and personnel, taking into account the staffing philosophy for the thermal power project.

The instructions for the related parts shall be accurate and easy to understand and shall contain the necessary sequence of individual activities. The diagram and drawings associated with the instruction shall be clear and unambiguous.

It is an essential requirement that all information and plant data contained in the manual must be project specific and derived from the design, manufacturers / suppliers and commissioning data of the as-built plant. Where the Contractor includes standard brochures the installed item of plant or equipment shall be clearly identified. All sections shall contain an introductory description of the particular item/system including its function and operating criteria and any special features. On the basis of the commissioning and running experience of the Plant, the instructions shall be amended to a final form within three months of the end of commissioning and, for this purpose, the Contractor shall supply the required number of printed copies of all approved amendments for insertion in the bound set of instructions.

The entire O&M manuals including that of the sub venders shall all adopt the same format paper size etc. The Contractor shall prepare manuals integrating all equipments supplied by the sub venders.

19.6.7 Operating Instructions:

The instructions shall include at least the following specific procedures/practices /items:

- starting-up
- shutting down
- operation / procedures during fault conditions
- surveillance and monitoring of plant. check lists
- standard readings
- operational parameters (especially limiting values in critical areas)
- isolating procedures
- Earthing /switching
- trouble-shooting
- fault reporting
- normal operational reporting
- compliance with requirements for interfacing with grid.
- safety/security/fire fighting/ first aid
- general plant standards and guidelines.
- test procedures
- maintenance and operating management systems
- drawings, schematics, logics and wiring diagrams, function diagram, P&IDs.
- protection

19.6.8 Maintenance Instructions:

The instructions should provide for the three maintenance functional groups – 1) Mechanical, 2) Electrical, and 3) Control and Instrumentation - and shall include at least the following:

19.6.9 Maintenance Management System

- a complete and accurate description of the main plant items and systems of the Power Station specific to each function
- detailed maintenance procedures and intervals for all plant items.
- assembly and disassembly procedures.
- spare parts
- use of special tools and equipment
- lifting procedures
- drawings, detailing tolerances



- schematics, logics and wiring diagrams, function diagrams P&ID's.
- isolating procedures,
- Safety and Codes of Safe Practice.
- firefighting/first aid
- set-up and calibrating procedures.
- optimisation of Control Loops
- diagnostics and trouble shooting
- specialist maintenance/repair procedures including welding procedures.
- materials test procedures

19.6.10 Owner's Responsibilities

The Owner agrees that the Contract will be concluded in accordance with the EPC method of building the power project. It is the Contractor's duty to ensure that design standards and conditions meet the requirements and that the power project shall operate safely, reliably and with high efficiency, having the same performance as stipulated and guaranteed.

The Owner may examine, check and approve the drawings and documents at his discretion with the aim of ascertaining that all these drawings and documents meet the requirements specified in the contract documents. The Contractor shall have an active and cooperative working relationship with the Owner. If there is a disagreement over any issue, Owner and Contractor shall work together to reach some conclusion through mutual consultations.

The drawings and documents of the Contractor shall be returned with observations if any within fourteen working days by the owner. The Contractor shall clarify the observations raised by the owner and shall attempt to correct the drawing or document subsequently only.

**20.0.0 ENVIRONMENTAL PROTECTION****20.1.0 Applicable Standards**

The project must conform to the national standards of the Republic of India. The following standards and /or regulations are to be applied:

20.2.0 Environmental quality standards

The discharge of pollution in water and air as well as noise levels shall meet with the stipulations of Tamil Nadu Pollution Control Board as well as other Acts of the Government under the Ministry of Environment and Forestry. If there should be a discrepancy between standards and this specification from the more stringent requirement will apply.

Contractor shall comply with the following Environmental clearance obtained for the project, as applicable for the EPC scope:

- Environmental Clearance (EC)
- CRZ clearance for captive port, seawater intake and outfall
- Consent to Establish (CTE) issued by TNPCB

20.3.0 Fundamental Requirements of Environmental Protection for Power Projects**20.3.1 General principles**

To protect the environment, power projects should comply with state regulations, carry out composition and review system for environmental impact assessment (EIA) report and execute the "Three Simultaneousness" system, namely, simultaneous design, construction and operation of both pollution prevention facilities and the main plant. The preparation of EIA is not a part of EPC Contractor's scope.

Environmental protection design for the power project will be based on the requirements of environmental impact report and relevant stipulations, and state of the art, proven technology will be adopted. This will guarantee that the plant will run in a safe, efficient manner and with high availability, and satisfy the demands of protecting the environment. The air emissions of the plant will meet the Pollution control board norms and guidelines. The plant effluent shall also meet the stipulations laid down by Pollution control board. The general pollution control board (PCB) requirements shall be imposed. Any add-on requirements during public hearing and EC shall be imposed as amendment.

20.3.2 Atmosphere Pollution Prevention and Control

The Steam generator shall be equipped with efficient Electro Static Precipitators (ESP) with a capacity as specified in the Annex 2.1.1- Specified design data Steam Generator & its auxiliary – Volume II - Section 2.1. The ambient air quality within the power project premises shall strictly conform to the Central Pollution Control Board (CPCB) as well as Tamil Nadu Pollution Control Board norms (TNPCB) & requirements. No deviation/correction in this regard is acceptable.

20.3.3 Water Pollution Prevention and Control

The plant should be designed to economize on water use and to set up a water management system featuring equilibrium between water feed and water discharge.

- Waste water (including all effluents, acid and alkali waste, oily waste, Blow down, Ash water recovery etc.) from the plant shall be treated in distributed mode and will reach

- the standards before it is discharged. Plant water pollution shall meet the TNPCB and CPCB Norms and requirements. No Deviation/correction in this regard is acceptable.
- Sewage disposal shall conform to the TNPCB and CPCB Norms and requirements. No Deviation/correction in this regard is acceptable.

The plant shall be designed for zero discharge for raw water based effluents. All plant effluents such as from DM plant, service water, sewage, etc., shall be treated for reuse to ensure zero discharge

20.3.4 Noise Pollution Prevention and Control

The Contractor shall take all necessary measures for noise attenuation in order to meet the specified noise levels. Noise pollution shall meet the TNPCB and CPCB Norms and requirements. All equipment shall be specified for a design to run without undue vibration and with the least amount of noise.

General requirements of noise control:

The noise level shall meet the MoEF and TNPCB environmental requirements specified for the project.

20.3.5 Environmental Monitoring Station

Six (6) nos. of environmental monitoring stations shall be provided by the EPC Contractor in accordance with "Environmental Protection Design Stipulation for Thermal Power Projects". It shall be provided with the instruments according to Environmental Monitoring norms to supervise and monitor the pollutants emitted during power generation so that it meets with the ambient air quality standards and also that environmental quality and trend can be known so as to provide scientific basis for pollution prevention and control. The environmental monitoring station will be designed in such a way as requiring no staff and Tamil Nadu State Pollution Control Board should be consulted in deciding the location of the stations.

20.3.6 Flue Gas Emission Levels

In order to meet the environmental quality requirements, the Contractor has to guarantee that at all loads and operating conditions of the Steam Generator the flue gas emission levels (Suspended Particulate Matter, Sulphur Di Oxide, NO_x) will strictly adhere to the norms and requirements of CPCB & TNPCB. No deviation/correction in this regard is acceptable.

The Contractor shall provide on-line automatic Continuous Stack Emission Monitoring (CEM) for monitoring the levels of SO_x, NO_x and SPM. The Contractor shall also provide stack monitoring kits for monitoring SO_x, NO_x and SPM at plant boundaries.

Low NO_x emissions are to be ensured by installing the low NO_x coal burners.

20.3.7 Green Belt

Adequate plantation shall be provided along the periphery and in the power project to satisfy the norms and stipulation as laid down by the Govt. of Tamil Nadu and MOEF, Govt. of India.

20.3.8 Soil Contamination

Soil can become contaminated by oil and chemical spillage during Operation and Maintenance of the Plant. The entire plant shall be designed, operated and maintained in such a way to prevent any soil contamination and adequate provisions shall be made in the design.



20.3.9 Rainwater Harvesting

The rain water collected from the roof of buildings shall be channelised through the rain water down comers and routed to the garland drain around the buildings. These garland drains shall be connected to the plant storm water drainage network system all around the plant. Several recharge wells shall be located at strategic locations within the plant and shall be interconnected to the storm water drain network system to ensure recharging of the ground water table.

The storm water drain shall be finally connected to a Stage-1 drain.

**21.0.0 TRAINING REQUIREMENTS****21.1.0 Training requirements****21.1.1 General**

The Contractor shall be responsible for the instruction and training of the Owner's operation and maintenance personnel and his O & M contractor in all aspects of plant design, construction, erection, commissioning, etc. and in such a way that operation, maintenance and if necessary repairs of all the power project equipment and facilities specified can be handled competently by said personnel. The cost of travel expenses including travel insurance, boarding and lodging expenses of the training have to be borne by the EPC contractor. Daily allowance shall not be borne by the EPC contractor. This includes training in India and foreign countries.

Such training of the Owner's personnel shall be performed

- In Contractor's and/or sub supplier's/manufacturer's home office and/or workshops.
- In similar power projects and such power projects which are under erection and commissioning as well as at the proposed similar Power Project by using the training simulator.
- On the job site by the Contractor's and/or his sub-suppliers, supervisors and/or instructors deputed to the site for supervision of erection, commissioning, testing and trial operation and/or by specialized training instructors;
- At the Power Project by the supervisors deputed to the Plant during the Warranty Period;

In compliance with the provisions of the Contract and the requirements of this specification.

The personnel required for the safe and efficient plant commercial operation and maintenance of the various types of equipment installed shall be provided by the Owner in accordance with the recommendation to be made by the Contractor.

The training will be performed in English. Translators/interpreters shall be provided by the Contractor.

The Contractor's instructors shall use modern training techniques, procedures and aids and make available to the trainees all required notes, manuals, drawings, etc., to supplement the Operation and Maintenance Instruction Manuals.

The Contractor shall provide a detailed description about the recommended training services, including

- Number, category, seniority, required experience, profile required, etc. of the trainees
- Preliminary training program, showing
 - Training facilities, training aids places of training etc.
 - Training schedule
 - Specialty and details of lectures and training
 - Duration of training courses

for all kind of training activities, abroad, classroom, on the job site, at the proposed Power Project, etc.

The recommended training program should be based on the organizational and staff structures of coal fired power projects already in operation in India and should take into consideration not only the training for operation and maintenance staff, such as operators, skilled workers, foremen and technicians etc, but also for senior staff and key personnel employed for the management and organizational duties of the various power project



decisions, such as for operation, maintenance, instrumentation and control, chemistry, administration, security, spare parts handling, scheduling and engineering, etc.

An indicative training programme is proposed below which will be firmed up during contract stage:

Group	Number of man-month
Overall Plant Management	18
Operation Team	45
Mechanical Maintenance Personnel	30
Electrical Maintenance Personnel	15
C&I Engineers	15
Other groups as may be indicated by the Owner	9

The training programme includes all the aspects of training and the duration as per Annex 1.5.

The above training programme shall include training of 44 persons on 2 months Site training and 1 month training at manufacturer's works. Bidder shall indicate in his offer, the break-up of number of man-months of training overseas and in India meeting the above training programme.

21.2.0 Contractor's Obligations and Tasks

The Contractor shall make every effort to train the Owner's personnel and his authorized O & M contractors so that they can be qualified for the management, operation and maintenance of the Contract Plant

The Contractor shall nominate a person in charge of organization and co-ordination activities for training.

The Contractor shall select instructors with proper experience and skillfulness and English speaking capability to train the Owner's personnel.

The training program will be carried out according to the requirements of each specialty. It will consist mainly of but not limited to the following:

- Systematic explanation in a classroom of specific subjects, such as the equipment performance, construction, main systems, auxiliary systems, etc.;
- Visit to power plants;
- Practical training in similar power projects which are under erection and commissioning.
- Practical training on simulators and control rooms of similar power projects.
- Supply of all necessary training documentation (such as books, manuals, drawings), equipment, tools and instruments etc. The Contractor will make best effort to achieve above item (c) and (d) with utility authority.

The Contractor will make available free of charge to the Owner's personnel working cloths, safety helmets, stationery etc. as needed by the training program.



The Contractor shall allow the Owner's personnel to carry back all the technical documents supplied during the training.

The Contractor shall make at the end of the training period an evaluation of the results obtained by each trainee. These results will be confidentially notified to the Owner.

The Contractor shall assist the Owner's personnel in arranging their entry visas and all the formalities staying in foreign countries for training. The Contractor shall also take all the necessary measures to ensure the safety of the Owner's personnel during their stay in the foreign country.

The Contractor shall appoint a person in charge of logistic coordination. This person shall take care for booking of rooms according to the requirements of the Owner and arranging for transportation (free of charge) from their living place to the training site. The cost of travel expenses including travel expenses, boarding and lodging expenses of the training have to be borne by the EPC contractor. Daily allowance shall not be borne by the EPC contractor

The Contractor shall provide free medical services to the Owner's personnel during their stay in the foreign country.

21.3.0 Owner's Responsibilities

The Owner shall appoint a person as official representative of the Owner's trainees.

The trainees shall understand the English language and shall follow the training courses with due diligence. During their stay abroad the Owner's personnel shall observe the Laws of that country and the rules/regulations of the factories/plants where the training will be conducted. The official holidays or national holidays, Saturdays and Sundays shall be the holidays of the Owner's personnel.

For the successful completion of the training program, unless mutually agreed by the parties, the program cannot be interrupted for vacation leave.

The cost of travel expenses, boarding and lodging expenses of the training/inspection have to be borne by the EPC contractor.

21.4.0 Training schedule and program

The Training program for the Owner's personnel will be defined during the liaison meeting.

Two (2) months before the arrival of the first group of the Owner's personnel in training site, the Owner shall inform the Contractor of the date when the Owner's personnel are expected to be sent to training site

Within 2 (two) weeks after receipt of the Owner's information mentioned above, the Contractor shall confirm its agreement or indicate difficulties, if any, for the staying of the personnel. Thirty (30) days before the arrival of the Owner's personnel in the training site the Owner shall inform the Contractor of the brief career of the personnel including names, date of birth, nationality, specialty, experience, qualification, position and knowledge of foreign languages, passport details etc., so that the Contractor can assist in arranging their entry visas.

The Contractor shall not charge the Owner with the costs for the training activities in the respective training sites.

In case the Owner fails to send his personnel to attend the above training, the Contractor shall reimburse the relevant amount to the Owner

**ANNEX - 1.1****COAL ANALYSIS****Coal Parameters:**

The steam generator shall be designed for the following conditions:

- **Best Coal** : 100% Imported Coal
- **Design Coal** : 70% Imported & 30% Domestic Coal on weighted average
- **Worst Coal** : 50% Imported & 50% Domestic Coal on weighted average

The analysis of fuel is given below:

Coal Analysis**Coal Quality Parameters**

Sl.No	Description	Domestic Coal	Imported Coal
1.	HIGHER HEATING VALUE -As Fired basis given Kcal/kg	3000 (GCV as received basis)	5700 (as received basis)
2.	TOTAL MOISTURE %	During rainy season 20% (inherent + surface)	16.5%
3.	HGI Abrasiveness expected YGP Shale and sand stone content Feed coal size	45 to 55 Average 52 50 to 70 mg/kg 20% max. up to 50 mm.	51

Bidder to consider specified HHV for all purposes.

DOMESTIC COAL PARTICULARS:

Particulars		Units	Parameters
A. Proximate Analysis			
1.	Moisture	%	16.00
2.	Volatile Matter	%	19.00
3.	Ash	%	45.00
4.	Fixed carbon	%	20.00
Total		%	100
B. Ultimate Analysis, % (As received)			
1.	Carbon	%	27.70
2.	Hydrogen	%	2.60
3.	Nitrogen	%	0.52
4.	Oxygen	%	7.26
5.	Sulphur	%	0.50
6.	Ash	%	45.00



Particulars		Units	Parameters
7.	Moisture	%	16.00
8.	Carbonates	%	0.38
9.	Phosphorous	%	0.04
10.	Others	%	-
Total		%	100.00
C. Ash fusion temperature (deg C)			
1.	Initial deformation, IT	deg C	1100
2.	Spherical, ST	deg C	1200
3.	Hemispherical, HT	deg C	1300
4.	Fluid, FT	deg C	-
D. Ash Analysis (%)			
1.	SiO ₂	%	59.54
2.	Al ₂ O ₃	%	29.00
3.	Fe ₂ O ₃	%	6.42
4.	CaO	%	1.50
5.	Na ₂ O	%	0.08
6.	K ₂ O	%	-
7.	TiO ₂	%	1.60
8.	SO ₃	%	0.25
9.	P ₂ O ₅	%	0.51
10.	MgO	%	0.50
11.	Others	%	0.60
Total			100.00
E Resistivity of fly ash		Ohm - cm	1.73x 10 ¹²

IMPORTED COAL

Particulars		Units	Parameters
A. Proximate Analysis (As received)			
1.	Moisture	%	16.50
2.	Volatile Matter	%	36.45
3.	Ash	%	6.62
4.	Fixed carbon	%	40.43
5.	Total	%	100.00
B. Ultimate Analysis, (%) (As received)			
1.	Carbon	%	60.12
2.	Hydrogen	%	4.38



Particulars		Units	Parameters
3.	Nitrogen	%	1.48
4.	Oxygen	%	10.37
5.	Sulphur	%	0.53
6.	Ash	%	6.62
7.	Moisture	%	16.5
8.	Carbonates	%	-
9.	Phosphorous	%	-
10.	Others	%	-
Total		%	100.00
C. Ash fusion temperature (deg C)			
1.	Initial deformation, IT	deg C	1230
2.	Spherical, ST	deg C	1270
3.	Hemispherical, HT	deg C	1320
4.	Fluid, FT	deg C	-
D. Ash Analysis (%)			
1.	SiO ₂	%	36.00
2.	Al ₂ O ₃	%	13.90
3.	Fe ₂ O ₃	%	14.80
4.	CaO	%	12.70
5.	Na ₂ O	%	0.70
6.	K ₂ O	%	1.70
7.	TiO ₂	%	0.80
8.	SO ₃	%	10.60
9.	P ₂ O ₅	%	0.20
10.	MgO	%	8.60
11.	Others	%	-
12.	Total	%	100.00



The plant should be suitable to accept imported coal, sourced from any country. The limiting parameters of imported coal are furnished below:

Sl. No.	Particulars	Unit	Parameters
1	Total Moisture (ARB)	%	Up to 23 (Max)
2	Ash (ADB)	%	-
3	Gross Calorific Value (ADB)	Kcal / Kg	5800 - 6500
4	Sulphur (ADB)	%	Up to 1 (Max)
5	Fixed Carbon (ADB)	%	30-50
6	Volatile Matter (ADB)	%	25-45
7	HGI		45-60
8	IDT (Under Reducing Atmosphere)	Deg C	1100-1250
9	Size	mm	< 50

Note: ADB stands for “As dried Basis” and ARB for “As Received Basis”

**ANNEX - 1.2****FUEL OIL ANALYSIS**

Specification of Heavy Fuel Oil (HFO)
Flash point (°C) min. 66 K.
Viscosity in Centistokes @ 50°C max. 370
Ash by wt. % 0.1
Water content by volume % max 1
Sediment by weight % max 0.25
Total Sulphur by weight % max 4.5
Gross calorific value, Kcal/kg 10800
Specification of LDO/ HSD Oil:
Specific gravity @ 15° C 0.8348
Gross calorific value, Kcal/kg 10400
Pour point (°C) max. 12
Flash point (°C) min. 66
Sulphur % (T) max. 0.5 K
Viscosity in Centistokes @ 50°C max. 7.5
Ash by wt. % 0.01
Water & sediment Vol. Max. % 0.25



**ANNEX - 1.3
SEAWATER ANALYSIS**

REFER VOLUME III FOR TYPICAL SEAWATER ANALYSIS

**ANNEX - 1.4
MANDATORY SPARES**

Bidder shall supply mandatory spares required for the equipments/systems to be supplied by them as per the list mentioned in the specification.

Bidder shall supply equivalent mandatory spares for the items not applicable in the list for which equivalent systems/equipments are offered.

A) MECHANICAL

Sl no	Equipment	Name of spares	Unit	Qty
	Turbine			
1		Complete assembly of journal bearings and thrust bearing for TG	Set	1
2		Thrust pads for thrust bearing (complete assembly)	Set	2
3		Rotor coupling bolts and nuts complete assy. For entire TG rotors	Set	1
4		Complete set of internals required to form hp control valve with servo motor except valve body.	Set	1
5		Pilot valve for hp control valve	No	1
6		Complete set of internals required to form IP control valve with servomotor except valve body.	Set	1
7		Pilot valve for IP control valve	No	1
8		Complete set of internals required to form hp stop valve with servo motor except valve body.	Set	1
9		Test valve for hp stop valve	No	1
10		Complete set of internals required to form IP stop valve with actuator except valve body.	Set	1
11		Test valve for IP stop valve	No	1
12		Fasteners for hp inner & outer casing	%	20 % of each type & size
13		Fasteners for IP inner & outer casing	%	20 % of each type & size
14		Fasteners for LP inner & outer casing	%	20 % of each type & size
15		Fasteners for all bearing pedestals for TG	%	20 % of each type & size
16		Oil gourd assembly for all bearing pedestals for TG	Set	1 set of each type & size
17		Turbine drain valves with actuators.	%	10 % of each type & size



Sl no	Equipment	Name of spares	Unit	Qty
	Hp bypass system			
1		Complete set of internals required to form hp by pass valve with servo motor except valve body.	Set	1
2		Complete set of internals required to form hp bypass spray control valve with servo motor except valve body.	Set	1
3		Complete set of internals required to form hp bypass spray isolation valve with servo motor except valve body.	Set	1
4		Complete assembly of pump with motor for oil unit	Set	1
5		Accumulator bladder	No	2
	LP bypass system			
1		Complete set of internals required to form LP by pass control valve with servo motor except valve body.	Set	1
2		Pilot valve for LP bypass control valve	No	1
3		Complete set of internals required to form LP bypass spray control valve with servo motor except valve body.	Set	1
4		Pilot valve for LP bypass control valve	No	1
5		Complete set of internals required to form LP spray isolation valve with servo motor except valve body.	Set	1
	Turbine oil system			
1		Complete pump assy for lube oil pumps – AOP	No	1
2		MOP	No	1
3		JOP	No	1
4		DC JOP	No	1
5		Control oil pump	No	1
6		EOP	No	1
7		Impeller for oil vapour extraction pumps	No	3
	Turbine oil purifier			
1		Bearing required for complete assy of one purifier	Set	1
2		'O' rings required for complete assy of one purifier	Set	1
3		Filter & gaskets required for complete assy of one purifier	Set	1
	Control oil purifier			
1		Bearing required for complete	Set	1



Sl no	Equipment	Name of spares	Unit	Qty
		assy of one purifier		
2		'O' rings required for complete assy of one purifier	Set	1
3		Filter & gaskets required for complete assy of one purifier	Set	1
4		Duplex/ strainer for control oil system	Set	1
	Turbine gland seal			
1		Seal steam control valve	No	1
2		Leak steam control valve	No	1
	Governing system			
1		Bellow for accumulator in governing system(set comprising of complete replacement for one TG unit)	Set	1
2		Complete set of o rings required for replacement in turbine governing rack of 1 unit	Set	1
3		HYD speed governor	No	1
4		EHC	No	1
5		HYD amplifier	No	1
6		Over speed trip device	No	1
7		Over speed trip testing device	No	1
8		Main trip valve assy	No	1
9		Emergency governer	No	1
10		Follow up pistons for governing system (complete replacement for one TG unit)	Set	1
11		Gear for loading device (complete set consisting of gear foe loading device & its motor and all other fixing/ assy. Materials except housing	Set	1
12		Gear for start up device (complete set consisting of gear for startup device & its motor and all other fixing/ assy. Materials except housing	Set	1
13		Turbine thrust bearing trip device	No	1
14		Servo motor for CRH NRV	No	1
15		Extraction valve relay	Set	1
16		Up to 2" size of hand operated valves of each class type size	%	10
17		Above 2" valve hand / motor operated valves each class type, size	%	5% of population or minimum 1 no. Which ever is higher
18		Actuator for motor operated valves	%	10% of population or minimum 1 no. Which ever is higher



Sl no	Equipment	Name of spares	Unit	Qty
	Heaters			
1		HP heater shell side safety relief valve	No	1 no each type and size
2		HP heater tube side safety relief valve	No	1 no each type and size
3		LP heater shell side safety relief valve	No	1 no each type and size
4		LP heater tube side safety relief valve	No	1 no each type and size
5		HP heater level gauge glass with packing	No	1 no each type and size
6		Low vacuum condenser protection device (set of internal required to form one protection device except body)	Set	1
	Condenser			
1		Condenser level gauge glass with packing	No	1
2		Condenser vacuum pump(set of internal required to form one pump except pump body)	Set	2
	Condenser online tube cleaning system			
1		Ball circulating pump(complete)	Set	1
	Turbine driven boiler feed pump			
1		Journal bearings and thrust bearings	Set	1
2		Emergency stop & control valves excluding servo device & switch box	Set	1
	Feed pump			
1		Cartridge for bfp	No	1
2		Wear ring set (rotating & stationary)	Set	1
3		Mechanical seal (de & nde)	Set	2
4		Journal bearing, thrust bearing, thrust collar	Set	2(each)
5		Thrust balanceing drum	Set	1
6		"o" ring complete	Set	1
	Booster pump			
1		Wear ring set (ortating & stationery)	Set	1
2		Mechanical seal (DE & NDE)	Set	2
3		Journal bearing, thrust bearing, thrust collar	Set	2(each)
4		Thrust balanceing drum	Set	1
5		"o" ring complete	Set	1
6		Rotor with impeller	Set	1
7		Reduction gear box assy	Set	1
	Lub oil system			
1		Aux oil pump	No	1
2		EOP	No	1
3		JOP	No	1
4		Lub oil purifier(bearings, o	Set	1



Sl no	Equipment	Name of spares	Unit	Qty
		rings, filters, gaskets)		
5		Oil vapour extraction pump		
	Motor driven boiler feed pump			
1		Fusible plug for hyd coupling	No	4
2		Bearings for motor	Set	1
3		Lup oil pump	No	1
	Condensate extraction pump			
1		Thrust bearing	Set	1
2		Radial bearing	Set	1
3		Complete rotating parts (assy required to form 1 CEP including shaft, impeller, etc., without casing)	Set	1
4		Mechanical seal	Set	1
5		Wear rings	Set	1
	CPU			
1		Service & regeneration vessels(for each type & size)		
2		Diffuser, distributors & nozzle	%	10
3		Perforated laterals & under drain collectors	%	10
4		Gaskets etc	Set	2
5		Nut 7 bolts etc	Set	1
6		Valves	%	20 % of each type 7 size
7		Pumps & blowers along with drive motors		1 no each type & size
8		Ejector & dozing pump		1 no each type & size
9		Resin trap		1 no each type & size
	Debris filter			
1		Actuator along with motors	Set	1
2		Debris discharge valve	Set	1
	DMCCW pump for TG			
1		Impeller wear ring, pump bearings, pump shaft, mech seal, shaft sleeves, nut & bolts	Set	1 set reqd for assembling for 1 pump
	DMCCW pump for SG			
1		Impeller wear ring, pump bearings, pump shaft, mech seal, shaft sleeves, nut & bolts	Set	1 set reqd for assembling for 1 pump
	HP/LP chemical dozing system			
1		Dozing pumps & drive	No	1 no for each type & size
2		Agitator	No	1 no for each type & size
	Compressor			
1		Complete internals for assembling of 1 compressor except casing	Set	1



Sl no	Equipment	Name of spares	Unit	Qty
2		Filter elements	Set	1 set each for pre & after filters
3		Tube nest for inter cooler	No	1
4		Tube nest for after cooler	No	1
5		Valves in compressor house	Set	1 set of each type
6		Auto moisture trap	Set	2
	Cooling water system			
1		CWP		
2		Bearings	Set	2
3		Thrust pads	Set	1
4		Shaft sleeves	Set	1
		Fasteners	Set	1 set reqd for assembling one pump
	CT blow down pump			
1		Bearings	Set	2
2		Thrust pads	Set	1
3		Shaft sleeves	Set	1
4		Fasteners	Set	1 set reqd for assembling one pump
	ACW pump			
1		Bearings	Set	2
2		Thrust pads	Set	1
3		Shaft sleeves	Set	1
		Fasteners	Set	1 set reqd for assembling one pump
	Horizontal centrifugal pump for each type			
1		Bearings	Set	2
2		Thrust pads	Set	1
3		Shaft sleeves	Set	1
4		Fasteners	Set	1 set reqd for assembling one pump
	Coal handling plant			
	Idlers			
1		35° troughing idlers complete with base frame and mounting brackets etc.		5% of total installed quantity
2		35° impact idlers complete with mounting brackets and base frame etc.		5% of total installed quantity
3		35° troughing training/self aligning idler complete with base frame and brackets etc. (if used)		5% of total installed quantity
4		Transition idler complete as in (1) above.		5% of total installed



Sl no	Equipment	Name of spares	Unit	Qty
				quantity
5		Flat return idlers complete with mounting brackets etc.		5% of total installed quantity
6		Flat return trainer complete with mounting brackets etc.		5% of total installed quantity
7		2-roll return idler set complete with mounting brackets etc.		5% of total installed quantity
8		Belt cleaning spiral rubber disc return idler complete with mounting brackets etc.		5% of total installed quantity
	Belt conveyors (including belt feeders / reversible belt feeder)			
	Gear boxes (each type and rating)			
1		Complete gear box assembly with hold back device	Set	1 set
2		Oil seals	set	3 sets
3		Cooling fan with cover (if applicable)	No.	2 nos.
4		Hold back device	Set	2 sets
5		Bearings	set	1 set
6		Oil level indicator	Set	2 sets
	Fluid couplings (each type and rating)			
1		Fluid coupling complete	No.	1 no.
2		Resilient driving plate assembly	no.	1 no.
3		Bearings	no	2 nos.
4		'O' rings for each size	set	1 set
5		Multi disc assembly	no	2 nos.
6		Fusible plug	no	10 nos.
7		Seal kit	set	2 sets
8		Gland nuts and diaphragm	set	1 set
9		Complete actuator and engaging assembly (including motor, gear box, etc.)	set	1 set
10		Oil pump motor set	set	1 set
11		Oil filters	set	5 sets
12		Oil cooler valves	no	2 nos.
	Flexible coupling			
1		One complete coupling assembly of each size & type of all conveyors with pilot bore		
	Gear coupling			
1		Complete gear coupling with bolts and seal kit with pilot bore	no	2 no. of each type
2		Bolts for gear coupling	set	2 set of each size
3		Seal kit for gear coupling (o-ring)	set	2 set of each type



Sl no	Equipment	Name of spares	Unit	Qty
	Brake			
1		Thruster brakes	no	1 no. of each size
2		Thruster brake liners (shoes)	no	2 no. (min) in each size & type
	External holdbacks			
1		Complete holdback	set	1 set of each rating
	Pulleys			
1		Pulley complete with shaft (excluding bearings & plummer blocks) Complete with lagging	no	1 no. of each type & size
2		Plummer block complete with bearings & sleeves	no	2 nos. of each type and size
	Belting			
1		For main conveyors	%	30% length of each type & rating of belt or thickness or one full length of the shortest conveyor whichever is higher
2		For belt feeder	length	1 complete length of each.
	Belt cleaners and skirt board			
1		Complete belt cleaner (internal & external, both)	No	Min 2 nos (two) of each type & size
2		Modular segments for skirt board	%	5% of total population of each type & size
3		Blades for belt cleaners	%	5% of total population of each type & size
4		Skirt rubber	%	5% of total population of each type & size
	Vibrating grizzly feeder			
1		Bearings	Set	2 sets of each type & size
2		Seals	Set	2 sets of each size
3		Liners	Set	1 set
4		Screen plates	Set	5 sets
5		VGF rotating part assy. Along with drive & driven unbalanced Shafts / vibrating blocks,	Set	1 set of each type and rating and direction



Sl no	Equipment	Name of spares	Unit	Qty
		bearings, coupling shafts, gear boxes, Sheave & unbalanced weights as applicable		
6		Hoses (if applicable)	Set	2 sets
7		Drive unit assembly [including electric motor, hydraulic pump, Hydraulic motor, flexible shaft, gear box, as applicable]	Set	1 sets
8		Base and supporting springs, rubber pads	Set	2 sets of each type & size
9		V belts	Set	4 sets of each type & size
	Crushers			
1		Plummer block assembly complete with bearing/lock nut/lock Washer etc.(DE & NDE)	Set	4 sets (i.e. for each crusher)
2		Shaft seal.	Set	4 sets.
3		Hammer sets	Set	5 sets or 375 no. Whichever is more (1 set Means hammers required for one crusher)
4		Screw jack assembly for the door sealing (if applicable)	Set	1 set.
5		Rotor assembly complete consisting of rotor, shaft & keys. End Discs, centre discs, distance rings, suspension bars, disc Clamping nuts and shaft extension etc. But without hammers rings, Bearings and bearing blocks	Set	1 set.
6		Cage bars, if applicable	Set	4 set.
7		Breaker plate with ht bolts	Set	4 set.
8		Crusher frame liners	Set	2 sets (for complete replacement)
9		Suspension bars with brass plug	Set	8 sets
10		Kick- off plate with ht bolts	Set	8 sets.
11		Screen plate upper & lower with ht bolts	Set	4 sets each
12		Tramp iron pick up plate	No	2 no. Each
	Fluid coupling for crusher			
1		Fluid coupling complete	set	1 set
2		Bearings	set	2 set
3		Seal kit (sealing rings)	set	2 sets
4		Fusible plugs	no	8 nos.
5		Oil pump motor set (if applicable)	set	1 set of each type
6		Water pump motor set (if applicable)	set	1 set of each type



Sl no	Equipment	Name of spares	Unit	Qty
7		Oil filter	set	3 sets
8		Complete actuator and engaging assembly [including motor, Gear box etc.]	set	1 set
9		Cooler assembly (if applicable)	no	1 no.
10		Oil/water valves (if applicable)	no	2 nos. of each type
11		Gear coupling of crusher drive along with bolts and sealing kit.	set	2 sets
12		Multi disc assembly (for fluid coupling)	sets	2 sets of each type and rating
13		Resilient drive plate assembly	set	2 sets of each type and rating
14		One complete hydraulic door operating mechanism for one crusher Including hydraulic cylinders, hoses, valves, hydraulic pump, Panels, limit switches	set	1 set
	Stacker-reclaimer m/c & reclaimer m/c: one(1) lot of items as listed below shall be supplied for all stacker-Reclaimer machines			
	Long travel mechanism			
	Gear box			
1		Complete gear box unit	set	1 set
2		Bearing	set	1 set
3		Shrink disk	set	2 sets
4		Oil seal	set	1 set
	Brake			
1		Friction lining	set	2 sets
2		Brake drum	set	2 sets
	Complete carriage wheel assembly (each set comprising of 1 Wheel + 1 axle + 2 bearing + 2 locking assembly)			
	Slew drive			
1		Complete set of drive gear box unit	set	1 set
2		Friction lining of brake	set	1 set
	Bucket wheel			
1		Complete set of drive gear box unit	set	1 set
2		Coupling assembly	set	1 set
3		Shrink disk	set	1 set
4		Complete bucket	no	1 no.
5		Bucket teeth	no	8 nos.



Sl no	Equipment	Name of spares	Unit	Qty
6		For bucket wheel hydraulic system		
7		Pressure relief valve	no	2 nos.
8		Return line filter	no	2 nos.
9		Hp hose for power oil complete with end fittings	set	2 sets
10		Seal kit for hydraulic motor including oil seals	set	2 sets
11		Bucket wheel drive hydraulic motor	1 no.	1 no.
	PCRD			
		Drive and driven sprocket with chain	1 set	1 set
	CCRD			
		Drive and driven sprocket with chain	1 set	1 set
	Boom conveyor			
	Idlers			
1		Idler under central chute	set	5 sets
2		Troughing roller	no	4 nos.
3		Return roller	no	2 nos.
4		Impact roller	no	20 nos.
	Pulley			
1		Drive pulley	no	1 no.
2		Bearing for drive pulley	no	2 nos.
3		Tail pulley	no	1 no.
4		Bearing for tail pulley	no	2 nos.
	Gear box			
1		Complete gear box unit	set	1 set
2		Bearing	set	1 set
3		Shrink disk	set	1 set
4		Oil seal	set	1 set
	Brake			
		Friction lining	set	1 set
	Fluid coupling			
1		Complete set of fluid coupling	set	1 set
2		Multi disc assembly	no	1 no.
3		Resilient driving plate	no	1 no.
4		Fusible plug	no	6 nos.
	Boom luffing / hoisting			
1		Pressure relief valve	no	2 nos.
2		Return line filter	no	2 nos.
3		Hp hose for power oil complete with end fittings	set	2 sets
4		Hydraulic cylinder	no	1 no.
5		Repair kit for hydraulic cylinder including oil seals etc.	set	2 sets.
	Electrical & electronic items			
1		Drive motor		
2		Long travel drive motor	no	1 no.
3		Slew drive motor	no	1 no.
4		Bucket wheel drive power pack motor	no	1 no.
5		Boom conveyor drive motor	no	1 no.



Sl no	Equipment	Name of spares	Unit	Qty
6		PCRD drive motor	no	1 no.
7		CCRD drive motor	No	1 no.
8		Actuator for flap gate	no	1 no.
9		Brake/rail clamp		
10		Thruster brake actuator with motor	no	1 no. For each application
11		Rail clamp actuator with motor	no	1 no.
12		Carbon brush assembly for PCRD	set	1 set
13		Carbon brush assembly for CCRD	set	1 set
14		Position limit switch for Slew/Hoist/LT etc.	no	5 nos.
15		3.3 kV HRC fuse for 3.3 kV isolator	set	1 set (3 nos.)
16		Thyristor drive for slewing		
17		Electronic modules /card	no	1 no. Each card/ modules used in the system
18		Speed sensor/techno-generator	no	1 no.
19		Semi-conductor fuse for power thyristor	no	6 nos.
20		Trailing cable (for both power & control)	%	100% length of each type
21		Local control station	no	1 no. For each type
22		Pendulum limit switch	set	1 set each for CCRD & PCRD
23		Belt weigher		Item & qty same as indicated in electrical and C&I list.
24		Other electrical spares as applicable as per the electrical list		Item & qty same as indicated in electrical and C&I list.
25		Plc spares		Item & qty same as indicated in electrical and C&I list.
	Magnetic separators			
1		Pulley with plummer block & bearings.	set	1 set of each size & type
2		Motor, gearbox drive assembly complete	set	1 set of each size & type
3		Endless cleated conveyor belt	set	1 set
4		Ss cleats	no	10 nos.
5		Ss bolts for cleats	no	100 no.
6		Sheaves	set	1 set of each size & type
7		V-belts	no	2 nos. of each



Sl no	Equipment	Name of spares	Unit	Qty size & type
	Flap/ divertor gate			
1		Actuator (complete with motor, gearbox, limit, switches etc.)	set	1 set of each size
2		Bearings with bearing block	no	2 no. of each size
3		Position limit/ torque switch	no	8 no. of each size & type
4		Oil seals of actuator	no	2 no. of each size
5		Shaft	no	4 no. of each size
6		Pressure nut	no	10 no. of each size
	Rack & pinion gate			
1		Limit switch	no	2 no. of each size & type
2		Roller with bearings	no	2 no. of each size
3		Actuator (complete with motor, gearbox, limit, switches etc.)	set	1 set of each size
4		Sprocket	no	2 no. of each type.
5		Local control station	no	1 no. For each type.
	Travelling tripper			
1		Travel drive/CRD motor	no	1 no. Each
2		Tripper head pulley with pillow block & bearing	set	1 set
3		Tripper bend pulley with pillow block & bearing	set	1 set
4		Complete set of travel gearbox.	set	1 set
5		Travel drive & driven sprocket with chain	set	1 set
6		CRD drive & driven sprocket with chain	set	1 set
7		Complete motorised actuator for flap gate.	no	1 no.
8		Brake assembly for traverse drive complete	set	2 set
9		Festoon roller assembly	set	2 sets
10		Rail clamp actuator with motor	no	1 no.
	Coal scooper			
1		Complete set	no	1 no.
2		Motor assembly	no	1 no. of each type
3		Plummer block assembly with bearing	no	1 no. of each type & size.
4		Set of various limit switches	no	2 no. of each type and rating
	Vibrating feeder			
1		Drive motor	no	1 no. of each rating
2		Electronic modules/card for	no	1 no. Each



Sl no	Equipment	Name of spares	Unit	Qty
		feed rate controller		card/ modules used in the system
	Coal sampling system			
1		Plummer block	no	1 no. of each size & type
2		Hammers	set	1 set of each size & type
3		Liner plate	set	1 set
4		Cutter lip	no	1 no.
5		Cutter seal	no	1 no.
6		V-belts (for crusher)	set	1 set
7		Hammer pins	set	1 set of each type & size
8		Pulley	no	1 no. of each type & size
9		Conveyor belt	length	1.2 times length of each type rating
10		Gear box assembly for conveyor	no	1 no. of each type and rating
11		Gear box drive assembly for primary and secondary samplers	set	1 set of each type and rating
12		Solenoid valves with coils (if applicable)	set	2 set of each type
13		Hydraulic pump with motor and coupling (if applicable)	set	1 set of each type
14		Hydraulic motor (if applicable)	set	1 set of each type
15		Hydraulic cylinder (if applicable)	set	1 set of each type
16		Cylinder sealing kit (if applicable)	set	2 set of each type
17		Set of hoses (if applicable)	set	2 set of each type
18		Coupling with grid for primary sampler	set	2 sets
19		Screw conveyor gear box assembly	set	1 set
	Sump pump			
1		Complete pump assembly with pump, motor, coupling base etc.	set	1 set
2		Impeller with key & nut	set	2 set of each size & type
3		Oil seal	no	2 nos. of each size
4		Coupling bolt with bushes	set	2 sets of each type
5		Pump shaft	no	2 nos. of each size
6		Shaft sleeve	set	2 sets of each size
7		Bearing bush	set	2 sets of each



Sl no	Equipment	Name of spares	Unit	Qty
				size
8		Set of bearings	set	2 set
9		Valves	no	2 nos. of each size & type
	Electric hoists			
1		Brake linings	set	2 sets of each type
2		Brake coil	set	2 sets of each size
3		Rope guide & rope tightner	No	1no. of each type
4		Limit switch	Set	2sets of each type & size
5		Gear box / gear set	Set	2sets of each type
6		Motor / geared motor	No	1no of each type & rating
7		Drum bearing	Set	1set of each type & rating
	Ventilation system			
1		V-belt	Set	1 set of each type
2		Pre-filter element of pressurizing fans	set	2 sets of each type
3		Foundation rubber pads	set	1 set of each type & size
4		Bearings	set	1 set of each type & size
5		Plummer blocks	set	1 set of each type & size
6		Electric motor	set	1 set
	Ds system (plain water)			
1		Bearing for pump	set	1 set of each type.
2		Spray nozzles	%	10% of the total qty. Used in the system for each types of bags.
3		Sprinklers	%	10% of installed
4		Drive motor	no	1 no. For each rating
5		Solenoid valve	%	10% of the total qty. Used in the system for each types or min. 2 nos. Whichever is higher.
	Dry fog dust suppression system			
1		Solenoid valves	2	min. 2 no. of each size
2		Spray nozzles (complete)	no	30 no.
3		Pump impeller with key & nut for each type of pump	no.	1 no.



Sl no	Equipment	Name of spares	Unit	Qty
4		Pump shaft for each type	no	1 no.
5		Oil rings for each type of pump	set	2 sets
6		Valve for each type and size	no	1 no.
7		Bearing	set	1 set of each type & size.
8		Wearing ring	set	2 set of each type & size.
9		Coupling bolts & nuts (with bushes)	set	2 sets of each type & size.
10		Shaft sleeve	set	2 set of each type & size.
11		Globe valve/plug valves	set	2 set of each size.
12		Gate valve	no	2 no. of each size.
13		Strainers	no	1 no. of each type
14		Pressure regulating station	no	1 no. of each type
15		Hoses with connectors	no	4 no. of each type
	Compressor			
1		Air filter element	no	8 no.
2		Oil filter	no	6 no.
3		Discharge check valve	no	3 no.
4		Oil pump parts (including distance ring, eccentric rings, pump element, pin, and key, 'o' ring) as applicable.	set	2 sets
5		inlet valve assembly	no	2 no.
6		Electronic regulator	no	3 no.
	Bull dozer			
1		Manufacturers recommended spare parts list for 2000 hours of operations of each dozer supplied.	set	1 set for each dozer

FUEL OIL SYSTEM

Sl.no.	Description	Quantity
1.0	HFO/HSD unloading pumps	
	Coupling pads / bushes and coupling bolts	One set /pump
	Bearings	Two sets /pump
	Mechanical seals	Two sets/pump
	Couplings	One set/pump
	Coupling pads	Two sets/pump
	Set of seals, o-rings & gaskets	2 sets/pump
	Bearings for pump	2 sets/pump
	Set of all types of bushes sleeves	2 sets/pump
	Catridge	1 no each type
2.0	Drain oil pump/ recovery oil transfer pump/ waste water pump/ sump pump(for each type)	
	Bearing or bearing metals and wearing parts for each rotating unit.	1 complete set
	Connecting coupling for each rotating units	1 set



Sl.no.	Description	Quantity
	(coupling assembly)	
	Packing and gaskets of total installed	100%
	Inner wear and tear parts for each size and type of pump	1 set
3.0	HFO/HSD forwarding pumps	
	Rotor assembly complete (cartridge)	1 set. (1 set = all rotating parts including bolts, screws in one pump) each type
	All bearings in one pump and motor	1 set
	Relief valve	2 nos.
	Couplings	1 set (1 set = 1 pump and motor requirement)
	Motor	1 no for each type
	Gaskets, o rings for one pump	2 sets(1 set = 1 pump requirement)
	Coupling pads/bushes and coupling bolts	2 sets(1 set = one pump and motor requirement)
	Screw shaft	2 sets(1 set = 1 pump requirement)
4.0	Hoses	
	Unloading hoses (HFO & HSD)	20% of total quantity
	Steam and condensate hoses	20% of total quantity

FIRE PROTECTION SYSTEM

Sl.no.	Description	Quantity
1	Bidder to quote for each fire water pumps and foam system pumps - motor driven main fire pump / engine driven standby/jacking pump	
1.1	Impeller	1 no. Of each type and size
1.2	Pump bearings	1 no. Of each type and size
1.3	Pump shaft	1 no. Of each type and size
1.4	Bearing rings	2 set. Of each type and size
1.5	Shaft sleeves	2 set. Of each type and size
1.6	Bushings	2 set. Of each type and size
1.7	Bearing housing (if provided)	2 set. Of each type and size
1.8	Coupling and nuts (with bushes)	2 set. Of each type and size
1.9	Fuel injection nozzle	2 set. Of each type and size
1.10	Piston ring	1 complete set for each cylinder.
1.11	Fuel filters elements and seals	2 sets
1.12	Lubricating oil filter elements & seals	2 sets
1.13	Engine joints, gaskets and hoses	1 sets
1.14	Inlet valve	1 no.
2	Fire hoses with couplings	
2.1	7.5 m long fire hoses with and connections	1 no. 10% of population
2.2	Fire hose with end connection but 15 m long	1 no. 10% of population
3	Branch pipes with nozzles	
3.1	Nozzles with branch pipes and quick coupling ends	1 no. 10% of population
3.2	Nozzles of water monitor	1 no. 10% of population
4	Deluge valve accessories	
4.1	Clapper assembly complete (consisting of clapper, seat rubber, screws etc.)	1 no. 10% of population
4.2	Solenoid coils	1 no. 10% of population
5	Vales (Gate / Globe / Butterfly / NRV) accessories	
5.1	Reduction gear operator (gate / globe / butterfly)	1 no. 10% of population of each type & size



Sl.no.	Description	Quantity
5.2	Flap / door with pin (NRV)	1 no. 10% of population of each type & size
5.3	Disc (butterfly / globe)	1 no. 5% of population of each type & size
5.4	Seal rings (all types)	1 no. 10% of population of each type & size
5.5	Flap ring (NRV)	1 no. 10% of population of each type & size
5.6	Gaskets	1 no. 10% of population of each type & size
5.7	Bearing (butterfly valve)	1 no. 10% of population of each type & size
5.8	Complete valve assembly	1 no. For each type & size
6	Y-type strainer	
6.1	Strainer elements with o-rings and stiffeners	1 no. 20% population of each type & size
7	Basket type strainers	
7.1	Strainer elements with o-rings and stiffeners	1 no. 20% population of each type & size
8	MVM spray system	
8.1	Spray nozzles	1 no. 20% population of each type & size
9	HVW spray system	
9.1	Spray nozzles	1 no. 10% population of each type & size
9.1	QB detectors	1 no. 20% population of each type & size
9.1	QB detectors (for burner front area)	1 no. 20% population of each type & size
10	Smoke / heat detectors	
10.1	Photo electric heat detectors	1 no. 10% population of each type & size
10.2	Heat detectors	1 no. 10% population of each type & size
10.3	Indicator assembly for smoke detectors provided in false roof	1 no. 5% population of each type & size
10.4	LHS cables	1 no. 10% population of each type & size
10.5	Spot heat detectors (generator seal of unit)	1 no. 10% population of each type & size
10.6	Connectors or terminal boxes for interconnection of lhs cables	1 no. 10% population of each type & size
10.7	Multi sensor detectors	1 no. 10% population of each type & size
11	Infra-red detectors (IRD)	
11.1	IRD unit with local control unit, purging unit	1 no. 10% population of each type & size
	Compressor	
	Internals for compressor reqd for assembling of one compressor	1 set
	Filter elements	1 no. of each type & size

AIR CONDITIONING SYSTEM

Sl. No.	Equipment / package	Quantity
1.1	Vapor compression chiller	
(i)	Oil filter o ring	1 set
(ii)	Refrigerant filter	1 set
(iii)	Master solenoid valve	1 no.
(iv)	Master solenoid valve coil	1 set
1.2	Reciprocating compressor	
A)	Piston ring in sets	25% for each type and rating
B)	Piston in sets	30% for each type and rating
C)	Bearing in sets	25% for each type and rating
D)	Seal gasket and other wear out parts in sets	25% for each type and rating
E)	Valve head assembly	25% for each type and rating
F)	Crank shaft in sets	10% for each type and rating
G)	Connecting rod in sets	10% for each type and rating
1.3	Pumps (condenser & chilling water pump)	
(i)	Pump impeller	1 no. Of each type
(ii)	Pump bearing	1 set
(iii)	Pump motor bearing	1 set



Sl. No.	Equipment / package	Quantity
(iv)	Shaft sleeves	1 set
1.4	Cooling towers	
(i)	Nozzles for cooling towers	2 sets
(ii)	Float valve assembly	1 no
(iii)	Fan bearings	1 set
(iv)	Motor bearings	1 set
1.5	Packaged air-conditioners	
(i)	filters	1 set
(ii)	Expansion valve	1 set
(iii)	Motor for compressor	1 set
1.6	Air handling unit	
(i)	V-belt for AHU blower	2 sets of each type
(ii)	AHU blower bearings	1 set of each type
(iii)	Filters	2 sets of each type
(iv)	Blower motor bearing	1 set
1.7	Tube axial fan	
(i)	Bearings	1 set
(ii)	Filters	1 set
(iii)	Motor bearing	1 set

VENTILATION SYSTEM

S.No.	Item / Equipment	Quantity Required
1.0	Centrifugal Fans	
A)	V-Belts	2 sets of each type
B)	Blower Bearing Sets	2 sets of each type
C)	Blower Motor Bearings	2 sets of each type
D)	Seal Gasket And Other Wear Out Parts In Sets	2 sets of each type
E)	Vibration Isolators	2 sets of each type
2.0	Axial Fans	
A)	Fan Bearings	2 sets of each type
B)	Fan Motor Bearing	2 sets of each type
C)	Dry Filters	2 sets of each type and size
3.0	Air Washer System	
A)	Water Strainers	2 sets of each size
B)	Spray Nozzles	2 sets of each size
C)	Water Repellant Type Filters	2 sets of each size
4.0	Horizontal Centrifugal Pump	
A)	Impeller For Each of Pump Set	2 sets of each type
B)	Bearings	2 sets of each type
C)	Shaft Sleeves	2 sets of each type
D)	Bearings Motor	2 sets of each type

COMPRESSOR AIR SYSTEM

Sl. No.	Equipment / package	Quantity
I	Mechanical	
A	Compressed air system	
1.0	Dry air intake filter	2 nos.
2.0	Complete set of loading – unloading valve assembly	2 sets
3.0	Low pressure compressor element	1 set
4.0	High pressure compressor element	1 set
5.0	Inter cooler tube bunch	1 set
6.0	After cooler tube bunch	1 set



Sl. No.	Equipment / package	Quantity
7.0	Automatic purge drain valve for inter cooler and after cooler(auto drain trap)	1 set
8.0	Air outlet check valve	2 sets
9.0	Rubber air outlet compensator	1 set
10.0	Lube oil filter	2 sets
11.0	Lube oil pressure regulating valve	1 set
12.0	Differential oil seals for lube oil system	2 sets
13.0	Cooling water inlet and outlet connection rubber bellows	2 sets
14.0	Gear box component	
14.1	Different oil seals	2 sets
14.2	Set of bearings	1 set
14.3	Breathing system	2 sets
15.0	Components of l.p elements	
15.1	Gear pinion	1 set
16.0	Component of hp element	
16.1	Gear sets	1 set
16.2	Different safety valves	1 set
16.3	Flexible rubber stud couplings for coupling compressor to the motor	1 set

ASH HANDLING SYSTEM

Sl.no.	Description	Quantity
1.0	Bottom ash hopper	
1.1	Inspection window gasket	4
1.2	Inspection window sight glass	4
1.3	Access door gasket	4
1.4	Poke door gasket	4
1.5	Access door sight glass	4
1.6	Hopper feed gate housing	
1.6.1	Gland packing	4
1.6.2	Wear liner	2 sets
1.6.3	Roller set	2
1.6.4	Snap rings	4
1.7	Flushing / quenching nozzle	4 sets
1.8	Seal trough flushing	2 sets
2.0	Jet pump	
2.1	Nozzle inlet	2
2.2	Nozzle tip	20
2.3	Inlet piece	4
2.4	Jet pump complete assembly	1
2.5	Throat	4
2.6	'o' rings	10
2.7	Intermediate wear piece	4
3.0	Clinker grinder	
3.1	Driving shaft assembly with plumber block	2
3.2	Driven shaft assembly	2
3.3	Bearing assembly (expansion side)	4
3.4	Bearing assembly (non-expansion side)	4
3.5	Wear plate	8
3.6	Lantern rings / distance piece	8 sets
3.7	Shaft sleeve	4



Sl.no.	Description	Quantity
3.8	Wear ring	8
3.9	Gland packing	4 sets
3.10	Gear box assembly	2
3.11	Fluid coupling assembly	2
3.12	Driving sprocket	2
3.13	Driven sprocket	2
3.14	Chain set	4
4.0	Fly ash transmitters	
4.1	Level probe	8
4.2	Seals	20 sets
4.3	Inlet valve/outlet valve	8 sets
5.0	Fly ash extraction line isolation valves/fittings/couplings	
5.1	Fly ash extraction line isolation valve seats	8 nos
5.2	Fly ash extraction line isolation valve gate/flaps	8 nos
5.3	Fly ash extraction line couplings	8 nos
5.4	Fly ash extraction line fittings (bends/elbows/laterals)	8 nos
6.0	Air compressors	
6.1	Dry air intake filter	2 nos.
6.2	Complete set of loading – unloading valve assembly	2 sets
6.3	Low pressure compressor element	1 set
6.4	High pressure compressor element	1 set
6.5	Inter cooler tube bunch	1 set
6.6	After cooler tube bunch	1 set
6.7	Automatic purge drain valve for inter cooler and after cooler(auto drain trap)	1 set
6.8	Air outlet check valve	2 sets
6.9	Rubber air outlet compensator	1 set
6.10	Lube oil filter	2 sets
6.11	Lube oil pressure regulating valve	1 set
6.12	Differential oil seals for lube oil system	2 sets
6.13	Cooling water inlet and outlet connection rubber bellows	2 sets
6.14	Gear box component	
6.14.1	Different oil seals	2 sets
6.14.2	Set of bearings	1 set
6.14.3	Breathing system	2 sets
6.15	Components of l.p elements	
6.15.1	Gear pinion	1 set
6.16	Component of hp element	
6.16.1	Gear sets	1 set
6.16.2	Different safety valves	1 set
6.16.3	Flexible rubber stud couplings for coupling compressor to the motor	1 set
7.0	Water pumps (for each application based on the usage)	
7.1	Pump/motor couplings	
7.2	Rings	2 sets in each type of pump
7.3	Pump shaft	- do-
7.4	Casing wear ring	- do-
7.5	Shaft sleeve	- do -



Sl.no.	Description	Quantity
7.6	Bearings for pump with seal	- do -
7.7	Gland	- do -
7.8	Gland packing	- do -
7.9	Impeller along with wear parts	- do -
8.0	Ash slurry pumps	
8.1	Impeller with wearings parts	4
8.2	Casing liners	4
8.3	Liners(suction side and gland side)	4
8.4	Shaft sleeve	2
8.5	Lantern ring	2
8.6	Gland packing	2 sets
8.7	Bearings for pump with bearing seal	2 sets
8.8	Labyrinth seal complete set	2 sets
8.9	V-belts (complete set for pump)	2sets
8.10	Bearings for motors	2 sets
8.11	Casing for single casing pumps (if applicable)	2
8.12	Twin casing pumps inner casing (if applicable)	4
8.13	Pump shaft	4 nos
9.0	Expansion joints	2 sets
10.0	Knife type isolation gate	4
11.0	Assembly gate	4
12.0	Slide gate	4
13.0	Valve steam	4
14.0	Gland follower & packing	4
15.0	Ash slurry sump liners	One set for complete one sump
16.0	Valves (for gate, check, globe and diaphragm valves)	
16.1	Bonnet / cover gasket	Two (2) sets for every set of four (4) valves & specialities or part thereof subject to a minimum of 2 sets for each size and type of valve and speciality.
16.2	Gland packing	Two (2) sets per valve speciality for each size and type.
16.3	Spring for check valve	One (1) for each size of valve
16.4	Valve stem for nb50	Two (2) per set of 15 valves or part there of subject to a maximum of 25 for each size and type of valve.
16.5	Disc or disc seat as applicable for gate / globe valves and disc with bing pins for check valves	One (1) per set of 10 valves or part thereof for each size and type of valve.
16.6	Diaphragms	20% of total quantity in each type of size subject to a minimum of 5 in each type of size.
16.7	Body seat ring for gate, globe and check valves	One (1) per set of 25 or part thereof for each size and type of valve.
17.0	Ash slurry valves – knife gate	
17.1	Slide gate	4
17.2	Diversion cone & seat assembly	4
17.3	Valve stem	4
17.4	Gland follower & packing	4 sets
17.5	Associated spares for valve actuators	4 sets
18.0	Pipe lines	
18.1	Pipe lines in standard lengths for each size and type of pipe lines	10% of the total quantity used in the system for each size & type



Sl.no.	Description	Quantity
18.2	Gaskets for each size	10% of total quantity used in the system for each size
18.3	Sleeve couplings of different sizes with fasteners	10% of the total quantity used in the system, minimum two sets of each size
18.4	Pipe bends	3 nos. Of each type and size
19.0	Drain sump pumps	
19.1	Impeller with wearing parts	2 sets
19.2	Casing liners	3 sets
19.3	Bearing for motor & pump with seal	2 sets
19.4	Shaft sleeve	2 sets
19.5	Shaft enclosing tube (column pipe)	2 sets
20.0	Blowers (for each fluidizing blowers and silo aeration blowers)	
20.1	Impeller/rotor complete with bearings, shaft, seals, thrust block etc.	2 sets in each type of blower
20.2	Fixed blades/ diffusers	1
20.3	Outlet air filter/oil filter	2
20.4	Lubricating oil filter	2
20.5	Bearings for motor & blower	- do -
21.0	Vent bag filters	
21.1	Bags with fixing clamps	10% of total bags
21.2	Solenoid valve	4 nos.
21.3	Timers	2 nos.
22.0	Pressure switches	2 nos. In each service
23.0	Pressure gauges	2 nos. In each service
24.0	Butter fly valves	
24.1	Disc. Seal rings	2 nos. For each size
24.2	Flange gasket	2 nos. For each size
24.3	Seat / seal claming belt	2 nos. For each size
24.4	'o' ring seals / gland packing	2 nos. For each size
24.5	Associated spares for motor actuators	1 set
25.0	Vacuum pumps	
25.1	Vacuum pumps internals	4
25.2	Gears	2 nos for each size
25.3	Bearings for pump and motor	2 nos for each type and size
25.4	Seal	2 nos for each type
25.5	Coupling	1 no for each type
26.0	Instruments of each type/ rating including but not limited to the following	quantity for each of the items is 10% or minimum 1 no each type)
26.1	Pressure gauge	
26.2	Temperature gauge	
26.3	Flow indicator	
26.4	Flow switch	
26.5	Pressure switch	
26.6	Temperature switch	
26.7	Level switch with gasket	
26.8	Control valve	
26.9	Solenoid valve	
26.10	Transmitter	
26.11	Controller	
26.12	Indicator	
26.13	Recorder	
26.14	Air filter regulator	



Sl.no.	Description	Quantity
26.15	Draft gauge	
27.0	Airlock / blow tank system	
27.1	Air lock / pump tank inlet outlet valve assemblies	2 nos
28.0	Fly ash storage hopper	
28.1	Storage hopper filter	2 sets
28.2	Storage hopper filter pulsation solenoid valves	50% of total population
28.3	Storage hopper aeration sectionalizing valves	50% of total population
28.4	Storage hopper aeration pad	50% of total population
28.5	Storage hopper isolation valve	1 no
28.6	Storage hopper isolation valve storage hopper dry fly ash retractable chute assembly	1 no
28.7	Valves	10 nos for each type
28.7	Vacuum breaker	Complete assembly

MILL REJECT SYSTEM

One 'Set' Refers to one complete set required for one Compressor / Equipment.

Sl. No.	Equipment / Package	Quantity
I	Mechanical	
1	Dome type inlet valve	
	Dome shaped head for inlet valve	1 no.
	Inflatable seal for inlet valve	4 nos.
	Insert ring	1 no.
	Spigot piece	1 no.
	Top plate	1 no.
	External lip seal	4 nos.
	Shaft seal	4 nos.
	'O' ring	4 nos.
	Spring pin (inner)	2 nos.
	Spring pin (outer)	2 nos.
	Set of gasket	2 nos.
	Pneumatic cylinder seal kit	1 no.
	Air limit switch seal kit	1 no.
	Quick exhaust valve diaphragm for seal	1 no.
	Quick exhaust valve diaphragm for pneumatic cylinder	1 no.
	Silencer for valve assembly	1 no.
2.	Conveying line upto silo top	
	Pipe line fittings, bends, spool pieces	8 nos. For each size and type.
3.	Knife type isolation valve	
	Assembly of gate	2 nos.
	Slide gate	2 nos.
	Valve stem	2 nos.
	Gland packing	4 nos.
4.	Actuators complete with motor for all motorized valves of each type and rating.	5 % in each size, type rating & make.
5.	Reverse pulse jet bag filter	
	Filter bags	8 nos.
	Pulse valve coil	2 nos.



Sl. No.	Equipment / Package	Quantity
	Pulse valve diaphragm	2 nos.
	Spray nozzle for surge hopper	4 nos.
6.	Air compressor	
6.1	Dry air intake filter	2 nos.
6.2	Complete set of loading – unloading valve assembly	2 sets
6.3	Low pressure compressor element	1 set
6.4	High pressure compressor element	1 set
6.5	Inter cooler tube bunch	1 set
6.6	After cooler tube bunch	1 set
6.7	Automatic purge drain valve for inter cooler and after cooler(auto drain trap)	1 set
6.8	Air outlet check valve	2 sets
6.9	Rubber air outlet compensator	1 set
6.10	Lube oil filter	2 sets
6.11	Lube oil pressure regulating valve	1 set
6.12	Differential oil seals for lube oil system	2 sets
6.13	Cooling water inlet and outlet connection rubber bellows	2 sets
6.14	Gear box component	
6.14.1	Different oil seals	2 sets
6.14.2	Set of bearings	1 set
6.14.3	Breathing system	2 sets
6.15	Components of L.P elements	
6.15.1	Gear pinion	1 set
6.16	Component of hp element	
6.16.1	Gear sets	1 set
6.16.2	Different safety valves	1 set
6.16.3	Flexible rubber stud couplings for coupling compressor to the motor	1 set

CRANES (FOR EACH CRANE)

Sl. No.	Description	Quantity
1.0	Spares for long travel unit	
A	Set of axle bearings	1 set
B	Set of gearbox bearings with sleeves	1 set
C	Long travel end shaft bearings	1 set
D	Coupling	1 set
E	Seals for travel gear box	1 set
F	Long travel brake shoes	1 set
G	Long travel brake springs	1 set
H	Long travel brake shoe liners	1 set
2.0	Spares for cross travel unit	
A	Axle bearings	1 set
B	Set of gearbox bearings with sleeves	1 set
C	Set of seals for gearbox	1 set
D	Cross travel end shaft bearing	1 set
E	Coupling	1 set
F	Cross travel brake shoes	1 set
G	Cross travel brake springs	1 set
H	Cross travel brake shoe liners	1 set
3.0	Spares for main hoist	1 Set
A	Main hoist pulley bearings	1 set
B	Set of bearings for rode drum	



Sl. No.	Description	Quantity
C	Set of bearings for gear box	1 set
D	Set of seals for main hoist	1 set
E	Main hoist brake shoes	1 set
F	Main hoist brake springs	1 set
G	Main hoist brake shoe liners	1 set
H	Disc pad	1 set
4.0	Spares for auxiliary hoist (if applicable)	
A	Aux hoist pulley bearings	1 set
B	Set of bearings for rode drum	
C	Set of bearings for gear box	1 set
D	Set of seals for main hoist	1 set
E	Main hoist brake shoes	1 set
F	Main hoist brake springs	1 set
G	Main hoist brake shoe liners	1 set
H	Pair of slings	1 set
I	Disc pad	1 set
5.0	Electrical: control panels/motors	
A	Power contactor of each rating	2 nos.
J	Over load relays of each rating	2 nos.
J	MCCB/MPCB of each rating	2 nos.
J	Push button of each type	2 nos.
J	Spares for VVVF drive of each rating	As required
	Set of bearings for main hoist motor	1 set
	Set of bearings for aux hoist motor	1 set
	Set of bearings for cross travel motor	1 set
	Set of bearings for long travel motor	1 set

SPARE PARTS LIST OF BOILER

Sl.No.	Description	Unit	Qty	Remark
1	Various spec tube of water wall system/superheater /reheater/economizer etc.,	M	Each 160	
2	Oil gun atomization	Pc.	20	
	Oil gun wearable parts	Pc.	4	
3	Furnace sootblower nozzle	Pc.	4	
4	Complete assembly of water wall soot blowers	Pc	4	
5	Long travel retractable soot blower nozzle	Pc.	4	
6	Small travel retractable sootbolwer nozzle	Pc.	4	
7	Ah sootblower nozzle	Pc.	4	
8	Bi-water level gauge's glass, gasket, isinglass	Pc.	4	
9	Observation door	Set	10	
9	Air heater upper/lower bearing with housing	No	2 each	
10	Nozzles washing, fire fighting) for air heater	Set	2	
11	Complete internals for assembling of one valve for desuperheater	Pc.	Each type 2	



Sl.No.	Description	Unit	Qty	Remark
	regulation valve of superheater and reheater			
12	Motor-driven stop valve for desuperheater	Pc.	Each type 2	
13	Man hole gasket for drum	Pc.	Each type 8	
14	Tube bends for waterwall, economizer, super heater and reheater	Pc.	Each type & size 10	
15	Spares for air and gas damper			
16	Complete leaf reqd for assembling one damper	Set	Each type & size 1	
17	Pressure gauge	Pc.	Each type 4	
18	Pressure reducer valve	Pc.	Each type 4	
19	Magnetic valve	Pc.	Each type 4	
20	Pneumatic valve	Pc.	Each type 4	
21	Inlet joint	Pc.	Each type 4	
22	Spares for burner			
23	Retractor for heat ignitor	Set	2	
24	Heat flexible spark rod	Set	2	
25	Coal nozzle	Pc.	8	
26	Coal nozzle body	Pc.	8	
27	Complete oil gun assembly(full) HSD&HFO	Set	8	
28	Ignition gun	Set	2	
29	Tighting nut	Pc.	8	
30	Eddy piece	Pc.	8	
31	Atomize piece	Pc.	8	
32	Oil valve	Pc.	2	
33	Flushing valve	Pc.	2	
34	Observation hole	Pc.	10	
35	Tilting mechanism internal to assemble one corner	Set	1	
36	Complete internals to form one safety valve except valve body	Set	1 each type & size	
37	Hand operated valves upto 2" size	%	25% of total population	
38	From 2" to upto 6" valves	%	5% of total population or min 1 no which ever is higher	
39	Above 6" valves (complete internals for assy. One valve except valve body	Set	1 no each type & size	

SPARE PARTS LIST OF MIDDLE SPEED MILLS

No	Description	Unit	Qty	Remarks
1	Grinding roller sleeve(for 3 mills)	Piece	9	
	Roller assy with journal & bearing assy	Set	9	
2	Bull ring segment	Set	6	
3	Scraper assembly(long/short)	Set	Each 4	
4	Vane wheel assembly	Set	3	



No	Description	Unit	Qty	Remarks
5	Bowl extension ring	Set	2	
6	Protect plate	Set	16	
7	Spring assy	Set	3	
8	Complete assy of lub oil pump	Set	1	
9	Complete assy of impeller , rotor shaft for seal air fan	Set	1	
10	Drive end & nde bearings for seal air fan & motor	Set	2	

SPARE PARTS LIST OF ESP

No	Description	Unit	Qty	Remarks
1	Emitting line(barbed wires)	No	50	
2	Emitting line(spiral wires)	No	50	
3	Collecting plate	No	10	
4	Concavo bush and convex bush	No	40	
5	Clip for collecting plate	No	40	
6	Support insulator	No	2	
7	Shaft insulator	No	2	
8	Rapper bearing	Sets	Each10	
9	Collecting rapping hammer with inner & outer arms	No	10	
10	Emitting rapping hammer with inner & outer arm	No	10	
11	Major pin wheel	No	2	
12	Minor pin wheel	No	2	
13	Electric heating for support insulater	No	4	
14	Electric heating for hopper	No	4	
15	Relay	No	4	
16	Motor drive protecting controller	No	6	
17	Motor drive protecting controller	No	6	
18	H.v major loop fuse	No	5	
19	H.v control loop fuse	No	5	
20	Protect motor contactor	No	3	
21	Heat up contactor	No	3	
22	Fast melt core	No	20	
23	Damping resistor	No	2	
24	Voltage dependent resistor	No	10	
25	Indicating lamp	No	Each 3	
26	Exhaust fan	No	3	
27	Current transformer	No	2	
28	Isolating transformer	No	2	
29	Level detector	Pc	2	
30	Silicon control striking unit/relay panel	No	Each 1	
31	Silicon dropper for t/r	No	1	
32	Sampling resistor	No	Each 4	

SPARE PARTS LIST OF PA FANS

No	Description	Unit	Qty	Remarks
1	Pressure gauge	Pc.	1	
2	Thermometer	Pc.	1	
3	Temperature measuring unit for bearing platinum resistance	Pc.	1	
4	Leafstalk-shaft seal	Set	1	
5	Retaining screw for blades	No	12	
6	Rotating oil seal	Set	1	
7	Flexible pipe	Pc	3	
8	Hose coupling	Pc	3	



9	Filter core	Pc	4	
10	Complete shaft & blade assy required to assy one fan	Set	1	
11	Coupling & bolts , nuts for fan & motor	Set	1	
12	Hydraulic servo motor	Set	1	
13	Complete assy of lub oil pumps	Set	1	

SPARE PARTS LIST OF ID FANS

No	Description	Unit	Qty	Remarks
1	Radial axis seal	Pc	4	
2	Instrument (common for two units)			
3	Pressure gauge	Pc.	1	
4	Thermometer	Pc.	1	
5	Temperature measuring unit for bearing platinum resistance	Pc.	2	
6	Leafstalk-shaft seal	Set	1	
7	Retaining screw for blades	Pc	12	
8	Hose coupling	Pc	3	
9	Flexible pipe	Pc	3	
10	Filter core	Pc	4	
11	Complete shaft & blade assy required to assy one fan	Set	1	
12	Coupling & bolts , nuts for fan & motor	Set	1	
13	Hydraulic servo motor	Set	1	
14	Complete assy of lub oil pumps	Set	1	

SPARE PARTS LIST OF FD FANS

No	Description	Unit	Qty	Remarks
1	Pressure gauge	Pc	1	
2	Thermometer	Pc	1	
3	Temperature measuring unit for bearing platinum resistance	Pc	2	
4	Leafstalk-shaft seal	Set	1	
5	Retaining screw for blades	Pc	12	
6	Rotary oil seal	Set	1	
7	Flexible pipe	Pc	3	
8	Hose coupling	Pc	3	
9	Filter core	Pc	4	
10	Complete shaft & blade assy required to assy one fan	Set	1	
11	Coupling & bolts , nuts for fan & motor	Set	1	
12	Hydraulic servo motor	Set	1	
13	Complete assy of lub oil pumps	Set	1	

SPARE PARTS LIST OF APH

No	Description	Unit	Qty	Remarks
1	Main drive bearings	Set	1	
2	Complete assembly of gear box internals	Set	1	
3	Complete assembly of fluid coupling	No	2	
4	Resilient plates	Set	2	



PLANT WATER TREATMENT PRE TREATMENT PLANT

Sl. No.	Description	Quantity
1	CIRL Diaphragm Valve	
a.	Complete valve	Two (2) Nos. each of different size of valve in the system
b.	Diaphragm	Five (5) Nos. each of different sizes valves
c.	Valve spindle	Two (2) Nos. each of different sizes valves
2	2. Other type valve (except Control valve)	
a.	Complete valve	One (1) No. each of different size of valve in the system
b.	Sampling & needle valve	Four (4) Nos. each type & size
c.	Pressure Gauge	Two (2) Nos. for each Range/Type
3	Level Gauge	
a.	Glass Tube	Five (5) Nos. for each size
b.	Off-set value	Two (2) Nos. for each size
4	Level Switch (conductivity type)	
a.	Float & Rod	One (1) No. for each size
b.	Switch Assembly	One (1) No. for each size
5	Clarifloculator Bridge	
a.	Worm gearbox	One (1) No.
b.	Shaft for trailing wheel	One (1) No.
c.	Flocc. Drive head complete with bevel & pinion set.	One (1) No.
d.	Central bearing housing complete.	Two (2) Sets
e.	Current collectors.	One (1) Set
f.	Weir with stuffing box.	One (1) No.
g.	Bearing; Impeller with shaft & gear unit for each type and size of air blowers.	Two (2) Sets
h.	Floats for each size and type with links & levers.	Two (2) Sets
i.	Bearings & brake linings for each type & rating of hoists.	Two (2) Sets
j.	Rope grid & complete length of wire rope for each type of hoists rating	One (1) No.
k.	Bearings; shaft sleeve; impeller; and mechanical seal for each type & duty parameters of pump sets.	One (1) set each
l.	Controller valve assembly complete.	Two (2) Nos.
m.	Periphery drive worm gearbox coupling.	Two (2) Nos.
N	Membranes for ultra filtration	25% of total population
6	RO plant (SWRO & BWRO)	
a.	RO Membranes	25% of each type & size
b.	'O' Rings of all sizes	10% of total quantity
c.	Flexible connectors	10% of total quantity
d.	Micron Cartridge Filter Element	1 set complte for 1 no.catridge filter.
e.	Metering pumps for dozing system in pre treatment, RO,RO-DM plant	1 No each type & size
f.	Complete internals reqg for assembling high pressure pump except casing	1 No each type & size
7	Maintenance Spares	
a.	Pr. Gauge Flow Indicator (Bypass / on line type)	Two (2) Nos. for each Range / Type



Sl. No.	Description	Quantity
b.	Float	Two (2) Nos. for each size
c.	Meter tube	One (1) No. for each size
d.	Gaskets	Three (3) Nos. for each size.
8	Level Gauge	
a.	Glass tube	Five (5) Nos. for each size
b.	Offset valve	Two (2) Nos. for each size
9	Level switch (side mounted)	
a.	Float & Rod	One (1) No. for each size
b.	Switch assembly	One (1) No. for each size
c.	Magnet	One (1) No. for each size.
10	Conductivity Instrument	
a.	Complete meter	One (1) No. for each size.
b.	Neon Lamp	Two (2) Nos. for each size.
c.	Power Supply Card	One (1) No. for each size
d.	Controller PCB	One (1) No. for each size
e.	Transformer	One (1) No. for each size
f.	Relay	Two (2) Nos. for each size
g.	Meter Movement	One (1) No. for each size.
h.	Cell	One (1) No. for each size.
11	PH Instrument	
a.	Complete meter with cell & accessories	One (1) No. for each size.
b.	Neon lamp	Eight (8) Nos. for each size.
c.	Power supply card	One (1) No. for each size.
d.	Amplifier PCB	One (1) No. for each size.
e.	Controller PCB	One (1) No. for each size.
f.	Transformer	One (1) No. for each size.
g.	Relay	One (1) No. for each size.
h.	Meter movement	One (1) No. for each size.
i.	Electrodes Assembly	One (1) No. for each size.
12	Annunciator	
a.	Hooter	Two (2) Nos. for each size.
b.	Lamps	Twenty Four (24) Nos. for each size.
c.	Flasher cord	Two (2) Nos. for each size.
13	Control Panel	
a.	Indicating lamps	Twenty Four (24) Nos. for each size.
b.	Switches rotating	Two (2) Nos. for each size.
c.	Fuses with fuse holder	Twelve (12) Nos. fuse for each rating
d.	Terminal Block	Two (2) Nos.
e.	Mimic Lamps	Twelve (12) Nos. for each color
f.	Push Button	One (1) set.
14	PLC	
a.	Processor card	One (1) No.
b.	Input / Output card	Two (2) Nos.
c.	Communication card	One (1) No.
d.	Power Supply card	One (1) No.
15	Motors – Bearings	One (1) Set each for drive end and Non drive end.
16	RO DM Plant CIRL Diaphragm valve	
a.	Complete valve	2 Nos each type & size
b.	Diaphragm	Five (5) Nos. each of different sizes valves
c.	Valve spindle	Two (2) Nos. each of different sizes valves
2	Other type valve (except control valve)	



Sl. No.	Description	Quantity
a.	Complete valve	One (1) No. each of different size of valve in the system
b.	Sampling & needle valve	Four (4) Nos. each type & size
3	MEDIA	
a.	Cation Resin	10% of Total Quantity filled initially
b.	Anion Resin	10% of Total Quantity filled initially
c.	Rasching Rings	10% of Total Quantity filled initially
4.	Internal fittings	One (1) set for each type of exchanger/fitter.
5	NOT-Return Valve	
a.	Body Seat ring	Two (2) Nos. for each size valve
b.	Flap rings	Two (2) Nos. for each size valve
6	For each type & duty of united and horizontal pumps	
a.	Bearing	One (1) Set
b.	Gland packing	One and half (½) Kg.
c.	Shaft Sleeve	One (1) Set
d.	Impeller with shaft	One (1) Set
e.	Mechanical Seal	One (1) Set
f.	Ejector	One (1) Set for each type



B) MANDATORY SPARES FOR ELECTRICAL

(* One set corresponds to actual quantity of components and devices as installed for the equipment at Site)

Sl.No	Description	Unit	Quantity
1.	Generator		
a)	Generator bearings for turbine end and exciter end	Set*	1
b)	Exciter bearings	Set*	1
c)	Oil guard rings for turbine end and exciter end bearings	Set*	1
d)	Stator winding bars and connections (one set comprising of two bars of each variant)	Set*	1
e)	Hydrogen Seal assembly	Set*	1
f)	Tube bundle for Hydrogen cooler	Set*	1
g)	Generator phase and neutral bushings complete for one machine	Set*	1
h)	Brush- holder assembly with housing for exciter for rotor winding E/F sensing	Set*	1
i)	Brush Gear assembly complete with brushes for slip ring (if applicable)	Set*	1
j)	Gaskets of all types (One set should include all types and sizes of gaskets for one generator and auxiliaries)	Set*	1
k)	Insulating packer below slot wedges	Nos.	50% of slot no's
l)	Ripple springs		50%
m)	Lines (Insulating material below the retaining spring	Set*	1
n)	Spacers (Insulating material below the retaining spring	Set*	1
o)	Hydrogen seal rings TE, EE each for phase and neutral side	Set*	2
p)	Set of Teflon hoses with connectors (for stator cooling system)		50% of the no of slots
q)	Retaining rings (Un machined)	Set*	1 pair
2.	Generator Excitation system		
2.1	Generator Brushless Excitation system		
a)	Electronic modules of each type for automatic voltage regulator	Nos.	2
b)	DC field breaker	No.	1
c)	Relays of each type	Nos.	2
d)	Diodes and fuses	Nos.	25% of one unit
e)	Thyristors	Nos.	100% of 1 Unit
2.2	Generator Static Excitation system		
a)	Static rectifier element with heat sink and fuse assembly		1x100% of one bridge
b)	Relays	Nos.	2 Nos. of each type
c)	Electronic modules of automatic voltage regulator	Nos.	2 Nos. of each type
d)	Excitation Transformer	No.	1 No
e)	Complete DC field breaker	No.	1 No



Sl.No	Description	Unit	Quantity
f)	Field flashing breaker	No.	1 No
g)	Over voltage suppressor (Thyristor based)	Sets	2 Sets
h)	Shunt trip and closing coil for field circuit breaker	Sets	2 Sets
i)	Initial excitation diode	Sets	2 Sets
j)	Thyristor cooling fan	Set	1 Set complete for one unit
3.	Generator Gas system		
a)	Diaphragm valve of each type	Nos.	1
b)	Gas valves of each type and size	Nos.	1
c)	Valves for H ₂ and CO ₂ manifold	Nos.	2
d)	Safety valves	Nos.	2
e)	Hydrogen gas regulator from cylinder to manifold	Nos.	3
f)	Filter for gas analyser	Set*	2
4.	Generator Seal oil system		
a)	Complete motor and assembly for ACC loyal pump of each type	Nos.	1
b)	Motor pump set for DCC oil set	Nos.	1
c)	Pump and motor bearing	Set*	1
d)	Screw pump (Bearing rotting) -----	Set*	1
e)	Vacuum motor pump	Nos.	1
f)	Differ trail pressure regulator pump	Nos.	1
g)	Non return shut off valve of each type	Nos.	1
h)	Float valve of each type	Nos.	1
i)	Duplex filter	Nos.	2
j)	Bellow for differential pressure regulator	Set*	2
5.	Stator Water cooling System		
a)	Pump	Nos.	1
b)	Motor	Nos.	1
6.	GIS Switchyard		
a)	GIS Equipment		
	i. Gas filling valve	Nos.	4
	ii. Rupture disc	Nos.	2
	iii. Rupture disc removing kit	Nos.	4
	iv. Replacement set of CB molecular sieve	Set*	4
	v. Replacement set for gasket of CB operating mechanism door	Set*	4
	vi. Gasket for CB operating mechanism window	Nos.	6
	vii. Replacement kit of absorber cartridge	Nos.	4



Sl.No	Description	Unit	Quantity
	viii. Set of gaskets	Set*	2
	ix. Maintenance kit for terminal block for VT	Nos.	6
	x. Maintenance kit for terminal block for CT	Nos.	6
	xi. 40 kg gas SF6 bottle	Nos.	1
	xii. CB coil for opening or closing	Nos.	3
	xiii. CB auxiliary contact bloc	Nos.	3
	xiv. Pressure switches	Set*	1
b)	Substation Automation		
	i. BCU	Nos.	2
	ii. Ethernet Switch of each type	No.	1
	iii. Numerical relay of each type and rating –	Nos.	10% of total population or 2-Nos whichever is higher
	v. Auxiliary relays of each type and rating –	Nos.	10% of total population or 2-Nos whichever is higher
	v. Multiplexers	Nos.	10% of total population or 2-Nos whichever is higher
7.	OPGW Communication equipment		
a)	Power supply cards	Nos.	2
b)	Subscriber Line Interface Cards	Nos.	2
c)	Common cards	Nos.	2
d)	Fuse	Set*	1
8.	Generator transformer		
a)	HV Bushing with metal parts	Nos.	3
b)	LV Bushing with metal parts	Nos.	3
c)	HVN Bushing with metal parts	No.	1
d)	Oil temperature indicator	No.	1
e)	Spring operated pressure relief valve	No.	1
f)	Set of valves	Set*	1
g)	Magnetic oil level gauge	No.	1
h)	Silica gel breather	No.	2
i)	Winding temperature indicator with all accessories	Set*	1
j)	Gaskets	Set*	1
k)	Buchholz relay	No.	1
l)	cooling fan with motor assembly	No.	1
m)	cooling pump with motor assembly	No.	1
n)	Oil flow indicator	No.	3
o)	MCCB/MCB / MPCB of each type and rating	Set*	1
p)	Silica gel breather	No.	1



Sl.No	Description	Unit	Quantity
q)	Air Cell(oil pressure equipment)	No.	1
9.	Standby maintenance transformer		
a)	HV Bushing with metal parts	Nos.	3
b)	LV Bushing with metal parts	Nos.	3
a)	HVN Bushing with metal parts	No.	1
b)	LVN Bushing with metal parts	No.	1
c)	Oil temperature indicator	No.	1
d)	Spring operated pressure relief valve	No.	1
e)	Set of valves	Set*	1
f)	Magnetic oil level gauge	No.	1
g)	Silica gel breather	No.	2
h)	Winding temperature indicator with all accessories	Set*	1
i)	Gaskets	Set*	1
j)	Buchholz relay	No.	1
k)	cooling fan with motor assembly	No.	1
l)	cooling pump with motor assembly	No.	1
m)	Oil flow indicator	No.	3
n)	Motor for OLTC	No.	
o)	MCCB/MCB / MPCB of each type and rating	Set*	1
p)	Tap changer contacts	No.	
q)	OLTC surge relay	No.	
r)	Silica gel breather	No.	1
s)	Air Cell(oil pressure equipment)	No.	1
10.	Bus reactor		
a)	HV Bushing with metal parts	Nos.	3
b)	HVN Bushing with metal parts	No.	1
c)	Oil temperature indicator	No.	1
d)	Spring operated pressure relief valve	No.	1
e)	Set of valves	Set*	1
f)	Magnetic oil level gauge	No.	1
g)	Silica gel breather	No.	2
h)	Winding temperature indicator with all accessories	Set*	1
i)	Gaskets	Set*	1
j)	Buchholz relay	No.	1
k)	MCCB/MCB / MPCB of each type and rating	Set*	1
l)	Silica gel breather	No.	1
m)	Air Cell(oil pressure equipment)	No.	1
11.	Isolated Phase Busduct		
a)	Bus support insulators	Nos.	10
b)	Flexible terminal connection complete with hardware for		



Sl.No	Description	Unit	Quantity
	i. Generator	Set*	3
	ii. Generator transformer	Set*	3
	iii. Unit Transformer	Set*	3
	iv. UT & SP cubical tap-off	Set*	3
c)	Seal off bushing suitable for		
	i. Main run	Nos.	1
	ii. Tap off run	Nos.	3
d)	CT of each type and rating	Nos.	3
e)	PT of each type and rating	Nos.	3
f)	Lighting arrester of each type & rating	Set*	3
g)	Expansion bellow of each type and rating	Set*	2
h)	Flexible connector for neutral grounding equipment	Set*	2
12.	Segregated phase Busduct of each rating		
a)	Bus support insulators	Nos.	10
b)	Seal off busing of each type	Nos.	3
c)	Flexible connectors	Set*	3
d)	Silica jell Breath	Nos.	3
e)	Rubber bellow	Set*	4
f)	Gas cut	Set*	1
13.	Non Segregated phase Busduct of each rating		
a)	Bus support insulators	Nos.	10
b)	Seal off busing of each type	Nos.	2
c)	Flexible connectors	Set*	3
d)	Silica jell Breath	Nos.	3
e)	Gas cut	Set*	1
14.	Auxiliary transformers of each type and rating (Oil filled)		
a)	HV Bushings with metal parts for each rating	Nos.	3
b)	LV Bushings with metal parts for each rating	Nos.	3
c)	LVN Bushings with metal parts for each rating	Nos.	1
d)	Oil Temperature Indicator	Nos.	5
e)	Magnetic Oil Level Gauge	Nos.	5
f)	Silica Gel Breather	Nos.	5
g)	Winding Temperature Indicator with all accessories	Nos.	5
h)	Buchholz relay	Nos.	5
i)	Pressure relief valve	Nos.	5
j)	Spring operated pressure relief valve	Nos.	5
k)	Set of valves for each rating of transformer	Set*	2
l)	Gaskets for each rating of transformer	Set*	2



Sl.No	Description	Unit	Quantity
m)	Radiator bank for each rating of transformer	Nos.	2
n)	Cooling fan with motor assembly of each type & rating	Nos.	5
o)	MCCB/MPCB/MCB of each type and rating	Nos.	3
p)	Silica gel breather of each type & size	Nos.	2
15.	Dry type Transformer of each rating		
a)	HV Bushings with metal parts for each rating	Nos.	3
b)	Winding Temperature Indicator with all accessories	Nos.	2
c)	Limit Switches	Nos.	2
d)	Temperature scanner	Nos.	2
16.	HT Switchgear		
a)	Circuit Breaker Components (for each voltage rating & current rating)		
	i. Complete poles of the each breaker size & rating	Nos.	3
	ii. Spring charging motor	Nos.	3
	iii. Primary disconnect (power) complete set of each type	Nos.	3
	iv. Aux. Contact set	Set*	3
	v. Limit switches	Nos.	3
	vi. Charging spring of each type	Nos.	3
	vii. Closing coil of each type	Nos.	3
	viii. Tripping coil of each type	Nos.	3
b)	Meters of each type	Nos.	3
c)	Energy audit meters of each type	Nos.	3
d)	Protection Relays of each type	Nos.	3
e)	Aux. relays of each type	Nos.	5
f)	Timer of each type	Nos.	3
g)	Inter posing relays	Nos.	3
h)	Control Switch and selector switch of each type	Nos.	3
i)	MCB along with close/open/trip auxiliary contacts of each type & rating	Nos.	3
j)	HT HRC fuses of each rating	Nos.	5
k)	Bus bar supporting insulator	Nos.	10
l)	CT, PT of type and ratio of each type	Nos.	3
m)	Anti pumping relay of each type & Rating	Nos.	1
n)	Lockout replays of each type	Nos.	5
o)	Moving contact assembly each install rating	Set*	5
p)	Stationary contacts (Fixed)	Set*	5



Sl.No	Description	Unit	Quantity
q)	Bus bar support insulators		5% of Total population
r)	Operating mechanism board for each type & rating	Nos.	3
s)	Ammeter of each type & range	Nos.	2
t)	Volt meter of each type & range	Nos.	2
u)	Multifunction Motor of each type & range	Nos.	2
v)	Carbon brushes for spring charging motors	Set*	20
17.	Electrical monitoring system (SCADA)		
	i. MCBs of each rating	Nos.	2
	ii. Ethernet switch	Nos.	2
	iii. Relays of each type	Nos.	2
18.	Bus Transfer Panel		
	i. MCBs of each rating	Nos.	2
	ii. Electronic cards and modules of each type	Nos.	2
	iii. Auxiliary relays of each type	Nos.	2
	v. Relays of each type	Nos.	2
19.	Generator circuit breaker		
a)	Fixed arcing contact	Set*	2
b)	Moving arcing contact	Set*	2
c)	Fixed load contact	Set*	2
d)	Moving load contact	Set*	2
e)	Operating mechanism	Set*	2
f)	Closing coils	Set*	2
g)	Tripping coil	Set*	2
h)	Closing springs	Set*	2
i)	Tripping springs	Set*	2
j)	Circuit Breaker auxiliary contact	Set*	2
k)	Gaskets	Set*	2
l)	Support Insulator	Set*	2
m)	Complete interrupting chamber with surge capacitor, disconnect switch, earth switches of one pole	Nos.	2
n)	Surge Capacitor	Set*	2
o)	Auxiliary Switches	Set*	2
p)	Relays	Set*	2
q)	Position indicators	Set*	2
r)	Pressure Gauge and Pressure switches	Set*	2
s)	Density monitor	Set*	2
t)	SF6 Filters	Set*	2
u)	Valves	Set*	2
v)	Spring charging motor	Set*	2
w)	Spring charging motor micro switch	Set*	2
x)	Motor for disconnect & earth switch	Set*	2



Sl.No	Description	Unit	Quantity
20.	LV Switchgear		
a)	Circuit Breaker Components		
	i. Spring charging motor of each type	Nos.	3
	ii. Power contacts, complete set	Set*	5
	iii. Auxiliary contact set	Set*	5
	iv. Limit switches of each type	Nos.	5
	v. Charging spring of each type	Nos.	5
	vi. Closing coil of each type	Nos.	5
	vii. Tripping coil of each type	Nos.	5
b)	Auxiliary Contactor with 2NO and 2NC add-on block		3 sets of each type
c)	Contactor complete set – power & Auxiliary contactor	Set*	5
d)	Electronic over load relay with current display unit of each type and rating	Nos.	5
e)	CTs for Overload protection (motor feeder) of each type and rating	Nos.	5
f)	CTs for incomer/ bus coupler and outgoing feeders of each type and rating	Nos.	5
g)	VTs for Incomers and BusVT of each type and rating	Nos.	5
h)	Meters (Multifunction meters, Digital meters, Analog meters) of each type and rating	Nos.	5
i)	Protection Relays of each type and rating	Nos.	5
j)	Control transformer (415V/110V) of each type and rating	Nos.	5
k)	Control transformer (415V/230V) of each type and rating	Nos.	5
l)	Aux. Relay and timer of each type and rating	Nos.	5
m)	Inter posing relays	Nos.	5
n)	Control Switch and selector switch	Nos.	5
o)	MCCB / MPCB / MCB with auxiliary contacts of each type and rating	Nos.	5
p)	Indicating lamps (LEDS) with resistor of different colors	Nos.	10
q)	Annunciation units of each type and rating	Nos.	5
r)	Bus bar supporting insulator	Nos.	10
s)	Anti pumping relay each type & rating	Nos.	5
t)	Lockout replay of each type	Nos.	5
u)	Timers of each type	Nos.	5
v)	Moving contacts of assembly of each installed rating	Set*	10
w)	Stationary (fixed) contact	Set*	10
x)	Air Circuit breaker of each type and rating	Nos.	2



Sl.No	Description	Unit	Quantity
y)	Bus seal off Bushing of each type	Nos.	5
z)	Bus bar support insulator		5% of total population
aa)	Indicating lamps – Qty to be changed as	Nos.	50
bb)	Ammeter of each type and rating	Nos.	5
cc)	Voltmeter of each type and rating	Nos.	5
dd)	Arc chute (for each rating)	Nos.	5
ee)	Inter phase barriers of each type	Nos.	3
21.	For Battery of each type and rating		
a)	Inter cell connectors with insulated cover	Nos.	10
b)	Inter row connectors with insulated cover	Nos.	10
c)	Battery stand insulators	Nos.	10
d)	Cell insulators	Nos.	10
e)	Nuts, bolts & washers-each type	Set	1
f)	Vent plugs	Nos.	10
g)	Spare dry cell	Nos.	10
22.	For battery charger		
a)	SMPS modules of each type & rating	Nos.	5
b)	LEDs lamps of each type & rating	Nos.	5
c)	Contactors	Set*	2
d)	SMPS module for each type and rating	Nos.	10
e)	MFM each type and rating		5% of total population or one number whichever is higher
f)	Blocking Diode for each type and rating		5% of total population or one number whichever is higher
g)	Relay for each type and rating		5% of total population or one number whichever is higher
h)	BHMS sensors for each type and rating		10 % of total population
i)	Electronic circuit module	Set	1
j)	MCCB for each type and rating		10% of total population or one number whichever is higher
k)	Voltage regulator assembly		10% of total population or one number whichever is higher



Sl.No	Description	Unit	Quantity
23.	DG Set		
a)	Diesel engine		
	i. Fuel injection nozzles	Set*	2
	ii. Crank shaft with standard size journals	Set*	1
	iii. Main bearings	Set*	1
	iv. Big-end bearings	Set*	1
	v. Diesel filter packs	Nos.	20
	vi. Mobile oil filter packs	Nos.	20
	vii. V-belt for radiator fan	Nos.	5
	viii. Fuel injector	Nos.	5
	ix. Fuel injection piping	Set*	1
	x. Ring gear for fly wheel	Set*	1
	xi. Starter	Set*	1
	xii. Nozzle tester, barring bar, slings, eyebolts and other special equipment necessary for servicing the engine	Set*	1
	xiii. Pressure switch	Set*	1
b)	Generator (DG set)		
	i. Instruments of each type	Nos.	2
	ii. Relays of each type	Nos.	2
	iii. Timers of each type	Nos.	2
	iv. Indicating lamp of each type	Nos.	2
	v. Fuses of each type and rating	Nos.	2
	vi. Rotating diodes and fuse for main field excitation of each rating	Nos.	2
	vii. Temperature scanner	Nos.	2
	viii. Carbon brushes for Generator and self-starter motor	Set*	10
	ix. CT of each type and rating	Set*	1
c)	AMF panel		
	i. Protection relays of each type	Nos.	2
	ii. Auxiliary relays of each type	Nos.	2
	iii. Indicating lamp each type	Nos.	2
	iv. Meters each type	Nos.	2
	v. Fuses of each type and rating	Nos.	3
24.	UPS of each rating		
a)	HRC Fuses of each type and rating	Nos.	5
b)	Semiconductor fuses of each rating	Nos.	5
c)	Electronic cards and modules of each type	Nos.	2
d)	Thyristors /Power transistors / power diodes of each rating	Nos.	5
e)	Filter capacitors & Chokes of each rating	Nos.	5
f)	Static transfer switch	Nos.	5



Sl.No	Description	Unit	Quantity
g)	Maintenance by pass switch for each type and rating	Nos.	2
h)	MCCB for each type and rating	Nos.	10 % of total population
i)	CTs of each type and rating	Set*	1
j)	Rectifier cards	Set*	1
k)	MFM for each type and rating	Nos.	1
l)	Rectifier transformer for each type and rating	Nos.	1
25.	Control & Relay panels		
a)	Breaker failure relay	Nos.	5
b)	Trip Circuit supervision relay	Nos.	5
c)	Self reset trip relay	Nos.	5
d)	Hand reset trip relay	Nos.	5
e)	Timer relay	Nos.	5
f)	Auxiliary relays	Nos.	5
g)	DC supervision relay	Nos.	5
h)	Pole discrepancy relay	Nos.	5
i)	Fuse failure relay	Nos.	5
j)	MCBs of each rating	Nos.	2
k)	Auxiliary relays of each type	Nos.	2
l)	Relays of each type	Nos.	2
m)	Voltmeter, ammeter, MW meter, MVA meter, Frequency meter for each type and rating	Nos	2
n)	Transducers of each type and rating	Nos	2
o)	Synchroscope	Nos	1
26.	Elevators of each capacity		
a)	Car shoe liner	Set*	2
b)	Counter weight shoe liner	Set*	2
c)	Car shoe	Nos.	2
d)	Counter weight shoe	Nos.	1
e)	Lock contact	Nos.	2
f)	Lock shorting base	Nos.	2
g)	Each type of roller	Nos.	2
h)	Break liner with rivet	Nos.	1
i)	Thrust bearing	Set*	2
j)	Motor bearing	Set*	2
k)	Landing gate shoe liners	Nos.	2
l)	Car safety switch	Nos.	1
m)	Control relay	Nos.	2



Sl.No	Description	Unit	Quantity
n)	Push buttons with indicating lamps	Nos.	20% of total population
o)	Level indicating lamps	Nos.	20% of total population
p)	VVVF control cards and power supply cards for each type and rating	Complete 1-set	1
27.	Telephone system		
a)	Set of fuses	Set*	2
b)	Digital card of each type	Set*	1
c)	Digital type telephone instruments	Nos.	5
d)	Exchange server for each type and rating	Nos.	10 % of total population or 1-No which is higher.
e)	Power supply cards for each type and rating	Nos.	10 % of total population or 1-No which is higher.
28.	Illumination system		
a)	Each type and rating of HRC fuse	Nos.	10
b)	Each type and rating of MCBs	Nos.	10
c)	Each type and rating of lamp	Nos.	10 % of total population or 1-No which is higher
d)	Each type and rating of ballast	Nos.	10 % of total population or 1-No which is higher
e)	Each type and rating of starter	Nos.	10 % of total population or 1-No which is higher
f)	Each type and rating of igniter	Nos.	10 % of total population or 1-No which is higher
g)	Each type and rating of capacitor	Nos.	10 % of total population or 1-No which is higher
h)	Each type and rating of receptacles	Nos.	10 % of total population or 1-No which is higher
i)	Lighting Switches	Nos.	10 % of total population or 1-No which is higher
j)	Junction Boxes(each type)	Nos.	10
k)	Photo voltaic sensor	Nos.	10 % of total population or 1-No which is higher
l)	Electronic circuit for the above	Nos.	10 % of total population or 1-No which is higher
29.	11 kV and 6.6 kV Motors of each type and rating		
a)	Driving end bearing	Set*	1
b)	Non driving end bearing	Set*	1



Sl.No	Description	Unit	Quantity
c)	Termination kits (If elastimod type)	Nos.	2
d)	Termination kits end connections	Nos.	10
e)	Temperature indicators	Nos.	5
f)	Motors of each & rating	No.	1
30.	LT Motors of each type and rating		
a)	Driving end bearing	Set*	1
b)	Non driving end bearing	Set*	1
c)	Terminal block for motors up to 30 Kw each rating	Nos.	10
d)	Terminal block for motors above 30 Kw each rating	Nos.	5
e)	Motors of each type & rating	Nos.	10% of installed quantity or 1 –no is higher whichever is higher
31.	DC Motors of each type and rating		
a)	Driving end bearing	Set*	1
b)	Non driving end bearing	Set*	1
c)	Carbon brushes of each type	Set*	10
d)	Brush assemblies of each type	Set*	2
e)	Terminal blocks of each type	Set*	2
f)	Motor of each type & rating	Nos.	10% of installed qty or 1-no Which ever is higher
32.	Electrical actuator, complete assembly, of each rating	Nos.	2
33.	Substation automation and Electrical management system		
a)	Keyboard		2 nos. of each type
b)	Mouse		2 nos. of each type
c)	Color laser printer (A4)		1 no.
d)	Printer toner for all printers		2 nos. of each type
e)	132 Column Printer Head		1 no.
f)	Drum for A3 scanner cum copier, printer		1 no.
g)	24" Monitor		1 no.
h)	Ethernet switch		2 nos. of each type.
i)	Control units for LVS		1 no.
j)	Graphical Interface Unit		1 no. of each type & model
k)	Hard disk		2 nos of each type
l)	Gateways		1 no. of each type
m)	Fibre optic Ethernet signal converters		2 nos. of each type
n)	Portable hard disk Drive 1TB		2 Nos.

**C) CONTROL & INSTRUMENTATION**

Sl. NO.	PARTICULARS	QUANTITY
1.00	DISTRIBUTED DIGITAL SYSTEM (DCS)	
	Keyboard	10% or 3 nos. of each type.
	Mouse	10% or 3 nos. of each type.
	Color laser printer (A4)	1 no
	Printer toner for all printers	10% or 3 nos. of each type.
	132 Coloumn Printer Head	2 nos.
	Drum for A3 scanner cum copier, printer	2 nos.
	24" Monitor	3 nos.
	Ethernet switches, Routers	10% or 2 nos. of each type.
	Work stations with licensed software loaded along with monitor	2 nos. of each type and model.
	Server for unit LAN or Information Work Stations (As applicable)	1 nos. _
	Net work components like Switch /repeaters/hubs etc. (as applicable)	2 nos. of each type and model. _
	Other drives/peripheral devices of each type and model no. in MMIPIS like terminal Servers, DAT tape drive etc. (as applicable), which are not covered in above items but are required to make the system complete.	2 nos. of each type and model
	Control units for LVS	1 no.
	Graphical Interface Unit	1 no. of each type & model
	Network Cables and Connectors.	10% or 3 nos of each length & each type
	Cat6 cable	1 Km
	Fibre optic cable	500 metres of each type
	RJ 45 connector with box	20% or 2 nos. of each type
	Harddisk	5 nos of each type
	Gateways	1 no. Of each type
	Fibre optic Ethernet signal converters	2 nos. Of each type
	Portable hard disk Drive 1TB	5 Nos.
	Prefab interconnecting cables with connectors	2 nos. of each type and length.
	System bus cable with connectors	2 nos. of each type and length.
	I/O bus cable with connectors for remote I/O units	3 nos. of each type and length.
	Power Supply Modules & Power Packs for control system	_ 20 % or 4 nos. of each type, model and rating, whichever is more.
	Intelligent UPS for workstation, server, PCs	1 no. of each size and rating
	Electronic modules of each type and model for control system (This shall include all type of cards like I/O cards, controller cards, CPU module or Card, logic cards etc.)	_ 10% or 2 nos. of each type and model whichever is more
	Bus coupler/Interface hardware and other communication devices (If applicable)	_ 10% of each type and model
	Relays	10% of each type and rating
	PCs	1 no. of each type & model.



Sl. NO.	PARTICULARS	QUANTITY
	Batteries used for battery backup of RAMs (If applicable)	_ 10% of each type and model
	Fuses	200 %
	Expendable items including but not limited to the followings Cooling fans for Power supply and cabinets	_ 10 % or 2 nos. of each type and model, whichever is more.
2.00	CONTROL AND INSTRUMENTATION SYSTEMS / EQUIPMENTS FOR SG RELATED SUB-SYSTEMS	
1	Flame monitoring system	
	Complete Flame Scanner Assembly including scanner head assembly, scanner housing, and fibre optic cables.	_ 20% or 4 nos., whichever is more
	Flame Scanner Lens	100%
	Electronic cards for scanners	10% or 2 nos. of each type whichever is more.
	Power Supply Modules	20% or 2 nos. of each type whichever is more.
2	Coal feeders	
	Motion monitor	10% or 2 nos. whichever is more.
	Speed pick-up	10% or 3 nos. whichever is more.
	Torque switch	10% or 3 nos. whichever is more.
	Load Cell	20% or 6 nos. whichever is more.
	Electronic cards & Power Supply cards	10% or 2 nos. whichever is more.
	Clutch (if applicable)	10% or 2 nos. whichever is more.
	Local indication lamps	200 %
	Panel meters	10% or 2 nos. whichever is more.
	Limit switch assembly for coal-on-belt, no coal flow, shear pin failure, etc.	10% or 2 nos., whichever is more.
	Coupling (eddy current type etc., VFD as applicable)	10% or 2 nos. whichever is more.
3	Electromatic Safety Valves Pressure switches, local PB stations and solenoid Valves.	10% or 2 nos. of each type whichever is more.
4	Furnace Temperature Probes Thermocouple	2 Nos.
5	Acoustic Pyrometers	
	Signal Processor and interface modules	20% or 2 nos. of each type and model whichever is more
	Sensors and Transceivers	20% or 2 nos. of each type and model which is more.
	All Electronic Cards including Power Packs	20% or 2 nos. of each type and model which is more.
	Seal kit for Sound Generator	20% or 2 nos. of each type and model which is more.
6	Furnace and Flame viewing system	
	Flame Cameras	10% or 2 nos., whichever is more
	Electronic Modules	10% or 2 nos. of each type whichever is more
7	Conductivity type level monitoring system (for driplegs)	



Sl. NO.	PARTICULARS	QUANTITY
	Electrodes	50% of population
	Electronic Cards	20% or 2 nos. of each type and model whichever is more.
	Lamps/LEDs of display units	100%
8	Mill and Air heater Fire detection system.	
	Thermocouple	10%
	Process actuator switches	10%
9	Acoustic steam Leak Detection system (ASLD)	
	Processor and Interface modules	10% or 1 no. of each type and model, whichever is more
	Sensors and Transceivers	10% or 1 no. of each type and model, whichever is more including sensors
10	Temperature elements	
	RTD's of each type and length(with head assembly, terminal block & nipple)	10% or 2 nos. of each type and length, whichever is more
	Thermocouples of each type like K-type, R-type, metal etc. (with head assembly, terminal block & nipple)	10% or 2 nos. of each type and length which ever is more
	Thermowell for application like mill outlet temperature and SH/RH/Eco/ flue gas temp. in furnace	10% or 2 nos. of each type and length whichever is more
	Temperature transmitters	10% of each type and model
11	Local Indicators like temperature gauges, pressure gauges, differential pressure gauges, flow gauges, flow meters etc.,	10% or 2 no. of each make, model and type whichever is more and for each plant (to be divided to various ranges in proportion to main of all make, model, type population)
12	Process Actuated Switch Devices Includes all types of Pressure, differential pressure, flow, temperature, differential temperature, level switch Devices	5% or 1 no. of each type and model whichever is more
13	PD Type Flow Transmitters	1 no. of each type and model
14	Flue Gas Analyzer Instruments for Oxygen (i) Electronic Card Assemblies of each type (ii) Sets of Gaskets/ "O" rings (iii) Temperature Sensor & heater Assembly (iv) Complete Probe with shield assembly. (v) Consumables like filter elements.	1 no. each complete instrument. 2 sets 20% 2 nos 100%
15	CO Analyser Chopper motor Electronic cards	2 nos. 2 nos. Of each card
16	Opacity monitor Transmitter Receiver Power supply module Signal output module Light source	2 nos. 2 nos. 2 nos. 2 nos. 2 nos.
17	SOx NOx CO Analyser Electronic cards Chopper motor Light source	1 no. 2 nos. 2 nos.
18	Water Analysers – pH Transmitter Cell Electronic cards	2 nos. Or 20% of each type which ever is more 1 no. Of each type



Sl. NO.	PARTICULARS	QUANTITY
	Tranmitter Electronic Unit	1 no. Of each type
19	Electronic modules for Silica, Phosphate, Dissolvd Oxygen, Hydrazine analysers	1 no. Of each type
20	Environment Management System Analysers : Optical source Chopper motor Electronic modules Power supply modules	2 Nos. For each type 2 Nos. For each type 2 Nos. For each type 2 Nos. For each type
21	Special Instruments (i) Coal in Fly Ash Sensors Electronic modules (i) Secondary air flow measurement Sensors Electronic modules (i) Coal balancing system Sensors Electronic modules Motorised Actuator for orifice	6 nos 3 Nos 1 No 1 No 10 Nos. 5 each type 5 Nos.
22	POWER SUPPLY SYSTEM – 24 VDC (To be provided for each system)	
	Silicon controlled thyristors, diodes, power transistors	_ 100%(1 Lot)
	Capacitors	1 set
	Filter regulators	20% of each model or 2 nos. whichever is more.
23	INSTRUMENTATION CABLE, INTERNAL WIRING & ELECTRICAL FIELD	
	Pre fabricated cable of each type.	10% of installed quantity
	Pre fabricated cable connector of each type	10% or 1 no. of each type and model, whichever is more.
	Other cables	5% of each type, pair and size of actual installed quantity
24	CONTROL VALVES, ACTUATORS & ACCESSORIES	
	Pneumatic and electro-hydraulic actuator assembly	10% or 1 no. of each type, model and rating, whichever is more
	Valve trim (including cage, plug, stem, seat rings, guide bushings etc.)	1 set for each type of control valve.
	Diaphragms, O' rings, seals etc. of all types, make etc.	200%
	Pressure Gauges of all types, make, rating etc.	10% or 2 nos. of each type whichever is more.
	Solenoid valves (if applicable)	10% or 2 nos. of each type whichever is more.
	Positioner units (complete unit)	10% or 1 no. of each type whichever is more.
	Pneumatic air-filter/Regulator of each type, make, rating etc.	10% or 2 nos., whichever is more
	Position feedback transmitters	10% or 2 nos. of each type whichever is more.
	Torque and limit switch assembly	10% or 2 nos. of each type,
	Air lock relays	10% or 2 nos. of each type, whichever is more
25	PADO	



Sl. NO.	PARTICULARS	QUANTITY
	Work station with all accessories and licensed software, along with Monitor	1 no.
	Interface cards	10% or 2 nos. of each type whichever is more
26	MICROPROCESSOR BASED/PLC BASED CONTROL SYSTEM FOR ESP/CAS etc	
	Complete set including integral microprocessor based control system alongwith system & application software and special cables	10% or 1 set whichever is more
	UPS Electronic cards IGBT Modules of each type MCBs of each type	10% or 2 nos. min. whichever is more
	Digital Indicators of each model, type & range (including relevant digital indicators of electrical system)	10% or 2 nos. min. whichever is more
	Card Reader	10% or 2 nos. min. whichever is more
	Cooling fans in control panels	10% or 2 nos. min. whichever is more
	LVS Lamps	24

**ANNEX - 1.5****TRAINING**

(Total within 52 man months, Group training Number of man month as per clause 21.1.1 of page 93 of 164 is inclusive of the training as per this Annex)

PRODUCT	AREAS OF TRAINING REQUIREMENT			
	Product Design	Plant Visit	Visit To Manufacturer's Work	Operation & Maintenance Of Plant
STEAM GENERATOR	Thermal design and hydraulic circulation balance	Familiarization with various system and equipment	Manufacturing processes of pressure parts, and equipment	Control philosophy operation, notices, logic & protection schemes, O&M manual familiarization O&M issues
	Combustion and Air & gas weight calculation	Performance data collection analysis and review	Welding process	
	Pressure part calculation	O&M feed back	Testing facilities	Familiarization of special maintenance techniques.
	Pressure part and strength calculation			
	Equipment and system sizing and selection of mills, fans, airpreheater, soot blowers, dampers, valves heater, soot blowers, dampers, valves, feeders, burners startup system, fuel firing system, draft plant			
	Flow scheme development of air & flue gas, fuel oil, auxiliary steam, main and reheat steam feed water.			
	Layout of over all plant, steam generator area, pressure part arrangements, platforms, equipment, piping and duct, coal pipe, flue gas ducts, bunker arrangement, valves and damper, ESP area, cable & piping tressels etc.			



PRODUCT	Product Design	Plant Visit	Visit To Manufacturer's Work	Operation & Maintenance Of Plant
	Erection strategies, erection procedures			
	Performance and demonstration tests.			
MANDAYS	120	20	20	20
CFD model development and validation for Steam Generator	Familiarisation of fundamentals and basis for the development of the CFD models.			
	Solving of set of simple problems by Employer's engineers with the help of trainer.			
	Hands on experience on the development of detailed/realistic CFD models for the steam generator and ESP. The Bidder/trainer shall develop CFD models for SG & ESP as per the Contract requirement with complete association of the Owner's engineers.			
	Validation of the above CFD model for SG & ESP by Bidder in association with the Owner's Engineers.			
MANDAYS	120 for SG and 60 for ESP			



PRODUCT	Product Design	Plant Visit	Visit To Manufacturer's Work	Operation & Maintenance Of Plant
TURBINE GENERATOR AND IT'S INTEGRAL AUXILIARIES	Turbine cycle optimization and turbine performance in off design condition.	Familiarization of power plants of various makes of turbines for super critical units	Manufacturing processes of turbine	
	Rotor design and strength calculation	Collection of data for analysis of availability of turbines	Assembly of turbine	
	Rotor dynamic behavior studies wrt natural frequency, critical speed, vibration etc.	Comparative studies for integral systems of turbine	Testing of turbines	
	Blade profile/root design and blade strength design, blade vibration analysis	O&M history/problems related to turbine	Product development in process	
	Casing & diaphragm design	Failure analysis	Future plan for technology induction	
	Labyrinth seal selection & design for different turbine configurations		R&D work in progress	
	Selection of turbine type (i.e. Tandem vs cross compounding, separate HP/IP vs combined HP/IP, material of construction etc.)			



PRODUCT	Product Design	Plant Visit	Visit To Manufacturer's Work	Operation & Maintenance Of Plant
	Design principle for Up rating/down rating of existing design/ modules for the specific project.			
	Selection of nos., type and arrangement of bearings, load calculation on bearings, bearing oil flow calculation			
	Selection, design and control principle for Turbine governing system			
	Performance calculation			
	Steam path audit			
	Layout principle of various equipment's of TG and its integral system			
	Latest technological advancements			
MANDAYS	45	10	10	
Boiler Feed Pumps	Techno-economic studies for Selection of BFP Configuration and its drive	Familiarization of power plants of various makes of feed pumps	Manufacturing process of various components of BFP	
	Criteria for selection of boiler Feed Pump parameters	Data collection of BFP parameters & configuration	Assembly of BFP	
	Rotor design, strength calculation and rotor dynamic behavior studies wrt critical speed, vibration etc	Collection of data for analysis of availability of BFP	Testing, capabilities of BFP at works wrt performance, NPSH, thermal shock, dry run, visual cavitations, string test, axial thrust measurement	



PRODUCT	Product Design	Plant Visit	Visit To Manufacturer's Work	Operation & Maintenance Of Plant
	Impeller design and its hydraulic behavior	O&M history/problems related to BFP	Product development in process	
	Role of critical para- meters such as NPSH(R), Suction specific speed, running clearances, speed etc. in design of feed pumps	Comparative studies for various types of BFP& its features	Future plan for technology induction	
	Material selection of BFP components		R&D work in progress	
	Guiding factors for selection of BFP seals			
	Computation of axial thrust under various flows			
	Performance calculation			
	Transient analysis in pump suction piping wrt NPSH margin			
	Latest technological trends in BFP design			
MANDAYS	20	5	10	
Condenser	Selection of condenser type and its optimization wrt temp rise across condenser, pressure drop in condenser, surface area etc.	Comparative studies of salient features	Manufacturing process of various components of condenser Assembly	
	Techno economic studies for Selection of condenser tube material and other parts depending on water quality	Collection of data for analysis of availability of Condenser	Testing capability at works	
	Condenser support selection & design	O&M history/problems related to condenser	Product development in process	



PRODUCT	Product Design	Plant Visit	Visit To Manufacturer's Work	Operation & Maintenance Of Plant
	Sizing of condenser w.r.t. super critical units		Future plan for technology induction	
	Latest technological trends in condenser arrangement and design		R&D work in progress	
	Condenser vacuum system design			
MANDAYS	10	5	5	
Feed Regenerative Equipment's	Thermal and mechanical design calculation of heaters	Comparative studies of salient features	Manufacturing process of various components of heaters	
	Basis of selecting horizontal/vertical heaters	Analysis of data	Assembly	
	Selection of TTD and DCAs for various heaters, and their effect on turbine heat rate	O&M history/problems related to heaters	Testing capability at works	
	Configuration of HP heaters (2x50% v/s100% capacity		Product development in process	
	Sizing criteria for De- aerator/Heaters		Future plan for technology induction	
	Selection of tube & tube sheet material of heaters		R&D work in progress	
	Latest technological trends in heaters design			
MANDAYS	15	10	10	



PRODUCT	Product Design	Plant Visit	Visit To Manufacturer's Work	Operation & Maintenance Of Plant
3-dimensional CFD modeling	CFD model development and validation of design data for steam turbine, BFP, CEP, condenser, heaters etc.			
MANDAYS	20			
R.O AND DESALINATION	30 (MANDAYS)	10 (MANDAYS)	10 (MANDAYS)	
COAL HANDLING SYSTEM	60 (MANDAYS)	20 (MANDAYS)	20 (MANDAYS)	
ASH HANDLING SYSTEM	60 (MANDAYS)	20 (MANDAYS)	20 (MANDAYS)	



PRODUCT	AREAS OF TRAINING REQUIREMENT			
	Product Design	Plant Visit	Visit To Manufacturer's Work	Operation & Maintenance Of Plant
CONTROL & INSTRUMENTATION				
DDCMIS-Man Machine Interface - Hardware & Operating System	Hardware & Software organization of the system	Operational feedback		
	Basis of selection of H/W memory sizing			
	Operating system features, interface with other system, openness & inter- operability			
	Upgradability			
	System testing features			
MANDAYS	16	6		
DDCMIS-Man Machine Interface System Engineering & Application Software	Specific system customisation	Operation feedback		
	Various system			
	modules & interface with OS			
	Database organization & development			
	Development of mimics			
	Other application like calculations, logs historical storage functionalities & use			
MANDAYS	40	6		



PRODUCT	AREAS OF TRAINING REQUIREMENT			
	Product Design	Plant Visit	Visit To Manufacturer's Work	Operation & Maintenance Of Plant
DDCMIS - Control System Hardware	Basic design features for system & its modules	Operation feedback	Manufacturing processes special attention to handling of the modules	
	System capabilities & system design techniques		Maintenance facilities	
	Communication with MMI & other system			
MANDAYS	20	5	10	
DDCMIS- Control system Application Software	Database structure Organisation & interface between application program & database	Operational feedback	System integration & System capabilities testing	
	Application for implementation of Control functions			
	Study of standard algorithms & development of new algorithms			
MANDAYS	12	4	4	
DDCMIS - Control Loop Study Loop Study	General description of closed loop controls of thermal power plant	Specific operational feedback		
	Critical analysis of few control loops e.g., TSCS Stress Control boiler startup control etc.			
MANDAYS	4	2		



PRODUCT	AREAS OF TRAINING REQUIREMENT			
	Product Design	Plant Visit	Visit To Manufacturer's Work	Operation & Maintenance Of Plant
DDCMIS- Burner Management System	Hardware logic, NFPA/ VDE requirements other safety standard	Operational feedback	Manufacturing procedure& precautions for handling the system	
	Flame scanner location		System testing facilities	
MANDAYS	10	3	3	
DDCMIS - EHTC, Turbine stress control system, Turbine protection system& ATRS	Basic design concept& features	Operational feedback	Manufacturing procedure & precautions for handling for handling the system	
	Logics of turbine stress control system		System testing facilities	
	Implementation of failsafe philosophy in turbine protection system			
MANDAYS	10	3	3	
DDCMIS- Burner Management System	Hardware logic, NFPA/ VDE requirements other safety standard	Operational feedback	Manufacturing procedure& precautions for handling the system	
	Flame scanner location		System testing facilities	
MANDAYS	10	3	3	



PRODUCT	AREAS OF TRAINING REQUIREMENT			
	Product Design	Plant Visit	Visit To Manufacturer's Work	Operation & Maintenance Of Plant
PLC	Hardware organization		Manufacturing process of PLC hardware	
	Operating system features		Integration & testing facilities	
	Data base organization			
	Logic/loop algorithm			
	Development of control logic & loop s/w & MMI application development			
MANDAYS	10	-	2	
Electric Power Supply System	Theory & design features		Manufacturing/assembly process	
			Testing methodology	
MANDAYS	5	2		



PRODUCT	AREAS OF TRAINING REQUIREMENT			
	Product Design	Plant Visit	Visit To Manufacturer's Work	Operation & Maintenance Of Plant
(ELECTRICAL) GENERATOR	(a) Design aspects of the following areas	- Operational feed back - Familiarisation with different sub-systems	(a) Manufacturing process for	
	- Insulation system		- Core	
	- Cooling medium & arrangement		- Winding bars	
	- Winding & core support systems		- Assembly	
	b) Design aspects of other auxiliary systems		(b) Testing facilities	
MANDAYS	30	15	15	
Generator Excitation System (Brushless/Static Excitation) including AVR.	Design features of various sub-systems	- Operational feed back - Familiarisation with various equipment functioning at reference plants	-Manufacturing process & testing facilities for various equipment of excitation system	
	Excitor			
	PMG			
	Transformer			
	Controllers & different limiters etc.			
	PSS & associated system studies			
MANDAYS	30	15	15	
EMS and IEMS	Basic design concept& features	Operational feedback	Manufacturing process	
	Hardware organization			
	Operating system features		Integration & testing facilities	



PRODUCT	AREAS OF TRAINING REQUIREMENT			
	Product Design	Plant Visit	Visit To Manufacturer's Work	Operation & Maintenance Of Plant
	Development of logic & MMI application development			
MANDAYS	10	5	5	
SAS	Basic design concept& features	Operational feedback	Manufacturing process	
	Hardware organization			
	Operating system features		Integration & testing facilities	
MANDAYS	5	2	2	
Boiler Feed pump H.T. Motor	Design Criteria for the Stator core & wdg Rotor core & wdg Insulation system Cooling arrangement	Operational feed back	Manufacturing process & test facilities	
MANDAYS	10	5	5	



Tamil Nadu Generation and Distribution Corporation Ltd.

2 X 660 MW Udangudi Supercritical Thermal Power Project

TENDER ENQUIRY DOCUMENT FOR EPC CONTRACT

[BID SPECIFICATION No. SE/C/UP/EE/E/OT No. 01/2015-16]

VOLUME - II

SECTION - 2

DETAILED TECHNICAL SPECIFICATION - MECHANICAL

FICHTNER Consulting Engineers (India) Private Limited
Chennai, India



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VOLUME – II
SECTION – 2
DETAILED TECHNICAL SPECIFICATION - MECHANICAL

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**VOLUME- II****SUB-SECTION - 2.1****STEAM GENERATOR AND AUXILIARIES****1.0.0 GENERAL**

This section covers minimum requirements for design, engineering, manufacture & assembly, inspection, erection, testing commissioning and performance testing of Pulverized coal fired Super critical Steam Generating units along with its auxiliaries to well established engineering practices, safety codes and other relevant codes and standards.

The steam generators shall be of supercritical, once through type, two pass (gas path), water tube, direct pulverized coal fired, (preferably tangentially fired with tilting burners) balanced draft furnace, single reheat, radiant furnace, using spiral wall (inclined) or vertical plain / rifled type water wall tubing and the evaporator shall be suitable for variable pressure operation from sub critical to supercritical pressure range and suitable for outdoor installation. Items though not specifically mentioned but needed to complete the equipment and systems to meet the intent of specification, shall be deemed to be included in the scope of work of Contractor. The scope of supply and services for each steam generating unit shall include all items but will not be limited to this specification.

2.0.0 CODES AND STANDARDS

- All equipment, systems and work covered under this specification shall comply with all latest statutes, regulations and safety codes, as applicable in the location where the equipment will be installed.
- All the parts of the steam generator including pressure parts, vessels, piping, valves including safety valves and fittings shall meet or exceed all the requirements of latest editions of Indian Boiler Regulations (IBR).
- Any other standards acceptable to IBR can also be considered, provided the requirements of those standards are equivalent or exceed the IBR requirements.
- Wherever the specification stipulates requirements in addition to those specified in IBR, the same shall also be complied by the Contractor.
- In cases where IBR does not govern, other international standards established to be equivalent or superior to the codes and standards specified, are also acceptable. However, in the event of any conflict between the requirements of the equivalent codes and standards, and the requirements of the Indian standards/ regulations, the latter shall govern, unless, specified otherwise in the specification.
- It shall be responsibility of the Contractor to obtain the necessary approvals of Inspection Authority/ Chief Inspector of Boilers on behalf of the Owner, as may be required for designing and design calculations, manufacturing and erection procedure, testing etc. as called for under the IBR. It includes Registration of boiler erection and inspection fees to be paid, obtaining certificates to use the boiler, steam testing and obtaining Register number including Co-ordination with Boiler inspectorate, arrangement of visit to site by Director of Boiler, Deputy Director of boiler, etc., All such documentation submitted to statutory authorities shall also be submitted to the Owner for his review. It shall also be the responsibility of the Contractor to furnish the requisite documentation as required by the Owner for getting the Steam Generator registered under IBR.



- Codes/Standards for integral piping and valve shall be ANSI B 16.34 and ANSI B 16.25 (valves), ANSI B 31.1 (for piping) and ANSI B 16.5 (flanges), ASTM-A-335, ASTM-A-106, SA 210 and SA 213 (High Pressure / temperature piping and tubing). Wherever definite design stipulations are not available in the IBR, the ASME Section- I and IBR (for Steam Generator Integral Piping) shall be referred.
- The steel structures and foundations shall be designed for earthquake conditions as per IS-1893 and wind loads as specified in IS-875.
- Manufacturing standard can be considered in the absence of codes and standards on a case-to-case basis and subject to Owner's approval.
- Boiler efficiency shall be calculated based on ASME PTC-4.0 (energy balance method) (Loss method without credits) / B S EN12952-15,2003 (Loss method without credits)

3.0.0 SCOPE OF SUPPLY

3.1.0 Water/ Steam System

Complete steam/water cooled furnace with separators, water wall headers, drains, drain funnels, drain pipelines up to and including startup flash and drain tanks and necessary stubs for chemical cleaning and wet lay up. Two retractable type temperature probes with duplex type elements at the furnace outlet, along with supports, cooling arrangements, position indicators etc.

Adequate no. of steam-water separators along with separator storage tanks at the evaporator outlet, of welded construction, along with all internals, safety valves, mountings, fittings, nozzles, manholes, instrumentation tappings, valves, drains, pipings and its fittings, etc.

Complete Start-Up Recirculation and Drain System Comprising:

- 1 x100% start-up recirculation pump complete with motor and cooling water lines, connecting pipe work between separator/ drain collection vessel.
- One motorized and One manual isolation valves at suction of start-up recirculation pumps and Motorized isolation, electrohydraulic operated control valves and Non return valves at discharge of the start-up recirculation pumps.
- Inlet feed water pipeline along with necessary separator and its collection vessel, level control and valves.
- Pump minimum flow control valve and recirculation flow control valve.
- Mixing box at pump suction, a non-return valve upstream of the Mixing box on the recirculation line from separator, along with necessary piping and valves.
- Piping with necessary level control valves from separator/ drain collection vessel to start-up flash tank. A start-up and emergency drain control valve upstream of flash tank with a motorized isolation valve upstream of drain control valve.
- 2 x 50% drain pumps with necessary isolation valve, control valve, minimum flow facility and piping up to condenser . The pumps are designed for the worst operating scenario including the start up without Boiler start-up recirculation pump in operation and entire flow diverted to condenser.
- Start up flash tank, drain tank with all piping, headers, valves, supports and hangers, insulation, tank level control system, and instrumentation etc.
- Start-up flash tank with drain piping up to station drains, to be cooled by service water system by the Contractor.
- All level controls, electro-hydraulically operated fast acting valve with safety features, their isolating valves, bypass/ non-return, drain valves etc. for the start-up circuit.
- Separator safety valves with drain pans.



- l) External high pressure cooler for each motor rated for 100% duty to remove the heat generated by the motor and bearings during operation.
- m) Steam Water analyzer system.

Complete evaporator, superheater and reheater system, including headers, connecting pipes, vents, drains, drain funnels, pipelines up to flash and drain tank, nitrogen connections, sampling connections, start-up lines, safety valves with silencer and drain pans etc.

Electromatic valves on SH and RH outlet), complete with solenoid valve assembly, pressure sensing device, impulse piping, accessories, necessary instrumentation etc., and a remote operated motorized isolation valve on the upstream side of each Electromatic valve.

Desuperheater system for superheaters and reheater each comprising of :

- a) 2 x 100% pneumatic control stations for each desuperheater rated for full duty.
- b) One (1) No.pneumatic/motor operated isolating valve upstream of each control valve
- c) Two (2) Nos. electrically operated isolating valve downstream of each control valve
- d) Quick acting block valve (pneumatically operated) at upstream of superheater spray control station on the common super heater attemperation line.
- e) One non-return valve on the spray water line near the spray point.
- f) Drain valve at after downstream of non-return valve to clear spray nozzle blockage.
- g) One flow nozzle on each spray water line

All startup vents shall be provided with two valves in series – one motorized isolating and other motorized regulating type.

All start-up vents, first lowest and second lowest set pressure safety valves electromatic relief valves at superheater & reheater outlets, first lowest and second lowest set pressure safety valves on the water separators shall be provided with silencers.

Non steaming type Economiser system with connecting pipes, headers, etc. with non-return valves ,vents , drains and sampling connections.Feed line shall consists of non-return valves and flow element as near as the inlet.

Steam Generator integral piping consists of valves and fittings, feed check valves, motorized main steam stop valve with integral motorized bypass valve with actuators including hand wheel, motorised drain/vent valves, safety valves and electromatic safety valves for separator, superheater and reheater (as applicable) ,Safety valve escape pipings and start up vent line with silencers, drip trays, shock absorbers etc.

Complete steam and water sampling lines with sample coolers & collectors, cooling water distribution lines, chemical feed line, drain lines, vents, tanks, all necessary stub connections with isolating valves for chemical cleaning and lay up of Steam Generators including nitrogen capping connections, nitrogen piping system up to the isolating valves for capping of separator, super heater and reheater.

Necessary specialties in the steam and feed water, spray water lines, steam generator startup and warm-up system.

All fittings and mountings.

Steam Generator inner Casing, outer sheet steel casing, Aluminium sheet casing/insulation jacket for equipment, frames and supports, buck stays, tie bars wherever necessary.

Adequate number of doors and ports necessary for access, inspection and supervision including service air nozzles and connecting piping.

Non – Return valve and isolation valve for boiler fill line.



3.2.0 Combustion System

- Furnace with Front, Opposed or tangential firing system. Preferably tangential firing system.
- HSD & HFO burners complete with actuators, piping & valves, HEA ignitors, flame detectors and all necessary accessories, etc.
- Coal burners and wind box complete with registers, flame detectors for each burner.
- All necessary fuel air dampers and secondary air dampers and respective controls.

3.2.1 Heavy Fuel Oil Firing Equipment

- HFO burners completes with diffusers, actuators, flame detectors, shut of valves, tips extension pipes for each burner and its ancillaries.
- All integral piping for heating steam, condensate, atomizing and scavenging steam to connect the various equipment.
- HFO supply and return lines

3.2.2 HSD Start-up System

HSD burners, complete with actuators, flame detectors all pipes and valves for HSD and two quick acting valves for each burner. All integral piping for atomizing and purging air.

3.2.3 Ignition System

High Energy Arc (HEA) ignitors for each HFO & HSD burners completes with transformers, control cabinets, cabling, etc.

Individual oil burner shall be provided with IR type or a suitable flame scanner.

3.2.4 Scanner Air System

Scanner air supply system with fans 2 Nos. AC drives (1 No. from normal supply and 1 No. from normal/emergency AC supply) along with required ductings.

3.3.0 Coal preparation and firing System

- Pneumatically operated sliding type shut off gate at each Coal bunker outlet gates with proper approach and Electrically operated (shut off gate at each coal feeder inlet).Chain wheel and chain shall be provided for above said shut off gates for manual operation for from feeder floor.
- Coal chutes to feeder inlet and from feeder outlet to pulverizer with remote operated shut off gate.
- Gravimetric Coal feeders, together with variable speed drives.
- Coal pulverizers complete with drives, outlet gates and classifier
- Pulverized coal piping from pulverizer to coal burners along with coupling, supports, and sampling device.
- Pulverizer inerting system with necessary piping, valves, fittings and supports.
- Primary air system, including ducts, dampers, shut-off gates, 2 x 60% BMCR capacity primary air fans with blade pitch control complete with drives, Control system and forced lubrication system and bird screen and rain protection hood.
- 2 x 100 % Sealing air fans with drives and seal air piping to pulverizers.
- Dampers in pulverizers and seal air system.
- Bunker emptying Chute shall be provided upto ground to unload the coal from bunker to trucks.



- Detecting instruments to detect choking, flow and no flow of coal between bunker and feeder.

3.4.0 Combustion air System

- Two (2)Nos. axial type forced draft fans (2x60% BMCR capacity), complete with motors, forced lubrication system with blade pitch control for air flow control including filters, bird screen and rain protection hood.
- Two (2)Nos. axial type Primary Air fans (2x60% BMCR capacity), complete with motors, forced lubrication system with blade pitch control for air flow control including filters, bird screen and rain protection hood.
- Two (2) steam coil air preheaters in secondary air bypass duct, complete with common condensate tank, integral piping, control and isolation valves for steam and condensate along with necessary controls. The condensate to be feed to the flash tank through steam trap.
- Two (2 x 60% BMCR capacity) tri sector type regenerative air pre heaters, complete with washing drives, fire fighting devices and fire alarm devices and rotor stoppage alarm.
- Air ductwork up to wind box with necessary dampers, expansion joints, silencers and supports.

3.5.0 Flue Gas System

- Electrostatic precipitator, complete with all necessary electrical equipment, structure, insulation and cladding and dust handling equipment with mono rail and electric hoists for transformer-rectifier sets.
- Wear resistant plates in flue gas ducts at corners and direction changing areas (min 5 mm thick)
- Two (2 x 60% BMCR capacity) Nos. axial type induced draft fans complete with motors and forced lubrication system with blade pitch control for air flow control
- Flue gas duct work inclusive of dampers and expansion joint with supports up to the chimney.
- Continuous Emission Monitoring system (CEMS for Sox, NOx, SPM, CO and CO2) etc.

3.6.0 Steel Structure, Wall cladding, insulation and Casing

- Complete structural steel works for Steam Generator, coal bunker, lift, lift shaft, pipe (and belt conveyor bridges) and for auxiliary equipments.
- Foundation bolts and anchor channels for all equipment supplied.
- Complete buck stays and tie bars.
- All necessary access galleries, stairways ladders and platforms.
- Roof and wall cladding for the Steam Generator pressure parts including main platforms, safety valves, blow-off valves, etc.
- Roof and wall cladding for lift shaft and staircases
- Protection sheds (or hoods) for all fans
- Steam Generator inner casing wherever necessary.
- Steam Generator outer sheet steel casing, Aluminium sheet casing/insulation jacket for equipment including hot air ducts.
- All necessary lagging, metallic cladding and insulation for all the equipment.

3.7.0 Steam Generator Accessories

- Electrically operated automatic sequential type intelligent soot blowing system for furnace, super heaters, convective and radiant heating surfaces ,air preheaters and economizer complete with necessary piping, PRDS valves, spray control valve and other specialties



with instruments and controls as required for carrying out on load cleaning. Washing water hoses and supply lines for off load cleaning of heating surfaces.

- Auxiliary steam system including High and low pressure control station (Electro Hydraulic/ Electro Pneumatic), desuperheater, spray control station, downstream piping and valves upto equipment e.g. SCAPH, air preheater soot blowers, oil burners (with atomisation), fuel oil heaters etc. using auxiliary steam.
- Utility stations for air, steam and water from connection branch of main distribution supply up to the consumer, including hoses, hose couplings and isolating valves.
- Two(2) Numbers of 3000 kg capacity passenger-cum-goods lift for each Steam generator with necessary landings and interconnecting platforms to the TG buildings at required elevations.
- Fire fighting equipment for steam generator, complete with all integral pipes, valves, nozzles, hoses.
- Burner maintenance trolley along with accessories
- Electric operated maintenance & Steam Generator inspection cradles (sky climber) for fast inspection and repair of all the walls of combustion chamber.
- Temporary piping/valves for boil out and acid cleaning/EDT
- Temporary piping/valves for Steam Blowing
- Equipment and provisions for stand-still conservation (storage) of the steam generator. Nitrogen gas pipeline, valves & fittings for connection to Steam generator.
- Mill reject handling system
- Furnace Safeguard Supervisory system
- Supply and application of paints as required.
- Auxiliary Boiler.
- All other accessories and auxiliaries as required.

3.8.0 Sampling

Sample coolers with entire stainless steel piping from sampling point including a collecting rack positioned at SWAS room at TG area for the following services:

- a) Water and steam sampling at steam-water separator.
- b) Main Steam Sampling.
- c) Feed Water at inlet to Economiser Sampling.
- d) Condensate sampling.
- e) Reheat steam sampling.

3.9.0 Pipes and Valves

Complete high pressure and reheat steam system, feed water and spray water pipe work and accessories required for use including valves, funnels, headers, silencers, steam traps, measurement devices, mountings and fittings for the auxiliary systems of the Steam Generator such as venting, drainage, atomizing and purging steam, steam coil air heater steam and condensate, soot blower steam, fire fighting water, Steam Generator & regenerative air preheater water washing, cooling water, cooling air, sealing air, service air, instrument air and inert gas system.

Auxiliary steam header for each unit and interconnecting piping between unit auxiliary steam headers sized for auxiliary steam requirement for start-up of other unit plus the steam requirement for fuel oil unloading and heating.

Auxiliary piping system, auxiliary cooling water, fuel oil, Mill inerting, atomizing steam, scanner air system, etc along with Pipe supports and associated structural works as required.



4.0.0 DESIGN REQUIREMENTS

The requirements specified are the minimum design and sizing requirements for the steam generator and its auxiliaries. Contractor's utilization of various values and requirements indicated in this specification shall in no way relieve the Contractor of his responsibilities to meet all guarantee requirements or of providing completely safe and reliable operating equipments/ systems.

The specified requirements shall be complied for the most stringent conditions resulting either from the range of coals specified or from the range of operating conditions specified (like 100% BMCR or HP heaters out or variable/ constant pressure operation etc.), or from both occurring simultaneously, unless otherwise specifically mentioned by the Owner.

Steam Generator and its auxiliaries shall be sized for 60% BMCR condition for single stream operation.

Typical characteristics of specified range of coals in General technical specification such as high abrasive, slow burning, high ash resistivity etc shall be given due consideration while designing Steam generator and its auxiliaries.

The design of Steam Generator shall comply with the design requirements set out in this section and also meet the requirements specified in Annex 2.1.1 - Specified Design Data

4.1.0 Steam Generator Rating

Boiler maximum continuous rating (BMCR) : Steam flow at superheater outlet shall correspond to at least 102% of the steam flow at turbine inlet under VWO (Valves wide Open) with 0% make up, design CW inlet condition plus continuous steam requirement for auxiliary systems of the unit (e.g. fuel oil heating etc) .

Steam Temperature

At Super Heater outlet : HP turbine inlet temperature plus temperature drop in HP main steam piping from Steam Generator SH outlet to HP steam turbine inlet.

At Reheater outlet : IP turbine inlet temperature plus temperature drop in hot reheat steam piping from Steam Generator RH outlet to IP steam turbine inlet.

Temperature control : The steam temperatures at superheater and reheater outlet(s) shall be guaranteed to be maintained at $\pm 5^{\circ}\text{C}$ of the rated value at all loads within control range (60% TMCR to 100% BMCR), under all operating conditions when firing specified range of coals.

Feed water temperature at economizer inlet : To be based on the turbine cycle optimization. The steam generator shall also be suitable for accepting feed water at low temperatures corresponding to HP heaters out of service condition without exceeding any of its design limits including design metal temperature.

**Steam Pressure**

At superheater outlet	: HP turbine throttle steam pressure plus pressure drop in HP steam piping.
At reheater outlet	: IP turbine throttle steam pressure plus pressure drop in HRH steam piping.
Steam generator control range	: 50% TMCR to 100% BMCR. However, the contractor to specify the feasible mill combinations below 60% TMCR.
Efficiency of Steam Generator	: The efficiency of the steam generator (on high heat value basis) in % as guaranteed by the manufacturer, shall not be less than the value as arrived with the following formula for the quality of performance coal. Minimum Steam Generator efficiency (%) = $92.5 - \frac{(50 \times A + 630(M + 9 \times H))}{HHV}$

Where,

A= % of ash in fuel

M=% of moisture in fuel

H=% of Hydrogen in fuel

HHV= High heat value of fuel in Kcal/kg.

4.2.0 Fuels**A) Coal**

- The steam Generator shall be designed for the range of coals and ash as specified in the General Technical Specification.
- Correction curves shall be furnished by the bidder for the variation of coal quality parameters for making adjustment on calculated efficiency during performance guarantee test of the unit(s).
- The steam generator and its auxiliaries shall be capable of giving BMCR rating and other operating capabilities without any trouble and limitations, when firing the specified range of coals.

B) Fuel Oil

- The characteristics of heavy fuel oil (HFO) and High speed diesel (HSD) are specified in the General Technical Specification.
- HFO shall be used for start-up, coal flame stabilization and low load operation of the steam generators.
- HSD firing facilities shall also be provided for cold start ups of the steam generator(s).
- The design and construction of the steam generator shall be such as not to call for any other liquid or gaseous fuel than that specified for purpose of operation of the steam generator at low load including initial ignition.
- High energy arc (HEI) igniters shall be used for ignition of HFO/HSD fuel oil directly.

4.3.0 Ambient Conditions

The steam generator and its auxiliaries shall also be sized that they are capable of giving BMCR within the range of ambient air conditions as specified in the General Technical Specification.



4.4.0 Limiting Parameters for Steam Generator Design

The steam generator design shall comply with the following limiting parameters while firing specified range of coal, under reference ambient air condition as specified in the Specification.

- i) Excess air at economiser outlet at TMCR load: 20% (minimum). In furnace no air leakage shall be considered by the bidder while sizing FD fan. Bidder shall indicate the minimum excess air & unburnt carbon loss at which unit can be operated on sustainable basis meeting all other requirements for the range of coal specified.
- ii) Flue gas temperature at air-heater outlet (corrected) at TMCR load: 125 °C (minimum).

4.5.0 Operating Modes

The steam generator shall be designed for all the operating modes and operating conditions specified in General Technical Specification.

The design of steam generator shall such that it does not call for any oil support beyond 30% BMCR load when firing any coal from the range specified with adjacent mills in service and mill load not less than 50% of its capacity. This shall be guaranteed and demonstrated by the Contractor.

In case of sudden load throw-off, in worst case from 100% BMCR, the steam generator shall be capable of automatically bringing down the steam generating capacity to match with HP-LP bypass capacity of 60% BMCR flow considering main steam parameters at the upstream of valves and CRH steam parameters corresponding to 60% TMCR condition on the downstream.

Steam generator shall also be capable of satisfactory, stable and safe operation in case of rapid load changes in downward direction due to external disturbances or equipment malfunction. Under such conditions the system shall stabilize itself through proven concepts and controls and within the recommendations of National Fire Protection Association, USA(NFPA), Section 85 C, 8502 and 8503

Bidder can offer either 1x100% or 2x50% bypass valves to suit the layout. The bidder to indicate minimum load of steam generator to which it can be brought down under such condition, during short turbine outages or export load rejection, with a view to save fuel and reduce heat losses. The unit shall be capable to operate at house load conditions.

The steam generator shall be designed to operate for sliding /modified sliding pressure operation. Thermal design of steam generator and selection of materials shall be suitable for both the operational modes.

4.6.0 Operation without HP heaters in service

Steam generator shall be designed for continuous operation with HP heaters out of operation. The steam generator heat output under HP heaters out condition shall be equal to at least 100% BMCR heat output with HP heaters in service.

For two stream HP Heaters configuration, plant output shall not be less than 100% TMCR with one stream of HP heaters out condition.

For single stream HP Heaters configuration plant output shall not be less than 100% TMCR with any one of the HP Heaters out of operation.

Under this condition the superheater and reheater outlet steam temperature shall be maintained at rated values within the whole control range of steam generator load. Further,



during such operation the metal temperature of various pressure parts shall not exceed the limits stipulated in their design/ selection.

4.7.0 Operation with/ without Turbine HP- LP Bypass System

As specified elsewhere, when unit trips under full load, HP-LP by-pass system will come into service. This will call for Steam Generator operation in HP-LP bypass mode, with SH flow of 60% BMCR capacity and feed water temperature corresponding to bypass operation at economizer inlet. For such condition the economiser shall be suitably designed to take a thermal shock of sudden change of feed water temperature due to bypass operation.

Irrespective of the fact that HP-LP bypass system is provided for smooth start-up, fast loading and house load operation of the unit; the steam generator shall also be capable of start up without HP-LP bypass system in service.

4.8.0 Rate of Loading

The steam generators shall be designed for minimum rate of loading/ unloading specified in the General Technical Specification from 50% to 100% (TMCR) loads without compromising on design life of pressure parts. Bidder shall clearly bring out the max. rates of loading/ unloading achievable with steam generator offered and the corresponding limiting variations (+ %) of Steam Generator parameters such as throttle pressure, oxygen in flue gas, SH steam temperature, RH steam temperature, furnace draft, etc.

4.9.0 Provision for Future Installation of FGD System

A flue gas desulphurisation (FGD) system may be installed by the Owner in future to meet the requirements of pollution control.

Following provisions needs to be kept by the bidder for this purpose:

- a) Suitability of duct between ID fan and chimney for future interconnection of FGD system with minimum modification.
- b) The ducting and supporting structure to be designed to take care of future guillotine damper to be installed between the two tap offs before chimney.

The space provided for FGD shall not be occupied for other purposes.

4.10.0 Furnace

Furnace shall comply with requirements specified in the Annex 2.1.1-Specified Design Data at 100% BMCR with or without HP heaters out of service and with range of specified coals, under most stringent combination of operating conditions.

Definitions of Acronym/terms used in the Annex 2.1.1-Specified Design Data.

- a) Burner zone is defined as the centre line distances between the top and bottom burner plus 3.05 meters of furnace height. Further, heat input is the input from coal.
- b) For FEGT, the furnace exit plane shall be defined as the plane above the furnace nose tip or the plane beyond which the transverse tube pitching is less than 600 mm whichever is positioned first in the flue gas path.
- c) Furnace cooling factor in kcal/h/m² is the ratio of NHI or heat available and effective projected radiant heat absorbing surface (EPRS). Calculated EPRS shall be reduced by at least 10% to account for deterioration of furnace walls surface condition due to fouling and slagging.
- d) NHI or heat available in furnace is obtained by considering the GCV of the fuel minus the radiation loss, unburnt combustible, moisture in the air, latent heat of moisture in fuel and



- that formed by combustion of H₂ in the fuel plus the sensible heat of combustion air (primary plus secondary air), all above 27°C.
- e) Furnace residence time shall be defined as the residence time of the fuel particles from center line of the top elevation coal burners to the furnace exit planes. For this purpose the furnace exit plane shall be defined as the horizontal plane at the furnace nose tip for two pass Steam Generators.
 - f) Pressure withstand capability of the furnace shall correspond to minimum +/- 660 mmwc at 67% yield strength or maximum expected pressure/draft of fans, whichever is higher.
 - g) To protect tubes against falling clinkers, the following shall be considered
 - Wear bar at hopper panel tubes area or
 - Providing additional thickness on the spiral tubes for the hopper portion.
 - h) Lower side of hopper panel exposed to sea water to be protected with shield plates.
 - i) Boiler columns shall be encased with RCC up to 8 m to avoid corrosion.
 - j) The makeup water for Bottom ash hoppers shall be sea water. The arrangement of pump (LP pump) for make up to the Bottom ash hopper to be furnished.

Maximum heat liberation rate is defined as the ratio of NHI (or) heat available and furnace volume.

Maximum burner zone heat release rate is the ratio of NHI (or) heat available to the burner zone area.

4.11.0 Pressure parts

The design of all pressure parts (tubes, headers, vessels etc.) shall be as per IBR or other international codes with the approval of the Owner.

Design pressure of the Steam Generator pressure parts shall be at least 1.05 times the maximum operating pressure, or as required by IBR/ other international codes, whichever is higher. Further, maximum operating pressure for design of the steam generator parts up to separator(s) inlet shall be arrived at by adding an additional margin for the increased pressure drop in the evaporator tubing due to scaling during operation over a period of time. This additional margin shall be equal to atleast 5% of maximum operating pressure with evaporator tubing without scaling or actual expected increase in the pressure drop in water wall/ evaporator section, which ever is higher.

The thickness of the pressure parts (steam and water tubes/ headers, pressure vessels etc.) shall be calculated using IBR formulae/factor of safety etc. (and not as per codes/ formulae non acceptable to IBR). Such thickness as per IBR formulae shall be arrived at after allowing for tube bend thinning allowance, where applicable as per IBR/ international codes. Additional erosion allowance on the calculated tube thickness shall be provided at specified locations as specified by the Owner in these specifications.

In line with IBR, the maximum permissible temperature/ metal temperature for design of different components of the Steam Generator shall be considered as specified in the Annex 2.1.1, Specified Design Data.

Materials used for Steam Generator tubing, headers, piping, vessels and other pressure parts shall comply with maximum permissible temperature limits for various materials as specified in the Annex 2.1.1, Specified Design Data.

4.12.0 Steam Generator Startup Recirculation and Drain water system

The startup recirculation & drain system shall be designed for maximum possible recirculation & drain flow under all possible normal, abnormal conditions.



The circulation system shall ensure adequate circulation during start up, and low load operation of the system.

The start-up drains shall also be routed to the main condensers of the steam turbines through flash tanks, valves etc.

The recirculation system piping and components shall be sized so that the start up and shut down is possible even without the availability of the start-up recirculation pump.

4.13.0 Super heaters and Reheaters

Spray water for superheater attemperation shall be tapped off from a suitable source upstream of HP heaters (from BFP discharge or Kicker stage outlet). The bidder can also tap off the spray water from a suitable location downstream side of HP heaters, provided, bidder has experience of such tapping, details of which shall be provided to Owner.

The steam generator design shall ensure that rated RH outlet temperature is achievable for the entire range of operation by use of primary control device only, while firing from the specified range of coals and all the following operating conditions:.

- a) Normal operation.
- b) Operation of steam generator with reduced feed water inlet temperature during the conditions of HP heaters out of operation and/or HP-LP bypass operation.
- c) Continuous operation of steam generator at BMCR conditions.
- d) Unit start-up.
- e) With middle mill combination at 100% TMCR load.

The RH spray water shall be tapped from BFP interstage, however, be used for temperature control in case of emergency conditions.

Maximum allowable spray water flow for superheater and reheater shall be as per the requirements specified in the Annex 2.1.1-Specified Design Data. Superheater and reheater desuperheating spray systems complete in all respects and conforming to ASME standard no. TWDPS, Part-1

The steam temperature downstream of desuperheater shall have at least 10°C super-heat to ensure proper evaporation.

4.14.0 Economiser

Economiser design shall comply with the requirements specified in the Annex 2.1.1, Specified Design Data.

Economiser shall be non steaming type.

Economizer shall be designed to preclude the possibility of evaporation at any load, startup constant pressure and sliding pressure operation. The design of the economiser shall be such that the tube elements can be easily replaced when necessary.

4.15.0 Air Pre-heater

The design of air pre heater shall take care of the problems of corrosion at low temperature end of air heater.

The air pre heater shall be suitable to take care of the high ash content of the coal, sulphur content of the coal and fuel oil.



Air pre heater design shall also ensure that there is no need for economiser bypass to get the desired mill outlet temperature, for the whole range of specified coals.

Air Pre heater Design shall comply with requirements specified in the Annex 2.1.1-Specified Design Data.

Design ambient condition for air pre heater design is the reference ambient condition specified condition in the Annex 2.1.1-Specified Design Data.

4.16.0 Steam Coil Air Pre Heater (SCAPH)

Steam Coil Air Pre Heaters (SCAPH) shall be designed and sized to increase the air heater inlet temperature based on minimum ambient condition specified in the General Technical Specification.

Design of SCAPH and connected bypass duct work suitable to handle flows corresponding to 60% BMCR loads without any undue noise/vibration.

4.17.0 Auxiliary steam PRDS

Auxiliary steam pressure reduction and desuperheating station shall be sized based on the criteria specified in the Annex 2.1.1-Specified Design Data.

4.18.0 Coal Firing System

A) Coal Pulverisers

- Mills shall be located by the side/front of the boiler.
- The mills offered by the bidder can be of Vertical spindle Bowl type
- Bidder shall guarantee the wear life of mill wear components (for whole range of specified coals) specified in the Annex 2.1.1- Specified Design Data.
- The bidder shall indicate YGP (Yancey, Geer and Price method) index considered for design of wearing components, and shall furnish curves along with his offer indicating the variation in guaranteed wear life with variation in quality of coal fired. Separate curves for different wear elements of mill shall be furnished i.e. grinding rolls, balls, rings etc. The curve shall be subject to Owner's approval.
- Bidder shall provide mill correction (HGI, Moisture, Finess, Ash and Worn out condition) and mill performance curves after award of Contract.

There shall be N+1 standby mill available for 100% BMCR with worst coal & N+ 2 standby mills available for 100% BMCR with design coal.

- Design criteria for coal pulveriser shall be inline with the requirements specified in the Annex 2.1.1, Specified Design Data.

B) Pulversied Coal Pipe and Coal Feeders

- Coal piping and feeder system design shall comply with the requirements specified in the Annex 2.1.1- Specified Design Data.



C) Primary Air Fans & Seal Air Fans

- Design criteria for primary air fan and seal air fan shall comply with the requirements specified in the Annex 2.1.1- Specified Design Data.
- Design ambient condition for fan is maximum ambient condition specified in the General Technical Specification.

D) Coal Burners

- Coal burner shall be designed based on the criteria detailed in the Annex 2.1.1, Specified Design Data.

4.19.0 Fuel Oil firing system

- Fuel Oil firing system shall be designed based on the criteria detailed in the Annex 2.1.1, Specified Design Data.

4.20.0 Draft Plant

The forced draft (FD) fans and induced draft (ID) fans shall be capable of maintaining balance draft conditions in the furnace over the entire load range with any one or both FD fans and any one or both ID fans in operation while burning the specified whole range of fuels.

Fans shall have stable characteristics suitable for parallel operation and sharing of the load equally without hunting over the entire load range.

The selection of fan type as well as its type of control shall be based on the requirement of maintaining stability of flow and maximum possible fan efficiency, from its test bed rating point down to the minimum continuous fan discharge that may be required during any part-load operation of the plant.

Fans shall be designed to bring the critical speeds well outside the respective operating ranges.

Complete detailed calculations of fan sizing shall be submitted after award of contract.. These calculations shall be subject to approval by the Owner.

Both FD and ID fans shall be sized based on the criteria specified in the Annex 2.1.1, Specified Design Data.

The sizing criteria specified in the Annex 2.1.1, Specified Design Data shall consider air heater and ducts in normally fouled up condition. The static pressure requirements only shall be considered without any credit for velocity pressure recovery.

4.21.0 Flue Gas Ducts and Air Ducts

Flue gas and air ducts shall comply with the requirements specified in the Annex 2.1.1, Specified Design Data.

Minimum thickness of 7 mm shall be provided for flue gas ducts before ESP and 6 mm from ESP outlet to chimney.

Minimum thickness 5 mm shall be provided in the air ducts.



Wear resistance plates made out of tougher material such as boron carbide, tungsten carbide, etc., shall be provided in flue gas ducts at corners and direction changing areas (min 5 mm thick)

Corrosion allowance of 1.5 mm shall be considered for stress calculation for gas ducts.

4.22.0 Electrostatic Precipitator Design Data

The electrostatic precipitator(s) shall be designed to comply with the requirements stipulated under 'guarantee point' and 'design point' specified in the Annex 2.1.1, Specified Design Data.

The minimum specific collection area shall change in inverse proportion to the spacing between collecting plates i.e. for collecting plate spacing of 300 mm, the minimum specific collection area shall be $240 \text{ m}^2/\text{m}^3/\text{s}$ for worst coal firing with one field out of service at 100% BMCR condition and for collecting plate spacing of 400 mm, the minimum specific collection area shall be $180 \text{ m}^2/\text{m}^3/\text{s}$ for worst coal firing with one field out of service at 100% BMCR condition

The corona power shall be defined as the product of, average bus voltage and mean current divided by the collection area served by one TR set.

Bidder shall furnish the detailed calculations in support of ESP gas flow, inlet dust burden, ESP efficiency as offered by him both at ESP design and guarantee points during detailed engineering.

4.23.0 Other Features

Steam generator shall be suitable for firing all the range of coal and worst coal as specified .It shall be capable of giving guaranteed max. continuous output under the most adverse condition satisfactorily. Performance coal shall be considered for guarantee purpose. For the designing of steam generator for worst fuel type, the maximum / minimum range of coal constituents shall be considered.

The Steam Generator and its integral piping, valves and fittings shall be designed so that any proposed acid cleaning process (if required) may be carried out without any need for exchanging valves during cleaning procedures which may come into contact with the cleaning liquid.

In case of accidental interruption or failure of any important equipment the change to the stand-by unit shall be achieved automatically without shut-down of the Steam generator concerned. If that is not possible in some cases the Steam generator shall be run down to minimum load as quickly as possible or shut-off safely. Special consideration must be given in the design of the equipment to the notable seismic activity in the region.

The steam generator and its auxiliaries shall be designed to operate at full load(100% BMCR) even at the frequency of 47.5 Hz.

The furnace size shall be designed in such a way that there shall not be any flame impingement on water walls on any face of the furnace walls, no accumulation of slag on the walls, tubes or hoppers or other part of the Steam generator unit that will interfere with the continuous operation of the unit and no fouling in superheaters when burning range of coal specified and under all conditions of load up to the maximum output which can affect the reliability of the unit.

The gas velocities shall be selected considering ash content of the fuel. The gas passages shall be designed to ensure a smooth flow without any abrupt change in direction. Erosion



problems in tubes shall be taken care of by providing low gas velocity and least nos. of baffles, screens etc. The erosion allowances considered in tube design shall be clearly indicated.

5.0.0 CONSTRUCTION REQUIREMENTS

5.1.0 Steam Generator startup recirculation system

The Recirculation Pump shall be hermetically sealed glandless zero leakage type without requiring any external sealing arrangement.

The pump and motor shall be hermetically sealed, of heavy-duty design and construction, shall be provided with necessary handling arrangement and shall be suitable for the maximum operating pressure and temperature.

The pump-motor sets shall be submerged in Steam Generator water and shall be mounted on the steam generator re-circulating system. The motor shall be mounted below the pump.

The pump casing shall be one piece casting with end suction and single discharge or forged construction with welded inlet and outlet discharge nozzles. The impellers shall be one-piece casting secured to the shaft in overhung position on the extended motor shaft. The impeller mounting shall allow the hub to freely expand and contract independent of the shaft.

Bearings shall be lubricated by liquid in motor cavity. Bearing material shall be leaded bronze impregnated with polytetra fluora ethylene or equivalent subject to approval of Owner.

The entire pump and motor shall be enclosed in a pressure tight casing, motor being protected from the high temperature fluid inside the pump casing by a suitably designed thermal throttle. The motor shall be of Wet Stator Construction. The liquid inside the motor shall be circulated by an impeller mounted on the motor shaft in a closed cycle and shall be cooled by external high-pressure indirect water/water heat exchanger. The temperature of the high-pressure water leaving the motor cavity to the cooler shall not exceed 60°C or as per proven OEM practice, subject to approval of Owner. The cooler shall be adequately sized to reduce the temperature to below 50°C.

Motor windings shall be of non-hygroscopic material and shall withstand continuous water pressure and temperature variation. Cooling water for the heat exchanger shall be tapped off from Bidder's own cooling water system.

A high temperature motor cavity alarm/ trip shall be provided. The alarm and trip temperatures shall be adjustable.

Pump design and installation shall be so as to ensure adequate NPSH under all operating condition of the steam generator including cold start.

The materials of construction of pump and motor shall be suitable for continuous operation with Steam Generator quality water normally encountered in such service and shall ensure long service life. The materials shall be suitable to withstand the possible effect of erosion, corrosion electrolytic effect etc.

The stator windings in the motor shall be cooled with suitable insulation impervious to water. The insulation shall have sufficient dielectric strength to withstand the rated phase-to-earth voltage in slot portion and phase-to-phase voltage in end windings.

The insulation material shall not have any tendency to plastic deformation even under extreme operating condition like the conductor temperature, mechanical forces, vibrations etc.



The power and instrumentation leads shall be taken out of the motor through properly sealed water-tight glands, shall run through flexible metal conduits or metal cable sheathing and shall have adequate provisions of differential expansion of pump casing and conductor.

Motor design and construction, in addition to the features described above shall meet the requirements specified in relevant electrical part of this specification.

The Bidder shall indicate the safety protections and interlock scheme provided for the recirculation water pump. The motor shall be protected against external heat exchanger cooler leakage and against possible heat conduction during idle operating condition. The safety features adopted under such condition shall be elaborated in the offer.

5.2.0 Economizer

Erosion allowance of minimum 1mm in addition to IBR requirements shall be considered while arriving the economiser tube thickness. Apart from this, minimum 10% thinning allowance on bends shall be considered.

Economiser shall be bare tube and inline type, arranged for counter flow of feed water and flue gases with modular construction. It shall be fabricated from seamless tubes in suitable modules to facilitate block erection.

Stainless steel erosion shields shall be provided with for the leading tubes of each tube bank of the economiser. Minimum 5 mm thick sturdy cassette baffles shall be provided for all front and rear bends of the economizer banks. The cassette baffles shall cover complete bends and additional 300 mm straight tube length.

Steam/ water cooled hanger tubes/headers / Mechanical supports supporting the economiser shall form part of steam/ water circuit such as not to cause any dislocation /damage to the tube banks/setting.

Ash hoppers shall be provided for the economiser.

If the steam generator has the flue gas downflow section with horizontal tube banks, the top most row shall be shielded to reduce erosion.

Headers shall be located external to gas path and shall be drainable completely. If locating headers in gas path becomes unavoidable, then suitable erosion shields must be provided.

The economiser header shall be provided with drains and suitable opening with forged weld on caps for internal inspection and chemical cleaning.

Clear cavity height of minimum 1.5 m shall be provided between two sections/ banks of the economiser for maintenance access.

Access/opening alongwith air/ gas tight hinged quick opening door shall be provided for approach to each tube bank.

Necessary walkways, platforms, runway beams, motorised hoists etc. shall be provided for removing, handling and placement of complete tube bank/section at ground level for repair and replacement.

Space provision shall be provided on gas inlet side of the economiser for future addition of minimum 20% economiser surfaces. Structures and hangers shall be designed considering loads due to these additional surfaces also.



5.3.0 Steam Generator separator/Mixing Chamber/Headers

Design of pressure parts/Steam Separator shall be as per IBR or other equivalent international standard.

The Separator and Drain vessels shall be of fusion-welded construction with welded hemispherical dished ends. All weld joints shall be properly heat treated and 100% radiographed during manufacturing.

The separators/ drain collectors shall be equipped with suitable nozzles for steam/ water connections, tapplings for instrumentation, sampling and other mountings/ fittings etc. The tapplings and nozzles shall comply with heat treatment, weld and other requirements as per ASME Section-I/ BS 5500. Relevant requirements of IBR shall also be satisfied.

Manhole shall be provided with forged steel cover.

Minimum load with separator dry shall be 25% BMCR

5.4.0 Furnace and water wall

The furnace shall be designed conservatively with sufficient volume to provide complete and efficient combustion of specified range of fuels.

The height of furnace bottom shall be about 10.50 m above ground level and smaller side of opening for bottom ash hopper shall be 110 cm (minimum).

Water/ steam walls shall be of membrane wall construction made from seamless tubes. Clinker breaker shall be provided at inside hopper panel.

The thickness of water wall tubes shall be increased by minimum 0.6 mm over and above the calculated thickness as per IBR to account for tube erosion and corrosion. Further, an additional tube thickness of 1.0 mm over and above the thickness of water wall tubes as calculated above shall be provided on all water wall tubes coming within a radius of half a meter of each wall blower to guard against premature tube failure due to soot blowing. Alternatively, fasciated tubes may be provided in the soot blowing radius to guard against impact of soot blowing.

There shall not be any flame impingement on water walls.

Headers shall be located external to gas path to the extent possible and as per the manufacturer's standard practice.

Minimum 10% thinning allowance shall be provided wherever there is bend in the tubes of furnace and water walls.

Adequate numbers of furnace observation and tapping points shall be provided for local instruments, gauges, switches, test pockets etc.

In case water wall orifices are provided, these should be supplied with indexing holes and index pins.

To protect tubes against falling clinkers, the following shall be considered

- Wear bar at hopper panel tubes area or
- Providing additional thickness on the spiral tubes for the hopper portion.

Lower side of hopper panel exposed to sea water to be protected with shield plates.



Boiler columns shall be encased with RCC up to 8 m to avoid corrosion.

The furnace water walls shall be equipped with all necessary access and inspection doors, access doors being located at both side walls.

For indicating of the flue gas temperature at furnace exit during start-up, sufficient nos. of retractable temperature measuring probes shall be provided on two opposite sides of the combustion chamber. These retractable measuring probes shall be provided with electric actuators.

A sufficient number of observation ports shall be provided in the appropriate positions to allow for visual observation of the flames, the combustion process and roots and the tip of the flames of each burner. Adequate numbers of tapping points shall be provided for local instruments, gauges, switches, test pockets etc.

Site welding to the furnace and Steam generator tubes, such as, studs for refractory, shall be avoided as much as possible.

No additives are to be used to improve combustion, fouling problems, corrosion problems or other reasons.

5.5.0 Superheaters and Reheaters

- Superheaters and reheaters shall be designed, suitably sectionalised and positioned to comply with the requirements of the specified load(s), coal(s) and whole range of operating conditions like sliding and constant pressure operations, HP heaters out of service, HP-LP bypass operation etc.
- Construction of superheater(s) and reheater(s) shall have following features:
 - i) Heating surfaces arrangements:
 - a) Tubes, banks, sections shall be made from seamless tubes and shall be drainable to the maximum possible extent.
 - b) Even temperature distribution shall be ensured at gas and steam side by criss crossing the steam paths between LHS and RHS.
 - c) Use of girdling loops shall not be allowed. .
 - d) Elements shall be uniformly spaced to avoid gas bypassing.
 - e) Minimum clear spacing between any two sections of horizontal tube banks shall be 1500 mm.
 - f) Maximum depth of tube bank sections in the direction of gas flow shall be 2 meters or maximum soot blowing radius whichever is lower.

ii) Supporting arrangement

All horizontal surfaces shall be supported by steam cooled hanger tubes. The hanger tubes shall not hamper the access to any part of heat transfer surfaces. Horizontal surface support by water cooled hanger tubes is also acceptable provided the contractor has proven experience with the same.

iii) Arrangement of headers

Headers shall be located out side the gas path to the extent possible and shall be fully drainable. Wherever locating the headers in the gas path becomes unavoidable, these shall be suitably protected with erosion shields. The arrangement of header shall be such that it does not cause the high localised flue gas velocity zones near tubes downstream side of the header. The established design practices of the manufacturer shall be given due credence.



iv) Attemperators

Attemperators shall be made from corrosion/ erosion resistant steel, and shall be fitted with removable liners. These shall be located at inlet or between the two stages of superheaters and reheaters.

v) Minimum tube thickness

- a) Leading tubes of each bank shall be provided with additional thickness of minimum 1.0 mm as erosion allowance over and above the calculated thickness as per IBR.
- b) Balance of tubes in the bank shall be provided with additional thickness of minimum 1 mm as erosion allowance over and above the calculated thickness as per IBR.
- c) Minimum thinning allowance of +10% shall be provided on bends in addition to the above.

vi) Tube and header materials

The materials shall be appropriate for most adverse operating conditions and as specified elsewhere in this specification (Alloys containing molybdenum only without any suitable stabilization with vanadium and chromium shall not be used. Total content of molybdenum, tungsten, silicon, vanadium, titanium, tantalum etc., individually or all together, if not otherwise specified, shall not exceed the limits specified in relevant material codes).

vii) Maximum number of material grades that can be used in one tube bank shall be limited to three (3).

- Superheater(s)/ reheater(s) design shall cater to the operation requirements as elaborated elsewhere in this specification throughout the control range, for specified fuel and under all operating conditions like constant and sliding operations, HP heaters out of service, HP-LP bypass operation, top mills in service etc.
- There is no damage is caused to the reheaters with sudden closure of turbine interceptor valves.
- The reheater shall be provided with isolators both at inlet and outlet to facilitate isolation of reheater during hydraulic tests.

For continuous temperature monitoring, minimum nos. of thermocouples as per following shall be provided:

- a) For superheaters and reheaters elements placed before furnace exit plane (in the direction of gas flow), chromel-alumel thermocouples on at least two elements of every fifth assembly between the two headers shall be provided for tube metal temperature detection out of gas path (in SG casing).
- b) In addition to the above, adequate number of chromel-alumel thermocouples for measurement of tube metal temperatures outside the gas path shall also be provided. Total number of thermocouples including those at (a) above shall, however, not be less than 2 (two) thermocouples per RH/SH assembly between the two headers.

For maintenance and inspection of SH and RH, the following shall be ensured:

- a) Minimum 1.5 m clear cavity height between two sections/ banks of heat transfer surfaces for personnel access. For vertical surfaces, minimum clearance between the two banks shall be 600 mm.



- b) Access opening shall be provided alongwith air/ gas tight hinged door for approach to above maintenance spaces without any hindrance from hanger tubes. All access doors shall be of 500x500 mm size (minimum) and access doors above 0.8 m from the nominal floor level shall have access platforms. Hanger tubes of horizontal banks shall have access opening for crossing.
- c) Stainless steel erosion shields shall be provided for all bends of all SH and RH sections and hanger tubes in areas where flue gas temperature is below FEGT. For the pendent tube sections, the erosion shields on the leading tubes and wherever else considered necessary by the bidder as per his proven practice shall be acceptable.
- d) Arrangement shall be provided for internal inspection of attemperators.
- e) Arrangement of structural steel, runway beams, motorised hoists, walkway platform etc. shall be provided for removing, handling and placement of tubes banks/section at ground level for repair and replacement.
- f) Headers and pipes if made of using X20 Cr Mo V 12-1 material shall have provisions to ensure that no site welding of this material with similar or dissimilar material is needed.

Complete information on the system used to protect the superheaters/reheaters during starting-up and shutdown of the units shall be provided. Suitable allowance shall be provided for the super heater tubes to counter the erosion condition.

5.6.0 Steam Generator Integral Piping, Valves, Fittings and Mountings

- In addition to specific requirements indicated in the subsequent paragraphs below, the steam generator integral piping, valves, fittings and mounting shall also comply with all specification requirements of piping, fitting and valves given in Section-2.20 of this specification.
- Silencers shall be provided for boiler start up vent, all first lowest and second lowest set pressure spring loaded safety valves and electromatic valves.
- Temperature Element shall be provided on all drain lines including soot blower drain line.
- Air release valves, two in series, shall be remote motor operated and shall be connected to a funnel with drain leading to drain trench.
- Complete valve schedule including control valve sizing calculations, characteristics, and data sheets etc. shall be furnished and shall be subject to Owner's approval.
- All Steam Generator drains shall be combined in groups (drain stations) depending on the pressure level and lead to the drain system. The arrangement of drain system shall comply with following requirements :
 - i) Drain lines upto drain valves and drain valves shall be designed for the maximum operating parameters of main process line to which it is connected.
 - ii) Drain system shall be sized to enable draining of complete pressure parts in maximum one (1) hour.
 - iii) The drain valves shall be of low noise and erosion resistant type. The limiting noise level for regulating drain valves shall be 90 dBA. The noise level for TG, regulating drain valves and for air motors shall not exceed 90 dBA and 95 dBA respectively, and that for safety valves and associated vent pipes shall not exceed 105 dBA.
 - iv) The flow velocity through the drain valves shall not exceed 90 m/s.
- Drain valves (two in series, one manually operated isolation and other motorised regulating) shall be provided for draining furnace walls, superheaters, reheaters, economiser, headers, steam line, auxiliary steam line and feed water lines. Valves shall have plugging/ locking keys and shall be located at appropriate location for convenient operation. The piping from drain valves shall be connected to flash tank.
- All remote operated control valves shall be provided with the following:



- i) 100% bypass control valves, remote operated and exactly identical to main control valve.
 - ii) Separate power operated isolation valve on upstream side of each of main and bypass control valve.
 - iii) Separate electrically operated isolation valve on down stream side of each of main and bypass control valve.
 - iv) Pressure gauge at inlet and outlet of each respective control station in the common line of main and bypass control valve.
- Drains from headers, gauge glasses and integral piping of steam generator shall be terminated into one or more drain collection headers which in turn will be connected to Steam Generator drain tank. The drain shall be connected to the plant drain system after the same has been cooled by the cooling water. Selection of design conditions of drain tank shall be as per BS:806 and the atmospheric vent pipe shall be extended upto SG top canopy level. Suitable arrangements to prevent overflow in this tank shall be furnished. The valves in the drain line shall be power operated and regulating type with provision of a motorized isolating valve on upstream side and manual isolating valve on downstream side. The water level control station shall be complete with the control valves, bypass valves, and the level controllers.
 - Steam Generator fill line shall be provided with a non-return valve of size not less than 100 NB and a stop valve.
 - All required sampling points shall be provided along with root valves including that for feed water at economiser inlet, saturated steam, superheated steam reheated steam. The sampling probes shall be provided as per relevant section of the latest ASME power test code. For laboratory samples, necessary sample coolers with valves and cooling water pipe shall be provided. The root valves shall be of stainless steel. The cooling water shall be taken from the main cooling water system. Drain from sample coolers shall be terminated at appropriate floor level. Each steam and water terminal connection for vent, drain, instrument tapping point and sampling shall be provided with two valves.
 - Tapping points shall be provided for all the instrumentation and controls as required for performance guarantee tests.
 - All the valves (including drain, vent and air release valves) required to be operated during startup and shut down of steam generator shall be provided with remote motorized operation. For valves located in inaccessible locations, remote operation facility shall be provided to enable startup, shutdown, load monitoring from unit control room.

5.7.0 Safety valves / Pressure relief devices

- The number, size, location and setting of safety valves on separator/on outlet pipeline, superheaters and reheaters shall be as per IBR/ASME. The safety valves, installed on the Steam generator separator, super heater outlet and reheater shall be set to blow in a predetermined sequence.
- The safety valves of adequate capacity and setting pressure shall be provided on all steam lines including soot blowing lines, auxiliary PRDS lines and the steam lines, wherever pressurisation may take place.
- Combined capacity of the spring loaded safety valves shall not be less than 100% BMCR for Separator and superheater.
- Electromatic relief Valves shall be provided for Super heater. Electromatic relief valve is set to operate at a lower pressure than spring loaded valves and reduces spring loaded safety valve maintenance substantially.
- Capacity of electromatic relief valves shall be 15% BMCR for super heater.
- Electromatic relief valve of suitable capacity at reheater outlet shall be provided, if recommended by the manufacturer.
- All equipment necessary for gauging the safety valves and for hydraulic test purposes shall be supplied.
- Set points of H.P. bypass stations and safety valves in the H.P. system shall be selected, so that the H.P. bypass reducing stations will open first. During a trip of the turbine at full



load and availability of the H.P. bypass reducing station, no safety valves on the H.P. side shall open.

- The set pressure of the reheater safety valves and of the low pressure bypass stations shall be chosen so that opening of the reheater safety valves will be avoided to the largest possible extent.
- The noise level during lifting of safety valves of separators, superheaters and reheaters shall not exceed 105 dBA with the provision of silencer on the first lowest and second lowest set pressure safety valve. Noise level of HP & LP bypass valves shall not exceed 115 dBA during valve operation.
- Safety valves shall have access platforms of adequate size to permit two people to work with access ladders and maintenance access walkways for reaching the platforms. Access shall be provided on both sides of safety valves.

5.8.0 Miscellaneous mountings

For main steam, cold and hot reheat pipes leading to the turbines, pressure test locks shall be installed in the vicinity of the steam generator so that it will not be required during a pressure test of the Steam generator, to block the supports of the whole piping system. Pressure test lock refers to the locking arrangement provided in spring hangers. Springs hangers shall be in locked position during hydro test.

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- The supply shall include for the Steam generator all necessary connections, valves, fittings, etc. requested for later cleaning of the Steam generators after some years of operation. The volume of supply shall be such as to permit easy connection of the acid cleaning equipment to the Steam generators, avoiding any cuts and welds of pressure parts.

5.9.0 Drain System

- Flash and drain tanks shall be designed and fabricated as per requirements of IS/ASME section VIII.
- All drain connection to the tanks shall be tangential, and wear plates shall be provided to prevent erosion due to high pressure and high velocity drains.
- Flash tank design shall not allow discharge of any free water from vent. The steam velocity through the vent pipe shall not exceed 90 m/s. Vent pipe size shall be so selected that no pressurisation takes place in the flash tank.
- Drain tank shall be complete with drains, overflows, access manholes and any necessary internal pipes, baffles and access ladders.
- Provisions shall be made for easy access for inspection and maintenance.

5.10.0 Fuel oil firing system

- Design and installation of HFO and HSD firing system shall comply with N.F.P.A. (National Fire Protection Association) standards and/or recommendations or other similar standards. Changeover from one fuel to another should be possible without reducing the load on the Unit.
- Tracing shall be provided for heavy fuel oil lines.
- Burner tip material shall be corrosion resistant due to oil containing sodium, vanadium, sulphur, chloride etc.
- Heavy fuel oil and High speed diesel oil trip valves and nozzle valves shall be suitable to handle oils at temperature and pressure required at the burners. Further, these valves shall confirm to ANSI leakage Class-VI under shut off pressure conditions of respective pumps.
- The solenoids of trip valves and individual burner nozzle valve shall be of single coil heavy duty construction having class 'H' insulation.
- The closing time of trip and nozzle valve shall be less than one (1) second. The



- valves shall close when de-energised /failure of air supply.
- Fixed drip tray for each oil burner to contain any oil leakage
- Oil gun cleaning station and the facility for blow off of the oil guns using auxiliary steam at each firing floor. For this purpose auxiliary steam tapping with necessary isolation valves and necessary hose connection shall be provided.
- Interlock shall be provided for automatic purge before light up and after failure to first oil burner operation.
- Contractor shall furnish the fuel oil requirement for startup, commissioning and trial operation, PG tests along with base offer.

5.10.1 Ignition System

HFO and HSD burners shall be ignited by High Energy Arc ignitors. HEA Igniters for lighting up of oil, located at the same elevation of oil burner (one per burner) with spark rod retract mechanism, exciter, fire ball cum discriminating scanners and control box. Each flame scanner has to monitor only his own flame.

5.10.2 Scanner Air System

Scanner air fans One (1) No. AC drive (Normal Supply) and One(1) No. standby AC drive (Supply from Normal/Emergency supply) are provided to supply air to cool the flame scanner head assembly and fuel oil guns. Scanner cooling air system with necessary ductwork, dampers, supports etc. shall be provided.

5.10.3 Fuel oil drain system

The fuel oil drains from different equipments and piping etc. of a steam generator shall be brought by gravity to the drain oil tank provided for steam generator. The oil collected in these tanks shall be periodically pumped back to the fuel oil storage tanks Adequate heating arrangement shall be provided for drain oil tanks.

5.10.4 Oily water drain system

The oily waste water drains from each steam generator area shall be collected in the oily water collection pit. This shall be periodically pumped to effluent treatment plant using sump pumps.

5.10.5 Coal Preparation and Firing System

The coal storage, preparation and firing system shall commence with the raw coal bunker, shut-off valve/ gate at raw coal bunker outlet and shall include raw coal feeders with shut off gate at inlet, coal pulverisers, primary air and seal air fans, pulverised coal piping, coal burners and associated auxiliaries.

The design of coal preparation and firing system shall ensure the following:

- a) Complete safety of the plant, equipment and the personnel.
- b) Complete compliance with the latest NFPA (USA) requirements and other requirements specified hereinafter.
- c) Coal supply to the mills shall be from the individual coal bunkers having useful storage capacity of minimum 14 hours with the unit operation at 100% BMCR while firing worst coal as specified, considering operating mill bunkers only.
- d) Coal bunkers shall complete with lining, inertisation, dust collecting equipments and deblocking devices (e.g Vibrators)
- e) Comprehensive flowability study shall be conducted for the coal bunker hopper to ensure smooth flow of coal in all seasons with different moisture contents and different percentage of mill operating configurations. Bunker hopper valley angle shall be



considered as 73 deg for bunker sizing in the technical offer or as per coal flowability study conducted as per specification requirement which ever is maximum.

5.10.6 Coal Shut off gates/valves, chutes

- Bunker shut off gate(s) and coal feeder inlet gate(s) shall be provided with the following features:
 - a) Size of gates/valves shall be suitable for round bunker opening of minimum 914.4 mm (36").
 - b) Shut off gates/valves shall be motor operated, with double rack and pinion drive arrangement and shall be of non-jamming type.
 - c) Gate/ valve design shall ensure dust tight enclosure and shall be of self cleaning type.
- Shut off valves/gates shall be designed to operate with "bunker full of coal" condition without its motor getting overloaded. Normal motorised as well inching operation of these shut off gates/valves should be possible from the feeder floor. For manual operation from feeder floor level, wheel and chain shall be provided for each gate/valve.
- The chutes between bunker outlet gate and inlet to the coal feeder shall not have internal diameter less than 914.4 mm. The chute between feeder outlet and pulveriser inlet shall not be of internal diameter less than 600 mm.
- The chutes shall be made of minimum 12mm thick SS-410 material and shall be of fully welded construction. The chute between feeder outlet and pulveriser inlet shall have a SS lined hopper with suitable reinforcement. The provision shall be made for the insertion of poke rods in two direction opposite to each other at outlet of the bunker and inlet of the feeders.
- Suitable coupling (Dresser or equivalent) shall be provided for chute connection(s) at outlet of feeder and pulveriser with SS 410 inner ring.
- The arrangement of permanent bunker emptying chute alongwith necessary coal flow diversion valve shall be provided between each bunker and RC feeder. Necessary access shall be provided for operation of coal flow diversion valves. The emptying chute shall enable unloading of bunkers on trucks at ground level. An arrangement with a temporary chute fitted on the bunker downspout alongwith a permanent chute from the feeder floor to the ground level shall also be acceptable
- Suitable indicators shall be provided in the downspout between bunker and feeder to detect presence of coal flow to ensure minimum seal height at inlet to feeder and trip the feeder if the level of coal tends to be below the seal height.
- All components coming in contact with coal and the roller bearing shall be of stainless steel material.

5.10.7 Coal feeders

- The raw coal feeders shall be of gravimetric, belt type with minimum size of 914.4 mm (36"). Each RC feeder shall be sized for 1.2 times the maximum capacity of coal pulveriser. The feeder casing shall be designed to withstand an explosion pressure of $3.5 \text{ kg/cm}^2(\text{g})$.
- The RC feeders shall comply with all the stipulations of NFPA.
- The feeder belt shall be of multi- ply reinforced rubber of single piece construction with arrangement for tracking and to prevent spillage. The width of the belt shall have sufficient margin while operating in conjunction with feeder inlet opening. Suitable arrangement shall be provided to adjust belt tension without opening doors
- All components coming in contact with coal (except belt) shall be made of stainless steel.
- All site equipment shall be suitable for 70°C ambient temperature and other environment conditions envisaged.
- Each feeder shall be equipped with :
 - Variable speed motor or transmission
 - Worm reducer assembly
 - Multi- ply reinforced rubber belt of single piece construction



- 1 inspection door 0.5 x 0.5 above coal feeder and at front and rear side
- Temperature indicator
- Inner illumination lamps
- Inspection windows
- Control gate with outside scale
- Chutes between feeders and mills.
- Detection for “No coal” flow shall be provided to stop the feeder when no coal is detected on the conveyor and when pluggage occur at feeder outlet. Paddle type coal alarm switch shall be provided for this purpose over the feeder conveyor for indication of loss of coal flow and near the feeder discharge to stop the feeder in the event of coal pluggage at the feeder outlet.
- The feeder control system shall be microprocessor based. Coal weighing shall be automatic and shall include local and remote indication for rate of flow and totaliser counter. The feeder control cabinet shall be located in control equipment room (CER).
- The mass flow of the coal powder shall be adjustable with online orifice adjustment using micro wave based flow measurement.
- The weighing accuracy of the feeder shall be + 0.5% with repeatability of 0.1%. Facility for in-built calibration shall be provided.
- The following facilities shall be provided for the feeders:
 - a) Spraying water inside the casing.
 - b) Providing purge air to the feeder.
- Feeders shall be provided with adequate number of manholes on for quick and easy release of the feeder jamming. Easy access to any part of the feeder internals shall be possible without dismantling the complete casing.

5.10.8 Coal mills

- The coal pulveriser shall be of vertical spindle type. Each mill shall be fed with coal by an independent coal feeder. The coal pulverizers shall be of the “applied force mill” type suitable for pressurized operation in conjunction with primary air fan.
- The milling system selected shall respond to load change, remain in service for long operating periods, maintain prescribed performance throughout the life of elements and accept wide variety of coal.
- The classifier design shall be of static type and shall be capable of maintaining rated conditions of fineness under all conditions of operation, load changes and specified fuels. Further, the classifier vanes shall be adjustable externally and shall be lined with suitable wear resistant material to ensure the guaranteed wear life.
- The classifier shall ensure reduction in particle of 50 mesh and increased quantity through 200 mesh percentage to ensure uniform sizing and distribution of particles. Fineness adjustment shall be possible while the mills are in service.
- Outlet of the classifier shall have aerodynamic shape to prevent eddies.
- Provision shall be provided in the mill design for future accommodation of rotary classifier in place of stationary classifier. For this purpose necessary structure, piping, spare piece etc. shall be provided.
- Fineness adjustment shall be possible while the mills are in service. Mill grinding ring/race shall be segmental and grinding elements must be wear resistant and shall be made of superior Hi-chrome or equivalent material to ensure the guaranteed wear life.
- The mill noise level shall not exceed the specified values. While selecting lagging, background noise from adjacent mills, drive system and other secondary and stray noises shall be taken into account.
- Seal air fans common for all the mills shall be provided for each steam generator unit. The fans shall preferably be located at ground floor.
- The sealing system shall prevent ingress of any dust into the bearings and leakage of coal-air mixture to atmosphere.
- The seal air fans shall take their suction from atmosphere/PA fan cold air duct. Silencers shall be provided, if required, at the suction of the fans to restrict noise level within permissible limits.



- The gear box design shall ensure that there is no ingress of coal dust into gear box under all conditions of operation. Each mill shall be provided with its own forced lubrication oil system, including 2x100 % oil coolers, oil tank, 2 x 100 duplex filters and 2 x 100% oil pumps. The design of lubrication system shall ensure continuous operation of mill bearings. Sealing air connections and seals shall be provided on the mill journals and on the mill casing in order to protect the bearings against the entry of dust. The gear box shall give trouble free operation of not less than 100,000 hours of mill operation.
- The mill motors shall be adequately sized and selected motor capacity shall enable restart of the mill after a trip with mill full of coal. Such restart shall not call for any emptying of the mill.
- Inlet coal pipe between RC feeder and the mill shall not have any reduction in section throughout the length, including at entry point on top of the mill.
- The material of construction of wear parts shall be selected taking into account highly abrasive nature of coal resulting from coal contamination with silica sand and alpha-quartz.
- The grinding rings/ race shall be made of material having hardness of minimum 550 BHN at the surface with adequate chilled depth. The grinding rolls shall be of insert type sinter cast rolls with minimum hardness 350 BHN. Minimum difference between hardness of rings/race and rolls shall be 100 BHN. Tapping points shall be provided on each pulverized coal pipe at mill outlet and shall be suitable for coal sampling as per ISO 9931. The sampling provisions shall be complete with screwed plugs, compressed air purging connections at tapping points, heating arrangement and other requirements as per ISO 9931.
- One (1) no. of Rota probe shall be provided for each steam generator for coal sampling as per ISO 9931. Further, four (4) nos. of Dirty Pitot tubes shall be provided for steam generator and shall be suitable for measurement of coal-air velocity in the coal pipes.
- Convenient approach/access from nearest platform floor shall be provided for coal sampling/ measurement points.
- Mill outlet temperature control shall be capable of achieving and maintaining rated temperature for adequately drying the specified coal range for all unit loads.
- The flap of power operated mill discharge valves shall be totally out of coal path during operation of the mill.
- The mill shall be capable of running at part loads and ensure minimum turn-down ratio of 2:1.
- It shall be possible to isolate the mills from the hot air/gas ducts and from the dust ducts in such a way that the Steam Generator operation will not be disturbed when isolating one mill, and that the maintenance work such as rearmouring has not to be done under hard conditions. Doors of the mills shall be provided with hinges and quick acting opening & closing facilities.
- All mill wear parts shall be arranged so as to facilitate easy replacements without total dismantling of mill. Suitable measures shall be taken to prevent, under all operating conditions, each part of the mill by being endangered by over temperature. Lifting and hoisting devices required for maintenance shall be provided.
- Adequate numbers of access doors/windows with access ladders shall be provided to facilitate access to various parts of mill. The access doors shall be suitable for on load inspection and maintenance of the mill. The oil pumps and filters shall be readily accessible.
- Necessary ladders and approach platforms for mill bay hoist shall be provided at one end/ corner to carry out any maintenance activity on hoists.

5.10.9 Inerting system for mills and coal pipes and ducts

- Special care is to be taken to avoid explosions inside the mills and coal pipes, especially when burning coal with a self-ignition temperature of 220°C and high volatile content.
- The provision of the plant with an inerting system will be mandatory. It shall consider an inerting system based on steam with motor operated valves and all relevant equipments.
- Inerting system shall be capable of performing the following function:



- The system shall deliver a high inerting flow to the mill to quickly reduce the oxygen level in the mill to 7% to reduce the explosion potential. The system shall be designed to meet the above flow requirements in the event all pulverizers require simultaneous inerting.
- The system shall deliver a low inerting flow to the off-line mill to maintain inert atmosphere during hazardous conditions.
- The system shall deliver a cleaning steam flow capable of emptying a tripped mill into the furnace under specific interlocked conditions.

5.10.10 Distribution of pulverized coal

- Pulverised coal pipes from the mills to the burners shall be arranged in view of maximum symmetry, to achieve even distribution to all burners
- The coal air mixture velocity in the coal pipes shall not be lower than the critical fallout velocity under all conditions of mill operation from start up of Steam Generator onward.
- The fuel pipe shall preferably have no horizontal run and if horizontal run is necessitated due to layout constraints it shall tilt either towards mills or burners.
- Calculated static loading of each support of the pulverized coal pipes shall be increased by at least 25% to arrive at the design load, to take care of the shock loading, occurring in the pipe work under abnormal conditions of operation.
- The individual pulverised coal ducts behind the distributors shall be provided with shut-off devices, which upon shutdown of one mill shall be closed for avoiding the recirculation of the flue gases. Changes of mills load shall not cause any disturbance of the gas and dust flow in the ducts. No unreasonable wear of ducts shall occur.
- The guide plates, wherever provided in the coal pipe, shall be removable and access to them shall be obtained through detachable cover. The guide plates shall be made up of suitable abrasion resistant material.
- Pulverized coal piping shall be ceramic lined with the thickness of not less than 15 mm wherever necessary.
 - i) From mill outlet upto and including 1st bend and two times pipe diameter straight length down stream of first bend.
 - ii) All bends between 15° and 30° angle and straight length down stream of the bends equivalent to one pipe diameter.
 - iii) All bends 30° and higher and two times diameter straight length downstream of the bend.
 - iv) The burner inlet elbow and the pipe piece after the elbow.
 - v) Pulverised coal pipe from mill to classifier (in case of separate classifier).
 - vi) The ceramic material shall have alumina content of not less than 90%. The ceramic lining shall be minimum 15 mm thickness and shall provide guaranteed life of 25000 hrs.
- Purge air connections shall be provided after the mill discharge valve to clean pulverised coal pipes of any deposits etc.
- Provisions shall be made at suitable locations on pulverized coal piping for sampling the pulverized coal. Suitable sampling equipment shall also be provided.

5.11.0 Pulverized fuel burners

5.11.1 Burner Design

- Coal firing system shall be designed for minimum turn-down ratio.
- The coal burner design shall ensure a steady log mean density of coal air mixture distribution as it enters the combustion zone, without allowing the coal dust to settle down.
- The burner design shall minimise erosion.
- The burner shall be designed to ensure smooth variation in the fuel flow without affecting the air to fuel ratio.
- The air to fuel ratio around the burner shall be optimized to ensure low emission of Nox. Total Nox emission (fuel as well as thermal Nox) shall not exceed 750 mg/Nm³



- Burners shall be provided with automatic control with flame scanner and safety protection.
- Each burner shall be provided with its own ignitor and flame scanner. The burners shall be robust and shall stand long operation periods. Adequate measures shall be taken to protect coal burners which are not in operation from being damaged by radiation of heat coming from the furnace. Necessary cooling arrangement shall be provided for non operating burners.

5.11.2 Burners Construction

- Each coal burner shall be served by one separate coal pipe and shall be provided with one knife edge type gate valve at burner inlet. The valve shall be power operated and hooked up to burner management system.
- Compartmented wind box shall be provided for supply of secondary air for combustion.
- The material and construction of burner shall withstand radiation from the furnace, and shall not be damaged when not in use.
- Burner design shall ensure freedom from deposits and distortion under all operating condition in the furnace. Further, burners shall not require adjustment to maintain flame shape.
- The parts subjected to high temperature which cannot be protected by other means shall be made of alloy steel. Further, burners parts subject to abrasion that may require replacement at frequent intervals shall be easily removable.
- Minimum operating life of burner parts without requiring any maintenance and replacement shall be guaranteed for minimum 8000 hours.
- Burner shall be removable or replaceable from outside the steam generator without entry to the furnace.
- Air register construction shall be such that tangential air vanes are always free to move. The support bearings shall preferably be located outside. In case the support bearings are located inside, minimum period of operation shall be 16000 hours without calling for maintenance of any sort during this period.

5.12.0 Primary Air Fans

- The fan characteristics shall be compatible with pulverized coal system resistance and Steam Generator operation at rated loads, during Steam Generator start up and low load operation with minimum number of mills. The system resistance curves shall always be sufficiently below the fan stall line. The best efficiency point of the fan shall be close to 100% TMCR operating point.
- The fan control system shall be designed to achieve stable and satisfactory operation with air flow control and air pressure controls. Fan flow control shall be by blade pitch control. The final control element shall be electrically/ pneumatically operated and shall not have a backlash or play etc. The regulating dampers for air pressure control shall operate in the range of 20% to 85% steam generator loads up to BMCR conditions. The system shall be capable of working on automatic mode for all regimes of operation in a steady and stable manner.

5.12.1 Constructional Features

- Material of construction
 - Fan Blades : High strength Aluminum alloy with minimum hardness of BHN-75
 - Base Plate : Cast Iron and Welded Steel
 - Casing : Sheet Steel of suitable thickness
 - Fan inlet boxes, diffuser and intermediate pieces : Fabricated with sheet steel of thickness not less than 5 mm.



- Special features
 - i) The fan suction shall be provided with rigid bird and trash screen assembly and shall have suitable arrangement to prevent rain water from directly entering the fan.
 - ii) The fan design shall be over hung type. The layout of PA fans shall ensure interchangeability of impellers. Similar fans shall have same direction of rotation.
 - iii) The contractor shall submit detailed calculations for Owner's approval to confirm compliance with the sizing requirements specified else where in the specification.
 - iv) Pulsation shall be avoided by suitable design of fan and connecting ductwork.
- Fan bearings:
 - i) The rotor assembly shall be supported over a oil lubricated bearing assembly consisting of antifriction/sleeve bearing adequately sized to take care of radial thrust loads.
 - ii) Bearing housings shall be provided with vibration pad and sensors for remote monitoring, interlock and protection.
 - iii) In case of oil lubricated bearing, the design shall be such that bearing are lubricated by external force oil lubricating system in which oil is cooled by external cooler. In addition, sump lubrication shall also be provided.
 - iv) One number duplex RTD and temperature indicators shall be provided for local and remote monitoring of the bearing metal temperature of fans for each bearing.
- Each primary fan shall be provided with its own forced lubrication oil system, including 2x100 % Lube. Oil coolers, Lube. Oil tank with heater, 2 x 100 duplex Lube. Oil filters and 2 x 100% oil pumps. The lube oil pressure shall be higher than cooling water pressure. Each bearing shall be provided with an oil level indicator and screwed drain plug if applicable. Further Flow sight glasses shall be provided in the return oil lines from the bearings to lubricating oil system
- Silencers shall be provided to limit the noise level to the specified values.
- Fan vibration monitoring pads shall be provided.
- Fan housing shall be designed for ease of maintenance and access to the fan wheel or impeller. The casing shall be split type to provide easy removal of the fan wheel or impeller for replacement and repairs. Access doors shall be provided in each suction chambers, casing. The casing section shall have gasketed joints to ensure air-tight sealing. Drain connections shall be provided at the bottom most point of fan housing.
- Fan casing shall be properly stiffened to minimize vibrations and distortions during operation.

5.12.2 Primary Air flow measurements

- PA flow measuring devices shall be provided at air inlet to each mill for total air flow measurement and control.
- Independent tapping points with necessary isolating valves shall be provided for control, measurement and performance test.
- Location, type and design of flow measuring devices shall be subject to Owner's approval.
- Necessary temperature element points for temperature compensation in the flow measurement shall also be provided.

5.12.3 Balanced draft system

- To maintain balance draft conditions in the furnace over the entire load range while burning the stipulated range of fuel , 2 x 60% forced draft (FD) fans and 2 x 60% Induced draft (ID) fans shall be provided.



- Both FD and ID fans shall operate with highest possible efficiency which shall be nearly equal at the 100% TMCR and test block points.

5.12.4 Construction Features

- The construction of FD & ID fans shall comply with the following requirements:

Description	FD fans	ID fans
Type of fan	Axial type	Axial type
Type of fan blade	Stream line, aerofoil shaped section	Stream line, aerofoil shaped section
Blade material and thickness	High strength Al-alloy BHN-75 (min)	High strength Al- alloy with anti wear spray coating/ liners or Equivalent subject to approval of Owner.
Fan critical speed	Not less than 125% of fan maximum operating speed	Not less than 125% of fan maximum operating speed
Fan component design	To withstand torsional stresses three times the normal full load motor torque at all speeds	To withstand torsional stresses three times the normal full load motor torque at all speeds. The shaft material shall be 15 Mo3 or better or equivalent subject to approval of Owner. The operating stresses shall be limited to 2kg/mm ² . Welded zones shall be suitably stress relieved and residual stress shall be considered for design.
Fan casing material and plate thickness	5 mm (min.)	Abrasion resistant high BHN Steel 8 mm (min.)/ 12mm (min.) mild steel with liner thickness 6 mm (min.) or equivalent subject to approval of Owner.
Fan housing design pressure	Shut off head of the fan	Shut off head of the fan

- Fan components along with servo/blade pitch control mechanism shall be designed to withstand and continuously operate with the maximum air or flue gas temperature that these fans will be required to handle.
- ID fan components shall also be designed to withstand the excursions upto 300°C which may persist for about 30 minutes duration.
- Each FD & ID fan shall be provided with its own forced lubrication oil system, including 2x100 % oil coolers, Lube. Oil tank with heater, 2 x 100 duplex lube. Oil filters and 2 x 100% lube. Oil pumps.

5.12.5 Fan Bearings

- Bearing shall be provided with oil bath to avoid damage in case of complete loss of plant auxiliary power when the fans must coast down without power.
- Oil reservoir in bearings housing shall be sized for maintaining lubrication for extended periods in case of oil circulation system being out of service.
- One number duplex PE-RTD and temperature indicator shall be provided for each bearing.
- Bearing housings shall be provided with vibration pads and sensors for remote monitoring and interlock/ protection.



5.12.6 Fan Balancing

- The fans shall be statically and dynamically balanced before dispatch to site. Balancing of each fan shall be checked and adjusted at site, if necessary.
- Natural frequency of fan components shall be established by vibration testing to ensure that no part of the wheel is adversely excited by any force generated at operating speeds.
- For axial fan cantilever, variable pitch blade shall be subjected to natural frequency. The other components of ID & FD fan wheels need not be subjected to natural frequency test if supplier can prove that these component are very rigid and have very high natural frequency compared to the operating frequency of respective fans giving justification.

5.12.7 Operational Requirements

- FD & ID fans shall meet the following operational requirements:

Description	FD fan	ID fan
Mode of operation	a) Two fans in parallel b) One fan operation (One as well as both streams in operation).	Two fans in parallel One fan operation (One as well as both streams in operation). Reverse rotation
Fan Control	Capable of operating in automatic mode for all regimes of operation in a steady and stable manner.	Capable of operating in automatic mode for all regimes of operation in a steady and stable manner.
Vibration monitoring system	Suitable pads matching with vibration pickup shall be provided on fan bearing housings.	
Bearing metal temperature monitoring	Shall be possible from remote as well as locally using adequate nos. of duplex platinum RTDs.	

- The fans shall be suitable for parallel operation and sharing the load equally over the entire range of operation without hunting. Pulsation shall be avoided by suitable design of fans and connected ductwork.

5.12.8 Flow measuring devices

- The draft plant shall include aerofoil type flow elements in the air system for total air flow measurements and control, each with three pairs of tapping points.
- Three nos. duplex temperature element with thermo wells for temperature compensation shall be provided.

5.12.9 Fan casing

- The fan casing shall be of split type to facilitate easy removal of the fan wheel or impeller for replacement and repairs.
- Access doors shall be provided in each suction chamber casing and diffuser.
- The sections shall have gasketed joint to ensure air tight sealing.

5.12.10 Fan Layout

- The layout of FD & ID fans shall ensure interchangeability of the impellers. Similar fans shall have same direction of rotation.

5.12.11 Drain connections

- Drain connections shall be provided at bottom most point of the fan housing.



5.12.12 Fan suction

- Silencers shall be provided at the suction of FD fans to limit the noise level to 85 dBA at a distance of 1.0 m.
- Fan suction shall be provided with rigid bird and trash screen assembly and shall have suitable arrangement to avoid rain water from directly entering the FD fan.
- Location of FD fan hood shall prevent entry of dusty air into fan.

5.13.0 Steam coil air preheater(SCAPH)

- To ensure that the Steam Generator exit gas temperature does not fall short the dew point secondary air shall be preheated by steam coil air preheaters.
- SCAPH and connected air ducts shall be designed to handle flows corresponding to 60% BMCR loads with one of the two streams working without any undue noise/ vibration.
- The steam supply can be taken from the auxiliary steam line. All steam and drain piping control and isolating valves, and all other fittings and drain condensate pumps (If required) shall be provided in order to satisfy the above requirements..
- SCAPH shall have modular construction with adequate tube spacing to avoid chocking by contamination in the entering air. The position of the steam coil air preheater shall allow for the complete draining of all pressure parts.
- Facility shall be provided for complete isolation of SCAPH from the air flow path.
- SCAPH should be in service only during startup, low load and under abnormal conditions. It shall not be in service under all normal operations for the complete specified range of fuel.
- Heating coils shall be easily removable for cleaning and maintenance. Drain connections (blind flanges or screwed plugs) shall also be upstream and downstream of the SCAPH in the bottom of the air duct (not only in the SCAPH frame).
- Proper approach and adequate facility (platform, runway beam, hoist etc.) for removal and placement of SCAPH modules on ground level shall be provided.
- SCAPH shall be located in the bypass duct of secondary air duct instead of locating at main duct.
- The requirement of Steam coil air preheaters will be ascertained by the Steam Generator manufacturer based on the site ambient conditions; sulphur content in the range of coal specified and required no. of cold start-ups during the life of the plant.

5.14.0 Regenerative air heaters

- The steam generator shall be equipped with Two (2) Nos. of trisector regenerative Air pre-heaters as the last stage of heat recovery, in which both the primary and secondary air are independently heated up in the same air heater. The sections for the primary air and secondary air shall be apportioned in accordance with the primary air/secondary air flow ratio for the design point. Sizing of air-preheater(s) shall also ensure that there is no need for economizer bypass to get the desired mill outlet temperature, for the whole range of specified coals.
- Air and flue gas ducts at inlet and outlet of APH shall be of aerodynamic design to ensure uniform flow distribution across the duct sections at all loads.
- The air pre heaters shall be of rotary regenerative, Lungstorm or approved equivalent type with axis of rotation as vertical. The construction of air pre heaters shall conform to the following:

- a) Heating Elements
 - Cold End : Corten steel, minimum 1.2 mm thick
 - Hot/Intermediate End : Carbon steel, minimum 0.8 mm thick.
(Sacrificial hot end element to a height of 300 mm to 400 mm. or Equivalent subject to approval of owner)



- b) Bearings(Sump lubricated and forced cooled lub oil system)
- | | | |
|----------------------|---|---------------------------------|
| Cold End | : | Spherical roller thrust bearing |
| Hot/Intermediate End | : | Radial guide bearing |

Only metallic hoses shall be used for bearing cooling and lubrication. Rubber hoses shall not be acceptable.

- c) Air heater seals
The seals shall be of externally adjustable and easily replaceable type.

The maximum air-in leakage to flue gas does not exceed 8%, one year after demonstration of above guaranteed air-in-leakage. Within this period of operation till all air heater leakage demonstrations are completed by internal adjustments shall be allowed. The seal design/construction shall be such that the above requirements are satisfied.

Seals shall have life not less than 2 years (with leakages not exceeding permitted limits)

- d) Air heater drive system

The drive system shall consist of one (1) no. peripheral AC drive and One(1) no. standby AC drive (supply feed from emergency DG set) with gear box and automatic clutching/ declutching facility, and one (1) no. independent air motor drive with its gear box and automatic clutching facility for rotation during non availability of AC drive system. An air receiver of storage capacity to cater to 10 minutes (minimum) operational requirement of air motors shall be provided.

- Ash hoppers shall be provided for collection of ash.
 - Sacrificing basket for APH shall be provided at hot end
 - The rated air temperature exiting the air heater shall be achievable upto 100% BMCR load with design coal.
 - Facilities along with the grids for flue gas sampling and gas temperature measurement on both the inlet and outlet sides of APH(s) shall be provided.
 - Alarms for rotor stoppage and failure of drives and lubrication system shall be provided.
 - Air pre heater off load water washing facilities (including hoppers, water connections etc.) with drainage connected to station drains shall be provided.
 - Air heater elements shall be arranged in baskets and shall be easily removable in groups/baskets for maintenance.
 - Observation ports with vapour proof light shall be provided at air inlet duct for rotor inspection.
 - Maintenance facilities
- a) The arrangement of walkways, platform, runway beams, trolley, hoists etc. as required, shall be provided conveying, lowering and placement of elements/baskets to ground level.
- b) Hinged access doors shall be provided in the housing for internal inspection, cleaning, maintenance and replacement of elements without dismantling air heaters.
- c) Galleries and platform around air heater and access to observation ports/access doors etc. shall be provided. Platforms shall be capable of taking load and storing elements for at least one sector of the air pre heater.
- d) Special T&P kit including Hydraulic lifting cylinders for supporting shall be provided for removal of bearings and for replacement of shaft.
- Permanent firefighting facilities alongwith thermocouple type fire sensing device and redundant temperature elements shall be provided for each bearing and oil sump. Fire



fighting facilities on cold end and hot end of the air preheaters shall be provided and the fire fighting facilities shall cover both flue gas sides of air preheaters. Connections for fire water shall be taken from fire water lines. Necessary water draining system, connected to station drains shall also be provided.

5.15.0 Duct work and Dampers

5.15.1 Duct Work

- Air Ducting includes Cold air ducting from FD fans to air heaters with interconnecting duct and SCAPH bypass duct, Cold air ducting from PA fans to air heaters with interconnecting duct, cold tempering air ducting to mills from PA fan outlets, hot secondary air ducting from air pre heater to burner wind box including interconnecting ducts and hot primary air ducting from air heater to mills. Air ducts are fabricated from 5 mm steel plates.
 - Flue gas ducting shall include,
 - i. Flue gas ducting from economiser to air pre heaters
 - ii. Flue gas ducting from air pre-heaters to dust collector(ESP) inlet including interconnecting duct
 - iii. Flue gas ducting from dust collector (ESP) to ID fans including inter connecting duct
 - iv. Flue gas ducting from ID fans to stack.
 - v. The flue gas ducts shall be fabricated from minimum of 7 mm thick Carbon steel plates before ESP and minimum of 6 mm thick carbon steel plates after ESP. The ducts shall be of welded construction with all necessary dampers expansion joints, access doors and necessary supporting steel. Wear resistant plates in flue gas ducts at corners and direction changing areas (min 5 mm thick)
 - Duct design shall take into account following all occurring together.
 - i. Wind Load
 - ii. Dead weight including weight of insulation, lining, wash water and vertical live load.
 - iii. Horizontal flue gas ducts shall be designed additionally for minimum 245 kg/m fly ash loading on the surface or for one fourth of duct full of ash or for maximum possible accumulation of ash in the duct work, under all normal, upset or abnormal operating conditions, whichever is higher. The ash density for the purpose of loading shall be at least 1300 kg/m³.
 - iv. The following minimum load factor shall be applied to the design loads
- | | | | | | | | | |
|--------------|------|------|------|------|------|------|------|------|
| Temp (Deg C) | 27 | 38 | 93 | 149 | 203 | 260 | 316 | 321 |
| Load Factor | 1.00 | 1.02 | 1.12 | 1.19 | 1.25 | 1.29 | 1.34 | 1.42 |
- v. Expansion joint reaction.
 - vi. The duct work and its structure shall take into account loads due to future addition of FGD interconnection ducts and dampers in the duct between ID fan outlet and chimney inlet.
- All interconnecting gas ducts, connecting one gas stream to another, between the Steam Generator and the ESP shall have a minimum slope with respect to horizontal so that any chance of accumulation of ash particles in the duct can be avoided under all operating conditions.

The ducts shall be of rectangular cross-section and shall be of all welded construction. Circular ducts shall not be acceptable.



Internal duct stiffening shall be made of pipes and External stiffening shall be made of rolled sections.

The thickness of the duct plate shall be suitably increased, if required, in the transition zone at steam generator outlet where the flue gases change direction, to increase the wear life of the duct plates.

Material of construction of duct shall be as per following requirement:

Duct plates, turning vanes	:	ASTMA 36 or equivalent
perforated plates	:	ASTMA 36 or equivalent
Structural shapes	:	ASTMA 36 or equivalent
Pipe struts, trusses tracing	:	ASTMA 53 or equivalent
Erection bolts for ducts	:	ASTM A 307 or equivalent
Bolts for connection to structural steel	:	ASTM A 325, AISI A 325(friction type) or equivalent
Stainless steel	:	ASTM A 316 L
Gaskets	:	'Refrasil' by Hitco or equivalent
Access and inspection doors	:	Reinforced steel plate

The stiffeners provided on the ducts wall shall be of such a design and layout that no rain water can accumulate on the duct surfaces.

The flanges at the bolted joints shall have adequate stiffeners to avoid damages to the flanges.

All necessary wall boxes and floor collars shall be provided where the duct work pass through walls, floor and roof.

The floor collars shall be fitted with a high combing to prevent water and dust falling through the hole.

The duct work shall be fitted with a steel hood to cover the opening.

Weather proof flashing shall also be provided wherever necessary.

The configuration and design of ducts shall be coordinated with the pulveriser parts removal requirement.

Air and gas ducts shall not counter internal bracings which cause excessive pressure drop.

Duct work sections between expansion joints shall be checked and designed with regard to their ability to transmit loads to supports. Care shall be exercised to identify uplift condition.

Internal stiffening elements shall consist of trusses, preferably comprised of extra-strong steel pipes (minimum diameter 76.2 mm) acting in conjunction with external stiffeners. Such internal stiffeners for the flue gas duct between Steam Generator and ESP shall be provided with erosion protection shields. The number of internal trusses shall be limited to the minimum required for structural integrity and shaped so as to offer least resistance to gas flow and to minimise the accumulation of fly ash in the bottom of duct.

Corner angles shall be used on inside corners of all ducts to provide adequate continuity.

Inside welds of corner angles to duct plate shall be continuous and seal welded. Where inside surface of ducts will be coated, welds shall be full throat.



Field welding and all connection of bracing (stiffening elements) to stiffeners shall be well designed in order to develop full strength of the members. The gusset plates shall be of minimum 10 mm thickness.

The duct, plates, trusses, stiffeners and ductwork shall be designed as structures in accordance with relevant Indian Standards.

All opening inducts shall be reinforced for all design loads.

The expansion joints shall be of metallic type suitable for the service conditions.

The materials for joints shall be tested as per IS/ASTM/DIN or other international standards.

The minimum trouble free operational life of expansion joint shall not be less than 20000 hrs of operation from the date of commissioning.

Bolted plates or other positive closure means shall be provided in order to permit pressure testing of steam generator enclosure.

5.15.2 Dampers

Power operated gas tight isolation dampers along with their drives shall be provided at all locations required for carrying out internal repair and maintenance of pulverisers, electrostatic precipitators, ID fans, PA fans, FD fans when the steam generator is under operation. Interconnecting dampers shall be provided where necessary. As a minimum, the following locations shall be provided with power operated gas tight dampers:

On each hot air and cold air duct to each of the mills.	: Guillotine gate type
On each inlet and outlet to each ESP stream (there being four ESP streams, with eight inlets and eight outlets).	: Guillotine gate type
Before and after each ID fan.	: Guillotine gate type
At inlet to each of the regenerative air pre heater on flue gas side.	: Bi plane type Multi louver dampers
Before and after each of the regenerative air pre heater on air side.	: Bi plane type Multi louver dampers
At discharge of each of PA fan.	: Guillotine gate type
At discharge of each of FD fan.	: Biplane type dampers
Interconnecting duct dampers as necessary.	: Multi louver type

Heavy duty multi louver dampers shall be provided at locations not requiring tight shut off duty.

Pneumatically or motor operated control dampers shall be provided on the hot and cold primary air inlet to each mill, and at each air pre heater outlet on flue gas path (if applicable).

Damper gas tightness:

Damper gas tightness for the guillotine dampers shall be guaranteed for a gas tightness efficiency of 100% with or without use of sealing air

Damper gas tightness for the multi louver damper shall be guaranteed for a gas tightness efficiency of 99.3 % without use of sealing air.



Pressurisation fans:

- a) All dampers at ID fan discharge, primary and secondary air at APH outlets and mill inlets shall be provided with 2x100% pressurisation fans to achieve 100% sealing efficiency. Alternatively, for mill inlet gate, bidder may take seal air from PA fan cold air bus.
- b) The location and scheme for pressurisation system shall be to Owner's approval.

All dampers shall be designed to withstand the operating air and flue gas temperature without distortion.

The multi louver damper shall be capable of effectively stopping the flow when in closed position and while in full open position shall cause minimum pressure drop. The isolating damper design shall provide positive shutoff when closed.

All regulation dampers, vanes, blade pitch controls coming under auto regulation shall be able to provide the desired relationship between percentage opening and the flow.

The auto regulating dampers shall be capable of being operated between 20% to 85% opening as per the optimal requirements of control systems to achieve stable, steady and smooth automatic control of the plant and processes under all operating conditions.

There shall not be any backlash, play etc. with linkage mechanism, actuator and final control element.

Thermal expansion of ducting shall not produce stress in louvers, linkage arrangement etc.

Outlet dampers of seal air fans, scanner air fans and emergency dampers of scanner air shall be pneumatically operated, suitable for remote manual operation. Auto transfer damper is also acceptable for the scanner air fans.

All pneumatically operated interlocked dampers actuators shall be provided with solenoid valves.

Guillotine dampers:

All guillotine dampers shall be located in horizontal duct to avoid fly ash build up when in closed position and shall be of top entry type.

Multi louver dampers:

- a) The damper shall be of heavy duty construction and shall operate without bind or fluttering under operating conditions.
- b) The damper louver shaft shall be rigidly constructed to prevent bending and shall be suitably insulated to protect from over heating. .
- c) The spindles shall be adequately sized and bearings suitably insulated to protect over heating.
- d) The shaft bearings shall be mounted outside the damper box channel and arranged for convenient inspection.
- e) Stuffing boxes shall be provided on all damper blade shafts.
- f) The shaft shall be horizontal wherever possible.
- g) For preventing hot air or gases from escaping around damper shaft, double gland type stuffing boxes with graphite impregnated packing material shall be provided on all damper blade shafts.
- h) The dampers in flue gas paths shall be so located that the build up of grit behind the damper blades is reduced to a minimum.

**Diverter dampers/ flap dampers (if provided)**

- a) Dampers shall be single flap/double flap construction with flexible duplex seals mounted on the flap itself. The seals shall have minimum life of 3 years. The seal material shall be high nickel alloy equivalent or better than hastelloy C-276 (ASTM B575, UNS 10276) or Inconel 625.
- b) The diverter damper shall ensure sealing efficiency of minimum 99.3% on flue gas flow without seal air. To provide man safe isolation for on-line maintenance of air pre heater, 2x100% seal air fans per damper shall also be provided to attain 100% gas tightness.
- c) The diverter flap shall be totally out of flue gas flow path in order to avoid any erosion from ash.
- d) The damper design shall prevent ash accumulation when in closed position.

Weather hood to prevent rain water entry and accumulation shall be provided at damper top.

If grease lubrication is required, grease connection shall be accessible and suitable platforms etc. shall be provided.

Dampers operation:

- a) All dampers shall be arranged to facilitate local manual operation also from a gallery or floor level. Open and closed positions shall be clearly marked on the dampers
- b) The force required to operate the damper shall be limited to 35 kgs (maximum) at the rim of the hand wheel.
- c) The operating gear shall be fitted with a graduated indicator and shall be designed such that the damper may be retained in any position. The isolating dampers shall additionally be fitted with locking devices to permit locking in the fully open and shut positions.
- d) All powered dampers shall also have provision for manual operation during emergency and maintenance along with graduated local position indicator.
- e) Suitable all-around approach and platform shall be provided for manual operation of dampers and for carrying out maintenance on damper.
- f) All bearings for spindles for damper operating gear shall, be arranged for efficient grease lubrication. Grease lines of copper/ steel shall run from all greasing points on each damper to a convenient and easily accessible location adjacent to the respective damper and terminated with suitable clamps and grease nipples on a steel frame to facilitate easy lubrication.

5.16.0 Ash Hoppers

The Contractor shall furnish all necessary fly ash hoppers for Steam Generator, economizer, air heater, including air heater wash down hoppers as required. The capacity of each hopper (including any dust hopper) shall not be less than 8 hours storage when the Steam Generator is steaming at maximum continuous rating. The capacity of economizer hopper shall be 12hrs storage at maximum continuous rating. The capacity of the hoppers shall be calculated with ash content corresponding to the worst coal specified. Bulk density of bottom ash for volume calculation shall be considered 650 kg/m³ and for fly ash 750 kg/m³ and 1350 kg/m³ for structural design.

All hoppers shall be equipped with proper flanged pipe connection for attaching to fly ash removal piping system and the hopper slope shall not be less than 60 Deg.

Ash hoppers shall be provided, wherever necessary, below the vertical portion of the ducts where ash may accumulate. However, care shall be taken in the design of ducting arrangement so as to minimise the necessity of such hoppers.



5.17.0 Electrostatic Precipitator (ESP)

The electrostatic precipitator for each Steam Generator shall be designed for a dust concentration at ESP outlet with specified worst coal firing and with all fields in service and one field out of service as indicated in the Specified datasheet.

The ESP minimum requirements are:

- Fields with gas tight housing
- Electrically heated hoppers with sufficient steep hopper slope to avoid ash bridging and sufficient volume
- Access doors, platform stairs and inside gangways and ladders
- Weather proof pent house for complete ESP.
- Complete ESP internals and rapping devices
- Supporting structure
- Pipes and condensate traps for steam trace
- Thermal insulation
- Paintings

Electrical part:

- Transformer rectifier unit with spark control
- Control panel
- Discharge electrode supports and wrapper insulator
- Penetrating insulator
- Insulator heater
- Portable grounding rod
- ESP control centre for enclosed cubicle, indoor-use
- All motors
- Electric Hoist for erection & maintenance of Transformer Rectifier unit.

The design of the casings, access doors and holes in the casings for electrical and mechanical connections shall be such as to minimize air leakage into the precipitator. The rapping gear shall be arranged as far as possible without wearing parts inside the precipitator. The intensity and frequency of the rap shall be variable and the gear shall operate without undue noise. Special attention shall be given to uniform flue gas distribution across the precipitator.

Access shall be provided to each insulator compartment, to each hopper and before and after each field. The insulating devices at the high tension (HT) inlet passages are to be heated electrically.

One control panel for each precipitator shall be provided and placed near the ESP and shall contain all equipment and instrumentation for both automatic and manual controls. There shall be remote indication from these panels to the central control panel to indicate precipitator ON and OFF.

The insulating devices at the high tension (HT) inlet passages are to be heated electrically. All precipitator and rapping gear fault alarms for each ESP shall be brought up by a common signal at the control room to an alarm.

A safety interlock system shall be provided to prevent any access into the precipitator unless the electrical equipment is isolated and earthed.

Suitable space shall be provided to include an additional set of field in ESP in future to meet any stringent environmental norm/variation in coal properties.



ESP shall be able to meet the stipulated SPM emission requirement even when one electric field in each pass of the ESP is out of service while firing worst fuel with unit operation at 100% BMCR.

ESP hopper outlet flanges shall be terminated at a height of 3.5 m above ground level.

ESP shall be provided with effective ash evacuation system having controls for ash temperature and ash level in the hopper. Each hopper shall have a storage capacity of minimum of eight (8) hours with unit operation at MCR.

Specific weight of ash may be considered not more than 650 kg/m³ for determining hopper storage capacity and not less than 1350 kg/m³ for ESP structural design.

Pressure withstand capability of the ESP casing shall correspond to minimum +/-660 mmwc at 67% yield strength and flue gas temperature of 200 Deg C.

10% margin over ESP inlet flue gas flow and 10% margin over ESP inlet flue gas temperature shall be considered for ESP sizing. All fields ESP hopper shall be equally sized for 8 hours storage while firing worst coal at 100% BMCR conditions.

Physical scale modeling as well as CFD modeling of ESP shall be conducted.

5.18.0 Flue Gas Side Cleaning Equipment

A complete plant for on and off load cleaning of the Steam Generator heating surfaces shall be provided. The cleaning installation shall meet the requirements for coal and heavy fuel oil operation of the steam generator.

Soot blowers

The type of soot blowers to be provided for different sections of the Steam Generator shall be as below:

- i) For furnace chamber : Short rotary, single nozzle, retractable type.
- ii) Vertical pendent section : Two nozzles in diametrically opposite side, long retractable type.
- iii) For horizontal : Long rotary, multiple nozzle exchanger sections (rear pass) retractable type.
- iv) Air pre- heaters : Long retractable multi-nozzle soot blower for regenerative air preheater.

The scope shall include soot blowers for the regenerative air-heaters and for heating surfaces (Furnace, convective and radiant heating surfaces, economizers) complete with pipe work, supports, relief valves and all other equipment necessary to maintain the unit in a clean condition for efficient operation. For regenerative air preheaters sootblowers shall be provided on the cold end and Complete washing installation shall be provided. Washing water hoses and supply lines for Off load cleaning of heating surfaces shall also provided.

The soot blowers shall be capable of selective operation in areas of ash deposition (SMART) type or equivalent.

The numbers of sootblowing cycles shall be three per day as a maximum. Sootblowing shall be possible at any load of the steam generator. Design of soot blower shall be of self draining type.



Sufficient provision shall be provided for for soot blower at waterwall and second pass for the installation of future additional soot blowers.

All the equipment shall be provided and designed to the requirements of pressure parts and piping specifications wherever applicable. Provisions shall be made in the pipe work for fitting pressure gauges to enable pressure to be observed when sootblowing in order to make any necessary adjustments.

Retractable electric motor-driven sootblowers shall be of sufficient number and located so as to enable the Steam Generator to maintain full load, steam temperature and Steam Generator efficiency. The sootblowers shall be the retractable gun and/or lance type to suit the location.

Soot blowers shall be retractable even during emergencies such as drop in steam supply pressure, low steam flow, etc.

Soot blower control system shall be provided for automatic sequential operation of soot blowers, soot blower steam pressure control and drain temperature control etc. Indication of completion of sootblowing shall be provided on the unit control panel. All sootblowers shall be capable of convenient remote and local manual operation under emergency conditions. Complete automatic control equipment with cubicles arranged for automatic sequence control, remote control and indication shall be supplied for installation in the control room.

Control switches shall be provided for each sootblower in order that any blower may be selected in sequence or out of sequence, as may be required. Also the necessary steam supply valves shall be remotely controlled.

5.19.0 Washing installations for heating surfaces

The selection and supply of equipment for washing of the steam generator shall meet the following requirements:

Equipment and washing process shall be chosen, with regard to a minimum demand of service water. All relevant hoses, washing water utility stations at various Steam Generator platforms, connecting pipes and/or pumps (if required) from the water supply source to the utility stations and drainage ducts shall be provided under this contract.

For the regenerative air preheaters a fixed installed washing system shall be provided, which must be suited to wash one of the air pre-heaters when the unit is in operation.

Regenerative air heaters shall be supplied and designed to permit off-load washing. The system shall include all supply pipes, pumps dosing system, discharge pipes, dust separator complete with internals, discharge ducts and pumps (if required) from the dust separator. Dust separator may be carried out from concrete also, provided that the relevant cooling water connections exists.

5.20.0 Steel Structure, Enclosure, Insulation and Cladding

All structural work and architectural work shall comply rigidly with the requirements in detailed technical specification for civil.

5.20.1 Steel structure

For the steam generator and for its auxiliary equipment specified under this section (coal bunkers, electrostatic precipitators, conveyors, pipe racks, etc.) the following additional requirements shall be met:



The unit shall be supported by a structure which shall be free to move without restraint so that it may expand without damage.

Detailed information of the design adopted for supports of the pressure parts shall be given. The design shall be robust and capable of withstanding dead weights and shock load imposed by the tube assembly and separator and its storage tanks together with the economizer, air heaters, air collectors, ducts, flues, coal handling, ash handling and coal firing device.

All parts of the structure shall be sufficiently far away from the Steam Generator to avoid additional stresses imposed by heat except where the basic design of the unit dictates otherwise. In these instances the arrangements adopted shall be subject to special approval.

All parts of the steel structure exposed to adverse conditions shall be designed to avoid water accumulation.

Consideration shall be made that the steel structure can take over also forces of the pipes and ducts which will be eventually supported by the Steam Generator main columns.

In addition to this, the steel structure must be able to resist the forces resulting from water filling of the Steam Generator and pipes during hydraulic test or from other loads during erection.

Special care shall be given to the design of pipe racks for steam pipes, which must be able to support these pipes during water filling (hydraulic test or chemicals). In order to avoid over-dimensioning of the pipe racks and the appertaining foundations, consideration with regard to the simultaneity of forces shall be made.

Stairs and platforms shall be supported so that no forces shall be introduced into the Steam Generator body itself.

All nuts, bolts and washers must be galvanized or cadmium-coated, and properly protected against corrosion before installation.

Girders for fixing of lifting appliances required for dismantling and mounting during maintenance and overhaul shall be installed over all components having a weight heavier than 100 kg.

5.20.2 Platforms, Galleries, Stairways

The supplier shall include all the access galleries, stairways and platforms leading from main floor levels to individual items of the units. Such areas shall include access to valves and fittings, measuring points, access and inspection doors, mills classifier and roof, coal feeders measuring points (pulverized coal extraction) in coal pipes, soot blower heads, fan bearings, dampers and any other item to which access may be necessary during operation and maintenance.

Galleries, walkways, platforms, staircase, hand rails, ladders and gratings etc. as specified shall be provided at the Steam Generator floors including the interconnecting platforms between the Steam Generator floors and main building at four (4) elevations on either side of boiler (excluding ground floor) and between the Steam Generator and bunker buildings at four (4) elevations on either sides of Steam Generator as per the details given in the Technical Specification. Number of inter-connecting platforms between Boiler and Coal Bunker building for each level / floor shall be two (2) numbers on each side of Boiler i.e. four (4) numbers per elevation.

All supporting steelwork required carrying the flooring, together with any kerbs and hand railing necessitated by the arrangement of the plant shall be supplied.



2 (two) main access stairs from the grade up to the top and alternative means of escape from the main galleries shall be provided for the unit in addition to all local access galleries and stairways, required for operation and maintenance of individual item of the plant.

All supported steelwork, kicking strips and handrails associated with the galleries shall be included, to facilitate lowering and replacement of heavy components during overhaul, suitable shackles and extension beams shall be provided around the units at strategic positions.

The ladder treads, stair treads, platforms and galleries shall be galvanized as per IS 2629. Blast cleaning is applicable only for components having thickness 5 mm and above and coating thickness will be 610 GM/SQ.M.

Handrails shall be provided on each side of each gallery except where the open space between the gallery and the nearest adjacent equipment does not exceed 100 mm.

Step irons to be installed in the vertical parts of air ducts and flue gas ducts to provide internal access for the inspection of dampers, air heater elements, etc.

Handles to be arranged above each inside and outside access door of furnace, electrostatic precipitator, ducts and flue gas path to facilitate entering of personnel.

All burner and Steam Generator platforms have to be lead around the Steam Generator so that Steam Generator front wall, side wall, rear wall and air heater area can be inspected at one level without using stairs.

Ladders will not be accepted as the means of main access to all places where maintenance, checking and reading have to be performed. Ladders shall be used in special cases only.

All platforms, walkways, galleries shall be covered with galvanized welding steel gratings with a height of 30 mm or more.

All platforms, walkways and galleries shall be self-supporting without tie to the main station building. All main platforms (burner platforms, platform on the top, etc.) shall be fixed on the Steam Generator steel structure to allow freedom for expansion

Floor and walkway gratings shall be fabricated in sections convenient for handling and installation. Stair treads shall be of galvanized welding gratings of a height of 30 mm with cast abrasive nosings. The landings for stairs shall be covered with galvanized steel gratings. Due consideration shall be given to assure the required emergency exists on each Steam Generator level. Where the escape way exceeds 30 m, additional emergency ladders shall be provided.

Necessary access, platforms, walkways, handrails, staircase, ladders and gratings etc. for proper approach shall be provided for all equipments and accessories in the scope of this package so that operators and maintenance personnel can function conveniently and safely. The above provision shall include but will not be limited to the following locations:

- Bunker outlet gate.
- Mill discharge valve.
- All maintenance hoist levels.
- All dampers and their drives.
- Furnace seal trough level.
- All fans and associated motors. (Continuous platforms shall be provided around the fans and their corresponding motors).
- SCAPHs (If Applicable)



- Air preheaters
- All valves.
- All Observation ports, access manholes etc.
- All soot blowers.
- All Ash hoppers of economizer, Air-Preheaters, economizer Bypass (if provided) and duct (if any) which require fly ash removal by the ash handling system.
- 2. Necessary access, platforms, walkways, handrails, staircase, ladders and gratings etc. for proper approach shall be provided for all equipments and accessories in the scope of this package so that operators and maintenance personnel can function conveniently and safely.

The above provision shall include but will not be limited to the following locations:

- Bunker outlet gate.
- Mill discharge valve.
- All maintenance hoist levels.
- All dampers and their drives.
- Furnace seal trough level.
- All fans and associated motors. (Continuous platforms shall be provided around the fans and their corresponding motors).
- SCAPHs (If Applicable)
- Air preheaters
- All valves.
- All Observation ports, access manholes etc.
- All soot blowers.
- All Ash hoppers of economizer, Air-Preheaters, economizer Bypass (if provided) and duct (if any) which require fly ash removal by the ash handling system.

In addition to the platforms required for the operation of the Steam Generator, interconnecting platforms between Steam Generator and control room, between Steam Generator and bunker building, and between bunker building and annex building shall be provided.

5.20.3 Steam Generator Enclosure, Casing and Framing

Steam generator enclosure shall form air and gas tight envelop from combustion air inlet point to chimney inlet to prevent infiltration of extraneous air in to the combustion chamber and gas passes.

The enclosure integral with Steam Generator (except air heaters) shall be formed by water/steam cooling tubes using welded wall construction on all the four sides, roof and bottom. Where use of refractory is unavoidable, 4mm thick steel plate behind refractory shall be provided to form enclosure and any penetration (s) into the steam generator enclosure shall be sealed for gas tight integrity.

Seal plates of stainless steel (type 430) or better corrosion and erosion resistant steel material all around the furnace bottom shall be provided to prevent ingress of air.

Dissimilar metal welds (DMW) between austenitic and ferritic steels, martensitic and austenitic steels, martensitic and ferritic steel shall be avoided inside the Steam Generator enclosure for the pressure parts which are exposed to hot flue gases. However, if such DMW are unavoidable, same can be permitted at shop provided manufacturer has previous experience of such DMW and appropriate heat treatment is done after welding.

In the steam generator enclosure, minimum 1.5 m clear cavity height shall be provided in between the horizontal banks, sections of economizer, superheater and reheater for maintenance purpose.



The entire furnace shall be suspended from a suitable supporting structure to allow free expansion of surfaces and to prevent its distortion and dislocation of insulation. Thermal expansion of the furnace wall shall be in the downward direction

The design of steam generator casing including pent house shall ensure:

- a) The enclosure of steam generator shall be complete including superheaters, reheater and economizer headers.
- b) The casing, pent house and its supporting system shall be capable of taking additional loads due to accumulation of ash in the pent house up to a height of 300 mm or actual expected (in between two annual overhauls of the units) whichever is higher. This additional load shall be over and above other loads considered for casing design. The ash density for the purpose of loading shall be at least 1350 kg/m³.

Steam generator casing including pent house shall have following features:

- a) Rigid self containing structure with adequate stiffening.
- b) Welded wall construction, economizer to allow easy removal/ replacement. However pent house may be bolted/screwed type and shall be easily removable.
- c) Water proof/ tight construction under rains and winds with proper drainage system.
- d) All drainage arrangement like gutters, drain pipes, connected to plant drain system at ground level.

Steam Generator roof arrangement of proven design and architecture.

At least two pent house ventilation/cooling fans with their air inlet opening at opposite ends shall be provided.

The casing including pent house shall be provided with air tight access, observation and cleaning doors with frame having fire brickwork. Access alongwith platform shall be provided for easy and quick installation of scaffolding for furnace inspection/ maintenance.

Access and observation opening

The steam generator shall be provided with adequate number of access and observation openings doors at different levels and at various positions as per the Owner's approval. The doors shall be provided to permit access to the furnace, superheaters, reheaters, and other enclosed pressure parts and any other area requiring access. All doors shall be hinged and be air-tight. Suitable poke doors at the furnace bottom shall be provided for maintenance.

One of the access doors provided shall be suitable to take a power operated furnace tube maintenance cradle inside the furnace. This access shall be provided on one of the side walls and shall be such as to provide easy accessibility to introduce the maintenance cradle directly on the water wall hoppers, either in assembled condition or in dismantled condition to be assembled inside the furnace. Suitable number of openings in the roof superheater shall be provided to pull the maintenance cradle up and reach any place of all the water walls and pendent super-heaters to effect any repair on the tubes.

Design shall also include observations ports at various levels to facilitate observation of the furnace including inside surface of burners, ignitors, thermocouple connections and the burner flame.



All such openings e.g. manholes, peepholes etc. shall have suitable approach platforms and ladders from the nearest platform level. This shall assume easy and safe approach during operation and maintenance.

5.20.4 Insulation and cladding

Thermal insulation and cladding has been provided for the entire steam generator, flue gas / air ducting, ESP, etc. Complete thermal insulation including cladding, lagging, reinforcement, wire mesh, cleats, supports etc. will be furnished so as to maintain outside surface temp. of 60 degC with design ambient temp. of 40 degC.

Thermal insulation and cladding for valves, pipes, fittings shall be of the same construction and manufacturer as for the equivalent components used in all other sections of this specification.

As an exception from the general requirements, the Steam Generator wall cladding shall be carried out from trapezoidal (seawater proof) aluminum sheets of 0.8 mm thickness. All cladding sheets shall be provided with moisture barrier.

All insulation shall be on-inflammable, hot-resistant, chemically inert and shall remain so in the event of being saturated with water.

The use of asbestos and of glass wool as an insulator is prohibited. The thermal insulation shall consist of preformed slabs or blankets.

The whole outdoor insulation and cladding must be completely sealed as a protection against salty fog and other atmospheric conditions.

Insulation and cladding shall be fitted so as to allow thermal expansions of the equipment, specially piping, without suffering any damage.

Fittings, valves and pipe flanges shall be insulated with material having atleast the same thickness and insulating qualities as the material employed on the corresponding pipes.

A small hole to act as a leakage indicator shall be formed in flange lagging. All equipment susceptible of noise emission (e.g. fans, pressure reducing stations, etc.) shall be provided with sound insulation.

All pipes, ducts and other equipment on which condensation on the outer surface is liable to occur, shall be provided with a condensate water insulation.

5.20.5 Refractory

The SG shall be designed for a minimum of refractory material. In the 2nd path (if any) no refractory material shall be used.

5.21.0 Steam Generator Accessories

5.21.1 Auxiliary Steam Pressure Reducing and Desuperheating Stations (PRDS)

To meet the continuous and startup auxiliary steam requirements, two numbers auxiliary pressure reducing and desuperheating stations (PRDS), one taking tap off from main steam line (high capacity PRDS) and other taking tap off from cold reheat line (low capacity PRDS) shall be provided per unit. A high temperature unit header shall draw steam from above two PRDS stations. A low temperature unit header shall draw the steam from high temperature unit header through a desuperheater.



High capacity PRDS shall supply steam for following:

- i) Startup requirement of the unit
- ii) Continuous and intermittent requirement of the unit.
- iii) Startup requirement other units.
- iv) As standby to low capacity PRDS station.

Low capacity PRDS shall supply steam for normal requirements of its own unit. The sizing of high capacity and low capacity PRDS shall be subject to Owner's approval. Stub connections along with isolating valves shall be provided on low temperature header to meet the auxiliary steam requirement of other systems such as fuel oil system. Further, adequate number of spare connections shall also be provided on each header for Owner's use.

Sharing of load requirement between high temperature header to low temperature header shall be done in case low capacity PRDS is unable to meet auxiliary steam requirement on its own.

Low capacity PRDS shall be capable of supplying continuous requirement of auxiliary steam to the unit. The change over of control from high capacity PRDS to low capacity PRDS and vice versa shall be automatic with manual override facility.

In case each unit is provided with only high temperature auxiliary steam header as per manufacturer's standard and proven practice, auxiliary steam requirement at lower parameters shall be met with PRDS stations provided for individual application. Further, connections with individual PRDS shall also be provided to meet the auxiliary steam requirement of other systems such as fuel oil system.

The spray water for de-superheating station shall be supplied from boiler feed pump discharge or inter stage tap-off. The system is provided with pressure and temperature control valves to meet the requirements of auxiliary steam system.

5.21.2 Utility stations

In the Steam Generator area and on the various platforms, utility stations for air, water and steam shall be provided to meet the following purpose:

- Wet washing of the convective heating surface
- Air supply for tools
- Air supply for cleaning and/or cooling
- Steam supply for cleaning of components susceptible of contact with oil.

Adequate hoses of sufficient length shall be supplied

5.21.3 Fire extinguishing equipment

In addition to the fire-fighting equipment and installation provided for the whole unit, all equipment related to fire extinguishing and fire annunciation systems shall be supplied together with the components, i.e.

- Regenerative air preheater fire extinguishing, alarm and annunciation system
- Firing system, inertisation fire alarm and annunciation system
- Spray system for hazardous area within the coal firing system in addition to the hydrant system

5.21.4 Equipment for internal inspection

In order to reduce the standstill periods during inspection, cleaning and repair, Removable cradle for the internal inspection of the combustion chamber shall be provided. The inspection



cradle for the combustion chamber shall allow the access to the whole extent of the combustion chamber. The extent of the platform shall be dimensioned with respect to the largest expected repair work

All lifting appliances shall be provided with electrical drives.

5.21.5 Inside Cleaning of Pressure Parts

After erection of each Steam Generator the manufacturer shall perform boiling out and blowing out as a protection measure. If necessary the Steam Generators shall be passivated after this procedure. No acid cleaning measure is required but the Steam Generators themselves must be designed and fabricated in such a way that an acid cleaning process can be carried out if required by the Owner.

If it will be found out after Steam Generator erection that the inside tube and header surfaces are rusty and dirty, acid cleaning of Steam Generator and all other equipment will be carried out by the supplier without any costs for the Owner.

The criteria for above mentioned decision is as follows:

- Steam Generator separator and headers are to be visually clean without any corrosion.
- Cut tube samples may not have more than 0.11 mm corrosion layer or 15 mg/cm² corrosion layer.
- Recommended steam quality for starting up shall be reached within 2-3 days.

Atleast five months before the date fixed for the internal cleaning, the Steam Generator manufacturer shall submit to the approval of the client a complete and detailed specification of the procedures that will be carried out giving all sequential events and chemical analysis required. The temporary blow-off pipe and blow-off valve should have the same size as the main steam pipe and main steam valve.

5.21.6 Equipment and provisions for standstill conservation

In order to protect the Steam Generator and the appertaining pipe work during standstill periods, provisions shall be made to conserve the water/steam side of the Steam Generator. For standstill conservation, the hot and wet method shall be applied, i.e. that the Steam Generator shall be conserved with hydrazine to pH 10.5.

Conservation of reheater and reheat lines shall be done by the dry method by using absorption type dryers.

At flue gas duct entrance into the chimney, a damper shall be provided to separate the Steam Generator air flue gas side from outside during shutdown

5.21.7 Maintenance Equipment and Special Tools for Erection

For the maintenance equipment and special tools the following shall be considered:

- The supply shall cover one complete set of spanners and special wrenches to every type of nut and bolt on the plant, together with special tools, such as tube expanders and equipment for the preparation of tube ends before welding, valve seat lapping machine covering the whole range of valves, lighting devices for internal inspection, etc., shall be provided before start of erection. This equipment may be used during erection.
- All heavy parts of the auxiliary plant shall be provided with means for slinging or handling during erection and overhaul.



- One pump suitable for Hydraulic testing of boiler with permanent connection and with necessary isolation. The pressure rating is to be 1.5 times of design pressure of boiler.
- One set of quick erectable scaffolding system to erected inside the SG furnace ensuring full height coverage for capital overhaul .The scaffolding system shall be made of light weight material. Erection shall not take more than 24 hrs. The locking arrangement shall not call for any welding.

The weights of individual item of the plant shall be clearly marked before delivery to site on each item.

5.21.8 Sampling system

A complete sampling system, including sampling coolers with connections, nozzles, valves, fittings and pipes shall be provided. All required sampling points shall be provided along with root valves including that for feed water at economizer inlet, Steam Generator water, saturated steam, superheated steam and reheated steam.

The sampling coolers shall be fitted with stainless steel coils and stainless steel piping connections up to the takeoff point. All sample coolers shall be provided with stainless steel trays. The drain of these trays shall be laid to the waste drain system.

The position of each sampling point shall ensure representative samples and should be led to steam water analysis system (SWAS).The cooling water for sample cooler shall be taken from the auxiliary cooling water system. Drain from sample coolers shall be terminated at appropriate floor level. Each steam and water terminal connection for vent, drain, instrument tapping point and sampling shall be provided with two valves.

The sample coolers shall be designed so that no detrimental consequences will occur on interruption of cooling water supply. The throttle valves shall be located downstream of the sample coolers in order to avoid steaming of the sample.

6.0.0 DRIVE MOTORS

All drive motors shall be as per Specification for Electric Motor presented in relevant section of electrical specification.

7.0.0 INSTRUMENTATION & CONTROL

Refer Part II, Section 4 for Control & Instrumentation Specification.

8.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED ALONG WITH THE PROPOSAL

8.1.0 General

- a) Completely filled in technical schedules & other schedules for all equipments as enclosed with the Tender specification.
- b) Flow Diagrams and P&ID (Process and Instrumentation drawings) indicating Instruments and the destination / functionality of the signals Plot plan
- c) Plot plan and General arrangement drawing with section for Steam Generator & Auxiliaries etc., showing maintenance area
- d) Quality Assurance and plan
- e) Master Document List (MDL) for Mechanical, Electrical, Civil and C&I with schedule of submission
- f) Description of options and alternatives offered
- g) Complete description of the plant offered including description of the process and the equipment



- h) General descriptions of individual systems and descriptions of operation including description of start-up, shutdown and emergency shutdown procedures. Also behavior of boiler/steam generator and, turbine, etc. under transient conditions.
- i) Safety Plan
- j) Training program and schedule for training of Owner's personnel
- k) Space requirement for construction site and equipment
- l) Maintenance proposal (for SG)
- m) List of spares
- n) List of Special tools and Tackles
- o) Inspection intervals (major/minor) for six years along with the spares to be replaced during the above inspections. Contractor shall provide the cost of such spares on yearly basis.
- p) Contractor shall enter into a long term spare supply agreement with the OEM, and agree to transfer the same faithfully to the owner upon COD. Contractor shall commit to facilitate further negotiations on the spares with the OEMs directly by the owner.

8.2.0 Mechanical

- a) Start up curve for cold, warm and hot condition
- b) Installation references where 660 MW Supercritical units with proposed main steam and reheat steam parameters are in operation.
- c) Experience list for supply and installation plants of similar capacity supercritical Units and performance certificate of the plants indicating the availability and plant load factor from the date of COD.
- d) Steam Generator Manufacturer's experience list for the offered Capacity
- e) Deed of Joint Undertaking shall be executed by Contractor with following manufacturers
 - Steam Generator & Auxiliaries

The above shall be submitted clearly indicating the validity of the agreement and role and responsibilities among them

- f) Details of Technical Collaboration of the Steam Generator manufacturers with technology Supplier and role of the technology supplier for this project.

9.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED AFTER AWARD OF CONTRACT

The documents required for design, construction, installation, operation and maintenance of the entire plant shall be submitted by the Contractor in good time so as to permit the plant as a whole to be constructed in compliance with the specified time table.

Only the most important documents are listed below. The list and approval category of the doc/drawings shall be agreed sufficiently in advance before award of relevant order, so that corrections and amendments desired by the Owner as well as resubmission of the documents will not result in any delays with respect to the guaranteed time table. The Owner reserves the right to request from the Contractor additional drawings, documents, etc. as may be required for proper understanding and definition of the design and engineering of the Plant.

9.1.0 General

- a) Re-Submission of all the technical data furnished during pre award contract stage.
- b) Complete filled-in technical schedule.- For approval
- c) Plot plan - For approval
- d) General arrangement drawings /Equipment layout of all equipments along with sections indicating the unloading & maintenance area. - For approval



- e) Design basis for all the systems and major equipment sizing calculation - For approval
- f) P&ID (Process and Instrumentation drawings) indicating Instruments and the interlocks for all the systems - For approval
- g) Monthly progress report
- h) L2 network
- i) Quality plan for approval
- j) Prequalification document for different Vendors for Owner's approval.
- k) Equipment Testing procedure for approval
- l) Complete list of documents with proposed submission schedule
- m) Vendor Engineering document viz Data sheets, General arrangement drawing, material of construction, performance curves for approval for major items
- n) Painting & surface preparation procedure
- o) Technical specification

9.2.0 Mechanical

- a) Major equipment sizing calculation viz Fans, Coal Mill, ESP, Coal feeder for approval
- b) Boiler efficiency calculation, Combustion calculation, Air and flue gas duct sizing calculation, Critical pipe sizing calculation etc.
- c) Start-up and shut down procedure along with the curve for approval
- d) System description for all the systems. for approval
- e) Thermal calculation for critical items for approval
- f) Pipe sizing and determination of pressure & Temperature criteria. for approval
- g) Critical piping drg and calculation
- h) Acceptance and Performance test procedure and program
- i) Acid/Alkali/Boiling out procedures.
- j) Performance calculations write up.

Any other drawing or document which are not covered above but required to the effective commissioning of the project.



ANNEX 2.1.1

SPECIFIED DESIGN DATA – STEAM GENERATOR & ITS AUXILIARIES

DESCRIPTION	UNITS	DATA
GENERAL		
No. of Steam generator's required		One per unit
Reference ambient dry bulb temperature	°C	32
Reference ambient Relative Humidity	%	65
Type of Steam Generator		Super Critical
Fuel allocation for Steam Generator		
- For load carrying		Coal
- For Flame stabilization		HFO
- For Startup		HSD
Operation		Constant Pressure/Sliding Pressure
Code		IBR & ASME
Type of tubes and header for pressure parts		Seamless
Inspection / Access doors		Heat Resistant without water cooling
FURNACE (Furnace loading indicated below are as per CEA guidelines. Bidder shall optimize the furnace loading for range of coals as specified in Part-I, General Technical Specification.		
Maximum net heat input (NHI) per unit plan area	kcal/hr/m ²	5 x 10 ⁶
Maximum heat liberation rate	kcal/hr/m ³	1.1 x 10 ⁵
Maximum Effective Projected Radiant Surface area	kcal/hr/m ²	2.1x10 ⁵
Maximum burner zone heat release rate	kcal/hr/m ²	1.5 x 10 ⁶
Maximum heat input per burner	kcal/hr/ burner	55 x 10 ⁶
Maximum furnace cooling factor	kcal/hr/m ²	1.8 x 10 ⁵
Maximum furnace exit gas temperature (FEGT)	°C	60 °C below minimum initial deformation temperature (IDT) of ash
Minimum furnace residence time	Sec	1.72 seconds. Selected furnace residence time shall be coal specific.
Pressure withstanding capability	mmwc	Minimum ± 660 mmwc at 67% yield strength or maximum conceivable head of fans, whichever is higher as per latest NFPA standards.
No. of Coal burner elevation to be fed from one mill	No.	One
Buckstay spacing		To ensure that its natural frequency is sufficiently away from the flame pulsation frequency
Buckstay support		Self support from furnace walls with no interconnection with Steam Generator structure.
Furnace Bottom Hopper		Designed for hopper with one third full of ash/ clinker with density of 1350 kg/m ³ (minimum)
Loss due to Unburnt Carbon	%	Guaranteed unburnt combustible content in fly ash shall not be more than 1.5% by weight. Guaranteed unburnt carbon loss for boiler efficiency



DESCRIPTION	UNITS	DATA
		shall not be more than 1%
Furnace tube arrangement		Membrane
Max. flue gas velocity before gas flow changes the direction	m/s	10
WATER WALL		
Type of wall		Membrane
Type of tube		Seamless
SUPERHEATERS AND REHEATERS		
Maximum average flue gas velocity in sections/tube banks with transverse tube pitching 600mm or less and with 25% excess air at economiser outlet	m/s	10 (The maximum localized velocity across the cross section shall not exceed 12m/s)
Maximum allowable spray for superheater	%	8% of BMCR flow water flow. However, the control valve shall be sized for 12% of BMCR flow
Maximum allowable spray for reheater	%	Nil (Reheater attemperation shall be used only under emergency conditions). However, the control valve shall be sized for 5% of the BMCR flow.
Superheater(s)/Reheater(s) design shall cater to following operational requirements throughout the control range of Steam Generator, with whole range of specified fuels and under all operating conditions like, H.P. Heaters out of service, HP/LP bypass operation, top mills in service etc:		
SH outlet Steam temperature		At least 568 degree Celsius
RH outlet Steam		At least 596 degree Celsius
Note: The control system for SG shall be able to maintain SH/RH outlet temperatures within $\pm 5^{\circ}\text{C}$ of above values over complete control range of Steam Generator with whole range of specified coal.		
ECONOMIZER		
Type		Non steaming bare tube type, with counter cross flow arrangement.
Maximum average flue gas velocity through inter-tube space of the economiser banks (the gas velocity shall be calculated considering 25% excess air at economiser inlet)	m/s	8
PRESSURE PARTS		
a) Economiser tubes	$^{\circ}\text{C}$	Maximum working water temperature plus 11°C
b) Furnace and Steam Generator tubes	$^{\circ}\text{C}$	Saturation temperature corresponding to maximum working pressure plus 28°C
c) Superheater and reheater tubes in convection path	$^{\circ}\text{C}$	Maximum working steam temperature in convection path plus 39°C
d) Superheater and reheater tubes in radiation path	$^{\circ}\text{C}$	Maximum working steam temperature in radiation path plus 50°C
Pressure Parts Materials :		
a) Up to and including 400°C		Carbon steel to ASME SA-106 Gr. B/C or SA 210 Gr. C or approved equivalent.
b) Upto & including 550°C		Alloy steel to ASME SA-335: P-11/P-12/P-22/P-23; ASME SA213: T-11/T-22/T23/ or approved equivalent.
c) Upto & including 605°C		Alloy steel to ASME SA-335/213:P-91/T-91, T-92, or approved equivalent.
STEAM COIL AIR PREHEATER(SCAPH)		
Number of SCAPHs		One(1) in secondary air by-pass duct after each FD fan for tri- sector type APH
Air temperature at the inlet of each air pre heater (throughout Steam Generator		To keep average cold end metal temperature minimum 10°C above the acid dew point for flue



DESCRIPTION	UNITS	DATA
control range)		gases
AIR PRE HEATER		
Type		Regenerative type tri-sector air pre heaters with facility of steam coil heating on secondary air side to guard against low cold end temperature.
Steam Generator Load		a) 60% BMCR with worst coal and maximum moisture with one APH in service condition b) 100% BMCR with worst coal and maximum moisture with both APH's in service
Minimum average cold end temperature at 100% BMCR (with SCAPH's out of service)	°C	76
On load cleaning medium		Steam
Off load cleaning medium		Water
APH sizing shall also ensure following (for whole range of specified fuels)		
a) Minimum flue gas temperature (corrected)at APH exit at 100% TMCR load with design coal firing	°C	125
b) Air leakage	%	8% of the TMCR flue gas inlet flow entering air-heater
c) Minimum flue gas temperature	°C	5°C above acid dew point of flue gas
AUXILIARY STEAM PRDS		
a) High capacity auxiliary PRDS		
No of aux.PRDS/unit	No.	One
Capacity	t/hr	To meet the aux. steam requirements of the equipment in contractor's scope of supply when the unit running at 60% TMCR load plus start up auxiliary steam requirement of another unit plus auxiliary steam requirement of fuel oil system
b) Low capacity auxiliary PRDS		
No of aux.PRDS/unit	No.	One
Capacity	t/hr	To meet the aux. steam requirements of the equipment in contractor's scope of supply with unit running at 100% TMCR load plus auxiliary steam requirement of fuel oil system
FUEL FIRING SYSTEM		
Design of fuel firing system		To meet the requirements of Steam generator at 100% BMCR with worst coal.
COAL MILLS		
Number of Mills (N) corresponding to maximum 90% mill loading.		N+1 : 100% BMCR with worst coal N+2 : 100% BMCR with design coal (preferred total Number of Mills 8 (Min))
Maximum permissible mill loading for selection of mill capacity/type even during worn-out condition		80% of guaranteed capacity
Mill inside condition		Pressurised
Pulverized coal fineness at rated capacity of pulverizer	%	70% through 200 mesh(75 microns) 98% through 50mesh (300 microns)
Input Coal Size	mm	Upto 50
Design Hard grove grindability index of coal(HGI)	--	38
Wear Life of mill wear components		
a) Classifier cone and other items lined with ceramic materials	Hrs	25000
b) Classifier vanes	Hrs	25000



DESCRIPTION	UNITS	DATA
c) Seals (For Mechanical Seals)	Hrs	20000
d) Mill discharge valve	Hrs	15000
e) Grinding Elements (rolls, balls, rings and race)	Hrs	8000
Coal sampling device for sampling coal from coal mill discharge with rigid accessible platform		Required as per ISO/ASME. One working and one as standby
Coal mill system fire fighting		To meet NFPA / TAC requirements
Mill lube oil system		Integral / External
Mill grinding ring / Race		Segmental
PULVERISED COAL PIPE		
Velocity in coal Pipe		Minimum 15 m/s Maximum 28 m/s.
Minimum Continuous operating temperature for pipe design	°C	110
Special erosion protection (on identified areas)	-	Ceramic lining
Coal Pipe Material		Carbon Steel conforming to International standard
Guaranteed Life of wear parts	Hours	25000
Design Pressure (Minimum)	Kg/cm ² (g)	3.5 Kg/cm ² (g) as per NFPA requirement
RAW COAL FEEDERS		
Type		Gravimetric, belt type with minimum coal inlet pipe size of 36 inches
Operating range		1:5
Feeder capacity	%	Minimum 20% spare capacity over guaranteed mill capacity
Environment withstand capability as per NFPA norms		Operating pressure of 0.14 kg/cm ² Explosion pressure of 3.5kg/cm ² Ambient temperature 70°C (minimum) Other environmental conditions envisaged
PRIMARY AIR FAN		
Type		Two stage axial type with rotor blade aerofoil design
No of Primary air fan	Nos.	Two for each unit
Speed	rpm	1500
Control		Blade Pitch Control
Location of Silencer		At suction
Fan / motor bearings		Self aligning
Fan capacity		Fulfill both case (A) and Case(B).
Case (A)		
Steam Generator Load	%	60% BMCR with following conditions all occurring together
Number of stream in operation	-	One stream operation
Firing Coal	-	Worst Coal with maximum moisture content
Power Supply Frequency	Hz	50
Air Pre heater air in Leakage	%	15% of primary air leakage in RAPH or Guaranteed value whichever is higher
Ambient Condition	-	32 deg C with 67% relative humidity
Design Ambient condition		Maximum ambient temperature with 70% relative Humidity.
Case(B)		
Steam Generator Load	%	100% BMCR with following conditions all occurring together.
Number of stream in operation	-	Two stream operation
Firing Coal	-	Worst Coal with maximum moisture content
Power Supply Frequency	Hz	50



DESCRIPTION	UNITS	DATA
Number of mills in service		All mills including standby mill
Air Pre heater air in Leakage	%	15% or Guaranteed value whichever is higher
Ambient Condition	-	32 deg C with 65% relative humidity
Margin over 100% BMCR flow	%	25
Margin over 100% BMCR head	%	30
Design ambient condition		Maximum ambient temperature with 70% Relative Humidity.
SEAL AIR FANS		
Type	-	Centrifugal
Number of fans	Nos.	2x 100% common for all mills of each unit
Fan Sped	rpm	Not to exceed 1500rpm under test block condition
Margin over and above the calculated values under maximum duty condition	-	25% in flow 30% in head
Ambient Condition	-	Maximum ambient condition
Coal Burner		
Capacity		a)To cater to 100% BMCR load b)To ensure stable operation at and above BMCR with coal having lowest volatile matter without oil support
Minimum Turn down ratio of coal firing system		2:1.
Control		Centralized automatic control with flame scanner and safety protection.
NOX Limit		1.Low NOX design 2.Total NOx emission (fuel as well as thermal NOx shall not exceed 750 mg/Nm3)
Operation		Conforming to relevant NFPA guidelines.
FUEL OIL FIRING SYSTEM		
Fuel Oil firing capacity for HSD	%	7.5% BMCR heat input capacity
Fuel Oil firing capacity for HFO	%	30% BMCR heat input capacity
Oil burner		
a) Type	-	Steam/air atomised with HEA ignitors
b)Atomisation Medium	-	Air for HSD Steam for HFO
c) Capacity		>To cater for 30% BMCR heat input with HFO for load carrying and as oil support. > To cater for 7.5% BMCR heat input with HSD for startup at cold start conditions.
d)Minimum turn-down ratio of fuel oil burners	-	4:1
e)Control		Centralized automatic control with flame scanner and safety protection.
f)Burner cooling	-	HFO - steam or air HSD - air
g) Life	Hrs	16000
FD and ID fans		
Fan capacity		Fulfill case (A) and Case (B).
Description		FD fans ID fans
Number of fans	Nos.	Two for each unit Two for each unit
Type of fans		Constant speed axial Constant speed axial
Speed	rpm	≤1500 <750
Air/flue gas flow control	-	Blade pitch control Blade pitch control
Fan / motor bearings	-	Self Aligning Self Aligning
Fan sizing criteria		



DESCRIPTION	UNITS	DATA	
Case(A)			
Each fan Load		60% BMCR flow with following factors occurring together	60% BMCR flow with following factors occurring together
Number of stream in operation	No.	One stream in operation	One stream in operation
Type of coal firing		Design coal	Worst coal
Power supply frequency	Hz	50	50
Excess air requirement	%	20% over stoichiometric air requirement	20% over stoichiometric air requirement
Margin over 60% BMCR flow requirement	%	20	20
Margin over 60% BMCR pressure requirement	%	44	44
Design Condition	-	Maximum ambient temperature with 70% Relative humidity.	Maximum flue gas temperature plus 15 deg C
Air heater air-in leakage	%	10% of secondary air leakage or actual guaranteed value whichever is higher	10% combined primary and secondary air leakges into flue gas side of RAPH or actual guaranteed values whichever is higher
Pressure drop through ESP	mmwc	Not applicable	25 mm WC or actual value whichever is higher
Air-in leakage through ESP	%	Not applicable	1% or actual whichever is higher
Air-in leakage through ducts	%	Not applicable	2% through ducts or actual value whichever is higher
Pressure required at chimney inlet	mmwc	Not applicable	+ 10 mm WC
Operating Medium		atmospheric air	Flue gas
Case(B)			
Each fan Load	%	100% BMCR flow with following conditions taken together:	100% BMCR flow with following conditions taken together:
Number of stream in operation	No.	Two stream in operation	Two stream in operation
Type of coal firing		Design coal	Worst coal
Power supply frequency	Hz	50	50
Excess air requirement at Economiser outlet	%	20% over stoichiometric air requirement	20% over the stoichiometric air requirement
Margin over 100% BMCR flow requirement	%	20	20
Margin over 100% BMCR pressure requirement	%	44	44
Design Condition	-	Maximum ambient temperature with 70% Relative humidity.	Maximum flue gas temperature plus 15 deg C
Air heater air-in leakage	%	10% of secondary air leakage or guaranteed value whichever is higher	10% combined primary and secondary air leakges into flue gas side of RAPH or actual guaranteed values whichever is higher



DESCRIPTION	UNITS	DATA	
Pressure drop through ESP	mmwc	Not applicable	25 mm WC or actual value whichever is higher
Air-in leakage through ESP	%	Not applicable	1% through ESP
Air-in leakage through ducts	%	Not applicable	2% through ducts or actual value whichever is higher
Pressure required at chimney inlet	mmwc	Not applicable	+10 mmwc
Operating Medium	-	Atmospheric air	Flue gas
SCANNER AIR FANS			
Delivery head	%	121	
Capacity	%	110	
Frequency (minimum)	Hz	47.5	
AIR AND FLUE GAS DUCT			
Maximum velocity in flue gas ducts (the velocity shall be calculated considering 20% excess air at economiser outlet, worst coal firing at 100% BMCR load)	m/s	13(before ESP) 16(after ESP)	
Maximum velocity in air duct (the velocity shall be calculated considering 20% excess air at economiser outlet, design/ worst coal firing at 100% BMCR load whichever gives maximum air/gas flow)	m/s	16	
Flue gas duct plate minimum thickness	mm	7 mm before ESP. 6 mm from ESP outlet to chimney.	
Air duct plate minimum thickness	mm	5 mm	
Corrosion allowance	mm	1.5 mm	
Design pressure		Minimum $\pm$ 660 mmwc at 67% yield strength or maximum conceivable head of relevant fans, whichever is higher	
Type of Damper		Control Damper - Pneumatic	
		Isolation - Electric/pneumatic, where fast closing is desirable from process point of view.	
Duty		Intermittent / Continuous	
ELECTROSTATIC PRECIPITATOR			
No of ESPs per SG		One with min of 4 streams	
Installation		Outdoor	
Duty		Continuous	
Item		Guarantee point	Design point
Unit loading	%	100% TMCR	100% BMCR
Type of coal	-	Design Coal	Worst coal (Maximum ash coal from specified range)
Ambient air condition	-	Specified reference ambient condition	Maximum ambient condition
Gas flow per steam generator at the ESP inlet when firing respective coal	m3/sec	To be worked out by Contractor when firing the specified design coal at TMCR load considering 20% excess air at economiser outlet, 15% air heater in leakage and 2% duct leakage as a minimum.	To be worked out by bidder when firing the specified worst coal with max. ash at BMCR load, considering 20% excess air at economiser outlet, 15% air heater in leakage and 2% duct leakage as a minimum.
Gas temperature at ESP inlet	°C	125 deg C or predicted by	140 deg C or predicted

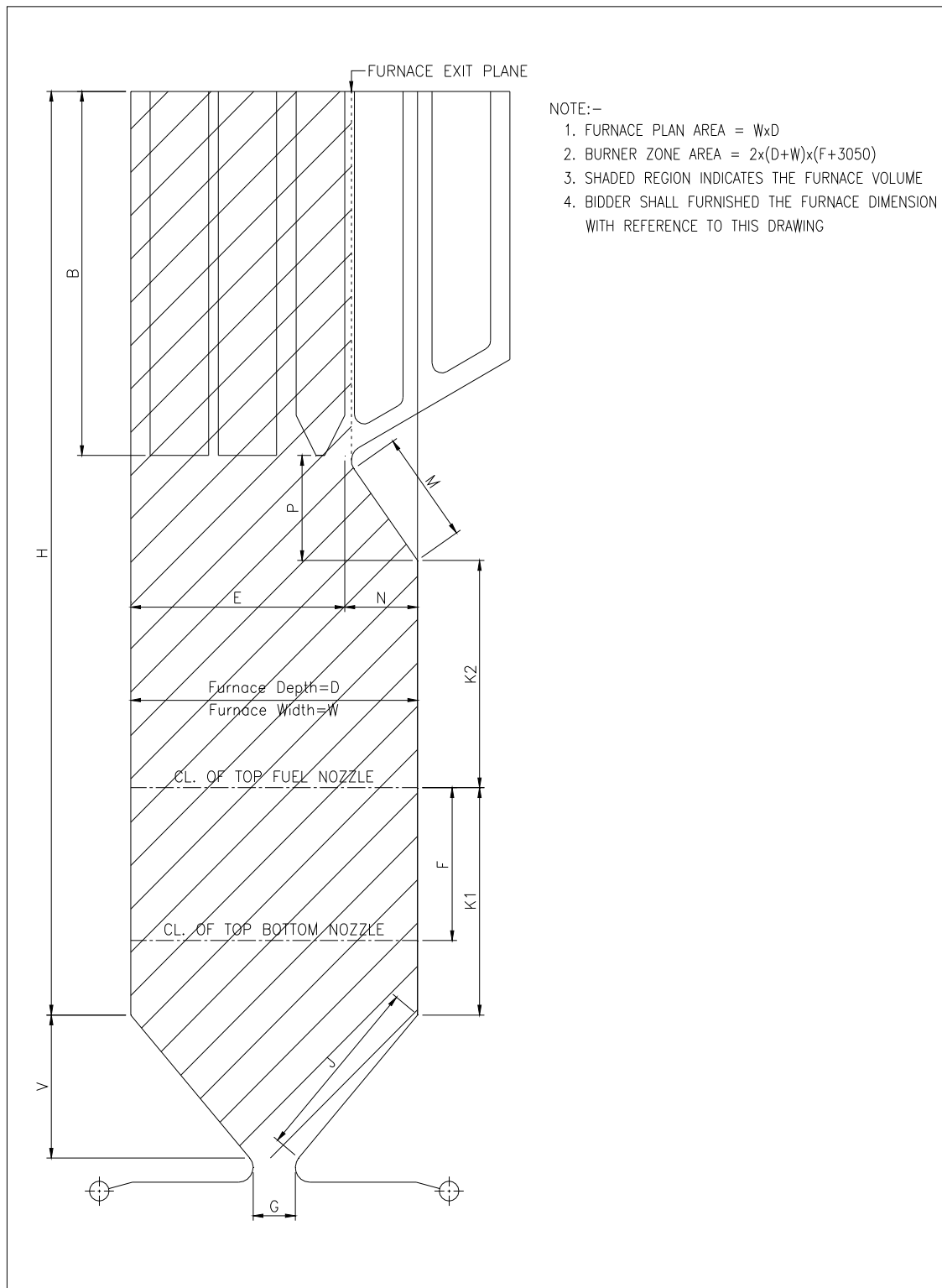


DESCRIPTION	UNITS	DATA	
		the Contractor under condition stipulated above, which ever is higher	by the Contractor under condition stipulated above, which ever is higher
Inlet dust burden	gm/Nm ³	To be worked out by the Contractor (based on 90% of ash or actual predicted whichever is higher being carried forward to ESP while firing specified design coal).	To be worked out by the Contractor (based on 90% of ash or actual predicted whichever is higher being carried forward to ESP while firing specified worst (maximum ash) coal).
ESP dust collection efficiency	%	To be worked out by Contractor to limit outlet dust burden (ODB) to <50 mg/Nm ³ (maximum) with one field out of service while firing design coal	To be worked out by Contractor to limit outlet dust burden (ODB) to 50 mg/Nm ³ (maximum) with one field out of service while firing worst coal
Maximum flue gas velocity through the ESP	m/s	1	1
Treatment time of the flue gases (minimum)	seconds	20	20
Other design parameters:			
a) Minimum aspect ratio	-	1.5	1.5
b) Design internal pressure at 67% yield strength	mmwc	±660	±660
c) Precipitator mechanical design temperature	°C	200	200
d) Short temp excursion temperature (for approx. thirty minutes at a time)	°C	300	300
e) Minimum dust hopper storage capacity (up to the maximum trip level based on design point conditions (while firing worst coal (with maximum ash)	hrs	-	8
f) Minimum hopper valley angle to the horizontal	degrees	60	60
g) Ash resistivity	ohm cm		1x10 ¹³
Insulation and Cladding			
Insulation, lagging, cladding & refractories			
Ambient temperature	°C	40	
Surface velocity	m/s	1	
Insulation surface temperature	°C	60	
Min thickness of insulation for SG	mm	75	
Min thickness of insulation for ESP	mm	70	
Min thickness of insulation for other surface	mm	40	
Soot blowers			
Number of Steam Generator operating hours without outage for wet cleaning	hours	8,000	
Cleaning medium		Superheated steam	
Drive		Dual electric drive for traverse and rotary motion.	
Other Data			
Galleries, platforms, floorings			
Minimum live load for design of platforms and galleries (for operation and	dN/m ²	500	



DESCRIPTION	UNITS	DATA
maintenance purposes		
Minimum live load of floorings (needed exclusively for inspection and operational purposes)	dN/m ²	250
Stairs		
Minimum live load	dN/m ²	250
Maximum inclination	deg	40
Minimum clear width	mm	1,000
Treads shall overlap by at least	mm	25
Ladders		
Minimum clear width	mm	800
CHIMNEY:		
Height of chimney	m	275
Minimum flue gas velocity when unit operating under normal condition (100% TMCR design coal)	m/sec	22
Maximum NOx emission while firing worst coal	mg/Nm ³	< 750

SKETCH FOR BOILER FURNACE



Furnace shall comply with requirements specified in the Annex 2.1.1-Specified Design Data at 100% BMCR with or without HP heaters out of service and with range of specified coals, under most stringent combination of operating conditions.



ANNEX 2.1.2

SPECIFICATION FOR AUXILIARY BOILER

1.0.0 SCOPE OF SUPPLY

One (1) no. water tube type, natural circulation, pressurized furnace, HSD fired, outdoor type auxiliary boiler with its auxiliaries, having steaming capacity of Minimum 50 TPH with steam parameters of 16 kg/Sq. cm(g) pressure and 350 deg.C steam temperature, complete with structures, piping, valves, fitting, mounting, draft plant, fuel oil pressurizing & firing system, water system, chemical dosing system, blow down tanks, ducting, damper, chimney, C&I, Control panel and Electrical Breakers, all associated works.

- a) Complete steam and water circuit includes feed control station comprising of 2x100% feed control valves and Saturated steam from evaporators section / drums shall pass to a convective superheater. Super heated steam shall be connected to aux steam header through a NRV and a motor operated isolating valve.
- b) Furnace including its fittings, mountings and other accessories.
- c) Steam drum complete with internals, safety valves, level indicators, chemical feed, pressure gauges, vents and drains, sampling connections, acid washing connection and thermocouples etc.
- d) Safety valves at drum, SH outlet and wherever required shall be provided.
- e) Feed system complete with feed water pressure type deaerator complete with necessary mountings and fittings and 2 x 100% electric motor driven boiler feed pump sets (one running & one standby) with auto-change over facility on failure of duty pump and NRV is fitted with discharge, together with all pipe work, valves fittings, controls etc. as necessary.
- f) Non steaming type Economiser system with connecting pipes, headers, etc. with non-return valves, vents, drains and sampling connections
- g) One no. D.M. Water storage tank sized for half an hour make-up water requirement of boiler at 100% BMCR and 2 x 100% makeup water pumps alongwith necessary valves, piping and fittings shall also be supplied.
- h) HSD system complete with HSD piping from HSD day oil tank to pressurizing pumps & from pump to burners, any recirculation/return line etc. complete line with necessary valves & fittings etc. are to be provided and two (2) nos. of positive displacement type HSD pressurizing pumps with motor drive.
- i) Complete flue gas ducting upto chimney including flanged & bolted joints self supports, etc.
- j) Complete draft system comprising of 2 x 100% FD fans complete with lube oil system and associated ducting system etc.
- k) 1 no of 35m high chimney with insulation and cladding and shall be provided with access door with cover and a drain connection.
- l) Complete boiler structures, supports and canopy including frames, supports and steel sheetings and shall be complete with guttering & downpipe, etc. as necessary.



- m) Platforms, ladders, gang way, handling provisions. Suitable platform & approach shall be provided for operation of auxiliary boiler and for attending all maintenance requirements of the boiler & its auxiliaries.
- n) Insulation and refractory for auxiliary boiler components & auxiliary equipments.
- o) Equipment Handling Arrangement at wherever required.
- p) Complete instrumentation and control

2.0.0 DESIGN REQUIREMENTS

The specific requirements as follows:

- a) Auxiliary Boiler shall be capable of achieving full load from cold conditions within maximum two (2) hours time.
- b) Two nos of HSD pressurizing pumps shall be sized for 100% MCR requirements of auxiliary boiler and an additional margin of 10%.
- c) The main burners of Aux Boiler are to be designed for firing HSD. The ignition system will use spark ignition system.
- d) Motor driven boiler feed pump shall be rated for continuous operation at 100% boiler, MCR with an additional margin of 10% on flow.
- e) D.M. Water storage tank sized for half an hour make-up water requirement of boiler at 100% BMCR.
- f) Safety valves at steam drum shall be designed for 75% MCR capacity and SH outlet shall be 30% MCR capacity.
- g) The pressure withstand capability at the furnace shall not be less than the maximum conceivable head of the FD fans.

3.0.0 CONSTRUCTION REQUIREMENTS

The specific requirements as follows:

Super Heater

Convective type, suitable to take care of hot end corrosion due to fuel oil.

Feed System

The pumps shall have stainless steel impellers. The shaft seals shall be hard faced water wear resistant material with automatic wear adjustment taken up and alignment. Each pump discharge is fitted with NRV.

Ducting

The duct shall be rectangular in shape & constructed from carbon steel plate. The ducting section shall have flanged & bolted joints self supported against all wind seismic and gravitational loads.

Structural Steel Work

All steel work & structures shall be capable of accepting seismic loading in addition to other loadings including dead weight, wind forces etc.



Auxiliary Boiler Canopy

To offer protection to the boiler against rainfall, a rain canopy shall be provided. This shall be made from steel frames, supports and steel sheetings and shall be complete with guttering & downpipe, etc. as necessary. The rain canopy shall not prevent reasonable access to boiler mountings and shall be arranged as necessary to allow the use of lifting tackles supported off the rain canopy steel work.

Chimney

The chimney shall be manufactured from CORTEN steel plate with insulation and cladding and shall be provided with access door with cover and a drain connection. The chimney shall be insulated with mineral wool.

Equipment Handling Arrangement

Where it is necessary to handle any item in excess of 55 kg. weight on the boiler for purpose of erection or maintenance a suitable lifting beam arrangement is to be provided. For loads one ton and above on lifts exceeding three meters electric hoists shall be provided.

**ANNEX 2.1.2.1****SPECIFIED DESIGN DATA – AUX BOILER & ITS AUXILIARIES**

Parameter	Units	Value
Steam Flow	T/Hr	50
Steam Pressure	kg/cm ²	16
Steam Temperature	Deg C	350
Feed water flow	T/Hr	
Fuel fired		HSD
Fuel Flow	T/Hr	
Atomization Medium		Air
Efficiency of Boiler	%	About 88
feed control valves	%	2x100
MDBFP	Nos	2 x 100
DM water and HSD storage capacity	hrs	1 Hr for DM Water /2 Hrs for HSD
HSD pressurizing Pumps	Nos	2
FD Fans	Nos	2 X 100%
Chimney	m	35
Ignition		Spark Ignition



VOLUME II
SUB-SECTION - 2.2
STEAM TURBINE & AUXILIARIES SYSTEM

1.0.0 GENERAL

This section covers minimum requirements for design, engineering, manufacture & assembly, inspection, erection, testing and commissioning of Steam Turbine.

The steam turbines shall be super-critical, condensing, single reheat and regenerative, tandem/ cross compound, multi-cylinder type to suit the unit rating and the supplier's proven design, and shall be throttle governing, horizontal type coupled to directly driven AC generator suitable for indoor installation as per manufacturer's standard and proven design.

Determination of main and reheat steam parameters, number of extraction points, number of turbine casings and stages, final feed water temperature, extraction steam parameters etc. shall be based on the optimization study by the Contractor considering turbine manufacturer's proven standard design for the unit rating and type. Contractor to ensure suitability of final feed water temperature for steam generator at all loads.

This section of the specification shall be read in conjunction with other sections of the specification as appropriate and the equipment offered shall meet the requirements as spelt out therein.

2.0.0 CODES AND STANDARDS

The equipment to be provided shall specifically conform to the latest editions of the following codes, standards, specifications and regulations. Also the system design shall conform to the requirements of applicable codes as specified in the General Technical Specification.

PTC-6	: ASME Performance Test Codes for Steam Turbines.
IEC:34-1	: Specification for rotating electrical machines.
IEC:34-3	: Specific requirement for turbine-type synchronous machines.
IS:7132	: Guide for testing synchronous machines.
IEC:34-2	: Method for determining losses and efficiency of rotating electrical machinery from test.
IEC:34-4	: Methods of determining synchronous machine quantities from test.
IEC:34-5	: Classification of degree of protection provided by enclosures for rotating machines.
IEC:34-6	: Methods of cooling rotating machinery.
IEC:34-8	: Terminal marking and direction of rotation for rotating machines
IS:3003	: Specification for carbon brushes of electrical machine
ASME-TDP1	: Prevention of water damage to steam turbines. (Part-I)
IEC-45	: International Electro- technical Commission
ANSI	: America National Standards Institute.
ASTM	: American society of testing and materials.
IEC 953-1	: Rules for steam turbine thermal acceptance tests

Manufacturing standard can be considered in the absence of codes and standards on a case-to-case basis on approval of Owner.



3.0.0 SCOPE OF SUPPLY

Each steam turbine generator unit shall be provided with the following equipment and accessories.

Steam turbine and auxiliaries specified herein for the TG set together with all accessories and auxiliary equipment including HP/LP bypass system required to make a complete and well integrated unit to satisfy the scope of this specification shall include but shall not be limited to the following (for each steam turbine unless indicated otherwise) :

3.1.0 Steam Turbine

- Steam turbine shall be complete with casings, rotors, bearings, temperature detectors, couplings, steam gland seal, rotor turning gear preferably hydraulic type and having local/remote operation facility, hand barring gear, emergency stop and control valves and reheat stop and control valves with their servomotors, Integral steam strainers with the emergency Stop and reheat stop valves or removable type steam strainers for start up and normal operation upstream of emergency stop and reheat stop valves, crossover/ cross around piping and electric motors for all its integral subsystems. Steam strainers integral with main steam emergency stop and reheat stop valves are also acceptable.
- Hydraulic/pneumatic power operated quick closing non-return valves (QCNRV) and ordinary non return valves for each extraction including steam lines to BFP turbine drives, and for each cold reheat line one hydraulic/ pneumatic power operated QCNRV shall be provided. The type of actuation i.e., hydraulic/ pneumatic shall be as per the standard proven practice of the Manufacturer.
- Blow out provision for emergency stop and control valve and reheater stop and control valve.
- Steam turbine governing and protection system complete with electro hydraulic governor with mechanical hydraulic back up or electro hydraulic system with 100% hot back-up, electro hydraulic converter, hydraulic converter, tracking devices, hydraulic speed governor, electrical speed sensors, speed/load adjusting gear, unloading gear (if applicable), vacuum breaker, motor drives, remote trip solenoids, over speed, low condenser vacuum, low lube oil pressure, high axial shift and other trip/protection devices, electrical components associated with electro hydraulic system, test devices and test panel inserts/testing facility etc.
- Explosion diaphragms for outer casing.
- Turbine gland sealing steam system with gland steam condenser, gland steam exhausters (2 x 100%), all associated motors, associated piping, valves and fittings, strainers/ filters, specialties, hangers and supports, necessary insulation and complete with instrumentation and control hardware including electro hydraulic/electro pneumatic controller, actuator, electro hydraulic /electro pneumatic converter etc. as to make the system complete in all respects.
- Turbine integral drain system consisting of warming, drain and vent system, associate piping and equipment complete with flash tanks (details specified in condensate system), associated spray system, piping, valves and fittings, valve motor drives or pneumatic actuators, specialties, hangers, supports, insulation, instrumentation and control etc. Drains from main steam, cold reheat and hot reheat lines etc. shall also be connected to these flash tanks(details specified in condensate system)



- Turbine preservation system consisting of adequate numbers of air driers including, fans, motors, filters, heater drying wheel, connecting pipings, valves, fittings etc. for preservation against corrosion of turbine during idle periods shall be provided. Write-up on the recommended system to be furnished. Bidder to elaborate the alternate preservation procedure recommended for turbine corrosion protection during long outage of plant in his bid.
- Boroscopic inspection ports in turbine for inspection of turbine internals shall be provided as per Contractor's standard practice. The inspection ports shall cover turbine internals as maximum as possible as per Bidder's Standard practice. The inspection port should be designed for ease of accessibility with leakage proof features while in operation.
- Hydraulic or pneumatic or DC operated device shall be provided for rapid reduction of vacuum in condenser to bring turbine rotor to rest as quickly as possible under emergency conditions.
- Blanking discs for emergency stop and reheat interceptors and control valves and special bonnets, as required for steam blow out. Provision for steam blow-out pipe connection with cold Reheat lines non-return valves.
- Steam turbine exhaust hood spray cooling system complete with spray arrangements, associated piping, instrumentation and control devices, valves and fittings, motor/solenoid operated valves and specialities, hangers, supports etc.
- Complete noise and thermal insulation, to the extent necessary
- Turbine cladding/covers/enclosures complete.
- Flush / cleaning provisions
- Sealing fixtures (for hydraulic pressure testing of steam lines) at HP and IP valve blocks.
- All primary Instruments and final control elements.
- Turbine Supervisory Instrumentation
- Transport Fixtures along with all special Tools & Tackles.
- Complete enclosure for turbine complete (If applicable as per OEM, However bidder to ensure the Noise level within the Limits).
- Fire detection and protection system for lube oil tank area and turbine and generator bearing area.

3.2.0 Turbine oil system

Lubricating oil system complete with main oil tanks including oil strainers, oil purifying system, oil pumps (as specified below) with drive motors, oil coolers (as specified below), strainers, vapour extractors (as specified below) with drive motors, maintenance opening, vent connection, all interconnecting piping, valves and fittings, hangers and supports, necessary instrumentation and control hardware to make the system complete in all respects.

- One (1x100%) shaft driven Main Oil Pump (MOP) with Two (2x100%) AC MOP
- (or)



Two (2 x 100%) AC motor driven main oil pumps with (2 x 100%) AC motor driven auxiliary oil pumps.

- 1 x 100% Emergency Oil Pump with DC motor drive.
- 2 x 100% Jacking oil pumps with one pump provided with AC motor and another pump provided with DC motor drive for emergency condition.
- 2 x 100% duty oil vapour extraction fans with AC proof explosion motor with oil separation in the piping.
- 2 x 100 % lubrication oil coolers equipped with change over device allowing continuous operation without interruption of oil flow and automatic oil temperature control device.
- One Duplex filter with change over valve for the complete lube oil flow.
- Automatic oil temperature control device.
- Centralised oil storage and purification system common for two units including clean oil tank, dirty oil tank, transfer pumps, purifying unit with interconnecting piping, necessary instrumentation and control hardware to make the system complete in all respects.
- Steam turbine control fluid and its purification system along with its conditioning system complete with control fluid tank, control fluid pumps (as specified below) with drive motors, strainers, accumulator, control fluid coolers(as specified below), waste fluid tank, purification equipment including fluid circulation pumps with drive motors, associated piping, valves, fittings and specialties, hangers and supports, instrumentation and control hardware to make the system complete in all respects.
- 2x100% Control oil pumps
- 2x100% control oil coolers
- 2 x 100% vapour extraction fans and drive
- One Duplex filter with change over valve for the complete control oil flow.
- Sheet metal ducts or cover for oil piping and other oil spray protection equipment.

3.3.0 Miscellaneous Items

- All sole plates, sub-sole plates, shims, jack-screws and wedges, as required, to set and align the turbine generator unit.
- All foundation frames/base plates, anchor bolts, sleeves, nuts etc. for all equipment under this section.
- Special lifting slings, lifting beams etc. for erection and maintenance of the turbine cylinders and rotors, generator stator and rotor, bolt heating device, tongue wrenches etc.
- Suitable lifting attachments i.e., lifting lugs, eye bolts, slings, etc. for all equipment to facilitate erection/maintenance.



3.4.0 Turbine Bypass System

- 60% BMCR HP bypass valve (minimum 1 x 100% or 2 x 50 % Capacity) and corresponding LP bypass steam conditioning valve (capable of handling steam flow to HP bypass valve and spray water used in the HP bypass system) with spray water valves, spray control station, throttling devices, fittings, de-superheating arrangement, hydraulic power pack, solenoid valves, quick acting devices, blanking devices for steam blowing, supports, associated piping including warm up arrangement, valves, instrumentation and control hardware, electrical devices and actuators/motors etc. For LP bypass valves, the control fluid supply can be taken from the common control fluid system if it is a standard practice of the Contractor.
- Spray water system consist of spray water control &, block valve, isolation valves, flow element, NRV, piping along with necessary instrumentation etc.
- Dump tube with spray water arrangement to meet the HEI requirement.

3.5.0 Piping, Valves, Fittings Supports etc.

The complete piping system as specified below and as required along with valves, control valves, fittings and supports, instruments, insulation and cladding etc.,

- Lube oil system
- Control fluid system
- Turbine gland steam seal system
- Exhaust hood spray system
- Seal oil system
- Spray water piping for steam turbine Generator, bypass system, dump tube station and other system as required.
- Any other piping system

4.0.0 DESIGN REQUIREMENTS

The design of Steam Turbine Generator shall comply with the design requirements set out in this section and also meet the requirements specified in Annex 2.2.1 - Specified Design Data.

Steam turbine proposed for this project is proven design with respect to HPT inlet pressure and temperature, IPT inlet temperature, HP, IP,LP blade profile and number of stages in HP, IP,LP turbines and the offered steam turbine with above design for the similar capacity should already be in successful operation. Contractor shall also furnish along with the bid, the reference list of power plants of similar capacity which are in successful for at least one years for the main steam and reheat steam parameters offered for this project.

The proposed steam turbine set should be operating under constant pressure mode from zero to 40% rated load, sliding pressure mode from 40% to rated load. The proposed TG set shall be capable of continuous operation under VWO condition also.

The design shall cover adequate provision for quick startup and loading of the unit to full load at fast rate. The unit shall have minimum rate of loading or unloading of 3% per minute above the control load (ie 50% TMCR).

Turbine vibrations shall be minimized and shall be with in the limits as per latest version of relevant standards of International Organization for standardization (ISO).



The turbine shall be provided with protective devices as per relevant IEC or equivalent, including the following:

- (a) Separately actuated over –speed trip device,
- (b) Emergency hand trip devices to facilitate manual tripping of the turbine locally and from control room.

The turbine generator units shall comply with general requirements and standards of relevant latest versions of IEC & IEEE or their approved equivalent or as per the Supplier's standard practices to be mutually agreed between the Contractor and Owner and the additional requirements as specified hereinafter. All materials, equipment and fabrication procedures, wherever applicable for the equipment covered in this specification, shall also be in accordance with the latest applicable code requirements.

Type of steam turbine shall be of tandem/cross compound construction, condensing type with adequate no. of steam extractions at optimum points for regenerative feed heating. HP turbine shall be of double casing design. The HP, IP and LP casings shall be independent of each other OR combined HP-IP and separate LP casing(s). LP turbine may consist of two separate turbines. HP inner casing, IP casing and LP casing(s) shall be of horizontally split type. HP steam dumping device shall be provided for evacuation of steam from HP turbine to the condenser after shutdown /tripping to avoid windage.

Gross continuous TG power output less the power consumed by excitation system at 100% turbine maximum continuous rating (TMCR) shall be guaranteed under design steam conditions with 0% make-up, all extractions in operation and design condenser back pressure

DM water make up to thermal cycle under BMCR condition 1%. However the system has to be designed for 1.5% DM water makeup

The turbine- generator set shall be capable of continuous 100% TMCR output under rated steam conditions, design condenser back pressure, 1 % make-up and 47.5 Hz grid frequency.

The turbine shall also be capable of operating continuously with valves wide open (VWO) to swallow 105% of TMCR steam flow to the turbine at rated main steam and reheat steam parameters.

The operating capabilities of various systems, equipments and associated auxiliaries in the scope of Contractor is specified elsewhere in the technical specification.

The plant and it's unit (s) shall be designed to operate with all the specified margins for continuous operation without any limitations under any of the conditions indicated in the technical specification.

Turbine shall be capable of continuous operation under all HP heaters out of service with maximum output commensurate with boiler heat duty corresponding to 100% operation with HP heaters in service and the same shall be demonstrated.

Turbine Generator set shall be capable of continuous operation with HP heaters out of service with maximum output not less than 660 MW

Contractor shall indicate the turbine over pressurisation (under VWO) possible and ensure corresponding continuous output of TG set as per IEC 45.

Turbine shall be capable of accepting variation in steam temperature and pressure as per IEC 45 in case continuous over pressure operation is possible.

Turbine shall be suitable for continuous base load operation. In addition Turbine shall be suitable for two-shift operation & cyclic load variations.



Turbine shall be capable of operating on constant pressure mode as well as on variable pressure mode during part load and start up operation.

TG set shall be capable of being started from cold condition to full load operating conditions in as short time as possible.

TG set shall be capable of operating on house load during sudden total export load throw off using HP and LP bypass system. Unit shall not trip on over-speed in the event of total export load throw-off.

Over speed during full load loss shall be limited to 8% of the rated speed.

The turbine generator and the associated systems shall be designed for minimum of 4000 hot starts, 1000 warm starts and 150 cold starts during its life. No component shall be stressed beyond acceptable safe stress and fatigue levels when operating under the stated duty conditions.

The steam TG set apart from being capable of operation on base load, shall also be suitable for two shift operation and cyclic load variations as the unit is expected to operate in automatic load-frequency control system.

Contractor shall provide adequate temperature measurement and other instrumentation etc. for adequately guiding the operator to regulate loading of unit to keep the thermal stresses and fatigue levels within safe limit.

Turbine Generator set shall be capable of operating on constant as well as variable pressure mode. Necessary facilities shall be provided for switching over to variable pressure mode of operation from constant pressure operation and vice versa from unit control board.

During sliding pressure mode, throttle pressure shall slide from 100% to 40% of rated pressure corresponding to 30% load.

The peak to peak value of vibration measured on bearing housing shall be minimized and shall be within limits as per ISO 10816 and ISO 7919.

All cycle drains shall be led to condenser through flash tanks. In addition, the provision shall be kept for main steam line drains and HP bypass line drains to be led to a separate atmospheric flash tank.

The steam turbine & its auxiliaries shall be capable of safe, reliable and continuous operation and shall be able to operate continuously with frequency variation of plus 3% and minus 5 %.

While operating under all the above conditions the variation in steam temperature and pressure shall be limited to the extent stipulated in latest IEC-45.

The start up and drainage system shall comply with relevant ANSI/ASME Standard TDP-1 prevention of water damage to steam turbines.

The turbine governing system shall meet the following requirements:

- i) The governing system shall be capable of controlling with stability the turbine speed between zero to maximum power output when the unit is operating isolated or in parallel with other units.
- ii) Over speed during full load loss shall be limited to maximum of 120% of the rated speed
- iii) Adjustable steady state speed regulation shall be provided between +3% to +8% of rated speed during commissioning.



- iv) Dead band at rated speed and at any power output within rated output shall not exceed 0.06% of rated speed.

The turbine shall be provided with protective devices as per relevant IEC or equivalent, including the following:

- (i) Separately actuated over-speed trip device.
- (ii) Emergency hand trip devices to facilitate manual tripping of the turbine locally and from control room.

4.1.0 Steam By-pass System

The HP/LP Bypass System shall be designed to handle 60% of BMCR flow and sized for 65% BMCR flow at rated steam conditions. LP bypass system shall be designed to condition the incoming steam from reheater to parameters matching the LP turbine exhaust steam and the capacity shall be commensurate with that of the HP bypass system plus the spray water used in HP bypass.

Steam dumping device shall be provided for dumping of desuperheated steam from LP bypass. Sizing of steam dumping device shall be adequate to accept the steam from LP bypass valve outlet with necessary spray water including abnormal condition like HP heaters out of services plus spray water used in dump tube.

The low pressure steam bypass system shall be furnished with perforated basket type dump tube of length as required to evenly distribute the fluid.

Dump tubes shall be designed to distribute the steam as evenly as possible in the steam turbine exhaust duct by individual dump tubes.

HP/LP bypass valve actuators shall be of Electro Hydraulic type.

The HP/LP bypass system shall be designed to control the flow and temperature of steam bypassing the HP and LP sections of steam turbine during the steam turbine trip or during major load rejections, so that the boiler can safely be kept on-line, without risk of lifting of Steam generator safety valves.

Each HP/LP bypass system shall be equipped with necessary control and instrumentation including all necessary positioners for continuously controlled actuators, power modules, various converters, power supply and other fault monitoring and alarming modules, position transmitters, etc.

Each bypass station shall be designed for the respective maximum steam pressure, i.e. the safety valve set pressure in the respective section and sized for maximum steam capacity generated taking into account the condensate injection for attemperation.

Attemperating water for the HP Bypass valves shall be taken from feed water pump discharge and for LP Bypass shall be taken from Condensate Extraction Pump discharge. Spray water system shall include spray water control valves, Non-return valve and isolating valves.

Warming up arrangement shall be provided for HP and LP bypass valves and associated piping.

HP-LP bypass system shall be suitable for operations under sliding pressure mode to enable short start up time.



HP-LP bypass system shall be capable of operation in parallel with turbine with all feed water heaters in service.

HP-LP bypass system shall facilitate hot and warm restart of the unit following a trip from full load, part loads, controlled shutdown and cold start up following a long shutdown.

The system design shall ensure that boiler operation is not affected in the event of loss of load on the turbine, by disposing off the steam produced in the boiler automatically by providing a quick opening device. The full stroking time of valve under quick action shall be within 2 to 3 seconds.

The HP/LP bypass system shall rapidly shutdown upon detection of low spray water pressure/ high steam temperature downstream of desuperheating stations and high reheater / condenser pressures.

Special attention shall be paid to the provision of draining the warm up drains as close to the bypass valves as possible in order to minimize steam hammer / thermal shock on bypass valves and upstream pipe work when bypass comes into operation.

The systems downstream of bypass valves shall be capable of withstanding the thermal shock due to failure of spray water.

Sufficient upstream and downstream straight length of piping shall be kept for each By-pass control valve, to permit desired controllability, based on applicable code recommendation/ good engineering practice. Downstream piping material shall suit the outflow temperature, depending upon the mixing length require by the de-superheater (to be ascertained by Temperature Element). Valve position, elevation & warming system shall be prevent water accumulator when closed & thermal shock when it opens.

5.0.0 CONSTRUCTIONAL REQUIREMENTS

The installation and dismantling of the various parts of the equipment must be possible without great difficulty and appropriate design features must be incorporated for this purpose.

All parts must be capable of accepting the loads occurring due to rapid load and temperature variation and also those occurring due to start-up, shut-down and continuous base load operation without limitation and without affecting the planned life.

The turbine generators must operate without any restriction and any limitation in time at each load between no-load and maximum continuous load and shall be ensured that ramping rate is not exceeded.

In so far as the special requirements given below for the individual parts of the plant also apply to other parts of the steam turbine plant, they are to be used there as applicable.

5.1.0 Steam Turbine

Casings

Casing shall be designed for maximum pressure and temperature to be encountered during service. The design of casing shall be such as to permit inspection of all main bearings without dismantling the casings.

The turbine casings shall be designed for a hydro-static test pressure of at least 50% in excess of the working pressure or as per proven OEM practice subject to approval of Owner.



There shall be no sudden cross section changes and sharp corners leading to stress concentrations.

The differential expansions if any between rotors and casings shall be kept to the minimum.

Steam tightness of HP and IP turbine casings shall be ensured by providing horizontal joints with metal to metal contact. Steam tightness of LP turbine shall be ensured by providing suitable seals.

Steam chest support arrangement shall be of proven type and shall be capable of accepting piping forces during operation without transmitting the same to the casings.

All extractions shall preferably be from the lower half of casing and extraction branches should be welded to casings except for LP casing extractions which can be bolted connections or as per proven OEM practice subject to approval of Owner.

In order that rapid assembly and dismantling of the turbine will be possible, the turbine casings are to be split horizontally and supplied with guides to permit safe lifting of the casing.

To check the condition of the turbine blading without opening the casings, openings are to be provided at suitable points on the casings. Casings shall be symmetrical in design to minimise the effects of thermal stress and creep. The design and surface preparation of the supports are to be such that thermal expansion is not prevented.

Adequate drainage facility shall be provided in casings for proper removal of drains during start-up.

LP casing shall be provided with completely self contained exhaust hood spray to protect the turbine against excessive temperature due to windage at no load; low load and HP-LP bypass operations. Exhaust hood spray cooling water shall be supplied from the main condensate extraction pump discharge. Pressure relief bursting diaphragms shall be provided for LP casing(s) to limit the exhaust hood pressure within a safe margin from design pressure.

Inspection holes shall be provided for field balancing of rotor without dismantling the casings.

Dismantling of casing should be possible with minimum removal of insulation.

Bearing inspection should be possible without necessity of dismantling the turbine casing.

Guide rods shall be provided to prevent damage to blades during erection and maintenance.

Suitable lifting gear and slings shall be provided for raising and lowering the upper portions of the turbine casings and rotors, blading or remainder of the machines.

Blading, nozzle segments:

The design of turbine blading will have to ensure high efficiency of energy conversion with low loading, stressing and vibration considerations to insure long-term reliability. All the blades shall be securely and adequately anchored to the rotor and design shall ensure quick and easy site replacement.

Material of nozzles and blades shall be hard, corrosion and erosion resistant alloy steel.

The turbine blading shall be designed to withstand the centrifugal stresses that arise due to rotation and bending stresses due to flow of steam. In addition HP blading shall withstand high temperature and LP blading shall resist corrosion and erosion in fast flowing wet steam. LP stage blade hardening up to 1/3rd (min) of blade length & width 25 mm or stelling as per the proven standard practice of turbine manufacturer. L.P blades design



without lacing wires is preferred. Fatigue strength, vibration damping shall also be provided in the design of blades.

There shall be no resonance of LP blading in the continuous operating frequency range of 47.5 Hz to 51.5 Hz. The Contractor shall furnish campbell diagrams for free standing stages of LP blading offered.

Free standing stages of LP turbine blades shall be independently tuned to avoid resonance frequency in the operating frequency range of 47.5 Hz to 51.5 Hz.

Stress induced in LP turbine blading due to back end steam loading under VWO conditions shall not exceed 90% of design stress value. Supporting calculations shall be furnished for the above.

The turbine stages operating in the wet steam region are to be provided with sufficient water drains.

Design shall ensure quick and easy site replacement of blading.

Rotors

Rotors shall be of forged alloy steel.

Uniformity of material composition and strength shall be ensured by examining adequate number of test specimen.

Dynamic balancing shall be carried out on composite rotor and blade assembly. The rotor shall be tested at an over speed of 120% of rated speed.

Completed rotor including coupling shall be capable of withstanding the shock loading and excess torque resulting from a generator short circuit without damage.

The procedures proposed for inspection of the rotors in order to ensure their soundness and homogeneity shall be stated in the specification, together with particulars of the thermal treatment proposed in order to minimize the possibility of distortion occurring in service. The HP and IP rotors shall be given thermal stability test.

Vibrations shall be minimized and shall be within limits as per Zone A of ISO 10816-2 and Zone A of ISO 7919.

Critical speed of composite rotor and blade assembly shall not be within $\pm 15\%$ of operating speed i.e. 3000 rpm or the range recommended by IEC-45. Contractor shall furnish studies carried out for combined critical speeds for the offered TG set.

Bearings

All the bearings are to be designed as horizontally split, forced lubricated type, lined with suitable anti-friction material and provision shall be available for adjustment and alignment of the rotors.

Complete even loading of the bearings is to be ensured by suitable measures. The thrust bearings must be capable of taking load from both sides and be self-aligning. They must be axially adjustable. The journal bearing shall be self aligning type with spherical seats.

The thrust bearing shall be of the Michell or Kingsbury tilting pad type and shall be capable of handling the maximum possible thrust in either direction under any combination of operating conditions. A thrust bearing wear indicator shall be provided with an alarm for excessive



thrust wear or standard practice of proved OEM subject to approval of Owner. It must be possible to check the thrust bearing wear during operation.

Provision shall be made for measuring bearing temperature as near the point of heat generation as possible and for measuring the oil temperature leaving the bearing.

No oil leakage shall take through bearings.

Independent supporting arrangement outside the turbine casings and easy access

One number portable type fire extinguisher shall be provided for the turbine and generator bearing area.

Following instrumentation shall be provided for each journal and thrust bearing:

- a) Necessary pick-ups and accessories for remote monitoring of vibrations (horizontal and vertical).
- b) At least two nos. duplex temperature sensing elements for remote monitoring.
- c) Local temperature indicators in each bearing lube oil drains along with RTDs for remote indication and annunciation.

Provision shall be made to permit vertical and horizontal adjustment of each bearing by shim manipulation, and not by scrapping or remetalling, in order to accommodate realignment without complete dismantling. It must be possible to dismantle the bearing shells without removing the turbine casings.

Steam Admission Valves (Emergency Stop Valves, Reheat Stop Valves, Control valve and Interceptor Valves)

The steam turbine shall be equipped with suitable emergency stop and governor controlled valves and reheat stop & interceptor valves connected to speed governing system, complete with interconnecting piping and supports. It is preferable to provide the steam strainers independent of the stop valves.

- (a) The valves shall close simultaneously and automatically when the over speed governor trips and upon action of other protective devices
- (b) Emergency stop and reheat stop valves shall be equipped with easily removable steam strainers for normal operation and extra fine mesh strainers, if required, for initial operation.
- (c) The valves shall be designed so as not to cause any objectionable noise and vibrations of the pipes and valves.
- (d) The valves shall be equipped with auxiliary contacts and limit switches for control interlocks and signaling. Additionally position transmitters shall be provided on control valves for remote indication and control.
- (e) Each valve shall be provided with two additional normally open (NO) potential free direct limit switch contacts in the valve closed position.
- (f) The valves shall be lagged with insulation and provided with lifting eye bolts(g) Valves shall be located close to the turbine casing for limiting turbine over-speeding to safe limits because of entrapped steam volumes.



- (h) The valves shall be hydraulically operated, fail safe type and equipped with test device to permit complete closing of one valve at a time while the unit is carrying load.

Provision shall be made for tripping of turbine from the unit control room and for local manual trip from the steam turbine front stand.

The emergency and reheat stop valves, if not mounted on the steam turbine casing, shall be connected to the steam turbine by piping flexible enough to avoid transmission of excessive forces and moments to the steam turbine casing.

Designed to avoid seizure under operating condition. Withstand high Erosion by stellite or other superior methods as per standard proven practice of the bidder for internal components of valves. Ensure that valves are stable and shall not vibrate at high steam velocities.

The hydraulically operated control valves shall have removable seats to facilitate any repair work required. Valves stem shall be made of wear resistant and oxidation resistant materials to provide reliable operation with a minimum of maintenance work.

The emergency stop and reheat stop valves shall allow for removal of stop valve internals for blowing out the main steam pipes. Suitable provisions shall be supplied to protect valve seats and other internals surfaces, and to deflect the blowout steam where inlet and outlet are not in a straight line. Designed to allow blowing out of Steam leads prior to startup. Suitable provision shall be made by the Contractor to perform on load testing of main steam stop valve and reheat steam stop valve without tripping the unit.

In order to facilitate the safe and reliable shut-down of the machine, the emergency stop valves and governor valves must be arranged with easy access.

Non-Return Valves

Contractor shall provide Hydraulic/Pneumatic power operated Quick closing type & ordinary NRVs of proven design for each Steam extraction line and for each CRH line one hydraulic/Pneumatic power operated QCNRV shall be provided.

NRVs shall be suitable for on load testing individually and shall be provided with fail safe design and shall close on loss of power.

The valves shall be full bore type designed for minimum pressure drop.

Each valve shall be provided with two sets of limit switches for both open and close position with two changeover contacts.

The material of the NRV's shall be compatible to the material of piping on which they are mounted.

Based on TSR (tip speed ratio) analysis to be carried out by the successful Contractor any additional requirements shall be met by him.

Valves shall be of proven design with respect to type, size and rating offered (Contractor shall furnish sufficient experience data for the same).

Valves shall close during unit trip.

Turning device

Suitable turning gear device shall be provided, either hydraulic type or AC electric motor driven type, capable of continuously rotating the turbine shaft to ensure fast uniform cooling and warming during the shut down and start up respectively as per standard proven practice



of Contractor. The design of the turning gear shall have minimum 25% additional capacity for turning.

Turning gear shall have provision of automatic engagement/ disengagement with shaft speed decrease/ increase at preset value.

Manual hand barring facility shall also be provided for manually cranking the turbine in case of emergency including AC power failure. Availability of lube oil shall be ensured to the bearings during manual barring operation.

Instrumentation and control shall be provided for local and remote operation.

Suitable interlocks of lubrication system shall be provided with operation of turning gear.

Suitable protection shall be provided to prevent the turning gear device from being started unless the jacking oil pump is in operation and an adequate jacking oil pressure has been established.

All other necessary interlocks and protections, as required, shall be provided.

Couplings

Shearing type rigid couplings shall be used. Couplings shall be designed to allow for removal of any rotor without opening adjacent turbine casings. Ensure ready disconnection preferably through bolts. Couplings with axially fitted bolts may be offered. Hydraulic bolt tensioning equipment is also preferred. Coupling shall be suitably lubricated, if required. Couplings shall be designed to take care of short circuit shock.

Provide sufficient allowance for taking up reaming / honing of bore holes for the machine to meet out the future requirements.

Material Requirements

The proposal shall include the schedule of materials used in turbine construction indicating chemical composition and designation of materials for following:

- i. HP casing, HP blade carrier, IP & LP casing
- ii. HP, IP and IP shaft and its coupling
- iii. HP, IP & LP moving and fixed blades
- iv. HP/IP/LP casing joint bolts
- v. IP/LP cross over/cross around piping
- vi. Turbine steam admission and extraction valves (Valve body, spindle and seat)

The steam turbine shall be built up using materials which are field proven for rated turbine inlet steam parameters. The Contractor shall be required to furnish necessary information during detail engineering for connection of HP and IP inlet nozzles, HP turbine exhaust nozzles, HP and IP stop cum control valve inlet and outlet MS and HRH strainer, inlet and outlet HP bypass and LP bypass valve inlet and outlet and CRH non return valve inlet and outlet nozzles.

Gland sealing system Steam turbine and BFP turbine

Gland sealing system for the TG set and BFP drive turbines shall comprise of spring back labyrinth seals. However, the gland seals of BFP drive turbine may not be of spring back type and shall be as per standard practice of the turbine manufacturer.



Turbine shaft glands shall be sealed with steam. Fully automatic gland sealing steam supply system shall be provided including necessary piping, valves, fittings and control and instrumentation as required.

Gland steam condenser shall be provided to condense and return to cycle all gland leak off steam alongwith 2x100% capacity motor drive exhausters to remove air and non-condensable gases. The exhaust gases shall be discharged above the TG hall roof level.

Suitable arrangement shall be provided to bypass gland steam condenser (designed to operate under vacuum condition also) alongwith desuperheating arrangement, if required, for the bypass to prevent unit tripping when gland steam condenser is not in operation. The exhaust shall be discharged above the TG hall roof level. The gland steam condenser shall be provided with bypass on water side also.

MDBFP to be located in the Zero mt or intermediate floor of TG (not in TG floor)

The gland seal material shall be of proven type.

The turbine shall be self sealing during normal operation of the unit. During startup and low load operation, sealing steam shall be supplied from high temperature or low temperature auxiliary steam header or CRH depending upon the sealing requirement. Facility shall be provided for automatic switchover from alternative source to the main source and vice versa.

During changeover of steam supply source from turbine or CRH or auxiliary steam header, there shall be no rubbing at glands and no undue increase in vibration and the system shall be capable of withstanding thermal shock.

Effective drain system shall be provided alongwith instrumentation to monitor and maintain the required temperature to avoid thermal shock to the rotor during changeover from self sealing to alternate source of sealing steam.

Two nos. modulating type control valves shall be provided, one discharging surplus steam to condenser and other for supplying extra steam to gland sealing header from steam source to maintain sealing steam header pressure at a preset value. These control valves shall be provided with electrically operated bypass valves.

Control valves shall be stay put during power failure and sealing steam header pressure shall be maintained by manual control of these valves.

Gland sealing arrangement provided by the Contractor shall permit easy examination and replacement of glands without lifting the upper half of the turbine casing. However, for BFP drive turbine, the arrangement for replacement of glands may be as per standard practice of the manufacturer.

The Desuperheater necessary for reducing the sealing steam temperature shall be taken from condensate extraction pump discharge. Where gland steam temperature control is achieved by use of direct contact spray type desuperheaters, the design shall include features to prevent water reaching the shaft glands in the event of malfunction of the desuperheater spray water control system.

Suitable arrangement shall be provided to drain the gland seal steam header during startup and shutdown conditions shall be provided. Suitable arrangement such as pressure relief valve shall be provided to maintain the desired pressure in the gland seal steam header.

A steam strainer shall be provided before the pressure reducing valve(s) of the steam supply to the glands or as per proven standard design of OEM subject to approval of OWNER. The strainer shall be sized to prevent entry of any foreign material which could damage the shaft glands. Details of the mesh size of the strainers proposed shall be given in the proposal. The



strainer shall be arranged to permit easy inspection and cleaning. Provision shall be made for measuring the differential pressure across the strainer.

System shall be designed to ensure the required minimum condensate flow through gland steam condenser during start-up and other normal/abnormal operating modes. Gland Steam condenser tubes shall be made of Stainless steel only.

Insulation

Ambient temperature is 40 °C for design of thermal insulation.

Contractor shall provide insulation and cladding for all equipment and piping with surface temperature more than 60 °C.

The temperature of cold face of finished insulation shall not be greater than 60 °C.

For the turbine, in order to avoid a possible penetration of oil, insulation with an oil-tight hard cover is to be provided. Asbestos insulating material will not be accepted.

Hot sections which cannot be insulated, such as for example observation openings, are to be provided with suitable protection.

Turbine cladding

The turbine cladding shall be designed as a sheet metal cladding and provided with sufficient corrosion protection. It shall cover the complete turbine area including the bearings. Heat build-up within the turbine cladding shall be avoided by suitable ventilation. Particular importance shall be attached to a good overall appearance of the turbine generator set with the turbine cladding installed. Furthermore, the cladding shall be easily dismantled/re-installed.

The turbine cladding shall be provided with access openings for inspection and maintenance.

Steam Strainer

The strainers shall pass the full steam requirements for rated turbine output and they shall be arranged for easy inspection and cleaning. The strainer shall be accessible without removing the inlet steam piping. Strainer integral to steam admission stop valve as per manufacturer standard will also be acceptable. Temporary fine mesh strainers shall be provided for use during commissioning period or separate steam blowing device shall be supplied by bidder subject to approval of Owner.

Maintenance Requirements

Each turbine shall be suitable for wet steam washing if applicable. Necessary stub connections on turbine/ piping shall be provided for future connection to wet steam washing system. Recommended washing procedures shall be furnished by the Contractor.

Necessary equipment shall be provided for forced cooling of turbine during emergency condition for quick access.

Turbine preservation system consisting of adequate numbers of air driers including, fans, motors, filters, heater drying wheel, connecting pipings, valves, fittings etc. for preservation against corrosion of turbine during idle periods shall be provided. Write-up on the recommended system to be furnished.

Boroscopic inspection ports in turbine for inspection of turbine internals shall be provided as per Contractor's standard practice. The inspection ports shall cover turbine internals as



maximum as possible as per Bidder's Standard practice. The inspection port should be designed for ease of accessibility with leakage proof features while in operation.

5.2.0 Turbine Governing System, Protective Devices and Unloading Gears

The steam turbine generator unit shall be equipped with an electro-hydraulic governing system with mechanical-hydraulic back up or electro-hydraulic system with 100% hot back-up.

The governing system shall be equipped with speed and load changers to control the speed or power output of the steam turbine within the limits. The speed/load changer provided shall be capable of adjusting the speed of the turbo set to any value in the range of 94% to 106% of rated speed for manual/auto synchronisation of the generator with the bus. It shall be capable of varying the load on the machine from no load to full load.

For remote control, suitable motor drive shall be provided. Indication of the speed/load changer position shall be provided on the operator's work station and console panel insert.

The governing system shall be equipped with a load limiting device capable of being operated both locally as well as remotely from unit control room for the purpose of limiting the amount of opening of the governor controlled valves to set the load at a pre-determined limit, while the turbine is in operation. A remote position indicator shall be provided on the console panel insert for indication of the setting of the load limit. Contacts shall also be provided on the load limiter for signaling load limited operation in unit control room.

Steam turbine shall be provided with electronically controlled electro- hydraulic governing system and back up governing system of mechanical hydraulic or electro- hydraulic type.

Contractor shall provide a separately actuated over speed device called quick acting emergency governor to trip the unit at 110% of rated speed in case speed governor fails to limit the turbine over speed.

The emergency governor resetting shall be as per manufacturer's standard practice. However, it shall meet the IEC-45 requirements for over speed trip.

Contractor shall provide means for testing the operation of emergency governor when the machine is on load without exceeding the rated speed of the unit.

Contractor shall provide emergency hand trip device on front pedestal/panel near turbine to facilitate manual tripping of the unit alongwith facility to trip turbine from UCB.

Turbine trip should occur under following condition. Over speed, backup over speed, complete EHG failure, Low lube oil pressure, High axial shift, high condenser pressure (low vacuum)-fixed set point & variable set point, thrust & Journal bearing wear, boiler tripped, shaft vibration very high, AC generator tripped, all circulating water pumps tripped, Fire protection, Main steam temperature very low, high HP exhaust steam temperature etc.

5.3.0 Other turbine equipment

Initial Pressure regulators, Low Vacuum unloading device (if applicable), vacuum breaker valves, Exhaust temperature limiting equipment, Pressure relief diaphragms for LP outer casing, Protection against water induction, supervisory equipment etc., shall also be provided to ensure reliability of the system.



The facility to adjust or bypass the initial pressure regulator from UCB during start up condition to facilitate starting with low steam pressure and during sliding pressure operation shall be provided.

Contacts shall ensure turbine unloading to a preset point to run on house load in case main steam pressure falls below a predetermined value.

Contacts shall be provided for signaling the initial pressure regulator in 'Operation' and 'Reset'.

In order to protect the condenser from excessively high temperature an automatically acting cooling device has to be supplied for the exhaust steam. The cooling shall be from main condensate pump discharge side.

The Pressure relief diaphragms shall be designed for the maximum possible steam flow.

Based on the standard proven practice of the Contractor, the Contractor shall provide a low vacuum unloading gear (If applicable) which shall ensure progressive decrease of steam flow to turbine below a preset value of condenser vacuum, thus restoring the condenser vacuum.

Contacts shall be provided for signaling the low vacuum gear in 'Operation' and 'Reset'.

The ingress of seepage steam into the turbine during standstill of the turbine and operation of the boiler shall be prevented. The turbine injection shall be provided with a control valve and a power operated NRV. In addition to these valves in the injection lines, stop valves shall be provided in order to make possible repair and maintenance work on turbines during shut-down.

The HP Steam turbine exhaust shall be provided with hydraulically / pneumatically operated quick closing non return valve. These shall be closed automatically when steam turbine is tripped.

Vacuum Breaker valve shall be sized for rapid reduction of vacuum in condenser for turbine rotor to be brought to rest as quickly as possible.

5.4.0 Steam turbine lubricating oil and purification system

A complete lubricating oil system shall be provided for the steam turbine generator unit and shall consist of following. The control fluid system shall be fully separated from the lubricating oil system.

Oil pumps

Centrifugal /gear type main oil pump (MOP) directly driven by turbine as per Contractor's standard practice with capacity to cater to lube oil required for bearings and emergency seal oil requirement. The grade of oil to be used with its complete specification shall be stated by the Contractor.

AC auxiliary oil pumps for start up, shutdown of TG unit and as standby to MOP for automatic operation, each pump having capacity to cater to lube oil and turning gear oil requirement.

DC emergency oil pump for meeting lube oil requirement of bearings during emergency, with automatic starting on low lube oil pressure preset value.

Jacking oil pumps with interlocking not to start till lube oil pressure is established.

Pressure transducers for monitoring pressure of jacking oil of each bearing.



The shaft driven main oil pump shall be designed to maintain adequate lubricating oil pressure over the entire operating frequency range without auxiliary oil pump cutting in.

The pump shall supply all oil requirements for the lubricating as appropriate under all conditions of load and operating frequency range specified. The auxiliary oil pump must be able to start automatically in the case of a drop in oil pressure. A pressure accumulator is to be installed in the oil system to avoid an unallowable drop in pressure during switchover of oil pumps.

Main Oil Tank

The tank shall be of welded construction and manufactured from high quality mild steel plate and shall have sufficient capacity to hold all the oil within the system.

Each unit lube oil tank of capacity to allow 8 oil changes per hour (at normal operating level) alongwith with vapour extraction fans driven by explosion proof AC motors. The tank shall be provided with non-corrodable strainers, level indicator visible from turbine operating floor/ oil room floor, man holes, platforms, railings, necessary piping, supports and accessories etc.

Special attention shall be taken in the tank design for handling hydrogen entertainment in the generator lubricating oil drains.

All vents shall be taken outside the building above the roof level. Horizontal vent pipe shall have a natural drainage back to the tank and suitable drainage arrangement for any oil build up shall be provided in the discharge piping of the extractors.

The base of the tank shall slope to a common point to facilitate complete draining and an accessible lockable valve shall be provided in the drain line. Piping shall be provided from the drain valve to a suitable point from where the oil can be drained into the transfer or drain tank.

Sampling points shall be provided at suitable locations on the oil tank.

Oil Filters

Duplex type filters/strainers with stainless steel element shall be provided at common lub oil supply line of the turbine. In addition to the above, the Contractor may provide filter/strainer at oil supply line to/oil return lines from bearing and generator seals as per his standard practice. The filter element size shall be five (5) microns or a size suited to requirement of the turbine.

Changeover from one filter to the other shall be possible without a reduction in flow or a momentary drop in pressure. The changeover valves shall be interlocked or arranged so that it is not possible to inadvertently cut off the supply of oil to the plant. A differential pressure gauge and differential pressure switches with alarm shall be provided on both filters. Adequate provision shall be made for draining and venting the section of filter undergoing maintenance.

Oil Coolers

DM water cooled lube oil coolers with 15% excess tube surface area, designed as per TEMA having oil pressure greater than water pressure.

The oil coolers shall be provided with dial type thermometers and manual three way valve on oil side for change over of coolers. Oil temperature at outlet of coolers shall be maintained within permissible limits as per requirement at inlet to the bearings. The changeover arrangement shall be such that one cooler cannot be isolated before the second is in service.

The oil side pressure of the oil coolers shall be higher than the water side pressure.



The cooler shell shall be constructed of carbon steel and shall be fitted with an air vent at the highest point and a drain valve at the lowest point.

The cooler water boxes shall be of fabricated steel. The highest point of each water box shall be supplied with a vent connection. The relief valve and all drain and air release valves shall be provided with pipe work leading to the nearest convenient drain trench.

The coolers shall be supported such that the water boxes can be removed without difficulty and adequate access to the tube plates is possible.

The arrangement of water box connections shall be such that tubes can be cleaned without breaking any oil or water pipe joints.

Oil Piping

Piping and all other components of system coming in contact with control oil shall be of stainless steel.

Double oil piping or equivalent shielding shall be provided for all high pressure lines and all pipes close to hot pipes and parts to protect against fire hazards.

Oil return lines from bearings shall be fitted with illuminated sight fittings or any other device to see the flow of oil depending upon the standard proven practice of the manufacturer.

The oil pipes are to be pickled and, on commissioning, oil flushing is to be carried out with cold and heated oil alternately. All the facilities necessary for commissioning are to be provided.

Oil supply lines to and oil return lines from bearings and generator seals should have provision for oil flushing filters. Oil flushing filters may not be provided in individual return lines if a common strainer is provided in the tank for return oil as per standard practice of the Contractor

Unit purification system

Each steam turbine shall be provided with a permanently connected, continuous oil purification system having following major equipment:

Oil centrifuge having capacity to purify not less than 20% of total oil charge in system per hour and constructed from high grade stainless steel. Purified oil shall not have any free moisture and maximum particle size shall be conforming to code 15/12 as per ISO 4406 with inlet oil quality conforming to code 21/18 as per ISO 4406.

Carbon steel anti-flood tank for each purifier.

Positive displacement feed and discharge pumps (if required), each having capacity 10% higher than purifying unit. Necessary interlock for preventing centrifuge operation in case these feed and discharge pumps are not operating shall be provided.

Indirect electric oil heater to heat oil to temperature not more than 65°C with facility to cut heater elements in steps.

Entire purification equipment shall be mounted upon a suitable metal base having a raised lip around the outside with a drain connection.

Alternatively, Contractor can offer oil purification system as per their standard practice. But, The purified oil shall be with no free moisture & max. particle size conforming to code 15/12



as per ISO 4406. This shall be demonstrated with inlet oil quality conforming to code: 21/18 as per ISO : 4406.

Central Turbine Lubricating Oil Storage and Purification System

A central turbine lubricating oil storage and purification system shall be provided common for two units. The system shall consist of identical dirty and clean oil tanks each with capacity of 1.5 times the capacity of unit oil tank, purification system identical to unit purification system and 2x100% capacity oil transfer pumps.

The purifier shall be fully self contained on an oil tight base plate and shall be provided with necessary piping.

The parts of the purifier which are liable for corrosion i.e. oil wetted parts shall be manufactured from stainless steel or superior material. The pumps required for purifying unit shall be of 110% the normal purifier capacity. Necessary indirect heating system shall also be provided.

The purifier shall be capable of being used both in operation and when the turbine is at rest. The oil separator delivered shall be of the self-cleaning design.

Suitable arrangement such as unloading pumps with strainers, piping and instrumentation shall be provided to unload the lube oil from barrels/unloading tank etc to dirty oil compartment or clean oil compartment of central lube oil storage and purification system depending up on the new oil quantity. Suitable arrangement shall be provided to evacuate the lube oil from main turbine lube oil tank, boiler feed pump turbine lube oil tank and clean oil tank and dirty oil tank of central lube oil storage and purification system to emergency oil pit during emergency condition such as fire accidents etc.

5.5.0 Turbine Control Fluid System

Each unit shall be provided with control fluid system consisting of the following:

Fire resistant fluid for control fluid system for servomotors of all hydraulically operated turbine stop and control valves, extraction NRVs and spray water valves for LP bypass system (if applicable). The grade of oil to be used with its complete specification shall be stated by the Contractor.

Fluid reservoir of adequate capacity fitted with non-corrodable strainers, level indications, level alarm switches and overflow devices alongwith draining and sampling connection. The surfaces of reservoir in contact with fluid shall be of stainless steel.

The reservoir shall be fitted with adequate vapour extraction fans, access ladders, platforms, railings and man holes with covers etc.

DM water cooled control fluid coolers with 15% excess tube surface area, designed as per TEMA having oil pressure greater than water pressure fitted with dial type thermometer and manual 3- way valve on oil side for change over of coolers. Oil temperature at outlet of coolers shall be maintained within permissible limits. All surfaces coming in contact with control fluid shall be of stainless steel.

Control fluid purifying unit to purify at least 2% of the total fluid charge in the system per hour on a continuous bypass basis alongwith 2x100% capacity AC driven purification pumps (for fluid circulation through purification system).

Piping and all other components of system coming in contact with control fluid shall be of stainless steel.



5.6.0 Turbine Drains System

Contractor shall provide warming-up and drainage system for the steam turbine system to drain away the condensate which may be formed due to steam coming into contact with cooler metal during start-up and stagnant steam sections. The drains shall be provided for every low point with automatic disposal of collected condensate. The drains shall be connected to the flash tanks via headers. The connections on the header shall be graded according to the pressure. The drains from main steam piping, HRH, CRH, BFP turbine system and auxiliary steam headers etc. shall also be connected to the atmospheric/HP/LP flash tanks.

The steam turbine drain system shall be designed in accordance with the recommendations outlined in ASME TDP-1 for protection against water induction to the steam turbine.

Drains shall be tapped off from main line through a drip pot with provision for removal of entrapped dirt. Each drain shall be provided with one locked open manual valve followed by one motor/ pneumatic operated leak proof angle valve on downstream side to be used for draining and warming-up the pipes as applicable. For sections having drain formation during normal plant operation such as auxiliary steam header lines and alternate steam lines to BFP turbines and deaerator, steam trap assembly shall be provided in parallel to the motorized/ pneumatic drain valve.

Drain valves shall be located in accessible areas to facilitate their maintenance.

5.7.0 Steam By-pass System

Each bypass station shall comprises a quick acting stop valve and a pressure control valve on steam line(operated by separate actuator), a desuperheater, a stop valve and a control valve on spray water injection line(operated by separate actuator),

The spray water system for temperature control shall be compatible with the bypass control valve requirements.

The steam conditioning and spray water valves actuators shall be provided with double acting electro-hydraulic piston type.

If the oil system is a self-contained unit, it shall have 100% standby oil pump connected to main system with necessary valves for isolation and maintenance. Hydraulic accumulators shall be provided on the hydraulic system to ensure positive supply of oil to hydraulic actuators even when hydraulic oil pumps are not available. Accumulator shall be adequately sized to ensure sufficient number of stroking operations of all connected actuators. The hydraulic system shall have online filtration arrangement to keep hydraulic oil clean. All control valves shall be of tight shut-off design and the actuators shall be designed for maximum shut-off differential pressure acting across the valve.

The valve stem should be protected against contact with the hot fluid. Complete assembly shall be designed as single unit. Constructional details of body and internals shall be designed based on above requirement.

Valve trim shall be designed and selected so as to give required steam outlet parameter in stable manner and within the specified sound level.

The HP/LP Bypass System shall be designed to handle 60% of BMCR flow and sized for 65% BMCR flow at rated steam conditions. Bypass valves shall be capable of handling atleast 120% of the stated maximum flow at the full open condition for HP valves and 125% for LP valves.

Sizing of control valves shall be done as per the latest edition of the ISA handbook.



Valves shall be designed to give class v leakage when the valve is fully shut and subjected to maximum inlet pressure as per ANSI B 16.104.

HP and LP bypass valves shall be provided with gland cooling arrangement, preferably using spray water, as per manufacturer's standard practice. Further, graph-oil packing rings or equivalent arrangement shall be provided for valve glands

Valve trim material shall be selected based on the service conditions. However SS316 trim material shall be offered as minimum. Stellite or other equivalent treatment shall be done for all valves offered for all steam service and high pressure reduction service. Cage guided valves may be offered for steam service. For water service it shall be preferably top or heavily top guided type.

Cage guided valves shall be avoided for water service. Seat rings shall be replaceable type. Seat rings shall securely lock in place to prevent leakage past the body. Where required as per the service condition seat surface shall be stellite. Anticavitation trim shall be offered where cavitation and flashing is expected.

The Contractor shall provide necessary blowout tools to protect the bypass valve, when the bypass steam pipes are blow out during cleaning of the steam lines before commissioning the plant.

6.0.0 TESTS ON TURBINE

In addition to the tests mentioned elsewhere the following shop tests shall be conducted as applicable on various components such as rotor, casings, blades, diagrams, valves, pipes, flanges, bolts, etc. All such tests shall be documented and forwarded to Owner:

- a) Boro-scope test
- b) Magnetic particle test for crack detection
- c) Heat stability test
- d) Resonant vibration tests
- e) Examination of threading tolerances etc.
- f) Chemical composition and quality tests on blades (moving)

After the assembly of various components of the turbine the following tests shall be conducted:

- a) Verification of fits and operating clearances.
- b) Balancing test
- c) Test at 120% of rated speed centrifuging as per manufacturer's standard practice.
- d) Tests for checking the proper operation of governors, control valves and auxiliaries.

7.0.0 DRIVE MOTORS

All drive motors shall be as per Specification for Electric Motor presented in relevant section of electrical specification.

8.0.0 INSTRUMENTATION & CONTROL

Refer Volume II, Section 4 for Control & Instrumentation Specification.



9.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED ALONG WITH THE PROPOSAL

9.1.0 General

- a) Completely filled in technical schedules & other schedules for all equipments as enclosed with the Tender specification.
- b) Flow Diagrams and P&ID (Process and Instrumentation drawings) indicating Instruments and the destination / functionality of the signals Plot plan
- c) Plot plan and General arrangement drawing with section for major building viz Power house building etc., showing maintenance area
- d) Quality Assurance and plan
- e) Master Document List (MDL) for Mechanical, Electrical, Civil and C&I with schedule of submission
- f) Description of options and alternatives offered
- g) Complete description of the plant offered including description of the process and the equipment
- h) General descriptions of individual systems and descriptions of operation including description of start-up, shutdown and emergency shutdown procedures,. Also behavior of boiler/steam generator and, turbine, etc. under transient conditions.
- i) Safety Plan
- j) Training program and schedule for training of Owner's personnel
- k) Space requirement for construction site and equipment
- l) Maintenance proposal (for STG)
- m) List of spares
- n) List of Special tools and Tackles
- o) Inspection intervals (major/minor) for six years along with the spares to be replaced during the above inspections. Contractor shall provide the cost of such spares on yearly basis.
- p) Contractor shall enter into a long term spare supply agreement with the OEM, and agree to transfer the same faithfully to the owner upon COD. Contractor shall commit to facilitate further negotiations on the spares with the OEMs directly by the owner.

9.2.0 Mechanical

- a) Heat and Mass balance diagram same for 100% TMCR condition (0% and 1 % makeup), VWO condition (0% and 1 % makeup), 60% TMCR (Constant and Sliding pressure operation), All HP heaters out condition, Auxiliary steam condition and house load operation with HP-LP bypass in operation,
- b) Start up curve for cold, warm and hot condition
- c) Installation references where 660 MW Supercritical units with proposed main steam and reheat steam parameters are in operation.
- d) Experience list for supply and installation plants of similar capacity supercritical Units and performance certificate of the plants indicating the availability and plant load factor from the date of COD.
- e) Steam Turbine Manufacturer's and Generator Manufacturer's experience list for the offered Capacity
- f) Deed of Joint Undertaking shall be executed by Contractor with following manufacturers
 - Steam Turbine and Auxiliaries



The above shall be submitted clearly indicating the validity of the agreement and role and responsibilities among them

- g) Details of Technical Collaboration of the Steam Turbine, Generator manufacturers with technology Supplier and role of the technology supplier for this project.

10.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED AFTER AWARD OF CONTRACT

The documents required for design, construction, installation, operation and maintenance of the entire plant shall be submitted by the Contractor in good time so as to permit the plant as a whole to be constructed in compliance with the specified time table.

Only the most important documents are listed below. The list and approval category of the doc/drawings shall be agreed sufficiently in advance before award of relevant order, so that corrections and amendments desired by the Owner as well as resubmission of the documents will not result in any delays with respect to the guaranteed time table. The Owner reserves the right to request from the Contractor additional drawings, documents, etc. as may be required for proper understanding and definition of the design and engineering of the Plant.

10.1.0 General

- a) Re-Submission of all the technical data furnished during pre award contract stage.
- b) Complete filled-in technical schedule.- For approval
- c) Plot plan - For approval
- d) General arrangement drawings /Equipment layout of all equipments along with sections indicating the unloading & maintenance area. - For approval
- e) Design basis for all the systems and major equipment sizing calculation - For approval
- f) P&ID (Process and Instrumentation drawings) indicating Instruments and the interlocks for all the systems - For approval
- g) Monthly progress report
- h) L2 network
- i) Quality plan for approval
- j) Prequalification document for different Vendors for Owner's approval.
- k) Equipment Testing procedure for approval
- l) Complete list of documents with proposed submission schedule
- m) Vendor Engineering document viz Data sheets, General arrangement drawing, material of construction, performance curves for approval for major items
- n) Painting & surface preparation procedure
- o) Technical specification

10.2.0 Mechanical

- a) Major equipment sizing calculation viz , Bypass valve, for approval
- b) Start-up and shut down procedure along with the curve for approval
- c) System description for all the systems. for approval
- d) Fire protection system layout
- e) Heating and ventilation system layout
- f) Pipe sizing and determination of pressure & Temperature criteria. for approval
- g) Critical piping drawing and calculation
- h) Acceptance and Performance test procedure and program



- i) Performance calculation write up.

Any other drawing or document which are not covered above but required to the effective commissioning of the project.



ANNEX 2.2.1
SPECIFIED DESIGN DATA

Description	Unit	Data
STEAM TURBINE		
Type of Steam Turbine		3000 rpm, Supercritical, tandem/ cross compound, single reheat, regenerative, condensing, multicylinder machine.
Maximum Continuous rating of each Turbine(TMCR) at generator terminal excluding excitation power.	MW	660
Maximum generation during valve wide (VVO) condition (with continuous operation capability)	MW	Minimum 5% over TMCR output
Operation Mode		Throttle governing in combination with sliding pressure.
Gross turbine cycle heat rate at 100% TMCR condition, 0% make up, 33°C cooling water inlet temperature and TDBFP in operation including pressure drop in main steam piping, reheater system and all the extractions of steam turbine.	Kcal/kWh	Shall not exceed 1850
Design & operational requirement including variations in rated steam		As per IEC 45
Main steam pressure at turbine inlet	bar	Contractor to furnish
Main steam temperature at turbine inlet	°C	Contractor to furnish
Main steam flow at turbine inlet	t/hr	Contractor to furnish
Hot reheat temperature at turbine inlet	°C	Contractor to furnish
HPT exhaust steam pressure	bar	Contractor to furnish
HPT exhaust steam temperature	°C	Contractor to furnish
IPT inlet steam pressure	bar	Contractor to furnish
IPT inlet steam temperature	°C	Contractor to furnish
Reheat steam flow at turbine inlet	t/hr	Contractor to furnish
Reheat steam temperature at turbine inlet	°C	Contractor to furnish
Maximum Pressure drop between HPT exhaust and IPT stop valve inlet	bar	Contractor to furnish
Frequency variation range around rated frequency of 50Hz	Hz	+3% to -5% (47.5Hz to 51.5Hz)
Final feed water temperature for heat rate guarantee point and TMCR condition		To be selected by Contractor based on his turbine cycle optimization.
Turbine protection against water induction		As per ASME-TDP-1-2006 (reaffirmed latest)
DM water make up to thermal cycle under TMCR condition		1% of throttle steam flow
HP/LP Bypass valve/Spray Valve		
Design Code		ANSI
Type of actuator		double acting electro-hydraulic piston type

**VOLUME II****SUB-SECTION - 2.3****CONDENSER, CONDENSER AIR EVACUATION SYSTEM &
CONDENSER ON LOAD TUBE CLEANING SYSTEM****1.0.0 GENERAL**

This specification is intended to cover the minimum requirements of design, engineering, manufacture, inspection and testing at manufacturer's works, supply, packing and delivery at project site, unloading, storage and in plant transportation at site, erection, supervision, pre-commissioning, testing, successful commissioning of condenser, condenser air evacuation system, condenser on load tube cleaning system and all accessories and associated piping, valves, specialties, controls, instrumentation, supports and insulation.

This section of the specification shall be read in conjunction with other sections of the specification as appropriate and the equipment offered shall meet the requirements as spelt out therein.

2.0.0 CODES AND STANDARDS

Condenser, Condenser air evacuation system shall be designed in accordance with **latest edition** of following codes, standards specifications and regulations. Also the system design shall conform to the requirements of applicable codes as specified in the General Technical Specification.

HEI	-	Heat Exchange Institute standard for liquid ring vacuum pump
HEI	:	Heat Exchange Institute standard for surface condenser
IBR	:	Indian Boiler Regulations.
PTC-12.2	-	ASME Performance Test Code on Steam Surface Condenser.
ASTM	-	American Society of Testing and Materials.

3.0.0 SCOPE OF SUPPLY

The scope of supply shall include but not limited to the following (for each unit unless indicated otherwise).

3.1.0 Condenser

- Horizontal surface of proven design (Type shall be as per below Annexure) with integral air cooling section and divided water box construction. Water box shall have cathodic protection. Water box shall have proper GRP lining / resin coated suitable for sea water application.
- Large box type screening structure with anti-vortex baffling at each hotwell connection to suction of condensate pumps.
- Provide suitable impingement guards or baffles on top row tubes. Similar guards for any steam or water connection to condenser. Other alternate arrangements to the satisfaction of Owner to protect top row of tubes shall also be considered.
- Water box interiors to be FRE lined with min 3 mm.
- Provision of motorized butterfly valves and expansion bellows at inlets and outlets of condenser cooling water of each half of condensers.



- f) Easily removable/hinged type water boxes along with suitable handling arrangement and provision of hinged manholes (of 460mm size) in shell, each water box and each hot well suction.
- g) Stand pipes with necessary connections for instruments, with water level gauges and isolation valves.
- h) Design for installation of LP heater(s) in condenser neck. The drain cooler to be installed outside the condenser neck.
- i) Water box, tube plates and support plates material shall be carbon steel as per ASTM-A-285Gr.C. with FRC lined for intended duty. Titanium cladding of required thickness shall be provided on water side of tube sheet plate.
- j) One no. Debris filter shall be installed above ground level at the outside of the TG building before the each inlet pipeline of condenser of each unit and adequate cathodic protection shall be provided for debris filter to prevent against corrosion.

3.2.0 Condenser Air Evacuation System

- a) 2x100% air evacuation pumps for each shell of multiple pressure condensers along with all accessories and instrumentation as per HEI recommendations.
- b) Steam water separator.
- c) Heat exchanger.
- d) The complete piping system as required along with valves, actuators, fittings and supports, insulation and cladding etc.

3.3.0 Condenser On Load Tube Cleaning System

- a) Sponge rubber ball type tube cleaning system designed for continuous & trouble free operation with provision of abrasive coated balls cleaning in case of hard deposits inside tubes.
- b) Suitably sized non clog type ball recirculation pump to inject the cleaning balls into respective CW inlet pipe.
- c) Suitable ball injection nozzles.
- d) Suitable ball collecting strainer to be provided at CW discharge pipe to collect the cleaning ball and the same will be drawn off to the suction of ball recirculation pump. Material of construction shall be of proven material suitable for sea water application.
- e) Sufficient capacity ball collecting vessel to hold the full charge of balls.
- f) Necessary piping, fittings and accessories for complete installation of the system.
- g) Automatic / manual ball sorter to sort out under size balls.
- h) The system should be complete with necessary instruments, protection and interlocks.
- i) Provision of manual and automatic back washing system with automatic collection of balls prior to back washing.
- j) Provision of ball monitoring system, which should at least consist of separate ball circulation monitor and ball oversize monitor.



- k) Adequate Cathodic Protection in COLTCS and other components of CW system to protect against corrosion.
- l) Avoid any dead zone inside the water box. There shall not be crowding of balls at the inlet of ball collecting strainer at discharge pipe.

4.0.0 DESIGN REQUIREMENTS

Steam condensing system shall be designed in accordance with the codes specified in this section and applicable codes specified in the general technical specification or any approved equivalent standards.

The steam condensing system shall be suitable for operation in conjunction with the turbine offered.

4.1.0 Condenser

Design manufacturing and testing as per Heat Exchange Institute, USA (latest) with proven design. Contractor to furnish thermal, hydraulic and mechanical design calculation for checking equipment capability.

Condenser to be designed for minimum air leakage and under normal operating conditions, the air leakage in condenser not to exceed more than 50% of design value taken for sizing of vacuum pumps. The same shall be demonstrated at site under actual operating condition failing which Bidder shall carryout necessary modifications.

Max. Oxygen content of condensate leaving the condenser shall be 0.02 ppm over the entire load range.

Quality of Cooling Water shall be sea water specified in this specification.

Shell material carbon steel as per ASTM-A-285 Gr.C or SA 516m Gr 485 or equivalent subject to approval of owner & suitable for intended service, welded construction and 16 mm minimum wall thickness. Hot well of material same as that of shell material, shall be longitudinally divided with proper drainage provision.

Condenser shall be spring supported or solid supported as per standard and proven practice of the OEM. The expansion joint of fully stabilised austenetic stainless steel all welded type shall be provided in the condenser neck if applicable.

Tubes shall be seamless type titanium as per SB 338 Gr 2 and continuous without any circumferential joint suitable for intended duty with average wall thickness 22 BWG (0.71mm) (minimum). Welded condenser tubes shall not be accepted. Top rows of tubes shall be extra thick. Provision for taking care of thermal expansion of tube bundle and proper drainage of tubes during shut down shall be ensured.

Water box, tube plates and support plates material shall be carbon steel as per ASTM-A-285 Gr.C. or SA 516m Gr 485 with resin or equivalent subject to approval of owner /GRP polyurethane lining/ coating lining and suitable for intended duty. Adequate cathodic protection of water box side shall be provided and Titanium cladding of required thickness (5 mm minimum) shall be provided on water side of tube sheet plate. Avoid any dead zone inside the water box.

Corrosion allowance of minimum 3.2 mm for water boxes, tube plates and 1.6 mm for shell, hotwell and condenser neck.



Ensure efficient steam distribution in the condenser when one half of the condenser is isolated and ensure at least 60% of rated output under this condition.

Suitable provision (like sliding and fixed base plate of condenser support feet etc.) for expansion of condenser shell to be made. Suitable provisions to be made for expansion between shell and tubes.

Provision of separate sponge ball type condenser on-load tube cleaning system for each half of condenser including ball circulation pumps, strainer and ball monitoring system.

The Condenser shall be designed for heat load corresponding to unit operation for VWO condition, VWO with 1% make up condition, HP heaters out of service condition, turbine operating at house load operation with HP-LP bypass operating at its rated capacity (60% BMCR) and rated steam parameters. Condensate temperature at all loads shall not be less than the saturation temperature corresponding to condenser pressure.

The Condenser hotwell shall be sized for three (3) minute storage capacity (between normal & low-low level) of total design flow with the turbine operating at VWO condition, 1 % make-up, design condenser pressure. The low-low level of hotwell shall be at least 200 mm above the bottom of hotwell.

Sizing of steam dumping device to accept the steam from HP-LP bypass with necessary spray water including abnormal conditions like HP heaters out of service etc.

Design of air removal section to cool the air and vapour mixture to atleast 4.17 deg. C below saturation temperature corresponding to 25.4 mm Hg (abs). Connections to air evacuation pumps shall be made at this section.

Design for exhaust steam from steam turbine, BFP drive turbine, HP-LP bypass system, heater drains and vents, boiler separator drains during start-up, low-load and abnormal conditions and other miscellaneous drains.

Designed to carry flooded weight (upto tip of last stage of LP turbine blades) for hydraulic and hydrostatic testing of condenser without installation of temporary supports or bracing.

C.W. butterfly valves with actuators to be designed as per AWWA-C504-80 or Owner approved equivalent standards. Valve's material shall be suitable for sea water application and the duty intended.

C.W. expansion joints made from high quality natural / synthetic rubber with carbon steel reinforcement rings and with flanges of 125 LB as per ANSI-B16.25. The material used shall be suitable for sea water application and the service intended. The expansion joints shall be designed to the deflections and fluid pressure through out plant life and shall be suitable to withstand full vacuum without collapse and the proposed arrangement for this shall be indicated in the offer. Further the design shall limit the reaction forces/moments on condenser CW nozzles and on C.W. piping.

Design, Material and construction of CW piping and butterfly valves shall be as per relevant standards and as specified elsewhere in the specification. All wetted components shall be proven and suitable for sea water application. The Cooling water pipe line from CWP to condenser and from condenser to CT shall be of RCC with Epoxy paint coated. The above ground portion at CWP and Condenser area may be MS with polyurethane coating.

DM Make-up water shall be added to condenser from an condensate surge tank of adequate capacity through a normal make up control valve sized for 1.5% of VWO flow with 1.5% Make Up and emergency make up control valve sized for 10% of VWO flow with 1.5% Make Up All necessary piping, valves, tank etc shall be engineered and supplied by the Contractor.



5% tube plugging margin shall be considered while arriving the heat transfer area.

Steam dumping device for dumping of desuper heated steam from LP bypass along with all accessories and instrumentation.

No damaging due to vibration during normal, abnormal and transient conditions and during turbine trip from full load to HP-LP bypass operation, feed heaters out of operation, VWO condition, 100% load and start-up condition etc. Contractor to ensure satisfactory operation under above operating conditions.

Natural frequency well above the frequencies induced by other associated equipments under all operating conditions including abnormal.

Provision for maximum deaeration and removal of non-condensable gases from steam and make-up water. Air removal section to be suitably baffled to prevent water carryover.

Air release valve and drain valve shall be provided in water box and condenser shell and also for complete drainage of water from hot well.

Provision in water box of adequate size nozzle and valve for priming of condenser.

Provision of catch trough below tube sheet in hotwell for detection of water leakage into steam side.

All extraction pipes routed through the condenser shall be provided with stain less steel shroud to prevent erosion

All bolts, nuts and stays etc. inside the steam space shall be of Low Alloy Steel as per SA 193 Gr B7 and SA 194 Gr 2H and where such parts project through tube plates they shall be fitted with stainless steel or approved cap nuts and protective sleeves. For deaerating zone, trays, fittings etc. made of stainless steel shall be provided.

Provision of motorized butterfly valve in each exhaust duct of BFP turbine for isolation of BFPT, when not in use.

4.2.0 Condenser Air Evacuation System

Single/two stage liquid ring type with both stages (if two stage pumps provided) mounted on a common shaft.

Suitable for indoor installation and for continuous duty.

Each pump and its accessories shall be mounted on common steel base plate. Pump shall be connected to motor by flexible coupling.

Heat Exchangers shall be shell and tube type / Plate type heat exchangers.

Material of tube shall be titanium suitable for sea water application and material of shell and tube plates as M. S. type ASTM-A285 Gr. C properly coated with resin / GRP.

For U-tube type: Removable tube bundle provision shall be provided. Alternatively-plate type heat exchangers with SS 316 plates and 20% area margin on plates also acceptable.

Heat exchanger sizing shall be done as per HEI.

Capacity of each pump in free dry air at standard condition with condenser operating at design pressure of 1 inch (25.4 mm) of Hg (abs) and sub cooled to 4.17 deg.C below



temperature corresponding to absolute suction pressure shall not be less than 30 scfm (51 m³ per hour) under standard conditions i.e. 760mm Hg (abs) and 21.1 deg. C.

Capacity of vacuum pumps shall be as per HEI standard.

Selection of materials for vacuum pumps and seal water recirculation pumps as below :

- (1) Casing -Nickel cast iron
- (2) Shaft -Carbon Steel (EN8)
- (3) Impeller -Nodular iron/stainless steel
- (4) Shaft sleeves-Nodular iron/stainless steel

Operational flexibility of all pumps during hogging and must be able to evacuate the condenser in specified time as per HEI.

Each pump shall be suitable for evacuating 100% designed air steam mixture and non-condensable gas as per HEI. Further the stand-by pump shall cut in automatically in case running pump fails or when condenser pressure falls back to a preset value.

Pumps shall be designed for no cavitation under all operating conditions.

Noise levels should not exceed limitations as specified in Section of General Technical Requirements and vibration levels shall be as per VDI-2056/ or as recommended by proved OEM subject to Owner's approval.

Following type tests are to be carried out on vacuum pump:

- (i) Cavitation test
- (ii) Wet air test

4.3.0 Condenser On Load Tube Cleaning System & Debris Filter

The ball collecting strainer should have redundant differential pressure transmitter, switch and gauge with remote seal type connection.

The no. of balls in circulation should be at least 10% of nos. of condenser tubes.

Bidder should indicate the number of ball losses in 1000 hrs. of normal operation.

Enough provision for homogeneous ball injection and even distribution of balls through out the condenser tubes.

Bidder should ensure that there should not be crowding of balls at the inlet of ball collecting strainer at discharge pipe.

Provision to prevent losses of ball during normal and abnormal condition including tripping of CW pump.

Tender Drawing for COLTCS may also be read in conjunction with the specification.

The ball recirculating pumps, collector, monitor etc. shall be skid mounted.

The Condenser on Load Tube Cleaning System (COLTCS) design has to be suitable for sea water quality.

4.4.0 Debris Filter



One no. Debris filter shall be installed above ground level at the outside of the TG building before the each inlet pipeline of condenser of each unit and adequate cathodic protection shall be provided for debris filter to prevent against corrosion. Fully automatic debris filter of suitable mesh size for sea water application shall be provided at the upstream of COLTS for each CW inlet line. Debris filter shall be supplied with automatic self wash system. The debris filter design has to be suitable for sea water quality.

5.0.0 CONSTRUCTION REQUIREMENT

If the condenser shells call for site assembly, care shall be taken in the assembly of shells, and the correctness of alignment shall be checked in a manner acceptable to the Owner prior to stitch welding. With stitch welding over, and on clearance of final alignment by the Owner, final welding shall be done by 'seam method' so as to ensure a minimum deformation of the welded parts. Only approved welders shall perform such welding operation. All the weld seams shall be properly ground and subjected to non-destructive examination. At least 10% of butt welded seams shall be subjected to radiographic examination.

If the superstructure portion or the upper portions of the condenser are not welded to the condenser shell in the Bidder 'works, then they shall be properly aligned with the Condenser shells at site. Any special fixtures required for such alignment shall be furnished along with the equipment and made use of by the Bidder. All welding shall be done as prescribed under in this volume above and the weld seams shall be properly ground and subjected to dye-penetrant examination.

The Bidder shall be governed by the following conditions during condenser tubes insertion and expansion.

- (1) The condenser shall be installed in its position prior to tube insertion. Tube insertion and expansion shall not be carried out in the open.
- (2) The tubes shall be free from any dents, mechanical damages or any other defects caused during the storage.
- (3) Both ends of the tube where tube expansion has to be carried out shall be thoroughly cleaned to a length of 100 mm to remove oil grease etc. The cleaning shall be done with a fine emery paper.
- (4) The surfaces of the holes in the tube plates and the tube support plates shall be thoroughly cleaned and shall be free from paint, corrosion spots, oxide scales etc. The method adopted by the Bidder for such cleaning of the holes shall meet the approval of the Owner. Final cleaning shall be performed by a chemical cleaning agent like Carbon Tetra Chloride.
- (5) The cleaned surfaces of the tubes and the reamed tube plate holes shall be free from any longitudinal scratches.
- (6) Tubes shall be inserted such that their ends shall project out 2 to 3 mm beyond the tube plate outer surface. The tube shall then be expanded using an electronic automatic torque control tube expanding unit or pneumatic tube expander so as to get 4% thinning of the tube walls and the elongation of the tube ends shall be 0.40 to 0.60 mm. Tube expansion shall be so controlled that neither over expansion nor under expansion of the tubes takes place. Tube expansion shall be checked with a dial bore gauge indicator. Tube expansion shall be carried out to a length of 70% to 80% of the tube plate thickness. In no case, the expansion shall go beyond the tube plate thickness. The tube insertion shall be such that the excess length of all tubes shall be at the same tube plate and they shall be cut off by a cutting tool followed by expansion. Both ends of tubes after expansion shall be flanged properly. Finally,



proper chamfering shall be carried out. Expansion of condenser tubes shall start from the peripheral holes of the tube plate and shall proceed towards the centre of the tube plate in such a sequence as to avoid any deformation of the tube plate.

- (7) Design for full vacuum and min. internal pressure 1.08 Kg/cm² (g). Minimum shell side design temperature 120 deg. C.

In case the condenser is supported on springs and the condenser neck is directly welded to the L.P. cylinder exhaust hood, then the final lifting and installation of the condenser on permanent support shall be carried out only after final installation of the L.P. casing. It shall be ensured that all spring supports are evenly loaded and the gap between the condenser and the spring supports is within +/-1.0 mm. Suitable adjusting bolts shall be used to further lift the condenser till the clearance between condenser neck and L.P. exhaust hood is suitable for welding and such clearances shall not exceed 3.0mm. The welding of the above connection shall be performed as called for as prescribed in this volume above. Suitable machined permanent spacers shall be provided and the condenser load shall gradually be transferred on to these spacers from temporary bolts.

The Hydrostatic testing of condenser steam space shall be carried out after connecting all the pipes with the condenser along with the condenser vacuum system by filling the steam space with water up to tip of last stage LP turbine blades. Any leakage detected shall be rectified immediately.

The water space shall be tested hydraulically along with the circulating water lines, after assembly of the waterbox doors.

After the hydraulic testing, the water boxes tube plates and covers shall be given suitable coatings of anti-corrosive paints. The paints and painting shall meet the approval of the Owner.

6.0.0 CONTROL AND INSTRUMENTATION

Refer Volume - II, sub section-4.10 of Control & Instrumentation Specification.

7.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED ALONG WITH THE PROPOSAL

7.1.0 General

- a) Completely filled in technical schedules & other schedules for all equipments as enclosed with the Tender specification.
- b) Flow Diagrams and P&ID (Process and Instrumentation drawings) indicating Instruments and the destination / functionality of the signals Plot plan
- c) Plot plan and General arrangement drawing with section for major building viz Power house building showing maintenance area
- d) Quality Assurance and plan
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- f) Description of options and alternatives offered
- g) Complete description of the plant offered including description of the process and the equipment
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- i) Safety Plan
- j) Training program and schedule for training of Owner's personnel



- k) Space requirement for construction site and equipment
- l) Maintenance proposal
- m) List of spares
- n) List of Special tools and Tackles
- o) Inspection intervals (major/minor) for six years along with the spares to be replaced during the above inspections. Contractor shall provide the cost of such spares on yearly basis.
- p) Contractor shall enter into a long term spare supply agreement with the OEM, and agree to transfer the same faithfully to the owner upon COD. Contractor shall commit to facilitate further negotiations on the spares with the OEMs directly by the owner.

7.2.0 Mechanical

- a) Heat and Mass balance diagram same for 100% TMCR condition (0% and 1 % makeup), VWO condition (0% and 1 % makeup), 60% TMCR (Constant and Sliding pressure operation), All HP heaters out condition, Auxiliary steam condition and house load operation with HP-LP bypass in operation,
- b) Start up curve for cold, warm and hot condition
- c) Installation references where 660 MW Supercritical units with proposed main steam and reheat steam parameters are in operation.
- d) Experience list for supply and installation plants of similar capacity supercritical Units and performance certificate of the plants indicating the availability and plant load factor from the date of COD.
- e) Steam Generator, Steam Turbine Manufacturer's and Generator Manufacturer's experience list for the offered Capacity
- f) Deed of Joint Undertaking shall be executed by Contractor with following manufacturers
 - Condenser,
 - Condenser Air Evacuation System &
 - Condenser On Load Tube Cleaning System

The above shall be submitted clearly indicating the validity of the agreement and role and responsibilities among them

- g) Details of Technical Collaboration of the Condenser, Condenser Air Evacuation System & Condenser On Load Tube Cleaning System manufacturers with technology Supplier and role of the technology supplier for this project.

8.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED AFTER AWARD OF CONTRACT

The documents required for design, construction, installation, operation and maintenance of the entire plant shall be submitted by the Contractor in good time so as to permit the plant as a whole to be constructed in compliance with the specified time table.

Only the most important documents are listed below. The list and approval category of the doc/drawings shall be agreed sufficiently in advance before award of relevant order, so that corrections and amendments desired by the Owner as well as resubmission of the documents will not result in any delays with respect to the guaranteed time table. The Owner reserves the right to request from the Contractor additional drawings, documents, etc. as may be required for proper understanding and definition of the design and engineering of the Plant.



8.1.0 General

- a) Re-Submission of all the technical data furnished during pre award contract stage.
- b) Complete filled-in technical schedule.- For approval
- c) Plot plan - For approval
- d) General arrangement drawings /Equipment layout of all equipments along with sections indicating the unloading & maintenance area. - For approval
- e) Design basis for all the systems and major equipment sizing calculation - For approval
- f) P&ID (Process and Instrumentation drawings) indicating Instruments and the interlocks for all the systems - For approval
- g) Monthly progress report
- h) L2 network
- i) Quality plan for approval
- j) Prequalification document for different Vendors for Owner's approval.
- k) Equipment Testing procedure for approval
- l) Complete list of documents with proposed submission schedule
- m) Vendor Engineering document viz Data sheets, General arrangement drawing, material of construction, performance curves for approval for major items
- n) Painting & surface preparation procedure
- o) Technical specification

8.2.0 Mechanical

- a) Major equipment sizing calculation viz Condenser Air Evacuation pump for approval
- b) Start-up and shut down procedure along with the curve for approval
- c) System description for all the systems. for approval
- d) Thermal calculation for critical items for approval
- e) Pipe sizing and determination of pressure & Temperature criteria. for approval
- f) Critical piping drg and calculation
- g) Acceptance and Performance test procedure and program
- h) Performance calculation write up.

Any other drawing or document which are not covered above but required to the effective commissioning of the project.



ANNEX 2.3.1 SPECIFIED DESIGN DATA

Description	Unit	Data
CONDENSER		
Design code	-	HEI
Type of condenser	-	• Single pressure stage / Dual pressure stage • Single pass/ Double pass • One shell / Two shells
Orientation of condenser tube axis	-	Perpendicular to turbine axis
Maximum cooling water inlet temperature	°C	33
Temperature rise of cooling water in condenser at TMCR condition	°C	Not exceeding 8.5
Maximum temperature rise of cooling water in condenser during abnormal condition	°C	Less than 10
Maximum cooling water velocity in condenser tubes with 10% blocked tubes	m/s	2.2
Min. size (OD) of the tube	mm	22.225
Minimum thickness of the tube	BWG	22
Minimum cooling water velocity in condenser tubes	m/s	According to requirement of sponge rubber ball equipment
Tube plugging margin	%	5
Tube side/Water box design pressure	bar	Shall be equal to circulating water pump shut-off head or 5 bar (whichever is higher) and vacuum of 0.1 bar (ab)
Tube side/Water box test pressure	bar	1.5 times the design pressure
Minimum Titanium cladding thickness for tube sheet	mm	5
Shell design pressure	Bar (g)	Full vacuum and 1.08
Shell design temperature	°C	120.
Fouling factor	Hr-m2-deg.C/Kcal	As per HEI
Maximum Cooling water side pressure drop across condenser with tube cleaning system in operation	mwc	6
Tube material	-	Titanium
Maximum oxygen content of condensate leaving the condenser over the entire range of operation	ppm	0.015
CONDENSER AIR EVACUATION SYSTEM		
Source of vacuum pump heat exchanger cooling water	-	Auxiliary cooling water.
Source of sealing water	-	Condensate water
Source of sealing make up water	-	Condensate water
Vacuum pump heat exchanger cooling water design pressure	-	Shall be equal to circulating water pump shut-off head and vacuum.
Pressure of make up water	-	CEP discharge pressure.
Maximum temperature of condenser cooling water	°C	33
Design code	-	HEI



Description	Unit	Data
Design back pressure	mm of Hg (abs)	25.4
CONDENSER ONLOAD TUBE CLEANING SYSTEM		
Design pressure of COLTCs equipment	bar	Shall be equal to circulating water pump shut-off head and vacuum.



VOLUME II
SUB-SECTION - 2.4
FEED WATER HEATING SYSTEM

1.0.0 GENERAL

This specification is intended to cover the minimum requirements of design, engineering, manufacture, inspection and testing at manufacturer's works, supply, packing and delivery at project site, unloading, storage and in plant transportation at site, erection, supervision, pre-commissioning, testing, successful commissioning of feed water heating system consisting of LP heater, Gland steam condenser, full capacity drain cooler, feed water storage tank, deaerator, HP heaters, drain system and extraction steam piping, all accessories and associated piping, valves, specialties, controls, instrumentation, supports and insulation.

This section of the specification shall be read in conjunction with other sections of the specification as appropriate and the equipment offered shall meet the requirements as spelt out therein.

2.0.0 CODES AND STANDARDS

Feed water heating system shall be designed in accordance with **latest edition** of following codes, standards specifications and regulations. Also the system design shall conform to the requirements of applicable codes as specified in the General Technical Specification.

ASME (B&PV), Sec VIII, Div I	: ASME Boiler & Pressure Vessel Code.
HEI	: Heat Exchange Institute standard.
IBR	: Indian Boiler Regulations.
ASME TDP-1	: Recommended Practices of Prevention of Water Damage to Steam Turbines Used for Electric Power Generation.
PTC 12.3	: Performance test code for deaerator.
PTC 12.1	: Performance test code for feed water heaters

3.0.0 SCOPE OF SUPPLY

The scope of supply shall include but not limited to the following (for each unit unless indicated otherwise).

- Deaerator
- Feed water storage tank with strainers, anti-vortex baffles, splash plates, spray valves, trays, stand pipe, relief valves, orifices, control, instrumentation, insulation, supports etc.
- Auxiliary steam supply system including actuated valves, check valve, isolation valves, control, instrumentation, insulation and supports.
- Required no. of HP heaters (Based on cycle optimization).
- Required no. of LP heaters with full capacity drain coolers (Based on cycle optimization).
- Relief valves on all heaters for shell side and tube side except condenser neck mounted heaters and startup vent and continuous vent for all heaters.
- Vents and Drains with valves for HP& LP heaters, auxiliary steam, feed water piping.



- Complete feed water , vent, drain inter-connecting piping system with fittings, valves, actuators, instrumentation, insulation, cladding and supports
- Foundation bolts and nuts
- Platform, grating and Ladders
- Special tools

All other miscellaneous facilities and materials for safe, reliable and efficient operation of feed water heating system equipments and accessories.

4.0.0 DESIGN REQUIREMENTS

Feed water heating system shall be designed in accordance with the codes specified in this section and applicable codes specified in the general technical specification or any approved equivalent standards.

The feed water heating system shall be suitable for operation in conjunction with the turbine offered.

4.1.0 Feed Water Heating System

The feed water heating plant shall be capable of raising the temperature of feed water from that in the condenser to the design value at the outlet of top heater at rated output with zero percent makeup.

4.2.0 Heaters

Heaters shall be designed for all operating conditions including transients like sudden load throw-off, HP-LP bypass coming into operation, preceding one or two heaters going out of service etc.

Heaters shall be designed with minimum pressure drop on tube side. Velocity of water/condensate through the tubes shall be restricted to 3.05 m/s under all operating conditions.

Each of the HP heaters shall be capable of handling 110% of the design flow from working BFP's at design condition without undue vibration and other deleterious effects.

Each of the LP heaters and drain coolers shall be capable of handling 110% of the design flow from working CEP's at design condition without undue vibration and other deleterious effects.

Terminal temperature difference (TTD) and Drain cooling approach (DCA) of heaters shall correspond to the heat rate guarantee conditions.

4.3.0 Deaerator and feed water storage tank

Deaerator shall be designed such that maximum oxygen content at deaerator outlet shall be 0.005 cc/litre measured as per ASME D-888 reference method-A or Indigo Carmine method at all operating condition.

Free carbon dioxide as measured by APH method shall be non traceable at all loads.

Deaerator shall be designed for efficient steam distribution and deaeration of condensate under all operating conditions including VWO, 1.0% make up, HP-LP bypass, all HP heater out of service.



The deaerator shall be capable of satisfactory operation under SGMCR, normal operation, condition of turbine trip and HP-LP bypass operation (full open) and lowest condenser pressure.

All LP heaters out and minimum back pressure shall not affect deaerator performance in any manner.

Feed water storage tank capacity shall be minimum 6 minutes storage of 100% BMCR flow between normal operating level and low-low level with a filling factor of 0.66. This capacity shall be exclusive of internal piping, baffles and dished end volume. This capacity shall be exclusive of the volume of internal piping, baffles and volume of the dished end. It shall be designed for maximum incoming steam flow when none of the LP heaters are working under HP-LP bypass condition.

Bidder to take into account the transient operating conditions such as sudden load throw off, cold condensate entering into the deaerator, low low water level in the feed water storage tank etc. with respect to NPSH requirement of booster pump while calculating the capacity of feed water storage tank.

The deaerator shall be of floating pressure type with pegging pressure of 3.5 ata during warm and hot startup, HP-LP bypass operation, major load rejection, turbine trip and low loads when extraction steam pressure is less than 3.5 ata. During cold startup the deaerator pressure shall be maintained at 1.5 ata with steam from auxiliary steam header. During hot and warm start-up, if the boiler start-up drain circulation pumps are in service, deaerator pressure shall be maintained at 3.5 ata. In case start-up drain circulation pumps are not in service and start-up drains are routed through condenser, deaerator pressure shall be maintained at 1.5 ata and steam supply shall be from auxiliary steam header. Deaerator operating pressure shall vary with load when it gets steam from turbine extraction/CRH pressure or worst operating condition with sufficient margins. Steam for initial heating of feed water shall be taken from the auxiliary steam header.

Sources of heating

- a) Extraction steam from turbine during normal operation
- b) Steam from CRH till extraction steam pressure is available.
- c) Steam from auxiliary steam header till CRH steam pressure is available.

4.4.0 Heater Drain system

Normally, the feed water heater drains shall be cascaded to the next lower pressure feed water heater. Drains from the lowest high pressure feed water heater and low pressure feed water heater shall be led to the deaerating feed water heater and surface condenser respectively during normal operation. In addition the high pressure heater drains shall have alternate paths to the surface condenser via the flash tank. The low pressure heater shall have an alternate path to the surface condenser via the flash tank.

Heaters shall be designed for handling drains from proceeding heaters for all operating conditions and under emergency condition drains shall be led to condenser bypassing the drain cooling zone.

Sentinel relief valves shall be provided on tube side. Relief valves on shell side shall be sized to pass flow from two ruptured tubes (four open ends) or 10% of design water flow at 10% accumulation whichever is higher and set to open at heater design pressure.



4.5.0 Design Pressure and Temperature

4.5.1 Heater Shell

HP & LP Heater shell side design pressure shall be as follows:

Maximum extraction steam pressure with 5% margin at turbine extraction flange and full vacuum for HP Heaters

Maximum extraction steam pressure with 5% margin at turbine extraction flange or $3.5\text{kg/cm}^2(\text{g})$ whichever is higher and full vacuum for LP Heaters.

This condition shall be satisfied under all operating condition. For HP heaters taking extraction from CRH line, heater shell side design pressure shall be same as CRH line design pressure.

4.5.2 Heater Tube

Heater tube shall be designed for shut off head of BFP/CEP at maximum speed (as applicable) plus maximum pump suction pressure at cold condition. It shall also be designed for full vacuum.

Over frequency operation of 51.5Hz shall be considered while determining the tube side design pressure based on above philosophy.

Alternatively, if feed control station is located at upstream of HP heaters and feed water system is designed without economizer inlet isolation valve, the HP heaters can be designed based on boiler design pressure meeting IBR requirement with provision of mechanical relief device to prevent BFP shut off pressure being communicated to the feed water system. Bidder shall comply with the new IBR amendment resolution 520.

4.5.3 Deaerator and feed water storage tank

Design pressure of deaerator and feed water storage tank shall be at least 105% of maximum extraction steam pressure rounded off to next higher 0.5 kg/cm^2 and full vacuum.

Minimum Design temperature of deaerator shall be compatible with heating sources temperature of maximum extraction steam and auxiliary steam.

Minimum Design temperature of feed water storage tank 50°C higher than saturation temperature corresponding to the design pressure.

5.0.0 CONSTRUCTIONAL REQUIREMENTS

The installation and dismantling of the various parts of the equipment must be possible without great difficulty and appropriate design features must be incorporated for this purpose.

All parts must be capable of accepting the loads occurring due to rapid load and temperature variation and also those occurring due to start-up, shut-down and continuous base load operation without limitation and without affecting the planned life.

5.1.0 Feed Water heating system

Each heater shall be designed for removal from service individually without shutdown of the unit, using hydraulically operated or motorised bypass and isolation valves. Alternatively group bypass arrangement for HP heaters comprising 2 x 50% streams can be offered by the bidder.



Provision shall be made for complete drainage of heaters both on shell side and tube (water box) side. Heaters shall be provided with startup and operating vents with orifices and relief valves on both shell and tube side.

Provision shall be made for removing non condensable gases collecting on shell side individually to the condenser. All LP heaters startup vents and operational vents shall be connected to condenser. Vent orifices shall be sized to pass 0.5% of rated steam flow to respective heater. Water box channels shall have access necessary openings of suitable diameter.

Tube material shall be stainless steel as specified in the specified design data.

Tube sheet shall be of carbon steel as specified in the specified design data and shall be welded to shell and water box.

Water box channels shall have access openings as specified in the specified design data. These shall be of self sealing type and bolted design shall not be acceptable.

Minimum tube size and minimum wall thickness after bending shall be as per applicable codes.

Minimum fouling resistance on tube inside and outside of tube shall be as per specified design data and as per HEI.

Stand pipe shall be provided with necessary connections for instruments and water level gauges with isolation valves.

Adequate baffling shall be provided to prevent vibration, ensure uniform distribution and free drainage of condensate shall be ensured.

Proper drainage of bled steam lines to be ensured. Each bleed lines shall have ordinary and power assisted NRVs and motorised isolation valves except for heaters mounted in condenser neck and extraction to heater from CRH line.

Prevention of super heated steam contact with tube plate and joint at entry to heaters.

Adequate provision must be made in the design for the possible expansion of the tubes and internals under the different temperature conditions.

No copper or brass shall be used in the internal construction of heaters to avoid copper pick up through condensate/drips.

Arrangement shall be provided for preservation by nitrogen blanketing during shut down.

Roller supports shall be provided for removal of shell of all heaters.

5.2.0 LP heater and drain cooler

Shell material shall be rolled steel as specified in the specified design data with SS-304 bands at cut points on shell to prevent damage against flame impingement during torch cutting.

Water box channel shall be of carbon steel as specified in the specified design data and shall be welded to tube sheet.

Provision shall be made for differential expansion between shell and tubes.



Roller expansion of tubes to tube sheets for LP Heaters; Roller expanded and seal welded for HP Heaters tubes to tube sheets joints. Tube shall be cold bent for fabrication.

Roller supports shall be provided for shell removal of all heaters except condenser neck LP heater and for LP Heater in condenser neck roller supports shall be provided for heater channel during tube bundle removal.

Shell attachments shall be provided for supports of condenser neck LP heater. Anti-flash baffles shall be provided to protect the turbine from water ingress.

LP heaters shall have provision of integral desuperheating, condensing and drain cooling zones except for condenser neck LP heater which has a separate drain cooler.

Details of tube sheets, tube to tube sheet joint, tube support plates and material of construction for drain cooler shall be identical to the LP heaters.

The installation and dismantling of the various parts of the equipment must be possible without great difficulty and appropriate design features must be incorporated for this purpose.

Special provisions must be made for the withdrawal of feed water tube bundles, e.g. rollers and/or hoists.

5.3.0 Feed water tank and deaerator for feed water system

Design and construction shall be as per IBR, ASME code for unfired pressure vessels, Section-VIII or any other equivalent code subject to approval of Owner.

Reinforced wide mesh strainer and anti-vortex baffles shall be provided at discharge connections from deaerator.

Fixed and saddle supports shall be provided on deaerator storage tank.

All pressure parts like shell, heads and nozzles shall be of carbon steel as specified in the specified in the specified design data.

Shell plate shall be of minimum thickness as specified in the specified design data and of welded construction.

Hardened 400 series stainless steel impingement plates shall be provided for flashed drain inlet from HP heaters, BFP recirculation, boiler start-up drains etc.

All water spray valves, splash plates, trays, vent condenser and other elements in contact with undeaerated water or non-condensable gases shall be of stainless steel 304.

Deaerator safety valves of adequate relieving capacity shall be made of 13% Cr. stainless steel disc and spindle.

Sparger pipe and nozzle shall be provided for feed water heating.

Maximum temperature difference between effluent and saturation temperature of incoming steam shall be 0.56 deg C at all load conditions.

The deaerator spray nozzles if provided and the nozzle strainer shall be of stainless steel. If separate deaerators are mounted on the feed water tank they must be lined completely with stainless steel.



Sufficient distance shall be provided between the normal regulated water level of the feed water tank and the maximum permissible level. Tripping of condensate extraction pumps must be provided to prevent overpressure in the tank. Additionally safety valves must be provided are able to discharge safely the maximum possible supply of water.

The tank must be suitably stiffened to safely withstand full vacuum.

Minimum recirculation and balancing leak off line from the boiler feed pumps shall be led to the feed water storage tank. The overflow from deaerator shall be lead to flash tank/condensate storage tank.

De-aerator is elevated suitably to provide sufficient static head to the feed water pumps so that cavitation at boiler feed pump does not occur at any operating condition.

The feed tank shall incorporate 2 manholes of size specified in the specified design data.

Separate deaerator should have at least 1 manhole of size specified in the specified design data.

Access platforms and ladders along with hand rails shall be provided on deaerator / feed water (deaerator) storage tank.

6.0.0 INSTRUMENTATION AND CONTROL

Refer Volume II, Section 4 for Control & Instrumentation Specification.

7.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED ALONG WITH THE PROPOSAL

7.1.0 General

- Completely filled in technical schedules & other schedules for all equipments as enclosed with the Tender specification.
- Flow Diagrams and P&ID (Process and Instrumentation drawings) indicating Instruments and the destination / functionality of the signals Plot plan
- Plot plan and General arrangement drawing with section for major building viz Power house building etc., showing maintenance area
- Quality Assurance and plan
- Master Document List (MDL) for Mechanical, Electrical, Civil and C&I with schedule of submission
- Description of options and alternatives offered

7.2.0 Complete description of the plant offered including description of the process and the equipment

- General descriptions of individual systems and descriptions of operation including description of start-up, shutdown and emergency shutdown procedures
- Safety Plan
- Training program and schedule for training of Owner's personnel
- Space requirement for construction site and equipment
- Maintenance proposal
- List of spares
- List of Special tools and Tackles
- Inspection intervals (major/minor) for six years along with the spares to be replaced during the above inspections. Contractor shall provide the cost of such spares on yearly basis.



- Contractor shall enter into a long term spare supply agreement with the OEM, and agree to transfer the same faithfully to the owner upon COD. Contractor shall commit to facilitate further negotiations on the spares with the OEMs directly by the owner.

7.3.0 Mechanical

- Installation references where 660 MW Supercritical units with proposed main steam and reheat steam parameters are in operation.
- Experience list for supply and installation plants of similar capacity supercritical Units and performance certificate of the plants indicating the availability and plant load factor from the date of COD.
- HP, LP Heater, Deaerator and Feed Water Tank Manufacturer's experience list for the offered Capacity
- Deed of Joint Undertaking shall be executed by Contractor with following manufacturers
 - HP & LP Heater
 - Deaerator & Feed Water Tank

The above shall be submitted clearly indicating the validity of the agreement and role and responsibilities among them

- Details of Technical Collaboration of the HP, LP Heater, Deaerator and Feed Water Tank manufacturers with technology Supplier and role of the technology supplier for this project.

7.4.0 Drawings & Documents to be submitted after Award of Contract

The documents required for design, construction, installation, operation and maintenance of the entire plant shall be submitted by the Contractor in good time so as to permit the plant as a whole to be constructed in compliance with the specified time table.

Only the most important documents are listed below. The list and approval category of the doc/drawings shall be agreed sufficiently in advance before award of relevant order, so that corrections and amendments desired by the Owner as well as resubmission of the documents will not result in any delays with respect to the guaranteed time table. The Owner reserves the right to request from the Contractor additional drawings, documents, etc. as may be required for proper understanding and definition of the design and engineering of the Plant.

(A) General

- Re-Submission of all the technical data furnished during pre award contract stage.
- Complete filled-in technical schedule.- For approval
- Plot plan - For approval
- General arrangement drawings /Equipment layout of all equipments along with sections indicating the unloading & maintenance area. - For approval
- Design basis for all the systems and major equipment sizing calculation - For approval
- P&ID (Process and Instrumentation drawings) indicating Instruments and the interlocks for all the systems - For approval
- Monthly progress report
- L2 network
- Quality plan for approval
- Prequalification document for different Vendors for Owner's approval.
- Equipment Testing procedure for approval



- Complete list of documents with proposed submission schedule
- Vendor Engineering document viz Data sheets, General arrangement drawing, material of construction, performance curves for approval for major items
- Painting & surface preparation procedure
- Technical specification

B) Mechanical

- Major equipment sizing calculation viz HP, LP Heater, Deaerator and Feed Water Tank, for approval.
- Start-up and shut down procedure for approval
- System description for all the systems for approval
- Thermal calculation for critical items for approval
- Pipe sizing and determination of pressure & Temperature criteria. for approval
- Critical piping drawing and calculation
- Acceptance and Performance test procedure and program
- Performance calculation write up.

Any other drawing or document which are not covered above but required to the effective commissioning of the project.



ANNEX 2.4.1 SPECIFIED DESIGN DATA

Description	Unit	Data
HP and LP HEATER		
Design	-	HEI
Type	-	standard U-tube horizontal type [LP heater type is specified below in this table]
No of HP and LP feed heaters	Nos.	To be decided by Contractor to achieve optimum cycle configuration.
Tube Material	-	ASTM A 213 Gr. TP304 for seamless tubes without circumferential joints or ASTM A 688 Gr. TP 304 for welded tubes.
Maximum content of carbon in the tube material	-	0.05%
Tube sheet material	-	ASTM A 266 Class II or ASTM A516 Gr.70 or SA350LF-2 or equivalent subject to approval of owner with SS overlay of atleast 6.35 mm after all machining (for HP heaters)
Tube support plates	-	Common quality steel – minimum 16mm thickness
HP & LP heater Shell Material	-	ASTM A516 Gr.70 or equivalent
LP heater water box channel	-	ASTM A516 Gr.70 or equivalent
HP heater water box channel	-	ASTM A-266 class –II or equivalent subject to approval of owner
Water box channel access openings	-	Minimum 450mm diameter
Minimum fouling resistance on tube inside	Hr-m ² -deg.C/Kcal	0.00004098
Minimum fouling resistance on tube outside	Hr-m ² -deg.C/Kcal	0.000061475
Minimum corrosion allowance for shell and water box	mm	3.2
Maximum pressure drop on tube side of each LP heaters	mwc	Heaters shall be designed with minimum pressure drop on tube side. Velocity of water through the tubes shall be restricted to 3.05 m/sec under normal operating conditions or Maximum pressure drop on tube side of 0.1 MPa whichever is minimum.
Maximum pressure drop on tube side of each HP heaters	mwc	Heaters shall be designed with minimum pressure drop on tube side. Velocity of water through the tubes shall be restricted to 3.05 m/sec under normal operating conditions or Maximum pressure drop on tube side of 0.1 MPa whichever is minimum.
LP HEATER		
Type	-	Horizontal U tube type with integral drain cooler.
Condenser neck LP heater	-	Straight or U tube design with



Description	Unit	Data
		separate drain cooler.
Drain cooler of condenser neck LP heater	-	U tube or straight
DEAERATOR AND FEED WATER TANK		
Type of Deaerator	-	Horizontal, spray-cum-tray type / Spray Type
Mode of operation of Deaerator	-	Variable pressure with fixed minimum pressure
Pressure parts like Shell, heads and nozzles	-	ASTM A-515 Gr. 70
Shell plate minimum thickness	mm	15.8
Manhole	mm	Minimum 500
Shell corrosion allowance	mm	3.2



VOLUME II
SUB-SECTION - 2.5
POWER CYCLE PUMPS & ACCESSORIES

1.0.0 GENERAL

This specification is intended to cover the minimum requirements of design, engineering, manufacture, inspection and testing at manufacturer's works, supply, packing and delivery at project site, unloading, storage and in plant transportation at site, erection, supervision, pre-commissioning, testing, successful commissioning of power cycle pumps, all accessories and associated piping, valves, specialties, controls, instrumentation, supports and insulation.

This section of the specification shall be read in conjunction with other sections of the specification as appropriate and the equipment offered shall meet the requirements as spelt out therein.

2.0.0 CODES AND STANDARDS

Power cycle pumps and accessories shall be designed in accordance with **latest edition** of following codes, standards specifications and regulations. Also the system design shall conform to the requirements of applicable codes as specified in the General Technical Specification.

HIS	: Hydraulic Institute Standards
ANSI B 16.5	: Code of steel flanges and pipe fittings
ASTM	: American Society of Testing and Materials.
ASME Sec V	: Non destructive examination
ASME Sec VIII Div 1	: Unfired pressure vessels
PTC – 8.2	: Centrifugal Pumps – power Test code.
PTC - 6	: Steam Turbine
API612	: Special purpose steam turbine for petroleum chemical and gas industry services
API 614	: Lubrication, shaft sealing and control oil systems and auxiliaries for petroleum chemical and gas industry services
EPRI	: Electrical Power Research Institute
ASME-TDP1	: Recommended Practices of Prevention of Water Damage to Steam Turbines Used for Electric Power Generation.
IS 10981	: Acceptance test for centrifugal mixed flow and axial flow pumps.
IS 1710	: Specification for pumps- Vertical turbine mixed and axial flow, for clear cold water.



The materials of the various components shall conform to the applicable IS / BS / ASTM / DIN standards.

All equipment covered by this specification shall comply with all applicable laws and statutory regulations, Indian Electricity Act etc.

3.0.0 SCOPE OF SUPPLY

The scope of supply shall include but not limited to the following (for each unit unless indicated otherwise).

3.1.0 Boiler Feed water pumps

- 2 x 50% capacity turbine driven boiler feed pumps (normally working)
- 1 x 50% capacity motor driven boiler feed pump startup/standby.
- Each main feed pump shall be provided with booster pump to meet the net positive suction head (NPSH) requirement.
- Piping with flow element and relief valve between booster pump and main pump.
- Turbine driven feed water pump, Motor driven feed water pump and booster pumps specified herein for the TG set together with all accessories and auxiliary equipment including gear boxes required to make a complete and well integrated unit to satisfy the requirement.

Scope of this specification shall include but will not be limited to the following (for each pump unless indicated otherwise):

- a) One complete minimum-flow system with ON/OFF type automatic recirculation valve, pipe work, lock open type isolation valves, drain and vent valves, orifice etc.
 - b) Pump warm up orifice, isolation valves along with piping, fittings, and instrumentation if required
 - c) Balance chamber leak-off flow orifice along with piping, fitting, valves and instrumentation.
 - d) Permanent and temporary basket strainer for each feed water pump along with differential pressure measurement, drain and vent valves.
 - e) Mechanical seals
 - f) Flexible couplings
 - g) Hydraulic couplings
 - h) Gear box assembly
 - i) Coupling guard
 - j) Integral piping and valves
 - k) Thermal lagging and cladding
 - l) Mechanical seal cooling system
 - m) Vibration monitoring system
 - n) Base plates with foundation anchor bolts/inserts, drip lip and drain.
 - o) Interstage bleed connection from boiler feed pump to supply water to reheat steam de-superheater and kicker stage tap-off from boiler feed pump to supply water to superheater attemperation.
 - p) A complete self-contained lubricating oil system including tanks, 2 x 100% lube oil pumps, oil purifier, 2x 100% capacity coolers, level indicator, sight flow glass, relief valve, thermometer, pressure regulators, strainers, piping, all instruments and control hardwares, etc for motor driven boiler feed pump.
 - q) Appearance cover.
- Portable type oil purifier unit.
 - Acoustic hood (if required)
 - Duplex R.T.D./thermocouples in all journal, thrust bearings and pump barrels.



- Local instruments, local gauge board and instruments to be mounted on the gauge board as required.
- Mobile cradle
- Each boiler feed water pump drive turbine shall include following apart from above specified items.
 - a) Suitable integral Gland sealing system
 - b) Emergency stop valves and control valves
 - c) Non return valves for single admission drives
 - d) Permanent and temporary steam strainers or Permanent steam Strainers and blanking device for steam blowing during commissioning will be supplied.
 - e) AC driven or hydraulically operated turning gear for TDBFP train
 - f) Hand barring gear for emergency condition.
 - g) Atmospheric relief diaphragm and its vent piping
 - h) Complete interconnecting piping
 - i) Complete lube oil and control oil system consist of following:
 - i) Oil reservoir capacity of five minutes retention time
 - ii) 1x100% capacity AC motor driven main oil pump
 - iii) 1x 100% capacity auxiliary oil pump
 - iv) 2x 100% capacity oil coolers
 - v) Duplex type full capacity oil filters of cartridge type with automatic bypass facility.
 - vi) 2x100% AC driven vapor exhausters.
 - vii) One DC motor driven emergency oil pump for bearing oil requirements.
 - viii) Capacity of centrifuge type oil conditioning system - 2400 LPH or 15% to 20% of total oil charge in the system per hour whichever is higher.
 - ix) Jacking oil system with 1x100% AC jacking oil pump and 1x100% DC jacking oil pump
 - j) Other accessories to render the system complete
 - k) Electro hydraulic governing system
 - l) Turbine supervisory system along with all control and accessories as specified elsewhere in the specification
 - m) Exhaust ducts from the auxiliary turbines along with metallic expansion joint and motorized butterfly valve. The exhaust duct shall be self-draining to the condenser.
 - n) Gland sealing steam supply piping from auxiliary steam header or CRH line during starting conditions and boiler feed pump drive turbine shall be self sealing during normal condition. All the steam-air mixture connection to gland steam condenser inlet line complete with all fittings, valves, necessary instrumentation and control hardwares to make the system complete in all respects.
 - o) Complete insulation inclusive of special material, if any, for the auxiliary turbines and piping in the scope of this specification.
 - p) Other accessories to render the system complete.
 - q) Gear box for TDBFP booster pump and flexible coupling (if required).
- Feed regulating station for feed water flow control during unit startup and normal condition, consisting of the following for each unit:
 - a) One pneumatically operated (0 to 30% BMCR capacity range) feed control valve.
 - b) Two numbers of motor operated gate valves with motor operated integral bypass valve, one each on upstream and downstream of pneumatically operated feed control valve.
 - c) One motor operated gate valve with motor operated integral bypass valve in parallel to the pneumatically operated feed control valve to bypass the feed control in the unit operation range of 30-100% BMCR.



3.2.0 Condensate Extraction Pump

Each Unit shall be provided with three 3 x 50% capacity condensate extraction pumps (2 working + 1 standby).

Condensate Extraction pumps together with all accessories required to make complete and well integrated units to satisfy requirements of the specification, including but not limited to the following. (for each pump, unless otherwise noted).

- AC drive motor
- Fabricated common base frame.
- Non lubricated, spacer type, flexible coupling with coupling guard.
- Pump suction permanent and commissioning basket type strainers including drain valves and supporting legs.
- Each strainer shall be provided with differential pressure indicator and switch along with isolation valve and piping.
- Vibration monitoring system and minimum flow facility.
- Pump and drive sealing/cooling arrangement.
- All integral piping with necessary valves, fitting and instrumentation for sealing, cooling, lubrication, bleed and vent, etc.
- Noise attenuation features / devices as required to limit the near field noise with in limits indicated elsewhere in specification.
- All necessary venting and draining equipment
- Foundation bolts, base plates, sole plates, bolt, nuts, washers, supports, covers etc.
- Expansion joint for each condensate extraction pumps
- Instruments, gauges, controls and panels.
- Minimum flow facility
- Excess condensate dumping line to CST and provision for direct draining to atmosphere also
- Pump bearing cooling water arrangement.
- Provision for recirculation line with suitable capacity to avoid starvation of pump and gland steam condenser.

The complete condensate and feed water piping system as required along with valves, control valves, flow meters, fittings, provision for commissioning activities, supports, instrumentation, insulation and cladding etc.,

4.0.0 DESIGN REQUIREMENTS

The pumps and auxiliaries shall be designed, manufactured, tested and supplied strictly in accordance with the codes and standard. All requirements specified in the following paragraphs are addition/modification to the above standards.

4.1.0 Boiler Feed Water Pumps

Design Criteria:

The combined flow of 2x50% turbine driven boiler feed pumps shall have 10% margin over feed flow corresponding to turbine VWO condition with 1% makeup, CW inlet temperature of 33°C and corresponding head. 10% margin on equipment and piping pressure drop at VWO condition with 1 % make-up shall be considered while arriving the TDH at design point.

The best efficiency point of the pump shall correspond to 100% TMCR condition with 1 % make up and corresponding head under rated condition.



Turbine driven feed pumps to be capable of generating the discharge pressure not less than 3% over steam generator highest safety valve set pressure and flow corresponding to BMCR requirements.

Two pumps shall also be capable of handling the flow and head corresponding to 100% TMCR with 1% make-up, CW inlet temperature of 33°C even at 47.5 Hz (Under Frequency Operation).

One TDBFP or MDBFP shall be capable of handling flow and head corresponding to 65% of unit rated load at run out point.

One TDBFP and the MDBFP together shall be capable of generating flow and head corresponding to 100% TMCR with 1% makeup conditions.

Other requirements

Combined flow of 2x50% TDBFP shall meet the following:

- a) BMCR flow and head corresponding to rated steam pressure.
- b) V.W.O. output, 1% makeup, worst condenser pressure (MDBFP should meet the corresponding requirement at 47.5Hz).

The characteristic curves of all the pumps shall be identical and shall be of continuously rising type with decrease in flow. The shut off head of the pump shall be between 120% and 130% of TDH at rated condition or 1.25 times of boiler design pressure whichever is higher.

The maximum continuous motor rating corresponding to maximum cooling water temperature at cooler inlet shall not be less than larger of the following conditions:

- a. Sufficient to drive the pump through the entire range of run-out flow to shut-off conditions operating at frequency variations from 47.5 Hz to 51.5 Hz
- b. 110% of pump design point rating. The maximum load demand of driven equipment at its entire range of operation at frequency variations from 47.5 Hz to 51.5 Hz

Motor shall not be overloaded during any mode of operations of the driven equipment.

Discharge flow of the pump shall not include any seal flow, warm up flow and balance leakage flow.

In designing the system, attention has been paid to minimization of slip losses, by adjusting the head between booster and main pump. While adjusting the same, adequate attention has been paid to the NPSH requirements of the main and the booster pumps during normal operation and transients. Location of de-aerating feed water heater and offset of suction piping from pumps are such that the sufficient margins on net positive suction head (NPSH) required by pump during normal and transient conditions, to avoid flashing/steaming in suction lines under all operating modes.

MDBFP to be located in the Zero mt or intermediate floor of TG (not in TG operating floor)

The ratio between NPSH(A) and NPSH(R) at 3% head drop for booster pump and main pump shall not less than 2.5 at design point corresponding to low-low level of deaerator and maximum pressure drop across the strainer.

Trip speed of TDBFP shall be 10% above the design speed of feed pump.

Motor drive shall be able to accelerate the pump from standby condition to its rated pumping condition in less than 15 seconds after receipt of starting signal while operating either singly



or in parallel with other operating pump. MDBFP and associated auxiliaries shall be designed for auto start-up on failure of running equipment/ auxiliaries.

The boiler feed pumps shall be capable of coasting down safely to standstill after it is tripped in the event of a sudden interruption of suction flow. The Bidder shall demonstrate this capability by a suitable dry-running test at his works and shall furnish full details of this proposed test including its duration etc. in his bid

The pumps shall be capable of accepting complete loss of water due to incidents such as inadvertent complete closure of suction valve and brought down to rest in controlled manner from design condition with simultaneous closure of suction valve.

The minimum flow of the booster pump and main pump shall not be less than 25% of their respective design flow.

ON-OFF type minimum recirculation valve shall be provided with valve body designed for 40% of design flow.

The first critical speed in water above the speed corresponding to turbine overspeed trip condition and internal clearances being 150% of new clearance or 130% of design speed whichever is higher.

Life due to wear due to cavitation of first stage impeller shall not be less than 40000 running hours.

The suction specific speed of first stage impeller for main pump and booster pump shall generally not exceed 8000 US units and 9500 US units respectively at their respective design point based on 3% head break down.

TDH per stage for the main pump shall not exceed 670 mwc at design point.

Casing design pressure for TDBFP shall be TDH at minimum flow with pump operating at trip speed under lowest operating density plus maximum suction pressure at booster pump. For MDBFP, the casing design pressure shall be TDH at minimum flow with pump operating at maximum speed at 51.5 Hz under lowest operating density plus maximum suction pressure at booster pump.

The pumps shall be designed for the highest practicable degree of availability and reliability under all conditions of operation such as operation on turning gear during startup, maximum and minimum temperature of feed water encountered during operation, abnormal pressure decay in deaerator, sudden generator load throw off, frequency variations (47.5 Hz to 51.5 Hz), HP heaters out of operation, HP-LP bypass operation.

Response and performance characteristics of BFP (Motor and turbine driven) shall be such that while operating in parallel the difference in flow handled by them and the flow proportionate to their rating corresponding to the load shall not be more than 5% of flow through any one pump.

The inner pump element comprising of shaft, impellers, stage casings capable of being removed and replaced as a unit without disturbing feed piping in not more than 12 hours and shall be demonstrated by bidder. Suction, discharge and interstage bleed connections need not be broken to dismantle the pumps.

Provision shall be made for pressure lubrication (if necessary) of MDBFP at the time of coasting down of the motor driven boiler feed pump in the event of AC power failure.

If bidder foresees any possibility of the feed pump operating at flow beyond its maximum flow handling capability due to low system resistance, bidder shall make necessary arrangements



to protect the pump from such high flow condition without any necessity of reducing the plant load.

During normal operation the discharge valve of standby BFP set is kept normally open. Each BFP set as a whole is capable of withstanding the reverse rotational speeds which would result from non-return valve failure under the most severe condition (i.e. remaining normally working pumps operating at full speed). The reverse rotation detection system to close discharge valve on detection of same is provided.

The capacity, head and efficiency of the pumps shall be guaranteed within the tolerances stipulated by Hydraulic Institute Standards, USA or any other International Standard.

Balancing drum shall be designed to balance 95% of total pump axial thrust. Balancing disc shall not be acceptable.

Thrust bearings of booster pump and main pump shall be designed for two times the worst thrust under turbine on trip speed, pump at shut off head and internal clearances 200% of new clearance. Thrust bearing shall be suitable for reverse rotation.

The Units shall be so arranged that start-up, running and shut down operation may be carried out from the central control room. Necessary interlock and provisions shall be made so that the standby pump will come into operation automatically and immediately whenever any operating pump trips.

The pump should be designed to withstand thermal shock encountered during the entire operating regime (normal and abnormal) of the unit.

Speed control range of the Boiler feed pump drive unit (both turbine and motor driven) shall cover the entire range of boiler feed pump operation, from minimum flow (i.e. pumps on recirculation) to the design head-capacity point with at least 5% margin on pump speed both on the high and low sides.

Basket type strainer shall be provided on the each booster pump suction to protect the pump from debris. Strainer shall be provided with necessary vents and drain along with piping and valves. High differential pressure switch alarm facility shall be provided for each strainer.

TDBFPs and MDBFP shall be accessible to turbine hall EOT crane for their erection and maintenance. In case MDBFP and TDBFPs are not accessible by turbine hall EOT crane, separate adequate handling facilities shall be provided for these equipments subject to purchaser's approval.

Bidder shall ensure that no components shall be included with use materials which are degradable and/or which will need replacement with 40,000 running hours with the exception of mechanical seal face material, which shall be capable of operating for at least 20,000 running hours.

Coolers shall be designed with margin of 20% over worst condition of heat generated in seals. Further in case of AC power failure, seals should be able to withstand operation without cooling water.

Design of drive turbines shall be in accordance with API 612 and 614 except as modified herein and generally used in thermal power plants and testing in accordance with ASME-PTC6. However, ageing factor on BFP drive turbine shall be considered same as for main Steam turbine generator.

Drive turbine shall be of dual admission type or single admission type with an external control valve, single cylinder, condensing type.



Fabricated steel baseplates shall be as per standard practice of bidder. The bed plate shall extend under all parts of the equipment from which oil or water may drip and shall have a raised lip with tapped drain connection with suitable grout holes.

The design requirements of Strainers are:

- The pressure drop of the strainer at design flow and clean condition shall not exceed 0.1 Kg/cm². Pressure drop at design flow and 50% clogged condition shall not exceed 0.15 Kg/cm²
- The clear area of strainer shall be five times the inlet cross sectional area of the connection piping.

4.2.0 Condensate Extraction Pumps

Design Criteria:

Design flow

The combined flow of 2x50% condensate extraction pumps shall have 10% margin over condensate water flow corresponding to turbine VWO condition, 1.0% makeup, CW inlet temperature of 33°C and corresponding head.

Design head

TDH at design capacity shall be derived based on deaerator maximum safety valve set pressure at VWO and equipment and piping pressure drops with 10% margin at VWO condition with 1.0 % make-up, static head etc. While Sizing the Condensate pumps the pressure drop across Condensate polishing unit shall be taken into account in the discharge head of the pump.

Best efficiency point

The best efficiency point of the pump shall correspond to 100% TMCR with 1% make-up condition and corresponding head under rated condition.

One pump shall be capable of handling the flow and head corresponding to 65% unit load.

Under frequency operation

Two pumps shall be capable of handling the flow and head corresponding to 100% TMCR, HP heaters out, 1.0% make-up and maximum CW inlet temperature of 36°C at 47.5 Hz.

Two pumps shall also be capable of handling the flow corresponding to HP-LP by pass operation with turbine under tripped condition as well as turbine on house load so as not to fall into over-discharge trip due to rapid action of the LP turbine bypass de-superheater spray.

Other requirements

NPSH(R) at 3% head drop shall be not more than half the NPSH(A) at design flow with lowest hot well level and maximum pressure drop across suction strainer. Under all other operating regimes, the NPSH(R) at 3% head break shall be well below NPSH(A).

The pump head curve must be continuously rising with a shut off head of atleast 115% to 125% of total developed head at design point.



The maximum continuous motor rating corresponding to maximum ambient temperature at cooler inlet shall not be less than larger of the following conditions:

- a. Sufficient to drive the pump through the entire range of run-out flow to shut-off conditions operating at frequency variations from 47.5 Hz to 51.5 Hz
- b. 110% of pump design point rating. The maximum load demand of driven equipment at its entire range of operation at frequency variations from 47.5 Hz to 51.5 Hz

Motor shall not be overloaded during any mode of operations of the driven equipment.

First critical speed of the pump shall not be within 20% of design speed.

Pump impellers shall be of closed and non over-loading type with wear rings provided on pump casing bowls.

Thrust bearing shall be provided for the combined thrust load of pump and motor with a rigid coupling between pump and motor or individual thrust bearings shall be provided for pump and motor with a flexible coupling between motor and pump.

The wear life due to cavitation for first stage impeller shall not be less than 40,000 running hours.

Peripheral speed of impeller shall not exceed 20m/s or limiting peripheral speed shall be as per standard and proven practice of the manufacturer.

Suction specific speed of first stage impeller shall generally not exceed 11,000 U.S. units based on 3% head break of that impeller at design point.

Discharge and suction connections shall be of weld neck type with raised steel flange as per ANSI B 16.5 and shall be located above floor mounting flange.

Bowls and discharge components shall be designed for pressure corresponding to shut off head at 51.5 Hz, operating specific gravity and maximum suction condition.

Suction components shall be designed to withstand full vacuum apart from suction side design pressure.

The pump internals shall be capable of being lifted out of casing after removal of motor and disconnecting discharge flange but without disturbing the discharge piping.

The minimum recirculation of the CEP shall preferably meet the minimum flow requirements of gland steam condenser.

5.0.0 CONSTRUCTION REQUIREMENTS

The installation and dismantling of the various parts of the equipment must be possible without great difficulty and appropriate design features must be incorporated for this purpose.

All parts must be capable of accepting the loads occurring due to rapid load and temperature variation and also those occurring due to start-up, shut-down and continuous base load operation without limitation and without affecting the planned life.

In so far as the special requirements given below for the individual parts of the plant also apply to other parts of the steam turbine plant, they are to be used there as applicable.



5.1.0 Boiler Feed water pumps (BFP)

The main pump shall be of horizontal, centrifugal type, multistage, outer casing barrel type with end rotor removal.

The booster pump shall be of single stage, two bearing design and double suction impeller type. Overhung impeller shall not be acceptable.

MDBFP shall be provided with a constant speed squirrel cage induction motor. MDBFP to be located in the Zero meter or intermediate floor of TG(not in the TG floor). The main pump shall be connected to the motor through a combined gear box cum hydraulic coupling and booster pump shall be connected at other end of the motor.

TDBFP shall be provided with a variable speed turbine drive. Main pump shall be connected to the turbine through a disconnect coupling and booster pump shall be connected at other end of turbine through a gear box.

Each boiler feed pump complete with booster pump driven by the same shaft as the main pump and accessories.

The boiler feed pumps, booster pumps, drive turbines, hydraulic coupling and major equipment shall be identical in design in order to provide complete interchangeability.

Booster Pump Side suction and discharge connections shall be of flanged type with weld neck raised face as per ANSI B16.5.

The pump shall have stiff shaft design and minimum internal clearances more than maximum static shaft deflection.

Pump Casing

The casings shall be of suitable design to withstand any possible thermal shock and/or high pressure and shall be constructed of materials specifically selected to prevent erosion and corrosion.

The barrel type outer casing of the B.F. Pump as well as the booster pump casing shall be supported at horizontal center line of the pump. The inner casing shall be of axially/radially split type in accordance with the standard proven practice of Manufacturer. The joints shall be constructed in such a way that the feed water discharge pressure acting between outer barrel and inner casing acts to seal the joints. The casing assembly complete with the rotating elements should be located accurately in the outer barrel and it should be possible to remove this assembly without disturbing the suction and discharge piping connections.

The Bidder shall supply a cradle with rollers and necessary attachments for the removal of the inner assembly.

Pump casings shall be provided with adequate number of vent and priming connections with valves. Casing drain, as required, shall be provided complete with drain valves. Necessary insulation cleats shall also be provided on the casing.

Shaft

The shaft shall be of tested forgings accurately machined and ground. The material specification and its heat treatment as well as particulars of thermal treatment, proposed to minimise distortion during manufacture, shall be stated in the Bid. Shafts should withstand the stresses set up when the pump will be started quickly. Shaft size should be so selected that



full driver output can be easily transmitted without excessive deflection, vibration, distortion or whip.

Impellers

The impellers should be accurately machined, finished to close tolerance and installed individually on the shaft giving special consideration to prevent recirculation between shaft and impeller.

The first stage of inlet impeller should be specially designed to provide most favourable conditions free from cavitation even during stringent suction condition.

Each impeller shall be balanced individually and the entire rotor assembly should be statically and dynamically balanced. The rotor shall be so designed that its first critical speed in air or water is above the operating speed.

Shaft sleeves of hardened wear resisting material shall be provided at all points of wear (if applicable). Ferritic wear surfaces shall be preferred. They shall be firmly secured and keyed to the shaft. The material and design shall be such that no internal leakage occurs between shaft and sleeve. The axial thrust of the rotor shall be carried by an approved type of hydraulic balancing device and an external oil lubricated thrust bearing fitted at the outboard end of the pump integral with the journal bearing housing. No axial thrust should be transferred to the electric motor at any condition of operation. The thrust bearing shall also be designed for additional load when pump gets vapour bound.

Shaft Seals

Shaft seals shall be of mechanical seal type both for main pump and booster pump. The seals shall be designed to have a minimum life of 20,000 running hours between overhauls. Liquid for sealing shall be supplied from pump discharge header.

Bearings

Each pump shall be equipped with forced oil lubricated babbitt lined sleeve bearings and tilting pad, double acting 100% thrust bearing. The sleeve bearings shall be horizontally split type. The thrust bearing shall be of sufficient size to carry the maximum unbalanced load in either direction due to any emergency operating conditions like the non-operation of the balancing device etc.

Thrust bearing shall be suitable for reverse rotation of pump. Temperature sensing elements shall be provided for bearing metal temperature indication and thermometers with alarm contacts shall be provided for bearing oil drain.

Lubrication

Each pump set shall be provided with a complete pressure lubrication system of sufficient capacity for both pump and drive motor. The oil cooler tubes shall be of stainless steel SS-304. The coolers shall be designed for service with auxiliary cooling water system (softened water). The oil pump shall be driven by the feed pump shaft and all parts of the system shall be mounted as an integral part of the feed pump assembly.

Provision must be made to ensure continuity of oil supply even during reverse rotation of feed pump, and during low frequency operation of oil pumps.

The oil system shall cover the entire lubrication of the pump, motor, gears, the booster pump as also the supply of oil to the hydraulic coupling. Arrangement for proper distribution shall be made using needle valves and orifice plates. The complete sealing/ cooling/ lubrication/



hydraulic oil system shall be self-draining to a tank from where the oil can be purified, cooled and pumped back to the system, or can be drained suitably, if required.

Required electrical interlock shall be provided for continuous, safe and trouble-free operation of the lubricating oil system, including supply pressure switches for automatic standby pump start, trip and alarm interlocks.

For auxiliary turbine driven pump sets, the pump lubricating oil shall be supplied from and returned to the auxiliary turbine lubricating system.

Coupling

Adequately sized spacer type, extension type or other approved type flexible couplings shall be used between the pumps, the fluid drive, the step up gear, and the motor drive. Couplings shall have adequate permanent lubrication arrangement and shall be provided with safety guards.

The couplings for turbine driven pumps shall be quick disconnect type suitable for remote manually disconnecting of the pumps from the turbine. Bidder may submit alternate offer with flexible metal diaphragm type coupling in case, he does not recommend the use of quick disconnect type coupling for offered pump set.

Gear Box

The gear boxes shall be of double helical type manufactured by hobbing process and shall be dynamically balanced. The high speed pinion shall be of heat treated forged steel with integral shaft and low speed gear shall be of forged steel keyed to the input shaft. The gear casing shall be horizontally split and accurately machined to provide oil tight joints. The gears shall be enclosed in an oil and dust proof gear casing made of grained cast iron or fabricated steel. Oil used shall be same as for the pump, motor and turbine and supplied from pump lubrication system. Gear boxes shall be designed for continuous service.

Service factor for gear box

- a) TDBFP (gear box between turbine drive and booster pump) : 2.0
- b) MDBFP (combined gearing/hydraulic coupling) : 1.4

Gear box shall be provided with two oil level gauges, drain fill vent thermometer dipstick with approved mounting valves, fitting etc. on gear casing.

Gear box shall be provided with separate thrust bearings to meet worst duty conditions. Bearings shall be of split sleeve type bronze backed with a high grade centrifugally cast tin base babbitt lining. Gear journal bearing shall have babbitted thrust faces next to the gear to act as locating surfaces for the gear train.

Design and manufacturing of gear boxes shall be as per AGMA 6011

Hydraulic Coupling

The hydraulic coupling shall be of combined gear box and fluid coupling type, and shall be provided with electric actuator, linkages and necessary amplifier units.

The hydraulic coupling shall be adequately rated to meet the requirement of pump characteristics while operating in the range of capacities specified.

The hydraulic coupling shall be complete with stainless steel impellers, casing, self supported double duty roller bearings, pillow blocks and Kingsbury/ Mitchell thrust bearing or proven



thrust bearing as per manufacturer's standard practice for inlet/outlet with removable covers, oil sump, duplex filters to remove all particles upto 5 microns, oil temperature and pressure gauges, control pump for oil regulation if provided, regulating valves, stainless steel scoop tube, 2x100% lube oil coolers, 2x100% working oil coolers, one portable type oil purifier of adequate capacity.

Other coupling

Other couplings shall be of flexible metal diaphragm type designed to limit the rotor end play with spacer. However, bidder may offer flexible gear coupling between gear box and booster pump for TDBFP.

Oil Coolers

Oil coolers shall be of shell and tube type. The tubes shall be roller expanded and flared at the ends and tube bundles shall be of removable type. Tubes shall be of stainless steel and shell shall be made of carbon steel.

Suitable corrosion allowance shall be provided for carbon steel and iron parts including shell, flanges etc.

Oil coolers shall be adequately rated with suitable fouling allowance in accordance with TEMA with necessary arrangements for changing over the cooler without interrupting the oil flow.

Cooling medium shall be demineralized water taken from closed loop equipment cooling system. Cooling medium shall flow in tube side.

Temperature and pressure indicators shall be provided on inlet and outlet branches of the water side and also on the shell side of each cooler. Adequate arrangement for draining and venting of all parts of cooler shall be provided.

DRIVE TURBINE

Casing

The casing shall withstand the maximum pressure and temperature likely to be encountered during normal operation and 25% over rated pressure for short term duration as per IEC 45.

Casing shall have uniform shape and thickness, free from sharp corners and shall be symmetric design to maintain thermal balance.

Provisions shall be made to take care of the effects of temperature changes on the alignment of the rotating parts relative to the casing and glands and free movement of casing due to expansion both longitudinal and transverse.

Casing shall be horizontally split at the centre line for raising and lowering the upper halves and rotor to clear off remainder of machine.

It shall permit inspection of the main bearings without dismantling the casing.

Horizontal casing joint shall be made steam tight with metal to metal contact. Gasket or grooves shall not be acceptable.

Horizontal joint bolts shall be heat tightened and necessary bolt heating equipment and accessories (if required) shall be provided by the bidder.

Control valve chest shall be an integral part of the drive turbine.

**Rotor**

Rotor shall be of forged steel, heat treated, accurately machined and proportioned in order to keep critical speed away from operating speed.

The rotor shall be dynamically balanced.

Turbine blading shall be designed to have a high efficiency of energy conversion, consistent with low loading, stressing and vibration consideration to ensure high degree of availability.

All nozzles and blading in steam path shall be of corrosion and erosion resisting alloy steel suitable for temperature encountered.

Rotor blading shall be securely fixed and readily renewable type.

Turbine blading shall operate smoothly over the operating speed range. The natural and harmonic frequency of vibration of last few rows of blades shall be such that they are well outside the operating range so as to avoid resonant vibrations.

Stop and control valves

Valves shall be arranged to close through a trip device actuated either by over speed governor or by action of other protective devices.

Stop valves shall be provided with removable stainless steel steam strainer for normal operation, and one extra strainer shall be provided for initial operation.

Valves shall be provided with removable internals to allow for steam blowing.

Valves shall be designed to resist erosion due to steam flow and to be stable and not to vibrate over entire operating range.

Control valves shall be designed to provide the required steam flow control when operating in conjunction with turbine governing system as specified elsewhere.

Control valves and their seats shall have stellite inlays with their stem hardened. Alternatively, nitriding of spindles and guide bushes shall also be acceptable as per standard practice of the manufacturer.

Stop valves shall have provision for on-load testing.

Inlet connections of control and stop valves shall be of flanged type.

Bearings

The bearing shall be designed to avoid oil whip. Bearings shall be spherically seated, horizontally divided type, with provision of adjustment and alignment of rotor, forced feed lubricated type, lined with babbit or suitable anti-friction alloy. The thrust bearing shall be of proven design as per standard practice of the manufacturer.

Bearings shall be arranged outside drive turbine so that these are readily accessible. Lower half of bearing shall be capable of being removed and replaced by minimum lifting of shaft.

Couplings

The disconnect coupling shall automatically disconnect the pumps from the drive turbine so as to permit independent operation of turbine on turning gear. Alternatively, dry type flexible



membrane coupling may also be provided between BFP and drive turbine to facilitate disengagement by dismantling of spacer bolts as per standard practice of the manufacturer.

Other couplings shall be of flexible metal diaphragm type, requiring no oil lubrication from the external source. However, the coupling between gear box and drive turbine may be oil filled flexible type without requiring external oil supply. Closure plates shall be supplied to allow drive turbine to be disconnected for spin testing.

Turning gear

Turbine shall be provided with an adequately sized AC motor driven or hydraulically operated turning gear for rotation of complete TDBFP train i.e. booster pump, gear box, drive turbine and main pump while unit being started or taken out of service.

Turning gear shall be so arranged that drive gear is engaged manually by means of external lever while turbine is at rest. When steam is admitted to the turbine and its speed reaches beyond turning speed, its gear shall automatically disengage and latch in a disengaged position.

Necessary interlock shall be provided to prevent the starting of turning gear motor and shall trip on loss of lube oil pressure and should have provision of starting from the control room.

Hand barring gear shall be provided for manually rotating the drive turbine in an emergency. The lube oil shall be made available to the bearings during such operation.

Lubricating oil system

Each drive turbine shall be provided with a complete lubricating oil system which shall provide lube oil for drive turbine, main pump, booster pump and disconnect coupling and also to cater the control oil of governing system and turning gear oil requirements.

It is preferable to have quality of lube oil and working oil for MDBFP and TDBFP identical to that of main turbine lube oil quality.

Suitably sized hydraulic accumulators shall be provided in governing oil system to maintain system pressure, when there is a change over from one running pump to stand by oil pump. Also provision shall be made for initial air purging of the governor system.

Turbine Exhaust pipe

Turbine exhaust shall be separately piped to the condenser of main TG unit in the downward direction.

Necessary metallic expansion joints, supports, hangers, tie bars and butterfly valve shall be provided.

Blades tuning

Turbine blades, in particular last stage blades shall be independently tuned to keep the blade resonant frequencies away from operating speed.

Protection against water induction

Turbine shall be designed for protection against water induction. All drains shall consist of motorised drain valves with isolating valves and drain piping for connection to drain flash tank i.e. for warming up drains before and after valve seats, casing drains, gland steam system drain, IP extraction, CRH and auxiliary steam lines alongwith necessary controls.

**Protection against erosion and corrosion**

Last stage blading of turbine shall be designed for protection against erosion and corrosion by moisture.

Governing system

Turbines shall be designed for electro-hydraulic or electronic control system to control speed from 0% to 100%. It shall be of the type which provides continuous corrective action until equilibrium conditions are obtained in response to changes in external signals or speed change resulting from other causes, such as changes in energy of the steam available to a turbine during sudden load pick ups or rejection on the main turbine generator unit. The system shall ensure controlled accelerating of the drive turbine and shall prevent over speed without tripping of the equipment under any operating condition or in the event of maximum load rejection.

Sources of steam from TD-BFP

During low unit load conditions, turbine bypass operation, shutdown operation when extraction steam pressure from IP turbine is insufficient to operate the drive turbine, steam from alternate source i.e. cold reheat steam shall be admitted through a separate set of stop and control valves. Both sets of control valves shall be controlled by electro-hydraulic governing system. Bidder can offer single admission turbine with an external control valve (to be operated from the same governing system).

During cold/warm/hot start of boiler, TDBFP can be started with auxiliary steam (in case MDBFP is inoperative) till motive steam from CRH is available.

All other auxiliaries shall be designed for auto start of standby equipment on tripping of running auxiliaries.

5.2.0 Condensate Extraction Pump

Pumps shall be vertical, centrifugal, multistage, cannister type, diffuser type with double suction first stage impeller.

The first stage impeller shall be specifically designed for low NPSH requirement and minimum risk of cavitation.

The shaft coupling shall be of flexible type in case the thrust bearing is provided on the pump and it shall be of rigid type if the thrust bearing is provided on the motor.

The construction shall ensure removal of pump shaft and impeller without disturbing the can.

Casing and rotors are to be provided with wear rings in order to permit easy replacement of the parts subject to wear. The seals are to be provided with sealing water connections. Condensate from the discharge pipe is to be used as sealing water. Pumps and driving motors are to be supplied on a common base plate.

The design and workmanship shall be such that the pumps are readily assembled or dismantled and that they will operate satisfactorily under all operating conditions without cavitation, pitting, excessive vibration, noise or undue wear.

The glands of the pumps and their associated suction valves shall be suitably sealed to avoid ingress of air into the condensate under all conditions. The casing vent shall also be complete with all valves, piping, etc., for each pump.



The installation height of the pumps and the NPSH value of the pumps are to be matched to one another so that there shall be sufficient suction head even under the most extreme operating conditions.

Condensate Extraction Pump Suction Strainers

The strainers shall be generally sized so as to keep the pressure drop across them to a minimum.

These strainers shall be provided with complete back-washing arrangements enabling them to be cleaned quickly and effectively without dismantling the strainer, or the use of tools.

The mesh size of the strainer element shall be chosen as necessary to prevent the risk of damage to the extraction pump from debris and foreign matter. If appropriate the strainer shall be provided with both coarse and fine mesh elements. One complete replacement set of strainer elements shall be provided with turbine unit (i.e one spare element of each mesh size.). High differential pressure switch alarm facility shall be provided for each strainer.

The design requirements of Strainers are:

- The pressure drop of the strainer at design flow and clean condition shall not exceed 0.1 Kg/cm². Pressure drop at design flow and 50% clogged condition shall not exceed 0.15 Kg/cm²
- The clear area of strainer shall be five times the inlet cross sectional area of the connection piping.

6.0.0 INSPECTION AND TESTING

Performance tests are to be conducted to cover the entire range of operation of the pumps. A minimum five combinations of head and capacity are to be achieved during testing to establish the performance curves, including design capacity points and two extremities of the range of operation specified. The tests shall be conducted as per Hydraulic Institute Standard.

Performance tests of Condensate Extraction Pumps should preferably be conducted with actual drive motors.

The Bidder shall submit in his proposal the facilities available at his works to conduct performance testing. If because of limitations on available facilities, a reduced speed test has to be resorted to establish pump performance, the same has to be mentioned in the offer and the applicable performance calculation procedure has to be submitted for approval of Purchaser. The power and the results of the reduced speed test will be extrapolated to the specified conditions as per HIS.

Overall performance test of the Boiler Feed pump shall be conducted in accordance with ASME P.T.C. 8.2 latest edition or equal to obtain following characteristics. Each pump including the spare rotating assembly (as applicable) shall be tested. At least one of the pumps shall be tested with water at actual working temperature. Tests should be carried out for the following:

- a) Total head developed, horse power requirement and efficiency at the rated condition.



- b) NPSH requirement for each rotor at rated speed and temperature, over the entire operating flow range both for 1% and 3% head drop. NPSH testing shall be governed by ASME P.T.C. and Hydraulic Institute Standards.
- c) To establish the pump characteristic curves for head vs. capacity, power vs. capacity, NPSH vs. capacity and efficiency vs. capacity.
- e) Gearbox testing at full load for transmission efficiency and smooth operation. Noise level to be measured.
- f) Hydraulic coupling speed vs. output and efficiency tests.
- g) Vibration at bearings and noise level shall be checked during performance tests.
- h) Tests for drive motors shall be as specified in the Standard specification for A.C. Electric Motors.
- i) Drive turbine shall be tested as per ASME PTC-6 at speed and load conditions corresponding to the guarantee point and at normal steam conditions.

7.0.0 CONTROL AND INSTRUMENTATION

Refer Vol-II, section-4 of Control & Instrumentation Specification.

8.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED ALONG WITH THE PROPOSAL

(A) General

- Completely filled in technical schedules & other schedules for all equipments as enclosed with the Tender specification.
- Flow Diagrams and P&ID (Process and Instrumentation drawings) indicating Instruments and the destination / functionality of the signals Plot plan
- Plot plan and General arrangement drawing with section for major building viz Power house building etc., showing maintenance area
- Quality Assurance and plan
- Master Document List (MDL) for Mechanical, Electrical, Civil and C&I with schedule of submission
- Description of options and alternatives offered
- Complete description of the plant offered including description of the process and the equipment
- General descriptions of individual systems and descriptions of operation including description of start-up, shutdown and emergency shutdown procedures,
- Safety Plan
- Training program and schedule for training of Owner's personnel
- Space requirement for construction site and equipment
- Maintenance proposal
- List of spares
- List of Special tools and Tackles
- Inspection intervals (major/minor) for six years along with the spares to be replaced during the above inspections. Contractor shall provide the cost of such spares on yearly basis.



- Contractor shall enter into a long term spare supply agreement with the OEM, and agree to transfer the same faithfully to the owner upon COD. Contractor shall commit to facilitate further negotiations on the spares with the OEMs directly by the owner.

(B) Mechanical

- Installation references where 660 MW Supercritical units with proposed main steam and reheat steam parameters are in operation.
- Experience list for supply and installation plants of similar capacity supercritical Units and performance certificate of the plants indicating the availability and plant load factor from the date of COD.
- Condensate Extraction Pumps, Boiler Feed Pumps & Boiler Feed Pump Drive Turbine Manufacturer's experience list for the offered Capacity
- Deed of Joint Undertaking shall be executed by Contractor with following manufacturers
 - Condensate Extraction Pumps
 - Boiler Feed Pumps & Boiler Feed Pump Drive Turbine

The above shall be submitted clearly indicating the validity of the agreement and role and responsibilities among them

- Details of Technical Collaboration of the Condensate Extraction Pumps, Boiler Feed Pumps & Boiler Feed Pump Drive Turbine manufacturers with technology Supplier and role of the technology supplier for this project.

8.1.0 Drawings & Documents to be submitted after Award of Contract

The documents required for design, construction, installation, operation and maintenance of the entire plant shall be submitted by the Contractor in good time so as to permit the plant as a whole to be constructed in compliance with the specified time table.

Only the most important documents are listed below. The list and approval category of the doc/drawings shall be agreed sufficiently in advance before award of relevant order, so that corrections and amendments desired by the Owner as well as resubmission of the documents will not result in any delays with respect to the guaranteed time table. The Owner reserves the right to request from the Contractor additional drawings, documents, etc. as may be required for proper understanding and definition of the design and engineering of the Plant.

(A) General

- Re-Submission of all the technical data furnished during pre award contract stage.
- Complete filled-in technical schedule.- For approval
- Plot plan - For approval
- General arrangement drawings /Equipment layout of all equipments along with sections indicating the unloading & maintenance area. - For approval
- Design basis for all the systems and major equipment sizing calculation - For approval
- P&ID (Process and Instrumentation drawings) indicating Instruments and the interlocks for all the systems - For approval
- Monthly progress report
- L2 network
- Quality plan for approval
- Prequalification document for different Vendors for Owner's approval.



- Equipment Testing procedure for approval
- Complete list of documents with proposed submission schedule
- Vendor Engineering document viz Data sheets, General arrangement drawing, material of construction, performance curves for approval for major items
- Painting & surface preparation procedure
- Technical specification

B) Mechanical

- Major equipment sizing calculation viz Condensate Extraction Pumps, Boiler Feed Pumps & Boiler Feed Pump Drive Turbine for approval.
- Start-up and shut down procedure for approval
- System description for all the systems for approval
- Thermal calculation for critical items for approval
- Pipe sizing and determination of pressure & Temperature criteria. for approval
- Critical piping drg and calculation
- Acceptance and Performance test procedure and program
- Performance calculation write up.

Any other drawing or document which are not covered above but required to the effective commissioning of the project.



ANNEX 2.5.1

SPECIFIED DESIGN DATA

Description	Unit	Data
CONDENSATE EXTRACTION PUMPS		
Design Code	-	HIS (Latest)
Type		Vertical, centrifugal, multistage, canister type
Number of pumps	Nos	3 x 50% capacity for each unit
Synchronous Speed	RPM	1500
Material of construction		
Bowl	-	Cast Iron
Impeller for 1 st stage	-	Stainless steel(12% Cr)
Stage Impeller	-	Bronze or chromium steel
Shaft	-	Stainless steel
Can	-	Fabricated mild steel
Frequency Variation	Hz	47.5 to 51.5
BOILER FEED PUMPS		
Design Code		HIS (Latest)
Number of feed water pumps for each unit	Nos	2 X 50 % turbine driven main boiler feed pumps (TDBFP) and 1 X 50% capacity electric motor driven standby boiler feed pump (MDBFP)
Type of pump	-	Horizontal Centrifugal multistage barrel type pump.
Control of motor driven feed pumps	-	Variable speed hydraulic coupling.
Frequency Variation	Hz	47.5 to 51.5
Material Of Construction		
Barrel		Forged carbon steel with austenitic stainless steel inlay in high velocity zones and sealing surface
Shaft	-	13% chromium steel forging
Impeller, inner casing, stage pieces	-	13% chromium steel casting
Wearing ring	-	13% chromium steel properties with antigalling properties
Balancing drum bush	-	13% chromium steel properties with antigalling properties
Balancing Drum	-	Stainless steel
Shaft Sleeves	-	High alloy chromium or chromium nickel alloy steel
Radial Bearings	-	Sleeve type
Thrust Bearings	-	Tilting pad, double acting, 100% thrust bearing(suitable material)
Booster pumps		
Design Code	-	HIS (latest)
Material of Construction		
Shaft, shaft sleeves and wearing rings	-	13% chromium steel forging
Casing	-	Cast Steel



Description	Unit	Data
Booster pump & CEP suction strainer		
Type	-	Basket type
Strainer Insert Material	-	Stainless Steel
Clear area of strainer (Flow opening area)	-	Five times the inlet cross sectional area of the connecting pipe
Maximum allowable pressure drop at clean condition and design flow	Kg/cm ²	0.1
Maximum allowable pressure drop at 50% clogged condition and design flow	Kg/cm ²	0.15
BFP suction strainer		
Type	-	Conical strainer
Strainer Insert Material	-	Stainless Steel
Clear area of strainer (Flow opening area)	-	Five times the inlet cross sectional area of the connecting pipe
Maximum allowable pressure drop at clean condition and design flow	Kg/cm ²	0.1
Maximum allowable pressure drop at 50% clogged condition and design flow	Kg/cm ²	0.15
Boiler Feed Pump Drive Turbine		Drive Turbine shall be sized for pump run out condition with minimum expected turbine inlet and maximum expected turbine exhaust steam parameters



VOLUME II
SUB-SECTION - 2.6
CONDENSATE SYSTEM

1.0.0 GENERAL

This section covers minimum requirements for design, engineering, manufacture & assembly, inspection, erection, testing and commissioning of condensate system.

This section of the specification shall be read in conjunction with other sections of the specification as appropriate and the equipment offered shall meet the requirements as spelt out therein.

2.0.0 CODES AND STANDARDS

The condensate system as specified here shall be designed and constructed in accordance with the requirements of Applicable Standards and Codes specified below and in General Technical Specification.

The equipment to be provided shall specifically conform to the latest editions of the following codes, standards, specifications and regulations:

ASME (B&PV)	:	ASME Boiler & pressure vessel code
IBR	:	Indian Boiler Regulations.
HEI	:	Heat Exchange Institute
HIS	:	Hydraulic Institute Standard
ANSI B 73.1	:	Horizontal Centrifugal pump end suction pump
ASTM	:	American Society of Testing and Material.
PTC -8.2	:	Performance Test Code of centrifugal pump.

3.0.0 SCOPE OF SUPPLY

The scope of supply shall include the flash tanks, drain transfer system, normal and emergency make-up system, condensate storage tank with all components and complete accessories and auxiliaries and shall include, but not be limited to the following (for each unit unless otherwise indicated).

3.1.0 Condensate system

Complete condensate piping from condenser hot well outlet to deaerator including following facility.

- Minimum recirculation facility with 2 x 100% recirculation control valves with isolation valves upstream and downstream. The minimum recirculation flow shall correspond to maximum of gland steam condenser minimum recirculation flow and CEP minimum recirculation flow.
- Excess dump facility with control valves, bypass arrangement and isolation valves
- Spray water system piping for various system as required and as specified elsewhere in the specification with control valves and bypass arrangements



- Condensate piping for LP heater along with individual heaters bypass piping arrangement as required and as specified.
- Flow element at gland steam condenser outlet.
- Flow element at deaerator inlet.
- Spool piece for performance flow measurement at deaerator inlet.
- All fittings and mountings.
- Complete instrumentation.
- Specialties as required.

3.2.0 Drain Transfer system

- HP/LP/Atmospheric flash tank and accessories including manhole, reinforcement, vent, drain piping, manifolds along with control valves and instrumentation.
- HP/LP flash tank vent piping to condenser including expansion joint.

3.3.0 DM water make up system

- Condensate storage tank along with necessary piping, fitting, valves, specialties and instrumentation for each unit. Tank shall be provided with excess dump facility from condenser.
- 2 x 100% cycle make-up pumps with auxiliaries and accessories.
- 2 x 100% steam generator initial fill pumps (i.e. each pump shall have capacity of filling the steam generator in 2 hour maximum) for each unit along with complete piping, fitting, valves, instrumentation and supports.
- Pumps shall be provided with minimum flow facility.
- Each pump shall be provided with suction strainer of adequate mesh size.

3.4.0 Piping, Valves, Fittings Supports etc.

The complete piping system as required along with valves, control valves, actuators, fittings and supports, insulation and cladding etc.,

4.0.0 DESIGN REQUIREMENTS

4.1.0 Flash Vessel

The flash tanks shall be adequately sized to take care of the total drains in the complete power cycle piping system. There shall be sufficient margin to accommodate the possible variation in drain quantities as well as flash steam. Flash tanks shall be designed as per the requirement of ASME boiler and pressure vessels (B&PV) codes, and ANSI standard.

The flash tank shall be adequately sized to take care of the following drains:

- a) Main steam, CRH and HRH line drains
- b) Main steam stop and control valves
- c) Reheat stop valves and interceptor valves
- d) Steam lead and all turbine drains including turbine casing drains and feed water heating system drains.
- e) HP & LP bypass valves and warming up line
- f) Turbine extraction steam piping system
- g) BFP turbine exhaust system.
- h) Any other drain from boiler drain tank as applicable.

There shall be sufficient margin to accommodate the possible variation in drain quantities as well as flash steam. The drains shall be provided for every low point with automatic disposal of collected condensate. The drains shall be connected to the flash tanks via headers.



The vents of the HP/LP turbine flash tanks shall be recovered by connecting it to condenser. Necessary metallic expansion joint shall be provided in the flash tank vent line.

Atmospheric flash tank vent shall be discharged to atmosphere. Atmospheric flash tank drain shall be discharged to near by trench after quenching.

The vents of atmospheric flash tank shall be open to atmosphere and drains of this tank shall be connected to the plant drain/ channel/pit.

Corrosion allowance of 3 mm shall be added to the design thickness of the shell and head of the vessels. The minimum thickness of the vessels including corrosion allowance shall not be less than 8 mm.

The minimum design pressure and minimum design temperature for the pressure vessels (except bellows) to be designed shall be 3.5 kg/cm^2 and 215°C respectively. Flash tanks shall also be designed for full vacuum condition.

The temperature in the flash tanks shall be maintained by using condensate spray or service water spray (for flash tanks open to atmosphere). The spray shall be automatically controlled. However, for flash tanks open to atmosphere continuous spray through an orifice shall also be acceptable.

In case the spray is in the manifold, the material for the flash tank manifolds shall conform to ASTM A335 Gr. P22 or better and its thickness shall not be less than Schedule 100 of ANSI B36.10 irrespective of temperature of the fluid handled.

4.2.0 Condensate Storage tank

The design code of the tank shall be ASME B&PV Sec VIII, Div-1. The capacity of Condensate Storage tank shall be boiler fill water volume or 24 hours storage of cycle make up, subject to a minimum effective storage of 600 m^3 .

The demineralised water for hotwell make-up system, steam generator initial fill, dosing system make-up, DM cooling water system make-up shall be supplied from the condensate storage tank. Excess condensate shall be dumped out of turbine cycle by excess condensate dump system to the condensate storage tank.

4.3.0 Cycle make up system

Rated flow of hot well make up pumps shall be sized considering a flow of 10% of VWO steam flow with 1.5% make-up condition. In addition a 10% of design margin and 20% for pump minimum flow margin or pump continuous minimum recirculation flow whichever is higher shall have to be considered on the above rated flow. The system shall have a normal make-up control valve to be sized for 1.5% of steam flow rate at valve wide open (VWO) with 1.5% make-up condition and an emergency make-up control valve to be sized for hot well make pump rated flow condition.

The pump motor rating shall not be less than the larger of the following :

- (a) Sufficient to drive the pump through the entire range of run-out flow to shut-off conditions.
- (b) 115% of pump design point rating.

Pump-motor set shall run smooth without undue noise and vibration. Acceptable peak to peak vibration limits shall generally be guided by HIS.



5.0.0 CONSTRUCTIONAL REQUIREMENTS

The installation and dismantling of the various parts of the equipment must be possible without great difficulty and appropriate design features must be incorporated for this purpose.

All parts must be capable of accepting the loads occurring due to rapid load and temperature variation and also those occurring due to start-up, shut-down and continuous base load operation without limitation and without affecting the planned life.

5.1.0 Flash tank

Flash tanks shall be vertical, cylindrical design and of welded construction with torispherical or hemispherical heads.

Drain/hot water inlet nozzles shall be tangential/ radial to the vessel periphery. Suitable vortex breaker arrangement shall be made at the liquid outlet to the vessel. In case the contractor finds better alternate arrangement, the same can be submitted for the purchaser's acceptance and approval.

The flash tanks shall be located on the ground floor of the power house. Necessary structural supports including anchor bolts shall be provided. Three support legs at 120 degree spacing shall be provided on each flash tank. Necessary lifting lugs for handling by the main plant building EOT crane shall be provided.

The flash tanks shall be provided with a full length level indicating gauge glass complete with protective rods, isolation valves and drains. Temperature indicators and temperature switches shall be provided on the flash tanks.

The flash tank and manifolds shall be designed to take care of the impact forces due to incoming drains.

A man hole shall be provided on the flash tank for inspection purpose. It shall be of min 500 mm diameter. The flash tank shall be provided with access ladders.

In place of ASTM 285 Gr. C material (refer specified design data), the Contractor may also offer ASTM 516 Gr 60 or IS 2062 Gr B materials provided the relevant code/standard permits use of these materials for the intended design parameters.

5.2.0 Cycle make-up pump and Steam generator initial fill pump

Pumps shall be identical in construction and similar parts of the pumps shall be interchangeable.

Casing shall be provided with a drain & vent connection comprising of an isolation valve and blind flange (with fasteners and gaskets) terminated at the edge of the base plate. The minimum size of any connection or piping shall be 1/2 inch nominal pipe size.

Each pump and its components shall be designed to facilitate installation and removal. Components requiring periodic inspections or maintenance shall be easily accessible.

Suction and discharge nozzles shall be flanged and shall conform to ASME standard.

Shaft sealing shall be by mechanical seal.

Sound power level shall not exceed 85 dBA at one (1) meter from the equipment.

The casing shall be designed to withstand the maximum shut-off pressure or 150% of maximum pressure under which the pump can operate at design fluid temperature, whichever is higher. Each pump shall preferably be of such construction that it is possible to service the



internals of the pump without disturbing suction and discharge piping connections. Casings shall be of such thickness as well be suitable for maximum discharge and hydrostatic testing pressure and pumping temperature, with a 3 mm minimum corrosion allowance.

Impeller shall be of shrouded type. Impeller shall be of single piece casting (fabricated impellers not acceptable), smooth finished and dynamically balanced along with shaft on proper balancing equipment so as not to cause any vibration.

Replaceable type wearing rings shall be furnished to prevent damage to impeller and casing. A suitable method of locking the wearing ring shall be used, such as by the use of grub screws. Wearing rings shall have a close tolerance fit to permit only a minimum of recirculation flow. Impeller wearing rings shall have surfaces harder than surfaces of opposed casing wearings or shall be made of non-galling material to suit the pump medium.

Bearings shall be of antifriction grease/oil lubricated heavy duty ball or roller bearings capable of carrying heavy loads in either direction of rotation for continuous operation. The bearing shall be designed for a minimum life of 40,000 hrs in continuous operation at rated pump conditions. Hydrodynamics radial and/or thrust bearings shall be provided if required. Bearing housings shall preferably be arranged so that bearings can be replaced without disturbing pump drives or mountings. The housing shall be effectively protected against the ingress of water, pumped fluid and dust. When oil lubrication is provided all bearing oil wells shall be fitted with visual oil level indicators. Non-pressure oil lubricated bearings shall be equipped with constant level oilers. Means of draining bearing housings shall be provided.

Proper lubricating may be by oil/ grease. In case of Oil lubricated bearings, the type shall be of the ring oil/Flooded type, incorporating an ample oil reservoir and fitted with an oil level sight glass/indicator and thermometer. Free access to all lubrication ports shall be incorporated in the pump design. Means of draining bearing housings shall be provided.

6.0.0 INSTRUMENTATION AND CONTROL

Refer Volume II, Section 4 for Control & Instrumentation Specification.

7.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED ALONG WITH THE PROPOSAL

(A) General

- Completely filled in technical schedules & other schedules for all equipments as enclosed with the Tender specification.
- Flow Diagrams and P&ID (Process and Instrumentation drawings) indicating Instruments and the destination / functionality of the signals Plot plan
- Quality Assurance and plan
- Master Document List (MDL) for Mechanical, Electrical, Civil and C&I with schedule of submission
- Description of options and alternatives offered
- Complete description of the plant offered including description of the process and the equipment
- General descriptions of individual systems and descriptions of operation including description of start-up, shutdown and emergency shutdown procedures,
- Safety Plan
- Training program and schedule for training of Owner's personnel
- Space requirement for construction site and equipment
- Maintenance proposal



- List of spares
- List of Special tools and Tackles
- Inspection intervals (major/minor) for six years along with the spares to be replaced during the above inspections. Contractor shall provide the cost of such spares on yearly basis.
- Contractor shall enter into a long term spare supply agreement with the OEM, and agree to transfer the same faithfully to the owner upon COD. Contractor shall commit to facilitate further negotiations on the spares with the OEMs directly by the owner.

(B) Mechanical

- Installation references where 660 MW Supercritical units with proposed main steam and reheat steam parameters are in operation.
- Experience list for supply and installation plants of similar capacity supercritical Units and performance certificate of the plants indicating the availability and plant load factor from the date of COD.
- Cycle make-up pump, fill pump and Flash Tank Manufacturer's experience list for the offered Capacity
- Deed of Joint Undertaking shall be executed by Contractor with following manufacturers
 - Cycle make-up pump and fill pump
 - Flash Tank

The above shall be submitted clearly indicating the validity of the agreement and role and responsibilities among them

- Details of Technical Collaboration of the Cycle make-up pump, fill pump and Flash Tank manufacturers with technology Supplier and role of the technology supplier for this project.

8.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED AFTER AWARD OF CONTRACT

The documents required for design, construction, installation, operation and maintenance of the entire plant shall be submitted by the Contractor in good time so as to permit the plant as a whole to be constructed in compliance with the specified time table.

Only the most important documents are listed below. The list and approval category of the doc/drawings shall be agreed sufficiently in advance before award of relevant order, so that corrections and amendments desired by the Owner as well as resubmission of the documents will not result in any delays with respect to the guaranteed time table. The Owner reserves the right to request from the Contractor additional drawings, documents, etc. as may be required for proper understanding and definition of the design and engineering of the Plant.

(A) General

- Re-Submission of all the technical data furnished during pre award contract stage.
- Complete filled-in technical schedule.- For approval
- Plot plan - For approval
- General arrangement drawings /Equipment layout of all equipments along with sections indicating the unloading & maintenance area. - For approval
- Design basis for all the systems and major equipment sizing calculation - For approval



- P&ID (Process and Instrumentation drawings) indicating Instruments and the interlocks for all the systems - For approval
- Monthly progress report
- L2 network
- Quality plan for approval
- Prequalification document for different Vendors for Owner's approval.
- Equipment Testing procedure for approval
- Complete list of documents with proposed submission schedule
- Vendor Engineering document viz Data sheets, General arrangement drawing, material of construction, performance curves for approval for major items
- Painting & surface preparation procedure
- Technical specification

B) Mechanical

- Major equipment sizing calculation viz Cycle make-up pump, fill pump and Flash Tank for approval.
- Start-up and shut down procedure for approval
- System description for all the systems for approval
- Pipe sizing and determination of pressure & Temperature criteria. for approval
- Acceptance and Performance test procedure and program
- Performance calculation write up.

Any other drawing or document which are not covered above but required to the effective commissioning of the project.



ANNEX 2.6.1

SPECIFIED DESIGN DATA

Description	Data
A) Cycle make-up pump and fill pump	
Design Code	HIS / ANSI B73.1
Type	Horizontal centrifugal pump
Impeller	Closed
Drive transmission	Direct
Seal	Mechanical seal
Lubrication	Oil / Grease /Self-liquid
Coupling	Spacer type
Accessories	Drain plug, vent, priming connection, Coupling guard, lifting lugs etc
Material of Construction	
Casing	CF8M/SS316
Impeller	Stainless steel
Shaft	316 L / AISI 410
B) Flash Tank	
Design Code	ASME SEC VIII
Shell and Head	ASTM 285 Gr.C
Wear Plate/baffle	ASTM 285 Gr.C
Nozzle Neck	ASTM 106 Gr.B
Manhole Nozzle flange and cover	ASTM 285 Gr.C
Coupling	ASTM A105
Bolts and studs	ASTM a193 Gr. B7
Nuts	ASTM a193 Gr. 2H
Gaskets	Spiral wound SS 316 with graphite



VOLUME II
SUB-SECTION - 2.7
CONDENSATE POLISHING UNIT & CHEMICAL FEED SYSTEM

1.0.0 GENERAL

This section covers minimum requirements for design, engineering, manufacture & assembly, inspection, erection, testing and commissioning of Condensate Polishing unit.

This section of the specification shall be read in conjunction with other sections of the specification as appropriate and the equipment offered shall meet the requirements as spelt out therein.

Bidder shall supply complete system including common regeneration facility as per his standard design and as elaborated in these specifications for treating the condensate.

2.0.0 CODES AND STANDARDS

The condensate polishing unit shall be designed and constructed in accordance with the requirements of Applicable Standards and Codes specified in General Technical Specification and elsewhere in the specification.

3.0.0 SCOPE OF SUPPLY

The scope of supply shall include the following with all components and complete accessories and auxiliaries, but not be limited to the following (for each unit unless indicated otherwise).

3.1.0 Condensate Polishing Unit

3.1.1 Service Vessels

3x50% capacity service vessels for each unit.

Service vessels shall be complete with condensate inlet and outlet connections, connections for resin transfer to and from the vessels, bed support-cum-underdrain system, inlet water distributors, air distribution arrangement for resin mixing, all fittings and appurtenances etc. as specified and as required.

External resin traps shall be provided at the outlet of each service vessel, designed for in-place manual back washing.

All necessary piping, valves and fittings with actuators necessary for their remote operation.

Common drain header for service vessels of each unit.

All necessary drains, vents and sampling points, with valves shall be provided as required.

3.1.2 Resin Trap

Outlet of each condensate polishing vessel and waste effluent header of common regeneration system shall be provided with a resin trap whereas at the outlet of Activated carbon filter a media trap shall be provided.



3.1.3 Emergency bypass system

Each condensate polisher service unit shall be provided with an automatic bypass for the condensate polisher on the condensate inlet and outlet headers of the unit with a butterfly type control valve and wafer type butterfly isolation valves on the upstream and down stream sides of the control valve.

Complete instrumentation and controls for this system, including the differential pressure transmitters, panel mounted indicating type controller with provision for remote manual operation, actuator for the control valve with position indicator etc.

Bidder shall design, supply and erect the piping between the service units and the common external regeneration facility, for transferring the exhausted and regenerated resins as required. Routing of this pipe line shall be developed by the bidder in line with his standard practice and shall be finalised in coordination with the Purchaser.

3.1.4 External Regeneration Facility

One (1) common facility for regeneration of the ion-exchange resins from the condensate polishers of two units shall be provided. The system shall include but not limited to the following:

Regeneration system

Two nos. resin separation/ regeneration vessels, one no. mixed resin vessel and one no. mixed resin storage vessel (to hold charge of one service vessel) shall be provided alongwith all internals, fittings and appurtenances for these vessels.

Resin injection hopper, complete with a water ejector system shall be provided for resin make-up to the resin separation/ regeneration vessel. The system shall be sized to handle upto 150 liters of as received new resins per single injection.

All necessary piping, valves and fittings with the actuators necessary for their remote automatic operation shall be provided. These shall include all drains, vents and sampling points with valves as required.

Common waste effluent header with one resin trap designed for in-place manual backwashing shall be provided.

2x100% capacity CPU regeneration water pumps shall be provided for water supply for chemical preparation/dosing and transfer of resin from service vessel to regenerating vessels and vice versa. The pumps shall be horizontal centrifugal type and conform to IS: 1520/IS: 5120 or equivalent without any negative tolerance. All wetted parts of the pump shall be of CF-8M.

Chemical dosing system

Complete facility for dosing of acid, alkali and ammonia (if applicable) shall be provided as per details given below:

2x100% capacity hydraulically operated ejectors or metering pumps shall be provided each for dosing of acid and alkali. Material of construction shall be suitable for liquid being handled.

Acid ejectors shall take suction from 2x100% acid measuring tanks and alkali ejectors from 2x100% alkali day tanks. Alkali day tanks shall be complete with carbon dioxide absorber and overflow seal. The capacity of tanks shall be atleast 20% higher than that required from process calculations.



For heating of alkali diluent water, 2x50% electrical heating coil in a MSRL tank shall be provided. The capacity of tank shall be minimum 20% higher than the maximum water demand. This tank shall be provided with burn out protection, pressure relief valve, level switches, temperature indicator etc. The heater shall be controlled by the temperature switches provided on the tank. The heaters shall be sized for heating the water from a temperature of 15 to 50 deg.C at the outlet of ejector. The water shall be heated to the required temperature within 5 hours.

All interconnecting piping, valves and fittings as required for the system.

Complete system for off-stream ammoniation of the resins, using ammonium hydroxide, shall be included in the offer, if felt necessary by the bidder to meet the system requirements. The system, if offered, shall include two (2) nos. bulk ammonia storage tanks (total one month storage), two (2) nos. motor-driven feed and recirculation pumps (each with 100% capacity), regenerant dilution tank, instrumentation and controls and all other appurtenances mounted on a separate structural steel skid.

Alkali solution preparation facility

Complete facility for preparing alkali solution from alkali flakes shall be provided as per details given below:

One (1) no. alkali preparation tank complete with electrically driven stirrer, and dissolving basket shall be provided. The tank capacity shall be equal to 120% of regeneration requirement of one polisher vessel.

2x100% capacity horizontal centrifugal type alkali solution transfer-cum-recirculation pumps shall be provided to fill the alkali day tank in one hour.

One (1) no. activated carbon filter shall be provided for alkali preparation. The rated flow of the filter shall not be less than the design capacity of the alkali transfer-cum recirculation pump, and the maximum velocity through the filter shall not exceed 12 m/hr. Depth of the filter material shall not be less than 1 m.

The prepared alkali shall be stored in two (2) no. alkali day tanks.

Facility of bulk storage tanks to hold 48% alkali lye shall also be provided and alkali dosing system shall be designed for this also.

All interconnecting piping, valves and fittings as required for the system.

Materials

All the equipment viz. tanks, valves, piping, resin trap etc handling acid, alkali, DM water etc. shall be of MSRL construction, Valves for handling acid, alkali, ammonia, etc shall be preferably of diaphragm type (MSRL).

Air blowers

2x100% capacity air blowers (1W+1S) shall be provided for subsequent mixing of the resins.

Further 2x100% capacity air blowers shall also be supplied for mixing the resins in the service vessels.

Each blower shall be complete with motor, V-belt drive with belt guard, inlet filter/silencer, flexible couplings and discharge snubber, all mounted on a single base.



Relief valve (s) shall be provided as required.

Bulk acid and alkali storage tanks

These tanks shall be horizontal, dished ends, cylindrical type as per BS-2594 or equivalent and shall be located outdoor near the regeneration plant. These tanks shall be made of FRP as per relevant codes. Vessels should be complete with vent, overflow, sample connection, manhole, stair case, platform, level indicator, fume absorber, CO₂ absorber, overflow seal pit etc. Specification of tank and pump shall be as below:

- Acid storage tanks : 2 Nos., 20 MT each.
- Alkali storage tanks : 2 Nos., 20 MT each.
- Acid unloading pump : 2x100%, 10 m³/h each (PP Casing/Impeller with EN-9 shaft)
- Alkali unloading pumps : 2x100%, 10 m³/h each (SS-316 construction)

Required number of hoses shall be provided to receive acid from road tankers.

DM water for regeneration

DM water required shall be drawn from DM water storage tanks by 2 x100% capacity CPU regeneration pumps taking suction from the DM water storage tank.

Effluent disposal system

Neutralizing pit shall be in two (2) sections of RCC construction and each section shall have a holding capacity of 1.5 times the waste effluent from each regeneration. Two nos. (1W+1S) Neutralized Waste Recirculation / Disposal pumps of horizontal centrifugal type with priming arrangement shall be supplied for waste recirculation and disposal to the Purchaser's central monitoring basin. Provision of dosing acid and alkali shall be provided to neutralise effluents before disposal. All piping, valves etc. shall be in bidder's scope.

3.2.0 Chemical Feed System

Ammonia and Hydrazine dosing system

Each unit shall be provided with independent and skid mounted dosing system for Ammonia and Hydrazine dosing.

Each chemical dosing skid shall consist of

1x100% capacity measuring tank,

2x100% capacity preparation/ storage tanks and

2x100% metering pumps per dosing system (Condensate system, deaerator system) per unit complete with strainers, piping, valves, fittings, instrumentation and control panel etc. Each system shall have multiple dosing points with double isolation valves.

In addition, bulk storage tank will be common for both units for storage of concentrated aqueous ammonia as per the available market standards subject to approval of Owner. 2x100% capacity transfer pumps shall be provided for transfer of concentrated ammonia from bulk storage to the measuring tank. The ammonia transfer pumps shall be of centrifugal type.

Hydrazine shall be received in small containers and hand pumps shall be provided for transfer of hydrazine to the measuring tank. The flow of chemical from measuring tank to the preparation/ storage tank shall be by gravity.



Oxygen Feed System

Oxygen cylinders skid with adequate number of oxygen filled cylinders.

Two (2) sets of oxygen decompression facility and regulating station including control valve shall be provided in each oxygen injecting skid for each unit.

Flow measurement device

Complete piping, fittings, valves and necessary instrumentation.

100% redundancy oxygen cylinders, decompression station and regulating station shall be provided for each unit.

3.3.0 Piping, Valves, Fittings Supports etc.

The complete piping system as required along with valves, actuators, controls, grating control valves, fittings and supports, insulation and cladding etc.

4.0.0 DESIGN REQUIREMENTS

4.1.0 Condensate Polishing Unit (CPU)

There shall be 3x50% capacity service vessels per unit designed as per condensate flow corresponding to maximum TG output at 1.0% make up, design condenser pressure and all HP heaters out of service.

The quality of influent (condensate at inlet of CPU), effluent (condensate at outlet of CPU) and service run length to be considered for design of the CPU shall be as below:

Normal conditions:

During normal conditions, the quality of influent and effluent shall be considered as below:

Description	Influent	Effluent
Sodium, ppb	10	2
Iron, ppb	50	5
Silica, ppb	30	5
Chloride, ppb	10	2
Ammonia, ppb	100	-
TDS (total dissolved solids), ppb (excluding ammonia)	100	20
pH	8 – 9.3	-
Conductivity, μ mhos/cm	-	≤ 0.1 at 25°C
Suspended solids (crud), ppb	50	5

Under the above operating conditions and design flow through the polisher units, the service run of the vessels shall be minimum 15 days (360 hrs). The mode of CPU operation during this period shall be either in hydrogen cycle or a combination of hydrogen and ammonia cycle which shall be decided by the bidder while maintaining the above effluent quality.

Bidder shall declare in his bid the number of days of operation in hydrogen cycle and ammonia cycle (if opted by the bidder) separately in a cycle of 15 days. Whenever specific conductivity starts increasing in the effluent, it shall be deemed that the ammonia cycle has commenced.

**Start up conditions**

During unit start- up conditions, the quality of influent shall be considered as below:

TDS, ppb	2000
Silica, ppb	150
Sodium, ppb	50

Crud (mostly black oxide of iron), ppb 1000

For design purposes, average crud loading shall be considered as 500 ppb.

For the above influent parameters under start up condition, total crud content of the effluent shall not exceed 150 ppb and Silica and sodium shall not exceed 20 ppb.

The useful service run between two regenerations under start- up conditions shall not be less than 50 hours.

The bed cross section shall be such that the average velocity of condensate through it shall not exceed 2 meters/min at the design flow rate. The effective depth of the mixed resin bed in the condensate polisher service vessels shall not be less than 1100 mm.

Maximum pressure drop under dirty conditions will be restricted to about 3.5 kg/cm² including the pressure drop across effluent resin traps.

Cation resins shall be regenerated by technical grade hydrochloric acid to IS:265 (concentration 30-33% by volume) and anion resins by sodium hydroxide, rayon grade to IS:252 available as 48% lye or as flakes.

The regeneration process offered by the bidder shall be of proven design and shall give resin separation compatible with the desired effluent quality. The bidder shall include inert resin in the system if he feels that it helps in better resin separation.

Bidder shall submit sizing calculations for resin volume provided and capacities of various regeneration equipment and neutralizing pit during detailed engineering.

Design pressure of service vessels shall be equal to shut off pressure of condensate extractions pump

Design temperature of the vessel shall take care of all operating regimes including HP-LP bypass operation.

All pressure vessels shall be designed and constructed in strict accordance with the ASME code Section- VIII or acceptable equivalent international standard. Suitable mill tolerances shall be considered for determining the thickness of the shells and dished ends. A minimum thinning allowance of 2 mm shall be considered for the dished ends.

4.2.0 External Regeneration Facility**Alkali solution preparation facility**

The tank capacity shall be equal to 120% of regeneration requirement of one polisher vessel.

The rated flow of the filter shall not be less than the design capacity of the alkali transfer-cum recirculation pump, and the maximum velocity through the filter shall not exceed 12 m/hr. Depth of the filter material shall not be less than 1 m.



4.3.0 Chemical Feed System

Ammonia and hydrazine feeding

Arrangements shall be made to inject Ammonia and Hydrazine in the feed water suction lines to the boiler feed pumps as well as at the condensate pumps discharge after the condensate polishing unit. Ammonia shall be used as pH control agent and hydrazine as oxygen scavenger. The concentration of aqueous ammonia to be dosed shall be around 3% and that of hydrazine around 0.6%.

The bulk storage tank for ammonia shall be sized to hold one month requirement of aqueous ammonia. The measuring and preparation/storage tanks for each chemical shall be designed to have storage capacity equal to one day requirement of chemical dosing.

The capacity of solution preparation and solution metering tank shall be based on 24 hours dosing of ammonia plus 20% margin. Ammonia Dosing pumps shall be provided with 25% margin above the design capacity. The transfer of solution from preparation tank to metering tank shall be by gravity.

Oxygen Feed system

Oxygen feed system shall be designed generally as per the guidelines of EPRI.

Oxygen after reducing pressure will be injected into condensate polisher outlet and deaerator water tank's downstream, and the dissolved oxygen in feed water will be controlled in a range of 30-150µg/l at economizer inlet.

Oxygen dosage to condensate will be controlled by condensate flow, while the dosage to feedwater will be controlled by feed water flow.

Oxygen feed system shall be controlled through Distributed Control Station (DCS) and also be capable on Local Control Panel (LCP).

5.0.0 CONSTRUCTION REQUIREMENTS

5.1.0 Service Vessels

All service vessels and regeneration area pressure vessels shall be fabricated from carbon steel plates to SA 285C or SA-516 Gr. 70 or equivalent and lined internally. Conical or flat end service vessels shall not be accepted.

Lining used may be soft rubber having a shore durometer reading of 40-70 on the A scale, or semihard rubber having a durometer reading of 45-70 on the D scale. The lining shall be applied in three layers, resulting in a total thickness of not less than 4.5 mm anywhere on the internal surfaces of the vessels.

Inlet water and regenerant distributor of service vessels shall be of hub and diffuser splash plate or header and perforated laterals. Material of construction shall be SS-316 except for acid service which will be of haste alloy-B.

Under drains shall be provided with screened laterals with internal perforated pipes and rubber lined flat bottom. For resin separation/ regeneration/ mixed resin vessels, it may have fully screened bottom (NEVA – clog type with pora septanurese screen, fully supported by subway grid or equal).

All internal fasteners shall be of SS-316 and heavy duty locknuts shall be used throughout.



5.2.0 Exchange resins

Cation-anion resin ratio shall be 1.5 parts cation to 1.0 part anion by volume. In case the bidder's process require any non ionic resin the same shall represent at least 10 percent of the bed volume, but not less than 15 cm of the bed depth in the resin separation/cation regeneration tank of the external regeneration facility.

The bidder shall include with the plant adequate resins for the condensate polisher service vessels along with one (1) spare charge of resin in the mixed resin storage tank. In addition a separate charge of resin shall also be included for using the resins during commissioning of unit.

The resins shall be in the form of spherical beads. The particle sizes and densities shall be carefully selected to facilitate clear separation between the resins during regeneration process.

The average force required to fracture the individual bead of cation resin in hydrogen form, anion resin in hydroxide form and Inert resin shall exceed 350 grams. Not more than 5 percent of the beads tested in each batch shall get fractured by forces less than 200 grams.

Base of the ion-exchange resins shall be copolymer of styrene and divinylbenzene forming a macroporous or macroreticular structure. The type of resins to be supplied shall as below:

Cation	: Strong acid, with sulfonic acid functional group
Anion	: Strong base, with quaternary ammonium (type- I) functional group
Inert	: Non ionic, compatible with the above type resins

The resins shall be of reputed manufacturer with adequate past record of successful service for not less than 3 years in similar application.

5.3.0 Vessel freeboard requirements

The pressure vessels in the common external regeneration facility shall be provided with adequate freeboards over the top of the settled resins, to minimize resin loss during their use. Minimum permissible freeboards are as follows:

- Mixed resin storage vessel – 50%
- Resin separation vessel – 75%
- Anion and cation regeneration vessels- 100%
- Activated carbon filter- 75%

In case resin separation vessel is also used as regeneration vessel then the free board shall be 100%.

5.4.0 Resin traps

Outlet of each condensate polisher vessel and waste effluent header of the common regeneration shall be provided with a resin trap. Pressure drop at design flow through a clean resin trap shall not exceed 0.35 kg/cm². Resin trap shall be of rubber lined steel construction and internals (cord and screen) shall be of Johnson Screens (Ireland) or equivalent (SS-316) construction.



5.5.0 Emergency Bypass system

In the event of excessive pressure differential between the condensate inlet and outlet headers, this control valve will open automatically to bypass requisite quantity of condensate to prevent this pressure differential from exceeding a preset limit. The control system shall be so designed that the control valve is able to bypass 50% of rated flow when any of the service vessel is out of service and 100% of flow when both the service vessels are out of service.

5.6.0 Piping

The arrangement shall avoid any sharp bends which cause segregation of the mixed resins, and pockets where the resins can get trapped. Suitable observation ports shall be provided in all critical areas to enable the operator to monitor completeness of the resin transfer operations. All necessary arrangements for venting and draining of the pipeline shall be provided.

Remotely operated valves suitably interlocked with the plant operation, shall ensure that the resins get transferred to and from only the particular service vessel which has been selected by the operator.

The resin transfer pipeline shall be of stainless steel type 304. The pipeline shall be sized for a flow velocity of between 2 and 3 m/s. The isolation valves on the resin transfer line shall be of eccentric plug type/ball valve of stainless steel construction.

5.7.0 Control and Operation of Plant

The regeneration system shall be external and common to the two units. Under normal conditions, it will hold a complete charge of freshly regenerated and mixed resin, ready for use, in its storage tank. For regeneration, resin from the exhausted exchanger vessel will be transferred hydraulically/hydro pneumatically to this facility. The empty exchanger vessel will then be filled up with the already regenerated resin which was stored in the regeneration facility. This exchange vessel shall come into service soon after pre requisite condition is satisfied or as and when desired by the operator. In the meantime, the exhausted resin shall be cleaned, separated, regenerated, mixed and rinsed before being stored for next use.

Control and operation of the condensate polishing unit.

The condensate polishing unit shall be controlled from plant DCS.

It shall be possible to select each of the CPU vessels for any of the following operations:

- Service
- Resin transfer from CPU vessel to regeneration plant
- Resin transfer from regeneration plant to CPU vessel
- Isolation from service
- Rinse recycle

A mimic diagram shall be provided for the CPU scheme on the front of the CPU control panel. Status of various valves shall be indicated by LED's on the mimic diagram.

5.8.0 Condensate polisher control system

Unit DCS based control to be provided as defined in C&I section 4.10. From this panel it shall be possible to initiate any of the following operating modes:



Rinse recycle

The rinse recycle shall be a manually initiated in full automatic sequence. This sequence shall include the rinse down step until the unit effluent quality is acceptable for boiler feed water. The effluent quality shall be determined by conductivity monitoring of the rinse water outlet. A panel mounted cation conductivity indicator shall be interlocked to prevent advancing of the automatic sequence until the rinse down is complete.

Service mode

Service flow rate for each polishing vessel shall be monitored by panel mounted flow indicators. During periods of low condensate flow the operator may select to remove one of the vessels from service by a manually initiated automatic sequence. A differential pressure switch installed between the influent and effluent headers shall on a high signal cause an annunciator alarm.

Panel mounted cation conductivity indicators shall be provided to monitor the polishing system influent and effluent streams as well as the discharge of each service vessel.

The sequence resin transfer from CPU vessel to regeneration plant and from regeneration plant to CPU vessel shall be initiated from the condensate polishing unit control panel but shall be controlled by the programmable logic controller in the regeneration control panel.

5.9.0 Regeneration control system

Manually initiated automatic sequences shall be provided for transferring resin from a vessel to the remote common facility for physical cleaning and chemical regeneration and for returning fresh resin to that vessel. Control for chemical dosing system and alkali preparation facility shall also be provided in it.

Regeneration shall include hydraulic reclassification of the resins and the transfer of the resins to the respective regeneration vessels. The separated resins shall then be backwashed, cation and anion regenerated with hydrochloric acid and sodium hydroxide solutions respectively, rinsed and then followed air scrubbing and a good backwash. The resin is then transferred back to the resin separation vessel and the resins are air mixed. The mixed resins after regeneration are given a final rinse with the discharge conductivity being monitored. If the quality is satisfactory, the mixed resin shall be transferred to the resin storage vessel otherwise regeneration sequence shall be repeated.

Demineralized water shall be used throughout the regeneration process for backwashing, regenerant diluent, rinsing and resin transfer. A conical bottom hopper having a water ejector will be used for resin make-up.

The complete control and operation of the regeneration plant shall be through plant DCS.

It shall be possible to operate the regeneration plant in auto/semi-auto /manual mode.

Following operations shall be possible from the regeneration control panel:

- Complete regeneration
- Resin transfer from CPU vessel to regeneration plant.
- Resin transfer from regeneration plant to CPU vessel.

In 'Auto' mode, once the sequence has been initiated, it shall proceed from step to step automatically.

In 'Semi-auto' mode each step shall be performed only after initiation by the operator.



In 'Manual' mode complete operation shall be by the operator by operation of the control switches on the panel.

On DCS failure, it shall be possible to operate the valves by means of manual operation of solenoid valves also.

It shall be possible to switch mode of operation from one to the other at any moment and the operation shall proceed on the newly selected mode from that time.

The system shall incorporate the necessary safety features. During automatic sequential operation, if any pre-requisite criteria is not fulfilled or missing for a pre determined time interval, the steps should not proceed further, and Alarm shall be provided. Missing criteria, sequence which is under hold up etc. shall be displayed on the panel.

A mimic diagram of the Regeneration system shall be provided on the front of the panel. The status of various drives and valves shall be indicated by LED on the mimic diagram.

Wherever standby equipments are provided, it shall be possible to select each of the drive on 'standby' duty.

The detailed logic for the sequence and for each of the drive shall be subject to the Purchaser's approval.

Start, progress and stop of each of the sequence shall be annunciated in all the control panels.

At any time only one of the sequence shall be in progress.

Interlocks

All interlocks for safe operation of the plant shall be provided. They shall specifically include the following as minimum requirement:

Service vessels shall be taken back in service, only after they have been pressurized.

Service vessels shall be taken up for resin transfer only after they have been completely isolated from the condensate system and depressurized.

Resin shall be transferred to and from only one service vessel at a time.

Resin transfer between the service and the regeneration skids shall be permitted only when the receiving vessel is initially empty.

It shall be possible for the operator to extend the timing of a particular step by isolating the timer for the duration. The timer will restart once the operator puts back the system on 'auto' and the other steps will then follow as programmed.

The regeneration sequence shall be prevented from advancing further in the event of tripping of a running motor or other fault condition which do not permit the various desired parameter of this step to be achieved. A manual override for this shall also be provided.

The immersion heater in the hot water tank can be put on only when there is adequate water level in the tank.



6.0.0 CHEMICAL FEED SYSTEM

Metering pumps for each chemical shall be of horizontal positive displacement, reciprocating and variable stroke type. All the chemical storage/handling tanks shall be of SS304. Transfer/dosing pumps shall be of SS-316 construction. The tanks shall be complete with necessary fittings and accessories etc. including manhole/hinged cover, motorized stirrers for preparation tanks, drain connection, exhaust through water seal for ammonia vapours and level switches etc. The provision shall be made for flushing of the transfer/metering pumps by the DM water/Condensate.

7.0.0 DRAWINGS, DATA / DOCUMENTS TO BE SUBMITTED ALONG WITH TENDER

- a) Duly filled-in technical data, bill of material and prices as per specified schedules.
- b) Technical write-up for the system.
- c) List of drawings/documents attached to tender.
- d) Time schedule for design, manufacture, delivery, erection, testing, and commissioning.
- e) P & I Diagram for the System
- f) Operation and control philosophy.
- g) Equipment layout drawings.
- h) Process design calculations with catalogues and equipment sizing calculations
- i) Utility consumption for various equipments (power, cooling water and instrument air requirements).
- j) List of tests the Bidder proposes to carry out in shop and at site after installation including those pertaining to their sub-Bidder.
- k) List of all maintenance tools, tackles and accessories required for maintenance of the offered equipment including bought out components.
- l) List of all recommended spare parts for all equipment offered including bought out components suitable for three (3) years operation.
- m) A bar chart indicating design engineering, procurement, manufacture, testing at shop, delivery, installation, testing and commissioning activity/duration of System offered.
- n) Quality Assurance Plan.
- o) Complete Electrical Load List
- p) Bill of quantities for civil works.

**Drawings, data / documents to be furnished by the successful Bidder**

The following drawings, data / documents shall be submitted for the approval / review of the Purchaser / Consultant by the successful Bidder.

Mechanical	Category
a) Drawing / Document submission schedule	A
b) Process design calculations with catalogues and equipment sizing calculations	A
c) Final Schematic, Flow and P&I diagram with interlock summary.	A
d) Final technical data sheets for all equipment/ tanks/ vessels/ instruments	A
e) Piping and Valve Schedule.	A
f) Equipment layout drawings.	A
g) Design calculations	A
h) Pressure vessel thickness calculations	A
i) FRP tank thickness calculations	A
j) Fabrication drawings of vessels & tanks	I
k) G.A. drawings , Data sheets of all equipment with sectional details giving details of materials.	A
l) Piping specification	A
m) Piping layout	A
n) Isometric drawings including pipe support drawings.	I
o) Technical literature for all equipment	I
p) Foundation bolt detail drawing.	A
Civil	
a) Complete civil inputs required for civil design	A

Any other drawings required for review during the detailed engineering stage, same shall also be submitted by contractor.

**VOLUME II****SUB-SECTION 2.8****EQUIPMENT COOLING WATER SYSTEM****1.0.0 GENERAL**

This section covers minimum requirements for design, engineering, manufacture & assembly, inspection, erection, testing and commissioning of Equipment cooling water (DMCW/CCW) system.

This section of the specification shall be read in conjunction with other sections of the specification as appropriate and the equipment offered shall meet the requirements as spelt out therein.

2.0.0 CODES AND STANDARDS

Equipment cooling water (DMCW/CCW) pumps and accessories shall be designed in accordance with **latest edition** of following codes, standards specifications and regulations. Also the system design shall conform to the requirements of applicable codes as specified in the General Technical Specification.

HIS	:	Hydraulic Institute Standards
ANSI B 16.5	:	Code of steel flanges and pipe fittings
ASTM	:	American Society of Testing and Materials.
PTC – 8.2	:	Centrifugal Pumps – Power Test code.
IS 10981	:	Acceptance test for centrifugal mixed flow and axial flow pumps.

3.0.0 SCOPE OF SUPPLY / SERVICES

The scope of supply shall include the pumps, PHE, tank with all components and complete accessories and auxiliaries and shall include, but not be limited to the following (for each unit unless otherwise indicated).

- Turbine generator auxiliaries and BOP auxiliaries
 - 3 X 50% Closed circuit cooling water (CCW/DMCW) pumps
 - 3 X 50% Plate Heat Exchanger
 - Complete interconnecting piping, fittings, valves, instrumentation, supports etc.
- Steam Generator (boiler) and BOP auxiliaries
 - 2 X 100% Closed circuit cooling water (CCW/DMCW) pumps
 - 2 X 100% Plate Heat Exchanger
 - Complete interconnecting piping, fittings, valves, instrumentation, supports etc.
- Any other equipment/ system not specifically mentioned here, but elaborated elsewhere in the specification.



4.0.0 DESIGN REQUIREMENTS

The primary cooling water systems shall be closed circuit type with Demineralised (DM) water. Sea water shall be used in the secondary (Auxiliary Cooling Water-ACW) circuit for cooling the primary circuit DM water, through a set of plate type heat exchangers as specified. All materials of construction used in primary (DM Water) circuit shall be suitable for the water quality that would be applicable for this system.

Water quality for primary side shall be passivated Demineralised (DM) water. Sodium Hydroxide dosing equipment shall be provided to maintain pH around 9.5 in the D.M. water side.

The outlet header from plate heat exchangers shall be suitably branched off to supply the cooling water to various auxiliary coolers of Turbine-Generators/ Steam Generators/ Station auxiliaries (BOP). Outlets from these auxiliary coolers shall be connected back into a common return header and led back to the suction of DMCW pumps to complete the closed loop primary cooling circuit of the respective module.

The primary cooling system shall be designed to provide the necessary cooling water flow to the following auxiliary coolers: (Refer flow diagram for ACW & DMCW System 00-1112140-M-004)

- a) Coolers for ID/ FD/ PA fans.
- b) Coolers for Air Preheaters, coal mills.
- c) Coolers for circulating water pump and motor
- d) Coolers for access doors, scaffold doors
- e) Coolers for SWAS, Sample coolers, Flame monitoring cameras
- f) Steam turbine control fluid coolers.
- g) Stator Water Coolers, Hydrogen Coolers, Seal Oil Coolers, Exciter cooler.
- h) Feed water pumps and drives coolers.
- j) Coolers of miscellaneous station auxiliaries.
- j) Condensate extraction pump.
- k) Ash conveying compressor
- l) Ash instrument air compressor
- m) IA & SA compressor
- n) Sample coolers
- o) Any other auxiliary coolers not specifically covered above.

Outlet of overhead tank shall be connected to the respective closed circuit return header to serve the following:

- a) The expansion of closed cycle water due to temperature fluctuations and to control other transients.
- b) For adequate Net Positive Suction Head (NPSH) for DMCW pumps.
- c) For normal make-up to closed loop cycle.
- d) Emergency water supply to critical (if applicable) coolers in case of power failure.

pH of DM water in the closed loop shall be continuously monitored and controlled at around 9.5. The control shall be achieved by dosing sodium hydroxide in DM water overhead tank and DMCW/CCW pump suction. The dosing shall be done automatically through a chemical dosing pump. Provision for manual dosing shall also be provided.

Normal make up water for DM water overhead tank shall be taken from the condensate extraction pumps discharge. Emergency make up water for DM water overhead tank shall be taken from the condensate transfer pumps discharge. The make up water required for dosing tank shall be tapped from both the normal and emergency make up water line to DM water over head tank.



Re-circulation line shall be provided with self regulating butterfly valve from the discharge header of DMCW pumps up to the suction header.

5.0.0 CONSTRUCTIONAL REQUIREMENTS

5.1.0 Pumps

General design and construction DMCW/CCCW pumps shall be as per HI standard.

Pumps shall be identical in construction and similar parts of the pumps shall be interchangeable.

Continuous motor rating at high ambient for all pumps shall be at least 10% above the maximum power requirement at any condition of entire characteristic curve of the pump.

Casing shall be provided with a drain & vent connection comprising of an isolation valve and blind flange (with fasteners and gaskets) terminated at the edge of the base plate. The minimum size of any connection or piping shall be 1/2 inch nominal pipe size.

Each pump and its components shall be designed to facilitate installation and removal. Components requiring periodic inspections or maintenance shall be easily accessible.

Suction and discharge nozzles shall be flanged and shall conform to ASME standard.

Shaft sealing shall be by mechanical seal.

Sound power level shall not exceed 85 dBA at one (1) meter from the equipment.

The casing shall be designed to withstand the maximum shut-off pressure or 150% of maximum pressure under which the pump can operate at design fluid temperature, whichever is higher. Each pump shall preferably be of such construction that it is possible to service the internals of the pump without disturbing suction and discharge piping connections. Casings shall be of such thickness as well be suitable for maximum discharge and hydrostatic testing pressure and pumping temperature, with a 3 mm minimum corrosion allowance.

Impeller shall be of shrouded type. Impeller shall be of single piece casting (fabricated impellers not acceptable), smooth finished and dynamically balanced along with shaft on proper balancing equipment so as not to cause any vibration.

Replaceable type wearing rings shall be furnished to prevent damage to impeller and casing. A suitable method of locking the wearing ring shall be used, such as by the use of grub screws. Wearing rings shall have a close tolerance fit to permit only a minimum of recirculation flow. Impeller wearing rings shall have surfaces harder than surfaces of opposed casing wearing or shall be made of non-galling material to suit the pump medium.

Bearings shall be of antifriction grease/oil lubricated heavy duty ball or roller bearings capable of carrying heavy loads in either direction of rotation for continuous operation. The bearing shall be designed for a minimum life of 40,000 hrs in continuous operation at rated pump conditions. Hydrodynamics radial and/or thrust bearings shall be provided if required. Bearing housings shall preferably be arranged so that bearings can be replaced without disturbing pump drives or mountings. The housing shall be effectively protected against the ingress of water, pumped fluid and dust. When oil lubrication is provided all bearing oil wells shall be fitted with visual oil level indicators. Non-pressure oil lubricated bearings shall be equipped with constant level oilers. Means of draining bearing housings shall be provided.

Proper lubricating may be by oil/ grease. In case of Oil lubricated bearings, the type shall be of the ring oil/Flooded type, incorporating an ample oil reservoir and fitted with an oil level sight glass/indicator and thermometer. Free access to all lubrication ports shall be incorporated in the pump design. Means of draining bearing housings shall be provided.



5.2.0 Plate Type Heat Exchangers

The plate heat exchangers are required to cool, DM water circulating in primary circuit with the cooling medium of Auxiliary Cooling Water in the secondary circuit.

The heat exchanger shall be of gasketed plate type complete with frame plates, pressure plates, heat transfer plates, flanges, gaskets, etc. The pressure containing parts shall be designed, fabricated and tested as per ASME Sec VIII Div.I.

The heat exchangers shall be adequately designed for the indicated hot and cold fluid flow rates which are the maximum values.

The plates which are in contact with both hot and cold fluids shall have design temperature higher of the two temperatures.

Calculations of the surface areas shall be based on the fouling factor considered and the frequency or time period between two successive cleanings.

The plate corrugations shall be such as to get high heat transfer coefficients, and prevent any stagnant pockets in the channels to minimize fouling. The plate design shall ensure sufficient number of contact points in order to reduce the contact pressure and minimize stress corrosion.

The model of heat exchanger shall be selected such that the frame can accommodate at least 10% extra plates than required for the duty specified in this specification.

The heat transfer plates shall be of corrugated design. The corrugation pattern shall be based on the total allowable pressure drop and the minimum required heat transfer coefficient. The thickness selected shall enable the plate to withstand the differential pressure & contact stresses arising out of bolt tightening.

5% margin on heat load shall be considered for PHE sizing. Frame of exchanger should be designed to accommodate 10% additional plates in future.

Double sealing arrangement should be provided at outer edge and around ports to avoid intermixing of fluids.

The inter-space should be vented to atmosphere.

Plate thickness should be adequate to withstand all operating conditions but not less than 0.6 mm.

Flanges shall be per ANSI B 16.5 or equivalent.

Minimum corrosion allowance for heat exchanger parts shall be 1.6 mm.

The corrosion allowance for the heat exchanger plate parts such as support plates, nozzles, sliding channels and frame shall be 1.6 mm (minimum).

5.3.0 Strainers and Filters

- a) The strainers shall have basket type straining elements permitting easy removal and replacement.
- b) The open area ratio (i.e. straining area to the inlet area ratio) shall be at least 6:1.
- c) The strainer shall have screen of stainless steel (AISI-304) construction with wire diameter of about 0.25 mm and open area of about 50%. Strainer screen shall be of 80 mesh or higher.



- d) Strainer body shall be made of Mild steel.
- e) Each strainer shall be provided with a pair of counter flanges and associated bolts nuts and gaskets. Material of counter flanges shall be of tested quality steel conforming to IS-2062. All strainers shall also be provided with oil drip plates beneath them for collection of oil.
- f) Bolts and nuts shall be as per IS-1363. Gaskets shall be minimum 3 mm thick.

5.4.0 Piping & Valves

Refer Volume-II section 2.20 for more details.

5.5.0 Tanks

Effective capacity of tank(s) wherever mentioned shall be from the minimum level (for alarm purpose) to high level (for alarm purpose).

All the overflow / vent connections shall be terminated up to the plant effluent system. Overflow shall be through seal and vent connections for alkali and DMCW tanks shall be through CO₂ absorbers.

5.6.0 Chemical Dosing Equipment

Chemical dosing to neutralize the corrosiveness of dematerialized water in primary side.

Periodic sampling for correct rate of dosing chemical.

Five percent solution of sodium hydroxide solution to be injected at the suction header of closed loop pumps.

One no. Sodium hydroxide solution preparation tank along with three numbers (3 x 50% capacity) of injecting (metering) pumps of reciprocating type shall be provided.

6.0.0 CONTROL AND INSTRUMENTATION

6.1.0 General

The I&C system shall consist of a field instruments, instrumentation & control cables and erection hardware.

6.2.0 Operational Philosophy

It is envisaged that primary operations including control and monitoring of Demineralized cooling water system will be carried out only from the Operator station of the plant DCS located in the central control room.

Apart from the CCR operation, local operation shall be provided through LPB (Local push buttons) located near the equipment.

6.3.0 DMCW Pump Controls

The complete controls will be implemented in the plant DCS.

The DMCW pump controls / interlocks shall be provided for safe and trouble free operation of three numbers DMCW pumps (2 working + 1 standby) per unit for TG auxiliaries and (1 working +1 standby) per unit for SG and BOP auxiliaries.

The Local / Remote operation selection shall be made through MCC. After getting the Remote selection as a permissive from MCC, drives shall be controlled / operated from DCS.



Emergency Stop push buttons will be provided to facilitate the emergency Stop operation of DMCW Pumps and will be wired to the SWGR directly.

The local start command from LPB of DMCWP shall be routed through DCS where all control logics, interlocks and permissive shall be implemented.

All alarms and Trips shall be annunciated in CCR.

Vibration monitoring system for the DMCW pumps shall be provided. Vibration monitoring system shall be wired directly to the VMAS server located in the electronic equipment room. Vibration measurement on X-Y axis for each bearing will be provided. Key phasor measurement shall be provided based on the OEM recommendation.

6.4.0 Controls / Instruments / Interlocks provided for DMCW Pumps

Field Instruments

Following Instruments shall be provided for DMCWP.

- One no. pressure gauge at suction and discharge of each DMCW pump for local reading.
- One no. pressure transmitter on the suction common header shall be provided for “pressure adequate” to start the pumps.
- One no. Pressure switches on the suction line shall be provided for “pressure low” to trip the running pumps.
- One number recirculation control valve & one number DP transmitter shall be provided on the recirculation line.
- Two nos. redundant pressure transmitters on the common header
- Cation conductivity, conductivity of discharge water available in the common headre shall be provided.

a. DMCW Pump Discharge

1. One pressure switch shall be provided on the individual DMCW pump discharge for “low low discharge pressure trip of DMCW pump”.

b. DMCW Common Header

1. One no. pressure transmitter on the common header of each Unit for sensing "Discharge header pressure low" for starting the stand by pump.
2. One no. Pressure gauge shall be provided at the common discharge header for local reading.

c. Plate Heat Exchanger (PHE)

1. A DP indicating Switch to sense the DP across the PHE and the same shall be annunciated in the Plant DCS as well.
2. One number Temperature element at the suction and discharge header for remote indication. One number Temperature Gauge and Pressure Gauge will be provided at the inlet and outlet of each PHE.



6.5.0 Controls / Interlocks for DMCW Pump & Discharge Valve

Starting of DMCW Pumps

The operation of DMCW pumps and its discharge valves shall be from Operator station in CCR. The DMCW pumps with its discharge valves are envisaged to operate in sequence, after start command is initiated by operator.

Any DMCW pump can be started only when following Permissive conditions are fulfilled.

- DMCWP suction valve - 'fully opened' measured through "ZSO" contact
- DMCW pump discharge motorized valve - 'fully closed'.
- Motor winding temp. "Not High".
- Pump bearing temp. "Not High".
- Motor bearing temp. "Not High".
- Discharge motorized valve" actuator ready to start".
- HT Switchgear "Available"

Starting of first DMCW Pump

1. DMCW pump 'start command' shall start the DMCW pump and simultaneously the command is issued to the discharge motorized valve to open.
2. In case the discharge motorized valve fails to open within the specified time, a DMCWP trip command shall be initiated.
3. In case discharge motorized valve fails to open within a specified time, an audio-visual annunciation shall be generated for operator's intervention for manual operation.

Starting of Standby DMCW Pumps

- After the system is primed (sensed through pressure), start command of standby DMCW pumps, will be given with time delay. If running pumps trips, the standby pump shall start automatically. Once standby pump start command is initiated, the corresponding standby pump discharge motorized valve shall open automatically.

Tripping of DMCW Pumps

DMCW Pumps shall trip in the event of following eventualities.

- Pump suction pressure "low low"
- Pump discharge pressure low
- Pump discharge motorized valve failed to open.
- Pump / Motor - bearings temperature "high high"
- Motor winding temp "high high"
- Motor & Pump vibration "high High"

When DMCW pump stops (or Trips) the motorized valve at DMCW Pump discharge, shall close fully.

6.6.0 DMCW Overhead Make-up Tank

In the event of low tank level sensed by the level transmitter, the DM water make up motorized valve shall open automatically. The valve shall close automatically at high level in tank.

One level gauge shall also be provided for local indication of water level in the tank.



ANNEX 2.8.1

SPECIFIED DESIGN DATA

Description	Data
A) CCCW PUMP (DMCW PUMP)	
Number of DMCW/CCW pumps for turbine generator auxiliaries.	3 x 50% for each unit
Number of DMCW/CCW pumps for steam generator auxiliaries and BOP auxiliaries.	2 x 100 % for each unit
Capacity of each pump	Design flow required for all the auxiliaries of the circuit + Design flow required for common auxiliaries + 10% margin.
Head of pump	As per system requirement +10% margin on friction head.
Type of Pumps	Horizontal Centrifugal type
Impeller type	Closed
Speed	1500 rpm
Drive transmission	Direct
Seal	Mechanical seal
Lubrication	Oil / Grease /Self-liquid
Coupling	Spacer type
Accessories	Drain plug, vent, priming connection, Coupling guard, lifting lugs etc
Shut off head	About 15% more than rated head
Material of construction	
Casing	ASTM-A-351 CF8M
Impeller	ASTM-A-351 CF8M
Wearing Rings	SS-316
Shaft	SS-316
Mechanical Seal	Manufacturer's Std
Base plate	MS fabricated - IS: 2062 (min thickness 10 mm)
Stuffing Box	ASTM-A-351CF8M
B)PLATE HEAT EXCHANGER	
Type	Plate type, single pass
Number of heat exchangers for turbine generator auxiliaries.	3 x 50% for each unit
Number of heat exchangers for steam generator auxiliaries and BOP auxiliaries.	2 x 100% for each unit
Design pressure	2 times working pressure or 1.5 times shut off head of respective pumps, whichever is higher.
Overall fouling factor	$0.8 \times 10^{-4} \text{ hr m}^2 \text{ deg.C/kcal}$
Material of Construction	
Heat transfer plate	Titanium
Plate Gasket	Nitrile Rubber
Thickness of plate	Contractor to furnish
Carrying Bar	CS (IS 2062)
Guide Bar	CS (IS2062)
Frame Plate / Pressure plate/ nozzle	CS (IS2062)
Nozzle Flange	CS (IS2062), ANSI B16.5
Overall Friction Factor (min)	$0.8 \times 10^{-4} \text{ m}^2 \text{ hr } ^\circ\text{C} / \text{kcal}$
STRAINERS	
Type	Self cleaning Strainers
Material of Construction	
Body	IS :2062 (ebonite lining)
Plates	Stainless Steel (SS:316)



Description	Data
Filters	SS 316
C) DMCW/ECW OVERHEAD TANK	
Quantity per Unit	One for each unit
Effective Capacity	10 Cu.M (Minimum.)
Type	Horizontal With Dished ends
Design Pressure	Atmospheric
Design Standard	ASME Boiler and Pressure Vessel code Section-VIII
Material of Construction	Plates to IS: 2062/ ASTM A36. Minimum shell thickness shall be 6mm.
Location	Power House floor at suitable elevation.
Accessories	Vent, Overflow & Drain connections, Manhole, approach ladder/platform etc.
D)ALKALI DOSING TANK	
Quantity per Unit	One for each unit
Effective Capacity of each	Suitable for the system
Size (Dia. x Height)	Adequate
Type	Vertical cylinder, dished bottom
Design Pressure	Atmospheric
Design Standard	ASME Boiler & Pressure vessels Code Section-VIII. Div.
Material of Construction	SS plates of minimum thickness of 6 mm
Dissolving Basket	AISI-316,
Agitator	Propeller type agitator (shaft, propeller etc. of stainless steel 316SS construction) along with drive motor of suitable rating and protection class. (With Slow speed reduction gear unit)
Accessories	Vent, overflow, drain & Sample connections.

**VOLUME - II****SUB-SECTION 2.9****FUEL OIL HANDLING SYSTEM****1.0.0 GENERAL**

This section covers minimum requirements for design, engineering, fabrication, manufacture & assembly, inspection, erection, testing and commissioning of complete Fuel Oil System.

2.0.0 CODES AND STANDARDS

The design, manufacture and testing of the equipment or any item as specified in this section shall comply with the requirements of the latest revisions of one or more of the following standards as applicable:

API 650 (2001)	Welded steel tanks for oil storage
IS - 803	Code of practice for design fabrication and erection of vertical mild steel cylindrical welded oil storage tanks.
IS - 800	Code of practice for general construction in steel
API STD: 2000	Venting Atmospheric and Low-Pressure Storage Tanks: Non refrigerated and Refrigerated
IS-1593	Code for Heavy fuel Oil (HFO)
IS-1460 (2005)	Specification for Diesel Fuels
IS-8183	Specification for Bonded Mineral Wools Group 4
ASME Boiler & Pressure Vessel (B & PV) Code	Section IX, Welding & Brazing qualification.
ASME Sec II	Material specification
ASME Sec V	Non destructive examination
ASME Sec.VIII, Div.I (2001)	Boiler and pressure vessel code
ASME/ANSI B31.1 (2001)	American Society of Mechanical Engineers Code for Power Piping
ANSI B 16.5 (1996)	Code of steel flanges and pipe fittings
BS-5351	Code for design & testing of steel ball valve
API-600	Code for design & construction of gate valve for sizes 50 NB or above
API-602 :	Code for design & construction of gate valve for sizes below 50 NB
NEC	National Electrical Code
NFPA 30	Flammable and Combustible Liquid Code



NFPA 850	Electric Generating Plants
BS 3274	Specification for tubular heat exchanger for general purposes
OISD – 118	Oil Industry Safety Directorate – Layouts for Oil and Gas Installations
Petroleum Act – 1934	
API 610	Centrifugal Pumps for General Refinery service
API – 676	Positive Displacement Pumps - Rotary
ASTM	American Society for testing & Materials
TEMA	Standard of the Tubular Exchanger Manufacturer's Association
ANSI 16.10	American Society of Mechanical Engineers Face to Face and End to End Dimensions for Valves
ANSI B 31.1	Power piping
ANSI B16.34	American Society of Mechanical Engineers Valves – Flanged, Threaded and Welding End
ANSI B16.5	Steel pipe flanges and flanged fittings
IBR	Indian Boiler Regulations.

If the equipment supplied does not conform to the above codes and standards, but it is manufactured to the Contractor's own standard developed from his experience, the same shall be clearly identified in the Bid, with sufficient data to support the design. The design shall be accepted by the Owner, if he is satisfied that the design proposed is based on adequate experience.

In addition to the above requirements, all equipment and procedure shall comply with applicable laws regulations and requirements of the state in which the project is located.

3.0.0 SCOPE OF SUPPLY

The list is by no means exhaustive and the items though not specifically mentioned but needed for safe, efficient, trouble-free and coordinated operation of the system

- HFO Unloading and Storage System
- HFO Forwarding System
- HFO Heating and Cooling System
- HSD Unloading and Storage System
- HSD Forwarding System
- Drain Oil and Oily Water Separator System
- Steam and Condensate System

The complete piping system as required along with valves, actuators, fittings and supports, insulation and cladding etc.



4.0.0 DESIGN REQUIREMENTS

Fuel oil system and its facilities shall be designed meeting the requirements of Pollution Control/Petroleum/Explosive rules of Central and State Governments.

The HSD shall be used for cold start-up, warm-up purposes, for start-up / commissioning activities and firing up to 7.5% MCR of the main boilers. The HFO shall be utilized as start up and secondary fuel for flame stabilization during low load operation (upto 30%) of the main boilers.

The HSD and HFO systems are represented in flow diagram 00-1112140-M-005.

4.1.0 HFO Unloading and Storage System

Heavy Fuel Oil (HFO) system shall be transported to site by road tankers. The system shall be equipped with dedicated facilities to unload and meter the deliveries by road tankers. The HFO unloading system comprises a HFO unloading header to enable the simultaneous unloading of ten (10) road tankers with connection branch to each tanker provided with ball valves. Simplex strainer shall be provided at each unloading pump suction. Flow meter shall be provided after the unloading pump discharge header to measure the quantity of flow into the HFO storage tank.

4.2.0 HFO Unloading Pumps

- The HFO unloading facility shall be designed to enable to unload 10 road tankers simultaneously and discharge to onsite storage tanks within one hour period
- Configuration shall be Three (3) nos- (2W+1S) each with a capacity of 100 Cum /hr.
- Head
 - a) The discharge head shall be adequate to meet the pumping from road tankers to a nearly full storage tank operation with the worst case oil viscosity.
 - b) A margin of 10 % shall be added to the calculated head requirement.
 - c) The discharge head of HFO unloading pumps shall be adequate to pump from the unloading header into a nearly full storage tank operation.

4.3.0 HFO Storage Tanks

The maximum storage temperature for the tank shall be at least 50°C. The tank shell temperatures caused by solar irradiation must be considered too.

Effective storage capacity of each HFO storage tank shall be 3000 m³.

No. of HFO Storage tanks : 2 Nos.

Note:

- Effective capacity shall mean the capacity between High level and Low level. High level shall be 100 mm below High High level and Low level shall be 100 mm above top of outlet nozzle.
- The FO storage tanks roof and shell metal thickness shall be as required by API: 650 plus a corrosion allowance of 3 mm (1/8 inch).
- Each HFO tank shall be equipped with floor coil heater. Heavy fuel oil tank shall also be designed to incorporate suction heaters for steam heating of the oil as it is withdrawn from the tank.



- The HFO Tanks should be located in such a way that the maximum dead stock for the NPSH required for the pump shall not be more than 100 Kl.
- Spare nozzles for suction and Recirculation shall be provided in each HFO tank for future use.
- Measurement points & control logics shall be employed in the unit DCS.

4.4.0 HFO Heating and Cooling System

Floor Coil Heater

The heavy fuel oil storage tanks shall be provided with steam floor coil heaters at the bottom of the tank to raise the temperature of oil from minimum expected temperature of oil under minimum ambient temperature to the handling / tank maintenance temperature in order to ensure flow ability of oil. The floor coil heater shall be of Serpentine type, using A106 Gr.B pipes and of welded type construction. Heating shall be provided from plant's auxiliary steam system.

Suction Heater

The function of the heavy fuel oil tank suction heater is to heat the required quantity of oil from the bulk temperature in the storage tanks to the temperature required at HFO forwarding pumps suction. The heater shall heat only the quantity of oil that is being withdrawn from the tank.

Fuel oil suction heater shall be shell and tube type heat exchanger designed for immersion in the oil. Heaters shall be designed for mounting on the tank shell by bolting to a flanged connection. Additional support shall be provided from the tank floor as required to properly support the weight of the heater. Heaters shall be designed for steam flow through the tubes, while the oil passes through the shell to the forwarding pump suction. Auxiliary steam shall be the heating medium.

HFO heaters

Design oil flow of each heater shall be matching with the pump capacity defined above and shall maintain the outlet temperature of HFO as required at the burner header. Working Oil pressure shall be as per requirement and design oil pressure shall be 1.5 times the working pressure. The heaters shall be sized considering inlet temperature as 30° C and the design shall conform to TEMA/ ASME SEC-VIII.

All heaters shall be provided with a 100 percent capacity. Configuration shall be 1 Working + 1 Standby.

Steam Heating & Electric Trace Heating

Steam heating shall be used for all Unloading tanker/storage tanks/suction coil heater in the fuel oil unloading, storage and forwarding pump house area.

Electrical Trace Heating shall be used for the HFO piping (both supply and return lines) between pump house area and the boiler front and HFO piping in fuel oil unloading, storage and forwarding pump house area. The Electric Trace Heating shall be of the self-regulating type.

A single thermostat shall not be used to simultaneously provide control over both flowing and non-flowing portions of lines.

The heater output shall be sufficient to replace the heat loss plus a 10% safety factor.



HFO Coolers

The function of the heavy fuel oil coolers is to reduce the temperature of the heavy fuel oil by cooling it from the Boiler return temperature to HFO storage tank maintenance temperature. HFO return oil cooler shall be cooled by service water. It shall be complete with make-up connection with float valve. Separate package type cooling tower with pumps shall be provided.. All coolers shall be provided with a 100 percent capacity. Configuration shall be 1 Working + 1 Standby.

4.5.0 HFO Forwarding System

The HFO from the storage tanks shall be supplied to boiler units by means of the HFO forwarding system, comprising of 3 Nos. (2W + 1S) HFO Forwarding Pumps. System shall be designed for a capacity sufficient for firing up each boiler for 30% load with recirculation. The excess oil shall be returned to the storage tank. The HFO forwarding pumps shall be designed to operate in parallel with each other with provisions for necessary relief valves. Duplex strainer shall be provided at forwarding pump suction & discharge common headers.

The pumps shall be selected at 110% of the actual required design flow to account for the wear over the operating life. Configuration shall have individual pumps for each unit with at least one standby. The common stand-by pump shall be put automatically in operation in case of operating pump trip.

- a) Design flow capacity each : Catering to 30% of the BMCR capacity of fuel oil for one boiler including continuous recirculation from burner header end, with 10% margin.

HFO pressuring Pumps Recirculation Control Valves Shall be designed to the maximum flow capacity of Full pump discharge flow and minimum flow capacity of 10% of pump discharge flow.

4.6.0 HSD Unloading and Storage System

The High speed diesel (HSD) shall be transported to site by road tankers and unload it to the HSD storage tank for further forwarding to consumers of the Power plant. The oil from the road tankers shall be unloaded to header through neoprene hoses. Simplex strainer shall be provided at each unloading pump suction.

4.7.0 HSD Unloading Pumps

- The HSD road tanker unloading facility shall be designed to enable to unload 5 road tankers simultaneously and discharge to onsite storage tanks within one hour period.
- Configuration shall be Two (2) nos - (1W+1S) each with a capacity of 100 Cum /hr.
- Head
 - a) A margin of 10% shall be added to the calculated head requirement.
 - b) The discharge head of HSD unloading pumps shall be adequate to pump from the unloading header into a nearly full storage tank operation.

4.8.0 HSD Storage Tanks

HSD storage tank shall be provided to have a effective storage capacity shall be 1000 m³.

No. of HSD Storage tanks : 1 No.

**Note:**

- Effective capacity shall mean the capacity between High level and Low level. High level shall be 100 mm below High High level and Low level shall be 100 mm above top of outlet nozzle.
- The HSD storage tanks roof and shell metal thickness shall be as required by API: 650 plus a corrosion allowance of 3 mm (1/8 inch).
- The HSD Tank should be located in such a way that the maximum dead stock for the NPSH required for the pump shall not be more than 30 Kl
- Spare nozzles for suction and Recirculation shall be provided in the HSD tanks for future use.
- Low level is the minimum static head required for the pump.

4.9.0 HSD Forwarding System

HSD forwarding pumps 3 Nos(2W+ 1S) shall be designed to supply the HSD flow requirement for the start-up of each boiler simultaneously.

The HSD forwarding pumps shall be selected at 110% of the actual required design flow to account for the wear over the operating life. Configuration shall have individual pumps for each unit with at least one standby. Duplex strainer shall be provided at forwarding pump suction and discharge common header.

- a) Design flow capacity each : Catering to 7.5% of the BMCR capacity of fuel oil for one boiler

HSD pressuring Pumps Recirculation Control Valves Shall be designed to the maximum flow capacity of Full pump discharge flow and minimum flow capacity of 10% of pump discharge flow

4.10.0 Drain Oil, Oily water and Oily Water Separator System**Drain Oil System**

The drain oil from various equipment of HFO, HSD Unloading system shall be collected in a common drain oil tank. The tank shall be rectangular tank of carbon steel construction. The drained oil shall be transferred to the HFO storage tanks by drain oil pump. The drain oil system shall be steam traced and insulated.

Drain oil pump shall be vertical positive displacement, twin screw, steam jacketed type pumps shall be provided to transfer the drained oil to heavy fuel oil storage tanks. Configuration shall be 1W + 1S.

Oily water System

The oily water mixture from HFO, HSD unloading area and sump area in the pump house and tank dyke area shall be led to the oily water sumps by gravity.

Oily Water separator System

The oily water mixture from Oily water collection sump shall be led to the oily water separator sumps through non clog vertical centrifugal pumps suitable capacity. Configuration shall be 1W + 1S. The waste water from oily water separator sump shall be transferred to Waste Water Treatment System for further treatment.



4.11.0 Steam and Condensate System

Auxiliary steam after pressure reduction / PRDS shall be available for Steam heating / tracing for Heavy Fuel oil unloading, storage system and HFO heaters along with drain oil system shall be provided to maintain the oil temperature and viscosity. PRDS shall be sized based on the Auxiliary steam parameters.

Condensate from storage tank heating and suction heaters shall be drained through steam traps to a header which shall lead to condensate flash tank. Condensate from truck unloading area shall be collected through the condensate drain header and led to the condensate flash tank of suitable capacity before discharging the same to oily water separator sump.

5.0.0 CONSTRUCTION REQUIREMENTS

5.1.0 Pumps

The HFO/ HSD/ Drain Oil Pumps shall be of positive displacement type with gear, screw or sliding vane rotary type or any other rotating element. Both HFO and HSD firing pumps shall be located in the same pump house.

5.2.0 Bearing

Bearing shall be antifriction ball or roller preferably split type or sleeve type. Bearings shall be adequately sized to absorb radial as well as axial thrust loads, if any. Bearings shall be of external type. In the latter case provision of lubrication of the bearings by oil or grease shall be made.

5.3.0 Mechanical Seal

Mechanical seal shall be provided at roots where the shaft extends from the casing. The seal material shall have low co-efficient of friction and shall be suitable for the fluid handled.

5.4.0 Relief Valve

- a) Each pump shall have relief valve either built-in with the body or end plate, or attachable as specified elsewhere for protection against damage due to accidental closure of discharge valve & pressure build up.
- b) The capacity of the relief valve shall be at least that of the pump to ensure the full discharge of liquid through the bypass line to the suction side of the pump during accidental pressure build up.
- c) The relief valve body shall be constructed from stainless steel/ The MOC of relief valve shall be same as the pump MOC with internals shall be stainless steel.

5.5.0 Jacketed Body

HFO Pumps and strainers at pump suction and discharge (as required) shall be of steam-jacketed type.

5.6.0 Timing Gear

Timing gear shall be provided to transmit torque from one rotor shaft to another and to maintain the proper angular relationship of the rotors. Proper lubricating arrangement for this shall be provided.



5.7.0 Coupling

- a) Pump shall be connected to its drive by means of flexible coupling.
- b) Coupling guard shall be provided.

5.8.0 Base plate

Common base plate for the pump and motor shall be provided. The base plate shall be suitably drilled for the anchor bolts. The base plate shall have drip pan and suitable draining arrangement.

5.9.0 Drive Motor

The design and construction of the drive motor shall be as specified in relevant Electrical specification.

5.10.0 Strainers and Filters

- a) The strainers shall have basket type straining elements permitting easy removal and replacement.
- b) The open area ratio (i.e. straining area to the inlet area ratio) shall be at least 6:1.
- c) The strainer shall have screen of stainless steel (AISI-304) construction with wire diameter of about 0.25 mm and open area of about 50%. Strainer screen shall be of 40 mesh or higher.
- d) Strainer body shall be made of Mild steel.
- e) Each strainer shall be provided with a pair of counter flanges and associated bolts nuts and gaskets. Material of counter flanges shall be of tested quality steel conforming to IS-2062. All strainers shall also be provided with oil drip plates beneath them for collection of oil.
- f) Bolts and nuts shall be as per IS-1363. Gaskets shall be minimum 3 mm thick.

5.11.0 Steam Traps with Strainers

- a) The steam traps shall be inverted bucket or thermodynamic type complete with integral or separate strainers.
- b) Traps shall have carbon steel body with stainless steel internals to AISI 316.
- c) Y-type strainers whether integral with steam traps or otherwise shall have body of Cast Steel Class 150 material and perforated metal screen of type AISI-316 stainless steel with about 0.8 mm perforation. The strainer shall have screwed blow off connections fitted with removable plug. The free opening area shall be at least three (3) times the internal pipe area.
- d) Numbers and location of steam traps shall be selected by the Contractor.

5.12.0 Fuel Oil Heaters

- a) The heaters shall be located adjacent to the fuel oil pumps, preferably on a common structural steel base plate with suitable drip lip and plugged drain connection.



- b) The heaters shall be shell and tube type heat exchanger designed as per HEI/IS-4503 or equivalent to meet the performance requirements as given. The heat exchanger shall be shell/straight tube single pass type having oil flow through the tubes. Care shall be taken in design and construction to prevent oil leakage into steam space.
- c) Suitable lugs for gripping the insulation material shall be provided on the heater shell.
- d) Each heater shall be furnished with cast steel flanged relief valves to protect the heater from excess pressure and air vents with valves in the oil and the steam compartment. Steam trap outlets and all drains shall be brought to one common point.

6.0.0 CONTROL AND INSTRUMENTATION

- a) The HFO and HSD unloading pumps shall be controlled/operated from the Local control panel. The unloading pumps shall be automatically tripped of in the event of high level in the connected storage tanks.
- b) The HFO and HSD pressurising pumps system shall be controlled and monitored from Central Control Room (CCR) through the DCS Remote I/O unit. The pressurizing pumps shall be automatically tripped in the event of any of the followings :
 - 1) low level in the connected storage tanks
 - 2) pump suction temperature lower than 55°C (for HFO only).

The stand by pressurising pump shall be automatically started in the event of either low pressure in respective pump discharge header or tripping of any of the running pumps.

- c) Drain oil pumps and recovery oil pumps shall have manual control/operation from the Operator Station in the CCR. Drain oil pump shall, however, be automatically tripped in the event of low level in drain oil tank.
- d) Steam flow to the HFO tank heaters shall be controlled by the pneumatically operated shut off valve (On/off type) on individual lines to maintain desired level of oil temperature. One pneumatic control valve shall be provided on the steam supply line to each suction heater in HFO tank to control the tank outlet temperature.
- e) Steam flow to each HFO heater shall be independently controlled by means of the control valve on steam line to control the heater outlet oil temperature. The motorized valves on steam supply lines to HFO heaters shall have start/stop facilities from the Local and also from the Central Control room
- f) Recirculation control valve shall be provided for HFO & HSD forwarding pumps to maintain pump discharge & to the protect pumps from over-pressurization of the piping in the event the downstream valves being closed with the pumps in service.
- g) All the transmitters, switches used in this area shall be explosion proof and shall have the zener protection.

7.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED ALONG WITH THE PROPOSAL

- Technical Data Sheets duly filled up
- System description Fuel oil unloading system
- General Arrangement Drawings
- Manufacturers catalogues
- Equipment layout drawings
- Electrical load list



- Technical Data sheets for the Motor and Actuators
- Load list / drive list
- Specification, data sheet and catalogues for motor
- Alarm list and Instrument list
- Technical data sheets of all instruments and control panel along with catalogue
- Write – up on operation & control philosophy
- Write-up on Control system
- Process & Instrumentation drawing
- GA drawing & Local control panel details
- Power consumption details
- Bill of Quantities
- List of Codes and Standards
- Lubricants list (with quantities for initial fill and make-up)
- Inspection and Test Plan (ITP)
- Quality Assurance Plan.
- List of tests to be conducted at shop and at site
- Testing procedures
- Surface protection & painting procedures
- List of all maintenance tools, tackles and accessories required for maintenance of the offered equipment including bought out components
- List of all recommended spare parts for all equipment offered including bought out components
- List of commissioning spares
- List of sub-vendors/ sub-contractors
- Detailed engineering, manufacturing and delivery schedule
- Details of similar job executed in last five years
- End user certificates

8.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED AFTER AWARD OF CONTRACT

Mechanical

- Final version of the technical data sheet with vendor drawings/catalogues and performance curves
- Final version of system description and control philosophy
- Design Criteria for the equipment
- Process design calculations with detailed equipment sizing design criteria.
- Capacity calculations (flow & head) for all pumps, heat exchangers, control valves etc., of the system.
- Pressure loss calculations across all filters (to be identified individually) and pipeline & valves
- All pressure vessels and tanks thickness calculations
- Insulation thickness calculation
- Detailed equipment layout showing details such as views, elevations, plans, sections, etc
- Final version of general arrangement of all equipment and vessels including details of materials
- Sectional drawings of all equipment giving details of materials and design calculations.
- Piping layout drawings, support drawing with bill of quantities.
- Piping isometric drawings for pipes >2"
- Pipe support drawings with details
- Final version of Utility Consumer list
- Equipment list with detailed technical specifications of all items.
- Pipe line list
- Valve list indicating detailed technical specifications (make, size, range)
- Piping specification



- Fabrication drawings of equipment & tanks
- List of oil, lubricants, grease etc. for all equipment, as required.

Civil

- Foundation outline drawing showing plan dimensions and elevations and loading details, pocket size, etc.
- Point of action of static and dynamic loads in plan and elevation for all equipment & tanks / structures.
- For foundations subject to vibrations in addition to the above, the following shall be furnished.
 - Weight of rotating parts.
 - Unbalanced force to be considered for dynamic design along with its direction and point of application.
 - Maximum allowable amplitude of vibrations in vertical and horizontal direction.
- Details of control room, layout, air-conditioning requirements etc.
- Layout and details of anchor bolts for equipment and tank / structures
- Embedment details
- Special instructions if any on civil works for both design and construction aspects

Electrical

- Technical Data sheets for the Motor and Actuators
- Control scheme for Motor Starter
- Control scheme/wiring diagram for Actuators.
- Load list/ drive list
- BOQ of Materials for Earthing.
- GA drawing & terminal box detail for Motor
- Motor curves including Torque Vs speed, Thermal withstand, Locked rotor curves (hot & Cold), Starting characteristics (at 80% & 100% rated voltage), Performance curve (output Vs efficiency, output Vs current, output Vs slip).
- Any floor opening/cut-out / embedded plate details for cable routing / equipment installation

Control & Instrumentation

- Final version of instrument list and I/O list
- Detailed P&ID
- Detailed write-up on operation, control & design Philosophy
- Power & control cable schedule
- Schedule of instruments and controls indicating operating parameters, ranges etc.
- List of alarm annunciations with set values
- Technical data sheets for all instruments and controls
- Sizing calculations for all flow elements and control valves
- Protection and interlocking logics for the System.
- Technical specification for relay based LCP
- General arrangement, front layout, internal arrangement etc. for the panel
- Internal and external cable inter connection details for LCP
- Interconnecting cable schedule
- Instrument location layout and cable routing layout
- Instrument air routing layout
- Junction Box (JB) schedule
- Instrument loop diagrams
- Power supply distributions diagram
- Instrument installation diagrams
- Control schemes



- Write-up for controls and interlocks provided.
- Detailed technical write-up and operating instructions of instruments
- Test Certificate for all the instruments

General

- Drawing / Document submission schedule
- Terminal point schedule
- Erection procedure/ manuals and Commissioning manuals.
- Operation and maintenance manual.
- List of maintenance tools spares for startup commissioning and trouble free operation
- Any other documents pertaining to the supplied equipment required for construction, operation, maintenance and repair.
- Material test certificates, inspection & test report, performance test report
- As built drawings
- Final version of surface protection & painting procedures
- Equipment nameplate details
- Erection Bill of Quantities

Any other drawings required for review during the detailed engineering stage, same shall also be submitted by contractor.



ANNEX 2.9.1

SPECIFIED DESIGN DATA

S.No	Description	Unit	Data
I	HFO UNLOADING PUMPS		
1	Type		Horizontal, twin-screw type, steam jacketed
2	Number	nos.	3(2Working + 1 Standby)
3	Rated capacity	m ³ /hr	100(each)
4	Rated head	mlc	As per design criteria
5	Duty		Intermittent and parallel operation
6	Type of drive		Directly driven by electric motor
7	Relief Valve		Yes
8	Material of construction		
8.1	Rotor		Stainless Steel
8.2	Shaft		Stainless Steel
8.3	Shaft sealing		Mechanical Seal
8.4	Casing & Rotor housing Material		CI as per IS :210 Gr. 260
8.5	Driving gear		Hardened and tempered alloy steel with machine cut teeth and ground finish.
II	HSD UNLOADING PUMPS		
1	Type		Horizontal, twin-screw type
2	Number	nos.	2(1Working + 1 Standby)
3	Rated capacity	m ³ /hr	50(each)
4	Rated head	mlc	As per design criteria
5	Duty		Intermittent and parallel operation
6	Type of drive		Directly driven by electric motor
7	Relief Valve		Yes
8	Material of construction		
8.1	Rotor		Stainless Steel or Equivalent subject to approval of Owner
8.2	Shaft		Stainless Steel or Equivalent subject to approval of Owner
8.3	Shaft sealing		Mechanical Seal
8.4	Casing & Rotor housing Material		CI as per IS: 210 Gr. 260
8.5	Driving gear		Hardened and tempered alloy steel with machine cut teeth and ground finish.
III	HFO PRESSURISING CUM FORWARDING PUMPS		
1	Type		Horizontal, triple-screw type, steam jacketed



S.No	Description	Unit	Data
2	Number	nos.	3(2W + 1S)
3	Rated capacity	m ³ /hr	As per requirement
4	Rated head	mlc	As per design criteria
5	Duty		Intermittent and parallel operation
6	Type of drive		Directly driven by electric motor
7	Relief Valve		Yes
8	Material of construction		
8.1	Rotor		Stainless Steel
8.2	Shaft		Stainless Steel
8.3	Shaft sealing		Mechanical Seal
8.4	Casing & Rotor housing Material		CI as per IS :210 Gr. 260
8.5	Driving gear		Hardened and tempered alloy steel with machine cut teeth and ground finish.
IV	HSD PRESSURISING CUM FORWARDING PUMPS		
1	Type		Horizontal, triple-screw type
2	Number	nos.	3(2W + 1S)
3	Rated capacity	m ³ /hr	As per requirement
4	Rated head	mlc	As per design criteria
5	Duty		Intermittent and parallel operation
6	Type of drive		Directly driven by electric motor
7	Relief Valve		Yes
8	Material of construction		
8.1	Rotor		Stainless Steel or Equivalent subject to approval of Owner
8.2	Shaft		Stainless Steel or Equivalent subject to approval of Owner
8.3	Shaft sealing		Mechanical Seal
8.4	Casing & Rotor housing Material		CI as per IS: 210 Gr. 260
8.5	Driving gear		Hardened and tempered alloy steel with machine cut teeth and ground finish.
V	HFO STORAGE TANKS		
1	Number	nos.	2
2	Effective Capacity	m ³	3000
3	Type of construction		Vertical, cylindrical, fixed roof type with atmospheric vents
4	Design Code		API 650 / IS:803
5	Operating /design Temperature	Deg. C	Tank maintenance temp/ As per design criteria
6	Design Pressure		API 650
7	Material of construction		Plates : IS 2062



S.No	Description	Unit	Data
7.1	Steel plates		Carbon steel IS 2062
7.2	Structural Shapes		Carbon steel IS 2062
7.3	Nozzles		Carbon steel IS 2062
7.4	Flanges		Carbon steel IS 2062
8	Venting Capacity		As per API 2000/ IS 803
9	Insulation		Yes
10	Steam floor coil heater & Suction heater		Required
VI	HSD STORAGE TANK		
1	Number		1
2	Effective Capacity	m ³	1000
3	Type of construction		Vertical, cylindrical, fixed roof type
4	Design Code		IS:803 / API 650
5	Operating/design Temperature	Deg. C	Ambient / 60
6	Design Pressure		API 650
7	Material of construction		Plates : IS 2062
7.1	Steel plates		Carbon steel IS 2062
7.2	Structural Members		Carbon steel IS 2062
7.3	Nozzles		Carbon steel IS 2062
7.4	Flanges		Carbon steel IS 2062
8	Insulation		Not applicable
9	Venting Capacity		As per IS 803/API 2000
10	Floor coil heater & suction Heater		Not applicable
VII	HFO STORAGE TANK- FLOOR COIL HEATER		
1	Design code		As per Manufacturer std subject to approval of Owner.
2	Design minimum heat load	kW	As per design criteria
3	No of heating element		As per requirement
4	Material of construction		A106 Gr B
5	Safety		All safeties as per code shall be provided. Bidder shall furnish a list of all such safeties.
6	Corrosion allowance	mm	1
VIII	HFO STORAGE TANK- OUTFLOW HEATER		
1	Design code		API / TEMA
2	Design minimum heat load	kW	As per design criteria
3	No of heating element		As per requirement
4	Material of construction		A106 Gr B
5	Safety		All safeties as per code shall be provided. Bidder shall furnish a list of all such safeties.
6	Corrosion allowance	mm	1



S.No	Description	Unit	Data
IX	HFO HEATERS		
1	Type		Shell (OIL) and tube(STEAM) type with U type seamless tube bundle heater
2	Design code		API / TEMA
3	No: of heaters		2(1W + 1S)
4	Material of construction		A106 Gr B
X	HFO COOLERS		
1	Type		Shell (OIL) and tube(WATER) type with U type seamless tube bundle heater
2	Design code		API / TEMA
3	Number		2(1W + 1S)
4	Material of construction		A106 Gr B
XI	HFO pressuring Pumps-Recirculation Control Valve		
1	Valve Type		Globe
2	Action		Single/Direct
3	Port		Single port
4	End connection		Butt weld / Flanged
5	Shutoff class		Class V
6	Positioner type		HART compatible
7	Handwheel		Top mounted
XII	HSD pressuring Pumps-Recirculation Control Valve		
1	Valve Type		Globe
2	Action		Single/Direct
3	Port		Single port
4	End connection		Butt weld / Flanged
5	Shutoff class		Class V
6	Positioner type		HART compatible
7	Handwheel		Top mounted
XIII	DRAIN OIL TANK		
1	Number		As per the Requirement
2	Capacity	m ³	As per the Design
3	Type of construction		rectangular
4	Design Code		API 650/ IS 803
5	Operating/design Temperature	Deg. C	45/60 Deg. C
6	Design Pressure	bar	API 650
7	Material of construction		Carbon Steel IS 2062, Underground
8	Insulation		applicable
9	Steam Coil Heater		applicable
10	Steam Suction coil Heater		Not applicable
11	Venting Capacity		As per API :2000 / IS 803
XIV	DRAIN OIL PUMP		
1	Number		2 (1W+1S) per drain oil tank



S.No	Description	Unit	Data
2	Type		Vertical , non clog, single screw pumps
3	Rated Capacity	m ³ /hr	Min 5
4	Head	mlc	As per Design criteria
5	Duty		Intermittent operation
6	Type of drive		Direct driven by electric motor
7	Material of construction		
7.1	Rotor		Stainless Steel
7.2	Shaft		Stainless Steel
7.3	Driving gear		Hardened and tempered alloy steel with machine cut teeth and ground finish.
XV	RECOVERY OIL TRANSFER PUMPS		
1	Number		2 (1W+1S)
2	Type		Vertical , non clog, single screw pumps
3	Rated Capacity	m ³ /hr	Min.5
4	Head	mlc	As per Design criteria
5	Duty		Intermittent operation
6	Type of drive		Direct driven by electric motor
7	Material of construction		
7.1	Rotor		Stainless Steel
7.2	Shaft		Stainless Steel
7.3	Driving gear		Hardened and tempered alloy steel with machine cut teeth and ground finish.
XVI	WASTE WATER PUMPS		
1	Number		2 (1W+1S)
2	Type		Wet pit, Vertical, non-clog, Centrifugal type
3	Rated Capacity	m ³ /hr	Min.5 (shall be finalized DDE)
4	Head	mwc	As per Design criteria
5	Duty		Intermittent operation
6	Type of Drive		Direct
7	Material of Construction		
7.1	Rotor		Ni- cast Iron (250 BHN)
7.2	Shaft		B.S.970 EN8 / Equiv
7.3	Casing & Rotor housing Material		Ni- cast Iron (250 BHN)
XVII	OILY WATER MIXTURE TRANSFER PUMP		
1	Number		2(1W + 1S) for each oil water collection sump
2	Type		Wet pit, Vertical, non-clog, Centrifugal type
3	Rated Capacity	m ³ /hr	Min 5
4	Head	mlc	As per Design criteria



S.No	Description	Unit	Data
5	Duty		Intermittent operation
6	Type of Drive		Direct
7	Material of Construction		
7.1	Rotor		Ni- cast Iron (250 BHN)
7.2	Shaft		B.S.970 EN8 / Equiv
7.3	Casing & Rotor housing Material		Ni- cast Iron (250 BHN)
XVIII	OIL WATER COLLECTION TANK		
1	Number	no.	As per the design requirements
2	Capacity	m ³	5
3	Material of Construction		RCC, Underground
XIX	OIL WATER SEPARATOR		
1	Number	no.	1
2	Capacity	m ³	DDE
3	Material of Construction		RCC, Underground
XX	CONDENSATE FLASH TANK		
1	Number	no.	1
2	Capacity	m ³	As per the design requirement
3	Material of Construction		Carbon Steel IS 2002, All requirements including the radiography shall be acceptable as per IS 2825
XXI	STRAINERS		
1	Type		Simplex/duplex type
2	Material of Construction		
2.1	Body		IS :2062
2.2	Plates		Stainless Steel (SS:304)
2.3	Filters		SS 304
XXII	STEAM TRAPS		
1	Quantity /capacity		As required
2	Type		Thermodynamic or Inverted bucket type Trap
3	Body		SA 105
4	Trim material		Stainless Steel (SS 316)
5	Screen		SS 316
6	Strainer		Integral with trap
7	End connections		welded



S.No	Description	Unit	Data
XXIII	HOT WATER LANCING PUMP		
1	Number		1 x 100%
2	Type		Wet pit, Vertical, non-clog, Centrifugal type
3	Rated Capacity	m ³ /hr	5 min
4	Head	mwc	As per Design criteria
5	Duty		Intermittent operation
6	Type of Drive		Direct
7	Material of Construction		
7.1	Rotor		Ni- cast Iron (250 BHN)
7.2	Shaft		B.S.970 EN8 / Equiv
7.3	Casing & Rotor housing Material		Ni- cast Iron (250 BHN)
XXIV	HOSES		
	Fuel Oil Unloading Hoses		
1	Type		Neoprene
2	Standard		Manufacturer's standard
	Steam and Condensate Hoses		
1	Type		Carbon steel –Electro zinc plated
2	Standard		Manufacturer's standard
	Hot Water Lancing Hoses		
1	Type		Carbon steel –Electro zinc plated
2	Standard		Manufacturer's standard

**VOLUME II****SUB-SECTION 2.10****COAL HANDLING SYSTEM****INDEX**

SUB-SECTION NO.	TITLE
2.10.0	MAIN SECTION
2.10.1	BELT CONVEYORS
2.10.2	CRUSHER
2.10.3	SCREENS
2.10.4	STACKER CUM RECLAIMER
2.10.5	DUST EXTRACTION, BUNKER VENTILATION AND ROOF EXTRACTOR SYSTEMS
2.10.6	DUST SUPPRESSION SYSTEM
2.10.7	COAL SAMPLING SYSTEM
2.10.8	IN-LINE MAGNETIC SEPARATOR
2.10.9	TUNNEL VENTILATION
2.10.10	BELT WEIGH SCALE
2.10.11	METAL DETECTORS
2.10.12	FLOW DIVIDER
2.10.13	GATES
2.10.14	HOPPER
2.10.15	COAL PILE RUN OFF PIT AND PUMP
2.10.16	BULLDOZERS
2.10.17	SUMP PUMPS
2.10.18	BELT VULCANIZER
2.10.19	OPERATION AND PHILOSOPHY FOR COAL HANDLING SYSTEM
2.10.20	STONE PICKING ARRANGEMENT
2.10.21	VIBRATING FEEDER



`VOLUME II
SUB-SECTION - 2.10.0
COAL HANDLING SYSTEM

1.0.0 INTRODUCTION

- 1.1.0 This section of the specification provides the detailed technical requirements for the Coal Handling System covers the requirements for design, materials, construction features, manufacture, shop inspection and testing at manufacturer's works, testing, commissioning, performance testing as per well established engineering practices, safety codes and other relevant codes and standards.
- 1.2.0 Compliance with this specification shall not relieve the Contractor of the responsibility of furnishing material and workmanship to meet the specified conditions.

2.0.0 SCOPE OF SUPPLY

The equipments to be supplied, erected / installed, tested and commissioned under the scope of this specification shall include but not be limited to the following:

- 1 Belt Conveyors and its technological structures
- 2 Conveyor galleries, tunnels, transfer points
- 3 Crusher houses, Junction towers, etc
- 4 Crushers and screens
- 5 Unidirectional stacker cum reclaimer with rails and all its accessories
- 6 Inline magnetic separators
- 7 Sump Pumps
- 8 Metal detectors
- 9 Inline conveyor scales
- 10 Traveling trippers with all accessories
- 11 Dust Extraction Systems
- 12 Bunker ventilation system
- 13 Dust Suppression Systems
- 14 Flap gates
- 15 Flow divider
- 16 Rack and pinion gate
- 17 Rod gate
- 18 Underground hoppers
- 19 Chutes and hoods, skirt boards
- 20 Electrical/ Manual Hoists
- 21 Belt sealing arrangements with all accessories.
- 22 Plant cleaning and service water system
- 23 Pumps for dust suppression system, service water system and coal run-off pit.



- 24 All necessary piping (water and air) fittings, valves and related instruments.
- 25 Coal sampling unit With all accessories
- 26 Elevator
- 27 Essential spares
- 28 Commissioning Spares
- 29 Recommended Spares
- 30 Pent House
- 31 Coal runoff water system with piping and pumps
- 32 Vulcanizer
- 33 Bull Dozer
- 34 Reversible belt feeder
- 35 Vibrating feeder
- 36 Stone picking arrangement
- 37 Any other mechanical equipment and accessories required to complete the Coal Handling system

3.0.0 SYSTEM DESCRIPTION

This description shall be read along with the coal handling system flow diagram. The Coal handling system comprises the following:

Incoming Conveying System

Coal shall be received at the port in ships and unloaded on to the pipe conveyors which shall feed into crushers. The rated capacity of these incoming conveyors is envisaged as 3000 T/h. Two streams of conveyors are envisaged from the jetty to plant.

Screening and Crushing System

The coal as received in the plant shall be expected to be of (-) 100 mm size. Two stream of conveyors each with the capacity of 3000 T/h feeding to vibrating grizzly screens to separate (-) 25 mm before feeding to crushers. Over size (+) 25 mm coal shall be fed to Ring granulator crushers for reducing to (-) 25mm size.

Blending

Blending of domestic coal and imported coal shall be done by reclaiming coal from the respective stock piles at the required proportion and conveyed to the succeeding conveyor where they get mixed. The proposed blending ratio of imported and Indian coal shall be as follows.

The coal shall be blended in the following options,

- i) Direct Feeding domestic coal by 30 % and Reclaiming imported coal by 70 %
- ii) Direct Feeding imported coal by 70 % and Reclaiming domestic coal by 30 %
- iii) Reclaiming domestic coal by 30 % and Reclaiming imported coal by 70 %.

For the worst coal, blending option shall be 50:50. Same options as stated above shall be adopted.

Conveying system for Direct Feeding to SG Bunkers

SG bunkers shall be filled by means of conveyors with traveling tripper. Bunker sealing arrangement is envisaged for covering the bunker opening when the feeding conveyor is away



from the opening. The clearance between the bottom of the tripper floor and top of coal bunker has to be covered with steel plate to avoid dust formation.

Coal stockpiles, stacking and reclaiming

Coal received at the plant shall be stored in four stockpiles. Rail mounted slewing type Stackers cum reclaimers are envisaged for stacking and reclaiming for the proposed plant. Stockpile shall be of trapezoidal cross section. The reclaiming shall be through the bucket wheel mounted on the tip of the boom conveyor. The rated capacity of stacking shall be 3000T/h. The rated capacity of reclaiming shall be 3000T/h. The machine shall be capable of stacking / reclaiming anywhere along the stockpile. The stockpile height shall be 10m.

Whenever the reclaimer is not available, coal shall be reclaimed by dozers into the emergency reclaim hopper (ERH). One set of emergency reclaim hoppers shall be provided for reclaiming and further it feeds boiler.

Bypass chute will be provided to bypass screen and crusher.

Below each of the emergency reclaim hoppers, rod gate, rack & pinion gate and vibrating feeders shall be provided for feeding coal to the belt conveyors. Vibrating feeders are driven by variable frequency drives thus adjusting the feed capacity.

During blending in some options combination of Stacker cum reclaimer and Emergency reclaimer shall be operated to meet the required coal quantity.

Coal yards shall be provided with plain water spray dust suppression system which would spray water on the stockpile wherever the Coal is being stacked and also dust control. Fire water system shall be provided along the rails for fire fighting purposes. The Coal yard would have a drainage system to drain out rain water.

Necessary entry points shall be provided in the stock yard for bull dozer movement. Roads shall be provided around the stockyard for the vehicle movement.

Necessary diversions/ interchanges by means of two way chutes shall be provided at strategic locations of the conveying system so as to render adequate flexibility in operation with minimum of complication. Refer flow diagram for no. of interchanging points in coal handling plant.

4.0.0 SYSTEM SIZING CRITERIA

Conveying, Stacking, Reclaiming and Bunker feeding is based on the following functional requirements:

1. Bulk density of coal considered for calculation:

For calculation of volume : 800 kg/m³

For structural design and load calculation : 1200 kg/m³

2. All the equipment shall be suitable for handling damp and sticky coal during monsoon season with moisture content of 25% and fines (-1 mm) up to 40%.
3. The service factor for selection of flexible couplings, brakes, etc., shall be minimum 1.5 of the motor rating.

The service factor for selection of gearbox shall be minimum 1.5 installed motor rating or 2.0 on shaft power and whichever is higher shall be considered for selection.



The service factor for selection of fluid coupling shall be minimum 1 installed motor rating.

4. The type of high speed coupling between motor and gearbox shall be as follows:
 - (a) For motor rating below 30 kW : Resilient type flexible coupling
 - (b) For LT motors of 30 kW and above : Traction type fluid coupling
 - (c) For HT motors : Actuator operated scoop type fluid coupling/ CST drive incorporated a wet clutch system that is located on the gear box ,allowing the motor to be started under no load condition.

For the scoop type fluid coupling, fan-cooling arrangement shall be provided. Geared couplings have been considered as low speed couplings for all the conveyors.

5. Coal handling system shall have 100% standby arrangement for reliability.
6. The motors, gearboxes, couplings, pulleys and belt for conveyors shall be standardized and no. of types shall be limited to minimum possible.
7. All equipment drives shall be capable of starting on full load. However two stream operations shall be considered for designing coal handling system. All electrical system, water requirement shall be designed accordingly.
8. Gear box for all equipment with drive motor rating of above 10 kW shall be hardened and ground helical / bevel helical type. All inclined conveyors shall be provided with hold back integral with the gearbox.
9. All equipments upto the crusher shall be designed for handling coal of (-) 100 mm and beyond the crusher house shall be designed for handling coal of (-) 25 mm nominal size.
10. Rated System capacity of all the system (except for the Emergency reclaim system) shall be 3000T/h and design capacity shall be margin of 10%.
11. Rated System capacity of Emergency reclaim system shall be 1000T/h and design capacity shall be margin of 10%.
12. Bidder shall provide sheds either in two stock piles or in four stock piles. If provided for two stock piles, the covered shed shall be 270m. If provided for all four stock piles , the covered shed shall be 140m. Stacker cum, reclaimers shall move inside the covered shed. Accordingly shed height shall be constructed. Width of the shed shall be constructed considering the dozer movements. .
13. Complete stockpile shall be accessible by stacker cum reclaimer.
14. Barricading (Wind Barrier) is provided around coal yard to avoid flying of coal dust. The height of the barricading will be 12m from FFL including RCC retaining wall of 1.0 M height .The barricading shall be of permanent colour coated perforated Galvalume metal sheet of approved quality and supported by structural steel / pipe with suitable foundation system. Galvalume sheet supporting structure and its foundation system shall be designed for critical combination of wind and other applicable loads as per the relevant standards. The coating and galvanization of Galvalume sheet shall be as per Section 5/Vol.II of the Specification (as applicable for coal handling) . Dust suppression efficiency of the board shall be 85% (min).
15. Stockpile paving shall be provided upto the roads provided around the stockpile.



5.0.0 LAYOUT AND MAINTENANCE REQUIREMENTS

- 5.1.0 Minimum clearance between the bottom of the tail pulley and floor in junction tower / crusher house / transfer house / tunnel shall be 500 mm.
- 5.2.0 The sizes of the junction towers, transfer houses and crusher house and the floor elevations shall be finalized by the Contractor considering a minimum clear walkway space of 1500 mm around the equipment in each floor. The clear distance between the floors shall be minimum 3000 mm (bottom of beam/hoist) and the headroom shall be suitable for handling / removing the equipment at the head end and tail end. The floors of junction towers and crusher house (like crusher) shall be designed for keeping the heaviest part of the equipment anywhere on the floor for maintenance purpose. Adequate space for maintenance of equipment shall be provided. The length and elevation of the conveyors shall be finalized by the Contractor based on the limitations for the inclination furnished. All underground conveyors shall be located suitably in enclosed tunnel. Conveyor tunnel shall be adequate depth having minimum height of 3500mm.
- 5.3.0 Adequate space around the crusher in the crusher house shall be provided for opening the cage of the crusher and for removal of the shaft.
- 5.4.0 Partitions with slide doors shall be provided in the crusher house between the crushers to enable maintenance of standby crusher when the other crusher is operating. Adequate maintenance space and handling facilities shall be provided on both sides of the partition wall. Independent handling facilities shall be provided for each crusher.
- 5.5.0 All conveyor galleries shall be provided with dust sweeping hoppers covered with removable chequered plates. There shall be one dust hopper for each walkway of gallery and the same shall be provided at each trestle location. Similarly, 2 nos. dust hoppers shall be provided for each floor or junction towers / crusher house. These dust hoppers shall be connected to a dust chute to enable the dust swept to be led to the ground level. Wherever monorails are projecting outside the building, sliding doors in the outer wall shall be provided. Floor wash from coal handling area shall be taken to ETP. Separate rain water pipeline from roof top of junction towers / crusher house upto ground level shall be provided.
- 5.6.0 There shall be Electric hoist and manual hoist for handling during maintenance. The path way of monorail shall be close enough for easy handling of the equipment to be lifted. Extension of the monorail outside shall be minimum three (3.0) meter from the out side of the wall/ column of the building.
- 5.7.0 When a belt is being changed it shall be possible to pull the new belt into position with the old. Suitable openings shall be provided in gantries, buildings, etc. Removable snub pulleys should be used to prevent the belt snagging on sharp corners.

Required and necessary hooks with sufficient capacities shall be provided at various locations of the transfer tower for maintenance / handling of equipment and for belt changing purpose.

- 5.8.0 Maintenance platform of minimum one meter width with handrails and access ladders shall be provided for the flap gates and flow divider accessibility.

There shall be two access staircases from ground level to different floors in the Crusher House. Out of the two staircases, one shall be located completely inside the crusher house and the other shall be located outside the crusher house with cover at two different ends of the crusher house.



6.0.0 INSPECTION, TESTING & PERFORMANCE GUARANTEES

6.1.0 System Performance Requirements

The coal handling system and equipment shall perform satisfactorily to meet the guarantee requirements specified in the following clauses.

The capacity figures specified for the equipment shall have to be achieved with tolerance on the positive side. The guarantee requirements shall be met without undue vibrations in the conveyor supports, junction towers, crusher house, transfer house, etc.

6.2.0 Functional Guarantees for Coal Handling System

The system shall be tested for performance for designed capacity specified for all the equipment have to be achieved with no negative tolerance.

1. **CONVEYORS:** The capacity shall be achieved with specified maximum input size of coal even while handling damp & sticky run-of-mill / crushed coal during rainy season having 25 % moisture content & fines upto 40 % with out any spillage / choking / over loading of equipment. The Contractor shall guarantee – speed, capacity, power consumption at motor terminals, vibrations & noise levels, alignment of conveyor belt, & trueness with the centre line.
2. **CRUSHERS & SCREENS:** shall be capable of delivering design capacity, with specified maximum input size of coal even while handling damp & sticky run-of-mill coal having 25 % moisture. The Contractor shall guarantee the design capacity & size of out put coal, noise & vibrations of the crushers at full load, power consumption. The screens shall screen out all the materials having dimensions of less than or equal to 25 mm size, even during rainy season with 25 % moisture content. Fines (-1mm) shall not exceed 10% of crushed product. Screens shall screen out 95% of sized material even during rainy season.
3. **STACKER RECLAIMER:** shall have the design capacity to stack or reclaim the specified coal even while handling well compacted, damp & sticky coal during monsoon season. The capacity shall be arrived at on working for 6 hours over complete cross section of the stock pile. The Contractor shall guarantee – design capacity of stacking / reclaiming, luffing & slewing area, speed of the intermediate conveyor, noise & vibration, power consumption.
4. **DRIVE MOTORS:** shall be suitable for direct on line starting fully loaded conveyors / feeders. The Contractor shall guarantee power consumption.
5. **NOISE LEVEL:** should not exceed 85 dBA at a distance of 1.0 meter from equipment.
6. **Vibration level of equipments at bearings** shall not exceed the following limits for different equipment. Vibration levels shall conform to the limits specified below and shall be measured as per BS 4675.

At the bearing of drive pulley, motor and gear box for the following equipment:

Crushers	: 160 microns
Conveyors	: 75 microns
Stacker reclaimers	: 115 microns
All other equipment / feeders, screens etc	: 75 microns.
Floors & columns of drive house	: 200 microns.



7. Magnetic separator shall separate the magnetic material of the sizes and shapes mentioned in this specification effectively.
8. Accuracy of belt weigh scale shall be as specified in data sheet
9. Endurance Test: each stream & each path shall be tested at design capacity for 24 hours to prove that the system functions satisfactorily with out any trip due to over load or system fault.
10. All necessary instruments including walkie-talkies
11. Dust Control System: At the outlet of the dust extraction system, the dust concentration should not exceed 50 mg/Ncu.m.
12. Dust Suppression System: shall effectively suppress the dust at all unloading points.

6.3.0 Guarantee Test Procedure

In accordance with the specification, on successful completion of trial operation, the plant shall be subjected to Guarantee Tests. Further, the PG Tests shall be conducted as per the procedure specified in the following paragraphs. Contractor shall prepare PG procedure document and same shall be subject to Owner's approval

6.3.1 Pre-requisite to the Guarantee Tests

The pre-requisites to be ensured by Owner and the Contractor prior to start of the tests as mutually agreed.

The plant shall be jointly inspected by Owner and the Contractor & a joint protocol shall be signed that the plant is fit for Guarantee Tests.

6.3.2 Testing for Performance Guarantees

6.3.2.1 Flow Path Capacity Tests

- i) For the direct Flow Path from JNT-1 to bunker feeding, two conveyor streams shall be formed with suitable CRISS-CROSS Combinations (if applicable) of 'A' or 'B' Conveyors/ intermediate equipment. 70:30 and 50:50 blending options are used for the capacity tests.
- ii) Above streams shall also be independently tested for performance & guarantee. Further, the equipment / conveyors (except common equipment) used for performance testing of one stream shall not be used for performance testing of the other stream.
- iii) In case of direct flow path, Guarantee test should include operation of the travelling trippers provided on conveyors However, for purpose of measurement of guaranteed power consumption the coal shall be discharged into the last bunker of unit-1.
- iv) While operating at the guaranteed capacity of various equipment of CHS, non-spillage of coal and non-choking of chutes / equipment shall be demonstrated as indication of smooth continuous flow through the conveyor system.

6.3.2.2 Major Equipment capacity tests

- i) Guaranteed capacity of all the major equipment as identified shall be established separately by operating only one equipment out of the two of a set at a time.



- ii) To confirm the guaranteed capacity of screens and crushers Guarantee test shall be conducted for combination of associated screens and crushers. But for one set (only), capacity of crusher shall be tested individually by blanking of the associated screen.

6.3.2.3 Power Consumption Measurement

- i) The guaranteed power consumption as total sum of all the equipment as specified shall be measured during capacity test of the identified Flow Paths for both the streams separately.
- ii) Measurement Terminal(s)

The guaranteed power consumption for the entire Flow Path shall be taken during capacity test as sum of the power measurements at the following terminals.

1. 6.6 kV CHS Switch board incoming terminal
2. Each of 415V CHS MCC incoming terminals

Further the power consumption for the equipment being fed from CHS board/LT board but not to be considered for guaranteed power consumption shall be measured separately at their respective MCC/LT & HT switchgear input terminals and shall be subtracted from the total power consumption measured. However, if conditions permit such equipment may not be operated during power measurement duration.

For Stacker / Reclaimer machine, the average power consumption shall be measured through energy-meter at HT switchgear feeder to Stacker / Reclaimer. For Conveyors, the power consumption shall be measured at their respective switchgear terminals.

Contractors may note that the liquidated damages for power consumption shall be levied separately and independently for individual coal flow paths i.e. direct path, stacking path and reclaiming path. Contractors shall guarantee the total power consumption for individual paths.

- iii) Time Duration

Power Consumption measurement shall be done only for 15 minutes after the conveyor flow rate stabilizes at the guaranteed capacity.

- iv) Meters

Ammeter / Voltmeter readings shall be noted from the meters mounted on the control desk / LT switchgear / HT switchgear or if necessary by means of clamp type meters.

For power measurement 3-Phase wattmeter (2/3 element) / two wattmeter method shall be used. Power measurement shall be taken after stable condition is achieved.

Watt meters shall have a min. accuracy class of $\pm 1\%$ Energy meter shall be of min. $\pm 1\%$ CTs & VTs shall have accuracy of $\pm 1\%$. All meter readings shall be recorded. No corrective allowance shall be allowed over the measured values.

The details of watt meters and energy meter along with their calibration certificate shall be furnished to Owner before start of tests.

6.3.2.4 General

- i) Test Duration



- a) Normal duration of the above capacity tests shall be four hours. However, minimum one (1) hour continuous & steady operation shall be required to establish the guaranteed capacities.
- b) In case of any minor interruption due to operation of electrical protection as well as stoppage due to safety reasons the duration of test shall be extended by the time lost in such interruptions. In case of exceptionally longer interruptions calling for re-mobilization and re-preparation of plant the implications shall have to be mutually discussed and agreed upon.

6.3.3 Testing for Demonstration Requirements

The specified performance parameters of various equipment / system including but not limited to the following shall be demonstrated to the full satisfaction of the Owner. All interlocks, indications, annunciations as per approved write-up on control philosophy shall be verified. Paths mentioned in it shall be demonstrated.

6.3.3.1 Conveyors

a) Conveyor Profile

- 1. Check against lifting of conveyor belts over concave curves at the time of start under empty belt, full load and partial load condition.
- 2. Check against wrapping, folding of belt over convex curves and at the beginning of trippers specially while feeding the initial bunkers.

b) Coasting Time

Coasting down time of conveyors including check for spillage / blockage of coal in the chutes.

c) Belt Alignment

Check against abnormal sway during operation

d) Self aligning idlers

Satisfactory performance. Free rotation.

e) Control / Sequential Operation

Auto & manual control / sequential operations include starting & stopping of coal handling plant equipments performance checks.

f) Protection Switches

Satisfactory operation of pull chord, belt sway, zero speed and chute blockage switches, etc.

g) Load Start

Ability to start under full designed load

h) Simultaneous Operation

Demonstration of simultaneous operation of both the streams under full load.



i) Vibration Level in Conveyors

Both velocity and amplitudes for all the conveyor drives and in each conveyor gallery under different conditions of conveyor operation as desired by Owner. Observations shall be recorded. The permissible limits shall be as per VDI 2056/ IS:12075/BS:4999, Part 142. Vibration at base frame of drive equipment and at drive floors of various buildings shall also be taken and this shall be within tolerable limits.

j. Skirtboard:

k. Perfect sealing with no spillage/no dust.

6.3.3.2 Crushers

1. Output coal size to be less than 25 mm.
2. Vibration measurement: Both RMS velocity and amplitudes at bearings shall be measured. Permissible limits shall be as per VDI 2056 / IS 12075 / BS 4999 Part 142.
3. Demonstration of design output even when handling damp sticky coal having maximum moisture level.
4. Easy operation of device for adjusting gap between cage bars / cage screen and hammers to be demonstrated.

6.3.3.3 Coal Sampling Unit

Demonstration of satisfactory operation of the system continuous for one week.

Satisfactory operation of the CSU shall necessarily include testing on random basis, trouble free smooth operation, absence of choking tendency and ability to collect samples automatically and continuously for a minimum of 24 hrs. of conveyors operation without requiring any manual intervention.

Demonstration of trouble free operation of all equipments including crushers even when handling damp sticky coal having maximum moisture level is to be demonstrated.

Free carriage and cutter movement proper dust door closing and perfect sealing.

Bias Test

Overall system performance (by collecting stop-belt samples)

Particle size reduction performance of the crushes. (The sampling system shall provide for collection and transport of reject in various stages of the sampling system to facilitate performance testing of the sampling system).

6.3.3.4 Metal Detector

1. Tests for detection of specified smallest size buried under coal.
2. Tests for detection of pieces of different metals like brass, SS, manganese steel, bars, scrap, brake shoes, shovel teeth etc.
3. Operation of sand bag marker.



6.3.3.5 In line magnetic Separators

1. Demonstration of magnet capacity to separate out specified sizes and weights of magnetic pieces
2. Collection of picked up pieces into tramp iron chutes / trolley
3. Position adjustment with turn – buckle arrangement

6.3.3.6 Flap Gates

1. Remote, local and manual actuation of gates.
2. Check for stroke and operation of limit switches.
3. Demonstration of actuation of gates while feeding coal in manual mode.

6.3.3.7 Travelling Trippers

1. Proper to & fro travel.
2. Operation of brakes and rail clamps at full load.
3. Check against dragging during startup or running.
4. Check against blockage of discharge chutes at full load.
5. Check for proper reeling / unreeling operation of flexible cable.
6. Satisfactory operation & functioning of bunker sealing arrangement.
7. Check against folding / wrapping of belt at the beginning of the tripper specially while feeding initial bunkers.

6.3.3.8 Dust Suppression System

1. Head of pumps to be measured.
2. Pressure available at sprinkler nozzle manifolds (on random basis) in running condition to be measured (pressure not less than 4.5 kg/cm²(g)).
3. Demonstration of the entire stockpile coverage by the sprinkler
4. Satisfactory spray atomization and dust suppression effectiveness.
5. Measurement of SPM before and after DS system operation

6.3.3.9 Ventilation System

1. Rated volumetric capacity and head of individual fans to be measured covering atleast 2 nos. of each type / application and rating.
2. Vibration measurement: Both RMS velocity and amplitudes at bearings shall be measured and measured. Permissible limits shall be as per VDI 2056/IS 12075/BS 4999, Part 142.



6.3.3.10 Gear Boxes

- i. Temperature not to exceed designed values.
- ii. Satisfactory operation of hold back.
- iii. No oil leakages.
- iv. No abnormal sound

6.3.3.11 Fluid Couplings

- i. No excessive rise of temperature.
- ii. No oil leakages
- iii. Satisfactory operation of temperature switches.
- iv. No abnormal sound

6.3.3.12 Brakes

Satisfactory operation and synchronization of brakes of various conveyors so as to hold up coal in chutes after tripping.

6.3.3.13 Belt Scrappers

Satisfactory operation of belt scrappers at various moisture levels of coal and proper adjustment.

6.3.3.14 Reversible Stacker / Reclaimer

1. Stacking at maximum boom height
2. Reclaiming at maximum and minimum stockpile heights
3. Long travel speed to & fro
4. Satisfactory operation of limit switches, alarms and other controls.
5. Slewing and Luffing motions
6. Rail tolerances
7. Satisfactory operation of rail clamps, cable reeling drums, belt weigher

6.3.3.15 Screen

Design capacity and screening efficiency.

6.3.3.16 Belt weigher

Standard execution : as mentioned in the data sheet;



6.3.3.17 Control & Instrumentation Equipments

- i) Demonstration and Inspection test for PLC, Microprocessor based system, Local control panels, etc., Detailed inspection and testing is explained in Section 4.
- ii) Satisfactory operation of the control operations and annunciations.
- iii) The redundancy test for control operation of coal handling plant.

6.3.3.18 Noise Levels

- i) Noise level measurement, for conformance to specified levels, to be done around the following equipment / areas:
 - 1. Conveyor drive, discharge terminal (including discharge chute, gearbox, coupling & motor).
 - 2. Screens
 - 3. Coal Crushers.
 - 4. Coal discharge chutes on intermediate floors in possible impact zones.
 - 5. Ventilation fans.
 - 6. Water supply & Dust suppression pumps.
- ii) Noise level measurement shall be done around the specified equipment location in the following manner.
 - a) The measurement shall be carried out with a calibrated integrating sound level meter meeting the requirements of IEC-651 or BS-5969 or IS:9779.
 - b) Sound pressure level shall be measured all around the equipment at a distance of 1m from the vertical projected plan of the equipment as a whole (this shall include coupling, gear box, motor etc.) at a height of 1.5 m from floor level. Microphone positions shall be at horizontal separations of not more than 1.5m around the equipment.
 - c) The measurement shall be done with slow or impulse response, as the case may be on the A-weighting scale. The average of the A-weighted sound pressure level measurements expressed in decibels to a reference of 0.0002 micro bar shall not exceed the guaranteed value indicated in the specification.
 - d) The tests shall be carried out with the equipment operating at near rated speed & load correction for back ground noise shall be considered inline with IS:4758. Noise level measurement shall be recorded.

7.0.0 DRAWINGS, DATA / DOCUMENTS TO BE SUBMITTED ALONG WITH OFFER

- 7.1.0 Completely filled up technical schedules and data sheets of tender documents
- 7.2.0 General arrangement and sectional elevations drawings for all the conveyors, transfer House's, tunnels, junction towers, crusher houses, etc.
- 7.3.0 Descriptions and write-up of the control systems



- 7.4.0 Control system configuration
- 7.5.0 Complete electrical load list.
- 7.6.0 Details of similar job executed in last five years
- 7.7.0 Mandatory spares
- 7.8.0 Start up and commissioning spares
- 7.9.0 3 years Operation and maintenance spares
- 7.10.0 Special Tools and tackles for erection & maintenance
- 7.11.0 Utilities requirement

8.0.0 DRAWINGS, DATA / DOCUMENTS TO BE FURNISHED BY THE SUCCESSFUL BIDDER

The Contractor shall submit the following data/information documents/ drawings to the purchaser/consultant, who in turn will review and furnish comments on drawings/documents. Contractor shall furnish a list of data / drawings / documents which will be submitted to the purchaser/consultant, with due dates of submission immediately after award of Contract. The Contractor on fortnightly basis shall update the list. All drawings shall be generated in AUTO CAD. The following list shall not limit the contractor, if any additional documents / drawings required for the review of the owner/ consultant same to be submitted.

Master document list to be submitted by the contractor listing all the documents/ drawings.

- 8.1.0 The contractor shall submit drawings, data sheets, design calculations/criteria, write up on operation, control interlock protection, type test procedure, guarantee test procedure and erection/O&M manuals.
- 8.2.0 General arrangement drawings for transfer houses, tunnel conveyors, conveyors, control rooms, crushers house, bunker bays, dust control/ventilation equipment etc. shall be accompanied by load data details along-with basis and embedded part details/anchor bolt schedule.
- 8.3.0 Fabrication drawings of conveyor technological structures, chutes/hoppers, feeders and trippers shall be submitted for reference.
- 8.4.0 Contractor shall furnish GA and cross sectional drawing, bill of material, performance characteristics and material specification as applicable for all equipment.
- 8.5.0 Contractor shall furnish selection calculations for all drives, gearboxes, couplings, brakes etc. for all equipment.
- 8.6.0 Contractor shall furnish the design calculations selection criteria for models of all major equipment.
- 8.7.0 Contractor shall furnish operation and maintenance instruction manual
- 8.8.0 Any other drawings required for review during the detailed engineering stage, same shall also be submitted by contractor.



8.9.0 Control & Instrumentation

1. Coal Handling plant control room layout
2. Control Schemes & Logic diagram along with write up of control system
3. Hardware and software design manual (covering exhaustive details of complete DCS based control system)
4. DCS BOM
5. G.A (General Arrangement) drawings of all control panels/ cabinets / local panels with all dimensional details.
6. Input / Output list
7. Drive list / Solenoid valve list
8. Annunciation list & SER list
9. List of set points
10. Maximum DCS bus utilization under worst loading condition calculation details shall be furnished.
11. Process mimic indicating Analogue and digital parameters
12. Marshalling philosophy
13. Cabinet / Panel wiring diagrams and internal layout drawings
14. Wiring diagrams for panel, local panel, junction boxes, actuators, starters etc.
15. Instrument index
16. Instrument hook-up diagram
17. Heat load and Power consumption data for DCS



VOLUME II
SUB-SECTION - 2.10.1
BELT CONVEYORS

1.0.0 CODES AND STANDARDS

The specific codes / standards followed for the design of the system are as below:

IS: 11592 - 2000	: Code of practice for selection and design of belt conveyors
IS 1891 Part-1- 1994	: Conveyor and elevator textile beltings spec.Part.1 General
IS 1891: Part 5 1993	: Conveyor and elevator textile belting - Specification: Part 5 Fire resistant belting for surface application
IS: 8531	: Specification for Pulleys for Belt conveyors
IS: 8598	: Specification for Idlers and idlers set for belt conveyors
IS:14386 -1996	: Belt conveyors-Traveling Tripper- Motorized for belt widths 650 mm to 1600 mm- Dimensions
IS: 2062	: Steel for general structural purposes.
IS: 1239 2004 part 1	: Spec for mild steel tubes tubular and other wrought steel
IS: 3589 2001	: Steel pipes for water and sewage (168.3 to 2504mm outside diameter)
IS 7155:1990	: Code of Recommended Practice for Conveyor safety
IS 7155: Part 3: 1986	: Code of recommended practice for conveyor safety: Part 3 Belt conveyors and feeders
IS 7155: Part 5: 1990	: Code of recommended practice for conveyor safety: Part 5 Apron conveyors/Apron feeders

Canadian Bureau of Mines Spec. No. EMR/MRL/80:21 (TR) for FR Grade Belting

Any other International standards such as ASTM / CEMA/ ASME / ISO / DIN / JIS for design of coal handling system shall be followed.

2.0.0 DESIGN REQUIREMENTS

- i. Angle of surcharge of all conveyors shall be considered as 20°. Trough angle of conveyor shall be 35°.
- ii. Maximum inclination of conveyors inside the tunnel shall be limited to 10 degree. The inclination of all conveyors (except the bunker bay conveyor) above the ground level shall not exceed 12 degree for crushed coal (-25mm) and uncrushed coal (+25mm). Inclination of



conveyor feeding the bunker bay shall be designed to prevent the lifting due to tripper movement. The conveyor shall be horizontal at the feed point as far as possible. In case the same is not possible, the inclination at the feed point shall be limited to 6 degree. Continuous conveyor running on the ground is not acceptable except for the conveyors at feeding point and yard conveyors. Clear headroom clearance of 8m for the road crossing and other areas to be maintained above the ground.

- iii. The artificial coefficient of friction shall be considered as 0.03 for calculating the power requirement for conveyors.

iv. Idlers

Idlers shall be three roll, 35 degrees troughing angle for carrying side and impact idler & two roll V type for return side for all belt conveyors.

The side brackets for all idlers shall be of pressed 'C' type. Conveyor idlers, below the magnetic separators shall be of non-magnetic material (stainless steel).

Carrying and idlers shall be placed at half of the normal distances of placed on the conveyors at the convex curve area.

Impact idlers shall be placed at 300mm distance at the feeding zone.

Carrying idlers shall be placed at 500mm distance within the skirt board length apart from the feeding zone.

Wobble tolerance idlers with ± 0.2 mm shall be provided below the belt weigher for better weighing accuracy.

One self cleaning type rubber disc return idler located near the head pulley for cleaning return belt shall be provided.

v. Pulley

All pulleys shall be of welded construction, MS construction and statically balanced.

Finished shell thickness shall be min. 16 mm for drive pulleys and 12 mm for non drive pulleys. Thickness of rubber lagging shall be 12 mm herring bone type for drive and 10 mm plain type for non drive pulleys with shore hardness shall be minimum 60 ± 5 on scale 'A'. The face width of the pulleys shall be considered as follows for conveyors having belt speed upto 3m/sec:

Belt width	Face width
650	BW+100mm
800 & 1000	BW+150mm
1200 onwards	BW+200mm

The shafts of pulleys shall be of C-40 or better. The deflection slope of pulley shaft at bearings shall not exceed 6 minutes under load condition.

Single snub with wrap angle not less than 210° shall be considered for design of conveyors.



All drive pulley shafts shall be supported on heavy duty, horizontal split type Plummer blocks of 4 bolts construction.

The pulleys below inline magnetic separators shall have shell of non magnetic SS-304. The plumber block shall be split type ,dust tight with double labyrinth seals.

Suitable guards shall be provided for all pulleys.

vi. Belting

Fire Resistance grade covers shall be considered for all CONVEYORS. Fire resistant property shall conform to Canadian Bureau of Mines Report No. FRL-269 and Flame retardation test conforming to ISO-340.

The belting shall be of Nylon-Nylon. Number of plies shall be minimum 4. The minimum cover thickness shall be 5 mm at the top and 3 mm at the bottom. Factor of safety shall be considered as minimum 10.

Yard conveyor belting shall be of Steel chord. The minimum cover thickness shall be 6 mm at the top and 4 mm at the bottom. Factor of safety shall be considered as minimum 7. Rip protection for steel chord belts shall be provided.

Belt rating shall be standardized by grouping the nearest rating to standard rating, (applicable only on the positive side) to reduce the spare inventory. Maximum belt sag shall be 2% between idlers.

vii. Brake

All inclined conveyors shall be provided with hold back integral with the gearbox and electro-hydraulic thruster brakes.

Electro-hydraulic thruster brakes shall also be provided for conveyors where the coasting time is required to be adjusted.

viii. Scraper

One sprung blade type (Tungsten carbide tip) and one torsion arm type (with poly urethane blade) belt scrapers at discharge pulleys and one no. V-plough type (with poly urethane blade) internal scraper shall be provided for each conveyor. Diagonal plough type scraper shall be provided for the reversible type conveyor/feeder at both head and tail ends. Scraper arrangement shall be easily maintainable without any hindrance with chute or any assembly.

ix. Take up

Take up arrangement sand pit, safety guards etc. shall be as per relevant Indian standards. The belt conveyors shall be equipped with suitable tensioning devices. The devices shall have sufficient travel to allow the easy removal and replacement of the belt pulleys. If dead weight tensioning units are employed they shall have slide rails on each side. The total weight should be made up of individual weights of not more than 15 kg each.

Conveyors/belt feeders shall be provided with either screw type (for conveyor length up to 40 m) or automatic gravity take-up (Horizontal / Vertical) (for conveyor length more than 40 m) as applicable.



The gravity take up shall be provided with a minimum travel of 2.5% of length of conveyor plus one splicing length for N-N belt wherever possible. The take arrangement shall be provided with a minimum travel of 0.5% of conveyor length for steel chord belt. CHP contractor shall give the recommended travel for the take-up considering the specified minimum travel. Wire mesh guard of 2.5m height above ground level / maintenance platform level around take up will be provided.

The gravity take up counter weight box shall not be more than 1500mm from ground level at its Lowest position. Intermediate platform shall be provided in take-up zone for the maintenance of the take-up pulley or counter weight.

x. Conveyor Galleries

All over ground conveyors shall be provided with covered galleries. This includes the conveyor and walkways. For yard conveyor, covered gallery shall be provided for the elevated portion of the conveyor. Gallery shall not hinder the SCR movement. For natural ventilation of the above ground conveyors, a gap of 300mm shall be provided throughout the length of gallery between roof & side cladding at the top and 200 mm at the bottom.

xi. Walk ways in the gallery

For Single conveyors, 1000 mm on one side and 800mm on the other side shall be provided. For the Double conveyors, 1000 mm walkway at center and 800mm on either side shall be provided. Near the stone picking arrangement and cross over in conveyor galleries walkway width shall be extended 1m on either side.

Walkways shall be covered with chequered plate with antiskid arrangement, handrails in each walkway.

xii. Conveyor Tunnels

For Single conveyors, 800mm walkway shall be provided on either side.

xiii. Chutes

- Uncrushed coal:
Mother plate: SS 409 M of thickness 16 mm
Joining procedure: Full thickness joint with inner surface matching on all borders
Minimum valley angle: 60 deg for all type of coal.
- Crushed coal:
Mother plate: SS 409 M of thickness 16 mm
Joining procedure: Full thickness joint with inner surface matching on all borders
Minimum valley angle: 60 deg for all type of coal
Angle of chute at feeding end: 45 deg.

Between flange joints of chute, 3mm thick neoprene gasket shall be provided. Direct impact of the material on the belt shall be avoided by providing inclined surface at the feed point. Inspection door to be provided on the chute at accessible location.



xiv. Traveling trippers

Trippers with two-way chute shall be driven by wheel drive, independent of main conveyor drive and shall be through electric motor, helical gear box, etc. It shall discharge coal to bunker.

Traveling trippers shall operate in conjunction with main line conveyor. Hydraulic brake shall be provided for tripper which shall ensure the tripper remains stationary during bunker feeding. Cable reeling drum shall be provided for power supply arrangement. Last bunker feeding is through the head pulley. Tripper moves over the first bunker to last bunker for coal feeding. Requirement of “feeding min. 2/3rd of first bunker” means tripper shall feed min. 2/3rd of the tripper floor opening for the first bunker. Accordingly Bunker bay design shall be taken care. This will be reviewed during detailed Engineering.

- xv. Concave curve shall be maintained as minimum 300m radius and convex curve shall be maintained as minimum 75m radius. However, if the calculated radius is greater than the specified radius the same shall supersede and the calculated radius to be considered for designing.



**ANNEX – 2.10.1
SPECIFIED DESIGN DATA**

SL. NO.	ITEM	UNITS	DATA
1.0	General		
1.1	Type of belt		Heavy duty application
1.2	Capacity (Design)	T/h	3300 Belt conveyors 1100 Belt conveyors
1.3	Belt Width	mm	2000 mm Belt conveyors for 3300T/h 1200 mm for Belt conveyors for 1100T/h
1.4	Belt Speed	m/s	2.9m/s - 2000mm 2.9m/s - 1200mm Belt feeder speed shall be limited to 2m/s.
1.5	Ratio of working tension to allowable tension		90%(maximum)
2.0	Pulley		
2.1	Type		Heavy duty type.
2.2	Lagging		Herringbone for unidirectional conveyors. Diamond groove for the head and tail pulleys of bidirectional conveyors.
2.3	Bearing life (minimum)	h	30,000
2.4	Bearings		Double row self aligning spherical roller bearing
3.0	Idlers		
3.1	Carrying idlers		Roller dia and thickness shall be minimum 152.4 & 4.85 mm, Spacing - 1000 mm
3.2	Return idlers		Roller dia shall be minimum 152 & 4.85 mm. Spacing – 3000 mm
3.3	Impact idlers		190 mm roll dia with 127 mm steel tube dia and 4.85 mm thickness. Min. 5 Nos. impact idlers will be provided at each feed point, at 300mm spacing
3.4	Self aligning carrying and return idlers		Will be provided on thrust bearing for swiveling. Side guide rollers will be provided.



SL. NO.	ITEM	UNITS	DATA
3.5	Bearings		Spacing shall be 12 m from the terminal pulleys and bend pulleys and 24 m apart thereafter. Spacing shall be 10 m for steel chord belt Single row deep groove ball bearing, - 35 mm dia minimum for carrying & impact idlers with double labyrinth seals. - 25 mm dia minimum for return idlers with double labyrinth seals.
3.7	Testing of rollers		Free rotation, friction, Dust & water tests, weather proof
3.8	Lubrication		Life lubricated (Factory lubricated & sealed for life)
4.0	Technological structures		
4.1	Stringers/Short supports		Min. stringer size - ISMC 150 for 1100T/h Min. stringer size - ISMC 200 for above 1100T/h and short support - ISMC100 for 1100T/h and short support - ISMC150 for above 1100T/h Short post shall be provided with sufficient cross bracing and knee bracing wherever required.
4.2	Deck plate		Min. 3.15 mm for full length of conveyors
4.3	Seal plate		Min. 3.15mm shall be provided throughout the conveyors.
5.0	Safety switches		Degree of protection for all switches: IP 65
5.1	Pull cord switches		First at 4 m and subsequent at 25 m interval on both sides of the conveyor
5.2	Belt sway switches		First at 15 m and subsequent at 50 m interval on both side. Self resetting type
5.3	Zero speed switch		One for each conveyor at non drive pulley. Non contact proximity type electronic switch



SL. NO.	ITEM	UNITS	DATA
6.0	Tensioning arrangement		Sand pit, safety guards for 2.5m will be provided. Counter weight shall be Cast iron and will be at a height not exceeding 1.5 m above GL.
7.0	Accessories		
7.1	Size of chutes		As per coal trajectory at impact zone. Tramp iron chute – 400 Ø 6 mm thk MS
7.2	Type and No. of belt cleaners		Three (3) nos. On each feeder. Out of three, two shall be at head end (external) and one at tail end (internal) for unidirectional conveyor and six (6) nos. 2 nos. at head end, 2 nos. at tail end and 1 no. diagonal scraper at each end for bidirectional conveyor. Head end / Tail end - Sprung blade type - Torsion arm type Tail end - 'v' plough type / Diagonal type
7.3	Skirt board		Length of feed point :6m (min.) side plate 6mm(min.) MS, Cover plate 3.15 mm(min) MS Liner :5 mm thick TISCRA/ SAILHARD Height: Not less than 750mm Width: 2/3rd of the belt width Skirt board shall be designed in such a way avoiding spillage if the conveyor is having multiple feeding points. Skirt board shall be extended minimum 3m ahead of the feeding zone.(applicable to multiple feeding also). Skirt board shall not be provided in the idler transition zone. Minimum 500mm shall be maintained behind the feeding zone.
7.5	Chute blockage switch		Required at each conveyor discharge, vibrating screen feeder, bypass chute, crushing feeding chute, fixed tripper discharge chute and all feeding chute nearest to skirtboard.
7.6	Cross over		Cross over at every 100m interval.
7.7	Sealing belt for bunker		
	i. No. of piles		Minimum three(3)



SL. NO.	ITEM	UNITS	DATA
	ii. Top/bottom cover		5mm/5 mm thick(fire-resistant)
	iii. Width(minimum)		150mm more than bunker slot
7.8	Slot for bunkers		
	i. Cross bars over slot opening		20 mm round MS flat bars spaced at 100 mm c/c. Slot opening size shall be minimum 600mm. Cross bars shall be furnished for slot openings. However detailed drawing shall be furnished during vendor engineering.



VOLUME II
SUB-SECTION - 2.10.2
CRUSHER

Ring granulator type crushers complete with accessories and subsystems shall be provided for sizing the input coal to guaranteed output of 98% or the size as required by mill. The crusher shall be suitable to handle different feed size and property of the input coal.

Crushers shall be capable to deliver normal rated output even when handling damp sticky coal having maximum moisture content specified elsewhere. No clogging or building up of material on crushing element shall develop.

Zero speed switches shall be provided for speed sensing. Temperature measuring elements and vibration monitoring system for crusher bearings shall be provided.

Crusher shall be lined totally from inside with abrasion resistant steel liners of adequate thickness. The suspension bars shall be extractable completely from non drive side and atleast 50% from the drive side.

Crusher shall be provided with hydraulic system to facilitate the opening of crusher door without any difficulty.

The crushers shall be mounted on independent spring foundation with vibration dampening device like GERB springs and dampeners.

Rotor shall be statically and dynamically balanced even when the crusher is under operation with the broken hammers / rings.

Vibrating monitoring system shall be provided for the ring granulator.

Provision shall be made for transferring coal from any conveyor to the crusher above the other conveyor (Refer Dwg. No. 00-1115112-M-007)



ANNEX – 2.10.2.1

SPECIFIED DESIGN DATA

SL. NO.	ITEM	UNITS	DATA
1.0	Type		Ring Granulator
2.0	Capacity (Rated/Design)	TPH	1815/2000
3.0	Number required		2W+2S
4.0	Maximum input lump size	mm	(-) 100
5.0	Output lump size	mm	(-) 25 (98% efficiency)
6.0	Materials of Construction		
6.1	Crusher shafts		Forged and heat treated alloy steel
6.2	Liner plates / for frame		SAIL-HARD / Manganese steel, 20mm thick
6.3	Rings		Mn steel IS 276 Gr. III
6.4	Breaker plate		Mn steel IS 276 Gr. III, 40mm thick
6.5	Screen plate		SAIL-HARD / SAILMA – 350 HI
7.0	Type of Fluid coupling		Electric Actuator Operated Scoop type
8.0	Maximum speed of Crushers	rpm	750
9.0	Method of opening maintenance door		Hydraulic cylinder
10.0	Fines (-1mm) in the output		Shall not exceed 10 %
11.0	Hard grove index		Refer coal analysis data.
12.0	Output size adjustment facility		Required
13.0	Tramp iron rejection		Required
14.0	Type of balancing		Both static and dynamic
15.0	Notes		
	1. Provision will be made for external lubrication.		



VOLUME II
SUB-SECTION - 2.10.3
SCREENS

Screens shall be Vibrating Grizzly screens and shall be provided with bars. Screens are provided to screen out (-) 25 mm coal. The segregated material shall be directly fed on to the corresponding belt conveyors provided under each grizzly feeder. Oversized coal shall be fed to coal crusher.

Inclination of grizzly pan shall not exceed 15 deg ~~10 deg~~ from horizontal. There shall be no vibration transmitted to the operating floor.

Deck of vibrating screening feeder shall have continuous solid deck section in the impact zone under direct coal fall and remaining deck shall be fitted with perforated deck assembly.

The width of vibrating screening feeder shall match to feed the material uniformly over the entire length of crusher rotor without any deflectors in the feeding chute.

Screening area excluding solid deck area shall be minimum 0.75 m² per 100 tonnes/hr of incoming feed.

Equipment shall be designed in such a manner that choking does not occur during operation, particularly during rainy season when the coal gets sticky

solid deck section shall be provided with replaceable tiscral or equivalent. Liner plate of adequate thickness. The perforated deck shall be wear resistant and shall be rigidly fixed with main frame along the length of grizzly deck.



ANNEX – 2.10.3.1

SCREENS

SL. NO.	ITEM	UNITS	DATA
1.0	Type		Vibrating Grizzly type
2.0	Capacity (Rated/Design)	TPH	1815/2000
3.0	Number required		2W+2S
4.0	Feed size		(-) 100 mm
5.0	Screens to separate	mm	(-) 25mm
6.0	Efficiency of screening		~~95%~~ 85%
7.0	Material of construction		
7.1	Drive shaft		EN-8 / equiv. as per BS 4363 Gr. 55C
7.2	Liner plate on solid deck		TISCRAAL / SAILHARD/ Abrasion resistant steel, 16 mm thick
7.3	Perforated deck liner		TISCRAAL / equivalent, 16 mm thick



VOLUME II
SUB-SECTION - 2.10.4
STACKER CUM RECLAIMER

The stacker cum reclaimer shall be rail mounted, slewing and luffing type with bucket wheel for reclamation. The number of discharges per minute shall be limited to 55. The bucket wheel drive shall be hydraulic type suitable for achieving variation in the capacity. Belt width shall match with the conveyor specification requirements. Stability factor shall be minimum 1.5. Stacker / reclaimer shall be capable of withstanding wind at non operating condition as per project information.

Number of driven wheels shall be at least half of the total number of wheels (Excluding that of travelling tripper). The travel mechanism shall be provided with electro hydraulic operated rail clamps monitored by limit switches (Open and closed positions).

All the angular movement points shall be provided with maintenance free bearings either lubricated for lifetime or self lubricating type for whole of the life of the machine. Bucket size shall be selected for peak reclaim capacity based on maximum 80% degree of fill with respect to water fill capacity of the bucket. Further, not more than 50% of annular ring volume shall be considered as effective volume.

The boom conveyor will be adequate capacity to match with the peak reclaiming by the bucket wheel. It will also be provided by suitable weighing scale having accuracy not less than $\pm 1\%$ for a range of 20 % to 120% boom conveyor rated capacity.

Walkways with hand railings shall be provided on both sides of boom conveyor.

The operator's cabin shall be supported by hydraulic cylinders mounted on the boom so as to enable operator to be in upright position at all times. Shock absorbers shall also be provided.

The cabin shall be weather proof, dust proof, and provided with adequate number of Shatterproof glass doors and windows to provide good all round visibility for the operator. Also a split air conditioner will be provided for operator's cabin.

Travel drive equipment and slew drive equipment shall be suitable for 150 starts/hr. with continuous reversals.

Cross over shall be provided on the boom conveyor.

Safety accessories required for the movement of two stacker cum reclaimer on the same yard conveyor shall be provided by the contractor. Anti collision device for stacker cum reclaimer shall be provided.

Teeth of bucket shall be hard faced. Travel drive equipment and slew drive equipment shall be suitable for 150 starts / hr. Ratio of boom length to rail track gauge shall not exceed 5.


ANNEX – 2.10.4.1
SPECIFIED DESIGN DATA

SL. NO.	ITEM	UNITS	DATA
1.0	Type		Unidirectional bucket wheel type Stacker-cum-reclaimer, cell less type bucket
2.0	Number required		4nos.
3.0	Capacity while stacking (Design)	T/h	3300T/h
4.0	Capacity while reclaiming (Design)		3300T/h
4.1	Average Reclaiming Capacity (over a period of 4 hours) (Design)	T/h	3300T/h
5.0	Wind pressure		
5.1	Operating	N/m ²	200
5.2	Non-operating		Max. wind pressure as per IS 875 (latest edition)
6.0	Maximum wheel load permissible with impact	T	30
7.0	Track gauge	m	Will be more than the 20 % of boom length
8.0	Effective stock pile height above graded level	m	10
9.0	Width of stock pile at the base	m	50
10.0	Length of the stockpile	m	600m length (Bulk density 0.8T/m ³ and angle of repose: 35deg). SCR shall reach the full length of the stockpile).
11.0	Slewing angle of Boom of stacker reclaimer	degrees	± 105° i.e., total 210°
	Type of rail	Kg/m	52
12.0	Type of drive for :		
12.1	Bucket wheel		Hydraulic motor without gear box and coupling directly coupled to the driven



SL. NO.	ITEM	UNITS	DATA
			shaft is to be provided for bucket wheel drive to avoid speed drop due to overload. (no. of buckets = Contractor to decide)
12.2	Slewing		Hydraulic drive
12.3	Long Travel drive		Hydraulic motor without gear box and coupling directly coupled to the driven shaft is to be provided for bucket wheel drive to avoid speed drop due to overload.
13.0	Type of brakes		Electro hydraulic thruster
14.0	Type of control of SCR		Automatic operation with PLC shall be provided in addition to manual control
15.0	Type of Totaliser for Stacker-cum-Reclaimer Boom Conveyor scale		Shall indicate the coal available in the stockpile at any point of time
16.0	Stacker cum reclaimer bypass option		Yes
17.0	Air conditioning for operating station in Stacker cum reclaimer		Required
18.0	Boom Conveyor		
18.1	Boom length	m	44
18.2	Belt width	mm	Same as conveyor specification
19.0	Speeds		
19.1	Travel	m/min.	10 to 20
19.2	Hoisting or Luffing	m/min.	5 (at the top of the boom)
19.3	Slewing	m/min.	6 to 30% (at bucket wheel tip)
20.0	Type of brakes		Electro hydraulic thruster
21.0	Material of construction		
	a) Machine body `		MS (IS: 2062)
	b) Wheels		Cast alloy steel
	c) Bucket wheel		MS (IS: 2062)



SL. NO.	ITEM	UNITS	DATA
	d) Buckets		TISCRA/SAILHARD / SAILMA 350 H or Equivalent
	e) Teeth		Manganese steel, Gr.I, IS: 276
	f) Blades		37 MnSi5



VOLUME II
SUB-SECTION - 2.10.5

DUST EXTRACTION, BUNKER VENTILATION AND ROOF EXTRACTOR SYSTEMS

1.0.0 CODES AND STANDARDS

The DE System equipment will be designed as per the latest Indian and international standards.

The list of some of the Codes & Standards is given below:

ACGIH	:	American Conference of Industrial Hygienists
ASTM-D-2234	:	Standards methods for collection of a gross sample of coal
IS:655	:	Specification of metal air duct
IS:4894	:	Specification of centrifugal fan
IS:1940-1-1986	:	Mechanical vibration – Balance quality requirements of rigid Rotors-Part-1-Determination of permissible residual unbalance
IS: 3938	:	Specification of Electric Wire Rope Hoists
IS: 875	:	Code of practice for design loads (other than earthquakes) for buildings and structures
IS:2062/IS-226	:	Steel for general structural purposes.
IS:325	:	Motors

2.0.0 DUST EXTRACTION SYSTEM

Dry type dust extraction system (DES) with pulse jet bag filters, compressor, air receiver, air dryer, fan dampers, ducting, gates, rotary feeders, screw conveyors, etc shall be provided in the specified areas (refer flow diagram). The dust collected in bag filter hopper shall be discharged onto the forward belt conveyor. Dust extraction system shall be designed based on the two streams of operation, however for bunkers, it should cater to all bunkers of two units.

- a) All extraction points shall be provided with butterfly type dampers.
- b) The fans shall have straight but backwardly inclined blades.
- c) The bag filter material shall be fire proof, non-woven type with antistatic property mounted on cages of GI. Pressure drop shall be limited to 100mm WC.

Fan static pressure shall meet the total system frictional loss in the system.

- d) Thickness of suction hood, dust collecting hopper and ducts shall be minimum 5mm. Thickness of casing of centrifugal fan shall be minimum 5mm.



- e) These shall be operated from the local control panels and interlocked with operation of conveyor equipment.
- f) The height of discharge duct shall be at least 3 m above nearest building but in no way it shall be less than 30 m from ground.

Refer Annex – 2.10.5.1 for Specified Design data

3.0.0 BUNKER VENTILATION SYSTEM

Capacity of bunker ventilation system shall be based on 12 air changes per hour considering half filled condition of all bunkers. Compressed air shall be used for cleaning of filter bags. The dust concentration at the extraction point to be considered for selection of bag filter shall be 10g/m^3 (minimum).

- a) All extraction points shall be provided with butterfly type dampers.
- b) The fans shall have straight but backwardly inclined blades.
- c) The bag filter material shall be fire proof, non-woven type with antistatic property. Pressure drop shall be limited to 100mm WC.

Fan static pressure shall meet the total system frictional loss in the system.

- d) The air to cloth ratio of the bag filter shall not exceed $1.5 \text{ m}^3/\text{min}/\text{m}^2$. The bag filter cleaning system shall be reverse pulse jet air system.
- e) Thickness of suction hood, dust collecting hopper and ducts shall be minimum 5mm. Thickness of casing of centrifugal fan shall be minimum 5mm.

Belt sealing arrangement over the bunker slots to avoid dust nuisance.

Refer Annex – 2.10.5.1 for Specified Design data

Bunker Floor Ventilation System

Bunker floor shall be ventilated using power roof extractor considering 8 air changes per hour. For specified Design data refer Annex 2.10.5.1.



ANNEX – 2.10.5.1 SPECIFIED DESIGN DATA

A) Dust Extraction System

Sl. No.	Item	Units	Data
1.0	Type of D.E. System		Bag Filter
2.0	Service		Continuous
3.0	No. of D.E. Systems required		Refer flow diagram
4.0	Maximum Emission Level in the Air Exhausted to the Atmosphere	mg/nm ³	50
5.0	The dust concentration at the extraction point to be considered for selection of cyclone & bag filter	g/m ³	10 (minimum)
6.0	Bag Filter Cleaning Arrangement		Automatic on line reverse pulse jet compressed air system. Necessary compressors, piping, valves, timers, etc. will be provided by CHS Contractor.
7.0	Operation of DE system		Will be started / stopped from the local control panels and will be interlocked with the conveyor operation. Suction hood will be in open position for the running conveyor and same will be in closed position for the standby conveyor.
8.0	Air to Cloth Ratio	m ³ /min/m ²	1.5 (Max.)
9.0	Method of discharge of the dust collected in bag filter hopper		To be discharged back on to the operating belt conveyor through rotary air lock and screw conveyor if required.
10.0	Isolation of extraction point		Manually operated butterfly type dampers.
11.0	Design philosophy for duct sizing and fan selection		Based on “balancing without blast gate” method as per ACGIH hand book. Duct will be sized based on a velocity of min.20 mps.
12.0	Dust collecting hopper		Adequate for storing dust collected in 4 hours operation.
13.0	No. extraction points for each belt conveyor		Min. 2, one at feed point and one at discharge point
	Notes: 1 The Contractor shall calculate independently the total air quantity, sizes of the ducting and fans, pressure drop in the ducting, equipment and air outlets etc., based on conveyor belt speed, width, sizes of various equipment involved and shall select		



Sl. No.	Item	Units	Data
	suitable dust extraction units. The minimum extraction quantity at various dust extraction points will be as per values given below and wherever is not specified, the same will be recommendations of “American Conference of Governmental Industrial Hygienists” (ACGIH).		
	Amount of air to be extracted		
	a) At the conveyor discharge pulley	:	1950m ³ /h / m of belt width upto speed of 1.0 m/s, 2787m ³ /h / m of belt width above speed of 1.0 m/s
	b) At the loading point of conveyor on the skirt board	:	1950m ³ /h m of belt width upto speed of 1.0 m/s , 2787m ³ /h / m of belt width above speed of 1.0 m/s
	* for 1m fall of material		
	“**” In case material fall is more than 0.92 meter, add 1700 m ³ /h.		
	c) Screen Inlet	:	min.915m ³ / hr/square metre area of screen
	d) Crusher Inlet	:	3600 m ³ /hr per metre width of inlet opening
	2. DE system equipment will be outdoor type. However necessary weather protection cover/ hood will be provided for the motors, control system for bag filter cleaning etc. Compressor will be indoor type.		
	3. 50 % more air will be considered for DE system for handling crushed coal which has more fines.		

B) Bunker Ventilation System (BVS)

Sl. No.	Item	Units	Data
1.0	Type		Twin cyclone separator with Dry type bag filter (with reverse pulse jet type)
2.0	Maximum Emission Level in the Air Exhausted to the Atmosphere	mg/nm ³	50
3.0	Location of fan, cyclone and bag filter		On Tripper floor roof
4.0	Other requirements		Will be as specified for DE system.
5.0	Cyclone separator		Efficiency of 99% down to 10 micron particle size. Made of 6 mm thk. MS plate.

**C) Bunker Floor Ventilation System**

Sl. No.	Item	Units	Data
	Power Roof Extractor Fan		
1.0	General		
1.1	Service		Exhaust
1.2	Mounting		Roof
1.3	Type		Tube Axial
1.4	Capacity		To suit system requirement
2.0	Material of construction		
2.1	Casing		Mild steel plate to IS 2062
2.2	Impeller		Cast Aluminium
2.3	Shaft		EN 8
2.4	Hood		MS (hinged type)
3.0	Accessories		
3.1	Weather proof lockable type disconnect switch		



VOLUME II
SECTION - 2.10.6
DUST SUPPRESSION SYSTEM

Dust suppression system (DSS) shall be provided for stockpile area and JNT in order to suppress the dust.

Dry fog system shall be provided for all the JNT specified in the flow diagram. Sprinkler type system shall be provided for stockpile. The type of nozzles shall be Swiveling type for stockpile area. Service water shall be used for DSS. The complete control system for the DSS shall be by the Contractor.

(Water storage tanks for DSS shall have capacity to serve for one (1) hour of total water requirement that includes service water requirement. Local water tanks shall be complete with manhole, drain, overflow connection, inlet connection with float valve etc. A water tank of RCC construction shall be provided by the contractor to store service water which supply water to DSS/service water application

- a) There shall be two (2) water pumps (1 working + 1 standby) for the sprinkler dust suppression system. The quantity of water to be sprayed for the stockpile shall be calculated based on minimum 6.25 litres of water per hour per tonne of coal stacked in a section of 90 metres length wherein a set of sprinklers operate simultaneously for two stockpiles. Total 4 sprinklers will be in operation simultaneously. Globe valves shall be provided at each sprinkler. The operation of each section of sprinklers shall be sequential.
- (b) Separate pumps (1W+1S) shall be provided for the Dry fog system. Each water spray header in DSS shall be provided with a solenoid valve to stop the water spray when the concerned plant and equipment of coal handling system do not operate.
- (c) Each DSS shall be operated from the local control panels and shall be interlocked with the respective conveyor / equipment.
- (d) The pipes for stockpile dust suppression system shall be buried below ground and suitable protection like wrapping and walls shall be provided.
- (e) Dust emissions level shall be less than $5\text{mg}/\text{nm}^3$ within 5m radius of DS application point for dry fog system.
- (f) All water application, piping shall be MS as per IS: 1239.
- (g) Another set of pumps (1W+1S) shall be provided for the service water application.

Common dedicated 2 X 100 % reciprocating compressors with air drier shall be provided. Compressed air shall be used for cleaning the bag filter in Dust Extraction system and dry fog dust suppression dust. The Refrigerator type air drier and air receiver shall be provided with other required accessories. Design pressure of the receiver shall be 25% more than the rated pressure. Corrosion allowance of 1.5mm shall be considered for the receiver.



ANNEX 2.10.6.1

SPECIFIED DESIGN DATA

Sl. No.	Item	Units	Data
1.0	Type		Dry fog system- JNT specified in the flow diagram Dry fog system at Crusher house at the crusher receipt and discharge Sprinkler type system-Stockpile
2.0	Location		Refer flow diagram
3.0	Type of nozzles		Swiveling type for stockpile, Dry Fog jet spray type for other areas. Each nozzle of DSS will be provided with in-built filter made of brass and shall also be of self cleaning type
4.0	Spray nozzle tip and housing		SS 304 and Aluminum alloy
5.0	Quantity of water to be sprayed at each feed and discharge points of conveyor.		As per manufacturer's standard (Minimum 2 no of nozzles for discharge side of conveyor and 4 no of nozzles for receipt side of conveyor shall be provided)
6.0	Method of operation of each DS system		Local panels. Solenoid valves will be provided at each header and interlocked with the respective conveyor operation.
7.0	Centrifugal Pumps		
7.1	Designation		Dust suppression
7.2	Liquid handled		Water
7.3	Type		Back pull out
7.4	Location		As per Requirement
7.5	Shaft		Coupled
7.6	Drive transmission		Direct
7.7	Seal		Gland
7.8	Coupling guard		Made of expanded metal bolted to the base plate
7.9	Flow per sprinkler	LPM	Flow shall be calculated based on design criteria.



Sl. No.	Item	Units	Data
8.0	Material of Construction		
8.1	Impeller		Bronze
8.2	Casing		Close Grained CI
8.3	Shaft / Shaft sleeve		EN-8
8.4	Impeller ring / casing ring		Bronze
	Notes: 1. Method of DSS operation in stockpile: The header pipe lines around the stockpile will be buried below ground to avoid obstruction for the movement of dozers in the stock pile area. Only Stand post for sprinklers will be above ground level. The spacing of the sprinklers will be such that it covers the entire stockpile. The spacing of sprinklers will be indicated by contractor. 2. A duplex strainer will be provided for service water pumps / DS water pumps at pump suction. 3. The pumps will be of outdoor type. Weather protection hood / cover will be provided for the motor.		



VOLUME II
SECTION - 2.10.7
COAL SAMPLING SYSTEM

Coal sampling system shall be provided for collecting the samples for analyzing the coal. The coal sampling system shall be as per BS-1017 / ISO – 1988 / ASTM D2234. Complete coal sampling system comprises primary cutter, primary & secondary crusher, Secondary cutter and other auxiliary shall be provided for collecting the final sample.

SPECIFIED DESIGN DATA

Sl. No.	Item	Units	Data
1.0	Location		As per the flow diagram
2.0	Type		Automatic type
3.0	Type of primary cutter		Swinging type
4.0	Materials of construction		
4.1	Cutter		S.S. 304/316
4.2	Liners for hoppers		S.S. conforming to AISI-409M
4.3	Trough of screw conveyor		SS-or MS with SS-liner

**VOLUME II****SUB-SECTION - 2.10.8****IN-LINE MAGNETIC SEPARATOR**

In-line magnetic separator shall be provided on belt conveyors to separate the magnetic tramp iron. The separator shall be located with adjustable tramp iron chute after determining the coal and tramp iron trajectory. Tramp iron chutes shall have minimum 50 deg angle with horizontal.

The magnet will be of material with high permeability and coil will be immersed in a non inflammable oil contained in a welded steel case fitted with expansion tank and relieve valve.

The magnetic separator shall be such that it will operate continuously without overheating.

SPECIFIED DESIGN DATA

Sl. No.	Item	Units	Data
1.0	Type, location and quantity	Nos.	As per the flow diagram
2.0	The minimum flux density at the operating distance from magnet lower face under hot running conditions	gauss	1000
3.0	Size of tramp iron to be lifted		M20 bolts & nuts/50 kg MS plates/50 kg MS round bars of L/D ratio within 5.
4.0	Magnetic coil material		Aluminum
5.0	Magnet core material		CRGO
6.0	Force index		1,00,000
7.0	Type of insulation for coil		H
8.0	Type of rectifier		Selenium
9.0	Max. operating temperature of coil under hot stabilized condition	°C	140
10.0	Efficiency of magnetic separator & Suspension Magnet for lifting M20 nuts when the nuts are buried at different depths along the conveyor belt		90%
11.0	Minimum operating height above conv. Belt	mm	400 for -25mm 450 for -100mm
12.0	Tramp iron chute		To be provided upto ground level
13.0	Material of chute work and other parts in magnetic zone		Stainless steel. SS-409M of 8mm thick



VOLUME II
SUB-SECTION - 2.10.9
TUNNEL VENTILATION

All underground tunnels will be provided with push pull type ventilation system by providing supply air fans and exhaust fan of adequate capacity. The Contractor has to provide HDPE pre-filter with efficiency of 90% down to 20 microns for the tunnel ventilation. Adequate capacity of supply air fan and exhaust fan shall be provided.

SPECIFIED DESIGN DATA

Sl. No.	Item	Units	Data
1.0	No. of air changes/hr.		12 (minimum)
2.0	Type of fan		Centrifugal fan (both for supply and exhaust fan) Exhaust fan shall be 70% of supply fan.
3.0	Location		Underground tunnels below emergency reclaim hopper
4.0	Velocity of air inside duct	mps	12 (maximum)
5.0	Material of duct		GI duct
6.0	Grills		GI construction with louvers
7.0	Centrifugal Fan		
7.1	Service		Ventilation.
7.2	Location		Covered shed
7.3	Type		SWSI / DWDI
7.4	Blade Type		Backward (min 5mm thick) with self cleaning
7.5	Construction		Class II
7.6	Drive		V-belt driven
7.7	Material of Construction		
7.7.1	Casing		MS (5mm thick minimum)
7.7.2	Shaft		EN-8
7.7.3	Impeller		MS / CS
7.7.4	Accessories Requirement		
	Flexible connection at fan outlet, inlet guard, fixed type		



Sl. No.	Item	Units	Data
8.0	inlet vane, outlet damper, spring type vibration isolator with minimum isolation efficiency of 80%, ribbed neoprene rubber pads between foundation block and floor, filter, slide rails etc shall be provided. Bearings		50,000hrs. (Minimum life)



VOLUME II
SUB-SECTION - 2.10.10
BELT WEIGH SCALE

Inline conveyor belt weigh scales shall be provided

- On conveyors to record the quantity of coal received in the plant and quantity of coal conveyed.
- Boom conveyor of SCR to record quantity coal available in stockpile and also reclaiming rate.

The belt scale shall be load cell type and will be continuous operating. Provisions for local and remote measurement of instantaneous through put, totalling, local signalling of load limits of conveyors shall be provided. Control of sampler, signals for remote indication and overload alarm shall be given in the belt scale. Suitable device for testing the accuracy by test weights shall be provided. The belt scales shall be of electronic microprocessor type. Weigh scales shall be of multi-idler type.

SPECIFIED DESIGN DATA

Sl. No.	Item	Units	Data
	IN LINE CONVEYOR SCALE		
1.0	Quantity	Nos.	As per the flow diagram
2.0	Location		As per the flow diagram
3.0	Troughing angle	Degrees	Refer conveyor section
4.0	Material handled		Refer description in the main section.
5.0	Range		20% to 120% of rated capacity requirement with 100% overload protection
6.0	Accuracy		±1% for SCR belt scale ± 0.25% for others
7.0	Measurement provisions		Flow rate indicator & totaliser
7.1	Type of totaliser		Digital, six digits
7.2	Local rate indicator		Required
7.3	Remote rate indicator		Required
7.4	Location of totalizer and remote rate indicator		CHS control room
8.0	Type of belt scale		Electronic/Microprocessor based
9.0	Type of load cell		Temperature compensated hermetically sealed and protected



Sl. No.	Item	Units	Data
10.0	Analog Readout		against shock and vibration 4-20 mA Current output for coal weighed shall be provided to CHP control system



VOLUME II
SUB-SECTION - 2.10.11
METAL DETECTORS

Metal detector complete with marker, warning horn, alarm annunciation, electricals, controls, etc are to be provided as required. Hooter with audible range of min 100m shall be provided.

The metal detector will identify magnetic and non-magnetic material and indicate its location.

Metal detector shall be mounted on conveyor structure, with necessary protection against coal bed hitting the coil. The coil shall have protection of IP- 65.

The capacity of metal detector shall be to detect minimum 25 mm Aluminum cube. In case of steel cord the sensitivity shall be 35 mm. Carrying idlers on either sides shall be placed closer to the detector as recommended by manufacturer.

No moving parts, electricity conveying devices like motor etc, shall be placed near the detecting zone.

No return idler be placed below the metal detector.

The short support below the metal detector shall be welded with the stringer to avoid vibration.

No metal construction like deck sheet etc. between idler and detector be placed.

It shall also detect other metals, like brass, copper, stainless steel, manganese steel, bars, scraps etc. It should ignore magnetite/iron and shall distinguish between metal pieces and magnetite/iron.

SPECIFIED DESIGN DATA

Sl. No.	Item	Units	Data
1.0	Location		As per flow diagram
2.0	Material handled		Coal
3.0	Annunciation Hooter Required		Yes
4.0	Audible range of Hooter	m	Minimum 100
5.0	Tramp iron markers		Sand bag
6.0	Scoop		Non ferrous material shall be removed using automated scoop without tripping the conveyor.



VOLUME II
SUB-SECTION - 2.10.12
FLOW DIVIDER

Flow divider with rack pinion, worm gear, geared motor (and provision for manual operation) shall be provided for dividing the coal in two-way chutes based on the requirements. The preferred location of the flow divider shall be perpendicular to the conveyor motion as it ensures required flow division. Accuracy of flow divider: +/- 5%.

SPECIFIED DESIGN DATA

Sl.No	Description	Unit	Data
1.0	Quantity required		As per flow diagram
2.0	Capacity through gate	T/h	0 to 100 % Variation
3.0	Max. Lump size of material handled	mm	Based on the location
4.0	Method of operation of the gate		Motorised
5.0	Shaft material		EN-8
6.0	Material Liner		10mm MS with 10 mm TISCRA/ SAILHARD
7.0	Limit switch		As per requirement
8.0	Mechanical buffer		Required
9.0	Linear speed	mm/s	30
Notes: 1. Manganese bar is kept at the impact zone. 2. Inspection door is required at each side.			



VOLUME II
SUB-SECTION - 2.10.13
GATES

1.0.0 FLAP / SECTOR GATES

Flap gates of non-jamming type with curved/straight blade design with electric actuator (and provision for manual operation) shall be provided for diverting the coal in two-way chutes. The gate surface shall be provided with 20mm thick TISCRA/ SAILHARD / wear resistant liner plate.

The actuator motor shall be dust tight. The flap gate shall be remote controlled with necessary interlock as required. All components including opening in the chute for shaft of gate shall be protected against dust. For Specified Design refer Annex 2.10.13.1.

2.0.0 RACK & PINION GATE

Motorized rack and pinion cut off gates complete with frame, gate plate with liner, limit switches, locking device, rollers, chain and sprocket, accessories, necessary fixing bolts for fixing the gate with chutes shall be provided in all the locations as indicated in the flow diagram.

Adequate rod gate shall be provided on top of rack and pinion gate. The slide gate plate thickness should be adequate with proper reinforcement to meet the requirement of load of coal in choked condition and abrasion of coal. All gates shall have manual operation facility by hand wheel/chain with limit switches for safety of the operator. Gate shall be normally actuated by rotary actuator with necessary limit switches. For Specified Design refer Annex 2.10.13.1.

**ANNEX 2.10.13.1
SPECIFIED DESIGN DATA**

Sl.No	Description	Unit	Data
A)	FLAP / SECTOR GATES		
1.0	Quantity		As per the flow diagram
2.0	Type of Gate		Non-jamming
3.0	Method of operation		Electric actuator, individually operated with provision for manual operation.
4.0	Material of Construction of Gate		20 mm thick TISCERAL/ SAILHARD or equivalent material liner.
5.0	Limit switches to indicate the different positions of gates.		To be provided
6.0	Mounting of limit switches		Outer surface of chute
7.0	Automatic operation:		
7.1	No. of Operation/ Hr		15 (with 10 consecutive switching)
7.2	Protection		Travel and thrust dependent
8.0	Manual Operation		
8.1	Maximum effort		Convenient for operation by single position
9.0	Material of Construction:		
9.1	Flap gate shaft		EN-8
9.2	Flap plate		MS (IS: 2062) Grade B
9.3	Liner (on flap gate)		6 mm SS 409M
9.4	Gate shaft		EN-8 (BS-970) / Equivalent
B)	RACK & PINION GATE		
	Designation		Refer flow diagram
	Location		Below ERH



Sl.No	Description	Unit	Data
	Quantity required		Refer flow diagram
	Capacity through gate	T/h	
	Minimum size of gate	mm	Contractor to indicate
	Lump size of material handled	mm	(-) 25 for ERH
	Method of operation of the gate		Motorized with facility for manual operation
	Material of construction		
8.1	Material of the gate		10 mm thick SAILHARD or equivalent on 10mm gate plate
8.2	Material of shaft		EN-8
	Notes : The gates shall be suitable for closing and opening the gate with hoppers full. Access platform with hand railing and staircase shall be provided wherever necessary.		

**VOLUME II****SUB-SECTION - 2.10.14****HOPPER**

Coal would be reclaimed by dozers into the emergency reclaim hopper (ERH). Vibrating feeder will be provided below the ERH for feeding coal to the belt conveyor

RH/ERH will be of RCC construction and will be provided with a side plate angle of 65 deg with horizontal. The minimum length and width of hopper will be minimum 6 m x 6 m. Grid will be provided on the top of hopper.

The ERH and grid over it will be designed for the accidental movement of the bulldozers.

The ERH will be provided with rack and pinion gates & rod gates.

SPECIFIED DESIGN DATA

Sl.No	Description	Unit	Data
1.0	Designation		ERH
2.0	Number required		As per flow diagram
3.0	Whether grid required on top of hopper		Yes
4.0	Size of grid openings	mm	To suit the lump size of coal and flow
5.0	Type of construction of hoppers		RCC
6.0	Shed over hoppers required		Yes
7.0	Storage capacity		Minimum 20T
8.0	Liner		5 mm SS-409M for ERH
8.1	Side plate angle		65 degree



VOLUME II
SUB-SECTION - 2.10.15
COAL PILE RUN OFF PIT AND PUMP

1.0.0 COAL YARD DRAINAGE

Around the coal stockpile, drainage channels shall be constructed to take all the effluent from the coal stock yard (sprinkling water, rain / leach water), which shall be ultimately led to a coal pile run-off pit sump.

2.0.0 COAL PILE RUN OFF PIT AND PUMP

Coal pile runoff water from the coal stockpile shall be fed into a collecting pond through RCC drains provided on around the coal stockpile. Coal particles shall settle down and clear water shall over flow to the adjacent sump. From this sump, clear water shall be pumped to ETP.

3.0.0 SPECIFIED DESIGN DATA

Sl. No.	Item	Units	Data
1.0	COAL PILE RUN OFF PIT, SUMP AND PUMP Purpose		Collecting the coal pile runoff water from the drainage channels around the coal stockyard and led to a collecting pond. Coal particles shall settle down and clear water shall over flow to the adjacent sump. Sludge will be removed manually.
2.0	Pit capacity	m ³	Each 1500m ³
3.0	Number of pit		2 (refer plot plan)
4.0	Pump capacity	m ³ /h	Suitably sized considering the maximum rainfall. The effluent shall not be let into storm water drain in any case. Shall be let into ETP. (N+1) pump to be provided in each location. Pump capacity shall be minimum 125m ³ /h.
	Note The necessary piping, valves and control shall be provided.		



VOLUME II
SUB-SECTION - 2.10.16
BULLDOZERS

SPECIFIED DESIGN DATA

Sl.No	Description	Unit	Data
1.0	Nos. Required		Four (4)
2.0	Type		Diesel Engine driven Crawler Tractor Unit with Coal Dozer attachment
3.0	Handling Material (of less than or equal to 50mm)		Coal
4.0	Condition of Grade		(a) Generally leveled (b) Climbing Crushed coal pile of a height of 10 m (max.) and reclaiming / dozing
5.0	No. of speed steps		Forward: not less than three (3) Reverse: not less than three (3)
6.0	Engine Rating (BHP)		Not less than 242KW (324 H.P.)@2000r/min.
7.0	Adequate number of flood lights for Illumination during night works.		Required
8.0	Portable Fire Extinguisher inside the Operator's Cabin		Required
9.0	Heavy Duty 12/24 Volt Battery to enable operation of Engine Starting Motor		Required
10.0	Generator suitable for charging the Battery when the Engine is in Operation		Required
11.0	Engine power for dozing the coal from the stock pile of following Dimensions		
	i) Stock pile width	m	50



Sl.No	Description	Unit	Data
	ii) Angle of repose	degrees	35°
	iii) Max Height of stockpile	m	10
	iv) Bulk density (Compacted)	kg/m ³	1000
12.0	All Standard Control & monitoring features		Required
13.0	All Standard accessories as applicable		Required
14.0	All special accessories as recommended by mfg. for this application		Required
15.0	Noise level limitation		85(dBA) measured at a distance of 1.5m From the outline of the equipment.
	Notes : 1. All Controls of the Dozer will be brought into the Operator's Cabin. 2. Dozer will be used for moving, spreading, leveling, compacting and dozing the material specified. The dozer will be capable of stable operation on steep slopes, Side banks and in dust laden atmosphere. 3. Tests & Test certificates:- Equipment covered by this specification will be tested by the vender at site to establish its guaranteed operational performance / capacity over a period of eight weeks. 4. Consumables required for the test will be supplied by Contractor 5. Hand operated brake shall be provided.		



VOLUME II
SUB-SECTION - 2.10.17
SUMP PUMPS

Sump pumps with 100% standby shall be provided. The drive motor of all the sump pumps shall be mounted at least 1.0m above the floor level.

High and low level switches, non return valves etc shall be included in the system. Margin of 20 % on calculated head.

SPECIFIED DESIGN DATA

Sl. No.	Item	Units	Data
	SUMP AND SUMP PUMPS		
1.0	Pump detail		Open impeller, Non-clog type, grease lubricated. 30m ³ /h capacity. Speed limited to 1450rpm. Shall be Pumped to ETP.
2.0	Number of pumps		Two(2) (1W+1S) at each pit location
3.0	Liquid to be handled		Coal slurry with specific gravity of 1.1and maximum lump size of coal will be 25mm. and solid content will be 25%
4.0	Mounting		The drive motor will be mounted at 1.0 m above floor / ground level.
5.0	Pump accessories requirement		Automatic float level switch for start/stop, suction strainer, sump cover plate etc will be provided
6.0	Pump discharge point		To coal pile run off pond
7.0	Sump size(length x width x depth)	mmxmmx mm	1000 X 2500 x 1500(minimum)
8.0	Sump type		Will be twin pit type
9.0	Pump Material of construction		
9.1	Casing		CI(210 BHN)
9.2	Impeller		ALLOY CI (2%Ni CI)
9.3	Pump shaft / Line shaft		EN-8
9.4	Strainer		CI



VOLUME II
SUB-SECTION - 2.10.18
BELT VULCANIZER

For each type of belt, one number hydro mechanical type portable belt vulcanizer complete with kit and vulcanizing solution shall be provided for repairing and splicing conveyor belts. The Belt vulcanizer shall be used to vulcanize / repair belts including making of general diamond tooth, rectangular or saw tooth type transverse splice, repairing longitudinal slit, edge, spots in belt. The material of construction of heating surface is Aluminum. The machine shall be suitable for vulcanizing full splice length in one setting and shall also be suitable for the maximum belt width. The machine shall be capable to generate adequate pressure and temperature as recommended by the supplier of the belt. However, pressure and temperature shall not be less than 7 kg/cm² and 140° C respectively. Cable of 30m length of adequate size shall be included along with switch, plug etc. for connection between socket and temperature control box and platen. Separate belt vulcanizing machine shall be envisaged for suitable for vulcanizing steel cord and NN belt. Vulcanizing kit and glue to be supplied along with it along with its tools.

Hooks shall be provided on transfer points, conveyor galleries for belt handling and replacing the new belt. Space to be provided near the take up for making joints.

**VOLUME II****SUB-SECTION - 2.10.19****OPERATION AND PHILOSOPHY FOR COAL HANDLING SYSTEM****1.0.0 GENERAL**

The Coal Handling Plant shall be operated, monitored & controlled from the CHP local control room through the DCS remote I/Os with the redundant Processor, power supply, communication module, redundant communication link with the main plant DCS.

In plant coal handling local control room shall be provided with Two (2) no. 24" LCD TFT type Operator station and CHP Mimic panel for control and monitoring the CHP locally in addition to remote monitoring from the central control room in the main plant DCS.

CHP mimic panel with hard wired push button for back panel operation. Two No. large screen display (84") complete with control station and other hardware at CHP control room for controlling & monitoring coal handling system.

The operation and control system of the Coal Handling Plant shall cover the total functional requirements of the plant which includes normal start-up, shutdown and emergency operations, sequence control, interlock & protection, monitoring & alarm etc. All the instrumentation for monitoring, Protection and smooth operation of the plant shall be provided. The Coal handling system comprising conveyors, Crushers, screens, magnetic separators, Metal Detectors, belt weigher, belt feeders, dust control system, compressor system, water system, etc. Stacker/Reclaimer (S/R) shall be controlled and operated from the Operator station in the operator's cabin. Remote I/O racks with the dedicated redundant controllers/processors for S/R shall be provided for connecting the signals of the S/R system to the DCS cabinets in the CHP local control room. Location of RIO panel shall be in S/R's operator cabin.

Dust suppression, Dust extraction & Coal sampling system, shall have local control panels mounted near the equipment. Local start/stop facility for conveyors & other equipment shall also be provided for maintenance requirements.

2.0.0 OPERATION & CONTROL PHILOSOPHY

2.1.0 The Coal handling Plant comprises of the many equipment's the details are as follows:

Operation of the following equipment's of coal handling plant is from the CHP control room. For control & operation more details refer Vol-II, section 4.10C&I

- Conveyors, Flap gates, Crushers, Vibrating Feeder & Screens.
- Inline magnetic separators (ON/OFF control with indication)
- Metal detectors (ON/OFF control with indication)
- In line Belt Weigh Scale (ON/OFF control with indication).
- The Stacker/Reclaimer shall be controlled through Dedicated PLC.

2.2.0 Conveyor System

2.2.1 Conveyor System The starting sequence of the conveyors shall follow a direction opposite to that of flow of material.

Any individual equipment (belt conveyor etc.) should not be allowed to start unless the equipment immediately following the same in the direction of flow of Coal is already in operation.



Stop / tripping of any equipment from running condition shall trip all preceding equipment in the system, but shall not effect succeeding ones which shall continue to operate. Interlocking of various conveyors shall be achieved with limit switches and zero speed switches. Crusher Motor shall not be stopped during the sequential operation of the conveyor system.

Adequate no. of Pull cord switches shall be provided along the length of each belt conveyor, which shall enable the respective conveyor to be stopped immediately. Belt Protection switches, Pull Chord Switch & Belt Sway Switch, shall be identified/addressed by a specific number in the Control Room. All the safety switches shall be addressable type.

Operator can select anyone of the programmed paths from the operator station located in the CHP Control Room. Operation of the Coal handling plant shall be based on the Coal flow path selection. The operator can select the desired Coal flow path in the Operator station.

The flow stream path is selected by positioning different flap gates/ feeders at the desired position from monitor to select the conveyors. The system shall be in operation with a time delay and with a hooter sound. If selection is wrong, the DCS shall generate an audio-visual warning.

The control system shall be designed for "Auto" & "Manual" operation of the conveyors in the selected path. Auto/Manual selection shall be done from the Operator station. Auto Mode: In the "Auto" mode, the conveyors and related equipment shall start sequentially when the "System Start" is activated. During stopping, when the "System Stop" is activated, all conveyors shall stop sequentially (in the reverse sequence) allowing time delays for clearing the materials on conveyor.

Manual Mode: In Manual Mode, the operator shall start the conveyor system in the same sequence as in Auto mode by pressing individual "Start" buttons on Operator station. The operator shall also stop the conveyor system, by pressing "System stop" or individual "Stop" buttons in the reverse sequence.

During 'sequence start' in both auto and manual modes, first the required number of hooters shall be energized simultaneously for a preset time of 1 minute or so (adjustable) as per the program. After the preset time, the hooters shall stop and a preset time of two minutes (adjustable) shall be allowed for the movement of the personnel and for the permissive of the conveyor system operation.

The Status of the sequence i.e; each conveyor/ equipment ON/OFF status shall also be displayed on MIMIC panel at CHP control room.

2.3.0 Flap gates and flow divider

All flap gates and flow divider shall be motorized and remote controlled from the control room. Their position shall be indicated on the Operator station of control room.

2.4.0 Metal Detector

The starting of conveyors are interlocked with the metal detectors to start the conveyors energizing the metal detector is mandatory. Once the metal is detected, the corresponding conveyor shall trip. It shall be possible to restart the conveyors, after local resetting of metal detector & putting back the marker bag in position. Metal detector ON/OFF indication shall be provided in the Operator station.

In case of tripping of conveyor system, metal detector shall de-energize after a time lag. Following individual indications shall be provided on Local Control panel:

- Metal Detector 'ON'
- Metal Detected



2.5.0 In Line Magnetic Separator

The starting of conveyors are interlocked with the ILMS provided in BCN to start the conveyors energizing the ILMS is mandatory .It shall be possible to start the conveyor only after energizing the magnet of ILMS. Further, if conveyor system trips magnetic separators shall de-energize after a time lag and audio-visual annunciation shall appear at CHP control room.

Following individual indications are provided on Local control panel:

- Magnetic separator ON.
- Magnetic separator OFF.
- Magnetic separator AVAILABLE.

2.6.0 Coal Sampling Unit

Coal sampling unit shall be controlled through Local Control Panel.. Push buttons, LED indications of status, alarms shall be provided on the local control panel for manual operation and monitoring.

Monitoring of sampling system shall be provided in the CHP Operator station.

Local push button stations shall be provided for all individual equipment of Coal sampling system near the equipment.

2.7.0 In line conveyor scale)

Belt weighers are provided to measure the flow rate and total quantity of coal delivered to the bunker. Belt weighers are located on conveyors (refer flow diagram) and boom conveyor of stacker cum reclaimer. It will provide 4-20 mA analog signal to the DCS.

2.8.0 Safety Switches

Belt Watch Panel operating at 24V DC supply is provided for the PCS and BSS in the Conveyor System. Each conveyor consists of programmable type safety switches namely Pull chord sWitch(PCS), Belt sway switches(BSS), Chute jam switch (OS)and zero speed switch (ZSS). The function of these switches is to protect the conveyors during abnormal or emergency conditions. PCS-These switches will trip the conveyors if it is pulled from any point of the conveyor the pull chord run through both sides of conveyor.

BSS-These switches will trip the conveyors if the belt slides on to the switch.

ZSS-These switches will trip the conveyor, if the belt speed at tail pulley is less than the desired \ speed. ZSS is provided at tail pulley for all conveyors. All the above mention safety switches shall be provided on both side of the conveyors.

2.9.0 Bunker Level Measurement

One (1) no. RADAR type Level Transmitter (4-20mA type) shall be provided for each coal bunker.

The level Transmitters shall be interfaced with the DCS for viewing the level of coal in the bunker.

Display and annunciation of High and Low level signals shall be available for operator at Control Room by means of 4-20mA.



In case of level high in bunker level, the feeding conveyor shall be stopped. Bunker level shall be continuously displayed with low, low-low, high and high-high indications on the Operator station.

2.10.0 Stacker cum Reclaimer

The sequence of operation, control and interlocking etc., of the Stacker /Reclaimer shall be achieved through dedicated Operator station mounted local to the equipment.

Remote I/O racks with the dedicated redundant processors/controllers for S/R shall be installed in the operator cabin of the S/R system. The soft link communication between the S/R Remote I/O unit and the DCS cabinets in the CHP local control room shall be through cable reeling drum.

Operation of the Stacker/Reclaimer shall be through Stacker/Reclaimer Operator station. The protection, interlocks, controls and logics for the Stacker/Reclaimer operation shall be within the Stacker cum Reclaimer's DCS processors/controller.

2.11.0 Dust Suppression System

The DS water supply pumps shall start automatically and always be running as long as the coal handling system is running (only for the running conveyor). Once the coal handling system stops, the main DS water supply pumps shall stop automatically.

All necessary instrumentation and field sensors for control and operation shall be provided.

2.12.0 Dust extraction System

The following sequence shall be followed for starting the DE system:

Start Screw conveyor (if applicable) or feeders of bag filter.

Start RAV of bag Filter

Power to sequential controller

Start Centrifugal Fan Motor

Open motorized damper of fan inlet

DES shall operate only for the running conveyor

2.13.0 Brake for Conveyors

Brakes are for all conveyors irrespective of coasting time to avoid the jamming of chute while stopping the conveyor.

2.14.0 Travelling Tripper

The Travelling Trippers shall be operated manually by the local control station provided on the bunker bay.

Based on the level indicated by the bunker level indicator (Low) the operator will select the bunker and position the Tripper. After filling this bunker the operator will select the next bunker which indicates Low.

The last bunker is filled directly by the conveyor without operating the tripper. For this the material is guided to the conveyor itself by operating the flap gate provided in the tripper.



The flap gate in the tripper is positioned in such a way that the material from the conveyor is always directed to the bunker. To avoid spillage from tripper during unit change, the flap gate in the tripper shall be operated and the material is guided to the conveyor itself.

After filling all bunkers, indication will be given to the CHP control Room and the material shall be directed to the stock yard by selecting the stacking mode.

3.0.0 PROTECTION & INTERLOCKS

Protection and Interlock shall be provided for all the equipment's and a system to safeguard the equipment's against abnormal conditions which may result in the failure of the equipment's and protect the operating personnel. Controls shall be provided to start/shutdown various systems and/or any equipment with associated auxiliaries and to operate the CHP with safety.

Generally the following equipment shall come under interlock scheme:

- Conveyors
- Flap gates
- Rack & Pinion gates
- Metal detectors
- Magnetic Separators
- Crushers
- Vibrating Screens/feeders
- Belt Scale

Safety interlocks to be taken care for conveyors and other equipment as a minimum are:

1. Conveyors

- Pull chord switch -not operated
- Belt Sway switch -not operated
- Chute Block switch -not operated
- Brakes for conveyor -not operated
- Zero speed switch -Closed at 90% approx. of belt conveyor speed

2. Crusher

- Zero Speed -not operated
- Vibration level-not high
- Temp of Windings -not high
- Temp of Fluid coupling Oil-not high

3. Flap Gates/ Rack & Pinion Gates

- End of travel limit switches -reset

4.0.0 ANNUNCIATION

Each of the Coal handling plant equipment shall have status and alarm indicated in the Operator station. Operating stop and trip condition of each equipment shall be indicated. Similarly energised, de-energised and trip conditions of magnetic separators shall be indicated on the Operator station.



Individual point Annunciation shall be provided for each of the following in the Operator station as a minimum:

- Annunciation for trip of individual belt conveyors
- Annunciation for Fault in individual conveyor Hydraulic drives / crusher motor, screen motor trip on fault of HT motors.
- Annunciation for trip of individual crusher, screen and feeder.
- Annunciation for HT motor trip due to high bearing temperature and winding temperature.
- Annunciation for trip of conveyor due to metal detection by metal detector.
- Annunciation for Stacker-cum-Reclaimer
- Individual annunciation for the following conditions of the electrical power system:
 1. 6.6 KV INCOMER UNDER VOLTAGE
 2. 415 V INCOMER UNDER VOLTAGE
 3. DC SUPPLY FAILURE FOR 6.6 KV SWGR
 4. DC SUPPLY FAILURE FOR 415 V MCC
 5. TRIP CIRCUIT UNHEALTHY FOR 6.6 KV SWGR
 6. TRIP CIRCUIT UNHEALTHY FOR 415 V MCC



VOLUME II
SUB-SECTION - 2.10.20
STONE PICKING ARRANGEMENT

Manual Stone Picking arrangement at a suitable location in the conveyor gallery shall be provided complete with platforms, overhead lighting, hand railings, suitable seating, safety hook & holding arrangement for manual pickers, disposal chutes to ground level etc.

Location:

- Before the crusher house
- Before the bunker bay

Provision for minimum 3 person/conveyors shall be provided in each location in series (at an interval). Total 6 persons in each location for two conveyors. Cross over arrangement shall also be provided at each location.



VOLUME II
SUB-SECTION - 2.10.21
VIBRATING FEEDER

Vibrating feeders shall be mounted on the floor with the help of helical springs made of alloy steel. No rubber/synthetic material for the support shall be acceptable. Vibrating feeders shall be provided with removable abrasion resistant liner plate.

SPECIFIED DESIGN DATA :

Location	:	As per the flow diagram
Type	:	Linear motion
Quantity	:	As per requirement
Type of Duty	:	Heavy duty, Continuous
Capacity	:	Each vibrating feeder shall be Below surge hopper - 1500TPH(Rated), 1650TPH(Design) Below reclaim hopper - 200TPH (Rated), 220TPH(Design)
Inclination of deck	:	Not more than 10 deg.
Drive	:	Hydraulic/ Electric motor
Noise level	:	85 dba at 1m distance.
Lubrication	:	Oil / Grease lubricated.
Material of Construction	:	
1. Material of Tray/ Thickness deck and 10 mm MS on Side plate	:	16 mm MS on Solid
2. Liners on Tray, Bottom and side thickness	:	10mm SAILHARD
3. Shaft	:	45C8 / EN-8.

**VOLUME II****SUB-SECTION 2.11****ASH HANDLING SYSTEM****INDEX**

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VOLUME II
SUB-SECTION - 2.11.0
ASH HANDLING SYSTEM

1.0.0 SCOPE OF SUPPLY

The equipments to be supplied, erected / installed, tested and commissioned under the scope of this specification shall include but not be limited to the following:

1.1.0 Bottom Ash Handling System

(Flow diagram – Bottom ash flow diagram)

- Bottom Ash Hoppers with hydraulic /electric operated slide gates with provision for manual operation etc.
- Scraper chain conveyors and its accessories.
- Clinker grinders - complete with drive motors, fluid couplings, gear boxes, chains & sprockets, Protective guards, feed sumps, seal water nobs etc.
- Jet pumps to convey bottom ash and economiser ash from the bottom ash hopper area to ash slurry sump.
- One (1) no Flushing apparatus for each Economiser hopper.
- One lot of Isolation valves, expansion joints, flushing apparatus and associated piping for evacuation of ashes from Economiser hoppers.
- Bottom ash overflow transfer pumps complete with drive motors, couplings & other accessories to pump BA overflow water to clariflocculator.
- BA overflow tank
- Drain sump pumps complete with drive motors, couplings & other accessories.
- Drain sump.
- Tube settler common for both the units with necessary isolating valves and level switches.
- Seal water Pumps
- AHS seal water tank
- Sludge pumps complete with drive motors, couplings & other accessories.
- One lot of Water piping, slurry piping, instrument air piping, fittings, valves, instrumentation, agitating nozzles, liners etc as per requirement and specification flow diagram.
- All other items required to make the system complete in all respects.

1.2.0 Fly Ash Handling System

(Flow diagram – Fly ash flow diagram)

- **Vacuum system**
 - One (1) lot of fly ash hopper isolating valves, intake valve (pneumatic operated), control system, level probes, adopter piece, etc., below each ESP hopper, APH hopper, Duct (if applicable) and stack hopper.
 - ESP and Buffer hopper Fluidizing blowers and associated drive units, heaters, silencers, filters, valves, instruments to supply hot air to fluidizing pads of ESP hoppers, Buffer hoppers etc.,
 - One lot of Water piping, slurry piping, instrument air piping, fittings, valves, instrumentation, agitating nozzles, liners etc as per requirement and specification flow diagram.
 - Liquid ring type vacuum pumps with all accessories to generate vacuum in first stage of vacuum conveying.
 - Bag filter with buffer hopper to collect dry fly ash from various fly ash hoppers by vacuum located near ESP first field.
 - Expansion joint shall be provided wherever required.
 - Drain sump



- Drain Pumps complete with drive motors, couplings & other accessories.
- All other items required to make the system complete in all respects.
- **Pressure pneumatic conveying system**
 - Transmitter vessels / blow tanks along with isolating valves, inlet and outlet pneumatic operated valves as applicable, control system, level probes, adopter piece, supports for transmitter etc., below buffer hoppers.
 - One (1) lot of fly ash piping with fittings, instruments, valves, flanges, hangers, supports etc. for complete system as required upto the silos.
 - Branch isolation / diverter valves wherever required as per flow diagram and to meet the system operational requirement.
 - Conveying air compressors - oil free screw compressors Transport air receivers for each unit with associated instruments and with dedicated refrigerant dryer of adequate capacity with drives and all accessories.
 - One (1) lot of conveying compressed air piping as per requirement with fittings, instruments flanges, supports, etc.
 - Instrument air compressor - Oil free screw compressors with dedicated refrigerant dryer common for both units of adequate capacity with drives and all accessories
 - Instrument air receivers with associated accessories. Air receiver along with safety relief valve, automatic drain trap and other accessories complete with supporting steel structures.
 - Expansion joint shall be provided wherever required.
 - Fly ash RCC storage silos with associated accessories.
 - Silo aeration blower and associated drive units, heaters, silencers, filters, valves, instruments to supply hot air to fluidizing pads of silo,
 - All other items required to make the system complete in all respects.
- **Ash slurry and water system**
 - Jet pumps to convey fly ash from fly ash silos to ash slurry sump.
 - Drain sump pumps complete with drive motors, couplings & other accessories.
 - Drain sump.
 - Hydro duct conditioner pumps complete with drive motors, couplings & other accessories.
 - Hydro duct conditioner sump
 - One lot of Water piping, slurry piping, instrument air piping, fittings, valves, instrumentation, agitating nozzles, liners etc as per requirement and specification flow diagram.
 - All other items required to make the system complete in all respects.

1.3.0 Ash disposal system

(Flow diagram – ash disposal system)

- **BA ash slurry**
 - Collection channel
 - Motorised plug valve
 - Slurry sump with its accessories
 - BA Slurry Pumps with its accessories
 - BA Drain sump pumps complete with drive motors, couplings & other accessories.
 - BA Drain sump.
 - One lot of Water piping, slurry piping, instrument air piping, fittings, valves, instrumentation, agitating nozzles, liners etc as per requirement and specification flow diagram.
 - BA Seal water pump with its accessories
 - BA Seal water sump with its accessories
 - All other items required to make the system complete in all respects.



- **FA ash slurry**
 - Collection channel
 - Motorised plug valve
 - Slurry sump with its accessories
 - FA Slurry Pumps with its accessories
 - FA Drain sump pumps complete with drive motors, couplings & other accessories.
 - FADrain sump.
 - FA Seal water pump with its accessories
 - FA Seal water sump with its accessories
 - One lot of Water piping, slurry piping, instrument air piping, fittings, valves, instrumentation, agitating nozzles, liners etc as per requirement and specification flow diagram.
 - All other items required to make the system complete in all respects
- **Water system**
 - AHS sea water tank with its accessories
 - Sea water FA HP pumps complete with drive motors, couplings & other accessories.
 - Sea water BA HP pumps complete with drive motors, couplings & other accessories.
 - Sea water BA LP pumps complete with drive motors, couplings & other accessories
 - One lot of Water piping, slurry piping, instrument air piping, fittings, valves, instrumentation, agitating nozzles, liners etc as per requirement and specification flow diagram.
 - All other items required to make the system complete in all respects.
- **Ash Water Recovery System**
 - Vertical turbine pumps for pumping the water from recovery water sump to clariflocculator.
 - One lot of recovery water pipe from ash pond to clariflocculator.
 - Clariflocculator
 - Required no. of dosing system arrangements.
 - Sludge pumps & piping to pump ash sludge into ash pond
 - Sludge sump and its accessories
 - One lot of Water piping, slurry piping, instrument air piping, fittings, valves, instrumentation, agitating nozzles, liners etc as per requirement and specification flow diagram.
 - All other items required to make the system complete in all respects.

2.0.0 SYSTEM DESCRIPTION

2.1.0 Bottom Ash Handling

Ash Source: Bottom ash and Economiser ash

Bottom ash formed due to the combustion of coal in the SG shall be collected in a refractory lined dry Bottom Ash Hopper (BAH). In this system, the bottom ash from the boiler furnace shall be discharged into the submerged scraper chain conveyor provided below the dry type bottom ash hopper. The scraper chain conveyor in turn shall feed bottom ash to clinker grinder where it gets crushed to (-) 25mm and feeds the buffer hopper (connecting the scraper chain conveyor outlet with jet pump). Bottom ash hopper refractory and bottom ash shall be cooled by the sea water. Overflow from the Scraper chain conveyor shall be collected in the overflow tank and recirculated by the overflow transfer pump to Clariflocculator. Common sea water tank shall be provided for the bottom and fly ash disposal system.

From economiser hoppers, coarse ash will flow to the scraper chain conveyor (above the maintained water level) by means of an adequately sized sloping pipe (for transporting slurry by gravity) duly assisted by jets (nozzles) placed at strategic locations for easy slurry flow.



The individual slurry outlet pipes shall combine to form a header in sloped gradient and the header will connect to each scarper chain conveyor. Each individual economiser hopper shall be provided with manual isolation valve, water seal cum expansion trough, flushing apparatus having water supply from BAHF water pumps for slurry preparation.

Fly ash from Economizer hoppers are also conveyed to bottom ash hopper using flushing apparatus and same shall be handled as a part of this system.

2.2.0 Fly Ash Handling System

Ash Source: ESP ash, APH hoppers, duct hoppers (if applicable) and Stack hopper.

Vacuum-cum-pressure system: The fly ash handling system shall be of vacuum-cum-pressure type. The fly ash collected in several sets of ESP hoppers located in the flue gas path shall be evacuated pneumatically.

The fly ash is sequentially extracted from these hoppers by creating vacuum in extraction piping. In this system, the vacuum shall be created using vacuum pumps. The total ash removal system shall be divided into parallel paths (4 Nos). In each path, clearance of ash from hoppers connected to common fly ash header shall be done one after another. Shifting of ash clearance cycle from one hopper to the next shall be automatic and based on vacuum level. The evacuation shall be done once in an eight (8) hours shift.

Fly ash shall be conveyed in dry mode through bag filter to buffer hopper. There shall be 4W Nos. of buffer hoppers for each unit.

a) Dry fly ash evacuation System:

The fly ash system shall be designed to collect fly ash in dry form in RCC silos. Fly ash lines from Buffer Hoppers shall be provided with pneumatically operated isolation valves for diverting fly ash to any of the silos.

For collecting fly ash in dry form, the system shall be designed such that the fly ash and conveying air mixture from fly ash hoppers is passed through buffer hoppers, where ash shall get separated and air shall flow to the vacuum pumps through Bag filters. The bag filters shall be pneumatic pulse jet type. The fly ash from the buffer hoppers shall be transported to RCC silo by using air from conveying air compressors. Adequately sized vent filter shall be mounted on top of the silos to filter the air and let it out to atmosphere.

2.3.0 Disposal of Fly Ash from Silo

Each storage silo shall be provided with a dedicated aeration system. Each silo shall have the following connections with rotary feeder to offer the unloading of ash in different form as below.

- 2 no. opening common for Unloading of ash in dry form to closed tank carriers through Telescopic chute.
- 2 no. opening for Wet disposal using jet pump.
- 1 Opening common for Unloading of ash through Dust conditioner into open truck.
- 1 One blind flange opening.

Silo area shall be provided with compound wall and gate considering stage-1 and 2.

2.4.0 Ash Slurry Disposal

- a) Common ash slurry pumps shall be provided for bottom and eco ash of two units. (2W+1S) shall be provided for two units. Ash slurry shall be discharged into common channel of ash slurry sumps from where it shall be disposed to Ash pond by means of



slurry pumps and associated piping. Number of slurry pumps in series shall be selected based on the total disposal distance. One pipeline shall be provided with each series of pumps. Slurry discharge line shall be flushed with water in order to prevent settling of ash inside the slurry pipe lines at the end of each operation.

- b) Common ash slurry pumps shall be provided for fly ash of two units. (1W+1S) shall be provided for two units. Ash slurry shall be discharged into common channel of ash slurry sumps from where it shall be disposed to Ash pond by means of slurry pumps and associated piping. Number of slurry pumps in series shall be selected based on the total disposal distance. One pipeline shall be provided with each series of pumps. Slurry discharge line shall be flushed with water in order to prevent settling of ash inside the slurry pipe lines at the end of each operation.

2.5.0 Ash Water Recovery System

- a) Ash pond decanted water shall be re-circulated back from ash pond to plant for treatment and reuse in ash handling system. The recovery water system shall be designed considering the bottom & eco ash disposal, fly ash disposal and flushing requirement for each pipelines.
- b) The water from the stilling pond shall be let out through the collecting well. The effluent outflow from these collecting ponds shall be gravity led through a discharge pipe with an isolation valve to a recovery water sump (close to ash pond).
- c) Water from collection sump shall be pumped to clariflocculator by using recovery water pumps. Parshall flume flow measuring instrument shall be provided for measuring the inflow to the clarifier. The clarifier shall be located partially above ground. The dosing system (100% standby) shall pump, measured quantity of coagulant solution into flash mixer of clariflocculator. The water from the clariflocculator shall be led in to a clear water sump by gravity through open channel located above ground. The clear sump shall be located partially below ground. The acceptable limit of suspended solids of the recovered clear water shall be less than 100 ppm. From the clear water tank, it shall be pumped to AHS sea water tank/sea water outfall.

Whenever ashes are disposed in dry mode and excess water during rainfall, clear water shall be taken to sea water outfall. Recovery water system shall be sized considering excess rainfall.

2.6.0 Major Structures

2.6.1 AHS Sea water tank and pump house

This house shall be common for the two units shall be housing

- Seawater FA HP pumps,
- sea water BA HP pumps,
- seawater BA LP pumps
- Ash seal water tank
- Ash Sea water tank
- seal water pumps for seal trough makeup, vacuum pumps & hydrodust conditioner, makeup
- Drain pump and its sump
- Tube settler (located outside the pump house)
- BA slurry pumps
- BA slurry sump

The pump house shall be complete with EOT crane, drainage facilities, etc.



2.6.2 Conveying Air compressor house

This house shall be common for two units for housing conveying air compressors with driers, ESP/ BH fluidizing blowers and heaters, instrument air compressors with air driers etc.. This house shall be complete with EOT crane, drainage facilities etc.

2.6.3 Recovery water pump house

Common pump house shall be provided for the two units. Pump house shall be housing recovery water pumps, Clear Water Pumps, Seal water pumps, etc. The pump house shall be complete with EOT crane, drainage facilities, Sludge pumps, dozing systems, etc.

2.6.4 Buffer Hopper

The ash from ESP conveyed using vacuum pumps shall be collected in the buffer hopper.

2.6.5 Fly Ash Silo

Four (4) Nos. of fly ash silo shall be provided for the two units for collecting the dry fly ash from the buffer hoppers.

2.6.6 Slurry pump house.

This house shall be common for the two units shall be housing

- FA ash slurry pumps and its sumps
- Drain pump and its sump

The pump house shall be complete with EOT crane, drainage facilities, etc.

2.6.7 Vacuum pump

All vacuum pump shall be located near the first field of ESP in proper building, necessary handling arrangement to be provided. Drain pump and its sump to be provided.

2.6.8 Silo utility building

This house shall be common for the two units shall be housing

- Hydro dust conditioner pumps and its sump.
- Silo fluidizing blowers etc.

The pump house shall be complete with EOT crane, drainage facilities, etc.

3.0.0 DESIGN & CONSTRUCTION REQUIREMENT

3.1.0 Ash generation for Each Unit

	BMCR requirement at 50:50 blending ratio (worst coal)
Coal consumption	
Ash handling design – ash content	26.0%
Bottom Ash	25%
Economiser Ash	5%
APH Hopper	5%



Stack Hopper	0.50%
Duct Hopper	2.50%
Fly Ash	90%

Operating time

Bottom ash hopper area to ash slurry pump and slurry sump to ash pond	Continuous
Fly ash hoppers to fly ash silo	4h in a shift
Fly ash silo to ash slurry pump and ash slurry sump to ash pond (4W+4S)- Jet pump to be considered.	8h in a shift

3.2.0 Density of Ash

Particle Density Bottom Ash, Economiser and ESP Ash	: 2.0 T/m ³
Bulk Density for Bottom & Eco Ash for Volumetric Calculation	: 0.65 T/m ³
Bulk Density for Bottom & Eco Ash for Structural Load Calculation	: 1.6 T/m ³
Bulk Density for ESP and airpreheater Ash for Volumetric Calculation	: 0.75 T/m ³
Bulk Density for ESP Ash and air preheater for Structural Load Calculation:	1.6 T/m ³

3.3.0 Slurry Concentration and Slurry Line Flow Velocity

Eco Slurry Concentration from economizer hoppers : 20% (max.)(w/w)

Bottom Ash Slurry concentration from
Bottom ash silo to ash slurry sump : 25% (max.)(w/w)

ESP Ash Slurry Concentration from fly ash silo
to Ash Slurry Sump : 30%(max.)(w/w)

At Slurry Pump Discharge Slurry Concentration for Bottom Ash and Fly Ash

For bottom ash	: 25%(w/w)
For fly ash	: 30%(w/w)
For	
Clarifier sludge	: 2-3 %(w/V)
Concentration of Economiser ash slurry	: 20 %(w/w) (max)

3.4.0 Slurry Line Velocity

- All slurry velocity: Min. 2.3 m/sec - Max. 2.8 m/sec.
- Ash slurry line flushing minimum velocity 2.3 m/sec or higher based on process requirement

3.5.0 Water and air Line Velocity

Location	Pipe size below 50NB	Pipe size 50NB-200 NB	Pipe size above 200 NB
Water Pump Suction	0.6-0.9m/sec	1.2-1.5 m/sec	1.2-1.5 m/sec
Water Pump Discharge	0.9-1.8 m/sec	1.5-2.4m/sec	1.8-2.8 m/sec
Compressed Air Below 2.0 kg/cm ² (g)	15-20 m/sec	20-30 m/sec	25-35 m/sec
Compressed Air above 2.0 kg/cm ² (g)	20-30 m/sec	25-40 m/sec	35-45 m/sec

**3.6.0 Selection Criteria of Volume of Various Hoppers / Tanks / Sumps**

BA Hopper	8 hrs of max. Furnace BA and ECO ash collection
BA Over Flow Sump	10 min. overflow from BA hopper
AHS seawater tank	1 hour of water consumption for both the units
Drain Sump	5.0 min of drain pump capacity
Sludge Sump	10 min. of max. Inflow Sludge
Buffer Hopper	30 min of Stream Capacity + 750 mm free board + Slope angle 60 degree
Fly Ash Silo (each)	4 silos of each 1000MT +1000 mm freeboard above max. ash level.
Tube settler sizing	Hydraulic loading: 3.0(m ³ /hr/m ²)
Weir Loading:	300 m ³ /day,
Inlet Flow to Tube settler	Maximum inflow + 25 % margin
Recovery water sump	30 minutes storage
Clear water sump	15 minutes storage
Seal water tank	30 minutes storage
Slurry sump	Minimum 5 minutes storage

3.7.0 Frictional Factors

Friction factor 'C' for Ash slurry lines	140
Friction factor 'C' for Sludge lines	130
Friction factor 'C' for Recovery Water lines	100
Friction factor 'C' for Bottom ash overflow lines	120
Friction factor 'C' for Water Lines	110
Friction factor 'C' for Drain Lines	100
Gravitational Head	Frictional factor C130 and Multiply by subsequent sp. gravity for calculation of slurry frictional head when flow under gravity.

3.8.0 Capacity and Head

Design capacity for vacuum pumps, blowers & compressors shall have 10% margin. Slurry pumps and all other pumps water pumps shall have 10% margin over and above total friction head requirement.

All water duty pump, BA overflow pumps, drain pumps and recovery water pump shall have 10% margin on capacity over actual requirement.



Pump Head (TDH)	1) For water duty pump (corresponds to "Rated Flow") + 10% margin on frictional pressure drop + suction lift + Static lift + Velocity head + Terminal Point head.
	2) For ash contaminated water pump (corresponds to "Rated Flow") +10% margins on frictional pressure drop + suction lift + Static lift + Velocity head.
	3) For ash slurry pump (corresponds to "Rated Flow") + 10% margin on frictional pressure drop + suction lift + static lift + Velocity head

3.9.0 General Requirement

- a. The ash handling system shall be designed and constructed in view of dust free operation. Fugitive dust emission at any area shall not exceed 50 mg/Nm³ for all solid sizes.
- b. Complete ash handling system shall be designed by considering sea water (CT Blow down) application. All SS material in contact with sea water shall have PREN 38 & CF35.
- c. Ash handling system shall be fully automated.
- d. The radius of 90° bends will be, minimum 5 times the pipe diameter for fly ash and minimum 3 times the pipe diameter for slurry line.

Pressure pneumatic handling system shall be as per proven design practice However, both lean phase and dense phase systems of proven design are acceptable.

- e. The minimum width of clear access corridor around equipment along with associated pipe & cables shall be 1200 mm. Space shall be provided for withdrawal & placement of the components during maintenance.
- f. A clear head room of 2500 mm shall be provided between the floor and any overhead piping/cable or any other obstruction. Adequate provision for natural ventilation and illumination shall be made as per good engineering practice.
- g. Access openings shall be provided with removable grating /chequered plate or with handrail.
- h. Ladder may be provided up to a maximum height of 3 m beyond which access through staircase shall be provided.
- i. All necessary auxiliary platforms for maintenance / inspection of equipment / instruments along with access from the operating floor are to be provided.
- j. Proper hook approach to access the equipment shall be given affect. Rolling shutters/ removable door shall be provided for removal of equipment from the building.
- k. Location & number of doors & staircases shall be based on operation & maintenance aspect, security aspect & fire protection & fire fighting aspect.
- l. In case vent valves are provided for the transmitter vessels this vent connection shall be provided above the highest ash level in the buffer hopper.



- m. As the slurry pumping is over a long distance necessary air release valves and surge tank (if necessary) shall be provided to avoid water hammer effect.
- n. The layout of ash slurry and ash water pumps shall be such that it shall be possible to maintain any pump set without disturbing the operating pump set and also it should not be necessary to dismantle the discharge piping for removing any ash water/ash slurry pump.
- o. The layout of water piping for the ash handling system shall ensure that all valves are located so as to be conveniently accessible. All the water piping to bottom ash hopper area, fly ash storage silo area from the pump house shall be routed in the overhead pipe rack only. In no case, the water pipes shall run in the trench. However, the bottom-ash slurry pipelines from the jet pump outlet to ash slurry sump can be run in the pipe trenches up to the nearest pipe rack and then routed on the pipe rack.
- p. All piping shall be arranged to provide clearance for the removal of equipment requiring maintenance and for easy access to valves and other piping accessories required for operation and maintenance.
- q. All pipe joints to be provided inside the ash slurry and ash water pump houses shall be flanged type with suitable gaskets.
- r. Access walkways / steps in the pump houses, control rooms, compressor rooms, etc., shall be minimum 1200mm wide. Suitable hand railing shall be provided for personnel safety, wherever required.
- s. Ash disposal lines from ash slurry Pump House up to the entry into the ash pond shall be routed on pipe rack. Concrete pedestals are provided only in the area (upto to the ash pond) as mentioned in plot plan. On the ash bund, the pipe line shall be routed on concrete pedestals, such that the bottom of the pipe line shall be at least 500mm over the ground for facilitating easy maintenance. Each slurry pipe line there shall be several discharge points at every 200 metres. Isolation valve shall be provided at discharge point.
- t. The height of the concrete pedestal on the bund shall also be designed such that a suitable downward slope is provided for ash slurry pipe lines up to the final discharge point, to avoid choke of pipe.
- u. Facilities for carrying out online and off-line maintenance of ash handling plant and auxiliaries shall be provided. In general, this should include adequate handling equipment, working space, platforms and safety devices.

4.0.0 DOCUMENTATION

4.1.0 Drawings, data / documents to be submitted along with tender

- 4.1.1 Completely filled up Technical schedules and data sheets of tender documents
- 4.1.2 Flow diagram of Ash handling system
- 4.1.3 System description
- 4.1.4 Complete electrical load list.
- 4.1.5 Details of similar job executed in last five years
- 4.1.6 List of erection and commissioning spares.



4.1.7 List of recommended O&M spares for 3 years normal operation.

4.1.8 List of Special Tools & Tackles.

4.1.9 List of makes of bought out items.

4.1.10 Control system configuration

4.2.0 Drawings, Data / Documents to be furnished by the successful Bidder

The Contractor shall submit the following data/information documents/ drawings to the purchaser/consultant, who in turn will review and furnish comments on drawings/documents. Contractor shall furnish a list of data / drawings / documents which will be submitted to the purchaser/consultant, with due dates of submission immediately after award of Contract. The Contractor on fortnightly basis shall update the list. All drawings shall be generated in AUTO CAD. The following list shall not limit the contractor, if any additional documents / drawings required for the review of the owner/ consultant same to be submitted.

4.2.1 Design Data - for approval

4.2.1.1 Design Data

- Design basis report for AHS.
- Design calculations for Pumps, Blowers, Compressor, silo, tanks, pressure vessels etc. and any other equipment found necessary.
- Technical data sheets of all Ash handling system equipment
- Sequence interlocks and block logic diagram.
- Design basis for foundations, civil works, structural etc.,
- Design basis for electrical systems/equipment
- Operational philosophy for operation of plant.
- STAAD input/output files
- Any other details found necessary.

4.2.1.2 Drawings & Documents —for approval

A) Flow Diagram of Ash Handling System and design/sizing calculation

B) General arrangement - Plans and Sections of the following subsystems:

- Bottom ash handling system
- Fly ash handling system
- Fly ash silo
- Fly ash silo unloading system
- Handling facilities
- Any other details found necessary.

C) Architectural drawing, GA & Reinforcement drawing for Concrete Works, and Steel GA and Fabrication drawing - for the following structures:

- Ash Water Tank
- Compressor building
- Ash slurry sump/ Pump house
- Ash Handling System Control/MCC Room
- Bottom Ash Hopper
- Fly ash silos



- Pipe racks
- Equipment foundation details
- Any other details found necessary.
- QAP and PG test procedure.

E) Following piping arrangement drawings

- Fly ash piping layout from fly ash hoppers to Fly ash silos.
- Water Piping
- HP Water & LP water Piping
- Refractory cooling water piping
- Seal Water Piping
- Cooling water piping
- Compressed air piping
- Instrument air piping
- Economizer ash slurry piping
- Water piping for fly ash collection system (dust conditioner)
- Bottom ash slurry piping
- Bottom ash overflow piping
- Slurry pipe layout
- Etc.,

4.2.2 GA drawings of the following equipment

- All pumps
- Transmitter vessel/Denseveyor.
- Slurry line valves
- Fly ash valves
- Pipe fittings
- Dust conditioner
- Rotary feeder
- Jet pumps
- Clinker grinder
- Blowers
- Air Compressors
- Air receivers
- Sump /drain pumps
- Heaters etc.,

Flow diagram for all systems indicating equipment, piping valves, specialties and instrumentation including performance test scheme, technical write-ups and performance test procedure.

Details of painting specification.

4.2.3 Control & Instrumentation Drawings & Documents for approval

The C&I Drawings / documents shall have the following as a minimum

1. Ash Handling plant control room layout
2. Control Schemes & Logic diagram along with write up of control system
3. Hardware and software design manual (covering exhaustive details of complete DCS based control system)



4. DCS BOM
 5. G.A (General Arrangement) drawings of all control panels/ cabinets / local panels with all dimensional details.
 6. Input / Output list
 7. Drive list / Solenoid valve list
 8. Annunciation list & SER list
 9. List of set points
 10. Maximum DCS bus utilization under worst loading condition calculation details shall be furnished
 11. Process mimic indicating Analogue and digital parameters
 12. Marshalling philosophy
 13. Cabinet / Panel wiring diagrams and internal layout drawings
 14. Wiring diagrams for panel, local panel, junction boxes, actuators, starters etc.
 15. Instrument index
 16. Instrument hook-up diagram
 17. Erection hardware BOQ
 18. Heat load and Power consumption data for DCS
- 4.2.4 Any other drawings required for review during the detailed engineering stage, same shall also be submitted by contractor.



VOLUME II

SUB-SECTION - 2.11.1

DRY BOTTOM ASH HOPPER

1.0.0 CODES AND STANDARDS

- IS: 2062 - Structural steel (tested quality).
- IS: 1239 - Mild steel tubes, tubular and other wrought steel.
- IS: 210 - Grey iron castings.
- IS: 6 - Moderate heat duty fire clay refractories Group A

In case of any conflict between the aforesaid standards and the stipulations of this specification, the later shall prevail.

2.0.0 DESIGN REQUIREMENT

Dry bottom ash hopper shall be provided with the effective capacity to collect 8 hours ash generation. Bottom Ash Hopper shall be completely above ground level.

A seal trough shall be provided around the top periphery of the bottom ash hopper for furnace sealing and to prevent ingress of air into the furnace. Flushing nozzles shall be provided in the seal trough for occasional flushing of the trough.

Access and maintenance platform minimum clear width of 1000 mm with Chequered plate covering all round the hopper at suitable level shall be provided. In addition, local platforms as required for observation/poking/ maintenance shall be provided.

Hopper drain valves, over flow and drain piping with seal box etc. shall be provided.

The refractory shall be designed to withstand the radiant heat from boiler furnace and in case of emergency allow storage of hot ash inside the hoppers with no quenching water available.

Spray quench nozzle shall be provided which shall be of blanket spray type. Each nozzle shall be provided with its own isolation and regulation valves. The nozzles shall be arranged so as to ensure adequate cooling of all refractory surfaces.

There is a possibility of slag built up on the hopper/transition chute surfaces.



ANNEX 2.11.1.1
SPECIFIED DESIGN DATA

S.No	Items	Unit	Data
1	No. required	No.	Two (2) nos. One (1) for Each Unit
2	Type of Hopper		Dry Impounded, Refractory lined
3	Number of outlets in each BA hopper	No.	Four (4)
4	Required storage capacity of ash in hopper	Hrs	8 Hrs of maximum bottom ash generation
5	Distance between top of hopper and operating level in hopper	mm	300
6	Minimum thickness of hopper plate	mm	Tested quality mild steel plates of thickness not less than 10 mm suitably stiffened with rolled section
7	Type of lining		Monolithic Castable Refractory 230mm
8	Furnace temperature	Deg C	1050
9	Material of construction of wear resistant feed plates		Ni-Hard Cast Iron (Minimum 340 BHN)
10	Type of gates at the outlets		Electric Motor operated or hydraulic cylinder Operated Water Tight Gates
11	Pressure range of boiler at furnace throat	mmWC	(-)40
12	Refractory cooling arrangement		Yes
13	Seal		SS316L
14	Refractory holding anchor		SS316 L
15	Feed chute to scrapper chain conveyor		316,L MIN. 5MM THK
16	Operating time to evacuate bottom ash in a shift of 8 hrs		Continuous
17	Cooling water header for refractory		SS
18	Sluicing/Arch Breaking/Wash Nozzles		Body: Cast Iron/mild Steel Nozzle Tip : Anti Corrosivetoool steel or stainless steel of hardness not less than 550 BHN
19	Hopper valley angle		45 deg
20	Dip pieces		Heat and corrosion resistant steel, minimum 10 mm thick.
21	Outlet gates		6 mm thick Carbon steel with stainless steel liners.

**VOLUME II****SUB-SECTION - 2.11.2****CLINKER GRINDER****1.0.0 CODES AND STANDARDS**

The design, manufacture and performance of clinker crusher as specified herein, shall comply with the requirements of all applicable codes. As far as practicable the equipment supplier shall follow the latest applicable Indian/International Standards.

2.0.0 DESIGN REQUIREMENT

The double roll clinker grinders shall crush ash clinkers to (-) 25mm size. It is mounted below the discharge chute of the hopper. A seal water line shall be provided with suitable interlock to the motor starting circuit, such that the grinder does not start till sufficient pressure and flow is obtained in the seal water line. If the clinker grinder is overloaded, the direction of rotation of motor shall be reversed for 3 minutes and then resume its original direction.

Clinker grinder chamber shall be provided with sufficiently big (100 mm size) drain connection with valve.

An adequately sized vent line from clinker grinder chamber shall open to atmosphere above the maximum level of water in bottom ash hopper.

Wear plates shall be provided on clinker grinder inlet & other wearing surfaces of the grinder chamber. The grinder speed shall not exceed 50 rpm and the drive motor speed shall not exceed 1000 rpm. Common steel fabricated base frame for grinder & drive shall be furnished. Grinder drives shall be so interlocked that the motor does not start till sufficient pressure is obtained in its seal water connection.

3.0.0 SPECIFIED DESIGN DATA

Sl.No.	Description	Unit	Data
	CLINKER GRINDER		
1	Number Required		Four (4) (2W + 2S) for each unit
2	Type of Grinder		Heavy duty double roll
3	Capacity	T/h	To match the Scraper chain conveyor.
4	Material to be Handled		Bottom ash clinkers
5	Max. Output Size Permissible	mm	25 mm
6	Type		915 mm wide double roll, automatically reversible
7	Seal water pressure		As required by the system
8	Max allowable Speed		50 rpm
9	Is Fluid Coupling Required?		Yes
10	Type of Transmission		Helical gear box, chain and sprocket.
11	Protective glands for coupling		Yes
12	Protective guard for belt/chain		Yes
13	Reversing mechanism		Yes
14	Common base plate of drive motor and gear box		Yes



Sl.No.	Description	Unit	Data
15	Materials of construction		
15.1	Rolls		Hadfield's Manganese steel (ASTM A128, 12-14% Mn) casting shop hardened to 300 BHN at all working surfaces and work hardened to 400 BHN at site.
15.2	Teeth of Rolls		Hadfield's Manganese steel (ASTM A128, 12-14% Mn) casting shop hardened to 300 BHN at all working surfaces and work hardened to 400 BHN at site.
15.3	Wear Plate/Liner		12-14% Mn Austenitic steel plates to IS:276, 10mm thick
15.4	Grinder Chamber		SS 316L – with 10 thk MN Steel/ Alloy CI liners
15.5	Shaft		SS 304/EN 8 or equal.
15.6	Shaft sleeve		SS 316L
15.7	Chain guard		As per IS 2062
16	Clinker outlet chute/ Ejector feed sump		10mm thick MS (IS:2062) lined with wear resistant liners.
17	Gland Packing		Graphite Teflon.
18	Testing and Inspection		
18.1	No load running test at manufacturer's works		Yes
18.2	Performance test at site		Yes
18.3	All tests may be observed by owner		Yes

**VOLUME II****SUB-SECTION - 2.11.3****JET PUMP****1.0.0 CODES AND STANDARDS**

The design manufacture and performance of the jet pump for handling abrasive boiler bottom ash as specified herein, shall comply with the requirements of the latest applicable Indian/British/ American/DIS Standard.

2.0.0 DESIGN REQUIREMENT

Jet pump shall be capable of evacuating 8 hour collection of bottom ash, coarse ash and fly in evacuation time stipulated elsewhere in the specification including time for changeover, flushing etc. with a minimum 25mm wear on the diameter of throat.

The design of jet pump shall allow for easy and quick inspection, removal and replacement of jet pump sections that are subjected to wear.

3.0.0 SPECIFIED DESIGN DATA

Sl.No.	Description	Unit	Data
1	Location		As per flow diagram
2	Number Required	Nos	As per flow diagram
3	Flow rate	T/h	Based on the evacuation time
4	Discharge Point		As per flow diagram
5	Material of construction		
5.1	Inlet Piece		Alloy CI with 4.5% Ni (min) 500 BHN IS- 4771
5.2	Nozzle Tip (Replaceable)		SS 304 with ceramic lining./ tungsten carbide
5.4	Nozzle Holder		CI with 2.5% Ni
5.5	Tube/outlet piece		Alloy CI with 2.5% Ni (min) 340 BHNIS- 4771
5.6	Gaskets		Rubber Compound
	General data All parts of the pump shall be suitable to resist		Wear and corrosion.
6	Tests to be conducted		
	Visual Inspection and Dimensional Check Against Approved Drawings		



VOLUME II

SUB-SECTION - 2.11.4

SCRAPER CHAIN CONVEYOR

Scraper units shall be provided with rail, wheels and suitable motorized self-propulsion arrangement to facilitate their removal from under the boiler furnace and its replacement with the standby scraper conveyor unit. In no case the angle of inclination of the sloped portion of the trough with the horizontal shall be more than 35deg. This drive shall be properly protected against overflow water, clinker etc. In no case the dia of the chain shall be less than 26mm. upper surface of the chain shall be case hardened to a depth of minimum 3mm to offer abrasion resistance. Size of the chain shall be provided with a factor of safety of minimum five (5) over the required chain pull during start-up condition with the upper trough being filled with ash up to maximum water level.

SPECIFIED DESIGN DATA

Sl. No	Items	Unit	Data
1.0	No. required	No.	Four (4) (2W + 2S) for each unit
2.0	Capacity		
2.1	Continuous normal operating capacity of each conveyor	T/h	Actual ash generation
2.2	Continuous minimum operating capacity during emergency	T/h	50% Margin over normal operation
3.0	Linear speed of chain	m/min	0.3-0.8 (maximum)
4.0	Linear speed of chain is fixed Variable or variable		variable
5.0	Minimum operating depth of water in upper trough	m	2.0m
6.0	Operating water temperature to Maximum be maintained in upper trough		60° C
7.0	Design of chain -associated components like sprocket & chain pulleys, fight connectors etc.		As per the recommendation of manufacturer.
8.0	Basalt Lining		
8.1	Hardness		8 Mhos (minimum)
8.2	Bending strength		300 kg/cm2 (minimum)
8.3	Compressive Strength		4500 kg/cm2 (minimum)
8.4	Density		2.8-2.9 gm per cm2
9.0	Final Drive Transmission	Kg/cu.m	chain and sprocket
10.0	Type of Couplings	mm	Fluid
11.0	Protective guard for couplings required	mm	Yes
12.0	Factor of safety for scraper feeder chain		Min. Six (6)
13.0	Make of scraper feeder chain		RUD/HEKO or equivalent.
14.0	Material of Construction		
14.1	Chain		40C-G/S4(RUD),Hardness: >HV750(can reach 800)
14.2	Scraper		16Mn+65Mn,Thickness 10mm
14.3	Drive chain wheel/guide wheel		CrNiMo alloy steel/CrNi alloy magnesium iron
14.4	Galvanic anode material and position of trough		Alloy made of Al,Zn,In inside of scraper chain side plate under the water



Sl. No	Items	Unit	Data
14.5	Trough structure		Q235-A
14.6	Material of liner in soleplate of upper trough/lower trough		Basalt, Thickness 40mm
14.7	Side plate angle of discharge chute	deg	70

**VOLUME II****SECTION - 2.11.5****ESP BUFFER HOPPER BLOWERS AND SILO FLUIDIZING BLOWERS****1.0.0 CODES AND STANDARDS**

The design, manufacture and performance of air blowers shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable Indian/British/American Standards. Nothing in this specification shall be construed to relieve Contractor of this responsibility.

2.0.0 DESIGN REQUIREMENTS**2.1.1 ESP & buffer hopper fluidizing Blowers and Silo Fluidizing Blower**

The requirement of compressed air for fluidizing the fly ash in the ESP & buffer hoppers of each unit and fly ash silo bottom shall be met by dedicated blowers of suitable capacity with adequate size of air heaters.

To prevent the blockage of the porous media and fan suction filters due to the accumulation of atmospheric dirt on the underside. Contractor shall pay special attention for selection of the suction filter on the air supply unit and shall bring out in their bid special features of filters to be provided. Suitable heating arrangement shall be provided at the discharge of centrifugal fans (if fans are envisaged for fly ash extraction) to raise the temperature of air at least 50 °C above the water vapor dew point. Schemes shall also include for thermal insulation of all air pipe work from the fan outlet to the point of contact of fly ash.

The blowers shall preferably be coupled to the motor directly through an approved type of flexible coupling. Coupling halves shall be bored and keyed to the shafts of the blower and motor by the Contractor. Coupling guards made of expanded metal and bolted to the base plate shall also be furnished.

In case blowers are offered with drive arrangement through Vee belts and pulleys, slide rails for motor shall be furnished, together with sheet/expanded metal guard for exposed moving parts.

The following accessories shall be furnished for each blower-motor set :

- a) Common base plate for blower and motor.
- b) Foundation bolts, nuts, sleeves etc.
- c) Flexible coupling between blower and motor with coupling guard (for coupled blowers).
- d) Vee belts and pulleys (for belt driven blowers).
- e) Slide rails for motors (for belt driven blowers).
- f) Suction filter (renewable medium type).
- g) Lubrication fittings.
- h) Silencer(s), if necessary.
- i) Safety relief valve
- j) Quick closing non-return valve
- k) Discharge pressure gauge with cock.



ANNEX 2.11.5.1

SPECIFIED DESIGN DATA FOR FLUIDIZING BLOWER

Sl.No.	Description	Unit	Data
	Air Blower		
1	General design data		Silo fluidization and ESP & buffer hoppers fluidization
2	Number Required		Refer flow diagram
3	Capacity	m ³ /hr	As per system requirement
4	Type		Rotary twin lobe type
5	Discharge Pressure	kg/cm ² (g)	As per system requirement
6	Medium Handled		Air
7	Specific Gravity of Medium		1.0
8	Maximum Speed	rpm	1500
9	Ambient temperature		Refer project data.
10	Design relative humidity		Refer project data.
11	Cooling		Air Cooled
12	Design conditioned		As mentioned for compressor
13	Type of belt		V.Belt
14	Material of construction		
14.1	Casing		CI to IS:210 Gr. FG260
14.2	Shaft		EN-8
14.3	Base Plate		MS/CI
14.4	Rotor		Alloy CI
14.5	Shaft Sleeves		SS 410
14.6	Bearings		Anti Friction
14.7	Heaters for fluidizing blowers		
a)	Type		Electrical
b)	Outlet temperature	Deg. C	150
c)	Temperature indicator/type		Yes/BI metallic.
d)	Insulation material		Mineral wool
e)	Temperature limit at surface	Deg. C	60
f)	Note: Thermal insulation of all air pipe work from the blower/heater outlet to the point of contact of fly ash to be provided by Contractor. All interconnected piping in blowers shall be Galvanized steel as per IS 1239 Heavy Grade.		

**VOLUME II****SUB-SECTION - 2.11.6****HORIZONTAL CENTRIFUGAL PUMP****1.0.0 CODES AND STANDARDS**

IS-1520 Horizontal centrifugal pumps for clear, cold and fresh water.

IS-1710 Vertical turbine pumps for clear cold fresh water

Standards of Hydraulic Institute, USA

IS-5120 Technical requirements for rotodynamic special purpose pumps.

IS-5639 Pumps for handling chemicals & corrosive liquids.

IS-6536 Pumps for handling volatile liquids.

IS-9137 Code for acceptance tests for centrifugal, mixed flow and axial flow pumps - class 'C'.

ISO 3555/ Acceptance tests for centrifugal, mixed flow and axial

BS 5316 Flow pumps, class 'B' tests.
Part 2

In case of any contradiction with the above standards and data sheet the stipulations in the data sheet shall prevail and shall be binding to the supplier

2.0.0 DESIGN REQUIREMENT**Pump Casing**

Pump casing shall be provided with adequate number of vents and priming connections with valves unless the pump is made self-venting and priming. Casing drain, as required, shall be provided complete with drain valves.

Pump design must ensure that the nozzles are capable of withstanding external reactions not less than those specified in API-610.

In cases where an expansion joint is located at pump discharge, the pump assembly will be subjected to an additional thrust which will be transmitted to the foundation. This additional thrust shall be taken into the consideration of pump design.

Impeller

The rotor assembly shall be statically and dynamically balanced and designed with critical speed substantially above the operating speed.

Impellers shall be made in one piece and securely fixed to the shaft. Means shall be provided to prevent loosing during operation including rotation in reverse direction.

Wearing Rings

Replaceable type wearing rings shall be furnished at suitable locations for each pump. The rings shall be so fitted as to prevent turning while the pump is in operation.

**Shaft**

Shaft size shall be selected considering that the critical speed shall be away from the operating speed as recommended in applicable code/standard. The critical speed shall be at least 20% above the maximum operating speed or above 60-70% of the lowest operating speed.

Shaft Sleeves

Renewable type fine finished shaft sleeves shall be provided at the stuffing boxes/mechanical seal. Length of the shaft sleeves must extend beyond the other faces of gland packing or seal end plate so as to distinguish between the leakage past shaft and shaft sleeve and that past the seals/glands.

Shaft sleeves shall be properly fastened to the shaft to prevent any leakage or loosening. Shaft and shaft sleeve assembly should ensure concentric rotation.

Bearings

Bearings shall be easily accessible without disturbing the pump assembly. A drain plug shall be provided at the bottom of each bearing housing.

Heavy duty sleeve/ball/roller type bearings shall be provided to take care of the radial loads.

In case of sleeve type radial bearings, axial thrust shall be absorbed in suitable hydraulic devices and/or thrust bearings.

Bearings and hydraulic devices (if provided for balancing axial thrust) shall be of adequate design for taking the entire pump load arising from all probable conditions of continuous operation, as specified in the 'data sheet'. Life of the bearings shall be guided by the design standard of the pump or as specified in data sheet. Thrust bearing shall be capable of running continuously at maximum load.

The bearings shall be oil/grease lubricated. Suitable lubricating arrangement for the bearings shall be furnished with the pump complete all accessories like pump, filters, pipings, fittings, valves, interlocking and supervising instruments etc. as necessary and specified in the data sheet. The design shall be such that the bearing lubricant does not contaminate the liquid being pumped.

Stuffing Boxes

Stuffing box design shall permit replacement of packing without removing any part other than the gland.

Stuffing boxes shall be sealed / cooled by the fluid being pumped/external clear water, as per requirement. All necessary pumps, piping, fitting, valves, instruments etc. as required for safe and trouble-free operation of the pumps and as specified in the data sheet shall be included in the pump supplier's scope of supply.

Mechanical Seals

Mechanical seals shall be provided if specified in the pump data sheet. The pump supplier shall co-ordinate with the seal maker in establishing the circulation rate for maintaining a stable film at the seal face in the chamber. The seal piping system shall form an integral part of the pump assembly



ANNEX 2.11.6.1
SPECIFIED DESIGN DATA FOR HORIZONTAL CENTRIFUGAL PUMPS -
DESAL WATER / SEA WATER RIVER WATER/ APPLICATION

Sl.No.	Description	Unit	Data
A)	Centrifugal Pumps (Water)-Desal Water		
1	Type		Centrifugal, horizontal
2	Qty.		As per the flow diagram.
3	Capacity		As per design requirement.
4	Casing		Axially split type / Horizontal / split casing/volute casing-
5	Impeller type		Closed
6	Drive transmission		Direct coupled
7	Seal		Mechanical seal/self water/ gland
8	Lubrication		Oil/grease/self liquid
9	Operating range		40% to 120% of rated flow.
10	Pump characteristic		Non overloading type & stable
11	shut off head		About 15 % more than the rated head.
12	Material of construction		
a)	Casing		CI to IS 210 Gr 260
b)	Impeller & casing rings		SS 304
c)	Shaft & shaft seals		SS 304
d)	Shaft sleeve		SS 410
	Notes: 10% margin shall be provided over the frictional drop in estimating the head of the pump		
B)	Horizontal Centrifugal Seal Water Pumps		
1	General		Seal water pumps
2	Max. Rated Speed (At 50 Hz)		3000 rpm
3	Pump Efficiency		MIN. 70%
4	No. of Pumps	Nos.	As per the flow diagram.
5	Features of construction		
6.1	Type of Pump		Back pull out
6.2	Impeller		Enclosed
6.3	Volute Casing		Single/Double/Diffuser
6.4	Shaft		Coupled.
6.5	Coupling		Flexible.
7	Materials of Construction		
7.1	Impeller		85-5-5-5 Bronze
7.2	Casing		Grained cast iron with 2% Ni.
7.3	Thrust bearing		Anti-friction type
7.4	Base plate		MS
7.4	Shaft		Heat treated stainless steel AISI 410
7.5	Shaft Sleeve		Type 316 stainless steel (replaceable)
7.6	Coupling		Cast steel/ forged steel.
7.7	Wearing rings		Stainless steel ASTM 351 8M
7.8	Stuffing box, glands and lantern ring		Bronze deep boxes with at least 5-6 packing rings.
8	Liquid data		
9	Liquid handled		Desal Water
10	Specific gravity		1.02
11	Temperature	°C	Ambient



Sl.No.	Description	Unit	Data
C)	Horizontal CENTRIFUGAL PUMPS –SEA WATER APPLICATION		
1	Type		Centrifugal, horizontal
2	Qty.		As per the flow diagram.
3	Casing		Duplex SS as per ASTM A 890 CE3MN Gr.5A
4	Impeller		Duplex SS as per ASTM A 890 CE3MN Gr.5A
5	Shaft		ST ST ASTM A 276 – SS316L ANLD
6	Shaft Sleeve		ST ST ASTM A 276 – SS316L
	Notes: Other details shall be same as the clarified water application.		

**VOLUME II****SUB-SECTION - 2.11.7****ASH SLURRY PUMPS****1.0.0 CODES & STANDARDS****Design**

The design, manufacture and performance of the horizontal pumps for handling abrasive slurry as specified herein, shall comply with the requirements of all applicable codes, the latest applicable India/ British/ American/Din standards, in particular the following:

IS: 5120: Technical requirement - rotodynamic special purpose pumps.

IS: 5639: Pumps for handling chemicals & corrosive liquids.

API: 610: Centrifugal pumps for general services.

2.0.0 DESIGN REQUIREMENT**Ash Slurry Pumps**

For pumping the bottom ash or fly ash slurry from the slurry sump to the ash disposal area, Respective slurry pumps will be used. Each set shall comprise of two horizontal ash slurry pumps, operating in series (if required) having a provision of installing 1 more additional pump in future. The first stage of ash slurry pumps shall be provided with fluid coupling with gear box arrangement and the second stage with V-belt drive (if applicable) as required, depending upon the disposal distance and/or wear of the impeller.

The pump shall be designed to have best efficiency at the specified duty point and shall be suitable for continuous operation at any point within the 'range of operation' specified.

Pumps shall have a continuously rising head capacity characteristics from the specified duty point towards shut off point, the maximum being at shut off.

The pump-motor set shall be designed in such a way that there is no damage due to reverse flow through the pump.

Each pump shall have single stage and shall be specially designed to handle abrasive slurry as specified in data sheet. Pumps shall be suitable for connection in series where system head requirement exceeds the head developed by one pump.

Pump Casing

Pump casing shall be of double casing type construction. The outer casing shall be designed to withstand the maximum shut-off pressure developed by the pump in series at the pumping temperature. The inner casing shall be replaceable type. Single casing pump shall not be accepted

Casing drain as required shall be provided complete with drain valves.

In case of pumps handling hot fluid, the pump casing nozzles will be subjected to reactions from external piping. Pump design must ensure that the nozzles are capable of withstanding external reactions not less than these specified in API-610.

In the case of installation, where an expansion joint or sleeve type coupling is located at pump suction and discharge, the pump assembly will be subjected to an additional thrust which will



be transmitted to the foundation. The pump shall be designed to withstand this additional load, calculated on the basis of pump/series shut-off head.

When system head requirement is more than the head developed by one pump, two or more pumps will be connected in series in the same pipe line, all the pump casings shall be hydrostatically tested to the requirement of last stage pump.

Each pump casing and internals shall be designed such that the casing can be rotated so that its discharge outlet covers 360° angle in vertical plane, at steps of 45°. The casing position shall be changeable at site at steps of 45° to suit pipe arrangement.

Impeller

The impeller shall be non-clog type, suitable for handling maximum size of solids specified.

The impeller shall be overhung type, shall be secured to the shaft and shall be retained against circumferential movement by keying, pinning or lock rings. The overhung shaft impellers should be secured to the shaft by an additional locknut or cap screw. All screwed fasteners shall tighten in the direction of normal rotation. Means shall be provided to prevent loosening during reverse flow condition/reverse rotation.

Shaft

Shaft size selected shall take into consideration the critical speed, which shall be away from the operating speed as recommended in applicable code/standard mentioned earlier. The critical speed shall also be at least 10% away from run away speed

Shaft Sleeves

Renewable type fine finished shaft sleeves shall be provided at the stuffing boxes. Length of the shaft sleeves must extend beyond the outer faces of gland packing so as to distinguish between the leakage between shaft & shaft sleeve and that past the gland.

Shaft sleeves shall be securely fastened to the shaft to prevent any leakage or loosening. Shaft & shaft sleeve assembly should ensure concentric rotation.

Bearings

Bearings of adequate design shall be furnished for taking the entire pump load arising from all probable conditions of continuous operation throughout its 'range of operation' and also at the shut-off condition. The bearing shall be designed on the basis of 20,000 working hours minimum for the load corresponding to the duty point.

Sleeve/ball/roller type bearings shall be provided to take care of radial loads.

In case of ball/roller type radial bearings, the same may be utilized for taking axial loads also by adopting suitable design.

In case sleeve type radial bearings are acceptable, axial thrust shall be absorbed in suitable thrust bearings.

Proper lubricating arrangement for the bearings shall be provided. The design shall be such that the bearing lubricating element does not contaminate the liquid being pumped.

Where there is a possibility of liquid entering the bearing, suitable arrangement in the form of deflectors or otherwise must be provided ahead of assembly.

Bearings shall be easily accessible without disturbing the pump assembly. A drain plug shall be provided at the bottom of each housing.

Stuffing Boxes

Stuffing box design should permit replacement of packing without removing any part other than gland.



Stuffing boxes shall be sealed/cooled by the liquid being pumped and necessary piping, fittings, valves, instruments etc. shall form an integral part of the pump assembly.

If external cooling/sealing water is required, all items like piping, fitting, valves, interlocking and supervising instruments etc. required for this purpose shall be supplied under this specification.

For the seals under vacuum service, the seal design must ensure sealing against atmospheric pressure, even when the pumps are not operating.

Base Plate & Sole Plate

For directly couple pump-motor set, a common base plate mounting both for the pump and motor shall be furnished. The base plate shall be of rigid construction, suitably ribbed and reinforced. Base plate and pump supports shall be so constructed and the pumping unit so mounted as to minimize misalignment caused by mechanical force such as normal piping strain, internal differential thermal expansion and hydraulic piping thrust. Suitable drain taps and drip lip shall be provided.

Variable speed Drive (Fluid Coupling)

The first stage pump of each series of ash slurry pumps shall be driven at a variable speed using a scoop type fluid coupling. The pump speed shall be manually adjustable within the range specified in data sheet.



ANNEX 2.11.7.1

SPECIFIED DESIGN DATA FOR SLURRY DUTY HORIZONTAL CENTRIFUGAL PUMP

Sl.No.	Description	Unit	Data
	Horizontal Centrifugal Slurry Pumps		
1	Application		Ash slurry pumps in ash slurry pump house B.A overflows pumps.
2	Medium		Ash slurry
3	Pump Efficiency		MIN. 70%
4	No. of Pumps for each unit.		Refer Flow diagram
5	Capacity	m3/hr	As per system requirement
6	Suction head discharge of 1st pump.		For the 1st pump in each set flooded.
7	Features of construction		
8	Type of Pump		Volute casing
9	Impeller		Non clog
10	Volute Casing		Double
11	Coupling		Ash slurry pump
11	Maximum permissible tip speed for pump impeller		28 m/sec
12	Slurry concentration		25-30% by weight
13	Maximum operating speed of the pump		Not exceeding 1500 rpm.
			Variable speed hydraulic /fluid coupling for first stage and gear box to achieve speed variation of (+) 10%, (-) 20% of rated speed.
			For second stage onwards- Belt drive
14	Lubrication		Grease/Oil
15	Type of sealing		External water sealing
16	Separate pumps for sealing/ cooling acceptable		Contractor to indicate
17	Pump and foundation to be designed for expansion joint/ sleeve coupling at pump suction & discharge		Yes
18	Bearings		Ball/roller
19	Thrust bearing to be designed for pump shut-off operation		Yes
20	No. of pumps per chain		As per Flow Diagram and system requirement
21	Duty		Continuous
	Scope of Supply		Yes
1	Pumps with drive motors		Yes
2	Driving power transmission device, fluid and flexible coupling as applicable		Yes
3	Motor slide rails		No
4	Guard for couplings/belts		Yes
5	Adapters for pump suction		Yes



Sl.No.	Description	Unit	Data
	and discharge		
6	Companion flange with bolts, nuts & gaskets for pump suction and discharge		Yes
7	Base plate for pump and drive unit		Yes
8	Foundation bolts, nuts, sleeve for all equipment		Yes
9	Eye bolts, lifting tackles etc.		Yes
10	Painting and protective coating		Yes
11	Erection, testing and commissioning service required		Yes
12	Supervision of erection required		Yes
13	Cooling/ sealing/ lubrication system with necessary pumps, piping, valves, tank, instruments etc.		Yes
14	Water for cooling/ sealing/ lubrication to be taken from		From seal water system by Contractor
15	Discharge pressure gauge		Yes
16	Suction pressure/ combination gauge		No
17	Materials of Construction		
17.1	Impeller and impeller ring		Chrome nickel cast iron Ni hard Type IV, 550 BHN OR 24% Chromium cast iron of 550 BHN
17.2	Outer Casing		Outer casing shall be cast steel ASTM-A216 or Spheroid graphite ductile iron ASTM 636, 65-45-12. OR 24% Chromium cast iron of 550 BHN
17.3	Inner casing		Inner casing (volute liner) shall be chrome nickel cast iron NI hard Type IV, 550 BHN OR 24% Chromium cast iron of 550 BHN
17.4	Wear plate (Bracket side and suction side)		Chrome nickel cast iron NI hard Type IV, 550 BHN OR 24% Chromium cast iron of 550 BHN
17.5	Suction Adopters		Chrome nickel cast iron Ni hard Type IV, 550 BHN OR 24% Chromium cast iron of 550 BHN
17.6	Discharge Adopters		Chrome nickel cast iron Ni hard Type IV, 550 BHN OR 24% Chromium cast iron of 550 BHN
17.7	Shaft		Carbon steel to AISI K-1040/EN 8
17.8	Shaft Sleeve		Hardened and ground SS (550 BHN) OR SS ASTM A 743 CA 15 (550 BHN)
17.9	Stuffing box		Alloy CI 400 (BHN)
17.10	Gland		Carbon Steel ASTM 216 GR.WCB
17.11	Gland packing		Asbestos Rope

**VOLUME II****SUB-SECTION - 2.11.8****KNIFE GATE VALVE****1.0.0 CODES AND STANDARDS**

The design, manufacture and performance of knife gate valve as specified herein shall comply with requirements of all applicable codes. As far as practicable the equipment supplier shall follow the latest applicable Indian/British/American standard.

2.0.0 DESIGN AND REQUIREMENT

The valves shall be of rugged construction designed for the service condition specified in the enclosed data sheet. Liberal wear allowances shall be provided in all components subject to attrition by flowing slurry.

The valves shall be suitable for trouble-free service with highly abrasive ash slurry containing solid lumps, clinkers etc. Design of the valves should be such that there is no possibility of entrapment of solid particles between gate and body seat leading to leakage of fluid in valve closed condition.

Design of the valve shall be such that sealing surfaces (body as well as gate) are effectively protected from direct abrasion by flowing ash slurry.

The valves shall be manually / cylinder operated type as required for service condition or as indicated in the data sheet. In case of cylinder operated valves necessary solenoid valves, needle valves etc for compressed air line shall be in the scope of tender.

All valves shall be provided with an open/close position indicator.

All parts of the valves coming in contact with flowing ash slurry shall be made from appropriate abrasion-resistant material commensurate with the materials specified in the data specification sheet for the principal valves components.

Limit Switch

Wherever, needed valves shall be provided with limit switches for interlocking purpose.

Limit switch shall have minimum of one normally open and one normally closed contacts.

For other electrical specification requirements relevant electrical sub-section shall be referred

**ANNEX 2.11.8.1
SPECIFIED DESIGN DATA**

Body and seat material	: Cast Iron FG 260 to IS 210 (min 10mm thick)
Plate/flap Material and Hardness	: SS with 400BHN on wers surface. Deflection cone : Ni-HARD ALLOY CI (450-600) BHN
Stem	: Stainless steel (SS-304) for knife edge gate valves

ACCESSORIES

Whether local position indicator required for Each type of valve	: Yes
Whether limit switches for open and close Condition required	: Yes
Whether solenoid valves, needle valve and all accessories for compressed air supply required	: Yes

TEST AND INSPECTION

Hydraulic test at shop required	: Yes/No
Hydrostatic test pressure :	
a) Shell	: 1.5 times maximum working pressure
b) Seat	: At maximum working pressure

Note : Contractor to select number of valves, type of actuation, size etc. as per system requirement for the applications shown in Flow Diagrams.

**VOLUME II****SUB-SECTION - 2.11.9****DRAIN PUMP****1.0.0 CODES AND STANDARDS**

The design, manufacture, performance and testing of the drain pumps shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed and shall also comply with latest Indian/British/American Standards, as applicable. In particular, the equipment shall conform to the latest editions of the following standards:

- i) IS: 1710 - Vertical turbine pumps for clear cold, fresh water.
- ii) IS: 5639 - Pumps handling chemicals and corrosive liquids.
- iii) IS: 5659 - Pumps for process water.
- iv) IS: 5120 - Technical requirements for rotodynamic special purpose pumps.
- v) IS: 5600 - Specification for sewage and drainage pumps.
- vi) Standards for Hydraulic Institute, U.S.A.

2.0.0 DESIGN REQUIREMENTS**Type**

Pumps shall be wet pit type, vertical shaft, single stage and non clog design with enclosed shaft.

Impeller

- i) The impeller shall be semi open or open (non-clogging) as per standard design of the manufacturer.
- ii) It shall be specifically designed to pass large solids or unscreened liquids. The clearance between the stationary and moving parts shall be such as to allow sustained performance without excessive maintenance.

Accessories

All accessories required for the efficient and safe operation of the pump-motor sets shall be furnished which shall include but not limited to the following:

- i) Base plate together with foundation bolts and nuts, sleeves, inserts etc.
- ii) Motor stool.
- iii) Lifting lugs, eye bolts etc.
- iv) Discharge pipe brought above the mounting plate.
- v) Coupling guard, if necessary.
- vi) Pressure gauge etc.



ANNEX 2.11.9.1

SPECIFIED DESIGN DATA FOR VERTICAL SUMP DRAINAGE PUMPS

S.No.	Description	Sump drainage pumps for BA hopper area, vacuum pump area, slurry pump area and Silo area
1.	Type	Vertical, Centrifugal, single stage, semi-open or (open non-clogging) type impeller.
2.	Duty	Intermittent, However, to be designed for continuous operation. Pump capacity shall be minimum 25m ³ /h
3.	Fluid to be pumped	with 30% particles by weight
4.	Suction Condition	Submerged
5.	Number of pumps	As indicated in the flow diagrams.
6.	Pump speed (Max.)	1500 rpm (Max.)
7.	Type of coupling between pump & Motor	Directly driven through flexible or rigid coupling/V-belt driven
8.	Location of pump thrust bearing	In Motor Stool
9.	Automatic Float Level Switch for Start/Stop	Yes
10.	Sump Cover Plate	Yes
11.	Stuffing Box	Yes
12.	Material of Construction	
a)	Inner Casing	Ni-hard, alloy CI with 550 BHN
	Outer Casing	IS 310 FG 260
b)	Impeller	Ni-hard, alloy CI with 550 BHN
c)	Impeller shaft	SS-316L
d)	Line shaft	SS-316L

**VOLUME II****SUB-SECTION - 2.11.10****FLY ASH SILO****1.0.0 DESIGN REQUIREMENT**

There shall be Four (4) Nos. of fly ash RCC storage silos with associated accessories. Each fly ash storage silo shall have the following auxiliaries and accessories.

- Adequately sized target/diverter boxes with pneumatic operated isolating valves located on silo top.
- Bag type vent filter (Pulsating jet type) with fan on the vent line at the top of fly ash storage silo.
- Pressure relief vent on the top of silo to safeguard the silo from getting pressurized.
- Dry fly ash unloading spout with all accessories such drive equipments, rotary feeder, and discharge chute with canvass, limit switches, dust suppression unit etc for unloading ash into closed tankers.
- Dust conditioning equipment with all accessories such as isolation/shut off gate, drive equipments, rotary feeder, fly ash dust conditioner with water spray nozzles, associated water piping, valves etc. to make the system complete in all respects.
- Silo level indicator with all accessories.
- Ceramic fluidizing pads to fluidise fly ash in fly ash silo.
- One (1) lot of maintenance/operating floor for silo unloading, staircase to approach upto top of silo, handling arrangement at top of silo, hand railings, ladder to approach inside silo etc.
- One (1) outlet connection with blind flanges for installation of jumbo transmitter at a later date.
- All other items required to make the system complete in all respects.

Each silo shall have the following connections with rotary feeder to offer the unloading of ash in different form as below.

- 2 no. opening common for Unloading of ash in dry form to closed tank carriers through Telescopic chute.
- 2 no. opening for Wet disposal using jet pump.
- 1 Opening common for Unloading of ash through Dust conditioner into open truck.
- 1 One blind flange opening.

a) One blind flange opening.

The bag filter unit shall be placed over the buffer hopper and silo top. Gross face velocity (considering 10% bag choked condition) shall not exceed 1 m/min. The performance of bag filter shall not get affected when 10% of bags plugged. Bag filter shall be supplied complete with automatic pulse jet cleaning with all necessary diff. pressure gauge, pressure switch solenoid operated pulse valve. Clean air plenum on bag filter with clear man height shall be provided for easy access of bags during maintenance.



**ANNEX 2.11.10.1
SPECIFIED DESIGN DATA FOR FLY ASH SILO**

Sl.No.	Description	Unit	Data
A	SILO AND ACCESSORIES		
1	General design data		
2	Type of Silo Construction		RCC fly ash silos (flat bottom)
3	Numbers and capacity	Nos	As per flow diagram and each 1000MT
4	Method of Venting Conveying Air from Silo		Through bag filter to Atmosphere
5	Silo Level Measurement		Continuous
6	No. of silo outlets		As per flow diagram,
7	Type of valve at silo outlets		Knife gate valve-Pneumatically operated)
8	Accessories and mountings		
8.1	Manhole		Yes
8.2	Ladder for Access Inside Silo		Yes (SS - Ladder)
8.3	Pressure and Vacuum Relief Door		Yes
8.4	Access Staircase from Ground		Yes
8.5	Fluidizing pads		Ceramic / Woven SS
8.6	Silo bottom fluidization		Yes
8.7	Adequately Sized Openings		Yes
8.8	Operating Floor at Dust Conditioner Floor		Yes
8.9	Silo Ash Level Indication		Yes
8.10	Hand Rails and Toe Plates all Round Roof Area Required		Yes
8.11	Silo Top Cover		Air & Water Tight RCC Slab
8.12	Monorail with Hoist to handle equipment from silo top to ground.		Yes.
8.13	Grating platform for inter-connecting two silos at silo unloading platform level and also at silo top		Yes
8.14	Tests at manufacturer's works		
8.15	Visual and Dimensional Check of all the Accessories of Silo		Yes
8.16	Particle emission at silo outlet		50 mg/nm3
8.17	Terminal Box		Yes.
8.18	Shed Over Silo Provided		Yes.
8.19	Clear head room from the ash discharge chute upto ground level for trucks to pass through Height of the platform supporting the Silo unloading equipments from ground level		5 .5 m clear
B	CONTINUOUS DUST CONDITION UNLOADERS		
1	General		
1.1	Designation		Continuous dust conditioner and unloader



Sl.No.	Description	Unit	Data
1.2	Type		Double Paddle type
1.3	Number Required		As per flow diagram.
1.4	Material Handled		Fly ash
1.5	Maximum moisture content.	%	20 (max)
1.6	Type of material		Highly Abrasive
1.7	Location		Underneath fly ash silo
1.8	Operation		Continuous during each Unloading operation
1.9	Number of Unloading Operations per Day		Frequent unloading During day time
1.10	Metering device		To be provided upstream of Paddle mixer
1.11	Type of metering device		Air lock type rotary feeder
1.12	Trough of paddle mixer		U-type.
1.13	Type of shaft		Hollow pipe
1.14	Material of construction		
a)	Trough		M.S. 6MM thick with SS 410/304 5 mm thick liners.
b)	Top cover plate		M.S. 4 MM thick
c)	Shaft		SS 410
d)	Paddles		SS 409
e)	Spray nozzles		SS 316
1.15	Inlet type		To suit silo outlet
1.16	Number of inlets		One
1.17	Type of gate at silo outlet		Knife gate valve
			- Pneumatically Operated
1.18	Number of Outlets		As per requirement.
1.19	Capacity	TPH	120 (for open truck only)
1.20	Water supply to spray nozzles shall be adjustable so as to condition the fly ash in order to control dust nuisance, without causing ash slurry formation.		
1.21	Necessary canvas chute from dust conditioner outlet to the inlet of trucks shall be included in the Contractor's scope.		
1.21	Necessary canvas chute from dust conditioner outlet to the inlet of trucks shall be included in the Contractor's scope.		
C	ROTARY FEEDER		
1	General		
1.1	Number Required	Nos.	As per flow diagram
1.2	Duty	hrs/day	24
1.3	Material Handled		Fly ash
1.4	Maximum Lump Size	mm	12
1.5	Capacity	TPH	120 -Dust conditioner –open truck 200-closed truck
1.6	Material of construction		
1.6.1	Inlet, outlet and rotor		MS fabricated. The edge of the rotor vanes shall be hardened to 340BHN for 100mm width.



Sl.No.	Description	Unit	Data
1.6.2	Shaft		EN-8
	Notes:		
	Alloy CI – Type 1a as per IS-4771 with hardness of 350 BHN min., for all parts coming in contact with fly ash. Alternatively MS fabricated with 10 thick TISCRA/ SAILHARD liners construction.		
D	UNLOADING SPOUT		
1	Total number required		As per flow diagram
2	Location		Below fly ash silo
3	Type		Telescopic chute.
4	Drive		Geared motor & chain drive with brake
5	Material of construction		
5.1	Thickness	mm	8 as per IS 2062
5.2	Outer bellows		Canvas cloth
5.3	Maximum horizontal movement	mm	400
6	Capacity	TPH	120 -Dust conditioner –open truck 200-closed truck
	Notes: a. Venting arrangement with filter and fan will be provided. b. Level probes and limit switches will be provided		
E	BAG FILTER		
1	Location		At the top of each buffer hopper & Silo
2	Type		Compressed air cleaned, reverse pulse jet type
3	Duty		Continuous-24 hours/ day
4	Material Handled		Dry Fly ash
5	Material of Construction		
5.1	Bags		Automatic pulse jet type, Polyester needle felt of antistatic type
5.2	Cages		GI
5.3	Casing		MS
5.4	Volume of Dust Laden Air to be handled	m ³	Shall match the flow rate of ash-air mixture Into fly ash silo
5.5	Air-to-Cloth Ratio	m/min	One
5.6	Maximum Dust Concentration in Air that shall be Let Out to Atmosphere	mg/Nm ³	50
5.7	Are Controls for Automatic On-line Bag Cleaning System Required?		Yes
	Temperature to withstand	Deg C	170 (continuous) 200 (occasional)
5.8	Tests		
	Visual and dimensional check at works		Yes
	Site tests for functioning of the automatic on-line bag cleaning system		Yes
	Check for dust concentration in the air to be let out to atmosphere at site		Yes

**VOLUME II****SUB-SECTION - 2.11.11****SLURRY LINE PLUG VALVE****1.0.0 CODES AND STANDARDS**

The design, manufacture and performance of Plug Valve as specified herein shall comply with requirements of all applicable codes. As far as practicable the equipment supplier shall follow the latest applicable Indian/British/ American Standards. In case of any conflict between the aforesaid standards and stipulation of this specification, the later shall prevail.

2.0.0 DESIGN REQUIREMENT

The valve assembly shall be of lubricated taper plug type design suitable for quick opening and closing.

The valves shall be motor operated type as required for service condition or as specified in data sheet.

All valves shall be provided with an open/close position indicator.

The design of the valves shall be such as to offer absolute leak tightness under the specified service condition and against the maximum working pressure as specified and as will be available.

The material of construction and hardness of the various parts of the valves shall be as specified in the data sheet.

3.0.0 SPECIFIED DESIGN DATA

MATERIAL OF CONSTRUCTION	
Body/cover	Carbon steel ASTM A 216 Gr WCB (0.3% Carbon).
Plug:	SS 316L NITRIDED TO 500 - 600 BHN Hardness
Stem	Carbon steel ASTM A 216 Gr WCB (400-450BHN suitably impregnated for low friction.)
ACCESSORIES	
Whether local position indicator required for each type of valve	: Yes
Whether limit switches for open and closed condition required	: No
Whether solenoid valves, needle valves and all accessories for compressed air supply required	: No



TEST AND INSPECTION

Hydraulic test at shop required : Yes

Hydrostatic test pressure

a) Shell : 1.5 times maximum working pressure or 1.2 times the shut off pressure, whichever is higher

b) Seat : Working pressure

Note : Contractor is to select number of valves, size etc. as per system requirement for the applications shown in the Flow Diagrams.



VOLUME II
SUB-SECTION - 2.11.12
COMPRESSED AIR SYSTEM

1.0.0 GENERAL

This section is intended to provide the scope, design, constructional and functional requirements for Conveying air and Instrument air requirements for Ash handling system.

2.0.0 CODES AND STANDARDS

The applicable standards and codes for various major equipment are given below. Latest editions of the following standards shall also be used.

TEMA	-	Tubular Exchanger Manufacturer's Association
ASME	-	American Society of Mechanical Engineers
IS	-	Indian Standards
VDI	-	Verein Deutscher Ingenieure
RMS	-	Reputed manufacturers standard

3.0.0 SCOPE OF SUPPLY

The scope of supply shall include but not limited to the following:

a. Screw type, Oil free Air compressors for both the units

- 3 (2W+1S) nos. for conveying air application for unit-1
- 3 (2W+1S) nos. for conveying air application for unit-2
- 3 (2W+1S) nos. for Instrument air requirement.

(with adequate capacity and discharge pressure as required for offered equipments shall be provided.

b. Three (3) numbers (2W+1S) Air Dryers of refrigerant type air dryers to match instrument air compressor capacity along with all accessories including control panel, flow meter, online digital dew point meter at the outlet of each dryer, etc.

Three (3) numbers (2W+1S) Air Dryers of refrigerant type air dryers to match conveying air capacity for unit-1 along with all accessories including control panel, flow meter, online digital dew point meter at the outlet of each dryer, etc.

Three (3) numbers (2W+1S) Air Dryers of refrigerant type air dryers to match conveying air capacity for unit-2 along with all accessories including control panel, flow meter, online digital dew point meter at the outlet of each dryer, etc.

c. Two (02) numbers of Instrument air receivers and three (03) numbers of conveying air compressors of adequate capacity (minimum 10m³) shall be provided along with all accessories such as pressure gauges, safety relief valves, electronic type auto drain traps, manual isolation / blow off drain valves, bypass control valve, fittings, pressure indicators, etc. The air receivers shall be vertical self-supporting cylindrical vessels with supporting legs for resting on their foundation.



4.0.0 DESIGN REQUIREMENTS

- The compressed air system shall consist of common inter connected systems for instrument air and service air.
- The set pressure of relief valve shall be 110% of the rated discharge pressure.

5.0.0 LAYOUT

Air compressors would be located indoor in a separate compressor room.

Air compressors are kept in compressor house. The compressor house shall be provided with necessary crane to handle equipment/components during maintenance. Air receivers shall be placed outside the compressor room. ADP equipment would be skid mounted and located indoor.

- Maintenance bay of at least one compressor bay width with adequate handling facilities and rolling shutters of adequate dimensions to enable truck entry shall be provided.



ANNEX 2.11.12.1
SPECIFIED DESIGN DATA

CL.NO.	DESCRIPTION	UNIT	DATA
A.	AIR COMPRESSOR		
1.0.0	General		
1.1.0	Designation		Air compressor
1.2.0	Number offered - Instrument and service air compressor		As mentioned above
1.3.0	Type		Two stage, Water cooled, Oil free compressor with drive motor and accessories like inter cooler, after-cooler, Oil cooler, Moisture separators, intake filters, Suction silencers, Vibration isolators, etc.,
1.4.0	Duty mode		Continuous, Load-Unload and ON-OFF operation.
1.5.0	Control mode		'Dual' control mode
1.6.0	Lubrication bearing		Forced
1.7.0	Location		Indoor
1.8.0	Type of drive-compressor connection		Direct
1.9.0	Galvanization of interconnecting piping		Yes
2.0.0	Material of construction		
2.1.0	Casing		Cast iron with corrosion resistance material
2.2.0	Rotor body		Forged Carbon Steel coated with Teflon
2.3.0	Shaft seal		High alloy steel
2.4.0	Inlet throttle valve		Aluminium alloy
2.5.0	Housing of valve		Aluminium alloy
2.6.0	Bull gear		Alloy steel
2.7.0	Pinion gear		Alloy steel
2.8.0	Timing gear		Low alloy steel
2.9.0	Gear box		Cast iron



CL.NO.	DESCRIPTION	UNIT	DATA
2.10.0	Blow of valve		Stainless steel
2.11.0	Unloading cylinder head		Aluminium
2.12.0	Tube of blow off cooler / oil cooler.		SS304
2.13.0	Outer casing of coolers		Carbon steel
B	INTERCOOLER AND AFTERCOOLER		
1.0.0	General		
1.1.0	Designation		Accessories for compressed air system
1.2.0	Nos. required		One set for each compressor
1.3.0	Type		Horizontal / Vertical shell and tube type with removable bundles, with counter current flow heat exchangers
1.4.0	Location		Indoor
2.0.0	Equipment parameters		
2.1.0	Outlet air temperature	°C	8 °C (Maximum) above cooling water inlet temperature
2.2.0	Design pressure	kg/cm ² (g)	1.25 times the maximum operating pressure
2.3.0	Hydrostatic test pressure	kg/cm ² (g)	1.5 times maximum operating pressure
2.4.0	Allowable pressure drop of air	kg/cm ² (g)	0.2
2.5.0	Minimum corrosion allowance	mm	3.0
3.0.0	Material of Construction		
3.1.0	Tube		Copper / CU-Ni / Stainless steel
3.2.0	Shell		CS SA 106 Gr.B / IS : 2002/ SA 516 Gr 70
3.3.0	Tube sheet		CS SA 105 / IS : 2002 / SS 316/ SA 516 Gr 70
3.4.0	Tube support plates		SA 516 Gr. 70 / IS : 2062
3.5.0	Auto-drain trap body & Trim		SS 316
4.0.0	Intake Air Filter		



CL.NO.	DESCRIPTION	UNIT	DATA
4.1.0	General		
4.1.1	Designation		Intake Air Filter for compressors
4.1.2	Nos. Required		One for each compressor
4.1.3	Location		Suction pipe of compressor
4.1.4	Type		Dry type
4.2.0	Performance Required		
4.2.1	Air flow rate		As per compressor flow rate
4.2.2	Filtering efficiency		99.50% down to 2 microns over entire capacity range of compressor
4.3.0	Special Feature		
4.3.1	Operating sound level		85 dB at 1 M (max.) from edge of Skid.
4.3.2	Filtering element equivalent		Compressed felt / manufacturer's standard
5.0.0	Air Receiver		
5.1.0	General		
5.1.1	Designation		Air receiver
5.1.2	Type		Vertical
5.1.3	Location		Outdoor
5.1.4	Receiver design code		IS : 2825 / IS : 7938
5.1.5	Number		Refer flow diagram
5.2.0	Equipment Parameter		
5.2.1	Capacity		Minimum 10 m ³
5.2.3	Design pressure		1.1 times the maximum operating pressure
5.2.4	Hydraulic test pressure		1.5 times maximum operating pressure
5.2.5	Relief valve set		10% higher than working pressure or atleast equal to design pressure whichever is higher



CL.NO.	DESCRIPTION	UNIT	DATA
5.3.0	Material of Construction		
5.3.1	Shell		IS: 2002 Gr 2A
5.3.2	End plates		IS: 2002 Gr 2A
5.3.3	Relief valve body		Cast steel
5.3.4	Relief valve spring		Spring steel
6.0.0	Air Drying Plant		
6.1.0	General		
6.1.2	Designation		Air Drying Plant for Instrument Air
6.1.3	Type		Refrigerant type
6.1.4	Duty		Continuous
6.1.5	Nos. required	Nos.	As per flow diagram
6.1.6	Location		Indoor
6.2.0	Operating Data		
6.2.1	Air flow rate	Nm ³ /min	To match compressor flow rate
6.2.2	Dew point (atmospheric)	°C	(-) 20
6.2.3	Maximum allowable pressure drop	Kg/cm ²	0.3
6.3.0	Tests		
6.3.1	Noise level		Limited to 85 dB (A) at 1.5 m from equipment in any direction
6.3.2	Capacity at rated discharge pressure of compressors		ASME Power test code for compressor and exhausters
6.3.3	Negative tolerance on guaranteed values of specific power consumption, air dryer dew point of air, air dryer pressure drop and water pressure drop.		0.00%
6.3.4	Performance test for air dryer – Rated dew point temperature		Yes
6.3.5	Material of construction		IS:2002

Note: Design, MOC, annunciations, trips for compressor (within the compressor and Air drying Plant skid) as per manufacturer standard will be subjected to approval by owner. Manufacturer shall be as per approved vendor list. DM water shall be used for Compressor cooling.



VOLUME II

SUB-SECTION - 2.11.13

FLY ASH BRANCH SEGREGATION VALVES AND FLY ASH FEED VALVES

Sl.No.	Description	Unit	Data
1.0	Vacuum system		
1.1	Type of valves		Swing type or slide plate type or any other type of proven design
1.2	Numbers required		(i) one (1) no. Fly ash feed valves under each fly ash collection chute i.e. each ESP hopper & APH hopper. (ii) one no. Fly ash Branch segregation valve for each branch pipe. (iii) Manual hopper isolation valve for each hopper
1.3	Size of valves		As per system requirements.
1.4	Method of operation		Solenoid operated pneumatically actuated with provision of manual override facility.
1.5	Material of construction		
1.5.1	Body		Alloy cast iron with hardness of 250 BHN (Min.)
1.5.2	Plate/disc		3mm thick stainless steel with 300-350 BHN hardness for fly ash segregation valves and 10 mm thick SS with 300-350 BHN.
1.5.3	Seat		Replaceable type alloy C.I or SS smooth finished minimum 250 BHN hardness.
2.0	Pressure System		
2.1	Type of valves		Plate type/ butterfly type/ dome type/cone type or any other type of proven design.
2.2	Number required		i) One (1) no. Feed valves at the inlet and outlet of air ejector/air lock/pump tank with manual isolation valve ii) Required no of Branch segregating valves for each branch pipe.
2.3	Size of valves		As per system requirements.
2.4	Method of operation		Solenoid operated pneumatically actuated with provision of manual override facility.
2.5	Material of construction		
2.5.1	Body		Alloy cast iron with hardness of 250 BHN (min.)
2.5.2	Plate/disc/dome/cone		Minimum 10 mm thick S.S. /alloy C.I 300-350 BHN
2.5.3	Seat (whenever applicable)		Replaceable type alloy CI or SS smooth finished hardness to 250 BHN (min.)



Sl.No.	Description	Unit	Data
3.0	Silo inlet valves / fly ash pressure Transportation Lines/interconnection valves		
3.1	Number Required		As indicated in the tender drawings and as required
3.2	Method of operation		Solenoid operation pneumatically actuated
3.3	Type		Inflated rubber seated Pneumatically Or Resilient rubber seated BI-directional valves Or Rotating disc type valve (having springs)
3.4	Material of Construction		
3.4.1	Dome valve		
	(i) Body		Cast iron FG - 260
	(ii) Dome		Alloy C.I min. 350 BHN

**VOLUME II****SUB-SECTION - 2.11.14****AIR LOCKS AND FLY ASH BUFFER HOPPERS**

i) Specified Design Data for air locks / Pump tanks

Sl. No.	Parameters	Data	Description
1.0	Numbers provided		Under buffer hoppers: minimum two(2) nos. Per buffer/intermediate hopper for dry ash transportation from buffer hoppers to storage silos.
2.0	Sizing of air locks/pump tanks		To cater to the ash removal rates as mentioned in reference clause of Design data in system capacity.
3.0	Material of construction		
3.1	Body		Tested quality MS to IS: 2062 10mm thick.

Fly ash buffer hopper bottom portion shall be conical in shape aeration pads shall be provided in conical portion to prevent compaction and to fluidize. Each hopper to include access door of dia 750mm or 750 x 750mm. Suitable platform and stairs shall be provided at different levels for equipment / bag filter/ valve maintenance.

ii) Specified Design Data for Dry Fly Ash Buffer/ Intermediate Hoppers

Sl. No.	Parameters	Data	Description
1.0	Number		As per flow diagram.
2.0	Material of construction		6 mm thick M.S. to IS: 2062 with 10 mm thick abrasion resistant Alloy C.I. liners of 300-350BHN hardness at sloping surfaces and outlet area.
3.0	Emission		Outlet emission level shall be within 50ppm



VOLUME II

SUB-SECTION - 2.11.15

ASH AND SLURRY CONVEYING PIPELINE

A) Specified Design Data for Pneumatic Ash Conveying Pipelines

Sl.No.	Description	Unit	Data
1.0	Pipe size (I.D.)		As required
2.0	Types of pipes		For vacuum system: Class - D cast iron pipes conforming to IS : 1536 or BS: 1211. For Pressure system: MS IS 3589 (9.52 mm thick) Buffer hopper to vacuum pump: min. 6mm MS pipes IS-3589
3.0	Type of joints		
3.1	Pipe to Pipe, Pipe to Fitting, Pipe to Valve & Valve to Fitting, Fitting to Fitting		Flanged /Sleeve Coupling (Flanged with every third joint of sleeve coupling)
3.2	Fittings (Bends, elbows laterals and spool piece etc.		Ni-hard/chrome-alloy cast iron or equivalent. Minimum hardness 400 BHN and wear back thickness minimum 20 mm.
4.0	Material of construction		
4.1	Sleeve		9.0 mm thick carbon steel ASTM-36/BS EN10025: 1993 Grade S:275 / 355/IS2062 or CI FG 260:IS:210
4.2	Flanges / end rings		Carbon steel to ASTM-A-108 / IS:2062 or CI. FG 260, IS:210. Steel and rings shall be formed from hot rolled section bar, free from circumferential welds.

B) Specified Design Data for slurry transportation pipes and Accessories for Bottom Ash, Economiser Ash and Fly Ash

Sl.No.	Description	Unit	Data
I	B.A. Economizer Ash and F.A. Slurry and disposal Pipes		
1.0	Type of pipes		ERW/SAW of API-5L Gr. B Casing Pipe with Cast Basalt Linear with min. 20mm thick
2.0	Pipe Size		As per the requirement
3.0	Thickness of Casing pipes		6.0 mm (Min.)
4.0	Type of Joints		Sleeve type coupling joints in straight length and flanged joints at fittings (bends, elbows, laterals etc.) (Flanged with every third joint of sleeve coupling)



Sl.No.	Description	Unit	Data
II	Pipe Fittings (Bends Elbows. Laterals Spool Pieces etc.)		
1.0	Material and hardness		Ni-Chrome alloy cast iron or equivalent. Min. Hardness 400 BHN Integral wear back of minimum 20 mm thickness
2.0	Basalt lining		20 mm thick cast basalt lined MS fittings (MS shell of 6 mm minimum thickness)
3.0			Hardness of 8 mhos (minimum)
III	Coupling		
1.0	Type		Sleeve type couplings with minimum 9.0 mm thick sleeves
2.0	Material of construction		
2.1	Sleeve		Carbon Steel to ASTM A-36/BS EN 10025:1993 Grade S:275/355
2.2	Flanges/End rings		Carbon Steel to ASTM A-108 Steel end rings shall be formed from special hot rolled section bar, free from circumferential welds.

Note: All slurry piping inside the BA and FA slurry pump house shall be basalt lined.



VOLUME II
SUB-SECTION - 2.11.16
OPERATION AND PHILOSOPHY FOR ASH HANDLING SYSTEM

The Ash handling system shall have DCS remote I/O units with the Redundant Processor, power supply, communication module etc for the control and monitoring of the bottom ash handling system and

Fly ash handling system.

It shall be possible to perform all operations such as “system ON and system OFF” and monitoring of the complete ash handling system from the Operator station in the local control room of Ash handling system

The Operator station shall be mounted on a control desk provided in the ash handling system control room. The DCS cabinets for Ash handling system shall be located in this AHS control room. Redundant communication link shall be provided for connecting the Remote I/O units and the main plant DCS.

Operation and monitoring of Fly ash handling system and its auxiliaries such as ash transmitters, conveying air compressors, etc. and the bottom ash handling system and its auxiliaries such as bottom ash hopper, clinker grinder, jet pumps, scraper chain conveyor etc. shall be from the DCS Operator station in the local control room of Ash handling system. The complete controls will be implemented in the DCS.

Bottom Ash hopper system shall be provided with a local panel mounted in the bottom ash hopper area to facilitate local operation. This local panel shall be provided with conventional operational hardware (push buttons, switches, indicating lamps, mimics etc.). DCS Remote I/O racks of bottom ash handling system located in the bottom ash area shall be housing power supply, I/O modules and communication modules etc. Remote I/O racks of bottom ash handling system shall be provided for connecting the signals of the local panel / bottom ash system to the DCS cabinets in the local control room. Location of RIO panel shall be in Bottom ash hopper Local panel room.

The fly ash shall be removed from the ESP, APH, duct and stack hoppers and transported to the buffer hopper either under auto mode (timer mode operation or level probe mode operation) or manual mode (one hopper at a time) selectively. Level probes shall be provided for each fly ash hopper to enable operation of the fly ash handling system.

The unloading of dry fly ash/bottom ash into the trucks shall be independently operated and monitored from their respective local relay based panel. The equipment status shall be indicated on the operator station in the AHS local control room by hardwiring the status signals to the DCS system.

The air compressors shall be provided with dedicated Microprocessor based control system. Controls and protection of the air compressor shall be realized in the dedicated control system including the loading and unloading operations. Start of standby on trip of running compressor shall be performed by the DCS.

Slurry pumps:

The electrical control and monitoring signals, as specified, in the electrical section of this specification are to be controlled and monitored from the AHS local control room. Bidder shall make the necessary provision for interfacing of Electrical signals to AHS DCS.



Local operation –

Local start/stop push button stations shall be provided near all the drives except for the motorised valves and solenoid valves. Local start push button shall be wired to the DCS. Local start command shall be executed only when all the permissive conditions are satisfied. Lockable type Local stop push button shall be connected to the MCC/switchgear.

Auto/manual selection shall be provided in the Operator station as soft selection for drives. The Local / Remote operation selection will be made through MCC. For systems provided with relay based local panels, the selector switches shall be provided on the local panel by Bidder.

For the motorized valves, integral starters shall be provided and these shall have local open, close and stop push buttons in addition to local / remote selector. The local / remote selector switches of all integral starters shall be locked and shall have a common key. By unlocking the lock, authorised personnel having the key may operate the motorised valve locally. Local mode selected shall be wired to the DCS for annunciation to operator in the control room.

**VOLUME – II****SUB-SECTION 2.11.17****VACUUM PUMPS**

Vacuum pump shall be of the low speed liquid ring type driven by an electric motor. A minimum margin of 10 percent (%) over the above capacity shall be considered for sizing of the vacuum pumps. Silencers shall be provided so that each vacuum pump complies with the noise level limits. All vacuum pumps and their drives shall be interchangeable.

SPECIFIED DESIGN DATA FOR VACUUM PUMPS

S.No.	Description	Vacuum pumps for fly ash vacuum conveying system
1.	Type	Low speed liquid ring type.
2.	Duty	Continuous
3.	Nos. of working and standby	As per requirement.
4.	Sizing criteria	To cater to the ash removal rates laid down under as specified. A minimum margin of 10% (percent) over the above capacity shall be considered for sizing the vacuum pumps.
5.	Material of Construction	
a)	Casing	CI
b)	Shaft sleeve	Stainless steel
c)	Impeller	Stainless steel
d)	Shaft	Carbon steel EN -8
e)	Type of coupling between the pump and motor	Flexible coupling with suitable guards or V Belt drive along with belt guards
f)	Accessories	Necessary separator silencer, adjusting valves and orifices piping, strainers, heatex changers for seal water system (if applicable) and other equipment as necessary and as required
6.	Inlet seal water temperature	36 deg. C
7.	Maximum tip speed of impeller of Vacuum pump.	15 m/sec.



VOLUME – II

SUB-SECTION 2.11.18
FLUSHING BOXES BELOW ECONOMISER HOPPERS

SPECIFIED DESIGN DATA FOR FLUSHING BOXES

S.No.	Description	Vacuum pumps for fly ash vacuum conveying system
1	Nos.	As per requirement.
2.	Material of Construction	
a)	Body	10 mm thick M.S. to IS:2062
b)	Liners	8 mm thick replaceable stainless steel liners of hardness 300-350 BHN.
c)	Nozzles	Body :Cast Iron/Mild Steel
d)	Tip :	Anti corrosive tool steel / stainless steel of hardness not less than 550 BHN.



VOLUME II

SUB-SECTION 2.11.19 - RECOVERY WATER SYSTEM

Description	Unit	Data
Recovery Pump		
Designation		Recovery water pump
Type		Vertical type
Total number of pumps		3nos. (2W + 1S)
Location		Indoor
Operation		Continuous
Total duration of operation/ day	h	18
Liquid data		
		Ash water
Specific gravity		1.05
Temperature	°C	Atmospheric
Material of Construction		
Bowl		Duplex SS 2205 to UNS 31803
Impeller		Duplex SS 2205 to UNS 31803
Shaft sleeve		Duplex SS 2205 to UNS 31803
Column pipe		Duplex SS 2205 to UNS 31803
Discharge head and tee		Duplex SS 2205 to UNS 31803
Pump shaft		Duplex SS ASTM A 890 CD 4M CU
Motor stool		Carbon steel (IS:2062)
Gland packing		Impregnated Teflon
Fasteners in pump assembly		SS 316L for fasteners submerged in water and alloy steel for other fasteners
Base plate/sole plate		Carbon steel(IS:2062)
Accessories and Services required		
Discharge pressure gauge		Yes
Companion flange		yes
Suction strainer		Yes
Bearing temperature indicator		Yes
Foot valves		Yes



Description	Unit	Data
Note: a. It shall be possible to operate these pumps over a range of 75% to 110% of rated capacity. b. NPSH test, Std running test, Hydrostatic test and Balancing tests and performance test to be done		
CLARIFIER		
		Clariflocculator
Number Required		One (1)
Rise Rate	m/h	1.5 (max.)
Retention Time	h	3 hrs. (2.5 for clarification & 0.5 for the flocculation)
Material of Construction	RCC	RCC
Effluent Quality (turbidity+ suspended solids)	ppm	50
Quality of water after clarification	NTU	<20
pH value of water after clarification		6.5 TO 8.5
Surface flow rate	m ³ /h/m ²	1.5
FLASH MIXER		
Number		One
Material		RCC
Shaft Material		SS 316L
Paddle Material		SS 316L
Note: Maximum effluent capacity shall be 10% margin over the rated capacity.		
SLUDGE CHAMBER		
Quantity		One (1)
Material of Construction		RCC
Storage Required	hrs	1 hrs.
Sludge disposal pumps		
Type		Vertical type
Number		1W+1S
Material of Construction		
Bowl		Duplex SS 2205 to UNS 31803
Impeller		Duplex SS 2205 to UNS 31803
Shaft sleeve		Duplex SS 2205 to UNS 31803



Description	Unit	Data
Column pipe		Duplex SS 2205 to UNS 31803
Discharge head and tee		Duplex SS 2205 to UNS 31803
Pump shaft		Duplex SS ASTM A 890 CD 4M CU
Motor stool		Carbon steel (IS:2062)
Gland packing		Impregnated Teflon
Fasteners in pump assembly		SS 316L for fasteners submerged in water and alloy steel for other fasteners
Base plate/sole plate		Carbon steel(IS:2062)
Recovery water piping		
Terminal Points		Complete recovery system
Inlet Piping to Clarifier		HDPE
Piping From Flash Mixer to Clarifier		RCC hume pipes to IS:458 Class P2
Sludge piping		HDPE
Flow Measuring Device Required At		Inlet and outlet of clarifier
Notes : In case of underground piping the pipes shall be suitably protected by coating & wrapping.		
Dosing Tank		
Quantity		As per Flow diagram
Capacity of each tank		Adequate to store solution required for one shift of 8 hours
MOC		FRP with vinyl resin
Solution concentration	%	10 -20
Agitator		High speed, motor driven
Dosing pumps		
Number		Two (2) x 100% per stream
Type		Positive displacement, diaphragm pumps
MOC		PP with PTFE diaphragm



VOLUME II
SUB-SECTION - 2.12
MILL REJECT HANDLING SYSTEM

1.0.0 GENERAL

This section covers minimum requirements for design, engineering, fabrication, manufacture & assembly, inspection, erection, testing and commissioning of complete Mill Reject Handling System.

2.0.0 CODES AND STANDARDS

The applicable standards and codes for various major equipment in mill reject handling system are given below. Latest editions of the following standards shall also be used.

TEMA	- Tubular Exchanger Manufacturer's Association
ASME	- American Society of Mechanical Engineers
IS	- Indian Standards
VDI	- Verein Deutscher Ingenieure
RMS	- Reputed manufacturers standard
IS:2825	- Code for unfired pressure vessels (with amendments latest)
ASME section VIII Division I	- Boiler and pressure vessel code

3.0.0 SCOPE OF SUPPLY

1. One (1) no pyrite hopper for each mill with all associated connections and accessories as per requirement and specification flow diagram.
2. One (1) no. mill reject conveying vessel for each pyrite hopper to transport mill rejects to storage bunker by means of dense phase conveying system.
3. One (1) no. storage bunkers per bunker bay (Two for each unit)
4. One (1) Pressure relief valve on the top of each bunker to safeguard the Mill reject storage bunker.
5. One (1) No. bag type vent filter on the vent line at the top of each Mill reject storage bunker.
6. One (1) No. rupture disc for each pyrite hopper.
7. Three (3) Nos. (2W+1S) – water cooled, Screw compressors (Oil free type) for unit 1 & 2 to supply air required for conveying mill rejects from transport vessel to storage bunker.
8. One (1) No. Air receiver with associated accessories for each bunker bay. Receiver shall act as a buffer to conveying compressors.
9. One (1) lot of water piping, instrument air piping, fittings, valves, instrumentation etc., as per requirement and specification flow diagram.
10. One (1) lot of mill reject conveying piping with fittings, instruments, valves, flanges, hangers, supports etc. for complete system as required upto silo for each unit.



11. One (1) lot of maintenance/operating floor for Mill reject bunker unloading, staircase to approach upto top of bunker, handling arrangement at top of bunker, hand railings, ladder to approach inside bunker if necessary etc.
12. One (1) lot of supports with access platforms, ladders, handrails, pipe racks, concrete sleepers (if required), etc. for all the air, water and mill reject conveying lines.
13. One (1) lot of base plates, guards, holding down bolts, anchorage channels, pipe sleeves, inserts etc. required for the complete mill reject handling equipment.
14. Insulation of human accessible parts/hopper/airlock vessel/pipe to maintain outside surface temperature at 60 deg. C
15. One (1) cylinder operated valve for each of inlet, outlet & bypass of pyrite hopper.
16. Necessary lifting devices of adequate capacity to handle the mill reject handling equipment.
17. All structural works (including pipe racks & structures) associated with the Mill reject handling system including foundation bolts, pockets, grouting and underpinning etc and minor civil works.
18. Proper reject handling arrangement below each bypass chute of pyrite hopper. One (1) Trolley for each bunker bay.
19. One (1) portable sump pump shall be provided for each bay to pump the drain to nearest drain
20. Any other items which are not listed but are required to make the Mill reject handling system complete in all respects as per this specification.

4.0.0 DESIGN REQUIREMENTS

- Type of mill shall be as per mill section.
- All the bends in the pneumatic handling system shall be provided with wear back of Ni-hard.
- The radius of 90 degree bends shall be minimum five times the pipe diameter.
- The emission level at the outlet of the bag filter shall be limited to 50 mg /Nm³
- Maximum temperature of the mill reject shall be 200 °C
- Bulk mean velocity of material in the Mill reject conveying pipe line shall be less than 10m/sec
- Bulk density of mill rejects
 - a) For volume considerations : 1.6 T/m³
 - b) For structural design/ load consideration : 2.4 T/m³
- The service factor for selection of gearboxes, resilient couplings, flexible couplings, brakes etc., shall be 1.5 minimum on the motor rating.

5.0.0 SYSTEM DESCRIPTION

The Mill Reject System comprises of collection of coal rejects/pyrites mills (type of mill – refer mill section) and transportation of the same to storage bunkers

**Mill Reject Handling System:**

This description shall be read along with the mill reject handling system flow diagram.

The Mill Reject System comprises of collection of coal rejects/pyrites from mills and transportation of the same to storage bunkers through dense phase pneumatic conveying system.

Each mill shall be provided with collection and transportation equipment comprising of one (1) pyrite hopper with water spray arrangement, valves at inlet and outlet and one (1) mill reject vessel. Each of the mill reject vessels shall be connected to storage bunkers through conveying pipeline of MS ERW heavy grade. Storage bunkers shall be of MS construction with SS liners and shall be provided with discharge gate at its outlet to discharge rejects into a truck. . Compressors shall be provided for conveying mill rejects from pyrite hoppers to storage bunker. The instrument air required for operation of various pneumatic valves shall be drawn from plant instrument air header. The water required for cooling of Dome valves and for spraying in pyrite hoppers shall be drawn from Service water distribution system. Radio Frequency type level probes shall be provided in pyrite hopper to start/stop evacuation cycle or for indication.

No of cycles shall be optimized for minimum air consumption and will be limited to six (6). Bulk mean velocity of material in the conveying pipe line shall be less than 10m/sec. Average velocity shall be computed from actual cycle time and length of piping (material travel path) during a number of conveying cycles.

6.0.0 CONSTRUCTION REQUIREMENTS

- a) The system shall be designed for the worst coal consumption.
- b) The Mill reject handling system shall be designed and constructed in view of dust free operation. Fugitive dust emission at any area shall not exceed 50 mg/Nm³ for all solid sizes.
- c) Mill Reject handling system shall be fully automated.
- d) Pressure pneumatic handling system shall be as per proven design practice.
- e) Based on the layout requirement, adequate provision for maintenance shall be envisaged.

Mill Discharge and Pyrite Hopper

Each coal mill discharge shall be provided with a pneumatic cylinder operated gate for discharging the rejects into a pyrite hopper.

The pyrite hopper shall be provided with one cylinder operated knife gate valve & one manual operated knife gate valve on upstream which shall be normally kept in open position. Necessary explosion vent of proven design shall be provided in each hopper. Grid shall be provided in the hopper to prevent passage of over size material to mill reject vessel. Suitable chute shall be provided to remove rejects collected on the grid. Pyrite hopper shall be designed to allow the grid to be replaced. Pyrite hopper shall be provided with by-pass chute with cylinder operated knife gate valve to unload the pyrite hoppers on the ground in case of emergency. The bypass arrangement in Pyrite hopper shall be provided for removing the raw coal to avoid mixing with rejects. Pyrite hopper shall be provided with manual operated knife gate valve & cylinder operated knife gate valve on downstream side which is normally kept in open position. Pyrite hopper shall be provided with level probes, temperature switches and Explosion vent. Arrangement of nozzles to spray water shall be provided when temperature goes beyond the preset value.

Each pyrite hopper shall be provided with two level switches – one to start the operating sequence and the other to indicate the hopper above grid choked condition.



Mill Reject Vessel

One (1) mill reject vessel shall be provided for each pyrite hopper to transport mill rejects to storage bunker by means of dense phase conveying system. Transport vessel shall be provided with inlet valves, outlet valve and air inlet valve. Inlet valve of mill reject vessel is normally in open position. After lapse of predetermined time or commencement signal by level probe of pyrite hopper, the inlet valve of mill reject vessel closes and air is injected through air inlet valve and the reject shall be conveyed to mill reject silo. . This cycle is repeated.

Conveying vessels shall be designed and tested based on codes and standards mentioned in the specification or equivalent Indian/international standard for pressure vessels. The vessel shall be designed considering the temperature of mill reject as 200°C. Design pressure of the vessel shall be 1.5 times the compressor discharge pressure.

The conveying vessels shall be constructed with tested quality mild steel plates. They shall withstand the abrasive action and hot condition of mill rejects and the operating air pressure. The conveying vessel shall be supported independently on steel columns. The vessel shall have suitably located and adequately numbered air connections for supply of compressed air for conveying mill rejects through pipes to mill rejects storage bunker.

The isolating valve at the top of vessel and the outlet bend piece at the bottom of the vessel shall be connected to vessel through air tight flanged joints. The material of construction for the outlet bend shall be alloy C.I. with 400 BHN.

Storage Bunker

Total storage capacity for each unit to store mill rejects for 24 effective running hours at worst coal. 3mm thick SS-304 liner in conical as well as vertical portion. The storage bunker shall be MS construction (as per IS 2062) plates with adequate stiffeners.). Adequately sized bag filter to vent the transport air to atmosphere, terminal boxes, level probe and pressure relief valve, shall be provided over top of storage bunker.

Motor operated undercut gate of double pivoted sector type shall be provided at the mouth of storage bunker to unload the rejects into trucks. Bunker shall be provided with access ladder inside the bunker, pressure relief door, external staircase from ground level to top of bunker, platform with outlet gate, etc.

Access platforms shall be provided with 32 mm thick MS grating 32 NB GI pipe hand railing shall be provided wherever required.

Suitable canvass chute shall be provided below the operating floor of the bunker.

Clear headroom of 5.5m and width of 5m shall be maintained below the operating floor.

Air Compressors

Water cooled screw air compressors (Oil free type) shall be provided to supply air required for conveying mill rejects from transport vessel to storage bunker. The compressors shall be of continuous indoor duty complete with necessary valves with vent pipe work ducted to a safe discharge outlet. The air pipe work shall be of ERW pipes to IS: 3589/1239 heavy quality construction.

At least 10% margin shall be provided on compressor capacity over and above the maximum flow requirement of simultaneous evaluation of all mills. DM water shall be used for Compressor cooling.

Mill reject compressor shall be located along with the AHS compressor.

**Air Receiver**

Air receiver shall be provided for mill rejects handling system. Air receivers shall be designed in accordance with IS: 2825. The air receiver shall be of vertical cylindrical design with dished ends.

The air receiver shall have inlet/outlet connections, safety relief valves, pressure gauges, Temperature gauge, pressure switches, flanged pipe connections, inspection manholes with automatic drain traps. Pressure gauges shall be provided at each air inlet line and on air receiver. The air receiver shall have structural platforms for maintenance of safety relief valves and instruments.

The finished receiver complete with all welded attachments shall be hydraulically tested at 150% of the design pressure. The test pressure shall be maintained for at least 30 minutes. All joints shall be gently hammered during the test.

The air receiver capacity (no. of receiver shall be minimum 4) shall be

- Selected to convey one complete cycle from one vessel without taking into consideration any air supply from the compressor. A margin of 25% shall be provided over and above the arrived air receiver capacity.
- Minimum capacity shall be 5 M3 capacity each.
- Capacity shall be maximum of the above criteria

Piping

All pipings shall be tested hydraulically after installation to minimum 1.5 times the maximum pressure encountered.

Mill Rejects Valves

Valves isolating mill pyrite hopper and rejects conveying vessel shall be of knife gate / dome type, (one number pneumatically operated and one number manually operated) quick opening and closing remote controlled design. The valve shall be of reliable and proven quality. It shall be possible to operate it cutting through the material flow. These shall be provided with proper sealing arrangement such that whenever the material is being conveyed from vessel to the silo, there shall not be any leakage of air from vessel to pyrite hopper / atmosphere. Solenoid valves and air piping shall be included in Contractor's scope, "Open" and "close" limit switches shall be provided for panel indication of open/close status of valve.

The valves shall be tested hydraulically to a pressure of minimum of 1.1 times (for seat) and 2.0 times (for body) the maximum pressure encountered. Air tests shall be conducted to detect seat leakage.

Compressed Air Line Valves

Remote actuated main valves on compressed air pipe lines shall be pilot operated solenoid pneumatic cylinder operated 100% leak proof valve.

Spring balanced two / three position control valve to actuate the pneumatic cylinder of main valves shall be either solenoid operated or pilot air pressure operated. In addition, mechanical lever for manual operation of valves shall be provided. Material of construction of valves shall have minimum surface friction and shall be rust and weather proof.

Pneumatic actuators shall be completely enclosed type, double acting. Material of construction shall be stainless steel. Integral micro limit switches for "Open" and "close" position shall be provided. External pointer for valve position and manual operation facility shall be provided.

The main valves shall be tested hydraulically to a pressure of minimum 1.1 times (for seat) and 2.0 times (for body) the maximum pressure encountered. Control valves and pneumatic cylinders shall be tested to a pressure of minimum 1.5 times the maximum pressure encountered.



Valves shall meet the requirements of international / Indian Standard Codes. Contractor shall clearly indicate in his offer the applicable standard / code.

Bag Filter

Vent with Bag filter of reverse pulse jet type shall be located at the top of Bunker to dedust the conveying air before venting into atmosphere. The material of filter bags shall be Polyester needle felt of antistatic type. The material of filter bags shall be suitable for prolonged operation up to a temperature of 200 °C without losing its collection efficiency and durability. Filter bags shall be suitably treated to minimize the chances of filter bags catching fire. Bag cleaning mechanism shall be automatic, and shall comprise of solenoid valves, air nozzles, adjustable solid state timer, pressure switches, piping and fittings etc. Nozzles shall be placed just above the filter bags to facilitate individual cleaning of each bag. 10% additional bags shall be considered.

Instrument Air System

The instrument air required for the mill reject handling system shall be met from the plant instrument air compressors. For equipment operation in the system, instrument air is provided at each bay through distribution pipe work from specified tapping point to pneumatic operated valves, vessel sealing arrangement, Dome valve actuator, Denseveyor panel and bag filter.

Cooling Water Requirement

Cooling water requirement of Dome valves & for spraying in pyrite hoppers shall be drawn from Service water distribution system and cooling water for compressor shall be met using DMCW water. MOC of the piping shall be SS.

7.0.0 OPERATION AND PHILOSOPHY

The pneumatic cylinder operated plate valve at mill outlet (Pyrite Hopper Inlet) is normally kept open. Mill Rejects from coal mill drop into the Pyrite Hopper through the grid. Oversize material is retained on the grid. Hand Wheel Operated Plate Valve on Over-size material discharge chute is operated on need basis. The High Level Probe in Pyrite Hopper picks up when Pyrite Hopper is full and grid is choked. The bypass chute is fitted with pneumatic cylinder operated plate valve. This Plate valve shall be provided with limit switch for interlock with pyrite hopper inlet valve and status monitoring switch shall be provided accordingly. Whenever this bypass valve is to be opened, it should be ensured that Pyrite Hopper inlet valve is closed. Also whenever the oversize valve is to be opened, it shall be ensured that Pyrite Hopper inlet valve is closed, for this purpose limit switches shall be provided on the same.

A temperature Switch in Pyrite Hopper is set to give alarm annunciation in case temperature goes beyond 60°C and set to open the Solenoid Valve in Spray Water line to spray water. Additionally the water spray solenoid valve is operated through a time control.

During normal operation, the Solenoid Valve on spray water line - (normally closed) is opened whenever dome valve is opened and water is sprayed for quenching mill rejects in Pyrite Hopper for 5 seconds (adjustable). Dome valve top plate is provided with continuous cooling water supply to protect the insert seal through a open drain cooling water system sourced from service water. RF Type Level Probe in Pyrite Hopper is set to pick up when mill rejects reach a preset level (low level or permissive level) generally kept equal to Vessel volume. Whenever RF Type Level Probes picks up, the dome valve of Denseveyor is actuated to open to allow gravity feed of mill rejects into Denseveyor. After a preset time-lapse dome valve is closed, insert seal is inflated through instrument air supply. Compressed air from Convey Airline is then injected to the Denseveyor. Mill rejects are conveyed to the storage bunker via pipe work and terminal box. On completion, the vessel pressure drops down and the system is reset for next cycle commencement signaled by the RF Type Level Probe in Pyrite Hopper. As a back-up to this, a timer provision is also made in control system. The batch cycling operation and conveying of mill rejects goes on till high level in storage bunker is sensed on



which further conveying to bunker is stopped till bunker is evacuated manually. The mode of operation is same for all mills. In each stream, vessel are in operation one by one during normal operation.

8.0.0 DRAWINGS, DATA / DOCUMENTS TO BE SUBMITTED ALONG WITH BID

- Completely filled up Technical schedules and data sheets of tender documents
- General arrangement drawing of Mill Reject handling system equipment with sections
- Write-up to Mill reject handling system
- Utilities requirement
- Complete electrical load list.
- Control system configuration
- Details of similar job executed in last five years
- List of mandatory spares.
- List of recommended O&M spares for 3 years normal operation.
- List of Special Tools & Tackles.

9.0.0 DRAWINGS & DOCUMENTS - FOR APPROVAL

The Contractor shall submit the following data/information documents/ drawings to the Owner / owner's consultant, who in turn shall review and furnish comments on only important drawings/documents. Contractor shall furnish a list of data / drawings / documents which shall be submitted to the Owner / owner's consultant with due dates of submission immediately after award of contract. The contractor on fortnightly basis shall update the list. The following list shall not limit the contractor, if any additional documents / drawings required for the review of the owner/ consultant same to be submitted. Master document list to be submitted by the contractor listing all the documents/ drawings.

- Design Basis for mill reject handling system
- Sizing calculations for system & equipment.
- Technical data sheets of all equipment.
- Sequence interlocks and block logic diagram.
- Design basis for design of foundations, civil works, structural etc.,
- Design & Operational philosophy for Mill reject system.
- Flow Diagram of Mill Reject Handling System and design calculation
- GA – Plans and section of all subsystems, Equipment & structures.
- P&ID for Mill reject handling system & compressor.
- Piping layout for Mill reject conveying, Air & water piping's.
- Equipment layouts of mill reject system
- PG test procedure.
- MQP's, QAP's for all the supplied items.
- STAAD input/output files

Bidder shall furnish operation and maintenance instruction manual

Control & Instrumentation

The C&I Drawings / documents shall have the following as a minimum

1. Mill Reject Handling plant control room layout
2. Control Schemes & Logic diagram along with write up of control system
3. Hardware and software design manual (covering exhaustive details of compete DCS based control system)
4. DCS BOM
5. G.A (General Arrangement) drawings of all control panels/ cabinets / local panels with all dimensional details.



6. Input / Output list
 7. Drive list / Solenoid valve list
 8. Annunciation list & SER list
 9. List of set points
 10. Maximum DCS bus utilization under worst loading condition calculation details shall be furnished
 11. Process mimic indicating Analogue and digital parameters
 12. Marshalling philosophy
 13. Cabinet / Panel wiring diagrams and internal layout drawings
 14. Wiring diagrams for panel, local panel, junction boxes, actuators, starters etc.
 15. Instrument index
 16. Instrument hook-up diagram
 17. Erection hardware BOQ
 18. Heat load and Power consumption data for DCS
- Any other drawings required for review during the detailed engineering stage, same shall also be submitted by contractor.


ANNEX – 2.12.1
SPECIFIED DESIGN DATA

Sl.No.	Description	Unit	Data
1.0.0	Mill Reject System		
1.1.0	Mill reject conveying capacity per unit	T/h	Design extraction rate of mill rejects from pyrite hopper will be 150% of expected mill rejects of coal consumption at 100% BMCR considering worst coal Each conveying line will be designed for a capacity corresponding to 150% of expected mill rejects with worn out mills Mill reject shall be as follows: - As recommended by mill manufacturer - Minimum 1% of coal consumption at BMCR considering worst coal Capacity shall be maximum of the above criteria
1.2.0	Type of conveying		Dense phase type pneumatic conveying.
1.3.0	Mills		
1.3.1	Type of mill		Refer mill section.
1.3.2	Arrangement		DDE
1.3.3.	Elevation of Mill reject spout (wrt FFL in mill area)	m	DDE
2.0.0	Pyrite Hopper		
2.1.0	Quantity		One per mill
2.2.0	Buffer Capacity		Minimum 1.5 m ³ or effective volume of 3 cycles whichever is higher
2.3.0	Material of Construction		
	Pyrite hopper body		MS plate of minimum 10 mm thick conforming to IS 2062, Gr A
	Grid		SS-304, 10mm thick flat / bar
	Liners		6mm thick SS-316
2.4.0	Accessories		As per the flow diagram & as required.
3.0.0	Mill Reject Vessel		
3.1.0	Location		Below pyrite hopper
3.2.0	Quantity		One per pyrite hopper
3.3.0	Type		Suitable for dense phase type pneumatic conveying.
3.4.0	Material of Construction		
	Vessel body		Cast iron/ fabricated out of MS plate Construction shall be as per ASME code for unfired pressure vessel or IS-2825.



Sl.No.	Description	Unit	Data
3.5.0	Design Pressure		1.5 times the compressor discharge pressure
3.6.0	Temperature of material to be conveyed	^o C	200.
3.7.0	Maximum size of material to be handled	mm	20mm, Occasionally upto 50mm
4.0.0	Transport air compressors and accessories		
	Type		Oil free, Screw compressor.
4.1.0	Capacity (FAD)	m ³ /h	As per system design requirement
4.2.0	Type of Cooling		Water
4.3.0	Pressure rating	kg/cm ² (g)	As per system design requirement.
4.4.0	Accessories to be Supplied.		
a)	Suction Air Filter area (twice compressor inlet size: Particle removal upto 5 micron).		Yes
b)	Suction Silencer		Yes
c)	Instrumentation as required		Yes
d)	Test Certificates for Materials of Construction for Compressor parts		Yes
e)	Notes		
	Tests to be witnessed by the Owner at manufacturer's works		
	Visual Inspection and Dimensional check		Yes
	Check for Capacity at specified discharge pressure. Flow measurement as per ISO 1217		Yes
4.5.0	Type of drive		Belt driven / Motor & gear box shall be directly coupled as per OEM practices.
5.0.0	Air Receiver		
5.1.0	Type		Vertical
5.2.0	Number required		Minimum 4 nos.
5.3.0	Working Pressure	kg/cm ² (g)	As per system design requirement.
5.4.0	Design Pressure	kg/cm ² (g)	1.5 times of the compressor discharge pressure
5.5.0	Nominal Volume of each receiver	m ²	As per system design requirement.
5.6.0	M.O.C of Shell/Body		MS: IS 2002Gr.A
5.7.0	Corrosion Allowance	mm	3
5.8.0	Code of Construction		IS 2825 / ASME Sec VIII
5.9.0	Manhole with cover for inspection & cleaning		Yes
5.10.0	One suitably sized safety valve set at 1.25 times the operating pressure of the receiver to relieve full compressor discharge capacity		Yes
5.11.0	One pressure gauge with isolating valve		Yes
5.12.0	Auto drain trap		Yes
5.13.0	Material test certificate required?		Yes



SI.No.	Description	Unit	Data
5.14.0	Tests at manufacturer's works to be witnessed by Purchaser's representative		
5.15.0	Visual inspection and dimensional check against approved manufacturer's drawing		Yes
5.16.0	Hydrostatic test at 1.5 times the design pressure		Yes
6.0.0	Piping		
6.1.0	Mill reject conveying		
6.1.1	Material of Construction		
	Pipe		MS ERW heavy grade to IS: 3589/1239
	Bends / Fittings / Laterals		Alloy CI to hardness 400 BHN. End connection shall be Flanged.
6.2.0	Conveying Air		
6.2.1	Material of Construction		
a)	Pipe		- For 50NB and below - MS ERW BLACK IS 1239 (PT-1). - For 65NB to 150NB - MS ERW BLACK, IS 1239 Heavy Class (PT-1) - For 200NB to 450NB – ERW, IS 1978 (or) API 5L GR. B (or) IS 3589 fabricated from IS 2062 plates
b)	Fittings		For 50NB and below - ASTM A 105 For 65NB and above – ASTM A234 Gr. WPB
c)	Flanges		ASTM A 105 (A283 GR-C for 200NB and above)
d)	Gaskets		GRAFOIL
e)	Line joint		For 50NB and below – Socket welded. For 65NB and above – Butt welded.
f)	Notes		
	Type of Mill reject conveying bend		Flanged, long radius. (Bend angle R = 5D)
7.0.0	Mill Reject Handling Valves		
7.1.0	Type		Slide type/ Dome/ Swing type
7.2.0	Material of construction		
a)	Body		Cast Iron, 225 BHN hardness
b)	Plate / Disc		10mm thick, 300-350 BHN SS
c)	Seat		Replaceable type alloy CI or SS smooth finished with hardness 250 BHN
7.3.0	Method of operation		Solenoid operated pneumatically actuated with provision for manual override facility.
8.0.0	Mill reject storage bunker and accessories		
8.1.0	Type		MS construction (as per IS 2062 with adequate stiffeners) SS-304 liner in



Sl.No.	Description	Unit	Data
			conical as well as vertical portion
8.2.0	Numbers required.	Nos	As per flow diagram
8.3.0	Method of Venting Conveying Air from bunker		Through bag filter to Atmosphere
8.4.0	Bunker Level Measurement and indicator		Continuous/RF type
8.5.0	No. of Outlets Required		One.
8.7.0	Type		Motor operated undercut gate of double pivoted sector
8.8.0	Purpose		Unloading mill reject to trucks
8.9.0	Accessories and mountings		
a)	Accessories		As per the flow diagram.
b)	Ladder for Access Inside Silo		Yes (SS - Ladder)
c)	Pressure Relief Valve		Yes
d)	Access Staircase from Ground Level to Silo Top		Yes
e)	Hand Rails and Toe Plates Required		Yes
f)	Monorail with Hoist to handle equipment from silo top to ground.		Yes
g)	Tests at manufacturer's works		
h)	Visual and Dimensional Check of all the Accessories of Silo		Yes
9.0.0	Bag filter		
9.1.0	Location		At the top of each Mill reject storage bunker.
9.2.0	Type		Compressed air cleaned, reverse pulse jet type
9.3.0	Quantity		1 No per silo
9.4.0	Duty		Continuous-24 hours/ day
9.5.0	Material Handled		Mill reject
9.6.0	Material of Construction		
a)	Bags		Polyester needle felt of antistatic type
b)	Cages		GI
c)	Casing & Duty		MS
9.7.0	Volume of Dust Laden Air to be handled	m ³	To match the flow rate of mill reject conveying system to bunker.
9.8.0	Air-to-Cloth Ratio	m/min	One
9.9.0	Maximum Dust Concentration in Air that shall be Let Out to Atmosphere	mg/Nm ³	50
9.10.0	Are Controls for Automatic On-line Bag Cleaning System Required?		Yes
9.11.0	Tests		
a)	Visual and dimensional check at works		Yes
b)	Site tests for functioning of the automatic on-line bag cleaning system		Yes
c)	Check for dust concentration in the air to be let out to atmosphere at site		Yes



Sl.No.	Description	Unit	Data
10.0.0	Terminal End Box		
10.1.0	Location		At the Discharge end of Conveying line i.e on Bunker
10.2.0	Type		M.S. Fabricated Box with Ni hard Deflector.
10.3.0	Hardness of deflector	BHN	500 – 550

Note: All equipment shall be suitable for seawater application.

**VOLUME - II****SUB-SECTION 2.13****PLANT COOLING WATER SYSTEM****1.0.0 GENERAL**

This section is intended to provide the scope, design, constructional and functional requirements for Condenser Cooling water system and Auxiliary cooling water system.

2.0.0 CODES AND STANDARDS

All materials, design, fabrication, manufacture, testing, and installation shall be as per stipulation of applicable approved National / International standards so far as they are equal to or more stringent than this specification. In addition to the codes and standard mentioned in Volume II, Section-1.0, GTS, the following standards or their approved equivalent shall be followed:

HIS	:	Hydraulic Institute Standard.
CTI	:	Cooling Tower Institute Publications
BS 4485	:	Specification for water cooling towers
IS 1710	:	Vertical Turbine Pumps for Clear, Cold and Fresh Water.
IS 5120	:	Technical requirements -Rotodynamic special purpose pumps.
IS 9137	:	Code for acceptance for centrifugal, mixed flow and axial flow pumps - Class 'C'
BS 5316	:	Acceptance tests for Centrifugal, mixed flow Part-1 and axial flow pumps -Class 'C' Tests (ISO 2548)
BS 5316	:	Acceptance tests for Centrifugal, mixed flow Part-11 and axial flow pumps -Class 'B' Tests (ISO 3555)

In general the pump shall meet all the requirements specified in IS 1710 and in case some requirement is not covered in the above stated standard then BS , ANSI and API standards shall be referred to in that order.

The applicable standards for material and components are indicated in the relevant data sheets.

3.0.0 SCOPE OF SUPPLY

The scope described here is by no means exhaustive and the items though not specifically mentioned but needed for safe, efficient, trouble-free and coordinated operation of the system shall be included in the scope. The System shall include, but not be limited to the following:

3.1.0 Cooling Tower

RCC counter flow Natural draft cooling tower with all equipment & accessories necessary for safe, suitable and efficient operation,



3.2.0 Cold Water Basin, CW Channel and Forebay

- RCC basin portioned into compartments with supporting structures and foundations
- Stop log gates at water outlets channels
- Over flow and sludge removal
- Removable screens at water outlet channels with provision for proper cleaning.
- Handling arrangement for the gates and screens
- Cold water channels up to CW pump house.
- Coarse screen for each CW, ACW and Blow down pump sump bay.
- Stop log gate for isolation of CW, ACW and Blow down pump sump bay.

3.3.0 CW Pump house

CW pump house consists of the following:

3.3.1 CW pumps

- Concrete volute type cooling water pump with all auxiliaries like bearing cooling water pump if any
- Electro Hydraulically Operated Butterfly Valves at each CW pumps discharge with accessing platform.
- Motor Operated Butterfly Valves at condenser inlet & outlet.
- Manual operated Butterfly valve where ever required
- Rubber Expansion Joint at each CW pump, CW blow down pumps and condenser inlet & outlet.
- Drive motors along with base plate, coupling, coupling guard etc. for the equipment with accessing platform.
- Vibration monitoring system.

3.3.2 EOT crane

- One no. EOT crane for handling the CW, Blow down pumps and semi-gantry/gantry cranes for handling screens & stop log gates shall be provided in the pump house. For more details refer section 2.19.

3.3.3 ACW Pumps

- Vertical turbine, Wet pit non-pull out type cooling water pump with all auxiliaries
- Motor Operated Butterfly Valves at each ACW pumps discharge.
- Non-return valve at each ACW pump discharge.
- Butterfly Valves at PHE inlet & outlet.
- Rubber Expansion Joint at each ACW pumps discharge.
- Drive motors along with base plate, coupling, coupling guard etc. for the equipment.

3.4.0 CW Chlorination System

- Hypochlorite dosing for more details refer Volume-II section 2.14

3.5.0 CW Make-up and CW Blow down system

CW make-up system Refer Volume-II, Section 2.14 for more details.

3 x 50% CW blow down pumps shall be provided in CW sump which will pump the CW blow down water to ash water make-up tank and to sea water out fall tank.



3.6.0 Submersible Pump

One no of Portable submersible pump for CW sump chamber and two no's of submersible pump for CT Basin shall be provided for each unit.

3.7.0 Piping

All necessary interconnecting piping's, pipe fittings, valves, Air release valve, rubber expansion joints etc. as per requirement for the system along with pipe supports.

All valves located at elevations shall be provided with operating platform with access ladder / chain sprocket arrangement.

Ultrasonic flow measurement shall be provided in CW and ACW pumps discharge header.

Debris filter shall be provided outside the TG building above ground with covered shed. Accordingly pipe to be modified.

Refer Volume – II section 2.20 on piping for more details.

3.8.0 Stop log gates

- One set of stop log gate for Unit # 1 CW pumps
- One set of stop log gate for Unit # 2 CW pumps
- One set of stop log gate for Unit # 1 ACW pumps
- One set of stop log gate for Unit # 2 ACW pumps
- Two set of stop log gate for Unit # 1 & 2 Blow down pumps

Each set will be suitable for isolating the sumps upto floor level.

Storage rack shall be provided for the stop log gates. Storage rack shall be located near the Pump house with gantry crane access.

4.0.0 DESIGN REQUIREMENTS

4.1.0 CW system

The Condenser Cooling Water System shall be designed to meet the cooling water requirement of steam turbine condenser. The CW system shall be closed circuit re-circulating type with Natural Draught Cooling Tower. The hot water return from Condenser shall be cooled in the cooling tower.

The Condenser Cooling Water Pumps shall be sized to meet the cooling water requirement of steam turbine condenser.

The delivery head of the pump shall be selected suitably considering

- Static head from minimum water level in CW sump to Cooling tower hot water riser pipe flange
- Condenser pressure drop
- COLTC Pressure drop
- Flow element pressure drop (If any)
- frictional drop in the pipes, pipe fittings, valve etc with 10% margin

Re-circulation to CW pumping system shall be provided from the discharge duct of each of the module. The re-circulation line shall be led upto the CW forebay through a motor operated Butterfly valve and a manual butterfly valve.



A common Re-circulation to CW blow down pumping system shall be provided from the discharge header. The re-circulation line shall be led upto the forebay through a Butterfly valve.

The cooling tower shall be designed to meet the requirement of CW & ACW systems. The design atmospheric wet bulb temperature shall be as per specified data sheet.

CW Make-up water is required to compensate for the evaporation and drift loss in the cooling tower and blow down from the CW system. CW make-up shall be normally from sea water intake pump house. Chlorine shall be dosed in the fore-bay and in the sumps of CW pump house as a biocide agent in the form of chlorinated water.

All wetted parts shall be suitable for the sea water application.

4.2.0 ACW system

The Auxiliary Cooling Water (ACW) pumps shall be provided to circulate cooling water on the secondary side of the Plate heat exchangers of TG, SG and BOP auxiliaries and Condenser Vacuum pump. The pumps shall be located in the CW pump house fore bay and circulate the cooling water through the PHE & Vacuum pump cooler and discharge into the Condenser outlet header.

All wetted parts shall be suitable for the sea water application.

4.3.0 CW Studies

a) CW Sump Model Studies

The Design of intake, Forebay, sump for CW system shall be based on BHRA/ HIS. Mathematical model study for pump and Physical hydraulic model studies for the CW channel, forebay and pump sump shall be conducted to achieve streamlined flow for CW, ACW and Blowdown Pumps. Physical model study shall include all the pumps of CW sump.

b) CW Transient Analysis

The hydraulic transient analysis shall be carried out for complete CW system by method of characteristics for various possible starts/ stop/ trip eventualities of CW pumps to avoid pressure surges/ vacuum in the system. Based on the transient analysis study, suitable remedial features shall be incorporated in the CW system design.

4.4.0 DMCW System

Refer Volume-II, Section 2.8 for more details.

5.0.0 CONSTRUCTION REQUIREMENTS

5.1.0 Cooling Towers

The cooling tower shall be designed for a continuous duty to cool the hot water received from the condenser and the auxiliary cooling water system at the required design parameters as indicated in the Specified Design Data as Annex – 2.13.1. The hot water enters the tower at a suitable height and falls downward over Splash type fills of PVC construction and the cooled water exits from the cooling tower basin for further transportation to the condenser and the auxiliary cooling water system.



To enable maintenance of the cooling tower basin, it shall be bifurcated into two parts by providing RCC partition. Accordingly each part of the basin at the cooled water outlet shall be provided with necessary screens and stop log gates for isolation purposes. Suitable handling arrangements shall also be provided for the same.

It shall be possible to drain the basin to a sludge pit which shall be located outside the cooling tower basin. In order to effect complete draining of the basin, the basin is sloped towards its periphery. Additional slope or drain channels shall be established towards a collecting sump which shall be located in the basin at the opposite side of the cooling water outlet provision in the basin. Embedded pipe made of steel to a nominal size of 300 mm shall be provided from the bottom of the collecting sump for draining the basin thro' this collecting pit. This pipe shall be further sloped into the sludge pit to enable draining of the basin.

The basin shall be below or above ground and shall have sufficient holding capacity. The basin shall be 7min storage capacity (from normal water level to low water level). A minimum of 300 mm free board shall be provided in the basin. The basin shall be divided into compartments by providing concrete partition wall designed for pressure on one side only. Maximum, minimum and normal operating water levels in the basin shall be clearly indicated in the data sheets.

The sludge sumps shall be provided with a sluice gate at the entry level of the drain pipe. Sludge pits shall be of adequate size and depth to enable lowering of submersible pump. Two numbers of sludge pump complete with electric motor shall be supplied for lowering into the sludge pits for each of the cooling tower. For each of the sludge pit pump discharge side valves, piping supports and clamps etc. shall be provided to dispose the drained water/sludge to the nearest plant drain.

Suitable access facilities shall be provided for the cooling tower as follows:

- Access to the hot water distribution level shall be provided thro' two numbers of external RCC staircase (with hot double dipped galvanised MS pipe hand rails) up to the hot water distribution level with suitable access ways inside the tower (around periphery and one across the diameter) within the hot water distribution level. Access to the throat level shall also be made available from these RCC stairs.
- External access ladders (four up to the throat level from ground level) and internal access ladders (four up to the top from the throat level) with protective cage in hot double dipped galvanised mild steel along with necessary landing platforms.
- A RCC platform all around the tower at the top for fixing aviation warning lights.
- Access doors at hot water distribution level, throat level and at top level in mild steel with anticorrosive polyurethane coating.
- Access to each basin compartment through internal RCC stair and suitably sloped wheel barrow access ramp.

5.2.0 Tower Fills

This section is intended to specify the constructional requirement of cooling tower fills.

Constructional Requirements

The fills shall be made of Virgin ultraviolet stabilized PVC material. The fill material shall promote a high rate of heat transfer, provide low resistance to air flow and maintain uniform water and air distribution throughout the fill volume. The fill shall be fire retardant and resist deterioration.



Minimum Testing Requirements

Required tests for Chemical and physical properties including hardness and density, verification of dimensions and thickness, ageing & deterioration resistance verification, load test for adhesives and other characteristics verification shall be conducted.

Lightning arrester shall be provided and warning light will be provided.

5.3.0 Pumps

The pump shall be designed to have best efficiency at the specified duty point and shall in no case less than 85%. The pumps shall be capable of continuous operation at any point within the operating range.

The pumps shall have stable head capacity characteristic continuously rising towards shut off conditions. Pump shall operate satisfactorily and continuously at run-out capacity. Pumps shall be capable of operating from 40% to 120% of rated flow.

Both working and standby pump shall have identical performance characteristics. The pump and motor shall be designed for manual as well as automatic start-up facility under standby condition.

The impeller shall be of semi open type and shall be of non overloading characteristic.

The pump shall be directly driven by a constant speed squirrel cage induction motor.

5.3.1 Vertical turbine pumps for ACW and CW Blow down system

The offered pump should be of proven design and Contractor shall provide satisfactory certificate from the end user. Otherwise for the offered pump, Contractor should have carried out the model test in the presence of Owner to predict the performance of the prototype. The specific speed of the model tested shall lie within $\pm 5\%$ of the specific speed of the pump offered. Model test shall include the cavitations test & Net Positive Suction Head Required.

Blow down and ACW Pumps shall be of vertical shaft, submerged suction, self lubrication type (water) design, complete with bowl, column, discharge head and drive assembly, etc. If the water quality is found to be unsuitable for self lubrication, the Contractor shall provide service water as external water for lubrication.

Column Pipes shall be flanged and bolted and shall be complete with bolts, nuts, & gaskets. The standard lengths of the column pipe pieces shall be dictated from considerations of ease of handling and as per IS: 1710.

The pump discharge shall be of above the floor type. Suitable arrangement shall be provided to take care of the discharge hydraulic thrust due to an untied expansion joint. This may be achieved either by sizing pump discharge head and base plate adequately to take care of the discharge hydraulic thrust.

The pump suction bell diameter shall be such as to limit the flow velocity at the maximum flow to within 1.5 m/sec.

The line shaft couplings shall preferably be of flanged type (if applicable).

The type of lubrication shall be self-water or forced water as required. Shaft bearings above minimum water level shall be of self lubricated type and below minimum water level shall be of water lubricated type. During initial filling and normal operation the lubricating water shall be tapped from water filling line/potable/nearest source and fed to overhead tank. The backup



source shall be tapped from a common header formed by taking a tapping from discharge of all ACW pumps and Blow down pumps. This water shall pass through 2 x 100% duplex filters and fed to overhead tank. In case of forced lubrication, lubrication water pump capable of meeting the total lubricating water flow requirement for one ACW pump along with drive shall be provided for each ACW pumps and blow down pumps.

Non – Reverse ratchet mechanism shall be provided for the vertical pumps to prevent the reverse rotation.

The pump and motor (complete assembly) should be designed for withstanding the run away speed attained with reverse rotation caused by reverse flow continuously even when all the remaining pumps are in operation. Necessary speed switches to detect reverse rotation shall be provided to prevent motor switching on while rotating in reverse direction. The indication shall also be provided for this purpose.

5.3.2 Concrete Volute pump for CW system

Major components of Concrete Volute pump consist of the concrete elements, the embedded parts and the “pull-out” or removable parts.

Concrete elements

The suction duct is integrated into the civil engineering work of the pumping station. Suction duct should be minimized head loss to achieve the overall high pumping efficiency and almost uniform velocity distribution at the impeller inlet to limit the secondary cavitation effects, noise, vibration and loss of efficiency. The suction duct shall be low level designed as shallow as possible to limit the groundwork volume.

The volute should be the double curvature volute to yields optimum efficiency. Below the volute, the suction bell is connected to a pre-formed intake suction box. All are prefabricated concrete elements.

In case square volute, transition piece should be provided for connecting the pump discharge line.

A manhole should be provided to permits impeller inspection without removal of the pump unit.

Embedded mechanical parts

Suction side designed part sealed in the concrete will be to secure the sealing ring at the pump inlet and upper designed part sealed in the concrete will be to accommodate the bottom of the casing cover.

Removable parts

Impeller

Impeller should be semi open type and material will be Duplex steel with a high Pitting Resistance Equivalent number ensures long service life for sea water.

Shaft

Shaft should be never in direct contact with the pumped water, most corrosion or abrasion problems, and maximizing reliability and availability. Removable shaft sleeves should be provided at the bottom part, under the cover of the stuffing box.



Bearings

Different types of bearings may be used, with one or two guiding bushes. One of the most reliable options is to install a single bearing – a rotary oil tank assembly above the shaft output sealing box. This leads to substantially reduce wear rates and results in much simplified monitoring and maintenance.

Thrust bearing

Thrust bearing should be conventional design, either of the antifriction or tilting pads type. Depending on the pumping unit, it may be installed on the bottom of the pump body, in the speed reduction gear, or in the motor (for pumps directly driven by a slow-speed motor).

Wear rings

The wear ring (or “sealing ring”) on the suction part limits the leak rate between the impeller outlet (high pressure area) and the suction side (low pressure area). The axial clearance between the wear ring and the impeller is easily checked during down times, without having to remove the impeller. A balancing ring designed to reduce axial thrust may also be installed at the bottom of the pump casing, depending on the amount of axial thrust to be absorbed.

Shaft seal

Sealing at shaft penetration should be achieved by a stuffing box. The packings are cooled by cooling water circulating through an aperture and directly taken at pump delivery. A filtering system is provided for in the case of water full of solid particles.

CFD Model shall be conducted for Concrete volute pump.

The pump and motor (complete assembly) should be designed for withstanding the run away speed attained with reverse rotation caused by reverse flow continuously even when all the remaining pumps are in operation. Necessary speed switches to detect reverse rotation shall be provided to prevent motor switching on while rotating in reverse direction. The indication shall also be provided for this purpose.

To tackle the back flow from pump discharge line Non – Reverse ratchet mechanism or other precaution should made for prevent the reverse rotation of pump.

Motor cooling should be provided.

Pump model test shall be according to DIN 1944 Class I or ISO 5198 Class A or JIS-B-8327-2002

Site guarantee test according to DIN1944 Class II or ISO 3555 Class B.

5.4.0 Plate Heat Exchanger

Further details refer Volume-II section 2.8 for more details.

5.5.0 Pump House

CW pumps, ACW pumps and blow down pumps shall be housed in a pump house equipped with an EOT crane of sufficient capacity for erection & maintenance of the pumps. These pumps shall be installed in individual chambers connected to the fore bay with provision for isolation of the individual CW pump chambers for maintenance. Each chamber shall be provided with coarse trash rack screen and stop logs of SS 316L material. CW electrochlorination system shall be housed in a room adjoining the CW pump house. MCC for the CW, ACW and Blowdown system shall be accommodated in a separate annex room.



6.0.0 CONTROL PHILOSOPHY

6.1.0 General

The I&C system will consist of a Remote I/O panel, field instruments, instrumentation & control cables and erection hardwares.

6.2.0 Operational Philosophy

It is envisaged that primary operations including control and monitoring of cooling water system will be carried out only from the Operator station of the plant DCS located in the central control room.

In addition, emergency stop command PB will be provided in the UCP of CCR.

2 nos. of Large video screens size 84 inch (Common for two (2) units) are interfaced with DCS for plant operation & monitoring of plant common systems / utility plants in CCR.

Apart from the CCR operation, mimic panel with hard wired push buttons for back panel operation shall be provided.

6.3.0 CW Pump Controls

The complete controls will be implemented in the plant DCS and the signal will be acquired through remote I/O panels of DCS.

The CW pump controls / interlocks will be provided for safe and trouble free operation of six numbers CW pumps (2 working + 1 standby per unit).

The Local / Remote operation selection will be made through MCC. After getting the Remote selection as a permissive from MCC, drives shall be controlled / operated from DCS.

Key lockable type Emergency Stop push buttons will be provided to facilitate the emergency Stop operation of CW Pumps and will be wired to the SWGR directly. The local start command from LPB of CWP will be routed through DCS where all control logics, interlocks and permissive will be implemented.

The CW pumps with its discharge valve (Inching type- electro hydraulic butterfly valve) is envisaged to operate in sequence, after CW pump Start command is initiated by operator.

All alarms and Trips will be annunciated in CCR.

Vibration monitoring system for all the CW pumps, ACW pumps and Blow down pumps shall be provided. Vibration monitoring system shall be wired directly to the VMAS server located in the electronic equipment room. Vibration measurement on X-Y axis for each bearing will be provided. Key phasor measurement shall be provided based on the OEM recommendation.

6.4.0 Controls / Instruments / Interlocks provided for CW Pumps

Field Instruments

Following Instruments will be provided for CWP. All the instruments used in CW lines will be suited for seawater service and diaphragm seals will be used.

**a. CW Forebay**

CW forebay motor operated valve is an on-off type motorized valve, whose operation is provided through Operator station in CCR.

1. Two number ultrasonic type Level transmitters (1 out of 2 logic) will be provided for
 - a. Opening CW fore-bay makeup valve at 'low water level' along with alarm.
 - b. Closing CW fore-bay makeup valve at 'high water level' along with alarm.
 - c. Deriving start permissive and trip of Blow down pumps

CW make up flow to forebay will be measured for indication in CCR.

b. CW Pump Sump

1. Two numbers of ultrasonic type level transmitters (1 out of 2) in each CW pump pit will be provided for
 - a. Indication of 'Low Water Level' for alarm annunciation purpose (Derived through LVM),
 - b. Sump Adequate Level' for pump start permissive purpose.
 - c. Tripping the CW pump at 'Very Low Water Level' condition (Derived through LVM).

c. CW Pump Discharge

1. One no. pressure gauge at discharge of each CW pump for local reading.
2. Two pressure transmitters (1 out of 2) will be provided on the individual CW pump discharge for "high discharge pressure trip of CW pump" through LVM and "pressure low trip" through LVM.

d. CW Common Header

1. Two Pressure transmitters (1 out of 2) on the common header of each Unit for sensing "Discharge header pressure Adequate" for full opening of the CW pump discharge butterfly Valve from 10° to 100%.
2. The above mentioned pressure transmitters will also be used for sensing "Discharge header pressure low" for starting the stand by pump.
3. One no. ultrasonic flow meter will be provided at common header of each unit CW pumps for indication.
4. One no. DP transmitter across the debris filter will be provided to initiate flushing incase the DP across the filter goes "high high" and "high" alarm. Apart from the DP transmitter, one no. DP gauge will be provided for local indication.
5. Pump reverse rotation switch will be provided to achieve start permissive for CW pumps.

6.5.0 Controls / Interlocks for CW Pump & Discharge Valve**a. Starting of CW pumps**

The operation of CW pumps and its discharge valves will be from Operator station in CCR. The CW pumps with its discharge valves are envisaged to operate in sequence, after start command is initiated by operator.



Any CW Pump can be started only when following Permissive conditions are fulfilled.

- CW Sump level not low – ‘Level Adequate’.
- CW pump discharge butterfly valve - ‘fully Closed’.
- Motor winding temp. "Not High".
- Pump bearing temp. "Not High".
- Motor bearing temp. "Not High".
- Pump reverse rotation "Not existing".
- Discharge butterfly valve "actuator ready to start".
- HT Switchgear Available
- Condenser CW inlet and outlet valves “Open”
- Motor Protection Relay “operated”.
- Cooling Tower inlet isolation valves “fully open”

Starting of first CW pump

1. CW pump 'Start command' will start the CW pump and simultaneously the command is issued to the discharge valve to open by 10°.
2. In case the butterfly valve fails to open within the specified time, a CWP trip command will be initiated.
3. When the CW header pressure is adequate, the CW pump discharge valve will further open to 100% viz. full open.
4. In case butterfly valve fails to open beyond 10° within a specified time, an audio-visual annunciation will be generated for operator's intervention for manual operation.

Starting of second CW pumps

After the system is primed (sensed through pressure), start command of 2nd CW pump, will be given with time delay.

Starting of Standby CW Pumps

- If any running pumps trips, the standby pump will start automatically. Once standby pump start command is initiated, the corresponding standby pump discharge valve will open automatically.

Tripping of CW Pumps

CW Pumps will trip in the event of following eventualities.

- Very low level in CW sump
- Pump discharge pressure low (after a time delay)
- Pump Discharge pressure high (after a time delay)
- Pump discharge butterfly valve failed to open
- Pump / Motor - bearings temperature very high
- Motor winding temp. very high
- Motor & Pump vibration very High

When CW pump stops (or Trips) the butterfly valve at CW Pump discharge, will close fully.

Stopping of CW pumps

Once the stop command of the CW pump is issued from the Operator station of the Plant DCS, the following operations will be done sequentially.



- The CW pump stop command issued to SWGR.
- CW discharge valve will be closed.

6.6.0 CW Condenser Inlet / Outlet

CW inlet and outlet of condenser will be provided with pressure gauges and temperature gauges for local indication. Temperature measurement provided at the condenser inlet/outlet, Pressure measurement provided at the condenser inlet/outlet and two numbers of DP indicating switches provide high alarm indications in the CCR. One DP transmitter shall also be provided for monitoring.

BF Valves Controls

- a. The open / close facility of each butterfly valve will be provided in CCR.
- b. Indication of each butterfly valve open / close status will be provided in CCR.
- c. Position status for inching type motor operated valves status will be provided in the CCR.

6.7.0 Condenser on Load Tube Cleaning System

The complete controls of COLTCS for each unit (2 sets)_ will be implemented in the plant unit DCS and the signal will be acquired through remote I/O panels (if required) of DCS.

The COLTCS will be operated from the unit DCS in the Central control room (CCR). All the controls / interlocks are done in the DCS provided. The following signals are interfaced with the DCS

- DP high alarm - normal recirculation pump operation.
- DP high alarm for Emergency back wash.
- System alarm for Balls monitoring.
- CW pump trip for interlocking to COLTCS.

b. ACW Pump Sump

Two numbers of ultrasonic type level transmitters (1 out of 2) in each ACW pump pit will be provided for

1. Indication of 'Low Water Level' for alarm annunciation purpose (Derived through LVM),
2. Sump Adequate Level' for pump start permissive purpose.
3. Tripping the ACW pump at 'Very Low Water Level' condition (Derived through LVM).

c. ACW Pump Discharge

1. One no. pressure gauge at discharge of each ACW pump for local reading.
2. One pressure transmitters will be provided on the individual ACW pump discharge for "high discharge pressure trip of ACW pump" through LVM and "pressure low trip" through LVM

d. ACW Common Header

1. Two Pressure transmitters (1 out of 2) on the common header of each Unit for sensing "Discharge header pressure Adequate" for full opening of the ACW pump discharge butterfly Valve from 10° to 100%.
2. The above mentioned pressure transmitters will also be used for sensing "Discharge header pressure low" for starting the stand by pump.



3. One no. DP transmitter across the filter will be provided to initiate flushing incase the DP across the filter goes “high high” and “high” alarm. Apart from the DP transmitter, one no. DP gauge will be provided for local indication.
4. Pump reverse rotation switch will be provided to achieve start permissive for ACW pumps.

6.8.0 Controls / Interlocks for ACW Pump & Discharge Valve

a. Starting of ACW pumps

The operation of ACW pumps and its discharge valves will be from Operator station in CCR. The ACW pumps with its discharge valves are envisaged to operate in sequence, after start command is initiated by operator.

Any ACW Pump can be started only when following Permissive conditions are fulfilled.

- ACW Sump level not low – ‘Level Adequate’.
- ACW pump discharge butterfly valve - ‘fully Closed’.
- Motor winding temp. “Not High”.
- Pump bearing temp. “Not High”.
- Motor bearing temp. “Not High”.
- Pump reverse rotation “Not existing”.
- Discharge butterfly valve “actuator ready to start”.
- HT Switchgear Available
- Motor Protection Relay “operated”.
- Cooling Tower inlet isolation valves “fully open”

Starting of working ACW pump

1. ACW pump ‘Start command’ will start the ACW pump and simultaneously the command is issued to the discharge valve to open by 10°.
2. In case the butterfly valve fails to open within the specified time, a ACWP trip command will be initiated.
3. When the ACW header pressure is adequate, the ACW pump discharge valve will further open to 100% viz. full open.
4. In case butterfly valve fails to open beyond 10° with in a specified time, an audio-visual annunciation will be generated for operator's intervention for manual operation.

Starting of common Standby ACW Pumps

- If any running pumps trips, the standby pump will start automatically. Once standby pump start command is initiated, the corresponding standby pump discharge valve will open automatically.

Tripping of ACW Pumps

ACW Pumps will trip in the event of following eventualities.

- Very low level in ACW sump
- Pump discharge pressure low (after a time delay)
- Pump Discharge pressure high (after a time delay)
- Pump discharge butterfly valve failed to open
- Pump / Motor - bearings temperature very high



- Motor winding temp. very high
- Motor & Pump vibration very High

When ACW pump stops (or Trips) the butterfly valve at ACW Pump discharge, will close fully.

Stopping of ACW pumps

Once the stop command of the ACW pump is issued from the Operator station of the Plant DCS, the following operations will be done sequentially.

- The ACW pump stop command issued to SWGR.
- ACW discharge valve will be closed.

6.9.0 Blow down pumps

Blow down pumps are started and stopped manually from the DCS. Local start / Stop are possible from LPBS.

Any Blowdown Pump can be started only when following Permissive conditions are fulfilled.

- Blow down Sump level not low – 'Level Adequate'.
- Blow down pump discharge butterfly valve - 'fully Closed'.
- Motor winding temp. "Not High".
- Pump bearing temp. "Not High".
- Motor bearing temp. "Not High".
- Pump reverse rotation "Not existing".
- Discharge butterfly valve "actuator ready to start".
- HT Switchgear Available
- Motor Protection Relay "operated".

Starting of working Blow down pump

1. Blow down pump 'Start command' will start the blow down pump and simultaneously the command is issued to the discharge valve to open by 10°.
2. In case the butterfly valve fails to open within the specified time a blow down pump trip command will be initiated.
3. When the blow down header pressure is adequate, the blow down pump discharge valve will further open to 100% viz. full open.
4. In case butterfly valve fails to open beyond 10° with in a specified time, an audio-visual annunciation will be generated for operator's intervention for manual operation.

Tripping of Blow down Pumps

Blow down Pumps will trip in the event of following eventualities.

- Very low level in blow down sump
- Pump discharge pressure low (after a time delay)
- Pump Discharge pressure high (after a time delay)
- Pump discharge butterfly valve failed to open
- Pump / Motor - bearings temperature very high
- Motor winding temp. very high
- Motor & Pump vibration very High



When blow down pump stops (or Trips) the butterfly valve at blow down Pump discharge will close fully.

Stopping of blow down pumps

Once the stop command of the blow down pump is issued from the Operator station of the Plant DCS, the following operations will be done sequentially.

- The blow down pump stop command issued to SWGR.
- Blow down pump discharge valve will be closed.

7.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED ALONG WITH THE PROPOSAL

- 1 Duly filled-in technical data sheet, bill of material and price list as per specified schedules.
- 2 Preliminary outline drawings indicating the principal dimensions of the equipment offered and locations of pump suction and discharge connections.
- 3 Foundation drawings with all design loads, direction and points of application. Loading data for thrust block, if provided, shall be indicated.
- 4 Cross-section drawings indicating the assembly of pumps and major parts thereof with materials of construction and special features. Drawings indicating the desired sump dimensions and also the clearances from suction bell for proper suction condition required for most efficient running of the pump.
- 5 Characteristic curves of pumps showing effective head pump input power, efficiency, submergence and NPSH, against capacity ranging from a shut-off condition to run out capacity.
- 6 Speed vs. torque curve of the pump corresponding to recommended mode of pump starting. Super-imposed on speed vs Torque curves of the motor, corresponding to 80%,90%,100% rated voltage.
- 7 Performance curve for single and parallel operation superimposed on system resistance curve.
- 8 A bar chart indicating design, procurement, manufacture, testing, delivery, installation, site testing and commissioning.
- 9 List of tests the Bidder proposes to carry out in shop and at site after installation including those pertaining to their sub-contractor.
- 10 List of maintenance tools, tackles and accessories required for maintenance of the offered equipment including bought out components.
- 11 List of instruments being offered with the package with necessary details regarding the same.
- 12 List of recommended spare parts for equipment offered including bought out components suitable for three (3) years operation of the equipment.
- 13 Write up on pump lubrication system
- 14 Complete descriptive and illustrated literature on the equipment and accessories being offered.
- 15 GA of vibration/temperature measurement points on CW pump



- 16 P&I diagram for cooling system for motor and pump
- 17 Technical leaf let/catalogue
- 18 Delivery schedule.

8.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED AFTER AWARD OF CONTRACT

	Description	Approval Category
1	Drawings/documents submission schedule	A
2	Final version of the technical documents/drawings listed in clause 14.0.0 above, as applicable.	A
3	Comprehensive quality assurance plan	A
4	General arrangement drawing of pump assembly and layout of pumpsets and associated equipments.	A
5	Detailed cross-section of the pump and other equipment and the details of the materials of construction with special feature, parts list.	I
6	GA of vibration/temperature measurement points on CW pump	A
7	Field wiring diagrams (between Field Instruments & JB	I
8	Test certificates and reports for all C&I items	A
9	Quality plan with scheduled date of inspection for C&I items	A
10	Test procedures and details of test to be conducted.	A
11	Test reports, Test certificates, performance curves and other particulars as required by applicable clauses of this specification.	A
12	Bearing schedule of all bearings giving specification and number of all bearings used in the equipment supplied under this section.	I
13	Pump data sheet, Motor datasheet, G.A drawing of Motor, Terminal box drawing, Quality Plan of Motor, Motor performance Curves.	A
14	Instruction manuals for the operation, maintenance, repair, replacement and spare parts ordering.	A
	1)The Instruction Manuals shall present the following basic categories of information in a comprehensive manner prepared for use by operating and/or maintenance personnel: a) Instruction for Erection b) Instruction for pre-commissioning check-up, operation, abnormal conditions, maintenance and repair. c) Write-up on Controls and Interlocks which are to be provided. d) Recommended inspection points and periods of inspection. e) Schedule or preventive maintenance.	



Description	Approval Category
f) Ordering information for all replaceable parts. g) Recommendation for type of lubricants, lubricating points, frequency of lubrication and lubricant changing schedule. h) Instruction Manual for Pump and Motor.	
Any other drawings required for review during the detailed engineering stage, same shall also be submitted by contractor.	
9.0.0 REFERENCE	
Cooling Water System flow diagram drg. no.00-1112140-M-003.	



ANNEX 2.13.1

SPECIFIED DESIGN DATA

Description	Unit	Data
COOLING TOWER		Natural draft cooling tower
Number of cooling towers		one per unit
DESIGN & OPERATING CONDITIONS		
Cooling water flow	cu m /hr	By contractor
Design atmospheric wet bulb temperature	deg C	28
Cold water outlet temperature	deg C	33
Design temperature range	°C	10
Design relative humidity	%	75
		As per volume II section 1.0 clause no.5.2.0 Bidder shall collect the actual data for a period of 20 years from the meteorological department pertaining to Thoothukudi location and design for plant accordingly. Design condition shall be subjected to owner's approval. Adverse condition of the above two shall be taken for the design condition without any commercial implication.
Tower operation		Continuous
Liquid handled		Sea water
FEATURES		
Drift eliminator		Required
Type of Fill		Splash
ELEVATIONS		
Basin depth		The basin shall be complete with 7 minutes storage capacity (from normal water level to low water level)
MATERIALS OF CONSTRUCTION		
Fill		PVC
Fill support		RCC
Drift eliminator		PVC
Water distribution pipes		GRP
Water distribution nozzles, splash plates / cups.		Polypropylene
Access doors, stoplogs and screens.		Hot dip galvanized mild steel with etch primer and bituminous painting. SS mesh.
PERFORMANCE TEST		
Method		As per CTI/BS
Instrumentation		By vendor
Water Conditions		
COC in CW system		1.3 (MOC and other requirements shall be suitable for operating COC of 1.5)
Chlorine dosing to control biological growth / algae		Yes
Sludge Pumping Unit		



Description	Unit	Data
Type of pump		Submersible type
Numbers provided for each unit		(1 W + 1S)
Design flow		To evacuate the entire basin water in Twelve (12) hours
Accessories		Control panel and one set of Suction and discharge hoses and its accessories for disposing the water.
Material of construction (MOC)		
Casing and Suction Bowl		Duplex stainless steel ASTM A 890-CD-4M-CU / Nickel resist cast iron ASTM A 439 Gr.D2
Impeller		Duplex stainless steel ASTM A 890-CD-4M-CU
Shaft		Duplex stainless steel ASTM A 890-CD-4M-CU
Shaft sleeve & coupling		DUPLEX SS
Design Code		IS 5120 / IS 1710 / HIS
BLOW DOWN WATER PUMPS and ACW water pumps (for Vertical Turbine pump)		
Type of pumps		Vertical type ,mixed flow, wet pit ,non pullout pump
No. of pumps for Blowdown system	Nos	3x 50%(2W+1S) common for both unit.
No. of pumps for ACW water system	Nos	2 x 100% for each unit
Delivery rate		Suitable to let out to sea +Ash water tank 5% Margin.
Delivery head		Suitable to let out to sea frictional drop in the pipes, pipe fittings, valve etc + 10% margin on frictional drop.
Location		Indoor
Type of line bearing lubrication		Self
Liquid for lubrication		Pumped liquid
Prime mover		Direct with AC Electric motor
Impeller type		Semi open mixed flow
Acceptable noise level		Not greater than 85 dBA at a distance of 1.0 m from the equipment
Material of Construction		
Suction bells		DUPLEX ST ST ASTMA 890/890M-CD3MN TYPE 4A
Column pipes		ASTMA 240-UNSS31803
Discharge Bend (Wetted Part)		ASTMA 240-UNSS31803
Discharge casing (Outer Structure)		MS IS 2062-Fe 410 W A Epoxy Painting
Fasteners in column assembly		SS AISI :316L
Impellers		Duplex ST ASTMA 890/890M-CD3MN Type 4A
Impeller bowl		Duplex ST ASTMA 890/890M-CD3MN Type 4A
Impeller shaft		Duplex SS as per ASTM A 276 UNSS 31803
Line shaft		Duplex SS as per ASTM A 276 UNSS 31803
Top shaft		Duplex SS as per ASTM A 276 UNSS 31803
Shaft sleeves		Duplex SS as per ASTM A 276 UNSS 31803
Shaft coupling (Muff Type)		Duplex SS as per ASTM A 276 UNSS 31803
Shaft bearings		Cutless rubber with ST ST SHELL
Gland		Duplex ST ASTMA 890/890M-CD3MN type 4A
Gland packing		PTFE
Stuffing Box		DUPLEX ST ASTMA 890/890M-CD3MN TYPE 4A



Description	Unit	Data
CONDENSER COOLING WATER PUMPS(for Concrete Volute pump)		
Type of pumps		Concrete Volute ,mixed flow,
No. of pumps	Nos	3 x 50% for each unit
Delivery rate		Suitable to supply cooling water to condenser +10% Margin.
Delivery head		Suitable to supply cooling water to condenser considering pressure drop across the condenser, frictional drop in the pipes, pipe fittings, valve etc + static head + 10% margin on frictional drop.
Location		Indoor
Type of line bearing lubrication		Self
Liquid for lubrication		Pumped liquid
Prime mover		Direct with AC Electric motor
Impeller type		Semi open mixed flow
Acceptable noise level		Not greater than 85 dBA at a distance of 1.0 m from the equipment
Material of Construction		
Suction Draft Tube		RCC
Casing / Volute		RCC
Impeller		ST ST ASTMA890/890M-CD3MN-TYPE 4A
Liner		ST ST ASTMA890/890M-CD3MN-TYPE 4A
Volute Radius Ring		SG Ni RESI-BSEN13835 XniCrNb20-2 (S2W)
Pump shaft		ST ST ASTM A 276 UNS 31803 (ANLD)
Intermediate shaft (Carden shaft)		Forged Carbon Steel
Lower & Upper Shaft sleeve		ST ST ASTM A 276 UNS 31803 (ANLD)
Pump shaft bearing		NAT RBR LND BRG SS 316 SHELL
Liner Holder Ring		ST.ST.ASTMA240/240M UNS S 31803(PLATE)
Discharge Divergent Pipe		MS IS 2062
Cover Ring		ST.ST.ASTMA240/240M UNS S 31803(PLATE)
Pump Cover		SG Ni RESI-BSEN13835 XniCrNb20-2 (S2W)
Stuffing Box		SG Ni RESI-BSEN13835 XniCrNb20-2 (S2W)
Volute Tongue		ST.ST.ASTMA240/240M UNS S 31803(PLATE)
Motor Base plate		MS IS 2062 – Fe 410 W A
Gaskets		NON ASB Gasket Ferrolite NAM37 OR EQ
Packing Gland		PTFE
2/2 Rubber Bearing Housing		SG Ni RESI-BSEN 13835 XnicrNb20-2 (S2W)
2/2 Pressure Reducing Bush		ST ST ASTMA 276-316L ANLD
Impeller Nut & Cap		ST ST ASTMA 276-316L ANLD
Portable Sump pump		
Type of pump		Submersible type
Numbers provided for each unit		1
Design flow		To evacuate the individual pump sump water in Tw0 (2) hours
Accessories		Control panel and one set of Suction and discharge hoses and its accessories for disposing the water.
Material of construction (MOC)		
Casing and Suction Bowl		Duplex stainless steel ASTM A 890-CD-4M-CU / Nickel resist cast iron ASTM A 439 Gr.D2
Impeller		Duplex stainless steel ASTM A 890-CD-4M-CU
Shaft		Duplex stainless steel ASTM A 890-CD-4M-CU
Shaft sleeve & coupling		DUPLEX SS



Description	Unit	Data
Design Code		IS 5120 / IS 1710 / HIS
RUBBER EXPANSION JOINTS		
Designation		CW Pump , ACW Pump, CW Blow down pump, Condenser inlet & outlet
Fluid handled		Sea water
Hydro test pressure		1.5 times of design pressure
Vacuum (test)	mm of Hg	730
Movements(min),Axial compression/elongation, lateral movement	mm	12
Control unit to be provided		Yes
Material of construction		
Bellow / Body		High Grade Abrasion Resistant Epdm / Neoprene Rubber
Tie Rod		Carbon Steel(GALVANISED)
Stretcher Plate Metal Reinforcements		IS 2062 Gr. A SS Steel Annular Rings
Retaining Ring Segments		Minimum 10 mm Thick Split Ring Mild Steel (GALVANISED)
Counter Flange		IS 2062 GR. A (GALVANISED)
Bolts & Nuts		IS 1367 CL. 4.6
BUTTERFLY VALVES		
Hand wheel required		Yes
Location		Indoor / Out door
Face to face dimension	mm	As per AWWA C504 / BS 5155 t
Actuator for BF valves		To be suitable for step operation
Up to 100 NB BF valve		Without gear operated
Above 100 NB to up to 500NB		With gear operated
Above 500NB BFV		Motor (eclectically) operated
Material of construction		
Valve Body		CI IS 210 Gr 260 / IS 2062 with Rubber Lining
Valve Disc		SS-316 L
Valve Shaft		SS-316 L
Body Seal Rings (If Applicable)		EPDM
Disc Seat Rings		SS-316 L
Seal Retaining Rings		MFG.STD
Bearings		SS-316 L
Internal Hardware		SS-316 L
External Hardware		CI IS 210 Gr 260 / IS 2062 with Rubber Lining



VOLUME II

SUB-SECTION 2.14

PLANT WATER TREATMENT, WASTE WATER & CHEMICAL TREATMENT SYSTEMS

1.0.0 GENERAL

This part of the specification covers the requirements for complete water system and accessories.

All systems shall be provided with adequate redundancy to ensure uninterrupted operation of the plant.

This section is broadly divided into the following:

- Sea water intake and outfall system
- Desalination and Water Treatment Plant
- Electro chlorination System
- Chemical Dosing system
- Waste Water Treatment System
- Miscellaneous Water System.

2.0.0 CODES AND STANDARDS

Design, manufacture, inspection and testing of the equipment covered by the specification shall, unless otherwise specified, conform to the latest edition of the codes and standards including all addenda mentioned below.

Pressure Vessels	:	ASME Sec VIII Div 1
Carbon Steel Tanks	:	IS 803 / API 650
Hor. Centrifugal Pumps	:	IS 5120 / API 610 / HIS
Vertical Pumps	:	IS 1710 / ANSI / HI 2.1-2.2-2000
Blowers	:	IS 4894
Butterfly Valves	:	BS 5155 / AWWA C 504/ IS :13095
Diaphragm Valves	:	BS 5156
Gate Valves	:	IS 780
Chemical Plant Piping	:	ASME B 31.3
GRP Piping	:	ASTM D 3517 / 2996 /AWWA C 950
GRP Tanks	:	BS 4994
CPVC Pipes	:	ASTM D1784
Flanges (Upto 600 NB)	:	ANSI B 16.5
Flanges (Above 600 NB)	:	AWWA C 207
Rubber lining	:	IS 4682 Part 1
GRP Pressure Vessels	:	ASME Sec X
Carbon Steel Pipes (LP)	:	IS 1239 / IS 3589
Underground Pipes	:	AWWA M 45
Vibration	:	ISO 7919 / ISO 10816
Chemical Handling Devices	:	IS 9222 Part 1
Occ. Safety Health Admin.	:	OSHA
Noise Level	:	ISO 1996
PE pipes and fittings	:	ISO 13953
HDPE pipes	:	ISO 4427



3.0.0 SCOPE OF SUPPLY

The scope shall consist of the following as a minimum:

3.1.0 Sea water Intake and outfall System

The water required for the Power plant shall be drawn from the sea by gravity through velocity Cap Intake arrangement Method. The seawater intake system include the velocity caps, seawater intake piping, desilting basin, channel, seawater intake pumphouse, seawater intake pumps, stop-log gates, screens, seawater piping to desalination plant and to CT basin, etc.

The seawater outfall system involves collection of reject seawater from CW blowdown system, SWRO system and filter backwash and pumping to sea through seawater piping and diffuser arrangement.

3.1.1 Intake Velocity Cap

The offshore velocity cap intake shall be located and designed to minimize fish entrainment, preclude interference with navigation, minimize bottom sediment withdrawal, and minimize warm water recirculation between the offshore intake and discharge structures. The design of the offshore intake also will be affected by wave forces determined from hydrographic conditions and has to be considered accordingly. Bathymetry studies and Geo technical report for offshore intake has to be carried out by Contractor.

Fish entrainment shall be minimized by placing a velocity cap at the offshore intake and maintaining an intake design approach velocity of 0.15 m/s.

Based on the preliminary studies the locational details of the velocity caps have been finalized as below and also refer the NIO report attached along with the specification:

	intake Quantity (m ³ /h)	Location Lat/Long	Distance from shore	Depth (m) -CD
Intake	25,600	8° 25.548'N 78° 5.511'E	2050 m	-5.40

The location of the velocity cap shall be as per the attached drg no 0-1112140-G-001 and to be designed as per MOEF / relevant norms.

The intake system shall be designed for 30,000 m³/hr considering margin. The system is sized considering the future requirement.

The velocity cap structure shall be preferably Bell mouth type and shall be sized to meet the requirements of the system. The aperture size of the intake screen shall be 5 mm x 5 mm.

The level of the velocity cap shall be decided by the Contractor to ensure that the system hydraulic losses are met and the required flow is achieved.

The velocity head shall be in concrete/ Duplex stainless steel/Suitable material for sea water and the equipments in contact with sea water shall be Duplex stainless steel and shall be suitable for sea water. The makeup water requirement for the 2 X 660 MW shall be restricted within 13500 m³/hr. Bidder shall furnish detailed water balance to confirm the water requirement. The intake pipe shall be alternatively operated using sluice gates till future units commissioned. Intake and outfall System shall be sized considering the partial flow / minimum flow operating conditions.

The system shall be designed for the cyclonic conditions.



Chlorination piping system :

The intake well shall be chlorinated to avoid marine growth / bio fouling. The chlorination pipes shall be sized as per the demand and shall conform to SDR 17 as per ISO 4427. The chlorination pipes shall be routed along with the main intake pipes. Pipes shall be protected from bio fouling once it is laid in sea.

3.1.2 Floating Fencing

Floating fence system shall be provided around the intake cap. The material of the fencing shall be fabric or any material suitable to the sea water, Oil & chemicals. They shall be minimum 1.2m height (Excluding the column/pile support). Fish nets shall be provided around the velocity caps. The chains shall be of high quality marine grade with MS hot dip galvanized / anti corrosive painting.

3.1.3 Marker Buoys

The Permanent Non-metallic, illuminating marker buoys suitable type as per IALA recommendations O-139 (AISM Standards) shall be installed at intake velocity cap structure and Outfall diffuser section. They can also be Solar powered.

The number of marker buoys as required shall be by convention to demarcate the installation shall be assessed and installed with suitable anchoring points. Pre-warning spheres shall be provided near the velocity cap at a suitable distance near the floating fence.

Air burst system:

2 x 100% compressors (One number working and One no. standby) shall be provided. The air compressors shall be oil free/non-lubricated and air cooled. The capacity of air compressor shall be arrived such that it shall be possible to charge the air receiver to the required pressure in 30 minutes.

The capacity of the air receiver shall be adequately sized for complete backwash of one intake screen at a time. The number of air receivers shall be considering maximum capacity of each air receiver as 10.0 m³.

Compressed air piping from air receivers to intake screens (individual piping for each velocity cap from onshore) with required automatically operated isolation valves shall be provided.

Compressors will be located in the sea water intake pump house. MOC of the compressed air piping will be HDPE and the rating shall be SDR 17.

The intake pipes shall have a suitable isolation facility at the intake forebay inlet. sluice gates shall be provided for isolation purpose.

Contractor shall design, supply and install suitable arrangement for the pigging system consisting of pig launchers, pigging pumps, pig receivers and pig launching platform at the desilting basin with suitable handling facility.

Provision shall be provided in the pipeline for remote vehicle inspection.

3.1.4 Sea Water Intake Pump house:

Seawater shall be drawn through the intake head velocity cap arrangement to a desilting basin is proposed onshore to take care of high turbidity. The desilting basin shall be further connected to the Sea water intake pump house through a channel. Sea water drawn for plant



use including CT make up and Desalination plant requirements. The scope shall include seawater Intake pumps, Pump sumps, Pump-house, Trash Racks, Traveling screens, FRP sluice gate, Stop Log Gates and their handling system along with screen wash pumps etc. Suitable handling system shall be considered within the pump-house for handling the pumps. Suitable handling system shall also be provided for screens and gates. Necessary sump modeling is included in the scope of the Contractor.

The low water level in the intake sump will be arrived at based on the low tide level and the hydraulic losses in the intake pipe and trash screens. The submergence of the pump, the sump dimensions and wall clearances shall be designed in accordance with Hydraulic institute standards. The pressure drop shall be calculated for the aged condition of the pipe with adequate margin.

The sump floor should be level (without slope) for a certain distance upstream of the pump, at least up to the travelling water screen (TWS). According to Hydraulic Institute guide lines, entry velocity at the location of the trash screen will be 0.3m/sec maximum.

The seawater intake pumping system shall consist of separate pumps for feed to desalination plant and make-up to cooling towers. For desalination plant feed, 3 x 50% vertical turbine pumps and For CT make up 3 x 50% vertical turbine pumps shall be considered. The pumps shall be of duplex SS having a PREN > 38. The Vertical turbine pumps shall be Non-pull out type and the discharge pipe shall be above floor discharge. Re-circulation facility back to the sump shall be provided. All pumps shall have margin of 10% on capacity & head over the actual requirement.

The complete seawater piping for CT make-up water system and the feed water system to desalination plant shall be of GRP. Pipeline shall be mainly underground with concrete encasement of 250 mm. Top of the buried pipe shall be atleast 1.5 meters below the ground level. Suitable air release valves shall be provided.

Transient analysis shall be conducted for makeup water piping from the Intake Pump house to the Cooling Tower & Desalination Plant.

Double ball Air release valves, Thrust blocks, valve pits, man holes for the pipes shall be provided by the Contractor wherever necessary.

3.1.5 Seawater Outfall System

Sea water outfall consisting of reject seawater of CW blow down, SWRO reject and Filter back wash. These reject seawater shall be collected in an outfall tank of suitable capacity and shall be pumped back to sea at an identified location offshore Using 3 x 50% Sea water Outfall pumps located in a pump house. Sea water outfall pipeline shall be terminated up to the outfall point as shown in the drg no. 0-1112140-G-001. The outfall pump shall be sized to take the outfall water upto the disposal point offshore.

Based on the preliminary studies the locational details of the outfall has been finalized as below and also refer the NIO report attached along with the specification::

	Outfall Quantity (m³/h)	Location Lat/Long	Distance from shore	Depth (m) -CD
Outfall	19,500	8° 25.95'N 78° 5.157'E	1060m	-5.00

The seawater outfall piping shall be of GRP, however piping at the terminal point where it will be submerged in the sea shall be of HDPE.



The outfall system shall be designed for 22,500 m³/hr considering margin. The system is sized considering the future requirement.

The above MOC shall be only used for sea water outfall piping. Sea water outfall pipes shall only be routed as per the following:

- Plot plan 00-1112140-G-001 REV 0, wherein “sea water outfall pipe from outfall pump house up to sea shore shall be routed adjacent to the external Conveyor trestle.
- As per clause no. 4.0.0 page 7 of 32, vol-II sec 2.20, pipeline shall be mainly underground with concrete encasement of 250mm.
- As per clause no. 2.1.0 page 12 of 164, vol-II sec 1, “from the shore, outfall pipe shall be routed on coal conveyor deck for which space will be provided”. Conveyor deck is in owner’s scope. The height of the top of Conveyor deck is approx. 8m (Above Power Plant FGL). However height will be finalized during detailed engineering without any price implication.
- Exact location of rising to conveyor deck will be finalized during detailed engineering without any implication.
- From the conveyor deck to sea water outfall location, pipe shall be buried in sea bed as per specification.

Bidder to consider one no. sea water outfall pipe as indicated in the tender specification. Pipe size shall be OD2000. Accordingly, bidder shall design, supply and erect the complete piping along with necessary supports along the the conveyor deck as per specification.

Necessary piping supports, thrust blocks required at the entry portion of the conveyor deck shall be provided by the bidder.

Necessary pipe supports for lowering the pipe from the conveyor deck to sea bed shall be provided by the bidder considering all the hydrodynamic forces acting on the pipe. Adequate measures shall be provided to protect the pipe from direct hydrodynamic forces.

Bidder shall furnish the load data of the outfall pipe line routed on the external coal handling system conveyor and Jetty to the owner for the design of the external coal handling system foundations and jetty.

Suitable air release valves shall be provided as per system requirement. Transient analysis shall be conducted for piping from outfall Pump house to discharge point at sea. Confirmatory Thermal dispersion study shall be conducted by the Bidder and any modifications to meet the Thermal dispersion is included in the Bidder scope.

3.1.6 Seawater intake and outfall piping

The Intake & outfall pipe shall be buried below the sea bed and shall be covered with rip-rap to prevent movement by currents and waves. The pipes shall be designed considering scour protection, hydrodynamic forces and buoyancy forces. The minimum earth cover above the top of the pipe shall be 1.0m generally and one pipe diameter or more in the inter tidal zone or as required by the statutory norms if specified higher.

The HDPE pipes shall be of suitable diameter, SDR 26, PE 100 material. The intake pipes shall be provided with man holes at every 200 m distance in the off shore. The size of the manhole shall be 1200mm. The HDPE pipe shall be conformed with IS 4984/ ISO 4427/ ISO 4437./ASTM D 3350.

Materials used for the manufacture of high-density polyethylene pipe and fittings shall comply with all requirements of ASTM D3350. The high-density polyethylene material shall be cell class of PE345664C or ASTM D3350 and shall be assigned a Plastics Pipe Institute



(PPI) recommended designation of PE3408. Pipe Manufacturer shall be a member in good standing of the Plastics pipe institute.

The backup flange for HDPE pipes, fasteners, supporting structures, clamps, etc for the pipes shall be duplex stainless steel of PREN > 38. The number of sea water outfall pipe shall be one.

The concrete anchor blocks shall be fitted to the HDPE pipes to counter the buoyancy forces. The fasteners for the anchor blocks shall be Duplex stainless steel. The stability of the pipes shall be designed as per DNV standard. The system shall be sized for intermittent operations.

The excess dredged material after backfilling shall be disposed off shore as per the statutory regulations in consultation with the owner..

3.2.0 Desalination and Water Treatment Plant

3.2.1 Desalination Plant

Desalination plant shall be based on Reverse Osmosis process. Contractor shall supply suitable pretreatment system to handle the raw sea water and make it suitable for the Sea Water Reverse Osmosis system (SWRO). Electro Chlorination system booster pumps (2W+1S) shall take suction from the CT make up pumps discharge header. Clarifier sludge shall be collected in sludge pit and led to ash pond by means of sludge transfer pumps.

The technical requirements shall be read along with the associated data sheets.

For sea water quality refer Volume II, Section 1, Annex – 1.3. However, contractor to carry out sea water analysis during detailed engineering and design the system considering worst parameters without any commercial implications for any variations within the range of 10% on TSS and 10% on TDS from the actual values indicated in the sea water analysis report provided along with the tender document. Variations on TSS and TDS if it exceeds beyond 10% the same shall be mutually discussed and finalized during detailed engineering with the owner. SWRO system shall be designed for a minimum TDS value of 38000 ppm or the higher value of the samples tested. The seawater sampling procedure during detailed engineering is subject to 3Owners approval.

The pretreatment system shall basically consist of Flow control station, Stilling arrangement, Parshall flume with suitable clarification system followed by pressure sand filters. Clarified water shall be stored in clarified water storage tank. Clarified water tank shall be covered tank. The clarified water from the clarified water storage tank shall be treated in Pressure sand filters and Ultra filtration system followed by cartridge filters before feeding the same to SWRO high pressure pumps. Contractor to consider suitable UF back wash and chemical cleaning systems for the UF module. The HP pumps shall pump the water through the RO Trains and the permeate water shall be collected in a common RCC desalinated water cum fire water storage tank. Energy recovery units shall be installed to recover the energy from the RO reject and reduce the power consumption. Handling equipment shall be provided to handle the SWRO high pressure pumps / motors. Material handling arrangements shall also be provided for handling all pumps, removing the cover of cartridge filters and heavy valves etc. The SWRO High pressure piping shall be of Duplex stainless steel (PREN > 38) of schedule 40 minimum and shall meet the pressure requirements of the system. Necessary instruments along with interlocks shall be provided for the safety of the RO system.

The RO Reject shall be collected in the reject water tank and transferred to outfall tank for further disposal.



Suitable Backwash system consisting of backwash pumps which shall utilize the clarified water or SWRO reject water for filter back wash shall be considered. Air scouring arrangement shall be envisaged for the pressure sand filters by dedicated blowers.

The backwash waste from the pressure sand filters shall be collected in the SWRO reject tank and then pumped to the Outfall tank.

Membrane Protection System consisting of:

- (i) CIP system for the RO skid consisting of Cleaning Solution tank, cartridge filter, cleaning pumps along with associated piping, valves and instruments. Separate Cleaning systems shall be envisaged for SWRO and BWRO system.
- (ii) SWRO flushing pumps taking suction from the Permeate Tank along with associated piping, valves and instruments.
- (iii) Suck-back Tank above each SWRO train with adequate head & quantity of permeate to ensure gravity flow from the low TDS permeate side to the high TDS brine side during an emergency shut-down (or) power failure to prevent the deterioration of the membranes.

SWRO Reject along with CW Blow down and filter back wash waste shall be collected in Outfall tank and pumped back to the sea by Outfall pumps.

Necessary chemical storage and dosing systems shall be provided. A two storied chemical house with chemical storage at the ground floor and dosing equipment on the first floor shall be considered. Electrically operated hoist shall be provided for handling chemicals in the chemical house. Ferric chloride shall be used as coagulant. Necessary bulk storage tank and unloading system shall be envisaged. Suitable polyelectrolyte shall be considered. All the dosing pumps in the pretreatment plant shall be proportional dosing type based on feed flow. Hydrochloric acid shall be used for conditioning the sea water for RO if required.

The complete desalination Plant shall be automatic, DCS controlled with necessary operator interface. Suitable on line instruments shall be provided for verifying the quality of water at various stages of treatment. Low pressure sea water piping shall be of GRP and high pressure piping shall be of duplex stainless steel having PREN > 38. CPVC pipes shall be used for chemical lines. For SWRO high pressure reject line super duplex stainless steel pipes to be provided.

All carbon steel structures and tanks/vessels shall be shot blasted to SA 2 ½ and epoxy painted externally. All stainless steel material in contact with sea water shall have a PREN > 38.

Transient analysis & stress analysis shall be conducted for piping from the SWRO feed Pump to RO high pressure pumps and HP pumps to SWRO and the reject lines.

Auto on/off valves shall be pneumatic or motorized with open and close limit switches. Manual over ride hand wheels to be provided for all valves for local operation. Control philosophy shall ensure proper failsafe positions of the valves in case of power or air failure.

Adequate instruments shall be provided for effective auto operation, monitoring and control of the plant. MOC of wetted parts shall be suitable for service fluid. Following instruments shall be provided as a minimum.

- Pressure Gauges at the discharge of all pumps and blowers.
- Flow transmitters at the inlet to each clarifier, inlet to Filters, suction of each RO High Pressure Pump, booster pump (if applicable), RO permeate, Reject, Filter Backwash (common), at the outlet of each Mixed Bed exchanger
- Flow control valves to be provided at HP pump discharge.
- Level transmitters and local level gauges for all tanks.



- Turbidity analyzers at the outlet of clarifiers and at the common outlet of gravity filters.
- SDI analyzer at each SWRO cartridge filter outlet.
- Pressure transmitters at suction and discharge of RO HP Pumps, (Booster pumps (if applicable) inlet and reject of both SWRO and BWRO, discharge headers of all pumps for auto start of standby pump.
- pH Transmitters at Cartridge Filter outlet, each SWRO and each BWRO permeate and at the outlet of each MB.
- ORP transmitters at the outlet of cartridge Filters.
- Temperature transmitters at SWRO inlet.
- Conductivity transmitter at the outlet of cartridge filters, individual SWRO and BWRO permeates and at the outlet of each MB.

All transmitters shall be indicating type. Two out of three logic shall be adopted for the following critical measurements:

- pH transmitters at cartridge filter outlet, each SWRO and each BWRO permeate
- Pressure transmitters at suction and discharge of RO high pressure pumps, booster pumps (if applicable), inlet and reject of both SWRO and BWRO, discharge headers of all pumps for auto start of standby pump.
- Conductivity analyzer at RO skid outlet.
- ORP analyzer at RO inlet.

Product water from the desalination Plant (i.e. SWRO) shall have a TDS of less than 500 ppm and shall be used for the following purposes. The capacity of Desalination plant shall be minimum 16 MLD. The water treatment plant area shall have space for future 16 MLD plant. Identical space for Pretreatment, Desalination & DM system and DM water tanks shall be provided by the Bidder in the WTP area.

Lime along with carbon dioxide dosing shall be considered at SWRO outlet to achieve the pH and LSI requirements. The permeate water from SWRO shall be utilized for the following applications:

- Service Water including HVAC.
- CHP dust suppression
- Potable water requirement
- Fire fighting system
- As input water for DM Plant
- AHP / ESP wash water/ Seal water
- Wet FGD system(Future)

3.2.2 DM Plant

The DM Plant shall follow the scheme of Brackish Water RO with Strong Acid Cation Exchangers(SAC), Strong Base Anion Exchangers (SBA), Mixed Bed. BWRO shall be sized for 3 x 50%, SAC -2 x 50%, SBA – 2x 50% and Mixed Beds shall be sized for 3 x 50%. Bidder to consider an additional provision to bypass both SAC and SBA and feed directly to MB units from BWRO outlet. SAC and SBA shall be sized for regeneration once in 20 hours. Mixed beds shall be sized for regeneration once in every 48 hrs. SAC, SBA and Mixed Bed regeneration chemicals shall be Hydrochloric acid and Sodium Hydroxide (Lye). The capacity of the DM Plant shall be arrived considering cycle make up requirement as 1.5% of the BMCR flow, Chemical dosing dilution requirements, SWAS make-up, H₂ gas generation, CPU & DM plant regeneration requirements, closed Cooling water system make-up requirements and Fuel Oil area PRDS requirement (If required).



Associated chemical handling, storage and dosing systems, RO CIP system etc shall be provided. Neutralizing pit shall be in 2 compartments with each compartment sized to collect the regeneration effluent from both CPU and DM plant. Recirculation cum disposal pumps shall be provided. DM Plant effluents shall be transferred to central monitoring basin for further use. Regeneration system for condensate polishing units shall be located in the DM Plant area.

Flow, conductivity and pH transmitters shall be provided at the outlet of individual BWRO and Mixed beds. Conductivity transmitters/comparators to be provided at the outlet of SAC and SBA vessels. Multi channel Silica analyzer shall be provided to verify the water quality at the outlet of each Mixed bed. Outlet Rota meters and inlet flow transmitter shall be provided for each Ion exchange vessel. Other instrumentation requirements shall be similar to desalination plant.

The DM water thus produced shall be stored in two DM water storage tanks each sized to store 1500 MT of DM water production of one stream. DM water shall be used for the Power cycle make up (Minimum 1.5 %), LP Dosing Chemical Preparation, H₂ Gas generation Plant, SWAS make up, regeneration of Mixed Bed units and the condensate polishing units. The DM water tanks shall have Seal pot arrangement for the overflow, CO₂ absorption system for the vent line. The DM water tank shall have 3 layers of PVC/PP balls.

Potable water shall be drawn from the product water of the SWRO, duly dosed with hypochlorite solution for disinfection purpose.

BWRO reject will have a TDS in the range of 2000 ppm and shall be collected in 100 m³ tank and can be pumped for further use either quenching the boiler blow down (as applicable), recycled back to the desalination system, for gardening purposes or CHP dust suppression system.

SAC, SBA, Mixed Bed and CPU regeneration effluents shall be collected in neutralizing pit, treated and neutralized effluent shall be transferred to central monitoring basin and utilized for horticulture and CHP dust suppression.

3.2.3 Control Philosophy

The RO – DM water System, referred here shall imply sea water pre-treatment system, Ultra filtration system, SWRO system, BWRO system, DM plant with all sub-systems and accessories. The operation of both RO-DM shall be carried out fully automatic (sequentially).

The RO – DM water System shall be controlled and monitored from the Desalination/WTP local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link, all hardware, software, other interfaces, cables and field sensors/instruments/erection hardware/furniture envisaged to control and monitor it.

The RO – DM water System local control room shall be provided with Two (2) no. 24" LCD TFT type Operator station and Mimic panel for control and monitoring the Desalination/WTP locally in addition to remote monitoring from the central control room in the main plant DCS. One No. large screen display (84") complete with control station and other hardware at control room for controlling & monitoring Desalination/WTP system.

For DM/RO plant One (1) no. A3 color printer in addition to 1 no. A4 BLW printer shall be provided in the local control room for the operator station.

Operator station in the Desalination / WTP local control room shall be provided with the access to monitor the main plant operations.



3.2.4 BWRO Plant

BWRO System consisting of RO-II Pass Feed pumps taking suction from Desalinated Water Tank, Cartridge filters, RO High Pressure Pumps, BWRO skids complete with membranes, pressure tubes, SS316L HP piping, valves and instruments, Degasser Tower and Degassed water storage tank with necessary DG blowers etc.

3.2.5 SAC, SBA and MB Plant

SAC, SBA and MB Plant consisting of Feed pumps, SAC, SBA and mixed bed units, DM Water Storage Tanks, DM Water Transfer Pumps etc.

Regeneration System consisting of Regeneration Pumps, Bulk Acid (With fume absorption system) & Alkali storage tanks, Acid & Alkali unloading pumps, Acid & Caustic measuring tanks, chemical transfer arrangement from bulk tanks to measuring tanks, dilution arrangements, hot water tank with electrical heating arrangement, ejectors etc along with associated piping, valves and instruments required for regeneration of mixed bed unit.

Neutralization system consisting of neutralization pit to collect regeneration wastes, neutralized waste disposal pumps to pump water to the central monitoring basin etc.

One (1) no Safety shower with Eye wash fountain near bulk Acid storage tank and One (1) near the DM Plant shall be provided as minimum.

3.2.6 DM Make up System

Three 3 x 50% DM Transfer pumps shall be located next to the DM Tanks and shall draw water from a common suction header. These pumps shall also supply make up water for Auxiliary boiler, overhead DMCW system expansion tanks, Chemical Preparation, Hydrogen generation, Fuel oil area (PRDS) requirement and condensate storage tanks. Each Pump shall be capable of meeting the requirements of one unit.

3.2.7 Control Philosophy

The DM transfer pumps and all associated controls shall be implemented in Desalination /WTP DCS. Control and monitoring of all other make up pumps including TG cycle make up pump, boiler fill pump etc shall be from the plant DCS. All necessary level controls of CST, DMCW overhead tanks etc shall be realized in DCS.

3.2.8 Service and Potable Water System

Service and potable water system consisting of Service Water Pumps for pumping water to the main plant Service Water Overhead Tank, Plant Potable Water Pumps for pumping water to the Potable Water Overhead Tank. Further Distribution of service and potable water in the various location shall be by gravity.

3.2.9 Chemical Storage System

Chemical Storage System consisting of Chemical house (G+1) for storing 30 days requirement of Desalination plant chemicals like Coagulant, Coagulant Aid, Acid, Antiscalant, Antioxidant along with dosing tanks & dosing pumps for each Chemical. Agitators for dilution, dissolving basket for effective mixing may be provided based on requirement.

Coagulant & Acid being consumed in higher quantity will be delivered to site in tankers, unloaded using Unloading pumps & stored in a Bulk Storage Tank. Bidder to consider 2 x 100% bulk tanks each of capacity to hold 30 days requirement or one tanker capacity of 20



Tonne whichever is higher. The unloading pumps shall also be used to transfer required quantity of chemical from the Bulk Tank to the Dosing Tank.

Addition of acid is optional and left to the Contractor.

Ground floor of Chemical House shall be used for storing chemicals and also house control panels, office, toilets etc. All dosing equipments including tanks, pumps etc. shall be located in the 1st floor. Complete chemical handling facilities like monorail of suitable capacity along with electrically operated hoist, lifting beam, eye wash and safety shower etc shall also be included.

3.2.10 Layout Requirements

The Pre-treatment system equipment comprising of Stilling chamber, Flash Mixers, Flocculators, Clarification system, Clarified Water Storage Tank will be located outdoor.

Ultra filtration system, Cartridge filters (For both Pass-I & Pass-II), HP pumps (For both Pass-I & Pass-II), Energy recovery units, RO skids (both first and second pass) and mixed bed units shall be located indoor in the Desalination Building which shall also house the MCC room, Control room & Laboratory. Pressure sand filters shall be located inside an open shed.

Degasser tower, blowers, Degassed tank, RO-II Pass Feed Pumps, DM Feed tank, Feed Pumps, DM Tanks, Bulk Chemical storage tanks etc will be outdoor. Regeneration equipment will be semi outdoor in an open shed.

Road access shall be available to chemical storage tanks for unloading chemicals from the tankers, Desalination building and chemical house.

Lay down space shall be provided for the HP pump and cartridge filters for maintenance. An overhead travelling hoist/crane will be provided for maintenance of the HP pumps.

Adequate space for access and maintenance will provided for all equipment.

An emergency shower and eye wash provision will be made near the acid and caustic storage area.

The Water Treatment plant layout will be compact to maximize the space utilization and will allow easy maintenance. The arrangement of membranes will be such as to permit easy removal of one (1) membrane assembly without disturbing the other.

3.3.0 Dis-infection System

3.3.1 Electro Chlorination System

Electro chlorination system shall be sized considering sea water intake system (shock and continuous), Desalination feed system, CW system (shock and continuous) and Sewage treatment plant for all the 2 x 660 MW units.

Chlorine will be dosed to remove organic matter present in the Circulating Water (CW) and to minimize biological growth on the piping as such since biological growth could promote corrosion, impair heat transfer and impair water distribution throughout the circulating water system.

The feed water to electro chlorination plant shall be taken from the Sea water intake pump house within the plant boundary.

The seawater is fed to the electro chlorination plant from the Sea Water intake pump house by means of Electro Chlorination system booster pumps (2 operating + 1 standby) which shall



take suction from the CT make up pumps discharge through self-cleaning filters (3 W + 1 S) where suspended solids with size bigger than 0.5 mm are filtered.

Sizing criteria

1. For sea water intake system – 1 ppm continuous dosing at forebay & 3 ppm shock dosing at velocity cap
2. Desalination feed system – 2 ppm continuous dosing
3. Circulating Water system – 1 ppm continuous dosing & 3 ppm shock dosing (once in a shift for 30 minutes)
4. Sewage treatment plant – 2 ppm continuous dosing

The flow control valves provided at inlet to each Electrolyser unit will control seawater flow rate. The filtered seawater is fed to the Electrolyser unit. The Capacity of the chlorine Generator shall be sized as per sizing criteria above. These generators units connected hydraulically in parallel with each other, having chlorine production to meet the system requirements. Each electrolyser unit will have two electrolytic cells connected electrically and hydraulically in series.

The Electrolyser will generate hypochlorite and hydrogen consuming the sodium chloride present in the seawater.

The active hypochlorite solution is collected in the 2 Nos. Sodium Hypochlorite storage-degassing tank where the liberated hydrogen gets vented out with air dilution.

This solution is pumped to the CW system in each pumping chamber by continuous centrifugal pumps. Each unit cooling water system has a dedicated continuous dosing pump and there will be one standby pump common for both units. There are two dosing pumps (1 operating + 1 standby) dedicated for shock dosing in CW system. Shock Dosing shall be done for one unit at a time. The Hypo shall be dosed upstream of Screens in each pumping chamber.

In the Water Treatment Plant, Hypo shall be dosed in the Stilling chamber (2ppm continuous dosing) There are 2 x 100% transfer pumps for Hypo dosing to Water Treatment Plant.

In sea water intake system, 3 x 50% hypo dosing pumps shall be provided for continuous dosing at the intake forebay and 2 x 100% dosing pumps shall be provided for shock dosing at velocity cap.

Dedicated 2 x 100% hypo transfer pumps shall be provided to cater to sewage treatment plant chlorination requirements.

For potable water disinfection 1 x 100% capacity dosing tank along with 2 x 100% dosing pumps shall be considered. Hypo chlorite required for potable water disinfection shall be procured separately and hypo chlorite generated from electro chlorination system shall not be used for potable water disinfection.

The hydrogen generated with the hypochlorite gets separated in the 2 Nos. hypochlorite storage cum degassing tank. The air dilution blowers (1 Duty + 1 Standby) for each Degassing Tank are provided in order to dilute the hydrogen stream with air, so as to get a non-flammable mixture (25% of LEL).

In case of failure of one blower, the other one will start automatically. An automatic interlock will shutdown the rectifier if both the blowers fail.

The transformer-rectifier unit provides the Electrolyser with direct current. Each Electrolyser unit will have individual transformer-rectifier. The current from the transformer - rectifier is transferred through Bus bars to the Electrolyzer.



Sampling valves will be provided at the outlet of the cell drain to monitor the cell performance.

The side reaction products of the electrolysis process after long periods of operation can accumulate on the electrodes. They shall be removed by dissolving them in a solution of diluted hydrochloric acid that shall be circulated through the Electrolyser unit.

The acid cleaning system consists of 1 x 100% HCl circulation tank and two circulation pumps (1 operating + 1 standby), which are hooked up to the Electrolyser units for cleaning.

3.3.2 Layout

The Electrolyser units & Transformer-Rectifiers will be located indoors.

Dilute HCl tank, Hypo storage tanks & Hydrogen dilution blowers shall all be located outdoor.

Road access shall be available to chemical storage tanks for unloading chemicals from the tankers.

An emergency shower and eye wash provision will be made near the HCl storage area.

MCC room, control room will be located indoor.

4.0.0 DESIGN REQUIREMENTS

4.1.0 Plant Water Treatment System

The Water Treatment Plant shall be designed based on the Sea Water Analysis provided along with this tender. The system provided shall be suitable for downstream requirements.

- DM Plant shall be sized suitable for 1.5 % of Cycle Make-up Requirements and also the requirements of DMCW makeup, LP Dosing Chemical Preparation, H₂ Gas generation Plant, SWAS make up, regeneration of SAC, SBA, Mixed Bed units and the condensate polishing units, fuel oil area PRDS requirement.

4.2.0 Waste Water Treatment System

All the wastes generated from the Power Plant shall be collected and treated according to the nature of the waste. The following wastes are envisaged from the Power Plant.

1. Cooling water blow down, filter back wash and the SWRO rejects shall be collected in the Outfall tank and the water will be pumped to sea.
2. Clarifier sludge and ETP Clarifier sludge shall be collected in sludge pit and pumped to the ash pond/ slurry sump.
3. Boiler Blow down suitably quenched with Service water and transferred to central monitoring basin and utilized for horticulture purpose.
4. BWRO Reject shall be suitably used back in the Desalination Plant or shall be utilized for CHP dust suppression/ green belt development.
5. DM Plant and CPU regeneration waste shall be pumped to the Guard Pond/Central Monitoring basin after neutralization.
6. Wastes from floor wash shall be led to the Common ETP Collection sump. Necessary sump shall be provided to collect the waste from different area depending on the layout. Sump pumps shall be used to pump the waste collected and transfer it to Common ETP Collection sump.
7. Coal pile runoff water from the settling tank shall be pumped to the common ETP collection sump. Coal pile run off transfer pumps and ETP clarification system to be designed for the maximum rainfall data.



8. Oily wastes from TG Area, Fuel Oil Handling Areas etc. shall be pumped and collected in collection tank and then treated in TPI/API type Oil water separators. The clear water is transferred to the Central Monitoring basin.
9. From the floor wash Collection sump, the wash water shall be pumped to a Clarifier for reducing the Suspended Solids with necessary dosing system. The clear water shall be led to the Guard Pond/ Central Monitoring basin of capacity 24 hours storage capacity and from there used for horticulture, CHP dust suppression, etc. The sludge from the clarifier shall be transferred to the PT Clarifier sludge pit and then pumped to ash pond.
The capacity of the ETP shall be decided suitably by the Contractor.
10. Sewage from the entire plant area shall be transferred by gravity flow and treated in common sewage treatment plant. Sewage from power plant shall be collected in common sewage collection sump. The collected sewage will be treated in Aeration tank followed by clarifications and the overflow from clarifier will be stored in a clarified water tank. The clarified effluent will be filtered in activated carbon filter and pressure sand filters and reused for horticulture applications. Sodium hypo chlorite should be dosed in the treated water for disinfection purpose.

4.3.0 Control Philosophy

The control and monitoring of waste water treatment plant shall be carried out from from plant DCS through Remote I/O.

5.0.0 CONSTRUCTION REQUIREMENTS

All the equipments / vessels / Tanks shall be designed for the maximum pressure / temperature / flow that the equipment / vessel is expected to be subject to under any circumstances. The MOC of all the Equipments / vessels / Tanks shall be suitable for the service fluid being handled.

All Bulk Storage Tank shall be 1 No. horizontal suitable for 30 days storage capacity of the respective chemical and shall be of FRP construction.

All Solution Preparation cum Metering Tanks shall be 2 x 100% vertical tanks each of 1 day requirement of the respective chemical and shall be of FRP construction with SS316 Agitator (Unless not suitable alternative MOC shall be used) and Dissolving Basket.

All Dosing Pumps shall be Positive Displacement – Diaphragm / Plunger Type, 2 x 100% of PP construction with PTFE Diaphragm.

All Air Blowers shall be 2x 100% Rotary Twin-Lobe Oil Free of C.I construction with EN9 shaft.

All Chemical Unloading Pumps shall be 2 x 100% Horizontal Centrifugal Pumps of capacity 15 m³/hr @ 15 mlc with PP wetted parts (Except wherever different MOC is specified).

All Pressure Vessels shall be designed based on ASME Sec. VIII, Div. I / IS 2825.

The data furnished above are in general and shall be inline with the specified data sheet.

Drawings, data / documents to be submitted along with tender

Duly filled-in technical data, bill of material and prices as per specified schedules.

Technical write-up for the system.

List of drawings/documents attached to tender.

Time schedule for design, manufacture, delivery, erection, testing, and commissioning.



P & I Diagram for the System

Operation and control philosophy.

Equipment layout drawings.

Process design calculations with catalogues and equipment sizing calculations

Utility consumption for various equipments (power, cooling water and instrument air requirements).

List of tests the Bidder proposes to carry out in shop and at site after installation including those pertaining to their sub-Bidder.

List of all maintenance tools, tackles and accessories required for maintenance of the offered equipment including bought out components.

List of all recommended spare parts for all equipment offered including bought out components suitable for three (3) years operation.

A bar chart indicating design engineering, procurement, manufacture, testing at shop, delivery, installation, testing and commissioning activity/duration of System offered.

Quality Assurance Plan.

Complete Electrical Load List

Bill of quantities for civil works.

Drawings, data / documents to be furnished by the successful Bidder

The following drawings, data / documents shall be submitted for the approval / review of the Purchaser / Consultant by the successful Bidder.

Mechanical	Category
a) Drawing / Document submission schedule	A
b) Process design calculations with catalogues and equipment sizing calculations	A
c) Final Schematic, Flow and P&I diagram with interlock summary.	A
d) Final technical data sheets for all equipment/ tanks/ vessels/ instruments	A
e) Piping and Valve Schedule.	A
f) Equipment layout drawings.	A
g) Design calculations	A
h) Pressure vessel thickness calculations	A
i) FRP tank thickness calculations	A



j) Fabrication drawings of vessels & tanks	I
k) G.A. drawings of all equipment with sectional details giving details of materials.	A
l) Piping specification	A
m) Piping layout	A
n) Isometric drawings including pipe support drawings.	I
o) Technical literature for all equipment	I
p) Foundation bolt detail drawing.	A

Civil

a) Complete civil inputs required for civil design	A

Any other drawings required for review during the detailed engineering stage, same shall also be submitted by contractor.



ANNEX – 2.14.1

SPECIFIED DESIGN DATA

Description	Unit	Data
SEAWATER INTAKE SYSTEM		
General		
Flow to be considered for Design of sea water intake system	M3/hr	30000
Intake pipe Size (From Intake Well to desilting basin)		OD 2000 PE 100 SDR 26, HDPE pipe
Manhole size		1200 mm
Facility for cleaning and maintenance of intake pipe		Pigging system shall be envisaged
Quantity of pipe	Nos	By Contractor (minimum 2)
Design code		ASTM D3350/ PE345664C or ASTM D3350 / IS 4984/ISO 4427/ISO 4437.
Chlorine dosing for the intake system		To be envisaged. Pipes shall be SDR 17
Air burst System		To be envisaged. Pipes shall be SDR 17
Compressor type		Non-Lubricated screw type
Quantity		1W +1S
Air receivers		To be provided
Mode of Operation		Fully Automatic
Duplex Stainless steel (PREN > 38) Sluice gate		To be provided for each pipe
Mode of Operation of sluice gate		Motor operated
MOC of Gate frame, shutter plate, shutter guide,		Duplex stainless steel (PREN >38)
MOC of anchor blocks		RCC
MOC of bolts & nuts for anchor blocks		Duplex SS
MOC of back up flange, bolts and nuts		Duplex stainless steel (PREN > 38)
MOC of puddle flange		HDPE/GRP
MOC of end flange		HDPE / GRP
Desilting Basin		
Quantity		1
Number of compartment		3
Minimum Size		Confirmation of Size by Mathematical Model Study& CFD. The required flow shall be achieved when one compartment is under maintenance. The system shall be sized considering the periodic dredging carried out for the jetty.
Stop log gates for desilting basin		To be provided
Sand slurry pumps		2
Type		Submersible pumps for maintenance of desilting basin with 50 mts power cable for each pump with trolley
Material of constructions		Complete Duplex stainless steel
Slurry pipe		The discharge slurry pipe (HDPE)



Description	Unit	Data
		shall be extended to the sea near HTL.
Material handling facility for stop log gate		To be provided.
Note:		
1. Provision shall be made in the desilting basin for construction of Sea water intake pump house for future 2 x 660 MW where in CT make up pumps, desalination feed pumps shall be installed. 2. Desilting basin & pump house forebay concrete shall be protected with suitable painting against sea water		
SEA WATER INTAKE PUMP HOUSE		
Location of intake Pumps		On shore within the plant boundary
Pipe routing		Below ground
Route Survey		To be conducted
Recirculation from discharge		Required. Through Control valve
Stop Logs, Trash Rack, Traveling Screen		Required
Material Handling for Pumps		Required
Air release valves		Required
Intake system Chlorination		Required
Material handling for Screens and Stop Logs		Required
Design of forebay		As per HIS standards
Physical Sump Model study		To be conducted by Contractor
CT Make –up supply Pumps		
Type		Vertical turbine Non-pull out pumps
Quantity		3 x 50%
Type of Lubrication		Oil/ Grease/ Self Lubrication (External flushing water To be self generated or from service water)
Column Pipe Connection		Flanged
Type of Coupling between Pump & Motor		Flexible
Pump Discharge		Above pump Floor
Desalination Plant Supply Pumps		
Quantity	Nos	3 x 50 %
Type		Vertical turbine Non-pull out pumps
Capacity	M3/hr	By Contractor
Type of Lubrication		Oil/ Grease/ Self Lubrication (External flushing water To be self generated or from service water)
Column Pipe Connection		Flanged
Type of Coupling between Pump & Motor		Flexible
Pump Discharge		Above pump Floor
Strainer		
Quantity	Nos	3 x 50 %
Capacity	M3/hr	By Contractor
MOC		SS 316L
Screen wash Pumps		
Quantity		2 x 100 %
Capacity		By Contractor
Type		Horizontal pump
MOC		Duplex SS (Casing, impeller and shaft)
OUTFALL SYSTEM		
Flow to be considered for design of sea	M3/hr	22500



Description	Unit	Data
water outfall system		
Pipe routing		Below ground
Effluents going to outfall		Pressure sand filter waste, UF system reject, SWRO Reject and CT Blow down
Outfall Water Quality Parameters		To be monitored (FRC, Oil, Temperature & pH)
Note: Power plant contractor to provide the outfall line size details to port contractor to enable allocation of space for laying the pipes along with tressle		
Outfall tank capacity	M3	5000minimum
MOC		RCC
Design		As per HIS
Stop log gates and Screens		Required
Outfall Pumps		
Type		Vertical turbine Non-pull out pumps with VFD arrangement
Quantity		3 x 50%
Type of Lubrication		Oil/ Grease/ Self Lubrication (External flushing water To be self generated or from service water)
Column Pipe Connection		Flanged
Type of Coupling between Pump & Motor		Flexible
Pump Discharge		Above pump Floor
Tensile strength of weld for HDPE pipes		As per ISO 13953 irrespective of sizes
Under water videography		To be provided
Hydro testing procedure for offshore pipes		Hydrotesting shall be done for the offshore HDPE pipes. Detailed procedure shall be furnished by the bidder.
Gates & Screens for Pumps		
Stop Log Gates (For Intake & Outfall pumps)		SS 316L guides and shutters
Trash Rack with automatic raking mechanism (for intake system)		SS 316 L
Travelling Screen (for intake system)		SS 316 L
Coarse screens / Fine screens		Shall be provided for outfall system
MATERIAL OF CONSTRUCTION FOR SEA WATER HANDLING PUMPS		
Bowl		Duplex SS 2205 to UNS 31803
Impeller		Duplex SS 2205 to UNS 31803
Pump shaft		Duplex SS ASTM A 890 CD 4M CU
Shaft sleeve		Duplex SS 2205 to UNS 31803
Column pipe		Duplex SS 2205 to UNS 31803
Discharge head and Tee		Duplex SS 2205 to UNS 31803
Motor stool		Carbon steel (IS:2062)
Gland packing		Impregnated Teflon
Fasteners in pump assembly		SS 316L for fasteners submerged in water and alloy steel for other fasteners
Base plate/sole plate		Carbon steel (IS:2062)
For the sea water handling pumps, Duplex SS shall have PREN > 38		



Description	Unit	Data
MATERIAL OF CONSTRUCTION FOR SEA WATER HANDLING STOP LOG GATES		
Type		Stop-log
Design code		IS:5620 or Equivalent
Flow (m ³ /hr)		Contractor to Finalize
Fluid to be handled		Sea water
Material of construction for stop log gate		SS316L
Exposed embedded parts		SS316L
Service water tank and Potable water tank at Intake Pump house		
Service water tank	Nos	1
Potable water tank	Nos	1
Capacity		1 m ³
Tank MOC		RCC.
Location		Above the Intake Pump House
Portable compressors for the intake pump house		Required
Quantity		2
Portable submersible dewatering pumps		2 (Duplex Stainless steel)
Desalination Plant (Common for 2 x 660MW)		
Flow control station		1 no. of motorized inching type butterfly valve with isolation valves in upstream and downstream along with bypass line with isolation valve at the inlet to stilling chamber
Clarification System		
Stilling Chamber		Common, RCC
Retention time (minimum) (Contractor to consider higher capacity if required to meet system requirements.)	Min	One (1) minute
Parshall Flume		One for each clarifier
Flash Mixer (RCC)		
Quantity	nos	2 x 60 %.
Retention time	Min	One (1) minute
Agitator		Required. Duplex Stainless Steel.
Flocculator		
Quantity	nos	2 x 60 %.
Retention time	Min	Twenty (20) minute
MOC of shell		RCC
Agitator		Required. MS FRP
Clarifier		
Quantity	nos	2 x 60 %
MOC		RCC
Clarification zone Retention time	Min	120 minute
Clarifier outlet Suspended solids	ppm	< 10 ppm
Sludge Pit		RCC, suitable to store 4 hours of sludge generated.
Sludge Transfer Pumps		
Quantity	Nos.	Two (1 W + 1 S)
Type		Vertical Non clog type
MOC		Duplex stainless steel
RPM		1500



Description	Unit	Data	
Air agitation		Required with air grid arrangement	
Air Blower		Twin lobe blower, 2 nos. (1W+1S)	
PT Chemical Dosing System			
Dosing tank		Fecl3	Polyelectrolyte
Quantity	Nos	2	2
Storage Capacity	Day	1	1
MOC		FRP with vinyl ester resin	
Agitator		MSFRP	MSFRP
Solution concentration		10 %	0.1 %
Bulk Storage tank	Nos	2	
Capacity	Days	15 m3 each or 30 days requirement whichever is higher	
Unloading pumps		2 x 100 %	
Type		Horizontal Centrifugal	
Pump MOC		PP	
Pump RPM		1500	
Mechanical seal		To be Provided	
Dosing Pumps			
Qty		2 x 100 % per stream	
Type		Positive Displacement, Diaphragm Pumps	
MOC		PP with PTFE diaphragm	
Operation		Automatic (i.e. proportional dosing based on change in feed flow)	
Suction Dampening pot		Required	
PT Chemical storage building		Two storeyed building with electrical hoist and weighing scale. Chemical preparation tanks and dosing equipments shall be located on first floor. Chemical storage space(for 30 days requirement) along with office room, toilet and switchgear room (if applicable) shall be located on ground floor.	
PT Service water overhead tank for chemical preparation.		2 m³ RCC tank	
Clarified water storage tank			
Capacity		4 hours requirement	
Number of Compartments		Twin Compartment	
MOC		Above ground fully covered RCC tank with suitable lining.	
Filter feed pumps			
Quantity	Nos	3 working + 1 standby	
Type		horizontal centrifugal	
MOC		Duplex (PREN > 38)	
Pump Efficiency	%	> 80%	
Pressure Sand Filter			
Quantity	Nos	As per system requirement with One Standby.	
MOC		IS 2062 with internal rubber lining of 4.5 mm thickness	



Description	Unit	Data
Type		Horizontal cylindrical filters with fine sand and gravels as filter media.
Loading Rate	m ³ /hr/m ²	max 10
Location		Shall have covered Shed
Back wash Pumps	Nos	Two (1 W + 1 S), Duplex SS
Air scouring Blowers	Nos	Two (1 W + 1 S), Twin Lobe, oil free discharge
Outlet Quality	NTU	< 2
Waste Backwash water		Shall be transferred to Outfall tank along with SWRO reject.
Ultra filtration system		
Type		Hollow fiber membrane
Molecular weight cut off		100KDa.
MOC		PVDF/Poly ether sulphone
Capacity		As per system requirement
Average flux	Lmh	60
SDI at UF outlet		< 3
Turbidity		Nil
Basket strainers		To be provided at the inlet of each skid. MOC – Duplex SS.
Minimum recovery	%	90
Make		Hydronautics / Norit (Pentair)/ Hyflux /Koch/ Dow
Note: UF skids to be designed in a manner that when one skid goes for back wash the other skids should be able to achieve the required product flow.		
UF permeate water tank		
Qty	No	1
Capacity		To hold water required for one back washing of all UF skids+ Downstream system requirement with suitable margin.
MOC		RCC covered tank
UF back wash pumps		1W+1S, MOC – Complete Duplex, 1500 RPM.
UF fast flush pumps(if required)		1W+1S, MOC – Complete Duplex, 1500 RPM.
UF chemical enhanced back wash system		To be provided with 1 x 100% chemical dosing tanks, 2 x 100% dosing pumps for each chemical.
Chemical cleaning system for UF		To be provided with one no. of chemical cleaning tank, 2 x 100% chemical cleaning pumps
SWRO feed pumps		
Quantity		3 nos. (2W+1S)
Capacity and head		As per system requirement with suitable margin
MOC		Duplex (PREN > 38)
RPM		1500
Pump Efficiency	%	> 80%
Micron Cartridge Filters (MCF)		
MOC of Housing		GRP/ Duplex SS
Quantity	Nos	2 working + 1 standby
Cartridges		PP, 2.5" x 40", 5 microns nominal rating
Capacity each		Suitable for one train of SWRO



Description	Unit	Data
SWRO System		
General data		
Total Capacity		Minimum capacity of the plant shall be 16 MLD.
Number of streams	Nos	3 X 50%
Nett Capacity Of each stream		5 MLD each.
Design Sea Water Temperature	Deg C	25 to 33 Deg C
Product water Quality	TDS	< 500 ppm
Feed water SDI	SDI	< 3
Average System Flux	LMH	< 14
Elements per vessel	Nos	7 (max)
System Recovery	%	30
H P Piping and Valves MOC		Duplex (PREN > 38)
Velocities in HP Lines	Mts/Sec	< 3.4
Velocities in RO Permeate Lines	Mts/Sec	< 2.0
Velocities in Other LP Lines	Mts/Sec	< 2.4
SWRO High Pressure Pumps		
Quantity	Nos	Two (2) (working) + 1 (standby)
Type		Horizontal axial / radically split casing multistage centrifugal pumps
MOC		Duplex (PREN > 38)
Pump Efficiency	%	> 80%
VFD		Required
Energy Recovery Unit		
Type		Pressure Exchanger / energy recovery turbine
Quantity	Nos	One per Stream
MOC		Duplex SS as per UNS 32750
Make		ERI / Pump Engineering / Fedco
Booster Pump (If applicable)		
Type		Horizontal end suction
Quantity	Nos	One per Stream
MOC		Duplex SS (PREN > 38)
Make		Preferably same as HP Pump
VFD		Required.
RO Pressure Vessel		
Size	Inches	8"
MOC		FRP
Pressure rating		1200 psi
Length		Suitable for 7 elements
Port configuration		Side port
SWRO Membrane		
Size		8"
MOC		Polyamide, spiral wound
Minimum salt rejection	%	Greater than 99.7
Membrane area	M2	< 40
Make		Hydronautics / Dow / Toray
Chemical Handling System		
Chemical storage - Dry		30 days storage in chemical house
Chemical storage - Bulk Liquid		30 days storage in Storage Tanks
Chemical unloading Pumps		2 x 100% for all chemicals
Chemical dosing Pumps		3 x 50 % for SWRO 3 x 50% for BWRO
Chemical Dosing tank		2 nos of dosing tank shall be



Description	Unit	Data
		provided for each dosing system with 12 hrs storage capacity each along with SS 316 agitators, level gauges, level switches, fume absorbers, overflow and drain lines.
Remineralization system consisting of Lime and CO2 dosing for SWRO product water		To be provided.
CIP System		
Capacity		Suitable for cleaning one SWRO Train
Cleaning Pumps		2 x 100%, SS 316
Cartridge Filter		1 no, 5 micron rating, SS 316 Housing
Cleaning Tank	One	FRP, One cleaning volume + 20%
Suck back tank		
Quantity		One per Skid
Capacity		Total Pressure vessels volume in the skid + 10 % Margin
MOC		FRP
SWRO Flushing pumps		
Quantity		2 x 100 %
Capacity		To Flush One RO Stream at a time @ minimum flow of 6 m3/hr per pressure tube.
Piping		
Low Pressure Sea water, Brine, product water, Cleaning solution, Air scour, ducting		Filament wound GRP with 1.6 mm inside and outside resin rich liners
High pressure sea water piping		Duplex (PREN > 38), Sch 40 (minimum).
High pressure reject piping		Super duplex stainless steel as per UNS 32750, sch 40 (minimum)
Chemical lines		CPVC
Valves	Size	
LP sea water and brine for isolation purpose	> 8"	B/F with DI body and Al Bronze/ Duplex SS disc and EPDM Seat
LP sea water and brine	All	Gate Valve, Duplex / Al Bronze
	All	Ball Valve, Duplex / Al Bronze
HP sea water and brine Isolation/ Interfacing between chemical cleaning & flushing lines.	All	Ball Valve, Duplex
HP sea water/ brine Control	All	Globe or plug Valve, Duplex
LP Product water/ Cleaning Solution	> 8"	B/F with DI body, SS 316L disc and EPDM Seat
LP Product water/ Cleaning Solution	All	Gate / Ball Valve SS 316 L
Process isolation valves for instruments	< 2"	Gate / Ball / Globe Valves with suitable material for service as above
Chemical Lines		Ball valves, CPVC
Reject Water Tank		
Quantity	No	1
	Hrs	Capacity to hold waste generated from SWRO & UF for a period of One (1) hour and two Filters back wash waste water quantity.
Capacity of tank		
MOC		RCC, below ground



Description	Unit	Data
Reject water Transfer Pumps		
Quantity		3 x50 %
Capacity & head		As per system requirement with suitable margin.
Type		Vertical centrifugal non clog type
MOC		Duplex SS
RPM		1500
Desalinated water cum fire water storage tank		
Quantity	No	One number with Three compartments
Total Capacity of tank	m3	13000 (Including Fire water requirement as per TAC)
Number of compartment per tank		3 (one compartment dedicated for fire water storage tank, capacity shall be as per TAC)
MOC		RCC, Above Ground
Pump House for desalinated water cum fire water storage tank		Completely above ground
Service water Pumps		
Quantity	Nos	2 x 100%
MOC		CI casing with SS 304 impeller
RPM	-	1450
Type		Horizontal Centrifugal
Potable water Pumps		
Quantity	Nos	2 x 100%
MOC		SS
RPM	-	1450
Type		Horizontal Centrifugal
ESP/APH wash pumps		
Quantity	Nos	2 x 100%
MOC		CI casing with SS 304 impeller
RPM	-	1450
Type		Horizontal Centrifugal
Ash water make-up pumps for seal water applications		
Quantity	Nos	2 x 100%
MOC		CI casing with SS 304 impeller
RPM	-	1450
Type		Horizontal Centrifugal
Service & Potable water tank for Plant		Twin compartment RCC Overhead tank to enable gravity distribution.
Capacity		
Service Water compartment		500 m ³
Potable water Tank		75 m ³
Provision of suction line from Overhead water tank with isolation valve for Colony Transfer Pumps (2 x100 %) with necessary provision of electrics		To be provided.
Boiler floor wash pumps		
Quantity	Nos	2 x 100%
MOC		CI casing with SS 304 impeller
RPM	-	1450
Type		Horizontal Centrifugal



Description	Unit	Data
Portable submersible De-watering Pumps		
Quantity	No	2
Capacity	M3/hr	100
Head	MWC	20
MOC		SS 316 L
Discharge hose		Required
Cable Length	m	50 (Minimum)
Trolley		Required
BWRO-DM Plant		
General		
Net Capacity	M3/day	Contractor to furnish
Number of streams	No	3x50%
Capacity		BWRO – 3x50% MB – 3 x 50%
Net flow rate of BWRO		To meet downstream DM water requirement
Scheme		Brackish water RO + Mixed Bed
DM Water Quality		
Conductivity		< 0.1 micro Siemens/cm at 25 Deg C
Reactive Silica	ppb	< 10
pH		6.8 to 7.2
BWRO Feed Pumps		
Quantity	Nos	Two working + 1 Standby
Casing + Impeller+ Shaft		CF8M / SS 316
Type		Horizontal centrifugal
RPM		1500
Micron Cartridge Filter		
Quantity	Nos	3 X 50%
Cartridge Filter MOC		GRP / SS 316L
Cartridges		PP, 2.5" x 40", 5 microns nominal rating
BWRO High Pressure Pumps		
Quantity	Nos	Two working + 1 Standby
Casing + Impeller+ Shaft		CF8M / SS 316
Type		Vertical in line multi stage centrifugal
RPM		1500
BWRO System		
No Of Trains	Nos	3 x 50%
System recovery	%	Minimum 70
Design Inlet TDS	ppm	500 irrespective of the TDS at the outlet of SWRO system. Additional TDS load if any due to Lime & CO2 dosing in SWRO product water shall be taken care in the system design.
Outlet TDS	ppm	< 20
Capacity		To meet DM water requirements
Average System Flux	LMH	< 25
HP Piping MOC		SS 316L
BWRO reject water tank		
Quantity	No	1
MOC		RCC
Capacity		4 hours storage
BWRO reject water transfer pumps		



Description	Unit	Data
Quantity	Nos	2 (1W+1S)
Capacity & head		As per system requirement with suitable margin
MOC		SS 316
RPM		1500
CIP System for BWRO		
Capacity		Suitable for cleaning one BWRO Train
Cleaning Pumps		2 x 100%, SS 316
Cartridge Filter		1 no, 5 micron rating, SS 316 Housing
Cleaning Tank	One	FRP, One cleaning volume + 20%
Degasser System		
Quantity of Towers	Nos	2 x 50%
MOC (Towers, Blowers & Ducting)		FRP
Blowers quantity	Nos	Three (2W + 1 S)
Degassed water tank/MB Feed Water Tank		
Quantity	No	One (common for both streams)
Capacity	Hrs	1 hour storage
MOC		FRP/RCC with suitable lining
DM Feed Pumps		
Quantity	Nos	Three (2 W + 1 S)
Casing + Impeller		CF8M / SS 316
Type		Horizontal centrifugal
RPM		1500
Strong Acid Cation exchanger		
Quantity	Nos	2 x 50%
Net Flow rate per hour	m ³ /hr	Contractor to indicate
Service cycle	Hrs	20 hrs service 4 hrs regeneration
Regeneration Chemicals		HCl
Design code and MOC		IS 2825 & IS 2062 with internal rubber lining as per 4682 Part I
Strong Base anion exchanger		
Quantity	Nos	2 x 50%
Net Flow rate per hour	m ³ /hr	Contractor to indicate
Service cycle	Hrs	20 hrs service 4 hrs regeneration
Regeneration Chemicals		NaOH
Design code and MOC		IS 2825 & IS 2062 with internal rubber lining as per 4682 Part I
Mixed Bed Units		
Quantity	Nos	3 x 50%
Net Flow rate per hour	m ³ /hr	Contractor to indicate
Service cycle	Hrs	48
Regeneration Chemicals		HCl and NaOH
Regeneration System		
Bulk storage Tank MOC,		Acid Alkali
		2 nos, FRP (Bisphenol), 30 days requirement each or one tanker capacity of 20 KL whichever is higher.
Unloading Pumps		PP SS 316
Capacity & head		15 m ³ /hr and 15 mlc
RPM		1500
Acid Measuring Tank		FRP, 120% of one regeneration requirement



Description	Unit	Data
Quantity		Two (2)
Caustic Measuring Tank		FRP, 120% of one regeneration requirement
Quantity		Two (2)
Agitator		Required.
MOC of agitator		SS 316 for caustic tank
Ejectors		Mild steel ebonite lined
Hot water tank for Caustic regeneration system		
Quantity		One
Capacity		To suit the system requirements
Temperature		60 °C
Heating Method		Electrical, with heating elements
MOC		MSRL
Thermal Insulation		To be Provided
MB Air Blower		
Quantity	Nos	Two (1 W + 1 S)
MOC		CI Body, DI lobes and EN9 shaft
Type		Twin Lobe, Oil free discharge
Neutralization System		
Neutralization Pit	MOC	RCC with acid/alkali proof lining
Quantity		One with 2 compartments
Capacity (each compartment)		1.5 times the waste generated from regeneration of MB and CPU unit.
Neutralization		By PVC Air grid, Re-circulation & Chemical addition by Acid & Caustic tanks. Air shall be tapped from MB blower.
Neutralized waste disposal Pumps		Two (1 W + 1 S), CF8M/SS 316
Capacity		To dewater the N. Pit in 4 hours
Type		Horizontal centrifugal
Casing + Impeller		CF8M / SS 316
RPM		1500
Priming arrangement		Required
Priming Tank Capacity	-	5 - 6 times the suction pipe volume (min).
Priming Tank MOC	-	FRP
Piping MOC		
Low Pressure Piping		CPVC/MSRL
HP Piping for BWRO		SS 316 L
Chemical handling Lines		CPVC
Valves		
LP Piping	> 8"	CI body, SS 304 disc, EPDM seat
HP Piping for BWRO (Isolation)		Ball Valve, SS 316
Process Piping	< 8"	Diaphragm Valves, CIEL
RO Control Valve		Globe, SS 316
Chemical Lines		Diaphragm valves
DM water storage tank		
Quantity	No	Two (one for each unit)
Space for another 2 tanks for future unit.		To be provided.
Capacity per tank	Hrs	1500 MT of DM water.
MOC		Carbon Steel epoxy painted.
CO2 absorption system for Vent line		Required
PVC/PP Balls		Required in Three layers
Seal Pot Arrangement for Overflow		Required



Description	Unit	Data
Manhole		Two in shell and one in Roof. (minimum)
DM water transfer Pumps		
Quantity	Nos	Three (2 W + 1 S)
Space provision for pumps of future units		To be provided.
Casing / Impeller / Shaft		CF8M / SS 316
Type		Horizontal centrifugal
RPM		1500
MB Regeneration Pumps		
Quantity	Nos	Two (1 W + 1 S)
Casing / Impeller / Shaft		CF8M / SS 316
Type		Horizontal centrifugal
RPM		1500
Electro Chlorination for 2 x 660 MW		
No. of streams		2
Capacity of each stream	kg/hr	To meet requirement for 2 x 660 MW units
Available Cl ₂ Content at outlet	ppm	2000
Acid Cleaning System		Required
Electro Chlorination System Booster Pumps		
Quantity	Nos	3 x 50 %
Capacity	M3/hr	By Contractor
Material of Construction		
Casing/ Impeller		Duplex SS 2205 to UNS 31803 PREN > 38
Shaft		Duplex SS ASTM A 890 CD 4M CU
RPM		1500
Automatic self-cleaning filters		
Quantity	Nos	3 x 50 %
Capacity	M3/hr	By Contractor
MOC of mesh		SS 316L, 500 microns
MOC of shell		MSRL/FRP
Electrolysers		
Quantity		As per system requirement
Capacity		As per system requirement
Design electrode life		> 5 years
Material of Construction		
Anode		Titanium as per ASTM B265 Grade II with MMO coating.
Cathode		Titanium as per ASTM B265 Grade II
Shell		PVC lined with FRP, To be designed to withstand 1.5 times of booster pumps shut off pressure.
MOC of gasket		Titanium impregnated with ebonite
Range of operation of plant		10 to 100%
Instruments - hypo storage tanks level transmitter, dosing flow transmitters, differential pressure transmitters, feed temperature transmitters, flow control valve for electro chlorination system, differential pressure transmitters for self-cleaning filters and hydrogen detection system.		To be considered.
Transformer - Rectifiers		One for each Electrolyser Unit



Description	Unit	Data
Hypo Storage Tanks		Two (2) Nos. Common for Cooling water system, Pretreatment plant, Potable water system, STP and other if any. One (1) near Intake Pump house for intake system
MOC		FRP
Hydrogen Sensors		To be provided
Hypo dosing pumps for Cooling Water System- Continuous dosing		
Quantity		3 x 50%
Capacity		As per system requirement
M.O.C of Casing, Impeller & Shaft		PP
RPM		1500
Hypo dosing pumps for Cooling Water System- Shock dosing		
Quantity		2 x 100 %
Capacity		As per system requirement
M.O.C of Casing, Impeller & Shaft		PP
RPM		1500
Hypo dosing pumps for Desalination plant		
Quantity		2 x 100 %
Capacity		As per system requirement
M.O.C of Casing, Impeller & Shaft		PP
RPM		1500
Hypo dosing pumps for Potable water system		
Quantity		2 x 100 %
Capacity		As per system requirement
M.O.C of Casing, Impeller & Shaft		PP
Hypo dosing tank for potable water		1 no, to store 24 hrs potable water disinfection requirement, FRP
Hypo dosing pumps for STP		
Quantity		2 x 100 %
Capacity		By Contractor
M.O.C of Casing, Impeller & Shaft		PP
Hypo dosing tank for STP		1 no, to store 24 hrs potable water disinfection requirement, FRP
Hypo Transfer pumps to Intake Pump house Tank		
Quantity		2 x 100 %
Capacity		as per system requirement
M.O.C of Casing, Impeller & Shaft		PP
RPM		1500
Hypo dosing pumps for Intake Water System - Continuous		
Quantity		3 x 50%
Capacity		As per system requirement
M.O.C of Casing, Impeller & Shaft		PP
RPM		1500
Hypo dosing pumps for Intake Water System – Shock		
Quantity		2 x 100%



Description	Unit	Data
Capacity		as per system requirement
M.O.C of Casing, Impeller & Shaft		PP
RPM		1500
Hypochlorite storage tank		
Quantity	nos	2 x 50%
Total Capacity		To store 24 hours of plant requirement
MOC		FRP
Hypochlorite storage tank- Intake pump house		
Quantity		1 x100%
Capacity		To store 24 hours of plant requirement
MOC		FRP
Dilute Hydrochloric Acid Storage Tank		
Quantity		1x100%
Capacity		20 KL or 30 days stock which ever is high
MOC		FRP
Hydrochloric acid Circulation pumps		
Quantity		2 x 100 %
Capacity		As per system requirement
M.O.C of Casing, Impeller & Shaft		PP
RPM		1500
Acid measuring tank		
Quantity	No.	1
Capacity		To store 120% of one cleaning requirement
MOC		FRP
H₂ Dilution air blowers		
Quantity		(1W+1S) for each Hypo storage tank
Capacity & Head		as per system requirement
M.O.C of Casing, Impeller & Shaft		SS 316
Type		Horizontal Centrifugal blowers
Transformer – Rectifiers		
Quantity		One dedicated for each Electrolyser Unit
Method of control		Thyristor
Output DC current		as per system requirement
Output DC voltage		As per system requirement
Cooling type		Air Cooled
Diffuser assemblies		
MOC		FRP/HDPE
		As per system requirement with a minimum of one diffuser set per CW pump chamber, one no. in stilling chamber.
Neutralization pit		1 no, to store and neutralize the cleaning effluents from electrolyzer units
Neutralization pit disposal pumps		2 x 100%, SS 316, horizontal centrifugal pumps
Effluent Treatment Plant		
Boiler Blow down water		



Description	Unit	Data
Sump		One per Boiler
Pump Type		Vertical Centrifugal
Capacity		To suit the system
Head		To suit the system
Quantity		1W+1S
MOC		CF8M/SS316
Floor wash		
Sump		One per Boiler. However as per layout, the quantity shall be increased by the Contractor.
Pump Type		Vertical Centrifugal
Capacity		To suit the system
Head		To suit the system
Quantity		1W+1S
MOC		CF8M/SS316
Coal Pile run off handling system		
Settling pond with overflow sump		Qty. - 2 x 100%, Capacity to be arrived based on maximum rainfall data
Coal pile run off pumps type		Vertical Centrifugal
Capacity		Capacity to be arrived based on maximum rainfall data
Head		To suit the system
Quantity		1W+1S
MOC		CF8M/SS316
Oily waste water–TG Area		
Oily waste water sump		Qty. – 1no. Capacity – to suit system requirement.
Pump Type		Screw Pumps
Capacity		To suit the system
Head		To suit the system
Quantity		1W+1S per unit
MOC		CI as per IS: 210 FG 260
Rotor		Stainless Steel 316
Shaft		Stainless Steel 316
Shaft sealing		Mechanical Seal
Casing & Rotor housing Material		CI as per IS: 210 Gr. 260
Driving gear		Hardened and tempered alloy steel with machine cut teeth and ground finish.
Oily waste water–Fuel oil Area		
Oily waste water sump		Qty. – 1no. Capacity – to suit system requirement.
Pump Type		Screw Pumps
Capacity		To suit the system
Head		To suit the system
Quantity		1W+1S per unit
MOC		CI as per IS: 210 FG 260
Rotor		Stainless Steel 316
Shaft		Stainless Steel 316
Shaft sealing		Mechanical Seal
Casing & Rotor housing Material		CI as per IS: 210 Gr. 260
Driving gear		Hardened and tempered alloy steel with machine cut teeth and ground finish.



Description	Unit	Data
Oily water Collection tank		One
Capacity	m ³	50
Oil water Separator Feed pump		
Pump Type		Screw Pumps
Capacity		To suit the system
Head		To suit the system
Quantity		1W+1S
MOC		CI casing with SS 316 Rotor & shaft
Oil water separator		
Type		API/TPI type
Quantity		1
Capacity		To suit the system
Slop oil tank		2 nos, 1000 litres min capacity each, GRP
ETP Common Collection tank		One
Capacity	m ³	Capacity to be arrived considering coal pile runoff water during maximum rainfall period and boiler area floor wash waste.
Clarifier Feed pumps		
Pump Type		Horizontal Centrifugal
Capacity		Capacity to be arrived considering coal pile runoff water during maximum rainfall period and boiler area floor wash waste.
Head		To suit the system
Quantity		1W+1S
MOC		CF8M/SS316
RPM		1500
Clarifier		
Type		Plate Type Lamella Clarifier
Quantity		One
Capacity		Suitable to treat the effluent generated from 2 x 660 MW units.
Coagulant/Coagulant aid Dosing System		2 x 100% dosing pumps, MOC –PP 2 nos of dosing tank shall be provided for each dosing system with 12 hrs storage capacity each along with SS 316 agitators, level gauges, level switches, fume absorbers, overflow and drain lines
Central Monitoring basin		
Quantity		One
Compartments		Two
Total Effective Capacity		One day storage
MOC		RCC
Treated water transfer pumps		
Pump Type		Horizontal Centrifugal
Capacity		Capacity to be arrived considering coal pile runoff water during maximum rainfall period and boiler area floor wash waste.
Head		To suit the system
Quantity		1W+1S



Description	Unit	Data
MOC		CF8M/SS316
Sewage Treatment Plant (2 x 660 MW)		
Capacity		Shall be Designed considering 0.5 person per MW and 45 litres per capita per day + Sewage effluent from Port of 10 m3/day.
Treated water		Shall meet the requirements of TNPCB and will be used for Gardening
Bar screen chamber		To be provided.
Oil and grease removal chamber		To be provided
Common sewage collection sump		
Quantity	No	1
Capacity		To hold 10 hours generation
Material of construction		RCC
STP feed pumps		
Quantity	No	2 x 100%
Type		Submersible / horizontal centrifugal pumps
MOC		CI with SS impellers
Capacity and head		To suit system requirement.
Aeration tank		
Quantity	No	1
Material of construction		RCC
Tube settler		
Quantity	No	1
Capacity		To suit system requirement
Material of construction.		RCC
Hypo dosing system		
Dosing tank		1 no, MOC – HDPE
Dosing pumps		2 x 100% , MOC - PP
Clarified water tank		
Quantity	No	1
Storage		4 hours
Material of construction		RCC
Filter feed pumps		
Quantity	No	2 x 100%
Type		horizontal centrifugal pumps
MOC		CI with SS impellers
Capacity and head		To suit system requirement.
Pressure sand filters		
Quantity	No	1
MOC		MSEP
Activated carbon filters		
Quantity	No	1
MOC		MSEP
Treated water collection tank		
Quantity	No	1
Capacity		4 hours storage
Material of construction		RCC
Treated water transfer pumps		2nos. capacity – as per system requirement
Note: All the capacities specified for tanks are effective volume.		



VOLUME II
SUB-SECTION - 2.15
FIRE PROTECTION SYSTEM

1.0.0 GENERAL

This section covers minimum requirements for design, engineering, fabrication, manufacture & assembly, inspection, erection, testing and commissioning of the fire protection system.

2.0.0 SCOPE OF SUPPLY

The scope of supply shall include, but not limited to, the following:

- Fire water pumping system combined for Hydrant system and MVWS system – The fire hydrant and MVW spray system shall have a dedicated adequate number of electrical motor driven main fire water pumps (minimum 3 Nos.) and 50% standby diesel engine driven pumps (minimum 2 Nos.).
- Fire water pumping system for HVW Spray system – The spray system shall be provided with dedicated pumping system comprising of adequate number of electric motor driven pumps and 100% standby diesel engine driven pumps.
- The common pressurization unit shall be provided for hydrant and spray water system network. Pressurization unit shall consist of Two (2) nos. of electric motor driven fire water jockey pumps (one working + one standby), One (1) no. hydro-pneumatic tank and Two (2) nos. air compressors (one working + one standby) of adequate rating for pressurization of hydro-pneumatic tank shall be provided.
- Fire water booster pumping system - Dedicated fire water booster pumps comprising of adequate number of electric motor driven main pumps and 100% diesel engine driven standby pumps shall be provided for higher elevation of boiler units/transfer towers/bunker floors.
- The seawater intake pump house shall be provided with one (1) no of Diesel Engine driven vertical turbine pump of capacity 410 m³/hr for supplying fire water to the coal stockpile area ring main header for fighting large coal stockpile fire. The material of construction for the pumps, piping and isolation gate valves (Duplex stainless steel) shall be rated for seawater duty. The sea water fire water pump outlet shall be connected to the main fire hydrant network near the coal stockpile through a normally closed isolation (Duplex stainless steel) gate valve.
- Hydrant system shall be provided for all the buildings, equipments and entire area of inside the power plant boundary including Boiler and ESP Areas, Mill Reject Handling System compressor house, ESP Control Building, Fly ash equipment building, HFO & HSD Pump House Area, HFO & HSD storage tanks and dyke area, Compressor House, Diesel Generator Area, Generator, Station, Unit transformers and all auxiliary Transformers, CW Pump House, Electrochlorination building (CW), Water Pretreatment Plant, Sludge Pump House, Filtered Water Reservoir and Pump House, Sea Water Intake Pump House, DM Plant with acid and alkali bulk storage tanks, Chemical House, Coal Handling Plant and Coal Storage Yards including all transfer points, bunker bay conveyors, sub-stations and control room, office building (Coal handling shall include complete ECHS & ICHS) Crusher House, Coal Handling Control Building, Ash Handling Plant Area including Ash Slurry Pump House, Ash Water Pump House, FA Conveying Blower Room, MCC rooms, All storage areas including O & M Store, Effluent treatment Plant, Open Storage Yard, Transformer Yard, GIS Switchyard & Grid Control Room Building, Service Building, Administrative building, CPU Regeneration building, All gate

houses, Canteen, Workshop, Chimney area, Diesel filling station, Fire water pump house, Cooling Tower Area, Fire Station, Ash silo area and any other building equipments inside power plant boundary.

- High Velocity Water Spray System (HVWS) for Generator transformers, Unit Auxiliary Transformers, Unit Transformers, Station Auxiliary Transformers, Standby/ Maintenance transformers, Bus reactors, CHP auxiliary transformers, AHP auxiliary transformers and Station transformers (All oil filled transformer of rating 10 MVA and above), turbine oil canal pipe lines in main plant, Boiler feed pumps lube oil tanks, coolers, consoles etc, Boiler burner front, main lube oil tank, clean and dirty lube oil tanks, and Generator seal oil system tanks and its coolers.
- Water spray system for steam turbine bearing housing and air pre-heaters or any other fire protection system as recommended by equipment supplier.
- Nitrogen injection based fire protection system in addition to automatic high velocity spray system shall be provided for transformers of 220Kv or higher voltage.
- Medium Velocity Water spray system – Cable gallery/Cable spreader rooms in the whole plant such as main plant area, ESP, AHP, CHP, WTP, CW, Sea water intake, FOPH and Switchyard control building etc, All Coal conveyor gallery in tunnels/underground and above ground, Transfer points, Junction tower and crusher house entire coal handling system of inside the plant boundary, Fuel oil pump house (Unloading and Forwarding pump house), Fuel oil storage tanks and Emergency DG building.
- Foam system shall comprises of SS foam tank, foam pumps foam inductors, balance proportioners, foam makers with discharge outlets, associated interconnection (SS and GI) piping, valves, fittings, instrumentation etc. for Fuel oil storage tanks.
- Portable and mobile fire extinguishers for entire plant buildings, equipment area, entire area.
- Fire tenders (One no. water type fire tender and One no. foam tender) with all equipments as per TAC norms with bay to station all fire vehicles.
- Two (2 nos.) numbers of fully equipped ambulance (Ventilators, oxygen cylinder, first aid kit, etc.) with all fittings and Fire Jeep.
- Fire tenders, Ambulance and Fire Jeep, All the vehicles (5 Nos.) shall be registered, permit and tax paid before handing over to TANGEDCO with name transfer.
- Clean agent (Automatic inert gas) gas flooding system for Central Control Room, Control Equipment Room, Computer Room and UPS & inverters Room in the TG building.
- Fire Detection and Alarm system for all Central Control rooms, Control Equipment Room, battery rooms, all switchgear rooms / MCC rooms, Computer rooms, Cable spreader rooms in whole plant such as main plant area, ESP, AHP, CHP, WTP, CW, Sea water intake, FOPH and Switchyard control building etc, Detection system for various equipments and in other auxiliary buildings cable spreader, MCC room and Control room.
- All necessary instruction and warning plates.
- All necessary facemasks, fire jackets, breathing and resuscitation apparatus and/or other protection devices for optimal protection of the personnel of fire station equipments. Fire service station with all equipments as per TAC norms with bay to station all fire vehicles
- Passive fire protection measures such as fire barriers for cable galleries and shafts etc., fire retardant coatings, fire resistant penetration sealing for all openings in floors, ceilings, walls etc., fire proof doors etc., shall be provided to prevent spreading and for containment of fire.



3.0.0 DESIGN REQUIREMENTS

The Power Plant is classified as Ordinary Hazard Occupancy as per TAC. The design and installation of complete fire protection system shall comply with regulations of Tariff Advisory Committee (TAC) of India. In the absence of TAC regulations, the National Fire Protection Association (NFPA) standard shall be adopted. All equipment, special purpose fittings, couplings or accessories shall be approved and certified for use in fire protection system application by TAC/UL/FM.

Fire water reservoir

The source of water required for hydrant and spray system shall be from the reserve storage provided in the desalination water storage tank. The tank shall have two equal compartments and both the compartments shall be connected to a common suction header of fire water pumps so that any fire pump can be fed by either fire water storage compartment as per TAC regulations. At least two (2) headers shall be taken out of pump house for making loops around various risks. Each loop shall be interconnected for better reliability of the system. To isolate the system due to damage/repair, suitable nos. of gate valves should be provided.

Pump house equipments

Dedicated fire water pumps shall be provided for the fire hydrant and spray system. Blind flange with valve connection for future expansion to be provided in the fire hydrant and spray system network. The fire water pump capacity and head will be designed as per the system requirement/TAC recommendation. The adequate number of fire water pumps (No. of Pumps, pump capacity and head will be firmed up during the detail engineering) shall be provided.

The fire hydrant and MVW spray system shall have a dedicated electrical motor driven main fire water pumps (minimum 3 Nos.) and 50% standby diesel engine driven pumps (minimum 2 Nos.).

Separate fire water pumping system with electric motor driven spray pumps and 100% standby diesel engine driven pumps shall be provided for HVWS system. The electrical power supply scheme for the motor driven fire pumps shall be in line with the TAC requirements.

All standby diesel engine driven pumps shall be provided with 2 x 100% Battery chargers and Batteries.

The fire water pumping system equipments are located in the comprehensive pump house, adjacent to the desalination water storage tank.

The common pressurization unit shall be provided for hydrant and spray water system network. Pressurization unit shall consist of Two (2) nos. of electric motor driven fire water jockey pumps (one working + one standby), One (1) no. hydro-pneumatic tank and Two (2) nos. air compressors (one working + one standby) of adequate rating (Initial filling of compressed air shall be provided within 2 hours) for pressurization of hydro-pneumatic tank shall be provided.

Interconnection between hydrant and spray system headers shall be provided by means of providing a normally closed isolation valve and non-return valve which permits flow from hydrant system to spray system and not vice versa.

Dedicated fire water booster pumps comprising adequate number of electric motor driven main pumps and 100% diesel engine driven standby pumps shall be provided for higher elevation of boiler units/transfer towers/bunker floors. The pumps and the drivers shall be complete with all accessories and appurtenances.

Above-ground piping shall be duly painted and complete with all fittings, isolation gate valves, check valves, globe valves, vent valves, drain valves and instrument isolation valves including check valve, etc. as required for the completeness of the system.



Pumps shall have continuously rising head characteristic curve towards shut-off with the highest head at shut off. Pumps shall be suitable for parallel operation. Pumps shall have non-overloading characteristics to avoid motor overload.

Pumps shall be capable of furnishing not less than 150% of rated capacity at a head of not less than 65% of rated head. The shut off head shall not exceed 120% of rated head for horizontal centrifugal pumps and 140% of rated head for vertical pumps.

The rating of electric motor shall be selected to provide the power required to drive the pump at 150% of its rated discharge. The rating and design of motors and switchgears shall conform to the relevant Indian Standards Specification. The motor shall be of continuous rating type and its rating shall be at least equivalent to the horsepower required to drive the pump at 150 % of its rated discharge.

The diesel engine drive of fire pump shall be rated at 120% of power required at duty point or at least equal to the power required by pump at 150% discharge at 65% head, whichever is higher after necessary correction for altitude and ambient temperature. The engine driven fire pumps shall be provided with redundant starting batteries.

Hydrant system

Hydrant system shall consist of a fire water ring main network of piping along with Isolation gate valves installed above ground (on RCC pedestals) around areas to be protected, hydrant valves (external / internal), hoses (15M/7.5M long hoses), hose cabinets, couplings, branch pipe, nozzles and water monitors along with all accessories. All accessories such as MS painted hose boxes etc. shall be provided as per TAC. External hydrants 'Hose houses or hose boxes' shall be located all around the periphery of buildings and internal hydrants 'Hose boxes' shall be provided at each landing floor of staircases through above ground main. Outdoor type fixed water monitors shall be provided for ESP areas, Boiler house, tall buildings, Coal stock pile area, bunker building, junction towers/transfer towers and other areas in the coal conveyors at locations where water cannot reach from hydrant system. When height of structure, tower exceeds 15M, the concerned hydrants shall be replaced by water monitors.

- The hydrant network shall be sized to ensure that about 3.5 kg/cm² pressures are available at the hydraulically remotest point (As per TAC) in the system with the hydrant pump discharging at rated head and capacity.
- The velocity in the hydrant main shall not exceed 5.0 m/s.
- At least two hydrant ring mains shall be provided with separate ring main for the main plant.
- Spacing of each outdoor hydrants shall be provided 45Mts.distance. The Internal hydrant/Landing valves shall be provided 45M distance in case of TG Hall, Mill Bay, Boiler and other area 30M distance in each floor space.
- Hydrants shall not be located less than 2M from building. No building shall be deemed to be protected by a hydrant unless such hydrant is within 15M of the building.
- Each of the landing valves and external hydrant valves associated with the main plant (Transformer yard, TG building and Boiler area) areas be provided with a hose box.
- Each ring mains be terminated with an isolation valve and a blind flange at all the corners to enable future expansion/modification by the client.
- Fire water booster system pump head shall be designed for internal hydrant of the farthest top most floor (boiler drum) of the boiler and pressure will be tested at that elevation.
- Fire brigade connection shall be provided.
- All the landings of boiler staircases, turbine buildings and other multi-storied structures, Coal handling plant transfer points/junction towers, crusher house, bunker floors and other Auxiliary buildings/non-plant buildings shall be provided with landing valves with hose box including the hose reels.

**High velocity water spray system**

HVWS system shall be designed as per TAC regulations. HVWS shall consist of above ground piping, along with relevant fittings, Deluge valves, Strainers, isolation gate valves, spray nozzles, quartzoid bulb detector and pressure switches. HVWS system shall automatically detect, control and extinguish any out-break or fire and simultaneously give audible alarm. This shall hydraulically open the deluge valve thus allowing water to be sprayed on to the equipment/area through projector nozzles in the form of a solid conical emulsifying spray. Local audible alarm shall be produced by water motor alarm gong. The operation of the Deluge Valve shall be annunciated in the Local Zonal Fire Alarm Panel as well as in the Central Fire Detection and Alarm Panel. The system shall also have a manual over riding facility along with regular testing facility.

Isolation gate valve and y-type strainer shall be provided on upstream and downstream side of deluge valve. Fast acting butterfly valves shall be provided as a bypass to deluge valve, so that this valve can be kept closed and can be operated manually, if there is any malfunction of deluge valves.

The density of spray for various high velocity water spray system shall be as follows:

Area/ Equipment	Spray density for each area	Applicable code
Generator transformers, Unit Auxiliary Transformers, Unit Transformers, Station Auxiliary Transformers, Standby/ Maintenance transformers, Bus reactors, CHP auxiliary transformers, AHP auxiliary transformers, Station transformers and All other oil filled transformer of rating 10 MVA and above, turbine oil canal pipe lines in main plant, Boiler feed pumps lube oil tanks, coolers, consoles etc, Boiler burner front, main lube oil tank, clean and dirty lube oil tanks, and Generator seal oil system tanks and its coolers.	10.2 lpm/m ²	TAC

- The pressure at the hydraulically most remote projector in the network shall not be less than 3.5 bars for outdoor transformers as per TAC manual.
- Boiler burner front detection and spray distribution pipe shall be flanged connection with no leakage including with all accessories.
- A pressure switch shall be provided at the down streamside of the deluge valve for remote annunciation of "Deluge Valve Open" alarm in the main Fire Alarm panel in central Control Room. Another pressure switch shall be provided in the detection line of the system for remote annunciation of "Detection circuit operated" alarm in the main Fire Alarm panel in central Control Room.
- Placing of spray nozzles shall be such that their spray cones overlap each other.

Medium velocity water spray system

MVWS system shall be designed as per TAC regulations. The medium velocity spray system shall consist of a network of open spray nozzles fitted with a special deflector to give required angle of discharge for the water around the area to be provided. The sprayers shall discharge a cone of water spray consisting of medium size droplets of water. The water supply to the MVWS system shall be controlled by a deluge valve which shall operate electrically actuated solenoid valve on release of water pressure.

Local audible alarm shall be produced by water motor alarm gong. The operation of the Deluge Valve shall be annunciated in the Local Zonal Fire Alarm Panel as well as in the Central Fire Detection and Alarm Panel. The system shall also have a manual over riding facility along with regular testing facility.



In order to avoid total flooding of the entire area of cable gallery / coal conveyor system, the area to be protected by MVWS system shall be divided into number of zones. Each zone shall have separate water supply network controlled by a deluge valve. A fire detection system provided for the MVWS protected area shall sense fire and shall actuate the deluge valve. In the event of fire in one zone, the deluge valve of corresponding zone and those of adjacent zones on either side shall be opened.

The cable galleries shall have number of rows of cable trays and each row will have number of tiers of cable trays. Each of the cable rows shall be provided with a network of water distribution piping and nozzles. The distribution network shall consist of distribution header for each row of cable tray and on these headers drop pipes shall be provided so as to cover all the tiers. Fire in the cable gallery/cable spreader room, addressable multi-sensor detector supplemented with linear heat sensing cable of digital type shall be used for detection of fire. Upon detection of fire MVW spray system shall be brought into operation by automatically opening of deluge valve, which shall allow the projectors located in that areas to direct water in the form of spray, which will cut off oxygen supply and extinguish the fire.

The MVWS system for coal conveyors shall be provided for both top and return conveyors. Junction towers/Transfer towers, Crusher house, and all other area shall also be covered. Fire in the coal conveyor will be detected by the linear heat sensing cables and infrared ember detectors which shall provide signal for electrical actuation of deluge valve. MVWS system spray nozzles shall be provided in row centre of the conveyor belt for top conveyor (The sprayers shall be installed in rows at the ceiling level above the centre of each conveyor belt and spaced at not more than 4M) and on either side of the conveyor at 4m intervals. Staggering of sprayers is recommended for bottom conveyors. Conveyor walk way shall not be affected by MVWS system pipe routing.

The MVWS system for fuel oil pump house and EDG building shall be designed considering the pump house as a single zone. A network of pipes with spray nozzles shall be located near the roof of the pump house which shall be connected to a deluge valve. The fire in the fuel oil pump house and EDG building shall be detected by a detection system comprising of quartzoid bulb detectors which shall actuate the deluge valve.

Isolation gate valve and y-type strainer shall be provided on upstream and downstream side of deluge valve. Fast acting butterfly valves shall be provided as a bypass to deluge valve, so that this valve can be kept closed and can be operated manually, if there is any malfunction of deluge valves.

Probe type heat detectors shall be used for detection of fire in the fuel oil storage tanks.

- For MVW spray system of cable galleries, the density of spray shall be 12.2 lpm/m² of the surface area as per TAC rules for spray system. The pressure at the hydraulically most remote projector in the network shall not be less than 2.8 bar.
- For MVW spray system of coal conveyors, the density of spray shall be 10.2 lpm/m² of the surface area as per TAC manual. The minimum pressure of 1.4 bars shall be achieved at the hydraulically remotest sprayer. However pressure at the hydraulically favorable sprayer shall not exceed 3.5 bars.
- For MVW spray system of fuel oil pump house and Emergency DG set building the density of spray shall be 10.2 lpm/m² of the surface area as per TAC rules for spray system. The pressure at the hydraulically most remote projector in the network shall not be less than 1.4 bar and 2.8 bar.
- For MVW spray system of fuel oil storage tank, the density of spray shall be 3 lpm/m² of the surface area same as adopted for fuel oil storage tank.
- Placing of spray nozzles shall be such that their spray cones overlap each other.
- A pressure switch will be provided at the down streamside of the deluge valve for remote annunciation of "Deluge Valve Open" alarm in the main Fire Alarm panel in central Control Room. Another pressure switch will be provided in the detection line of the system



for remote annunciation of “Detection circuit operated” alarm in the main Fire Alarm panel in central Control Room.

- The MVWS system shall be connected with fire hydrant line and tapping shall be provided wherever required from the fire water hydrant and MVWS system ring main network.

Fixed Foam System

Fixed foam system is provided for fuel oil storage tanks. The water for the foam system shall be tapped from the Hydrant system. The system will consist of at least two nos. of AFFF foam concentrate tank (2 x 100% capacity of SS foam tank), foam pumps, foam inductors, balance proportioners, foam makers with discharge outlets, associated interconnection (SS and GI) piping, valves, fittings, instrumentation etc. It will be discharged to the foam inductors through 2x100% capacity foam (One (1) Motor driven and One (1) diesel engine driven) pumps through balancing line, with control valves, flow controllers etc. along with deluge valves, strainers and isolating valves fixed piping valves and other accessories, etc.

- The system shall be designed for a foam application rate of 4.1 LPM per sq. meter. The duration of discharge shall be 30 minutes as per NFPA-11.
- The type of fire detection for the fuel oil tank will be tank mounted minimum 2 nos. of probe type heat detector with different temperature setting for fuel oil storage tanks.
- The foam concentrate pipe line pipe and fitting shall be SS material and all other pipes (foam water pipes) shall be GI pipes.

Automatic Clean Agent Fire Suppression System

The system shall be manufactured, designed, installed & commissioned in conformance with the stipulations of NFPA-2001.

At least 2 x 100% capacity Inert Gas cylinder batteries with each slave cylinder complete with non-return valve and control valve and each master cylinder having a pilot solenoid valve. Frame work support for cylinders for each area, Discharge manifolds, hoses, nozzles, and pneumatic horn for each area. Seamless pipe work, discharge nozzles, along with evacuation & gas release alarms and Warning sign boards shall be provided. Discharge nozzles will be provided on the gas distribution pipe network will be connected to a gas manifold, through a manually operated valve. The manifold will be connected to a group of inert gas cylinders.

Portable & Mobile Fire Extinguishers

Portable CO₂, Dry Chemical Powder, Foam type extinguishers and stored pressure type fire extinguisher (ABC fire) as per TAC requirements shall be provided. Stored pressure type fire extinguisher (ABC fire) 5 kg, Carbon Di-Oxide Type Portable Fire Extinguishers 9 kg, Dry Chemical Powder Type Portable Fire Extinguishers 10 kg, 22.5 kg carbon di-oxide type, trolley wheel mounted unit one each and Chemical powder type, trolley wheel mounted unit one each for TG control room, Switch yard control room, ESP control room and Fire station shall be provided. 50Lts foam type, trolley wheel mounted unit for TG building lube oil tank area, Fuel oil Pumping area, Fuel oil storage tank area and Transformer area shall be provided.

Fire Tenders

The chassis for carrying out fabrication work of fire water/foam tender shall be of Make TATA1109/TATA 2518 or Ashok Leyland Taurus/Beaver or Volvo. The chassis shall be equipped with power assisted steering. It shall carry an extension ladder of 10.5M length including with hydraulic platform to operate the water monitor and shall be capable of towing a trailer pump.

Water tender

One (1) number of water type fire tender consist of 4500Lts. capacity water tank with rear mounted multistage high pressure pump, DCP and CO₂ extinguishers including all accessories shall be fabricated as per IS:950.

**Foam tender**

One (1) number of foam fire tender consist of 3000Lts. capacity water tank, 500 Lts. Capacity foam tank with rear mounted multistage high pressure pump, DCP and CO₂ extinguishers including all accessories shall be fabricated as per IS:951/87 and IS:10460.

Electrical

HT and LT Motors, MCC, Cabling system complete with cable trays, supports, conduits, glands, lugs etc (for the cables of all the motors, push button stations, MCC/ Control panel, Auxiliaries etc including HT motors). Earthing system, Rubber mats, First aid box, Danger plate and any other electrical equipment and accessories required to complete fire protection system.

Control and operation philosophy**Fire water pumping system**

The fire water ring main network shall be a pressurised system provided with automatic starting of fire water pumps. The mode of operation of fire water pumping system shall be as follows:

Hydrant and MVWS System

The hydrant and MVWS system shall be a pressurised system provided with automatic starting of fire water pumps. The mode of operation of hydrant system shall be as follows:

- a) In the event of fire when hydrant valves and MVWS system deluge valves are opened, the pressure in the header will drop due to the resulting flow and at a preset low pressure in the header, the electric motor driven pumps shall start automatically by getting an impulse from a pressure transmitters mounted on the header.
- b) In case the electric motor driven pump fails to start, the pressure in the mains will drop further and sequentially start the other electric motor driven pumps. There will be a provision to start the pump manually in case of emergency.
- c) In case the electric motor driven pump fails to start, the pressure in the mains will drop further and sequentially start the standby diesel engine driven pumps shall come into operation by getting in impulse from a pressure switch provided at a preset low pressure. There will be a provision to start the pump manually in case of emergency.
- d) Stopping of all the above pumps shall be manual.
- e) Jockey pumps shall not be running when main pumps are in operation.

HWV Spray System

The mode of operation of hydrant system shall be as follows:

- a) On detection of fire the deluge valve is opened and water will be released from the projectors. This will cause a drop in pressure in the HVWS mains due to the resulting flow through the deluge valve. At a pre-set low pressure in the header, the motor driven pump shall start automatically by getting in impulse from a pressure transmitters provided on the header. A manual emergency release is also provided for manual local operation. Remote / manual operation will be possible from the deluge valve local control panel.
- b) In case the electric motor driven pump fails to start automatically pressure in the mains will drop further and the diesel engine driven pump shall come into operation by getting an impulse from pressure transmitter provided at a preset low pressure.
- c) Stopping of all the above pumps shall be manual.



- d) Jockey pumps shall not be running when main pumps are in operation.

Pressurization System

The mode of operation of the pressurization system shall be as follows:

- a) This system shall keep the hydrant system under pressurised state under all conditions.
- b) The pressurisation in the hydro-pneumatic tank is achieved by means of two air compressors. Two (2) nos. jockey pumps will assure that the volume of water inside the hydro-pneumatic tank will be refilled after reaching the minimum level.
- c) Small system leakages are met by make up water supply from hydro-pneumatic tank and electric driven jockey pump located in the firewater pump house. When the water level in the hydro-pneumatic tank falls to a predetermined low level the jockey pump starts automatically through an impulse from a level switch and pumps water to the hydro-pneumatic tank. The jockey pump will stop when predetermined high level is reached in the tank through an impulse from a level switch. However compressor shall start only when the water level has reached a high set point and the pressure in the tank falls below the determined set point and stops when the pressure in the tank reaches the determined set point sensed through a pressure switch. While deciding the settings it will be ensured that the jockey pump and compressor do not start simultaneously. The jockey pump and compressors are capable of both start and stop in either auto or manual modes.

Booster Fire Water Pumping System

The Booster Fire Water Pumping system will operate as follows:

- a) In the event of fire when hydrant valves of boiler upper elevations are opened, the pressure in the header will drop due to the resulting flow and at a preset low pressure in the header, the electric motor driven pump will start automatically by getting an impulse from a pressure switch mounted on the header on the down steam / discharge end of booster pumps.
- b) In case the electric motor driven pump fails to start, the pressure in the mains will drop further and sequentially start diesel engine driven pump. There will be a provision to start the pump manually in case of emergency.
- c) Stopping of all the above pumps will be manual.

Fixed foam system

Fixed foam extinguishing system shall be provided for the HFO/HSD storage tanks. The probe type heat detectors provided for the fuel oil system shall be part of the fire alarm addressable analog loop of MFAP. On receiving the signal from the probe type heat detector, MFAP will send a signal to the local control panel of foam pump and deluge valve, which will electrically actuate the foam system. A manual emergency release is also provided for manual local operation.

Control and instrumentation

The system will be designed for automatic operation. Control and operations are realized in the main plant DCS with all necessary interlocks for starting the fire water pumps in sequence.

All the fire protection equipments that includes the electric motor driven main fire pump sets, standby diesel engine driven fire pump and associated systems are interfaced with the DCS through the DCS remote I/O panel located at fire water pump house.



Fire water pump house shall be provided with One(1) no. 24" LCD TFT type Operator station for control and monitoring the FPS locally in addition to remote monitoring from the central control room in the main plant DCS.

In addition to the above, the control cum annunciation panel shall be provided with Auto/manual selection in fire water pump house. Control cum annunciation panel shall be connected to the MFAP for monitoring. Local control panel of booster fire pumps and foam pumps shall be connected to MFAP for monitoring

In case of power failure, the control system remains operative by being connected to the UPS system. It shall assure that the plant shall be shutdown according to the safety requirements.

Local Control Panels for all deluge valves shall be provided. Local control panels shall be provided for each diesel engine driven pumps and fire water booster pumps in the respective pump house. All the pump status annunciation in this panel/operator station shall be repeated to the Main Fire Alarm Panel in the Central Control Room.

Fire Detection and Alarm System

Two (2) nos Main Fire alarm panel (MFAP). One (1) shall be located in the main plant central control room and one in coal handling plant control room. The MFAP shall be Microprocessor based analogue addressable type complete with power supply, LCD colour monitoring display unit, matrix key pad, all input, output & control modules, 24 V sealed maintenance free battery & battery charger, built-in hooters etc.

One (1) no Repeater Fire alarm panel (RFAP) shall be located in Fire Station. The RFAP shall be microprocessor based analog addressable type complete with power supply, LCD display, matrix key pad, all input, output & control modules, 24 V sealed maintenance free battery & battery charger, built-in hooters etc.

One (1) no of Repeater Fire alarm panel (RFAP) shall be provided in the Switch Yard Control Building.

All interface cabling between fire alarm system and DCS system for HVAC equipment interlocks shall be complete with double compression glands, lugs, ferrules, markers etc.

Control Units, Heat detectors, Quartzoid bulb detectors, Operation work station, Addressable analogue photo electric smoke detectors, addressable analogue fixed temperature cum rate of rise heat detectors, indoor and outdoor manual call points hooters, response Indicators, addressable interface units, infra red detectors emergency exit and warning signs etc. shall be provided. Minimum one (1) no of siren (3 km range) complete with power supply and control unit including with all accessories. Loop cabling, interface modules etc. required for hooking up the system for annunciation in the main fire alarm panel and supply of all erection hardware shall be provided.

The type of detectors shall be provided in the following areas / equipments are given below:

Equipment to be protected	Type of Detection System Provided
Generator transformers, Unit Auxiliary Transformers, Unit Transformers, Station Auxiliary Transformers, Standby/ Maintenance transformers, Bus reactors, CHP auxiliary transformers, AHP auxiliary transformers, Station transformers and All other oil filled transformer of rating 10 MVA and above, turbine oil canal pipe lines in main plant, Boiler feed pumps lube oil tanks, coolers, consoles etc, Boiler burner front, main lube oil tank,	Water filled quartzoid bulb detectors and Manual call points.



Equipment to be protected	Type of Detection System Provided
clean and dirty lube oil tanks, and Generator seal oil system tanks and its coolers.	
All Cable galleries/cable spreader rooms/Cable vaults	Addressable multisensor smoke detectors and manual call points. Multisensor detector and digital LHS cable (LHS cables shall be provided in zigzag fashion (with an included angle of minimum 90 degree) each of the top tray, bottom tray and in every alternate tray) along with necessary number of interface units in the cable gallery will be cross zoned to actuate the water spray system.
All Switchgear rooms/MCC room, SWAS room, UPS room, Computer rooms, Engineers room, Air-conditioning equipment room, Control room, Control equipment room. Air washer room	Addressable multisensor detectors (Below the true ceiling, below the false ceiling and false floor as the case may be) and manual call points.
Battery and Battery charger room,	Addressable corrosion resistant rate of rise of temperature detector with fixed temperature element (Heat Detectors)
Fuel oil Storage tanks and dyke area	Minimum 2 nos. of probe type heat detector with different temperature setting and flame proof manual call points.
Auxiliary buildings/non-plant buildings	Addressable multisensor detectors (Below the true ceiling, below the false ceiling and false floor as the case may be) and manual call points.
Emergency Diesel Generator Building	Water filled quartzoid bulb detectors. Manual call point
Fuel oil pump house	Water filled quartzoid bulb detectors and Flame proof Manual call point
Coal conveyors	Linear heat sensor cables (Minimum 3 runs shall be provided one for top conveyor centre and (2 runs) each one run either side of the bottom conveyors), Minimum 3 nos Infra red type detectors for each coal conveyor: one each at a distance of 1-2 m from tail end and head end and one at the middle with Continuous air-blow system for cleaning of detectors and flame proof manual call points.
Entire Coal handling system area	Flame proof manual call points.
Hydrogen generation plant room	Gas detector and flame proof manual call points.
All Plant Buildings and entire plant area	Manual call points strategically located



4.0.0 CONSTRUCTION REQUIREMENTS

Two separate dedicated fire water ring main distribution network shall be provided for Hydrant, MVWS system and HVW Spray system as per TAC requirement

- All Hydrant, Spray and foam system pipe mains/pipes shall be routed aboveground on top of the concrete pedestals at regular intervals. In main plant area and coal (yard) stock pile area pipelines shall be routed in RCC pipe trenches filled with sand and covered with pre-cast RCC removable covers. Pipe trenches crossing through road or rail shall be through hume pipes.
- In case of requirement for modification in pipe routing during detailed engineering due to plant layout constraints, Contractor shall carry out such modifications at no extra cost to Purchaser.
- Fire water pipes shall be of Carbon Steel conforming to IS: 1239 (medium grade) and IS: 3589 (6.35mm thick).
- All aboveground piping shall be adequately supported by concrete pedestals at regular intervals.
- All buried pipes shall be double coated and wrapped as per IS: 10221 and/or IS: 15337.
- Over ground pipe normally empty but periodically charged shall be Galvanized pipes.
- The entire pipe network shall be hydraulically designed in such a way that the velocity of water in any section does not exceed 5.0 m/s at any segment of pipe network.
- All outdoor piping shall be buried such that the top of the pipe is atleast 1.0 M below the finished ground level.
- RCC hume pipes shall be provided as IS:458 NP class II for road crossings and NP class III for rail crossings.
- The yard piping shall be provided with strategically located sectionalising isolation gate valves to enable maintenance of defective pipeline and also to achieve maximum pressure at the remotest and highest hydrant at the time of fire as per TAC requirement.
- All fire hose connection branch pipe and couplings shall be of SS 304 construction and in accordance with IS: 903.
- The pipe work shall be provided with gate valves IS:14846 at suitable location to facilitate repairs or other necessary work on the system, all above ground valves shall be rising stem type. All above ground Gate valves, check valves and globe valves shall conform to IS:778.
- The hydrant valve shall be of SS 304 construction conforming to IS : 5290.
- The water monitors provided shall be of fixed type with Swiveling joints, SS 304 Nozzle and conforming to IS:8442.
- Deluge valve shall be quick release, hydraulically operated diaphragm actuated type of valve, set in closed position, by water pressure through external bypass check valve and restriction orifice from the inlet chamber to top chamber. The Deluge valve shall be of cast iron construction complete with all accessories.
- All the deluge valves shall be provided inside the deluge valve shed.
- Holiday test for wrapping and coating shall be provided.
- The medium/high velocity spray nozzle shall be of SS 304 construction.
- Hose cabinets shall be provided with 16 SWG thick body and 3 mm glass. The hose shall be provided with key box with break glass and pedestal where required. Fire hoses shall be of IS 636 type-A.

5.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED ALONG WITH THE PROPOSAL

- a) Master drawing/document list
- b) Time schedule for design, manufacture, delivery, erection, testing and commissioning.
- c) Duly filled-in technical data, bill of material and prices as per specified schedules.



- d) Technical write-up for the entire fire protection, detection and alarm system.
- e) Schedule for all type of fire protection, detection and alarm system for each type for various buildings, equipment and entire plant area.
- f) Flow diagram for fire water pumping system
- g) Flow diagram for fire water booster pumping system
- h) Flow diagram for foam pumping system
- i) Flow diagram for fire water from sea water make-up pumping system
- j) Schematic layout for hydrant system
- k) Schematic layout for spray system
- l) Flow diagram for foam system
- m) Schematic diagram for inert gas flooding system
- n) Schematic diagram for fire detection and alarm system
- o) Schedule of portable and mobile fire extinguishers
- p) Fire tender equipment details
- q) Ambulance equipment details
- r) Fire jeep equipment details
- s) Preliminary layout drawings for the complete scope of work
- t) Manufacturer's catalogue for Fire, Protection Detection and Alarm system.
- u) List of tests the Bidder proposes to carry out in shop and at site after installation including those pertaining to their sub-contractor.
- v) List of all tools, tackles and accessories required for maintenance of the offered equipment including bought out components.
- w) List of all recommended spare parts for all equipment offered including bought out components of the offered fire protection system.
- x) List of all mandatory spares for all the equipment as per TAC/technical specification
- y) Power consumption list and feeder list.

6.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED AFTER AWARD OF CONTRACT

- a) Final version of Master Drawing/document submission schedule
- b) Technical write-up for the entire fire protection, detection and alarm system.
- c) Schedule for all type of fire protection, detection and alarm system for each type for various buildings, equipment and entire plant area.



- d) P&ID for fire water pumping system
- e) P&ID for fire water booster pumping system
- f) P&ID for foam pumping system
- g) P&ID for fire water from sea water make-up pumping system
- h) P&ID for foam system
- i) Piping and equipment layout for fire water pump house
- j) Piping and equipment layout for fire water booster pump house
- k) Piping and equipment layout for fire water in sea water make pump house
- l) Piping and equipment layout for foam system pump house
- m) Foundation drawings with dead load as well as operating load and other data as required.
- n) GA drawings of the equipment, dimensional and sectional drawings of all equipment giving details of materials.
- o) Cross sectional drawings indicating the assembly of all the major equipment.
- p) Piping layout drawings and isometric drawings including pipe support drawings for all automatic high velocity / medium velocity spray / foam system.
- q) Hydraulic calculations for Hydrant system, high velocity spray system, medium velocity spray system and foam system.
- r) Composite layout for hydrant system
- s) Area wise fire water piping layout for hydrant and spray system
- t) Schematic diagram for inert gas flooding system
- u) Piping and equipment layout for inert gas flooding system
- v) Schematic diagram for fire detection and alarm system
- w) Fire detection and alarm system layout for each area
- x) GA and wiring diagrams for control cum annunciation panel, PLC panel, MFAP, RAP, local control panels etc.
- y) Instrument hook-up diagram for all type of instruments
- z) Protection and interlocking logics for Fire protection, detection & alarm system.
- aa) Portable fire extinguisher layout for the entire plant
- bb) Detailed and final drawing of fire tender equipment
- cc) Ambulance equipment details
- dd) Fire jeep equipment details



- ee) QAP for all manufactured and sub contracted items.
- ff) Comprehensive quality assurance plan.
- gg) Instruction manuals for the operation, maintenance, repair, replacement and spare parts ordering.
- hh) Training manual
- ii) Test procedures and details of test to be conducted.
- jj) Type and Routine Test certificates, material test certificates for major components.
- kk) Technical data sheet, GA drawing for motor
- ll) Power consumption list and feeder list.
- mm) Performance and characteristics curves for motor
- nn) As-built drawings for all equipment/systems supplied under this contract and all buildings / structures / works executed under this contract incorporating all changes/modifications upto the time of commissioning / handing over to the Owner/consultant.
- oo) Drawings/data to be required/submitted to statutory authorities
- pp) List of all tools, tackles and accessories required for maintenance of the offered equipment including bought out components.
- qq) List of all recommended spare parts for all equipment offered including bought out components of the offered fire protection system.
- rr) List of all mandatory spares for all the equipment as per TAC/technical specification



ANNEX 2.15.1

SPECIFIED DESIGN DATA

A. Fire Water Pumps for Hydrant System and Spray System

S.No.	Description	Electrical Motor Driven Pump	Diesel Engine Driven Pump	Jockey Pump
1.0	General Information			
1.1	Duty	Continuous	Continuous	Intermittent
1.2	Rated capacity (m ³ /hr.) / Nos.	By Contractor / (Minimum 3 nos. for Hydrant cum MVWS system and minimum 1 no for HVWS system)	By Contractor / (Minimum 2 nos. for Hydrant cum MVWS system and minimum 1 no for HVWS system)	By Contractor
1.3	Rated speed (RPM)	1500	1500	2900
1.4	Total head at discharge of the pump MWC	By Contractor	By Contractor	By Contractor
1.5	TAC Approved	Yes	Yes	Yes
1.6	Services	Hydrant and Spray System	Hydrant and Spray System	Common for Hydrant and Spray system
1.7	End connection	Side suction Side discharge	Side suction Side discharge	End suction
2.0	Material of Construction			
2.1	Casing	SS 304	SS 304	SS 304
2.2	Impeller	Stainless steel	Stainless steel	Stainless steel
2.3	Shaft	Stainless steel	Stainless steel	Stainless steel
2.4	Gland Packing	Graphite	Graphite	Graphite
2.5	Counter flange	Carbon Steel IS – 2062	Carbon Steel IS - 2062	Carbon Steel ASTM A 105
2.6	Base plate	Carbon Steel IS 2062	Carbon Steel IS 2062	Carbon Steel IS - 2062

B. Hydro-Pneumatic Tank

S.No.	Description	Hydro-pneumatic Tank
1	Type	Vertical cylindrical with dished end supported.
2	Capacity and Quantity	By Contractor and 1 No.
3	Code / Standard	IS : 2825
4	Working Pressure	By Contractor
5	Design Temperature	60 Degree.

C. Air compressor for Hydro-Pneumatic Tank

S.No.	Description	Air compressor
1	Type	Air Cooled Reciprocating Compressor
2	Quantity	2 Nos.
3	Application	For Hydro-pneumatic Tank Pressurisation
4	Free Air Delivery and Pressure rating	By Contractor

**D. Fire Water Booster Pumps**

S.No.	Description	Electrical Motor Driven Booster Pump	Diesel Engine Driven Booster Pump
1.0	General Information		
1.1	Duty	Continuous	Intermittent
1.2	Rated capacity (m ³ /hr.) / Nos.	As per system requirement / One (1)	As per system requirement / One (1)
1.3	Rated speed (RPM)	1500	1500
1.4	Total head at discharge of the pump MWC	As per system requirement	As per system requirement
1.5	TAC Approved	Yes	Yes
1.6	End connection	Side suction Side discharge	Side suction Side discharge
2.0	Material of Construction		
2.1	Casing	SS 304	SS 304
2.2	Impeller	Stainless steel	Stainless steel
2.3	Shaft	Stainless steel	Stainless steel
2.4	Seal	Mechanical seal	Mechanical seal
2.5	Gland Packing	Graphite	Graphite
2.6	Counter flange	Carbon Steel IS –2062	Carbon Steel IS -2062
2.7	Base plate	Carbon Steel IS 2062	Carbon Steel IS 2062

E. Foam Pumps

Sl. No.	Description	Electrical Motor Driven Foam Pump	Diesel Engine Driven Foam Pump
1.0	General Information		
1.1	Type	Gear	Gear
1.2	Service	Foam	Foam
1.3	Duty	Continuous	Intermittent
1.4	Location	In-door	In-door
1.5	End connection	Side suction Side discharge	Side suction Side discharge
1.6	Rated capacity (m ³ /hr.) / Nos.	By Contractor	By Contractor
1.7	Rated speed (RPM)	1500	1500
1.8	Total head at discharge flanged of the pump MWC	By Contractor	By Contractor
1.9	TAC Approved	Yes	Yes
2.0	Material of construction		
2.1	Casing	CF8M	CF8M
2.2	Rotor Gears	SS 316	SS 316
2.3	Rotor Shafts	SS 431	SS 431



Sl. No.	Description	Electrical Motor Driven Foam Pump	Diesel Engine Driven Foam Pump
2.4	End Covers	SS 316	SS 316
2.5	Stuffing Box Packing	Mechanical Seal	Mechanical Seal
2.6	Gland	SS316	SS316
2.7	Base Plate	M.S Fabricated	M.S Fabricated
2.8	Integral Relief Valve	SS 316	SS 316

F. Pipes and Fittings

Description	Data
Above Ground Piping (Normally Filled with Water)	
Pipe specification	IS : 1239 (part I) – Heavy class ERW MS Black pipes for sizes 150 NB and below.
	IS : 3589 – Grade 410 (wall thickness min – 6.35mm) ERW MS Black pipes for sizes above 150 NB
Pipe to pipe joint	Butt welded for size 65 mm NB & higher as per ANSI B16.9 and socket. welded for sizes upto 50 mm NB as per ANSI B16.11
Pipe to valve joint	Flanged and drilled to ANSI 150# B16.5 with neoprene gaskets between flanges for sizes 50NB & above. Screwed for sizes below 50NB.
Pipe fittings	IS 1239 (Part II) – heavy grade MS for sizes upto 150 NB Fabricated from parent material for sizes above 150 NB. Butt welded as per ANSI B 16.25 for sizes 65 NB and above and socket welded as per ANSI-B-16.11
Bolts, nuts & washers	Hot dip galvanised MS.
Corrosion protection	Refer relevant page of painting clause.
Above Ground Piping (Normally Empty)	
Pipe specification	IS : 1239 (Part I) – Heavy class galvanised ERW MS pipes.
Pipe to pipe joint	Screwed flange as required for sizes 65 mm NB & above and screwed socket for sizes 50 mm NB and below.
	Welding on GI Pipes shall not be carried out. All GI Pipe joint connections shall be threaded type only with sealant Teflon
Pipe to valve joints	Flanged for sizes 50NB & above, screwed for sizes below 50NB.
Pipe fittings	IS 1239 (Part II) Heavy grade galvanised MS Screwed flanged for sizes 65mm NB & above and screwed socketed as per ANSI B 16.11 or IS 1239, Part II for sizes 50 mm NB and below. All fittings and flanges for galvanized pipes shall be galvanized.
Bolts nuts & washers	Hot dip galvanised MS.
Pipe protection	Refer relevant page of painting clause.
Foam System	
Foam tank MOC	SS tank



Description	Data
Stainless steel seamless pipes upto 80NB	Stainless steel to ASTM A-312, TP-304, Sch.- 40s.
Fittings	Stainless Steel pipe fittings
15 NB to 40 NB	SS forged to ASTM A-182, F-304, 3000#
50 NB & above	SS Seamless to ASTM A-403, WP-304, Sch.- 40
SS flanges	Plate fabricated to ASTM A-240, TP-304
Gaskets	CAF as per IS:2712, Gr.W3.

G. Valves and Specialties

Cl.No.	Description	Specification Requirement
1.0	C.I Gate Valves	
1.1	Type	Rising spindle type
1.2	Sizes	50 NB to 600 NB
1.3	Rating	PN 1.6
1.4	End connection	Flanged and drilled to ANSI 150# B 16.5
1.5	Code / Standard	CI:IS 14846 rising spindle TAC approved
1.6	Material of construction	
	Body	CI IS : 210 Gr. FG 260
	Bonnet	CI IS : 210 Gr. FG 260
	Stem	Gun metal IS : 315 CTB2 or IS:320 HT2
1.7	Testing	As per IS : 14846
1.8	Test pressure	Body - 24 kg/cm ²
		Seat - 16 kg/cm ²
1.9	Approval	ISI marked/ TAC approved
2.0	Gun Metal Globe Valves	
2.1	Type	Rising spindle
2.2	Sizes	50 NB to 100 NB
2.3	Rating	PN 1.6
2.4	End connection	Flanged to B16.5
2.5	Code / Standard	IS : 778



Cl.No.	Description	Specification Requirement
2.6	Material of construction	
	Body	GM, IS:318 Gr.2, Casting
	Bonnet	GM, IS:318 Gr.2
	Disc	GM, IS:318 Gr.2, Guided
	Stem	HT brass, IS:320, OS & Y, Forged
	Hand wheel / lever	CI IS 210 Gr. 260
2.7	Testing	As per IS : 778
2.8	Test pressure	Body - 24 kg/cm ²
		Seat - 16 kg/cm ²
2.9	Approval	ISI marked / TAC approved
3.0	C-I Check Valves	
3.1	Type	Swinging disc type
3.2	Size	50 NB to 600 NB
3.3	Rating	PN 1.6
3.4	End connection	Flanged and drilled to ANSI 150# B 16.5
3.5	Code / Standard	As per latest BS / IS code.
3.6	Material of construction	
	Body	CI IS:210 Gr. FG 260
	Cover	CI IS:210 Gr. FG 260
	Disc	CI IS:210 Gr. FG 260
	Hinge pin	H.T brass IS : 320 HT-2
	Gasket	CAF IS 2712
3.7	Testing	As per latest BS / IS code.
3.8	Test pressure	Body : 24 kg/cm ²
		Seat : 16 kg/cm ²
3.9	Approval	ISI marked and TAC approved
4.0	Butterfly Valves	
4.1	Type	Wafer upto 300 NB, lug type upto 500 NB
4.1	Sizes	100 NB and above



Cl.No.	Description	Specification Requirement
4.3	Rating	PN 1.6
4.4	End connection	Flanged and drilled to ANSI 150# B 16.5
4.5	Code / Standard	IS: 13095
4.6	Material of construction	
	Body	SA 216 Gr. WCB, casting
	Shaft	SS 40, stub shaft
	Disc	SA 216 Gr. WCB, casting
	Hand wheel / lever	CS
4.7	Testing	AWWA-C 504
4.8	Test pressure	Body - 24 kg/cm ²
		Seat - 16 kg/cm ²
4.9	Approval	ISI marked / TAC approved
5.0	Hydrant Valve	
5.1	Type	Single / Double headed, female oblique type
5.2	Code / Standard	IS : 5290
5.3	End connection	
	Inlet	Flanged and drilled to ANSI 150# B 16.5
	Outlet	Female instantaneous coupling with spring lock type coupling with blank cap & chain.
5.4	Size	63 mm
5.5	Flow	Contractor to indicate
5.6	Testing	As per IS : 5290
5.7	Test pressure	Body - 21 kg/cm ²
		Seat - 14 kg/cm ²
5.10	Material of construction	
	Body	SS 304
	Female outlet	SS 304
	Stop valve	SS 304
	Blank cap	SS 304
	Bonnet	SS 304



Cl.No.	Description	Specification Requirement		
	Gland	SS 304		
	Hand wheel	CI IS 210 Gr. 260		
	Spring	Phosphor bronze to IS : 7608		
5.11	Approval	ISI marked / TAC approval		
6.0	Water Monitor			
6.1	Type	Horizontal and vertical swivel type		
6.2	Size	63mm / 75mm / 100mm		
6.3	Code / Standard	IS : 8442 Type-I		
6.4	Working pressure	9.0 kg/cm ²		
6.5	Design pressure	10.5 kg/cm ²		
6.6	Testing			
6.6.1	Test pressure	23 kg/cm ²		
6.6.2	Flow & throw test	63mm	75mm	100mm
	With water			
	Flow at 7 kg/cm ² (LPM)	1750	2580	3500
	Horizontal throw (m)	53	60	64
6.7	Discharge capacity at	63mm	75mm	100mm
	7 kg/cm ² pressure (LPM)	1750	2580	3500
6.8	Throw	63mm	75mm	100mm
	With water			
	Min. Horizontal (M)	53	60	64
	Min. Vertical (M)	Contractor to indicate		
6.9	Rotation	360°		
	Horizontal	Contractor to indicate		
	Vertical			
6.10	End connection	Flanged and drilled to ANSI 150# B 16.5		
6.11	Material construction			
	Water barrel	IS : 1239 (Part I)		
	Wire braided hose	PVC		



Cl.No.	Description	Specification Requirement
	Nozzle	SS 304
	Handle	MS to IS 2062
	Base flange	MS IS 2062. Drilled to ANSI 150# B 16.5
	Reducer & 90° Elbow	Seamless ANSI B 16.9 / IS:1239 (Part II) / IS 4310
	Swivel joints (horizontal & vertical)	SS 304
	(Horizontal / vertical) rotation lock	SS 304
	Grease nipple	SS 304
	Drain cock	SS 304
6.12	Approval	ISI marked & TAC approved
7.0	Branch Pipe & Nozzle	
7.1	Size	63 NB with 20 NB nozzle
7.2	Nozzle Type	Hexagonal, detachable
7.3	Code / standard	IS : 903-1995
7.4	Material of construction	
	Branch pipe / nozzle	SS 304
	Spanner	Steel of grade C-40 to IS:1570 (Part 5) chromium or zinc plated.
7.5	Testing	As per IS : 903
7.6	Approval	ISI marked/ TAC approved
8.0	Hose Coupling	
8.1	Type	Instantaneous male and female
8.2	Size	63 NB
8.3	Code / standard	IS : 903
8.4	Material of construction	
	Female half coupling	SS 304
	Male half coupling	SS 304
	Seal washer	Rubber
	Outer disc	SS 304
	Self locking nut	SS 304
	Locking latch	SS 304



Cl.No.	Description	Specification Requirement
	Spring	Phosphor bronze
	Guide disc	SS 304
	Knob	SS 304
8.5	Testing	As per IS : 903
8.6	Approval	ISI marked/ TAC approved
9.0	Fire Hose	
9.1	Type	Reinforced Rubber lined
9.2	Size	63 mm
9.3	Code / standard	IS:636 Type A
9.4	Length	15 m for external & internal hydrant
9.5	End fittings	Instantaneous spring lock type coupling at both ends.
9.6	Testing	As per IS : 636
9.7	Hose weight (gm/m)	IS : 636
9.8	Bursting pressure	IS : 636
9.9	Proof pressure	IS : 636
9.10	Kink test pressure	IS : 636
9.11	Change in length test pressure	IS : 636
9.12	Change in diameter test pressure	IS : 636
9.13	Approval	ISI marked/ TAC approved
10.0	Hose Cabinet	
10.1	Type	Fabricated out of 16 G MS sheet
10.2	Size	Approx. 750 x 600 x 250
10.3	Mounting	- Wall / column mounted for internal hydrant pedestal mounted for external hydrant
10.4	Special requirement	(i) Each cabinet shall accommodate 2 nos. of 15 m long hoses and 1 no. branch pipe & nozzle.
		(ii) Cabinet to have double door having toughened glass panel (3 mm) with rubber lining and marked 'Fire' on it in 80 mm size letters.
		(iii) Approved lock with duplicate keys kept wired in a break glass key cabinet in the hose box itself.
		(iv) A spanner and a set of spare rubber rings packed in fresh chalk to be kept inside the hose box.
		(v) Clamp for holding branch pipe to be provided.



Cl.No.	Description	Specification Requirement
10.5	Accessories	-Fastening nuts, bolts and hardware - Hammer for breaking the glass to take out the keys
11.0	Deluge Valve	
11.1	Type	Quick release, diaphragm/ piston actuated
11.2	Size	80 NB, 100 NB & 150 NB
11.3	Design data	Normal working pressure : 7 kg/cm ²
		Design pressure : 10.5 kg/cm ²
		<u>Test Pressures:</u>
		Body = 24 kg/cm ²
		Seat = 16 kg/cm ²
11.4	End connection	Flanged, Flat Faced to ANSI B 16.5 #150
11.5	Type of operation	Hydraulic (wet pilot)
11.6	All Trims and accessories	
11.9	Material of construction	
	<u>For Diaphragm type</u>	
	Housing	CI IS 210 Gr. 260
	Cover	CI IS 210 Gr. 260
	Clapper	Cast bronze IS 318 LTB-2
	Clamp ring	Cast bronze IS 318 LTB-2
	Seat	Cast bronze IS 318 LTB-2
	Diaphragm	Neoprene
	Seat rubber	Neoprene
	<u>For Piston type</u>	
	Housing	CI IS 210 Gr. 260/ eqvl.
	Top & side Cover	CI IS 210 Gr. 260/ eqvl.
	Piston rod	GM, IS : 318 Gr. 2
	Piston seat	GM, IS : 318 Gr. 2
	Piston	GM, IS : 318 Gr. 2
	Valve seat	GM, IS : 318 Gr. 2
	Guide way	GM, IS : 318 Gr. 2



Cl.No.	Description	Specification Requirement
	Comp. Spring	SS 304
	‘O’ Ring	Nitrile Rubber
	Valve disc	Nitrile Rubber
	NRV, ball	Brass, IS : 319
	Bolts	Stainless (wet parts) Hot dip galvanised MS (dry parts)
11.10	Testing	As per UL (Type test report to be enclosed)
11.11	Approval	TAC approval
12.0	Spray Nozzles(HVWS)	
12.1	Type	Open type, solid cone
12.2	Working pressure	3.5 bar
12.3	Material	SS304
12.4	K factor/Orifice size (mm)	17.5 / 7 & 33/10
12.5	Spray angle	Contractor to indicate
12.6	Approval	TAC approved
12.7	End connector	Screwed, 3/4" BSP
12.8	Marking	K – factor to be marked on hexagonal face.
13.0	Spray Nozzles (Medium Velocity Water Spray System)	
13.1	Type	Open type
13.2	Working pressure	1.4 – 2.8 bar
13.3	Material	
	Body, deflector & deflector pin	SS304
13.4	K factor / orifice size	21.05 / 6.6 mm
13.5	Spray angle	120°
13.6	Approval	TAC approved
13.7	End connector	½" BSP, Screwed
13.8	Marking	K – Factor to be marked on hexagonal face
14.0	Quartzoid Bulb Detector	
14.1	Material	SS304



Cl.No.	Description	Specification Requirement
14.2	Sensitive element	Heat sensitive bulb
14.3	Set temperature	79°C
14.4	Response time	Less than 20 seconds
14.5	End connector	½" BSP, Screwed
14.6	Approval	TAC approved
15.0	Y-Strainers	
15.1	Manufacture	As per approved vendor list
15.2	Sizes	80 NB to 300NB
15.3	End connector	Flanged and drilled to ANSI 150# B 16.5
15.4	Screen open area to pipe room sectional area ratio	4 : 1
15.5	Material of construction	
	Body	MS to IS : 2062
	Screen	AISI : 316, 18 BWG
15.6	Screen mesh	30 mesh
15.7	Testing pressure	Two times working pressure or 1.5 times design pressure whichever is higher.
16.0	Gate Valves	
16.1	Type	Rising spindle type
16.2	Sizes	50 NB to 600 NB
16.3	Rating	PN 1.6
16.4	End connection	Flanged and drilled to ANSI 150# B 16.5
16.5	Code / Standard	IS 14846 rising spindle TAC approved
16.6	Material of construction	
	Body	Duplex Stainless Steel
	Bonnet	Duplex Stainless Steel
	Stem	Duplex Stainless Steel
16.7	Testing	As per IS : 14846
16.8	Test pressure	Body - 24 kg/cm ²
		Seat - 16 kg/cm ²
16.9	Approval	ISI marked/ TAC approved



H. PORTABLE AND MOBILE FIRE EXTINGUISHERS

Sl.No.	Parameter	Unit	Description
	Pressurised Water Type Fire Extinguishers		
1	Type		Stored pressure type fire extinguisher (ABC fire) 5 kg
2	Design Standard		IS : 940
3	Quantity	Nos.	DDE
4	Guaranteed performance		
a	Capacity	lts	5
b	Max. effective range when tested in still air	M	7 – 9
c	Min. period during which the continuous jet shall be maintained.	S	75
d	Maximum period for discharge of 95% of the charge.	S	90
5	Constructional features		As per design code
6	Material of construction		As per design code
7	Physical data		DDE
8	Accessories		
a	Chemical charge		Yes
b	Mounting brackets complete with all hardware		Yes
c	Carrying Handle		Yes
d	Liquid level indicator		Yes
e	Any other as per design code		Yes
9	Approvals		ISI
10	Painting and testing		As per manufacturer.
	Carbon Di-Oxide Type Portable Fire Extinguishers		
1	Type		Carbon Di-Oxide type
2	Design standard		IS : 2878
3	Quantity	Nos.	DDE
4	Guaranteed performance		
a	Capacity	Kg	9
b	Max. effective range when tested in still air	m	2



Sl.No.	Parameter	Unit	Description
c.	Min. period during which the continuous jet shall be maintained.	S	8
d	Maximum period for discharge of 95% of the charge	S	18
5	Constructional features		As per design code
6	Material of construction		As per design code
7	Physical data		DDE
8	Accessories		
a	Chemical charge		Yes
b	Mounting Brackets complete with all hardware		Yes
c	Carrying handle		Yes
d	Liquid level indicator		Yes
e	Any other as per design code		Yes
9	Approvals		ISI
10	Painting and testing		As per manufacturer.
	Dry Chemical Powder Type Portable Fire Extinguishers		
1	Type		Dry chemical powder type
2	Design standard		IS : 2171
3	Quantity	Nos.	DDE
4	Guaranteed performance		
a	Capacity	kg	10
b	Max. effective range when tested in still air	m	4
c	Min. period during which the continues jet shall be maintained.	S	15
d	Maximum period for discharge of 95% of the charge	S	20
5	Constructional features		As per design code
6	Material of construction		As per design code
7	Physical data		DDE
8	Accessories		
a	Chemical charge		Yes
b	Mounting brackets complete		Yes



Sl.No.	Parameter	Unit	Description
	with all hardware		
c	Carrying handle		Yes
d	Liquid level indicator		Yes
e	Any other as per design code		Yes
9	Approvals		ISI
10	Painting and testing		As per manufacturer.
	Foam Type Portable Fire Extinguishers		
1	Type		Mechanical Foam type
2	Design standard		IS : 10204
3	Quantity	Nos.	DDE
4	Guaranteed performance		
a	Capacity	lts	9
b	Max. effective range when tested in still air	m	5 - 7
c	Min. period during which the continuous jet shall be maintained	S	50
d	Maximum period for discharge of 95% of the charge	S	60
5	Constructional features		As per design code
6	Material of construction		As per design code
7	Physical data		DDE
8	Accessories		
a	Chemical charge		Yes
b	Mounting brackets complete with all hardware		Yes
c	Carrying handle		Yes
d	Liquid level indicator		Yes
e	Any other as per design code		Yes
9	Approvals		ISI
10	Painting and testing		As per manufacturer.
	Trolley Mounted Carbon Di-Oxide Type Mobile Fire Extinguishers		
1	Type		Carbon Di-Oxide mobile type
2	Design standard		IS : 2878



Sl.No.	Parameter	Unit	Description
3	Quantity	Nos.	DDE
4	Guaranteed performance		
a	Capacity	kg	22.5
b	Max. effective range when tested in still air	m	5
c	Min. period during which the continuous jet shall be maintained	S	20
d	Maximum period for discharge of 95% of the charge	S	60
5	Constructional features		As per design code
6	Material of construction		As per design code
7	Physical data		DDE
8	Accessories		
a	Chemical charge		Yes
b	Mounting brackets complete with all hardware		Yes
c	Carrying handle		Yes
d	Liquid level indicator		Yes
e	Any other as per design code		Yes
9	Approvals		ISI
10	Painting and testing		As per manufacturer.
	Trolley Mounted Dry Chemical Powder Type Mobile Fire Extinguishers		
1	Type		Dry Chemical Powder Mobile type
2	Design standard		IS : 10658
3	Quantity	Nos.	DDE
4	Guaranteed performance		
a	Capacity	kg	50
b	Max. effective range when tested in still air	m	8 – 10
c	Min. period during which the continuous jet shall be maintained at length not less than 6 m	S	85
d	Maximum period for discharge of 95% of the charge	S	95
5	Constructional features		As per design code



Sl.No.	Parameter	Unit	Description
6	Material of construction		As per design code
7	Physical data		DDE
8	Accessories		
a	Chemical charge		Yes
b	Mounting brackets complete with all hardware		Yes
c	Carrying handle		Yes
d	Liquid level indicator		Yes
e	Any other as per design code		Yes
9	Approvals		ISI
10	Painting and testing		As per manufacturer.
	Trolley Mounted Foam Type Mobile Fire Extinguishers		
1	Type		Foam mobile type
2	Design standard		IS : 13386
3	Quantity	Nos.	DDE
4	Guaranteed performance		
a	Capacity	lts	50
b	Max. effective range when tested in still air	m	10
c	Min. period during which the continuous jet shall be maintained at length not less than 6 m	S	40
d	Maximum period for discharge of 95% of the charge	S	180
5	Constructional features		As per design code
6	Material of construction		As per design code
7	Physical data		DDE
8	Accessories		
a	Chemical charge		Yes
b	Mounting brackets complete with all hardware		Yes
c	Carrying handle		Yes
d	Liquid level indicator		Yes
e	Any other as per design code		Yes



Sl.No.	Parameter	Unit	Description
9	Approvals		ISI
10	Painting and testing		As per manufacturer.



VOLUME II
SUB-SECTION - 2.16
COMPRESSED AIR SYSTEM

1.0.0 GENERAL

This section covers minimum requirements for design, engineering, fabrication, manufacture & assembly, inspection, erection, testing and commissioning of compressed air system.

2.0.0 CODES AND STANDARDS

The applicable standards and codes for various major equipment in Compressed Air System are given below. Latest editions of the following standards shall also be used.

TEMA	-	Tubular Exchanger Manufacturer's Association
ASME	-	American Society of Mechanical Engineers
IS	-	Indian Standards
VDI	-	Verein Deutscher Ingenieure
RMS	-	Reputed manufacturers standard

3.0.0 SCOPE OF SUPPLY

The scope of supply shall include but not limited to the following:

- a. Six (06) Nos. of Screw type, Oil free Air compressors
 - 3 (2W+1S) nos. for instrument air application
 - 3 (2W+1S) nos. for service air requirement.(with adequate capacity and discharge pressure as required for offered equipments shall be provided.
- b. Three (3) numbers (2W+1S) of Heat of Compression (HOC) Rotary drum type air dryers to match instrument air compressor capacity along with all accessories including control panel, flow meter, online digital dew point meter at the outlet of each dryer, etc.,
- c. Three (03) numbers of Instrument air receivers and three (03) numbers of service air receivers of adequate capacity shall be provided along with all accessories such as pressure gauges, safety relief valves, electronic type auto drain traps, manual isolation / blow off drain valves, bypass control valve, fittings, pressure indicators, etc. The air receivers shall be vertical self-supporting cylindrical vessels with supporting legs for resting on their foundation.

4.0.0 DESIGN REQUIREMENTS

- The compressed air system shall consist of common inter connected systems for instrument air and service air.
- The set pressure of relief valve shall be 110% of the rated discharge pressure.
- Maintenance bay of at least one compressor bay width with adequate handling facilities and rolling shutters of adequate dimensions to enable truck entry shall be provided.



- Pressure requirement shall be based on the data furnished by BTG and other packages. Instrument air required for the coal handling system and ash handling system shall not met by these compressors. Capacity shall be considered for the maximum compressed air required for BTG operation (simultaneous starting of the two units.) Apart from the service air required for the BTG and also considering usage factor of 10% of total consumer point, service air compressor to be sized accordingly. Air consumed per station shall be 40 Nm³/h. Same capacity to be maintained for the instrument and service air compressor. Pressure drops across various items shall be included based on the layout.
- Operation of air compressors regarding selection of operating and stand by compressors and also method of starting of stand by compressor shall be as per manufacturer's practice.

5.0.0 LAYOUT

Air compressors would be located indoor in a separate compressor room.

Air compressors are kept in compressor house. The compressor house shall be provided with necessary crane to handle equipment/components during maintenance. Air receivers shall be placed outside the compressor room. ADP equipment would be skid mounted and located indoor. Auto drain trap shall be provided at boiler end, turbine end and wherever necessary.

6.0.0 DOCUMENTATION

6.1.0 List of drawings / documents to be submitted along with the Bid

- 1 Duly filled-in technical data (mechanical, Electrical and C & I), bill of material and prices as per specified schedules
- 2 List of drawings & documents attached for tender purpose
- 3 Deviation list
- 4 Spares list
- 5 List of all maintenance tools, tackles and accessories required for maintenance of the offered equipment including bought out components
- 6 P&I diagram for compressed air system
- 7 GA drawing of Inter and After cooler
- 8 Write up & drawings related to the control system of air compressors
- 9 General arrangement drawings of compressor plant with details of all accessories
- 10 Write up on air dryer
- 11 P&I diagram for air dryer
- 12 GA drawings for air dryer
- 13 Battery limit drawing / information
- 14 List of sub vendors
- 15 List of comparable installations
- 16 Pre commissioning, commissioning and PG test procedures
- 17 List of tests the bidder proposes to carry out in shop and at site after installation including those pertaining to their sub-bidder
- 18 A bar chart indicating design engineering, procurement, manufacture, testing at shop, delivery, installation, testing and commissioning activity/duration of system offered.
- 19 Quality assurance plan (QAP) (Shop items)
- 20 Complete Electrical load list
- 21 Equipment layout
- 22 Signed copy of the Tender specification for acceptance
- 23 Control, operation and design philosophy,
- 24 System write up,
- 25 GA of control panel, PLC panel,
- 26 System configuration drawing
- 27 Air conditioning load details



- 28 User's list,
- 29 Confirmation of all the clauses of the specification,
- 30 List of valves and flow elements,
- 31 list of spares, makes, catalogues and literatures,
- 32 QAP format
- 33 Process & Instrumentation Diagrams (PID) indicating primary sensors and secondary instruments, destination Reference (alarm, control etc)
- 34 Technical data sheets of all instruments and control panel along with catalogue
- 35 General Arrangement Drawings
- 36 Instrument list
- 37 Power consumption details
- 38 Bill of Quantities

6.2.0 List of documents / drawings to be submitted after award of contract**Category****6.2.1 Mechanical**

i. Flow diagrams and P&I diagrams for compressed air system	A
ii. Sizing calculations for compressors, air dryers, air receivers and FAD compressed discharge pressure calculation.	A
iii. Shell thickness calculations for air receiver	A.
iv. Final technical data sheets for all equipment/ vessels/ instruments etc...	A
v. GA drawings of compressor plant with details of all accessories	A
vi. Write up for air dryer	I
vii. P&I diagram for air dryer	A
viii. GA drawings of Inter and After cooler	I
ix. GA drawing for air dryer	A
x. GA drawing of air receivers.	A
xi. Foundation drawings with load data for air compressor.	A
xii. Write up on control system of air compressors	I
xiii. Drawings related to control system	A
xiv. Drawings/data sheets for valves, instruments, filters, strainers, air, water, impulse and lube oil piping, etc.	I
xv. GA drawing of compressor room showing layout of compressors, air receivers, air dryers, cooling water lines within Battery limits of the package	A
xvi. Operation and maintenance manual	A

**6.2.2 Electrical**

For electrical drawings / documents, please refer section – 3 of this specification.

6.2.3 Control & Instrumentation

The following drawings, data / documents shall be submitted for the approval / review of the Purchaser / Consultant by the successful bidder.

1. Detailed Control philosophy / operation philosophy / Design philosophy / Redundancy Philosophy	A
2. Engineering documents	
i. Input / Output list, Instrument list, Drive list	I
ii. Annunciation list & SER list	A
iii. I/O Assignment, List of Set Points, JB Schedule	I
iv. Loop schematics - For Each instrument	I
3. Control schemes / logic diagrams	A
4. Factory Acceptance Test (FAT) procedure / Site Acceptance Test (SAT) Procedure / Availability test procedure / PG test Procedure	A
5. Detailed Process & Instrumentation Diagrams (PID) indicating primary sensors and secondary instruments, destination reference (alarm, control etc)	A
6. Installation sketches (Individual Instrument Hook up Drawing and Installation isometric drawings)	I
7. Power supply and earthing schemes	A
8. Marshalling philosophy / cabling philosophy	A
9. Interconnection schedule (ICS) and cable schedule	I
10. Cabinet / Panel wiring diagrams and internal layout drawings	I
11. Cabinet / Panel / FTC / JB / Local Panel - terminal details	I
12. Wiring diagrams for panel, local panel, junction boxes, actuators, starters etc.	I
13. QAP for all major equipment	A
14. GA drawings of control panel / local panel	I
15. Spares list	A
16. All test certificates including degree of protection certificates and Explosion proof certificates for oil services	I
17. Data sheets of all field Instruments and Control panels	A



18. As built drawing after commissioning and O&M manual	A
19. Level-II PERT for I&C system	A
20. Purchase specification for PLC and all other I&C equipment.	A
21. System configuration drawing	A
22. Measurement / typical loop schemes for each signal type (AI,RTD,AO,DI,DO)	I
23. Power distribution scheme	I
24. Recommended earthing scheme	I
25. UPS and battery charger	A
26. Engineering inputs for implementing the communication link to DCS	I
27. Storage instructions for all equipment	I
28. Erection and commissioning manuals for all the systems / equipment / components including installation drawings	I
29. Design philosophy / Redundancy philosophy	A
30. Grouping philosophy of control loops in controllers	A
31. PLC configuration drawing / system architecture drawing including MMI	A
32. Hardware and software design manual (covering exhaustive details of complete PLC engineering)	A
33. Process mimics	A
34. GA drawing of control desk	A
35. Annunciator window layout and inscription	A
36. Data sheets of each and every item of PLC	A

6.2.4 General Documents

1. Contract network schedule.
2. Details of paints and painting material.
3. Installation drawings and manuals for all equipment / systems.
4. Detailed write-up for shop tests and site performance tests
5. Integrated operation and maintenance manuals for the complete plant as well as for all individual equipment.
6. Test certificates for type / routine and standard acceptance tests.



7. As-built drawings for all equipment / systems supplied under this contract and all buildings / structures / works executed under this contract incorporating all changes / modifications upto the time of commissioning / handling over to the Owner.
8. Project Design Manual consisting of studies of all the systems, design criteria, sizing calculations of all major equipment / systems etc.
9. Materials test certificates and performance test certificates for all equipment tested at works.
10. Detailed interface schedule for all terminal points identifying terminal point no., size, material, type of connection, design flow, pressure and temperature at the terminal points.
11. Storage instructions for all equipment.
12. Drawings / data to be required / submitted to statutory authorities.
13. Schedule of instruments for performance tests.
14. Schedules of places of shop test and inspection for all equipment.
15. Detailed write-up on all pre-commissioning and commissioning activities.

Any other drawings required for review during the detailed engineering stage, same shall also be submitted by contractor.



**ANNEX – 2.16.1
SPECIFIED DESIGN DATA**

CL.NO.	DESCRIPTION	UNIT	DATA
A.	AIR COMPRESSOR		
1.0.0	General		
1.1.0	Designation		Air compressor
1.2.0	Number offered		
	- Instrument and service air compressor		3 (2W+1S) nos. for instrument air application 3 (2W+1S) nos. for service air requirement.
1.3.0	Type		Two stage, Water cooled, Oil free compressor with drive motor and accessories like inter cooler, after-cooler, Oil cooler, Moisture separators, intake filters, Suction silencers, Vibration isolators, etc.,
1.4.0	Duty mode		Continuous, Load-Unload and ON-OFF operation.
1.5.0	Control mode		'Dual' control mode
1.6.0	Lubrication bearing		Forced
1.7.0	Location		Indoor
1.8.0	Type of drive-compressor connection		Direct
1.9.0	Galvanization of interconnecting piping		Yes
2.0.0	Material of construction		
2.1.0	Casing		Cast iron with corrosion resistance material
2.2.0	Rotor body		Forged Carbon Steel coated with Teflon
2.3.0	Shaft seal		High alloy steel
2.4.0	Inlet throttle valve		Aluminium alloy
2.5.0	Housing of valve		Aluminium alloy
2.6.0	Bull gear		Alloy steel
2.7.0	Pinion gear		Alloy steel
2.8.0	Timing gear		Low alloy steel
2.9.0	Gear box		Cast iron
2.10.0	Blow of valve		Stainless steel
2.11.0	Unloading cylinder head		Aluminium
2.12.0	Tube of blow off cooler / oil cooler.		SS304
2.13.0	Outer casing of coolers		Carbon steel
Note : Equivalent material for screw compressor shall be acceptable subject to approval			
B	INTER COOLER AND AFTER COOLER		
1.0.0	General		
1.1.0	Designation		Accessories for compressed air system
1.2.0	Nos. required		One set for each compressor
1.3.0	Type		Horizontal / Vertical shell and tube type with removable bundles, with counter current flow heat exchangers
1.4.0	Location		Indoor
2.0.0	Equipment parameters		
2.1.0	Outlet air temperature	°C	8 °C (Maximum) above cooling



CL.NO.	DESCRIPTION	UNIT	DATA
			water inlet temperature
2.2.0	Design pressure	kg/cm ² (g)	1.25 times the maximum operating pressure
2.3.0	Hydrostatic test pressure	kg/cm ² (g)	1.5 times maximum operating pressure
2.4.0	Allowable pressure drop of air	kg/cm ² (g)	0.2
2.5.0	Minimum corrosion allowance	mm	3.0
3.0.0	Material of Construction		
3.1.0	Tube		Copper / CU-Ni / Stainless steel
3.2.0	Shell		CS SA 106 Gr.B / IS : 2002/ SA 516 Gr 70
3.3.0	Tube sheet		CS SA 105 / IS : 2002 / SS 316/ SA 516 Gr 70
3.4.0	Tube support plates		SA 516 Gr. 70 / IS : 2062
3.5.0	Auto-drain trap body & Trim		SS 316
4.0.0	Intake Air Filter		
4.1.0	General		
4.1.1	Designation		Intake Air Filter for compressors
4.1.2	Nos. Required		One for each compressor
4.1.3	Location		Suction pipe of compressor
4.1.4	Type		Dry type
4.2.0	Performance Required		
4.2.1	Air flow rate		As per compressor flow rate
4.2.2	Filtering efficiency		99.50% down to 2 microns over entire capacity range of compressor
4.3.0	Special Feature		
4.3.1	Operating sound level		85 dB at 1 M (max.) from edge of Skid.
4.3.2	Filtering element equivalent		Compressed felt / manufacturer's standard
5.0.0	Air Receiver		
5.1.0	General		
5.1.1	Designation		Air receiver
5.1.2	Type		Vertical
5.1.3	Location		Outdoor
5.1.4	Receiver design code		IS : 2825 / IS : 7938
5.1.5	Number		Refer flow diagram
5.2.0	Equipment Parameter		
5.2.1	Capacity		i) Instrument Air 10 m ³ ii) Service Air 10 m ³
5.2.3	Design pressure		1.1 times the maximum operating pressure
5.2.4	Hydraulic test pressure		1.5 times maximum operating pressure
5.2.5	Relief valve set		10% higher than working pressure or atleast equal to design pressure whichever is higher
5.3.0	Material of Construction		
5.3.1	Shell		IS: 2002 Gr 2A
5.3.2	End plates		IS: 2002 Gr 2A
5.3.3	Relief valve body		Cast steel
5.3.4	Relief valve spring		Spring steel



CL.NO.	DESCRIPTION	UNIT	DATA
6.0.0	AIR DRYING PLANT		
6.1.0	General		
6.1.2	Designation		Air Drying Plant for Instrument Air
6.1.3	Type		Heat of Compression (HOC) Rotary drum type
6.1.4	Duty		Continuous
6.1.5	Nos. required	Nos.	As per flow diagram
6.1.6	Location		Indoor
6.2.0	Operating Data		
6.2.1	Air flow rate	Nm ³ /min	To match compressor flow rate
6.2.2	Dew point (atmospheric)	°C	(-) 40
6.2.3	Maximum allowable pressure drop	Kg/cm ²	0.3
6.3.0	Tests		
6.3.1	Noise level		Limited to 85 dB (A) at 1.0 m from equipment in any direction
6.3.2	Capacity at rated discharge pressure of compressors		ASME Power test code for compressor and exhausters
6.3.3	Negative tolerance on guaranteed values of specific power consumption, air dryer dew point of air, air dryer pressure drop and water pressure drop.		0.00%
6.3.4	Performance test for air dryer – Rated dew point temperature		Yes

Note: Design, MOC, annunciations, trips for compressor (within the compressor and Air drying Plant skid) as per manufacturer standard will be subjected to approval by owner. Manufacturer shall be as per approved vendor list. DMCW water shall be used for Compressor cooling.



VOLUME II
SUB-SECTION - 2.17

AIR CONDITIONING AND VENTILATION SYSTEM

1.0.0 GENERAL

This section covers minimum requirements for design, engineering, fabrication, manufacture & assembly, inspection, erection, testing and commissioning of Air Conditioning and Ventilation System and associated equipment to be provided by the Contractor.

2.0.0 SCOPE OF SUPPLY

This section sets out the scope of the installations covered by this specification as well as required supplies and services but without excluding other necessary components and services not mentioned.

2.1.0 Air Conditioning System

Air conditioning system shall be provided for all buildings or rooms as specified below:

- In which waste heat occurs which is not removed by other means and where, due to the installed equipment temperature limitations exist
- Intended for human habitation

and all other areas where equipment requires air conditioned atmosphere.

2.1.1 Water Cooled Chiller unit type Air conditioning system

Independent Water Cooled Chiller shall be provided for TG building and Service building air conditioned areas

- TG Building
 - Central Control Room
 - Electronic Equipment Room
 - Computer Room
 - Printer Room
 - UPS Room
 - Record Room
 - Shift In-charge room
 - Relay room
 - I & C Laboratories
 - Engineers room
- Service Building

2.1.2 Water Cooled Package Type Air conditioning System

Water Cooled Package unit shall be provided for the following areas:

- ESP Control Room
- Switch Yard Control room
- Coal Handling System Control Room
- Ash Handling System Control Room
- Administration building



2.1.3 Water Cooled Package Type/Split Type Air conditioning System

- For auxiliary buildings, if AC load is less than 5 TR, multiple split units shall be provided considering one number of standby unit.
- For areas having AC load more than 5 TR or equal to 5TR, Water cooled package units shall be provided

Depending on the capacity criteria mentioned above, either water cooled package unit or split type air conditioning system shall be followed for the following areas

- DM plant control room
- CW pump house control room
- Fire water pump house control room
- Fuel oil unloading/forwarding pump house control room
- SWAS Room (Dry Panel)
- Electro chlorination control room
- Hydrogen generation plant control room
- Road weigh bridge control room
- Sea water intake pump house control room
- Stack emission monitoring system control room
- Air compressor control room
- Fire water booster pump house control room
- Ash slurry pump house control room
- Ash water recovery pump house control room
- Elevator M/c room
- Operator cabin in crusher house
- Field maintenance Office
- HT Switch gear operator room
- Turbine control room at EL(+) 0.00 m,
- ETP control room
- STP control room
- Stores – maintenance officer room
- Storage shed for electronic items like PLC panels, DCS panels, cards etc.,
- Fire station control room
- Dormitory and dispensary

Any other areas if required air conditioned environment shall be provided with suitable AC plant

2.2.0 Ventilation System

Ventilation system shall be provided for all the buildings or rooms as specified below

- In which waste heat occurs which has to be removed but where temperature ranges do not necessitate air conditioning and all other areas which requires ventilation.

2.2.1 Evaporative type Ventilation System

2.2.1.1 Air Washer System

The Evaporative type system shall be provided in the following locations within the TG Building by air washers. A dedicated plant room shall be provided for air washer unit.

- TG Hall
- HT Switchgear Rooms



- LT Switchgear Rooms
- Electrical Rooms
- Cable Spreader Rooms
- Battery charger room
- SWAS room (wet panel)

2.2.1.2 Unitary Air Filtration System

Sheet metal type Unitary Air Filtration unit (UAF) of suitable capacity shall be envisaged for each unit of ESP Building non AC areas. A dedicated plant room shall be provided for UAF unit.

2.2.2 Dry type Ventilation system

2.2.2.1 Supply Ventilation System

The supply ventilation system shall be provided for the following areas

- All switchgear rooms/MCC rooms (Except TG and ESP building)
- Cable spreader rooms (Except TG and ESP building)

2.2.2.2 Simple Exhaust Ventilation System

The simple exhaust ventilation system shall be provided for the following areas

- Diesel generator room
- Air Compressor room
- Electro chlorination room
- Battery Room
- All Pump Rooms
- DM plant room
- Chemical House
- Hydrogen generation plant room
- Workshop
- Stores
- Elevator machine room
- AC plant room
- Toilets

2.2.3 Common equipment

- All controls, measuring and monitoring equipment, to an extent as well as additional instrumentation necessary for matching to specific designs of equipment and units.
- Hot dip galvanized duct work.

3.0.0 DESIGN REQUIREMENTS

3.1.0 Air Conditioning

Indoor / Outdoor Design Conditions

- Inside design conditions to be maintained in Air-conditioned area

Dry bulb temperature

Relative humidity



Occupied Area	:	24.0°C ± 1.0°C	50 ± 5%
Equipment Room	:	21.0°C ± 1.0°C	50± 5%

- The outdoor design data shall be taken from ISHRAE/ASHRAE Hand book
- Fresh air for air conditioned area shall be provided with 1 AC/hr or 35 m³/hr/person which ever is higher
- Bidder shall collect the actual data from the meteorological department pertaining to site location and design for plant accordingly
- Bidder shall adopt the Thoothukudi Metrological data (No. Of years shall be minimum of 20 years) and design condition shall be arrived based on the guidelines mentioned in ASHRAE .The design condition subject to the owner's approval

3.2.0 Ventilation System

Design & Technical Requirements

Room	Basis of Airflow rate: Air changes per hour
Evaporative cooled areas - T.G building operating floor, mezzanine floor, ground floor , MCC room / Switch gear room, Electrical room and Cable spreader room	6
MCC room / Switch gear room/ GIS room	15
Battery Rooms	30
Chemical house	20
Air Compressor building	15
Diesel generator room	30
Sea water intake pump house, CW pump house, Fuel Oil unloading / Forwarding pump house and all other pump houses	15
SWAS room (Non-AC areas)	15
AC Plant room	15
Workshop and Stores	6
Toilets in all buildings	15
Pantry in all buildings	15
Elevator machine room	15
Hydrogen generation plant room	20
Electro chlorination plant room	20

Supply and Exhaust Ventilation System

Area to be ventilated	Supply air system	Exhaust air system
TG Hall	Filtered Supply air ventilation system from air washer through ducting	Roof exhaust fans

Supply Air Ventilation System

Area to be ventilated	Supply air system	Exhaust air system
Various rooms like cable spreader room, switchgear room, battery charger room, SWAS room (Non AC) etc, in TG	Filtered Supply air ventilation system from air washer through ducting	Gravity dampers



Area to be ventilated	Supply air system	Exhaust air system
Building.		
ESP Switchgear Building	Filtered Supply air ventilation system from UAF through ducting	Gravity dampers
All other MCC rooms/Switchgear, cable spreader rooms,	Wall mounted supply fans with pre filters	Gravity dampers
GIS Building	Centrifugal fan with pre filter and fine filters along with ducting for supply air system, exhaust by gravity dampers will be provided for GIS building to maintain positive pressure and to prevent ingress of duct particles inside GIS building.	Gravity dampers. Exhaust fan inter linked with SF6 gas detector shall be provided for emergency purpose.

Simple Exhaust Ventilation System

Area to be ventilated	Supply air system	Exhaust air system
DM Plant Room	Fresh air through intake louvers	Wall mounted exhaust fans
Battery Room (2x50% capacity axial flow belt driven)	Fresh air through intake louvers	Wall mounted exhaust fans
Chemical house of PT Plant, workshop and stores, pantry in all buildings, Hydrogen generation plant room, Electro chlorination plant room	Fresh air through intake louvers	Wall mounted exhaust fans
All Pump houses	Fresh air through intake louvers	Wall mounted /Roof exhaust fans
Elevator machine room/ AC Plant room/ Compressor building	Fresh air through intake louvers	Wall mounted exhaust fans
Diesel generator room	Fresh air through acoustically treated intake louvers	Roof/Wall mounted exhaust fans
Toilets in all buildings	Through door undercuts/door louvers	Wall mounted Propeller type exhaust fans

3.3.0 General Design Requirement

- 3.3.1 Relevant Indian/International standards such as ISHRAE, ASHRAE SMACNA, etc., as applicable to HVAC system and latest issues of these applicable codes and standards shall be adopted.
- 3.3.2 10% margin in equipment capacity over peak heat load calculated considering solar load and all internal loads due to equipment, lighting, fresh air, occupants, etc have to be considered for air conditioning and ventilation system.
- 3.3.3 For sensible and latent heat load, 5% factor of safety shall be considered. .
- 3.3.4 All windows in the air-conditioned area shall be provided with light coloured venetian blind.



- 3.3.5 False-ceiling shall be provided in all air conditioning areas.
- 3.3.6 All the AC areas and air handling unit room, shall be provided with insulation on the under side of the roof.
- 3.3.7
- i) The evaporative type ventilation system for each area shall be sized based on either air flow rate calculated considering a room temperature of 3°C (Maximum) below ambient DBT during peak summer considering all heat loads or air flow rate calculated considering minimum number of air changes / hour as mentioned above, whichever results in higher air flow rate.
 - ii) The saturation efficiency of 90% and 70% shall be considered for air washer and UAF system
 - iii) The dry type ventilation system for each area shall be sized based on either air flow rate calculated considering a room temperature of 5°C (Maximum) above ambient DBT during peak summer considering all heat loads or air flow rate calculated considering minimum number of air changes / hour as mentioned above, whichever results in higher air flow rate.
 - iv) Exhaust air quantity from TG hall shall be estimated a 65%-70% of supply air quantity.
- 3.3.8 For switchgear and cable vault rooms, the supply air flow rate shall be maintained higher than that of exhaust air flow rate to prevent the ingress of dust into the room from outside.
- 3.3.9 If, as per manufacturer's requirements, any switchgear requires air-conditioning, the same shall be provided by the Tenderer.
- 3.3.10 The battery room shall be maintained at negative pressure to prevent leakage of fumes to outside from the battery rooms.
- 3.3.11 All equipment, ducts, pipes, controls, etc. shall be fully treated against corrosion and sealed against moisture, sand and dust ingress.
- 3.3.12 All plant including ducts and pipes as well as machines shall be vibration isolated or otherwise treated that:
- No excessive vibration is felt in the floors or walls of the rooms served by any machine.
 - The mechanically induced vibration levels in floors, walls and ceilings of rooms are sufficiently small as to limit the radiation of sound levels to the rooms within acceptable levels.

4.0.0 CONSTRUCTION REQUIREMENT

4.1.0 Water Cooled Chiller unit

The capacity of chilling unit shall be based on the following:

- Chilled water In / Out temperature : 12 deg C / 7 deg C
- Condenser water In/out temp : 33 deg C/ 38 deg C

Each Water Cooled Screw chilling unit comprises of the following:



- Microprocessor controlled water cooled chiller package unit suitable for R 134a having one no. of Rotary screw Compressor (Semi hermetic type) with motor, unit mounted starter, automatic capacity control etc.,
- One no. of Shell & tube water cooled condenser with hot gas inlet, liquid outlet, relief and purge connection for refrigerant, water inlet and outlet connection, drain connection with valve.
- One no. of Shell & tube flooded type chiller with liquid inlet, vapour outlet, connection for refrigerant, water inlet and outlet connection, drain connection with valve and chiller insulation.
- Thermostatic expansion valve, Refrigerant piping, valves and fittings interconnecting compressor, condenser, chiller and expansion device and refrigerant piping including insulation etc,
- Chilled water pumps, condenser water pumps including all interconnecting pipe lines, valves and necessary accessories.
- Induced draft cooling towers with valves and accessories
- Initial charge of Refrigerant Gas & Oil lubricants, base frames, vibration isolation pad, integral wiring and unit mounted isolator/fuse switch.
- Flexible connection (corirubber with retainer rods and flanges suitable to operate at the design pressure) between chilling unit and piping.
- Vibration isolators for chillers & Cooling towers.
- Necessary instruments for safe and reliable operation of the system

4.2.0 WATER cooled Package Air Conditioners

Each water cooled Package Air Conditioners comprises of the following:

- Scroll type refrigerant compressor (R 134a) with motor and drive package
- One no of Water cooled condenser
- One no DX cooling coil with air handling fan.
- Interconnecting refrigerant pipes to connect the compressor, condenser, and expansion device.
- Condenser water pumps including all interconnecting pipe lines, valves and necessary accessories.
- Induced draft cooling towers with valves and accessories
- Initial charge of Refrigerant Gas & Oil, lubricants.
- Necessary instruments for safe and reliable operation of the system.

4.3.0 Split type air-conditioning system

The major components of split type air-conditioner system is:



- i) Indoor unit comprising of:
DX -Cooling coil
Blower
Coarse filter
- ii) Outdoor unit comprising of:
Compressor
Condenser.

DX Dehumidifying & coil unit: The DX coil shall be standard staggered tube arrangement with seamless copper tube and aluminum plate fin mechanically bonded to copper shall be sized with following specification:

Face velocity	:	2.5 m/sec
Tube OD minimum	:	10mm
Wall thickness	:	0.5mm

Blower : The Blower shall be DIDW forward curved belt driven fan of suitable capacity and static pressure.

Coarse Filter : Coarse filter shall be washable dry panel filter having an efficiency of 90 % down to 20 microns and suitable for handling the units air quantity

Compressor : The compressor of split unit shall be Scroll type compressor (R 134a/407c/R410a).

Condenser : Condensers shall be fin-tube type seamless copper tubes and aluminum plate fin mechanically bonded to copper and shall be sized with following specification:

Face velocity	:	2.5 m/sec
Tube OD minimum	:	10mm
Wall thickness	:	0.5mm

The Condenser fan shall be of high efficiency propeller type

4.4.0 Centrifugal Pump

Each centrifugal pump set shall be either horizontal split casing/End suction top discharge pumps for chilled water and condenser water re-circulation. It shall comprise of the following:

- One no. horizontal split casing/ End suction top discharge centrifugal pump with adequately sized induction motor suitable for 415V, 3 phase, 50 Hz supply.
- Common base plate for the pump and motor, coupling with guard, anti vibration pads, foundation bolts etc.
- Chilled water pump set shall include thermal insulation of pump.
- Flexible connection (Corrubber with retainer rods and flanges suitable to operate at the design pressure) shall be provided between pump and piping.
- Drain piping from pump to nearest floor drain.



4.5.0 Cooling Tower

The cooling tower shall be induced draft (Single cell) FRP cooling tower with fan and motor, drive package, FRP basin, FRP air inlet louvers, fills, drift eliminators, nozzles, make-up connection, over flow connection, drain connection, ladder and supporting structure. The capacity of the cooling tower shall be equal to the condenser cooling capacity and designed for the following conditions:

- Approach : 5° C

4.6.0 Air Handling Unit

Air handling unit (AHU) shall be double skinned, draw through re-circulating type handling an air quantity equal to the dehumidified air quantity. The system shall consist of the following items:

- AHU Casing
- Inlet louvers
- Coarse filters section
- Cooling and dehumidifying coil section
- Fans Section (DIDW centrifugal type)
- Vibration isolators (minimum efficiency of 85%)

AHU casing

The AHU casing shall be in sectionalized construction with modules for dampers, filters, cooling coil, and fan section all housed in a galvanized sheet metal casing. The casing of AHU shall be double skin construction. Double skin sandwich panel (inside and outside) shall be fabricated using minimum 0.8mm (22g) galvanized steel sheet with 25mm thick polyurethane foam [PUF] insulation of minimum 38kg /m³ density in between the two skins. The skin shall be suitably stiffened and braced to eliminate distortion and drumming.

Pre-Filter

The pre-filter section shall be washable type filter panels suitably arranged in holding frames having a minimum efficiency of 90% down to 10 micron size. A differential pressure gauge shall be fitted across the filter.

Cooling coil unit

The cooling coil with capacity equal to the units refrigeration capacity shall be standard staggered tube arrangement fabricated from continuous aluminum fins mechanically bonded to seamless copper tubes sized with a face velocity of 2.5 m/sec.

Centrifugal Fan

The centrifugal fan shall be double inlet double width centrifugal forward curved V-belt driven fan by a totally enclosed motor of suitable capacity and static pressure. The blower / fan discharge velocity shall not exceed 10 m/s.

4.7.0 Plenum mounted Fine filter

The fine filter section shall be synthetic non-woven washable filter panels, suitably arranged in holding frames having a minimum efficiency of 99.9% down to 5 micron size. A differential pressure switch shall be fitted across the filter. The fine filter area shall be designed for a face velocity of not exceeding 1.75 m/sec.



4.8.0 Electric duct heaters

Electric air heater shall be finned tubular element sheathed type construction of either ductable or slip-on installation type. The electric heater shall be UL approved design & be provided with the following accessories conforming to NEC Article - 424.

- Step controller of either silicon control rectifier or SCR-vernier type for system requiring close RH tolerance.
- Program controller - with multiple humidistat's / thermostat energizing heater in steps- minimum 4-steps for areas requiring relatively higher RH tolerance.
- High temperature cutout with manual reset facility
- Fan circuit interlocking contacts
- Over current protection
- Safety disconnect switch (Interlocking with panel door).

All heater capacity shall be sized for winter heating load also and where heater are used as reheater for humidity control, facility shall also be provided to control room dry bulb temperature during winter.

4.9.0 Pan type Humidifier

Electric humidifier, shall be pan type steam humidifier. The humidifier shall consist of stainless steel basin insulated on outside with 25 mm resin bonded fiber glass thermal insulation of 25 kg/ cm. density covered with 20 SWG GI sheet on outside.

4.10.0 Fresh air unit

Each fresh air unit shall comprise of :

- a) One (1) no. Tube axial fan with motor
- b) Pre filter with HDPE media having 18 G GSS frame. The efficiency of the filters shall be 90% down to 10 microns. Maximum Velocity across pre filter shall be 2.5 m/s.
- c) Fine filter with HDPE media having 18 G GSS frame. The efficiency of the filters shall be 99.9% down to 5 microns. Maximum Velocity across Fine filter shall be 1.75 m/s.
- d) Fresh air Louver, Volume control damper and connecting duct

4.11.0 Make-Up Water Tank and softening plant

The Make-up water tank shall be made of G.I or FRP and shall be of adequate thickness and suitably reinforced. It shall be complete with make-up connection with float valve, quick fill connection, overflow connection and drain connection with valve. The tank shall be provided with level gauge glass. This tank shall supply make-up water to Cooling towers, Expansion tank and humidifiers. The tank size is to be designed based on capacity to hold water for 15 minutes of make-up water requirement. This make up water shall be treated through the Non-Chemical Water Softening Equipment (if required) installed in the common header of Condenser water pump outlets. Conductivity type level switches low, low low, high high shall be provided.

4.12.0 Expansion Tank

MS Expansion tank shall be insulated. The tank shall be complete with all the accessories, float valve, drain, overflow, makeup connection and vent connection. Conductivity type level switches low, low low, high high shall be provided.



4.13.0 Air Washer Unit

Air washer chamber housing the Air Intake Louver with bird screen, pre filter, air distribution plates, Stainless Steel Filters continuously flooded with water through spray nozzles, Die-extruded PVC Eliminators, Water tanks, marine light shall be manufactured of steel sheet in sections to facilitate easy dismantling and erection. The unit shall be fabricated from minimum 3 mm thick M.S. sheet duly painted with epoxy resin based paint from inside and outside with adequate stiffeners, bracings etc. The air washer tank also shall be made from minimum 6 mm thick MS sheet duly painted with epoxy resin based paint.

The various sections of the unit shall be bolted with suitable gasket to avoid leakage of water. All the sections of the units shall be Epoxy painted from inside and outside to prevent corrosion/ weathering damage. The nuts and bolts used for jointing the sections shall also be galvanized. All inside and outside parts of the fan shall be spray galvanized except the fan shaft that shall be of epoxy painted.

Properly hinged air tight epoxy painted inspection doors of suitable sizes shall have to be provided in filter and spray sections of each sheet metal Air Washer units.

The water shall be collected in a MS (6mm) fabricated tank and shall be re-circulated by means of the pump. This tank shall be complete with make-up connection with float valve, quick fill connection, drain connection with valve, water low level switch and overflow connection with siphon. Water from the washer chamber tank shall be taken through a primary screen type water strainer fitted in an accessible position in the tank. The strainer screen shall be manufactured of S.S netting in a S.S. Frame.

4.14.0 Unitary Air filtration unit

Unitary Air Filtration Unit shall consist of intake louvers with bird screen, pre filter, air distribution plates, one set of automatically cleanable type Stainless Steel mesh Filters with continuous water spraying arrangement over the surface of it to clean the filters, PVC die-extruded Moisture Eliminator sets after the above water flooded filters to eliminate the carry over of moisture, sump tank, circulating water pumps, piping and valves, centrifugal fans, outlet damper and plenum section. The entire components shall be neatly arranged and skid mounted and shall be self-enclosed by 3 mm thick MS casing duly painted with epoxy resin based paint. The casing front shall be provided with the air intake louvers with bird screen of GI construction. Each section i.e., filters, evaporative pad and pump section etc. shall be provided with access door for maintenance. All parts of the fan for this system coming in contact with moist air shall be epoxy painted. The fan section shall be designed to limit the noise level to 85 dBA within 1.0 m of the fan enclosure. On the whole, the assembly of UAF shall be designed so as to be structurally sound, air tight and also aesthetically pleasing.

The water shall be collected in a MS (6mm) fabricated tank and shall be re-circulated by means of the pump. This tank shall be complete with make-up connection with float valve, quick fill connection, drain connection with valve, water low level switch and overflow connection with siphon. Water from the washer chamber tank shall be taken through a primary screen type water strainer fitted in an accessible position in the tank. The strainer screen shall be manufactured of S.S netting in a S.S. Frame.

4.15.0 Centrifugal Fans

Centrifugal fans for Ventilation System shall be DIDW/SISW non-overloading type designed. Fan shall be driven with V-belt by a totally enclosed motor and the fan outlet velocity shall not exceed 11 m/sec.



Impeller shall be die formed aerofoil or laminar type of self cleaning and non-overloading characteristics. The impeller shall be statically and dynamically balanced according to ISO standard.

The fan casing shall be of welded construction and provided with flanges on inlet & outlet side for duct connection.

The fan impeller & casing etc. shall be protected by a suitable corrosion resistant.

Accessories like common base frame, anchor bolts, vibration isolators, V-belt guard, inlet guard and outlet damper, canvas etc., shall be provided. Centrifugal fans and drive motors mounted on common base frame to be mounted on spring type vibration isolators to prevent vibration transfer to floors as well as to the downstream side of duct.

4.16.0 Roof Extractors

Power roof extractor's impeller shall be of axial type. Casing shall be made of MS and impeller shall be made of aluminum. Hood of the roof ventilator shall be of hinged type providing easy access to motor and impeller. Mounting frame for mounting the roof ventilators shall be provided. Weather proof lockable type disconnect switch shall be provided such that, the hood can be opened only when the disconnect switch is in "OFF" position.

4.17.0 Axial Flow Fan

Directly driven axial flow fans with die cast aluminium impeller dynamically balanced, fitted with three-phase induction motor.

The fan casing shall be of galvanized steel material. Fan shall be provided with rain protection hood (for roof exhausted) / inlet cowl, filters (supply air fans), bird-screen, back-draft damper, (where necessary) grouting frame and cadmium plated fixing bolts.

For battery rooms, the wall mounted axial flow fan shall be of FRP coated cast aluminium impeller with blades of aerofoil design. The fan motor shall be externally mounted (outside the air path) on a bracket fixed to the casing with necessary V-belt drive. The motor shall be of explosion proof type.

4.18.0 Pre Filter

The pre filter section shall comprise of 50 mm thick washable filter panel suitably arranged in holding frames. The pre filter shall have a minimum efficiency of 90% down to 10 microns size. Maximum Velocity across pre filter shall be 2.5 m/s.

4.19.0 Air Distribution System (common for both air conditioning and ventilation) **Ductwork**

The ductwork inside the building shall be manufactured from hot-dip galvanized sheet metal, complying with IS-277 Gr 275 or better.

All ductwork support ties to the structure shall be made resilient with the use of 12mm thick non-intercellular neoprene strip, gaskets or washers. All ductwork connections to air handling equipment shall be made via 15 cm long connections of rubber impregnated canvas material.

Entire AC ducting shall be designed based on equal friction method and maximum velocity in the ducting shall be 7.5 m/s.



Maximum velocity in the duct shall be 11 m/s and velocity of air through supply air grilles shall be maximum 5 m/s for ventilation system.

Supports for Ductwork

Supports shall generally comprise hot-dipped galvanized mild steel sections and drop rods assembled in a suitable manner to permit adjustment for height and alignment of the ducts, and to prevent the transmission of vibration and/or noise.

Ducts shall be supported by the stiffening angles or angle flanges but where this is impractical, supporting angles shall be fixed to the ducts

Supply and Exhaust Air Grilles

In conventional attractive design, lamellas adjustable, aerofoil shape, broad front frame to allow airtight mounting. Frame and lamella made from steel with agreed stove enamel finish, conserved in nature color. Covered screw mounting with use of mounting frame shall be provided.

Air-flow control shall be by means of counter-moving, coupled lamellas, with sets of adjustable air deflection blades and an opposed blade damper located at the rear, adjustable from the front side.

Supply and Exhaust Air Diffusers

Square construction diffusers for mounting in false ceilings shall be provided. Air vanes in lamella form for air distribution to all sides, made from powder coated extruded aluminium with agreed finish, Connection boxes in air-foiled construction made of galvanized sheet metal with built-in throttling device and connecting piece.

Ceiling diffusers shall be of the adjustable eyelash deflection blade type and shall have an opposed blade damper located at the rear. The diffuser shall be fixed to the ductwork by a purpose-made sub-frame assembly.

Fire Dampers

The supply and return air ducts of air conditioning system and main duct of ventilation system shall be provided with automatic motor-operated fire dampers with fire rating of 120 minutes, at locations where ducts pass through wall/floors/ceiling slabs of electrical rooms in TG building & ESP building, for isolation/ maintenance/ fire-protection purpose. The operation of these automatic dampers shall be interlocked with the fire alarm system and shall also be possible to operate manually from the remote control panel. Required electrical contacts shall be provided in control panel of A/C plant for further wiring up to fire alarm panels.

Fusible link fire dampers of 60 minutes fire rating shall be provided for all other areas excluding electrical rooms where ducts pass through wall/floors/ceiling slabs for isolation/ maintenance/ fire-protection purpose.

Isolating Dampers

Consisting of frames of galvanized sheet metal, air foiled lamellas, adjustable from the outside by a lever and positioning device.

Lamella clutches by aluminium cogs mounted inside, bearing sleeves closed to the outside, including mounting flange for connection to an air-duct or mounting into an A/C-chamber.



Air Quantity Regulating Flaps

Air quantity regulating flaps for balancing, during first step of operation, of the mathematically-determined air quantities in each duct branch. These throttling devices shall be arranged in supply air ducts as well as in return air ducts.

Weather Louvers

Weather louvers shall be of hot-dipped galvanized angle-iron frame with built-in rain-rejecting galvanised iron or aluminium lamellas as well as bird protection screen of galvanized iron, Mounting frame of galvanized profile steel.

4.20.0 Insulation

4.20.1 Thermal Insulation

The entire supply / return air ducting shall be thermally insulated with 25 mm thk. fibre glass of 32 kg/cu.m. The exposed roofing also shall be thermally insulated.

The exposed roof slabs (Including beams and column etc.) of air- conditioning areas , air handling units room and Packaged Air conditioners (PAC) rooms will be insulated with 50 mm thickness fibre glass insulation of density 48 kg/m³ finished with 26 SWG aluminium cladding. For the portion ventilation system ducting exposed to outdoor ambient, thermal insulation of 25 mm fiber glass wool with aluminium cladding finished with sand cement plaster shall be provided.

4.20.2 Acoustic Insulation

The supply air ducting from each AHU outlet upto 5 meters shall be acoustically insulated with 12 mm thick resin bonded fibre glass of density 48 kg/cu.m covered with 30 G perforated aluminum sheets.

4.20.3 Chilled water pipe insulation

Chilled water piping shall be thermally insulated with expanded polystyrene of density 20 kg/cu.m and finished with sand cement plaster. The thickness of piping insulation shall be as follow.

Sl. No.	Pipe Diameter in mm	Insulation Thickness in mm
1	Upto 25 NB	40 mm
2	Above 25 NB to 125 NB	50 mm
3	150 NB	75 mm

5.0.0 CONTROL PHILOSOPHY

It is envisaged that primary operations including control and monitoring of TG building A/C system and monitoring of ventilation system shall be carried out from the AC and ventilation system local control room through the remote I/Os with the redundant Processor, power supply, communication module, redundant communication link with the main plant DCS. Apart from the DCS controls, selector switches and push buttons shall be provided for manual operation of all air-conditioning equipment.

Control, operation and monitoring of service building A/C system and monitoring of ventilation system shall be carried out from the PLC system located in the A/C control room of Service Building. Apart from the PLC controls, push buttons, selector switch shall be provided for manual operation of all air-conditioning equipment.



Control, operation and monitoring of CHP, AHP, ESP & Switch yard building A/C system shall be carried out from the respective air-conditioning equipment.

Operations of the ventilation equipment in TG building and ESP building shall be carried out from the respective ventilation LCP

Operation of the ventilation fans in other areas like AHP building, switchyard buildings, Compressor room, WTP room and all other buildings shall be carried out from the respective MCC.

One no. Local starter Panel shall be installed in each AHU room which will feed power to all the AHU fans, motors of 3-way mixing valves of AHUs, Fresh air fans (wherever applicable), Smoke Exhaust fans (wherever applicable) and their motorized isolating dampers, Fire damper motors, Electric heaters and Humidifiers. These equipment located in each AHU room shall be operated and controlled from the DCS operator stations located in the AC Plant Room as well as from this Local Starter Panel.

The Screw Chilling units shall incorporate microprocessor based control panel, which will also be interfaced with the DCS system.

The Screw Chilling units can be started only when its associated cooling tower fan, condenser & chilled water pumps are in operation.

All the drives of the AC system shall be manually started / restarted through DCS operator stations after any trip.

The chilled water system shall be provided with the following safety & operating controls:

(i) Operating Control

Room temperature control with the help of modulating 3-way chilled water flow regulating valve with the cooling coil of AHUs through the PLC system, getting sense from the temperature sensor and associated transmitter placed in the return air path.

Chilled water temperature shall be controlled based on the room load with the help of operating temperature sensor and through compressor's automatic unloading mechanism for screw chillers through the built-in Microprocessor based control panel of Screw Chiller. This control shall also be possible through the PLC system

One common PLC for Air-Conditioning System & Ventilation System shall be provided to control the followings.

- a) AC system for control building.
- b) AC system for ESP building.
- c) AC system for service building.
- d) Ventilation system (Air washers) for TG building.
- e) Ventilation system (UAF) for ESP building.

Further it may be noted that Control of auxiliaries buildings provided with split AC / package Units shall be independent of common PLC Control of auxiliaries buildings provided with dry ventilation system shall be independent of common PLC.

Room RH control with the help of humidifiers (if required) & duct mounted re-heaters through the DCS, getting sense from the RH & Temperature sensors and their associated transmitters placed in the return air path inside AHU rooms.

(ii) Safety Control

The chilled water system shall be incorporated with the following safety controls and interlocks:



- High discharge pressure cutout (HP).
- Low suction pressure cutout (LP).
- Low oil level cutout
- High winding temperature cutout through PTC sensors

Low chilled water temperature cutout by anti-freeze thermostat /temperature sensor for Screw chiller.

Cutout due to low flow of chilled water & condenser water by flow switches.

Cutout due to overload of all drive motors. High air temperature cutout by safety thermostat / temperature sensor for duct mounted electric heaters.

Safety controls of Screw chillers will also include Over/Under voltage and voltage unbalance protection, Single phase & Phase reversal preventer, over/under current and current unbalance protection and others as per manufacturer's standard.

Low cooling tower sump water level cutout for Condenser pumps. (Alarm for low water level in expansion tank & humidifier as applicable shall be provided).

Stopping of AHU fans in case of fire in the respective zone through the PLC.

Closing of fire dampers at the air supply duct from AHUs in case of fire with the sense from room mounted fire/smoke detector through zonal fire panel and the PLC.

(iii) Interlocks

The system components shall be interlocked with one another in the following way:

The Screw Compressor shall not start unless:

At least one cooling tower fan is running.

At least one condenser water pump is running.

At least one chilled water pump is running.

The duct mounted electric strip heater shall not be energized unless the respective AHU fans are running.

All the above Interlocking and the complete controls will be implemented in the respective control system mentioned above.. Whereas the chilled water temperature controls and the safety interlocks of the screw chillers shall be realized in the microprocessor based control panel as per the manufacturer's standard

On-Off-trip status for all the drives, electric heaters & humidifiers (if required) shall be available at the DCS operator stations located in the local control room of the AC and ventilation system

Motors of fire dampers provided in supply air duct of AHU shall remain energized in normal condition to effect opening of dampers. In the event of fire, the motors of fire dampers will be de-energized and the damper will close due to spring action, the relevant AHU fan motors will be tripped at the same time. These dampers shall be operated through the PLC getting signal from relevant duct mounted smoke detectors / fire alarm panel.

Provision for one common audio annunciation for any kind of malfunctioning in AC plant shall be kept through a hooter located in the AC Plant Control Room and suitably interfaced with the respective control system.



The DCS system shall be interfaced with:

- The Air Conditioning MCC cum PDB.
- The Microprocessor based control panels of Screw Chiller.
- The LCPs located in each AHU rooms.
- The Temperature and RH sensors and their associated transmitters located in the AHU rooms.
- The zone fire panels/ duct mounted smoke detectors.

6.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED ALONG WITH THE PROPOSAL

- Technical data sheet to be filled by Bidder.

7.0.0 DRAWINGS & DOCUMENTS TO BE SUBMITTED AFTER AWARD OF CONTRACT

- P&I Diagram Air conditioning System
- P&I Diagram Ventilation System
- DBR for Air Conditioning System
- DBR for Ventilation System
- Air conditioning System calculations
- Ventilation System calculations
- Specification for Air Conditioning System
- Specification for Ventilation System
- Equipment layout for Air conditioning plant room and AHU room
- Equipment layout for Air washer room and UAF room
- Ducting layout for AC and Ventilation system
- GA and data sheet for equipment for AC and Ventilation system
- Schematic duct layout for AC and Ventilation system

Any other drawings required for review during the detailed engineering stage, same shall also be submitted by contractor.



ANNEX – 2.17.1

SPECIFIED DESIGN DATA

Sl.No	Description	Unit	Data
A)	Chillers unit		
	Type		Water cooled Screw chillers
	No of units		3 x 50 %
	Flow		To suit system requirement
	Compressor		
	Type		Semi hermetic/
	Refrigerant		R134a
	Evaporator		
	Type		Flooded type shell & tube
	Condenser		
	Type		Shell & Tube
B)	Chilled /Condenser Water Pumps		
	Type		Horizontal split casing end suction top discharge Centrifugal pump
	No of units		3 x 50 % for chiller system and 2 x 100% for package air conditioning system
	Flow		To suit system requirement
C)	Air Handling Units		
	Type		Double skinned, horizontal floor mounted, draw through re-circulating type
	No of units		3 x 50 %
	Capacity		To suit system requirement
	Coil type		Chilled water type
	Coil construction		Copper tube with aluminum fins mechanically bounded
	Coil face velocity		2.5 m/s
	Fan		
	Fan Type		DIDW forward curved centrifugal fan
	No of fans per AHU		One
	Fan Outlet Velocity		< 10m/s
	Filter		
	Type		Pre Filter
	Filter material		Non Woven synthetic type, washable
	Filter efficiency		90% down to 10 microns
D)	Packaged Air Conditioners		
	Type		Water cooled type
	Area served		Refer clause 2.1.2
	Capacity		To suit system requirement
	No of units		N + 1, where N - no of working units, 1 no of standby unit
	Indoor unit		
	Cooling coil		Internally grooved copper tubing with slit fins
	Fan type		Centrifugal
	Compressor		Hermetically sealed Scroll
	Filters		
	Filter media		Non woven polyester media enclosed by HDPE mesh
	Efficiency		90% down to 10 microns
E)	Cooling Towers		
	Casing		FRP
	Redundancy		3 x 50 % for chiller system and 2 x 100% for package air conditioning system



Sl.No	Description	Unit	Data
	Air inlet louver		FRP
	Fill		PVC
	Nozzles		Bronze / Polypropylene
	Cold water basin		FRP
F)	Split Air Conditioners		
	Type		Air cooled type with 5 Star Rating inverter AC
	Area served		Refer clause 2.1.3
	Capacity		To suit system requirement
	No of units		N + 1, where N - no of working units, 1 no of standby unit
	Indoor unit		
	Cooling coil		Internally grooved copper tubing with slit fins
	Filters		
	Filter media		Non woven polyester media enclosed by HDPE mesh
	Efficiency		90% down to 10 microns
	Outdoor unit		
	Condenser coil		Copper coil with aluminum fins
	Compressor		Hermetically sealed rotary type
	Fan type		Propeller
G)	Air washer unit		
	Areas Served		Power house building
	Type		Spray type (Double bank)
	Flow		To suit system requirement
	Redundancy		All working
	Construction type		Sheet Metal type
	Casing		3 mm MS Sheet
	Tank		Minimum 6 mm MS Sheet
	Air Distribution Plate		18 - 24G GS Sheet
	Nozzle		Stainless steel/ Brass / PVC, Spray Nozzle
	Eliminator		PVC
	Spray Set Header		MS to IS 1239 / IS 3589
	Air intake louver		22 G GS Sheet with MS Angle Frame
	Filter		Flooded type stainless steel filter.
H)	Unitary Air filtration Unit		
	Areas Served		ESP building
	Redundancy		All Working. 2X50% UAF for each ESP building
	Type		Spray type (Single bank)
	Flow		To suit system requirement
	Construction type		Sheet Metal type
	Casing		3 mm MS Sheet
	Tank		Minimum 6 mm MS Sheet
	Air Distribution Plate		18 - 24G GS Sheet
	Nozzle		Stainless steel/ Brass / PVC, Spray Nozzle
	Eliminator		PVC
	Spray Set Header		MS to IS 1239 / IS 3589
	Air intake louver		22 G GS Sheet with MS Angle Frame
	Filter		Flooded type stainless steel filter.
I)	Air Washer/UAF Fan		
	Areas Served		Power house building
	Redundancy		2 nos of fan for each air washer and UAF
	Type		Centrifugal Fan, DIDW for Air Washer / SISW for UAF
	Casing		3.15 mm MS Sheet with spray galvanization
	Fan Shaft		EN8



Sl.No	Description	Unit	Data
	Fan Impeller		Mild steel spray galvanized
	Drive		Motor driven, coupled with fan through V-belt and Pulleys
	Outlet damper		18 G GS Sheet with 16 G Frame
	Other Accessories		Base Frame, Slide Rail, Belt Guard, Inlet Screen and Vibration Isolator to be provided
J)	Pumps for Air washer / UAF		
	Type		Horizontal split casing end suction top discharge Centrifugal pump
	No of units		3 x 50 % for air washer system and 2 x 100% for UAF system
	Flow		To suit system requirement
K)	Axial Flow Fan		
	Service		Supply/Exhaust
	Mounting		Wall/Roof/Duct
	Type		Tube axial/Propeller
	Capacity		To suit system requirement
	Redundancy for battery room exhaust fans		2x50%
	Material of construction		
	Casing		Mild steel plate to IS 2062
	Impeller		Cast Aluminium
	Shaft		EN 8
	Inlet Cone / Outlet cone		Mild steel
L)	Roof Extractor Fan		
	Service		Exhaust
	Mounting		Roof
	Type		Axial
	Capacity		To suit system requirement
	Material of construction		
	Casing		Mild steel plate to IS 2062
	Impeller		Cast Aluminium
	Shaft		EN 8
	Hood		MS

**VOLUME II****SECTION - 2.18****HYDROGEN GENERATION PLANT & CYLINDERS****1.0.0 GENERAL**

This section is intended to specify the detailed specification of the various mechanical equipments of the Hydrogen Generation Plant and Cylinders as covered in this specification.

The Hydrogen Generation Plant and Cylinders and associated accessories shall be designed, manufactured, inspected, tested, including supervision of erection, testing and commissioning to well established engineering practices, safety codes and other relevant codes and standards.

Compliance with this specification shall not relieve the Contractor of the responsibility of furnishing material and workmanship to meet the specified conditions.

2.0.0 CODES AND STANDARDS

The Hydrogen Generation Plant and all associated piping and systems shall be designed, manufactured, inspected, tested, to well established engineering practices and safety codes of the latest applicable Indian / British / American / DIN / ISO standards.

ANSI B 31.3	ASME code for process piping
BS: 5156	Diaphragm valves
AWWA C-504/BS 5155	Butterfly valves
IS 5120/ IS 9173	Pumps
IS 5312	Non return valve
IS 803	Storage tanks
OSHA, NEC, NEMA, ASTM, API 618	H2 Compressors
IS:7241	Glossary of terms used in cylinder technology
IS:7285	Specification for seamless steel cylinders for permanent and high pressure liquefiable gas cylinders
IS:8198	Steel cylinders for compressed gases (Atmospheric Gases, Hydrogen, High pressure liquefiable gas cylinders and dissolved acetylene gases)

3.0.0 SCOPE OF SUPPLY

The Hydrogen Generation plant will include but shall not be limited to the following:

- Two (2) nos. of Hydrogen Gas Generator / Electrolyser Units of Specified Capacity.
- One (1) no Common DM Water Storage Tank of required capacity with all necessary accessories and Instruments.
- One no KOH Tank for each Hydrogen gas Generator with necessary drain, vent, Chemical Filling line , Inlet, Outlet lines and all necessary Instruments.



- One no Motor Driven Electrolyser DM Pump for each Hydrogen gas Generator with all necessary Valves, Instruments and accessories for each stream.
- One no Dryer of Regeneration type for each Hydrogen Generator with necessary moisture traps, regeneration system, drains etc.
- Adequate nos. of Hydrogen storage tank with all accessories, Instruments and safety Equipments for each tank.
- Suitable nos. of Nitrogen Cylinders to Purge the Hydrogen Generator, with Nitrogen Cylinder Manifold, Valves, Instruments and Piping to Purge the Hydrogen Generator.
- Hydrogen piping manifold with necessary valves, Instruments, etc,
- All integral and interconnecting piping, valves , all types of pipe support, including pipe racks, etc for the entire Hydrogen Generation Plant .
- Any other equipment / accessory/component necessary for the effective, safe and efficient operation of Hydrogen Generation plant.

4.0.0 DESIGN REQUIREMENTS

The function of the Hydrogen Generation Plant system is to safely generate Hydrogen Gas of specified purity and store in the cylinders for use in Turbine Generator.

The Hydrogen Generation Plant shall be of 2 x 100% streams each of suitable Capacity of modular manifolds at 99.998 % (max) and dew point of -70°C. The moisture content in hydrogen shall not exceed 0.05 gm/m³. The complete hydrogen generation plant system equipments, layout shall be designed as per the guidelines of explosive authority (chief controller of explosives) of India and other statutory authorities for the design and installation of the plant. The hydrogen generation equipment (Electrolyser) shall be of **bipolar** design. The Production of each Electrolyser shall be variable between 20 and 100 percent. All the Piping and Valve material shall be of SS 316L grade.

Hydrogen Gas is generated by electrolysis of water, with KOH as the electrolyte. The water used here is DM Water, which is fed from a DM Water Storage Tank to Electrolyte Making Tank where the electrolyte will be mixed to form a solution of the required strength (28% KOH solution). The electrolyte solution is then pumped with the help of 1 x 100% electrolyte making pump to the Hydrogen Generator where the actual electrolysis process takes place. AC power will be supplied to silicon rectifier, which shall provide DC power to operate a battery of cells. By electrolytic process of water, each cell shall produce two (2) parts of hydrogen and one (1) part of oxygen.

The hydrogen thus generated from each battery of cells is passed through a catalytic hydrogen purifier to remove any traces of O₂ present.

Moisture from hydrogen shall be separated through an adequately sized Dual Tower Desiccant Dryer and then passed through a Hydrogen storage Tank of suitable capacity manufactured to IS or equivalent standards. From the Hydrogen storage tank, the gas shall be compressed and stored in the cylinders. The hydrogen cylinders shall be used for the generator cooling. Nitrogen Manifold is provided for adequate purging of the system.

5.0.0 TECHNICAL REQUIREMENTS

Hydrogen is proposed to be generated along with oxygen by electrolytic dissociation of water into its basic constituents:

The generated hydrogen gas output shall be regulated to a set value of an automatic control system, which regulates the electrical input. The plant utilising this process shall take up less space and there shall not be any problems in respect of water contamination, air pollution or



noise etc. The basic components of the hydrogen generation plant are as following, but not limited to the same.

5.1.0 Electrolyser

The Electrolyser shall be of modular type having Bipolar type Cells and shall be connected to each other to form a single unit. The cells and Electrodes in the Electrolyser shall be of corrosion resistant Material. The electrodes of the cells shall be such as to distribute the current evenly on the entire surface of the electrodes. Between the anodes and cathodes there shall be a diaphragm of woven pure asbestos for separating the gases generated in this space.

The Electrolyser will be designed to operate at part load of normal capacity without any disconnection and operation interruption and shall produce the hydrogen gas of specified parameters. All measuring instruments for Pressure, Temperature, controllers and control valves shall be provided. Safety devices will be provided to release the gas pressure, in case it goes above the limits.

The Electrolyser Cells shall have Diaphragms in between the electrodes in such a manner to prevent mixing of the Oxygen and Hydrogen gases. The design shall take care of avoiding or minimizing the Carryover of Electrolyte downstream of Electrolyser. The Cells shall be designed in such a way that they can be cleaned and maintained easily.

Sampling of H₂ gases from each cell with sight glass shall be provided for safe sampling & handling.

The mixing, filling, replenishing of electrolyte shall be required only during maintenance periods and not during normal operation.

The Electrolyser shall be protected against accidental grounding, arcing or electrical shock.

The level of electrolyte shall be automatically controlled.

5.2.0 Rectifier

For each electrolyser, transformer-rectifier set adequately sized to cater to the load demand shall be provided. The rectifier equipment shall be complete in all respects with air-cooled rectifier transformer, thyristor converter, electronic control and annunciation, filter choke etc. mounted on suitable panels.

5.3.0 Caustic Solution Tank

The electrolyte is typically stored in carboys and then drained or poured into the Caustic solution Tank with the aid of funnel provided for this purpose. The tank shall be of HDPE construction with flape type cover, half type. The outlet of transfer pump is connected to electrolyte during initial filling or make-up when gravity of electrolyte falls below a recommended density through quick coupler.

5.4.0 Hydrogen Dryer or purifying unit

The Purified Hydrogen from the catalytic Hydrogen Purifier shall be passed through a Dual Tower Desiccant Dryer unit filled with high performance molecular sieve and with heaters and related RTD of suitable Design to remove any moisture present in the Hydrogen gas. The Dryer shall have all necessary filters, valves, instruments etc.



5.5.0 Hydrogen Storage tank

Two Nos (2) of H₂ storage Tanks shall be considered between the H₂ Generator and Compressor for stability of pressure which acts as buffer cum suction pot. The volume of the tank shall be suitably decided by the Contractor and its working pressure shall be minimum 16 bar (g). The M.O.C shall be 16 MnR (SA 516 Gr. 70).

Design pressure of the Buffer Vessel shall be 32 bar (g).

Capacity of each tank shall be minimum 400litres

5.6.0 H₂ Charging Manifold

Minimum 2 nos of Hydrogen Gas Cylinder Manifold for cylinders shall be provided.. Each manifold shall be capable of simultaneous filling minimum 6 cylinders. Sufficient quantity of high pressure manifold valves, pressure gauges, non-return valves, high pressure unions for filling connection, temperature gauges, high pressure safety valves, water seal posts, high pressure brass fittings, copper pig tails for cylinder manifold, flash back arrestors, adaptors, regulators, and all necessary copper piping shall be part of cylinder manifold filling of hydrogen at a maximum filling pressure of 150 – 160 Kg/Sq.cm (g) shall be provided. The safety valve set pressure is 150/160 bar (g).

5.7.0 Catalytic Hydrogen Purifier

The hydrogen gas from the Electrolyser shall flow to the catalytic hydrogen purifier, which shall be capable of removing oxygen as impurity from the hydrogen gas to achieve the hydrogen purity of 99.998%.

5.8.0 DM Water & Electrolyte Mixing System

The electrolyte used shall be 28% KOH solution. In electrolyzer, water is consumed continuously, hence DM water system shall be considered.

Electrolyte making pump

Used for making electrolyte, pumping electrolyte into system or drawing electrolyte back into electrolyte tank.

Electrolyte Making Tank

It is used for making electrolyte by mixing with water. The volume of the electrolyte making tank shall be decided suitably by the Contractor. The M.O.C shall be SS304.

DM Water Pump

Used for feeding water into the system. Normally, the interval of feeding water is about 2 hours and finished in 10 minutes. The feed water pump capacity shall be decided suitably by the Contractor & pressure shall be 16-18 bar (g). This high pressure is required in order to pump water into system.

DM Water Storage tank

Two numbers DM Water Storage Tank of Capacity adequate enough for 5 days normal requirement of hydrogen gas generation on continuous basis at rated capacity of the Hydrogen generation Plant. Tank will be fitted with drain connections, level transmitters, level indications. The Tank shall be of HDPE construction. Water level shall be controlled via a solenoid valve with float type level switch assembly mounted at tank top.



5.9.0 Gas Washer

The gases coming out of separators shall be hot and saturated with lye containing water vapour. The gases shall be washed by DM water being circulated by a pump. The heat absorbed by the circulating water shall be dissipated by heat exchangers.

5.10.0 Gas Holder

Two gas holders for hydrogen shall be provided so that hydrogen gas flow to the holder from gas washer. However if Hydrogen storage cylinder exists between the generator and compressor, gas holder shall not be required.

5.11.0 De-Oxy Unit

The hydrogen gas from gas holder shall flow to de-oxy unit. The de-oxy unit shall be capable of removing oxygen as impurity from the hydrogen gas to achieve the hydrogen purity of 99.998%.

5.12.0 Gas Cooler

A gas cooler for H₂ coming out of the de-oxy unit shall be provided to cool the hot H₂ gas.

5.13.0 Hydrogen Compressors

A quantity of three (3), two-stage triple diaphragm hydrogen compressors is proposed for the compression of the hydrogen product. Each unit will be designed to compress required capacity of hydrogen gas. Two-stage triple diaphragm compressors proposed in this system incorporate a unique combination of simple design features to provide the best compressor benefits available in the market today for preserving the purity of the hydrogen product.

5.14.0 Quality Standards

The hydrogen gas produced shall conform to IS: 1090 Gr.I

5.15.0 Location

The Hydrogen Generating equipment shall be located indoor in a building specified.

The Building Areas shall be considered for classification in accordance with NFPA 70 and NFPA Documents referenced therein. Equipments supplied for areas which are classified hazardous or potentially hazardous shall comply with the requirements of NFPA 70 and referenced NFPA documents. Equipments with standard electrical protection maybe installed in separate unclassified areas as defined by NFPA70 and NFPA documents referenced therein.

6.0.0 CYLINDERS

Number of hydrogen gas cylinders for the unit shall be assessed in accordance with the following guideline

$N1 = L \times 30 \times N$ where

$N1$ = Total number of hydrogen gas cylinders to be installed.

L = Normal leakage rate per day (shall be assumed as minimum 5 cylinders per day)
Bidder shall be informed the normal leakage rate per day during detailed engineering.

N = Number of generating units (2 for this project).



The number of hydrogen cylinders required for the unit shall be as computed above or 300, whichever is higher.

Number of carbon-dioxide gas cylinders for the unit shall be assessed by following guidelines:

$$N_2 = \frac{M \times L}{V} + X \text{ where}$$

- N_2 = Total number of CO₂ cylinders required
 M = No. of fills required (to be taken as minimum two numbers)
 L = Total fill required for each turbo generator in Nm³
 V = Volume occupied by CO₂ in each cylinder, in Nm³
 X = No. of cylinders to be kept in stock additionally to account for unforeseen eventualities

The number of carbon di-oxide gas cylinders shall be as computed above, or 50, whichever is higher.

The total number of Nitrogen cylinders required for each unit shall be Forty (40) minimum.

The water holding capacity of each cylinder shall be 46.7 litres

N₂ Cylinder shall be hydro tested at a pressure of 250 kg/cm²(g) (minimum)


ANNEX 2.18.1
SPECIFIED DESIGN DATA

S.NO	Description	Units	Data
1.0	H₂ Generator and Accessories No. required / service Capacity Type Location	Nm ³ /hr	Two (1W+1S) Not less than 12Nm ³ /hr Electrolyser Indoor
2.0	Electrolyser Type		Bi Polar
3.0	DM Water Tank Type Orientation		Cylindrical Horizontal / Vertical
4.0	Lye Tank Type		P.V.C (High density) pre-fabricated with suitable mixing arrangement
5.0	Gas Washer Type		Direct cooling & washing by DM Water
6.0	Gas Holder Type Capacity	min.	Vertical Rising Bell (or) Any suitable arrangement 5 minutes hold up
7.0	De-Oxy-Unit Type Purity required at the outlet of the De-Oxy-Unit		Contractor to indicate 99.998% Hydrogen
8.0	Gas Cooler Type Orientation Gas temperature required at the outlet of cooler	°C	Shell & Tube (or) Any suitable type Vertical / Horizontal 40
9.0	Coalescence cum Activated Carbon Filter Type Rated flow Rated pressure Oil traces at down stream Accessories	Nm ³ /hr. Kg/cm ² (a) ppm	1 No. Pre-filter + sibmicron (duly assembled) Contractor to indicate 150 0.2 max. Drain valves & clogging indicator
10.0	Drying System for H₂ Gas Type Orientation		Moisture separating column type with automatic drain system Vertical



S.NO	Description	Units	Data		
11.0	Compressor and Accessories No of compressor Type	No's	3(2W+1S) two-stage triple diaphragm		
	Rated flow	Nm3/h	Contractor to indicate		
	Rated pressure	Kg/cm2(g)	150		
	Cylinder Manifold Type		Dual filling		
12.0	Purity Testing Instruments Gas analyser Recorder		Contractor to indicate Contractor to indicate		
13.0	Cylinder Pressure Testing Facility Cylinders		Contractor to indicate		
			H2 Storage Cylinder (Minimum Requirem ent)	CO2 Storage Cylinder (Minimum Requirem ent)	N2 Storage Cylinder (Minimum Requirem ent)
1	Number of cylinders (minimum)		As per clause 6.0.0		
2	Fluid handled		Hydrogen gas	CO2 Gas	N2Ga4
3	Purity		99.998%	99.9%	99.9%
4	Material of cylinders		Manganes e steel	Manganes e steel	Manganes e steel
5	Bottom shape of cylinders		Convex inwards so that the Cylinders can be kept in standing position.		

- Note:** 1. Suitable audio visual alarming devices shall also be included in the purity testing instrument system to give audio visual alarm where the purity of the hydrogen gas decreases below 99%.
2. The specified data is indicative and shall be minimum requirements for the equipment supplied.



VOLUME II

SUB-SECTION 2.19

CRANES AND HOISTS

INDEX

SUB-SECTION NO.	TITLE
2.19.0	MAIN SECTION
2.19.1	DOUBLE GIRDER EOT CRANE
2.19.2	SINGLE GIRDER EOT CRANE
2.19.3	HOISTS



VOLUME II
SUB-SECTION - 2.19.0
CRANES & HOISTS

1.0.0 GENERAL

This part of the specification covers the requirements for Cranes and Hoists.

This section of the specification shall be read in conjunction with other sections of the specification as appropriate and the equipment offered shall meet the requirements as spelt out therein. The system shall comprise of cranes and hoists.

2.0.0 SCOPE OF SUPPLY

The scope of supply shall have to meet all the requirements to make the system complete as per specification and for satisfactory performance guarantee of the complete crane and hoist.

Crane and Hoist shall be provided in the following area considering the design requirement of crane and hoist.

Crane:

- a) Two number of EOT crane for Power House building.
- b) GIS building
- c) BFP and its auxiliaries and its drives
- d) CW pump house
- e) Sea water intake pump house
- f) Screens and gates
- g) Desalinated water pump house
- h) Filtered water pump house
- i) Sea water outfall pump house
- j) Fuel oil pump house (unloading and forwarding)
- k) Air Compressor room (Instrument and service air)
- l) Ash Slurry pump & ash water pump house
- m) Recovery water pump house
- n) Conveying air compressor room
- o) Ash clarified water tank and pump house
- p) Sea water tank and ash slurry pump house.
- q) One number of 15T EOT crane for Store
- r) One number of 10T EOT crane for Workshop
- s) DG set building
- t) Any other areas as applicable

Hoist :

- a) Boiler area(ID fan, FD fan, PA fan, Boiler circulation pump, coal feeder area, Air preheater, seal air fan)
- b) ESP
- c) Bottom ash silo, fly ash silo and mill reject ash silo
- d) Mill reject compressor
- e) Power house building(Vacuum pumps, CEP, DMCW pumps, ACW pumps, butterfly valves at condenser inlet and outlet, condenser water box, Lube oil unit, control oil unit and central lube oil system)
- f) Electro Chlorination building
- g) Desalination building



- h) Gravity filtered pipe gallery
- i) Coal Handling System (Crusher House, Transfer towers, Head/Tail end of conveyors, Bunker building, flap gate, flow divider, junction tower, ERH, etc.)
- j) Water treatment plant, Effluent treatment plant and Sewage treatment plant
- k) Sea water intake pump house stop-log gates and screens.
- l) HVAC Building.
- m) AC plant,
- n) Fuel Oil Pump House,
- o) ETP
- p) Air Washer Room
- q) Chemical house
- r) Hydrogen generation building
- s) Any other areas as applicable

2.1.0 Crane

Crane shall be provided complete with all accessories as specified under, but not limited to the following:

- a) Box type steel bridge girder complete with bridge rails, end stoppers, walkway platforms across the span of either side of crane and access ladders for double girder crane, (cabin for TG hall EOT crane, etc
- b) End carriage complete with minimum two (2) nos. of wheels for each end carriage and access ladders from gantry platforms, spring buffers etc.
- c) Service cage with all protections and access ladder, for maintenance of DSL's.
- d) Crab (trolley) with wheels and drive equipment for hoists and trolley complete with motors, gear reducers with Suitable arrangement for collection of oil spillage, brakes, limit switches, couplings, rope drums, wire ropes, main hook, auxiliary hook, end stoppers etc.
- e) Set of crane longitudinal drive equipment complete with motor, gear reducers with Suitable arrangement for collection of oil spillage, brakes, shaft bearings, gear pinions, and limit switches.
- f) EOT crane runway gantry rails complete with fixtures comprising of fixing clamps (machined to suit rail flange contour), bolts, nuts etc for effective crane longitudinal runway length, end stoppers specified.
- g) Brakes for all motion, Anti-collision switch for TG hall EOT crane and limit switch for over hoisting/lowering, CT and LT motion.
- h) Runway conductors & bridge cross conductors with accessories.
- i) Crane shall be operated through Pendant Push Button station. TG hall EOT crane shall be operated from cabin as well as Pendant Push Button station.
- j) Crane buffer stops shall include the buffers on the crane itself. The stoppers to be fixed on the building frame and wheel stoppers shall be provided at either end of the crane runway.
- k) Lifting beam, loose slings and cradle shall be provided as required.
- l) The complete electrical equipment basically including:
 - Load break changeover switch mounted on the building structure.



- Cabling between the load break switch and the down shop leads.
- Down shop leads and current collector for crane.
- Load break switch on the crane bridge walkway
- Protective and control switch gear
- Motors
- Festoon cable system for crab
- Master controllers
- Pendant controller (where specified)
- Wireless remote control (where specified)
- Indicating lamps, push buttons.
- Lighting panel, lighting fixtures, Cabin fan, light, alarm/bell, socket outlets etc.
- All power and control cables.
- Cable trays & supports, Conduits, Cable glands, lugs & clamps etc.
- Crane earthing system
- Variable Voltage and Variable Frequency (VVVF) control for speed control of crane motors.
- Electronic Anti-collision device

2.2.0 Hoist

- a) Electrically operated trolley suspended, mono girder type hoists complete with drive motor.
- b) Hoisting cable, hoisting block and hooks complete with drive motor.
- c) Limit switches to prevent over travel while hoisting and lowering of the hook.
- d) Limit switches to prevent over travel of hoist assembly at both ends.
- e) Runway conductors for feeding power to trolley assembly.
- f) Pendant control stations suspended from hoist.
- g) Monorails for the travelling of hoist assembly.
- h) Brakes for hoist and trolley motion.
- i) Protective and control switch gear
- j) Motors
- k) All power and control cables including Festoon cable system
- l) Conduits, Cable glands, lugs & clamps, earthing etc.

2.3.0 Lifting tackles

The crane installations shall be supplied with all the ropes (slings), lifting beam (if required), chains, shackles etc. needed for maintenance of the plant equipment/component.

The minimum scope of supply per handling equipment (crane & hoist) for each lifting tackle includes the following items:

- Two (2) nos. single ropes each with 2 eyes at the ends, each rope 2 m long
- Two(2) nos. single ropes each with 2 eyes at the ends, each rope 4 m long
- Four (4) nos. shackles.

The load-bearing capacity of the ropes and shackles must be suitable for the relevant crane & hoist.

The maximum tension in the rope shall not exceed 1/8 of the calculated braking capacity of the rope. The ropes shall be of the stranded type, and galvanized wires shall be used.

The eyes of the single ropes must be secured with compression fittings. The length of the eyes must be at least 15 times the nominal diameter of the rope.

In special cases, where safe lifting of the relevant component is not certain, specially-made devices shall be provided. At least two (2) of these shall be provided in each individual case.



For each installation a list shall be submitted, showing the number, type, nominal load-carrying capacity and strength characteristics of the materials used. In addition, factory and acceptance certificates shall be submitted for all ropes (slings) and materials.

3.0.0 DESIGN REQUIREMENTS

- a) Cranes & hoist shall be provided in the areas where handling of the equipment /component to be lifted for maintenance weighing above 300 kg..
- b) The cranes and hoist designed to operate at 100% safe working load and subjected to over load test at 125% of rated load.
- c) The Turbine Building EOT crane is required to handle the heaviest component other than the generator stator. The main hoist is used for maintenance of the main steam turbine and electric generators, generator coolers, condensate pumps, lube oil units and other equipment located in power house building. The auxiliary hoist is used to handle smaller components more rapidly.
- d) Cranes and hoist shall be designed considering the ambient temperature of 50 °C.
- e) The cranes and hoist would be designed considering for hazardous area or non hazardous classification as required.
- f) Crane and hoist control shall be from Variable Voltage and Variable Frequency (VVVF) drive. Creep speed shall be achieved through VVVF drive for cranes.
- g) The hoists shall be provided with flexible trailing cable system.
- h) Manual Hoists shall be operated at floor level by means of endless chain.
- i) Specification for the gantry/semi gantry crane shall be referred from the single or double girder crane (based on the type of crane)
- j) The CW Pump house EOT crane shall be rated for the heaviest component to be handled in the CW Pump house.
- k) The lift for the CW Pump house EOT crane shall be based on lifting the circulating water pump out of the pump suction flume onto the maintenance floor area.
- l) Layout Considerations: The span of EOT cranes shall be derived based on the building layout with considerations to clearances and hook approach to handle all equipments.
- m) At crane girder level, Access walkway of minimum 500 mm width with safety handrails on one side shall be provided along the full span length of the cooling water building crane and other double girder cranes except TG hall EOT crane.
- n) At crane girder level, Access walkway of minimum 500 mm width with safety handrails on both side shall be provided along the full span length of the TG hall EOT crane.

3.1.0 Sizing Criteria

- a) The TG hall crane capacity shall be taken as 10% more than the single heaviest equipment/component to be lifted. And other cranes and hoists capacity shall be selected by considering 20% margin over the weight of the component to be lifted.



b) Crane and hoist selection criteria

Crane shall be provided in the areas where the handling of the equipments / components shall have requirement in both transverse and longitudinal direction. Otherwise, hoist shall be considered. Curved monorail with hoist shall also be considered, if the equipments / components are located inline with the monorail. Height of the building shall be finalized considering the required lift over other equipments, piping etc.

Type of Handling equipment	Crane & Hoist's Safe working load (SWL)
CRANE	
Double Girder EOT Crane	> 7.5T
Single Girder over head / Under Slung cranes	$\leq 7.5T$
HOIST	
Electric hoists	≥ 1000 Kg
Manual hoists with trolley	> 300 Kg and < 1000 Kg

Note: Electrical hoists shall be provided at all equipments / components location which has a lift more than 10 m (for all >300 kg and < 1000 kg). Hook shall be provided for all possible maintenance location for the weight less 300kg. Hoists shall also be provided if required specifically as mentioned in respective section..

- c) Auxiliary hoist shall be provided, for TG hall EOT crane and CW pump house EOT crane. AH capacity shall be rated for a minimum capacity of 20% from the main hoist capacity or 20% more than the single heaviest equipment/component to be lifted whichever is higher.

- d) For guidance purposes the following crane speeds shall be considered:-

	Double girder Cranes	Single Girder Crane
• Main Hoist	1m/min (for TG hall EOT crane) 2m/min (for other cranes)	2.5 to 5m/min
• Aux Hoist (if applicable)	5m/min	N/A
• Trolley Travel	10 m/min	10 to 15 m/min
• Bridge Travel	15 m/min	15 m/min
• Creep speeds	10% of operating speeds for all motion	

- e) Speeds for the electric hoist shall be

- Hoisting speed 3.5 m/min to 5 m/min
- Travel speed 5 m/min to 10 m/min
- Creep speeds 10% of operating speeds for all motion

**4.0.0 DOCUMENTATION****4.1.0 Drawings, data / documents to be submitted along with bid**

- 4.1.1 Completely filled up technical schedules and data sheets of tender documents
- 4.1.2 Crane clearance diagram showing various dimensions/data. (Including highest crane hook position, safe working load etc.)
- 4.1.3 General Arrangement Drawing of the E.O.T. crane assembly.
- 4.1.4 Wheel Loading Diagram.
- 4.1.5 Detailed drawing showing the features of the components of the Crane Bridge and trolley.
- 4.1.6 A detailed write-up on the crane control system. Drawings and data sheets showing the particulars of the controllers, switches, contactors, relays, other control devices and limit switches.
- 4.1.7 General arrangement drawing of protection, control and lighting panels.
- 4.1.8 Electrical /Control Schematic diagrams.
- 4.1.9 Equipment arrangement drawing.
- 4.1.10 Quality Assurance Plan /Inspection and Test Plan (ITP).
- 4.1.11 Field Quality Plan
- 4.1.12 List of tests to be conducted at shop and at site.
- 4.1.13 Testing procedures.
- 4.1.14 A comprehensive write-up and /or brochure on the details of the manufacturing facilities and the test facilities in the shop of the supplier..
- 4.1.15 Detailed engineering, manufacturing, delivery, erection and commissioning schedule and PERT chart.
- 4.1.16 Details of similar job executed in last five years.
- 4.1.17 Lubricants list (with quantities for initial fill and make-up).
- 4.1.18 List of erection and commissioning spares for each crane.
- 4.1.19 List of recommended O&M spares for 3 years normal operation.
- 4.1.20 List of Special Tools & Tackles.
- 4.1.21 List of makes of bought out items.
- 4.1.22 End user certificates.

4.2.0 Drawings, data / documents to be furnished by the successful bidder

	Description	Approval Category
4.2.1	Technical data sheets	A
4.2.2	Crane clearance diagrams showing various dimensions.	A



Description		Approval Category
4.2.3	Drawings showing general arrangement, clearance requirement, assembly, cross sectional data and material of construction for : a. E.O.T. Crane Unit b. Bridge Assembly and Components c. Bridge and long travel and Wheel Assembly d. Trolley e. Trolley Wheel Assembly f. Drive and Transmission Unit for Bridge Travel, Trolley Travel, and Hoist g. Suspension Unit for Hook Block h. Main Hook Block i. Protection, control and lighting panels. j. Electric hoist k. Manual hoist	A
4.2.4	Drawings on runway rails, fixtures to fix runway rails with the runway main girder and stops etc.	A
4.2.5	Design calculations of the following : Bridge girder, Rope drum, Machinery Shafts, Gearbox excluding proprietary items, Motor rating, Brake capacity, Bearing life, Wheel loading and current collector, angle iron conductor sizing.	A
4.2.6	Leaflets on proprietary items such as motors, brakes, gear box, coupling etc.	A
4.2.7	Electrical documents as listed in respective sections.	A
4.2.8	Material test certificates, including those for the Hooks and wire rope.	I
4.2.9	Report on various tests at shop and at site and certificates of approval by authorised authority for all flame proof components and test reports for the same if required.	I
4.2.10	Quality plans/ Inspection test plan and Field Quality Plan	A
4.2.11	Erection Manual	I
4.2.12	Operation and Maintenance Manuals	I

4.3.0 To be submitted after the award of contract:

- Completely filled in technical Schedules.
- Dimensional General arrangement drawing for Panels, Main Switch, Master controller etc.
- Schematic wiring diagram for Panels.
- Dimensional General arrangement drawing for Motors, Brakes etc
- Characteristic curves for Motors.
- Load requirement for each crane / hoist
- VVVF Control Features.
- Control write-up for tandem operation.
- Catalogues for the all the electrical items such as cables, brakes, limit switches, relays, meters, etc.
- Quality Plans for agreed list of equipments.



- Type test certificates.
- Sizing calculation for DSL.
- Sizing calculation for Motors & Brakes
- Sizing calculation for Cables.
- Lighting arrangement.
- Earthing layout drawing.
- Cable routing drawing.

4.4.0 Any other drawings required for review during the detailed engineering stage, same shall also be submitted by contractor.



VOLUME II
SUB-SECTION - 2.19.1
DOUBLE GIRDER EOT CRANE

1.0.0 CODES AND STANDARDS

The design, manufacture, erection and testing of the crane shall conform to the latest edition of the following codes and standards along with their amendments:

IS 3177	Code of Practice for Electric Overhead Travelling Cranes and Gantry Cranes other than Steel Works Cranes.
IS 807	Code of Practice for Design, Manufacture, Erection and Testing (Structural Portion) of Cranes and Hoists.
IS 325	Three Phase Induction Motors.
IS 2223	Dimensions of flange mounted ac induction motors (First Revision)
IS 1231	Dimensions of Three-phase Foot-mounted Induction Motors (Third Revision).
IS 2062	Steel for General Structural Purposes.
IS 2266	Steel Wire Ropes for General Engineering Purposes.
IS 3443	Crane Rail Sections.
IS 15560	Point Hooks with Shank up to 160 Tonne specification
IS 5749	Forged Ram shorn Hooks.
IS 3813/4164:	Specification for 'C' Hooks.

Any other International standards such as ASTM / ASME / ISO / DIN / JIS for design of coal handling system shall be followed.

2.0.0 DESIGN CRITERIA**a) Deflections and Camber**

- i. The total maximum vertical deflections of the girders for the safe weight of working load plus the weight of the crab in central position (without taking into consideration the impact factor) shall not exceed limit of span/900 as specified by the relevant IS 807 or any other code whichever is having higher deflection shall be taken for limit.
- ii. The girder shall be cambered by an amount equal to the maximum deflection due to dead load plus one half the live load and trolley.

b) Hooks

Hooks shall have swivels and safety latch.



c) Hoist rope

The rope shall be of flexible plough steel with lubricated hemp (fibre) core construction. Attachment to the rope shall be provided for fastening to the drum. Rope shall be of sufficient length so that drum has two full turns when hook is at the lowest position.

d) Drums

Rope-drums shall be grooved and welded steel conforming to IS 3177. Drum shall have minimum one spare groove when this hook is at its highest position.

e) Sheaves

Rope sheaves shall be of cast steel or fabricated steel with anti-friction bearings. Sheaves shall be fully guarded to prevent rope coming off.

f) Gears

Gears shall be cut from solid cast or forged steel blanks or shall be of stress relieved welded steel construction. Pinions shall be of forged carbon or heat treated alloy steel.

Split gears shall not be used. Gears and pinions shall be totally enclosed for all motions and must be dust proof and prevent oil leakage. Gear boxes shall have oil bath type for lubrication. Gear boxes shall have covers split horizontally for inspection.

Necessary oil level indicator, Drain plugs, Lifting lugs and guards shall be provided.

g) Bearings

Bearings shall be of ball or roller type only. All anti-friction bearings shall be of approved make, which are interchangeable with corresponding size bearings of other make. Bearing housings shall be of split type or so designed to permit easy removal of the shaft. The design shall be such that there is no ingress of dust and oil or grease does not leak out. Drip pans shall be provided to accept accidental leakage and drippings. Bearings shall have minimum life expectancy of 10,000 working hours.

h) Shafts, Axles, coupling, and Keys

Shafts and axles shall be made of forged steel and shall have ample strength, rigidity and adequate bearing surface for intended duties. Shafts and axles shall be accurately machined and properly supported. Shafts shall, as far as possible, be furnished straight. If shouldered, these shall be provided with fillets of ample radius or shall be tapered to avoid loss of strength and stress concentration. These shall be designed considering allowances for keys and splines.

All couplings shall be of steel. Flexible gear type coupling shall be provided

Keys and keyways shall conform to IS 2048 / 2291 / 2292 / 2293 as applicable.

i) Jacking pad should be provided to facilitate replacement of all bearings and wheels.

j) Sweeping plates shall be fixed to both ends of the end carriages.

k) Guard shall be provided on crane to prevent the hoist ropes coming in contact with down shop leads. Suitable guards shall be provided to revolving shafts, coupling etc.



- l) Steel made rail stops shall be provided at ends of rails for bridge and trolley welded to crane girders to prevent creeping of rails and running off of trolley. Stops shall match wheel radius for double/single girder overhead crane and buffers shall be provided as required.
- m) The span of EOT cranes shall be derived based on the final building layout with considerations to clearances and hook approach.
- n) Bridge and trolley frames shall be of fabricated structural steel sections. Mountings shall be designed to facilitate easy removal of the wheels, bearings and journals.
- o) Buffers shall be provided on trolley and bridge frames to absorb shock of impact without transferring to the frame.
- p) Crane Bridge shall be driven by two independent end drives.
- q) Wheel bases for end carriage shall not be less than 1/5 of the span or as per IS.3177
- r) The push button station shall be supported independently, earthed separately independent of suspension and shall comprise the following push buttons and indicating lamps:
 - i. 'Start' and 'Stop'
 - ii. Long travel - 'Right' and 'Left'
 - iii. Cross travel - 'To' and 'From'
 - iv. Hook - 'Hoist' and 'Lower'

Red lamp shall indicate supply 'ON'. All push buttons shall be hold-to run' type.

- s) Operator cabin for TG hall EOT crane

The operation cabin shall be enclosed type with ample space for mounting control panel. 4 to 6 mm shatter proof glass above 1m height of cabin on 3 sides shall be provided. The main control panels shall be mounted on the crane bridge.

The cabin shall be designed to give the operator clear view of the equipment being lifted in the bay. The operator's seat shall meet the above requirement and shall be comfortable. The cabin shall be adequately illuminated. The Cabin shall be air conditioned (window A/C type). Audible alarm and plug points shall be provided.

Apart from above the cabin shall have following requisites,

- Master controllers for all motions.
- Emergency stop push button
- Foot switch for alarm or bell
- Switches for lighting fixtures
- Switches for cabin fan.
- Operator's chair.
- Cabin light.
- Annunciation.
- Two (2) nos. of industrial socket.
- A foot operated type – electric warning horn/gong shall be provided at outside the cabin
- Deadmans handle/control for each of the crane motion shall be provided.
- Cabins Platform shall be provided with 10mm thick rubber sheet on the floor to comply with I.E rules.



The cabin and ladder shall be arranged as to prevent personnel from making accidental contact with run way conductors. One number of CO₂ type Fire extinguisher and tool box shall be provided in the cabin. Three number of CO₂ type Fire extinguisher shall be provided in the crane bridge girder. Cabin size shall be not less than 2.5m x 1.8m with 2M minimum clear height.

- t) EOT cranes conforming to Group M5 for Mechanical, Structural and M7 for Electrical of IS:3177 – 1999 shall be designed, manufactured, inspected, shop tested, erection, site testing and commissioning to well established engineering practices, safety codes and other relevant codes and standards.
- u) Safety arrangements shall be incorporated to prevent damage to motors on account of mechanical overload and electrical faults and to gearing shafts, etc. due to over stressing and other detrimental conditions.
- v) All materials / components shall be of tested quality and shall conform to the specification requirements and standards mentioned. Test certificates for MOC supplied shall be furnished for acceptance.
- w) For load carrying members the component plates, bars, angles and other rolled sections shall be minimum 8 mm thick.
- x) No cast iron part shall be used on the crane except for electrical equipment. However, in case of gear boxes casing only, use of cast iron of grade not less than 25, IS: 210 -1962 is recommended. Similarly, no wood or other combustible material shall be used in any part of the crane.
- y) Parts requiring replacement or lubrication shall easily be accessible without dismantling the other equipment and structures.
- z) Defects in the material like fractures, cracks, blow holes, pitting etc. are not allowed. Rectification /Replacement of any such flow are permissible only with the approval of the owner.
- aa) Overload protection system must be considered for the Hoist with additional operational limit switches.
- bb) Crane shall be complete with trolley, tracks, wheels, axles, drive mechanism, hoisting drum brakes, horns, warning, lights, limit switches etc.
- cc) Ladders shall be provided for accessing the walkway from operating floor on both sides of the building. Minimum 500 mm clear walkway shall be provided along the building columns on both sides of TG building (Full length) and one side of full length all double girder cranes.
- dd) Access ladder shall be provided for access the crane from building walkway. And ladder shall be provided for access the cabin & maintenance cage from crane walkway.
- ee) Platforms / walkways in crane shall be provided for maintenance with 750 mm clear inside width. Non skid steel plate of thickness 6 mm with toe guards of 100 mm height above the floor level and safety hand railing shall be provided along the full span length on either side of the crane bridge girders. The hand railings shall consist of 32 mm NB pipe in two (2) tiers. Top pipe shall be at about one (1) m and middle pipe shall be at about 450 mm height from the walkway platform level.



- ff) Two individual bridge girders in plate welded box type are fabricated from tested steel plates. Box section shall be adequately reinforced by internal diaphragms and ribs.
- gg) The brakes shall be located on input shaft / extension of input shaft of gear reducer. Coupling halves shall not be used as brake drums.
- hh) Anti-collision switch shall be provided wherever applicable.

3.0.0 ELECTRICAL REQUIREMENTS

- a) Electrical equipment shall be adequately rated to permit simultaneous operation of may combination of motions of the crane for it duty service.
- b) Motor ratings shall be 25% (at least) over the maximum power requirement. The hoist motors shall be rated to lift 125% of the design load at rated speed.
- c) Motors shall suit the duty class S4, cyclic duration factor 60% and 300 starts per hour and shall be suitable for VVF operation. Motor pull out torque shall not be less than 2.75 times/ rated torque. Motor shall have class F insulation temperature rise limited to class B and enclosures shall conform to the degree of protection IP-55.
- d) All motors shall be capable of the following :
 - Operating satisfactorily at full load for 5 minutes without injurious heating with 75% rated voltage at motor terminals.
 - Withstand 120% of rated speed for two minutes.
 - Current shall not exceed 6 times full load current for creep speed motor.
 - Withstanding the stresses imposed if started at 110% rated voltage.
 - Start with rated load and accelerate to full speed with 80% rated voltage at motor terminals.
 - The locked rotor motor withstand time under hot condition at 110% rated voltage shall be more than motor starting time at minimum permissible voltage by at least 3 seconds for motors upto 20 seconds starting time.
 - Maximum torque shall not be below 200% of full load torque.
- e) Each motor more than 30 KW rating shall be provided with space heater. All electrical equipment accessories and wiring shall have tropical protection.
- f) The crane(s) shall be furnished complete with all electrical equipment, accessories, like drive motors with VVF drives, conductors, insulators, protective & operating devices, cables, current collectors, all protective devices, anti collision limit switches, mechanical overload and protection for electrical faults etc.
- g) The limit switches shall be totally enclosed type IP-55.
- h) Each hoist shall be furnished with two (2) limit switches meeting the following requirements:
 - A screw type limit switch with self resetting features which will act in case of over hoisting.
 - A gravity operated hand reset type limit switch as a back up protection against over hoisting.
- i) Track type limit switches shall be provided on the bridge and trolley to prevent over travelling in either direction.
- j) Trailing cable shall be 1100 V grade, tinned copper, heat resistant, with EPR insulation and as per Class – 5 of IS-8130. Also should have inner PCP sheath and outer CSP sheath with nylon chord reinforcement & heat resistant, oil resistant and flame retardant heavy duty FRLS type.



- k) Necessary start/stop and emergency controls shall be provided. Automatic reset type limit switches shall be provided to prevent over-travel for:

- Over hoisting and lowering motions of the hook.
- Long travel motion
- Cross travel motion

- l) Down Shop Leads (DSL)

One (1) set of shrouded type down shop leads (DSL) with copper conductor for the crane runway length shall be provided. Conductor shall be colour coded for R, Y, B phases and ground. Current carrying capacity of Runway conductors shall be designed for simultaneous operation of the two cranes as applicable.

The shrouded copper bus bar conductor system shall comprise of 4 wire suitable for single power feed to mid point. The material of shroud shall be PVC suitable for 70 deg. C. The continuous current rating of the conductors shall be so chosen that the voltage drop from load break switch to the motor terminal is restricted to 3 % based on maximum derated current and 10% based on peak current. Minimum 20% allowance for wear and tear shall be provided over the calculated size.

- m) VVVF control

The VVF drive control shall be used for control of each motion. The VVF drive shall be equipped at least with 1024 pulse in card, droop control for synchronization and crane software. The rating of VVF shall be decided considering 250% of full load current of respective drive motor based on in panel rating with derated at 50 Deg C ambient temperature.

VVVF system shall be rated for continuous duty as per IEC 146 (clause II). Output frequency range shall be minimum 0 to 50 Hz at constant torque and 0 to 100 Hz at constant power. Efficiency of VVVF shall be minimum 97%.

Individual converters shall be provided for each vector drive. The harmonic content reflected on incoming line is to be limited to 5% THD and 3% for individual harmonics. Harmonics filters preferably along with 12 pulse converter/IGBT based converter shall be used to achieve this.


ANNEX 2.19.1
SPECIFIED DESIGN DATA – DOUBLE GIRDER EOT CRANE

Sl.No.	Description	Data			
1	Design, fabrication and testing of the crane conform to standard / code number	As per IS : 3177 – 1999 / IS:807			
2	Operation	Wireless remote control & Pendent push button for all double girder cranes. Wireless remote control + Operator cabin + pendent push bottom for TG hall EOT crane			
3	Crane Components				
3.1	Type of girder	Double girder box type			
3.2	Type of connection to end carriage	By fitted bolts			
3.3	Girder material	IS2062 Gr. A/B			
4	Rails-Bridge Girder				
4.1	Type / section	Rails sections as per IS: 3443 Grade 50 C 12. Joint to be butt-welded by thermit welding & fusion welding or by end clamping welded by thermit welding & Fusion welding or by end clamping arrangement.			
4.2	Material	Rail Steel			
5	Lifting hooks	MH		AH (if applicable)	
5.1	Type	Ram shorn for more than 50T or 'C' type swiveling hook with locking device.		'C' type swiveling hook with locking device.	
5.2	Material	EN 3A-BS 970 Class 2 IS:1875			
5.3	Standard conforming to	Ram shorn: IS:5749 Single hook (or) “C” hook: IS 15560			
6	Trolley				
6.1	Type	Fabricated			
6.2	Method of fabrication	Fusion welded			
6.3	Material conforming to IS:	IS: 2062 Gr. A or B			
6.4	Number of Trolleys	One (1) per crane			
6.5	Number of hoists on trolley	One (1) Main + One (1) auxiliary hoist (if applicable).			
7	Sheaves details	Main hoist		Aux. hoist	
7.1	Material	Fe 410 WA IS: 2062 Gr. A or B / CS Gr. 280-520 IS:1030 Design as per IS:3177-1999			
7.2	Diameter of equivalent sheaves in mm on root	Should not be less than 62% of calculated main sheave diameter		Should not be less than 62% of calculated main sheave diameter.	
7.3	Type of guards provided	Fabricated from sheet steel			
8	Coupling & shafting				
8.1	Coupling details (between motor and gear box)	Main hoist	Aux. hoist	Cross travel	Long travel
a)	Type	Flexible geared type			



Sl.No.	Description	Data			
b)	Guards and Enclosures	Provided			
8.2	Coupling details (gear box and wheels)	Cross travel		Long travel	
a)	Type	Flexible geared type			
b)	Guards and Enclosures	Provided			
8.3	Coupling details (gear box and rope drum)	Main hoist		Aux. hoist	
a)	Type	Flexible geared type			
b)	Guards and Enclosures	Provided			
8.4	Shafting (output)				
a)	Factor of safety	As per IS:3177-1999			
b)	Arrangement of lubrication	Grease cups / Nipples			
c)	Type of lubricant	Grease			
9	Gear box details				
9.1	Hoist Motions	MH		AH	
a)	Type of mounting of gear box	Horizontal / Vertical			
b)	Classification	Suitable for M5 duty			
c)	Type of gears	Helical / Spur		Helical / Spur	
d)	Type of lubrication (grease / splash / pump lubrication)	Splash lubrication			
e)	Difference in gear and pinion hardness	Min 20 BHN			
f)	Materials (gear / pinions)	Main Gears En 9/55C8/IS2707 Gr. 1 or 2 Pinions En 19/EN 24 Hardness conforming to IS:3177			
g)	Casings	Fabricated Fe 410w IS:2062 Gr A/B & stress relieved			
9.2	Travel Motions	CT		LT	
a)	Type of mounting gear box	Vertical		Vertical / Horizontal	
b)	Classification	M5 duty			
c)	Type of gears	Helical / Spur		Helical / Spur	
d)	Type of lubrication (Grease / splash / pump lubrication)	Splash lubrication			
e)	Difference in gear and pinion hardness	Min 20 BHN			
f)	Materials (gear / pinions)	Main Gears En 9/55C8/IS 2707 Gr. 1 or 2 Pinions En 19/ EN 24. Hardness conforming to IS:3177			
g)	Casings	Fabricated Fe 410w IS: 2062 Gr A/B & stress relieved.			
10	Warning gong	Operated from pendant. Suitable for 240V AC of noise level 95 dBA at 3.5 m			
11	Rope Drum				
11.1	Type	Rope drums shall be spur / helical gear type and should be fabricated from M.S. as per IS 2062 and should be stress relieved.			
11.2	Rope drums	Main hoist		Aux. Hoist	
a)	Material (Indicate IS)	Seamless pipe ASTM-106 or fabricated Fe410w IS: 2062 Gr. A/B & stress relieved.			
b)	Numbers provided	One for each hoist			
c)	Type of grooves	Identical right hand and left hand			
d)	Flange / flangeless	Flanged			



Sl.No.	Description	Data			
12	Wire Rope				
12.1	Rope details	Extra flexible plough steel conforming to IS:2266, Rope grade 1770			
12.2	Construction	6 x 36			
12.3	Factor of safety	Not less than 5.25 / As per IS			
12.4	Type of core	Fibre			
13	Wheels				
13.1	Wheels	Cross travel	long travel		
13.2	Type	Double flanged			
13.3	Materials	Forged Steel / C 55 Mn 75			
13.4	Hardness	300-350 BHN.			
13.5	Arrangement of lubrication	Grease			
13.6	Bearing for the wheels	Antifriction Bearings.			
13.7	Method of lubrication	Grease lubrication			
13.8	Bearing life	10,000 working hours			
14	Limit Switches				
	Type Quantity	Main Hoist:	Aux, Hoist (If applicable)	CT	LT
		Rotary geared + gravity type	Rotary geared + gravity type	lever type	lever type
		1+1	1+1	2*	2
14.1	Protection	Based on the location.			
15	Brakes	Main Hoist:	Aux, Hoist	CT	LT
15.1	Type	AC Electro Hydraulic Thruster operated + DC Electro Magnetic disc			
15.2	Quantity	1 + 1	1 + 1	1+1	1+1
15.3	Braking capacity	150%	150%	125%	125%
16	Buffer	Cross Travel		Long Travel	
16.1	Number	4		4	
16.2	Type	Rubber / Spring loaded type. To be designed to bring the loaded crane to rest from speed of 50% of the rated speed.			
17	Electrical				
17.1	Power supply	Shrouded type down shop leads (copper) shall be provided to supply power to crane. Power supply to Crab shall be through flexible trailing conductors.			
17.2	Rating	S4, 60% CDF			
17.3	Number of starts / hour	300 starts / hr			

Note: 1. Tandem operation will not be envisaged for the TG hall EOT cranes.

2. * Two number of one way lever type' limit switches or one no. two way lever type limit switch shall be provided for each CT & LT motion



VOLUME II
SUB-SECTION - 2.19.2
SINGLE GIRDER EOT CRANE

1.0.0 CODES AND STANDARDS

The design, manufacture, erection and testing of the crane shall conform to the latest edition of the following codes and standards along with their amendments:

IS 3177	Code of Practice for Electric overhead travelling cranes and gantry cranes other than steel works cranes.
IS 800	Code of practice for use of structural steel in general building construction.
IS 807	Code of practice for design, manufacture, erection and testing (structural portion) of cranes and hoists.
IS 2266	Steel wire ropes for general engineering purposes.
IS 3443	Crane rail sections.
IS 15560	Point hooks with shank up to 160 tonne specification
IS 4029	Guide for testing three phase induction motors
IS 5749	Forged ramshorn hooks.
IS 4164	Specification for lifting 'C' Hooks with eye - capacity up to 25 tonnes
IS 12162	Specification for lifting hook
IS 3832	Specification for hand-operated chain pulley blocks
IS 3938	Specification for electric wire rope hoists
IS 1835	Specification for Round steel wire for ropes
IS 7847	General Characteristic of Lifting hook.
IS 3815	Specification for point hook with shank

Any other International standards such as ASTM / ASME / ISO / DIN / JIS for design of coal handling system shall be followed.

Under slung crane / over head crane are required to be installed for handling various equipments during maintenance.

- a) EOT cranes conforming to M5 for Mechanical, Structural and M7 for Electrical of IS:3177 – 1999 and Class II of IS 3938 shall be designed, manufactured, inspected, shop tested, erection, site testing and commissioning to well established engineering practices, safety codes and other relevant codes and standards. However, Work shop single girder over head crane conforming to Group M7 for mechanical, structural and electrical of IS 3177.
- b) The crane shall be a complete unit with bridge girder, end carriages for long travel, travelling for cross travel, rope drums, wire ropes, sheaves, drive units, brakes, rails and fixtures, rail clamps (if applicable), end stops, buffers, conductors, all electrical etc. to



make the equipment complete in all respects. The steel used for the crane construction shall be of standard quality. All materials used shall be of recent manufacture, free from defects, mill scales, laminations, pitting, flakes, rust etc. All welds shall be free from defects like blowholes, lack of penetration, slag intrusions etc.

c) Bridge Girder

The crane bridge shall consist of single girder. In case of overhead crane, bridge girder shall be mounted on runway rails. In case of under slung crane, bridge girder shall be mounted on the bottom flanges of I-section. The trolley shall move on the bottom flange of the girder.

The bridge girder shall have enough strength to carry the rated load without causing undue stress or deflection.

d) Wheel

The LT wheel arrangement for overhead crane shall have double flanged wheel and CT wheel arrangement shall have single flanged wheel. The under slung crane shall single flanged wheel arrangement for both LT & CT. The wheels shall be machined on their tread to match the runway rail section for overhead crane and profile of the I-section for under slung crane.

e) The ratio between wheelbase and crane span shall be as stipulated in IS 807.

f) Trolley frames shall be fabricated from rolled structural steel section and not from re-rolled structural steel section.

g) Design shall provide for easy maintenance of all parts, particularly the wheel bearings on end carriage.

h) Platforms/walkways shall be provided for maintenance of crane components with access ladder to access the platforms from operating floor/maintenance area.

•
i) Deflections and Camber

i. The total maximum vertical deflections of the girders for the safe weight of working load plus the weight of the crab in central position (without taking into consideration the impact factor) shall not exceed limit of span/900 as specified by the relevant IS 807 or any other code whichever is having higher deflection shall be taken for limit.

ii. The girder shall be cambered by an amount equal to the maximum deflection due to dead load plus one half the live load and trolley.

2.0.0 ELECTRICAL REQUIREMENTS

a) Electrical equipment shall be adequately rated to permit simultaneous operation of any combination of motions of the crane for its duty service.

b) Motor ratings shall be 25% (at least) over the maximum power requirement. The hoist motors shall be rated to lift 125% of the design load at rated speed.

c) Motors shall suit the duty class S4, cyclic duration factor 60% and 300 starts per hour and shall be suitable for VVF operation. Motor pull out torque shall not be less than 2.75 times/ rated torque. Motor shall have class F insulation temperature rise limited to class B and enclosures shall conform to the degree of protection IP-55.

d) All motors shall be capable of the following :



- Operating satisfactorily at full load for 5 minutes without injurious heating with 75% rated voltage at motor terminals.
 - Withstand 120% of rated speed for two minutes.
 - Current shall not exceed 6 times full load current for creep speed motor.
 - Withstanding the stresses imposed if started at 110% rated voltage.
 - Start with rated load and accelerate to full speed with 80% rated voltage at motor terminals.
 - The locked rotor motor withstand time under hot condition at 110% rated voltage shall be more than motor starting time at minimum permissible voltage by at least 3 seconds for motors upto 20 seconds starting time.
 - Maximum torque shall not be below 200% of full load torque.
- e) Each motor more than 30 KW rating shall be provided with space heater. All electrical equipment accessories and wiring shall have tropical protection.
- f) The crane(s) shall be furnished complete with all electrical equipment, accessories, like drive motors with VVF drives, conductors, insulators, protective & operating devices, cables, current collectors, all protective devices, anti collision limit switches, mechanical overload and protection for electrical faults etc.
- g) The limit switches shall be totally enclosed type IP-55.
- h) Each hoist shall be furnished with two (2) limit switches meeting the following requirements:
- A screw type limit switch with self resetting features which will act in case of over hoisting.
 - A gravity operated hand reset type limit switch as a back up protection against over hoisting.
- i) Track type limit switches shall be provided on the bridge and trolley to prevent over travelling in either direction.
- j) Trailing cable shall be 1100 V grade, tinned copper, heat resistant, with EPR insulation and as per Class – 5 of IS-8130. Also should have inner PCP sheath and outer CSP sheath with nylon chord reinforcement & heat resistant, oil resistant and flame retardant heavy duty FRLS type.
- k) Necessary start/stop and emergency controls shall be provided. Automatic reset type limit switches shall be provided to prevent over-travel for:
- Over hoisting and lowering motions of the hook.
 - Long travel motion
 - Cross travel motion
- l) Down Shop Leads (DSL)

One (1) set of shrouded type down shop leads (DSL) with copper conductor for the crane runway length shall be provided. Conductor shall be colour coded for R, Y, B phases and ground. Current carrying capacity of Runway conductors shall be designed for simultaneous operation of the two cranes as applicable.

The shrouded copper bus bar conductor system shall comprise of 4 wire suitable for single power feed to mid point. The material of shroud shall be PVC suitable for 70 deg. C. The continuous current rating of the conductors shall be so chosen that the voltage drop from load break switch to the motor terminal is restricted to 3 % based on maximum derated current and 10% based on peak current. Minimum 20% allowance for wear and tear shall be provided over the calculated size.



m) VVVF control

The VVF drive control shall be used for control of each motion. The VVF drive shall be equipped at least with 1024 pulse in card, droop control for synchronization and crane software. The rating of VVF shall be decided considering 250% of full load current of respective drive motor based on in panel rating with derated at 50 Deg C ambient temperature.

VVVF system shall be rated for continuous duty as per IEC 146 (clause II). Output frequency range shall be minimum 0 to 50 Hz at constant torque and 0 to 100 Hz at constant power. Efficiency of VVVF shall be minimum 97%.

Individual converters shall be provided for each vector drive. The harmonic content reflected on incoming line is to be limited to 5% THD and 3% for individual harmonics. Harmonics filters preferably along with 12 pulse converter/IGBT based converter shall be used to achieve this.



**ANNEX 2.19.2.1
SPECIFIED DESIGN DATA FOR SINGLE GIRDER EOT CRANE**

	Description	Unit	Data
1.0	GENERAL		
1.1	Type of control proposed		Pendant
2.0	HOISTING SYSTEM		
2.1	Rope		As per IS 2266, Rope grade 1770
a)	Rope construction		IS 2266 / 6 x 36 multi strand construction Fibre core.
b)	Rope quality (material)		Extra flexible plough steel
c)	Factor of safety		As per IS
2.2	Rope drum		Hoist drum length shall be such that each lead of wire rope has a minimum of two full turns on the drum when the hook is at its lowest position not taking into consideration turns covered by wire rope anchorage and one spare groove for each lead of wire rope on the drum when the hook is at its highest position.
a)	Drum material		Fabricated from carbon steel as per IS 2062, Grade B and stress relieved or seamless pipe as per ASTM A 106 Grade A or B.
b)	Whether stress relieved		Yes (if fabricated)
2.3	Bearing type		Antifriction ball or roller
2.4	Hook		
a)	Hook type		Swivel "C" type single shank of suitable grade of either circular or standard trapezoidal section, point hook suitably heat treated with adequate lifting capacity. Swivel lock pin shall be provided.
b)	Hook material		Forged steel
c)	Safety latches provided		Yes
d)	Hook suspension		Thrust Bearing
2.5	Sheave material		Fabricated from cast steel / steel plate IS 2062 Gr A or B / CS Gr 280-520 IS 1030
2.6	Hoist Brake		
a)	Type		DCEM "fail to safe"



	Description	Unit	Data
b)	Torque		150% of rated torque or greater than the torque transmitted to the brake drum from the suspended load up-to the test load.
2.7	Gear box		Fabricated Fe 410w IS:2062 Gr A/B & stress relieved
a)	Material of gears		EN 9 / 55C8
b)	Material of pinions		EN 19 /EN 24
c)	Type of gears & pinions		Spur / helical
2.8	Limit Switch type		Rotary geared + gravity type
3.0	CROSS TRAVEL		
3.1	CT brake		
a)	Type		DCEM “ fail to safe”
b)	Torque	Nm	150% of rated torque
3.2	Gear box		Fabricated Fe 410w IS:2062 Gr A/B & stress relieved
a)	Material of gears		EN 9 / 55C8
b)	Material of pinion		EN 19 / EN 24
c)	Type of gears & pinion		Spur / Helical
3.3	Wheels		
a)	Materials		Forged steel
b)	Hardness	BHN	Not more than 200BHN
c)	Type		Single flanged
d)	Wheel bearing type		Antifriction Ball/Roller
3.4	Type of limit switches		Lever
4.0	LONG TRAVEL		
4.1	CT brake		
a)	Type		DCEM “ fail to safe”
b)	Torque	Nm	150% of rated torque
4.2	Gear box		Fabricated Fe 410w IS:2062 Gr A/B & stress relieved
a)	Material of gears		EN 9 / 55C8



	Description	Unit	Data
b)	Material of pinion		EN 19 / EN 24
c)	Type of gears/pinion		Spur / Helical
4.3	Wheels		
a)	Materials		Overhead Crane – C55 Mn 75 for overhead crane & Steel used for wheel shall not contain more than 0.06% of Sulphur or Phosphorous. Under slung Crane – Forged steel
b)	Hardness	BHN	Overhead crane – 300 to 350 BHN for under slung crane – Not more than 200BHN
c)	Type		overhead crane – Double flanged under slung crane – Single flanged
d)	Wheel bearing type		Antifriction Ball/Roller
4.4	Type of limit switches		lever
5.0	Type of Buffer Stoppers		Rubber / spring
6.0	Electrical		
6.1	Power supply		Shrouded type down shop leads (copper) shall be provided to supply power to crane. Power supply to Crab shall be through flexible trailing conductors.
6.2	Rating		S4, 60% CDF
6.3	Number of starts/hour		300 starts /hour



VOLUME II
SUB -SECTION - 2.19.3
HOISTS

1.0.0 CODES AND STANDARDS

The design, manufacture, erection and testing of the crane shall conform to the latest edition of the following codes and standards along with their amendments:

IS 800	Code of practice for use of structural steel in general building construction.
IS 807	Code of practice for design, manufacture, erection and testing (structural portion) of cranes and hoists.
IS 325	Three phase induction motors.
IS 816	Code of practice for use of metal arc welding for general construction in mild steel.
IS 2266	Steel wire ropes for general engineering purposes.
IS 2327	Straight sided splines for cylindrical shafts with internal centering-dimensions, tolerances and verification.
IS 2610	Power transmission straight-sided splines for machine tools-dimensions.
IS 15560	Point hooks with shank up to 160 tonne specification
IS 4029	Guide for testing three phase induction motors
IS 5749	Forged ramshorn hooks.
IS 4164	Specification for lifting 'C' Hooks with eye - capacity up to 25 tonnes
IS 12162	Specification for lifting hook
IS 3832	Specification for hand-operated chain pulley blocks
IS 3938	Specification for electric wire rope hoists
IS 1835	Specification for Round steel wire for ropes
IS 7847	General Characteristic of Lifting hook.
IS 3815	Specification for point hook with shank

Any other International standards such as ASTM / ASME / ISO / DIN / JIS for design of coal handling system shall be followed.

2.0.0 ELECTRIC HOIST

Electrically operated hoist shall be a complete unit with hoisting motor, rope drum, wire rope, traveling trolley, travel motor, necessary gearing, sheaves, brakes, hook, pendant push button station, contactor panel, conductor for travel motion, limit switches, end stops, buffers, earthing



terminals and all other accessories to make the equipment complete in all respects. Minimum factor of safety shall be (5) five for electrically operated hoist.

Parts requiring replacement or lubrication shall be easily accessible & without dismounting type.

Equipment will include the devices as required and comply with applicable standards/specification requirements.

Both hoists and trolleys are driven electrically as specified. Rope drum shall be as per IS 3938. Rope drum shall be either cast or welded to sustain concentrated loads resulting from rope pull.

All brake shall be of “fail to safe” design and will operate automatically in case power failure.

A) ROPE DRUM

Rope-drums shall be grooved and welded steel conforming to IS 3938. Drum length shall be such that each lead of wire rope has a minimum of two full turns on the drum when the hook is at its lowest position not taking into consideration turns covered by wire rope anchorage and one spare groove for each lead of wire rope on the drum when the hook is at its highest position.

B) WIRE ROPES

Wire ropes shall be extra flexible with well lubricated hemp core having thirty-six (6X36) wires per strand shall be provided. Wire ropes shall be of Right Hand Ordinary (RHO) lay construction.

C) HOOKS

Hook shall be forged steel supported on a ball or roller bearing. The hook shall rotate freely on this bearing. Hook shall have swivels and safety latch. Locking pin shall be provided to prevent swivelling of hook. The sleeves of hook block shall be encased in an oil tight casing permitting generous lubrication of wire ropes & sheaves & also preventing accidental trapping of hands.

D) SHEAVES

Rope sheaves shall be of cast steel or fabricated steel with anti-friction bearings. Sheaves shall be fully guarded to prevent rope coming off.

E) ELECTRICAL

- i. Motor ratings shall be 25% (at least) over the maximum power requirement. The hoist motors shall be rated to lift 125% of the design load at rated speed.
- ii. Motors shall suit the duty class S4, cyclic duration factor 60% and 300 starts per hour and shall be suitable for VVF operation. Motor pull out torque shall not be less than 2.75 times/ rated torque. Motor shall have class F insulation temperature rise limited to class B and enclosures shall conform to the degree of protection IP-55.
- iii. The VVF drive control shall be used for control.
- iv. The hoist shall be furnished complete with all electrical equipment, accessories, like drive motors with VVF drives, conductors, insulators, protective & operating devices, cables, all protective devices, start/stop and emergency controls, limit switches, mechanical overload and protection for electrical faults etc.

3.0.0 MANUAL HOIST

The chain pulley block shall be a complete unit with trolley, load chain, load chain wheel, hand chain, hand chain wheel, necessary gearing, brakes for hoisting, hook and other accessories.



Chain pulley block shall be of worm or spur gear type. Factor of safety shall be (5) five for chain pulley block.

The load chain shall be electrically welded, accurately calibrated, and pitched and polished as per IS. And Load chain shall be heat treated to give required ductility & toughness

The hand chain will also be electrically welded, calibrated, pitched and polished and will conform to IS: 3832.

The forged hook shall be properly heat treated and so designed that in loaded condition, it is free to swivel without twisting the load chain. The hook will conform to IS.

All other components of chain pulley block such as anchorage, guide, pawl, stripper etc. shall be designed and provided as per IS: 3832. Effort on the hand chain for traveling motion of manual hoist will not be more than 20kgforce.

**ANNEX 2.19.3.1
SPECIFIED DESIGN DATA FOR HOISTS****A) Electric Wire Rope hoist**

Sl.No.	Description	Unit	Data
1	GENERAL		
1.1	Design according to standard service class/ load class		IS 3938 Class II
1.2	Location (Indoor/ Outdoor)		(Based on the location)
1.3	Type of control		Pendant
2	HOISTING SYSTEM		
2.1	Wire Rope		
a)	Rope construction		IS 2266 / 6 x 36 multi strand construction Fibre core.
b)	Rope quality (material)		Extra flexible plough steel
c)	Factor of safety		Not less than 5 / As per IS
2.2	Rope drum		
a)	Drum material		Fabricated from carbon steel as per IS 2062, Grade B and stress relieved or seamless pipe as per ASTM A 106 Grade A or B.
b)	Whether stress relieved		Yes (if fabricated)
c)	Bearing type		Antifriction ball or roller
2.3	Hook		
a)	Hook type		Swivel “C” type single shank of suitable grade of either circular or standard trapezoidal section, point hook suitably heat treated with adequate lifting capacity. Swivel lock pin shall be provided.
b)	Hook material		Forged steel
c)	Safety latches provided		yes
d)	Hook suspension		Thrust Bearing
e)	sheave material		Fabricated from cast steel / steel plate IS 2062 Gr A or B / CS Gr 280-520 IS 1030



Sl.No.	Description	Unit	Data
2.4	Hoist Brake		
a)	Type		DCEM “fail to safe”
b)	Torque	Nm	150% of rated torque or greater than the torque transmitted to the brake drum from the suspended load up-to the test load.
2.5	Gear box		Fabricated Fe 410w IS:2062 Gr A/B & stress relieved
a)	Material of gears		EN 9 / 55C8
b)	Material of pinions		EN 19 /EN 24
c)	Type of gears & pinions		Spur / helical
2.6	Type of Limit Switch		Rotary geared + gravity type
3	TRAVEL		
3.1	CT brake		
a)	Type		DCEM “ fail to safe”
b)	Torque	Nm	150% of rated torque
c)	Gear box		Fabricated Fe 410w IS:2062 Gr A/B & stress relieved
i)	Material of gears		EN 9 / 55C8
ii)	Material of pinion		EN 19 / EN 24
iii)	Type of gears & pinion		Spur / Helical
d)	Wheels		
i)	Materials		Forged steel
ii)	Hardness	BHN	Not more than 200BHN
iii)	Type		Single flanged
iv)	Wheel bearing type		Antifriction Ball / Roller
e)	Type of Limit switches		Lever
4	Rating		S4, 60% CDF
5	Number of starts/hour		300 starts / hr

Note: Bearings: Antifriction type with minimum Life of 10000 working hours.

**B) Manual Hoist**

Sl.No.	Description	Unit	Data
1	Standards		IS 3832 / Class-II
2	Application		(Based on location)
3	Trolley and hoist operation		Hand operated
4	Material of construction		
4.1	Trolley frame		Cast steel / Mild steel
4.2	Gears (Trolley)		Machine cut cast steel / Forged steel / C40 / C50
4.3	Lifting hook (Swivel)		Shank 'C'. Forged steel. Safety latch and swivel lock pin.
4.4	Gears		IS 3681/4460
5	Trolley wheel		Forged / cast steel / C40 with minimum 200BHN and single flanged to suit standard I beam section.
6	Brake		Screw and disc friction type /Ratchet & pawl type

Fixed chain pulley blocks having 6 m lift shall be supplied by the Contractor.

- 1T capacity – 10 nos.
- 3T capacity – 10 nos.
- 5T capacity – 8 nos.
- 10T capacity – 3 nos.



VOLUME II
SECTION 2.20
PIPING, VALVES AND FITTINGS

1.0.0 GENERAL

This section is intended to provide the scope, design, constructional and functional requirements for all power plant piping, valves and fittings.

2.0.0 SCOPE OF SUPPLY

The scope of supply shall include but not limited to, the following:

High pressure/ power cycle piping

- High pressure piping covering complete main steam, hot reheat and cold reheat Piping between boiler and turbine nozzles, HP & LP bypass piping.
- Complete auxiliary PRDS and auxiliary steam piping system.
- All extraction steam piping.
- Complete feed water piping including booster pumps suction, interconnection between booster pumps and main pumps, boiler feed discharge piping upto economiser, recirculation, BFP warm up and leak off.
- Spray piping system for reheater/ superheater attemperation, HP & LP bypass system and auxiliary PRDS system.
- Condensate piping system.
- Condenser make up water system.
- Heater drains and vents piping including necessary flash tanks.
- Steam drains including necessary flash tanks.
- Valve gland sealing piping system.
- Miscellaneous line drains and vents including necessary flash tanks.
- Complete safety valve exhaust piping for safety valves on steam generator, HP piping, Aux. PRDS, heaters and deaerator etc.
- Start up vents, safety valves, pneumatic relief valves (PRVs), flash tanks and all vents from the respective equipments and pipes upto a level of one meter above the boiler house/ TG building roof. Silencers shall be provided for start up vents, lowest safety valve and PRV'S. All drains from respective equipments and pipelines shall be connected to the drain manifold of the flash tanks.
- Complete chemical dosing system piping.
- Any other piping system to make the power cycle piping complete.
- Complete steam blowing and chemical cleaning of piping including provision of temporary piping as required.
- Piping systems shall be complete with fittings/accessories, specialities, blow-down valves, vent valves, drain valves and safety valves along with their escape piping, drain piping and steam traps, expansion joints, insulation, hangers, supports, restraints/guides, snubbers and auxiliary steel etc. The drain system shall be complete along with drain pipes, unit flash tank, drain valves, root valves, relief/safety valves, control valves, motorised valves, gate/ globe valves, non return valves, break-down orifices, steam traps etc.

Low pressure piping and valves etc.

The scope of low pressure piping including miscellaneous piping shall cover piping systems for the following services from the terminal points within the main plant area as specified elsewhere:-

- Condenser cooling water system, Auxiliary cooling water system, closed cooling water system
- Condenser make up, boiler fill and deaerator fill systems
- DM water supply and distribution system
- Condensate polishing system
- Condenser on load tube cleaning system
- Condenser air evacuation system
- Drain water system
- Chemical dosing system
- Service water systems, Potable/ drinking water system
- Air preheater wash system
- Sea water intake and outfall system
- Cooling tower blow down and make up system
- Fire water piping system
- Fuel oil unloading, storage and forwarding piping systems
- Effluent system
- Ash slurry system
- Instrument air and Service air piping system
- Sludge system

All interconnection piping within and between the equipments and any other piping system

Piping systems shall be complete with fittings/ accessories and specialities, expansion joints, all isolating and regulating/ control valves, hand operated and/or motorized/pneumatic/ hydraulic actuators, surface painting/ protection, hangers, supports, trestles, restraints/ guides, snubbers and auxiliary steel etc as required.

Power cycle control valves

All the control valves as required complete with pneumatic actuators and accessories, which shall include but not be limited to the following:

- Desuperheating spray water control valves for superheater, reheater and auxiliary steam supply
- HP and LP heaters normal and emergency level control valves
- BFP recirculation control valves
- Deaerator level control valves
- Deaerator pressure control valves
- Condensate recirculation flow control valves



- Condenser normal make up control valves
- Condenser emergency make up control valves
- Feed water control valves (low load)
- Condensate recirculation control valve
- Excess condensate dump control valve
- Deaerator overflow control valve
- Boiler drain control valves

The power cycle control valves shall be complete along with suitable type of bypass valves. Each control valve shall be provided with arrangement of upstream and downstream isolation valves (hand/ pneumatically/ electrically operated). All other control valves not specifically included above but required for completeness of the system shall also be in the scope of the Contractor.

All other valves with in the system / Equipment / package.

3.0.0 DESIGN CRITERIA

The pipe work shall be designed and erected in accordance with ANSI / ASME B31.1 'Power piping', and the relevant codes and standards of ASTM & AWWA or an expressively approved equivalent standard and Indian Boiler Regulations wherever applicable.

All the piping system including main steam piping system, cold reheat steam piping system, hot reheat steam piping system and HP & LP bypass steam piping system shall after erection be subjected to hydrostatic test pressure as per IBR no:374. In view of the above, piping support system / selection of spring hangers for the above piping shall also be designed for hydrostatic pressure of the respective piping system without any requirement of additional / temporary supports during hydraulic testing of piping system.

All the power cycle pipe thickness shall be calculated as per ASME B31.1 and IBR-350 and maximum of thickness values calculated as per ASME B31.1 and IBR-350 shall be considered. Corrosion allowance as per IBR-350 shall be considered in power cycle pipe thickness calculation.

The present specification shall prevail against that of the code whenever the former is more restrictive.

The supply must be in accordance with the latest editions of the approved Standards as agreed by the Owner / Owner's Representative, incorporating any other features as required by this Specification and in accordance with the Piping Materials Specification. The requirement of Indian Boiler Regulation (IBR) shall be complied with as far as applicable.

All pipe components manufactured by the Contractor and parts on which he has worked, are to be marked clearly with an item number, specification number and material. This marking shall be permanent.

Sizes of pipelines shall be selected such that the velocity of fluid in pipes does not exceed the following limits under conditions of maximum possible volumetric flow :

Steam :

Superheated steam	75 m/s
Saturated Steam	40 m/s



Wet steam / Exhaust steam 30 m/s

Water and Condensate lines:

Pump suction lines (without feed water suction line) 1.5 m/s
Pump discharge lines 2.5 m/s
Feed water discharge lines 6.0 m/s
Feed water suction lines 1.0 m/s

Air lines:

Delivery line for reciprocating compressors 20 m/s
Suction line for reciprocating compressors 20 m/s
Suction and delivery lines for rotary compressors 20 m/s

Oil lines:

Lube and Control oil lines 1.0 m/s
Pump suction line for HSD/HFO 0.8 m/s
Pump discharge line for HSD/HFO 1.8 m/s

Pipe line under gravity flow shall be restricted to a flow velocity of 1 m/sec generally. Channels under gravity flow shall be sized for a maximum flow velocity of 1.2 m/sec.

The following "C" Value shall be used in HAZEN William's formula for calculating the friction loss in piping systems.

- i) Carbon Steel pipe : 100
- ii) C.I Pipe / Ductile Iron : 100
- iii) Rubber lined steel pipe : 120
- iv) PVC I HDPE pipes : 140
- v) GRP pipes : 150
- vi) RCC Conduits : 100

All rules of the art considering technical and economic parameters shall be carefully followed, namely:

- Lower values of velocities than those stated above shall be used to determine line size if dictated by considerations of pressure drop, NPSH, surges, water hammer, etc.
- The design flows considered in line sizing shall not be less than the rated capacities of equipment to which the piping is connected such as pumps, blowers, compressors, valves, flow limiting orifices, etc., or the system heat and/or mass balance diagrams.
- For lines conveying liquids, the design pressure must be equal to maximum operating pressure including the pressure reached during transients (water hammer.)
- The calculation of the pipe work shall consider also the highest possible temperature that can occur during any mode of operation together with the highest corresponding pressure.
- For the design of safety valves installed downstream of reducing stations, H.P. bypass valves or equivalent control valves, the maximum throughput of the fully open reducing or bypass valve, including injection water quantity, is to be taken as the basis for calculation.



- Sizes of Boiler feed pump suction piping shall be selected to meet the NPSH requirements of the pumps under transient conditions prevailing on loss of steam supply to feed water tank. Similarly for all pumps, NPSH requirements shall be satisfied in line sizing.
- The calculation of wall thickness required for pipelines subject to internal and / or external pressure shall be based on the formulae and recommendations as given in the applicable codes. Adequate allowances shall be made towards thinning due to bending, weakening at branch connections, threading, commercial tolerances on pipe wall thickness, corrosion and erosion, etc. and the same shall be subject to approval by Owner / Owner's representative.
- The pipe thickness for CW pipe shall be arrived for full vacuum conditions.
- In case of carbon steel materials, the nominal wall thickness of pipeline shall be not less than the minimum acceptable values given below, Contractor to furnish calculation justifying thickness selection :

NB mm (inch)	15 (1/2)	20 (3/4)	25 (1)	-	40 (1.5)	50 (2)	-	80 (3)	100 (4)
Min. thickness mm	3.73	3.91	4.55	-	5.08	5.54	-	5.54	6.02
NB mm (inch)	150 (6)	200 (8)	250 (10)	300 (12)	350 (14)	400 (16)	450 (18)	500 (20)	-
Min. thickness mm	7.11	8.18	9.27	9.53	9.53	9.53	9.53	9.53	-

- > NB 600 mm to NB 950 mm – 10.00 mm
- > NB 950 mm to NB 1200 mm – 12.00 mm

Sizes of NB 32 (1 1/4"), NB 65 (2 1/2"), and NB 125(5") shall not be used in the piping system. Minimum thickness for stainless steel pipes shall be Sch 40S as per ANSI B36.19.

- In addition to the required wall thickness in accordance with calculations, a corrosion allowance of 1.6 mm must be added for unprotected water lines where corrosion is to be expected.

4.0.0 DESIGN AND CONSTRUCTION OF PIPEWORK AND ACCESSORIES

The pipe work and its accessories shall be designed and arranged so that all parts can be mounted and replaced without difficulty. All important parts, such as valves must be accessible from the floors / platforms.

The platform must be able to withstand the weight of the valve removed as well as the weight of the appropriate number of persons handling the valve, and must be sized adequately providing both working space for the men and space for the valve.

For piping systems with a nominal pressure of more than 40 bar (g), drainage and venting facilities must be fitted with double valves.

The pipes with nominal diameter upto and including 40 mm can be arranged at site according to lengths and specification. The pipes with nominal diameter more than 40 mm can be installed according to the erection drawing designed. Pipe can be pre-fabricated or manufactured according to pipe length and specifications.

No tubes with nominal diameters less than 25 mm shall be used, except for impulse measuring lines, dosing pipelines and instrument piping.



The nominal size of the takeoff connections for instruments shall not be less than 15 mm for service conditions not exceeding either 62 bar(g) or 425°C and 25 mm for service conditions which exceed either of these limits.

For all system parts subject to acceptance retests relevant provision shall be made so that they can be separated to allow for those retests.

None of the forces and moments transmitted by the pipes to adjacent machines, apparatus and platforms must exceed the maximum permissible values, given by the manufacturers of these items.

Trench piping shall not be used unless found unavoidable.

To the extent that steam or hot water can remain or flow in pipe sections isolated for repair purposes, dump pipes with hand operated shut-off valves capable of being locked open or closed shall be provided for the safety of personnel.

Piping systems shall be protected against excess pressure caused by thermal expansion of locked-in fluids.

Valve sizes for vents and drains shall be 25 NB minimum. Vent lines, which are normally operated, shall be terminated at a minimum height of 3.0 M above the highest service platform.

For vents, pipes and any upward facing atmospheric exhaust, weather hoods and silencers as necessary shall be provided.

Manholes/Inspection chamber of adequate size shall be provided at approx. 100M interval for large diameter CW piping.

For tanks and pressure vessels, piping material for drains and vents shall be the same as that of the vessel. Suitable drains shall be provided upstream and downstream of valves to facilitate maintenance in the circuit safely.

In addition, plugged drain and air release bosses shall be welded at appropriate places in the piping to facilitate hydrostatic testing.

Steam traps should be avoided as far as possible. If provided, steam trap installation shall include a permanent strainer, upstream and downstream isolation valves and a globe valve as free drain. Steam traps shall be of the bimetallic or thermodynamic type, selected to suit the service conditions.

The Contractor shall furnish and install suitable thimbles at all points where pipelines pass through building floors and walls.

The Contractor shall provide effective flashing rings with rain-tight hoods for all pipes passing through the roofs or exterior walls.

All piping shall be cleaned and kept clean and free from all foreign matter before and during erection. The Contractor shall submit a detailed description of proposed steam blowing and other cleaning procedures for all pipelines, and no part of this work shall be started until these procedures have been approved. The Contractor shall furnish, install and dismantle all temporary pipes, hangers, anchors, etc. required for cleaning of all piping systems.

As many welds as possible shall be carried out in the workshop. Supports for H.P piping systems shall also be welded in the workshop.



Pipes from water drains, air vents and safety valves shall be grouped together where possible and routed to easily observed points equipped with covered funnels or to flash tanks.

So far as practicable, hangers and supports shall be standardized and the number of types and component assemblies shall be reduced to the minimum. Each pipe hanger and support component shall be of steel suitable for the maximum temperature that it shall attain during plant operation. Spring support assemblies shall be equipped with a means of locking the springs against movement. Rigid supports, clamps and restraints shall be used as far as possible.

The use of counterweights as a substitute for support spring assemblies shall not be permitted.

Sliding surfaces shall be constructed of non corrodible materials that do not rely on coatings such as paint, galvanizing, etc. for corrosion protection. Excessive friction shall be prevented.

Before plant start-up, all supports shall be checked to confirm that spring load indicators have assumed the proper cold load position and that all hangers and supports which do not incorporate springs are in the correct position. For springs which do not assume the proper cold load position, length of hanger tie rods to be adjusted in such a way that springs assume the correct cold position. After all required adjustments have been made, all threads shall be fully engaged and locked and all spring ties shall be disengaged

Seawater intake, Outfall and ACW Piping

The complete seawater piping for seawater intake, outfall piping, CT make-up water system, Auxiliary cooling water piping and the feedwater system to desalination plant shall be of HDPE/GRP. Actual piping MOC shall be referred from the respective section. Accordingly Bidder shall consider.

Pipeline shall be mainly underground with concrete encasement of 250 mm. Top of the buried pipe shall be atleast 1.5 meters below the ground level, Buoyancy effect shall be considered while selecting the depth. Suitable air release valves shall be provided. Transient analysis shall be conducted for piping from the Intake Pump house to the Cooling Tower & Desalination Plant.

Design Requirements for GRP pipe and fittings

Sl.No.	Design parameters	Sea water
1.	Stiffness Class	5000
2.	Vacuum	760mmHg
3.	Inner liner thickness	1 mm
4.	Resin type for inner Liner	Vinylester
5.	Glass type	ECR
6.	Resin type for Exterior Liner	Isophthalic
7.	Aggregate type	Silica Sand
8.	Exterior Layer thickness	0.5 mm
9.	Minimum initial specific stiffeners STIS	5000 N/m ²
10.	Ring bending strain	1.3



The size of the manhole shall of the minimum 600mm.

Design requirements for HDPE:

The Intake & outfall pipe shall be buried below the sea bed and shall be covered with rip-rap to prevent movement by currents and waves. The pipes shall be designed considering scour protection, hydrodynamic forces and buoyancy forces.

The HDPE pipes shall be of suitable diameter with rating of SDR 26 or better, PE 100 material. The intake pipes shall be provided with man holes at every 100 m distance. The size of the manhole shall of the minimum 600 mm. The HDPE pipe shall be conformed with IS 4984/ ISO 4427/ ISO 4437./ASTM D 3350.

Materials used for the manufacture of high-density polyethylene pipe and fittings shall comply with all requirements of ASTM D3350. The high-density polyethylene material shall be cell class of PE345664C or ASTM D3350 and shall be assigned a Plastics Pipe Institute (PPI) recommended designation of PE3408. Pipe Manufacturer shall be a member in good standing of the Plastics pipe institute.

The Flanges, fasteners, supporting structures, clamps, etc for the pipes shall be duplex stainless steel of PREN > 38. The fasteners for connecting concrete anchor blocks shall be of suitable material for sea water.

The minimum design pressure of sea water intake and outfall pipe shall be 6 kg/cm² (g). However higher value shall be considered based on the system requirement. Pipe shall also be designed for full vacuum conditions.

Actual piping MOC shall be referred from the respective section. Accordingly Bidder shall consider.

5.0.0 PIPING LAYOUT CONSIDERATIONS

A minimum 2.5 meter headroom shall be maintained to the lowest point of all piping components or insulation in walking areas and 8.0 meter above roadways unless otherwise approved by the Owner / Owner's Representative. A minimum passageway of 1.5 m shall be considered for access between and around all equipments and a 150 mm minimum clearance shall be provided between piping, including insulation if applied, and any point of adjacent equipment or piping including flanges and/or pipe supports.

Suitable Walkways of 750mm width for maintaining pipes and cables shall be provided on the pipe rack along with access ladders at suitable intervals.

50% extra space for the routing of future pipes for stage –II shall be provided in the pedestals and pipe rack. While designing the pipe rack / pedestal, extra 50 % load shall be taken in order to meet the future pipes. Number of the future pipes will be finalized during detailed engineering.

Additional clearance shall be provided, where required, for pipe movement due to thermal expansion. All valves, instruments, strainers, orifices, valve motor drives and other piping accessories shall be provided with adequate space for access and removal of parts for maintenance.

Bracket supports and other protruding attachments which constitute a hazard to operating personnel shall be elevated to a minimum of 2.5 m from the operator's access elevation.

All horizontal runs of outdoor piping shall be supported by pipe racks with a slope of 1:500 applicable for steam lines only and a minimum ground clearance of 8.0 m shall be considered



for road crossing. Steam lines inside building shall be laid with a slope of 1:100. These drain valves shall be lockable.

The instruments shall be positioned to allow easy observation. A 250 mm minimum clear space shall be provided from the bottom surface of pipe to trench bottom or finished grade.

All lines shall be provided with vent and drain connections at all high and low points, respectively, as per layout constraints with suitability for operation. All piping shall be arranged to permit complete drainage when a particular unit or system is shutdown. Condensate & water lines shall also be provided with vent & drain lines for hydro test conditions. Drain points shall have a suitable isolating valve. All such drain connections shall be piped to a suitable collection point.

5.1.0 Piping Flexibility Analysis

Steam piping systems shall be designed and analysed using CAESAR II software (latest version) in such a way that no excessive stresses, forces, moments or deflections can take place. This static analysis shall be done for plant operating, shut down, hydro test and occasional loading (e.g. Wind, Seismic, Safety valves popping up & Water / steam hammer conditions). As a general guidance a line shall be subjected to comprehensive stress analysis if it falls under any of the following categories.

1. All lines at design temperature above 100 Deg.C
2. All lines 100 NB and larger connected to sensitive rotating equipments.
3. All piping subjected to vibration
4. All relief lines connected to pressure relief valves and rupture discs
5. CW Supply and Return Line near pump and condenser.
6. Sea water intake, outfall and CT Makeup pipes.
7. Other lines which in the option of Owner or Owner's Representative requires a formal analysis.

Pipe sagging shall be restricted to 2.5mm and piping rotation to less than 1 degree. The calculations shall be based on design pressures, temperatures and weights of valves. In addition, the water weight for hydrostatic testing and the insulation weight shall also be taken into account.

The calculations shall determine the maximum combined pipe stresses and the forces, moments, and deflections at all points of support, anchors and restraints. In all calculations, the manufacturing tolerance (12.5% for OD pipes) shall be taken into account.

The design shall take into account possible maximum values, e.g. the maximum head of the pumps in the system as well as exceptional operating conditions, such as over pressures, vibrations and water hammer.

There shall be sufficient allowance for thermal expansion and displacement without excessive stresses. The thermal expansion of the pipe work shall be carefully analyzed and appropriate pipe routing and location of the supporting equipment to be decided to prevent the piping from causing excessive forces & moments at the anchoring points.

5.2.0 Pipe Supports and Hangers

Pipe supports shall be designed according to the layout requirements. Spring shall be used for pipe supports where restriction of vertical movement of pipe creates excessive stress in the piping system. Otherwise rigid supports like rod hangers, clamps, saddle supports etc. shall be used.



The supporting devices shall ensure that the finished system shall provide an uniform continuous slope for draining. Loads imposed on the building structure shall, in all instances, be subject to the approval of the Engineer.

All supports for piping, cables and fitting supplied under this Contract are to be clamped to building steelwork in preference to bolting, screwing or welding. Under no circumstances shall any part of the building steel work be drilled, cut welded without prior permission of the Owner / Owner's Representative in writing. No point of passage of pipes through or walls is to be used as a point of support except with the approval of the Engineer.

Sling supports shall not be dependent for flexibility on the flexure of supporting rods or straps.

All outdoor installation supports and hangers shall be suitably coated to withstand the local environmental conditions.

All spring supports shall be designed and fabricated to forestall the complete release of the piping load in the case of spring failure.

Supports for horizontal piping shall be spaced to prevent excessive sag, bending and shear stress in the piping, with special consideration given where components, such as flanges and valves, impose concentrated loads.

For standard and heavier wall thickness piping, the maximum spacing between supports on straight run of the piping shall be in accordance with ANSI B 31.1.

Vertical supports shall be spaced in such a way that no pipe load is transferred to attached equipment under cold position and also to prevent the pipe from being over stressed from the combination of all loading effects.

5.3.0 Fabrication & Erection of Piping Systems

The plant piping systems shall be fabricated, erected and tested in accordance with the requirements of ASME, ANSI, and API Standards.

All piping to be adequately supported during construction so that excessive moments or loads are not placed on equipment or other piping. The piping is to be installed to permit free expansion and contraction without damage to joints or supports.

Piping bending, wherever required, is to be fabricated with a minimum of five (5) diameter radius. The joint spacing between bevelled ends of pipe shall be maintained between 1.5 and 2.5 mm. Butt welding & end preparation for pipe connections with pipe and flanges shall be as per ANSI B 16.25.

All joints in high pressure and low pressure piping shall be of the fully butt welded type except at points where flanged connections are essential to permit dismantling of pipework for maintenance purposes or for matching flanged item of plants.

Interconnecting joints in all pipes shall be made by butt-welding. Such joints shall be made without the use of backing rings. The welds shall be performed entirely in Gas Tungsten Arc Welding (GTAW) process but where this is not practicable, a combination of GTAW for the root run, and Shielded Metal Arc Welding (SMAW) for the subsequent runs, is acceptable. Consumable insert rings may be used where considered necessary.

All flanged joints shall meet the requirements of ANSI B 16.5 or the equivalent Approved Standard. All flanges shall be machined on the edge and spot faced at the back to receive bolts, washers and nuts. For high pressure services flange faces must be of serrated finish. Blank flanges are to be solid steel and machined all over. Flanges having pressure ratings



less than 10 bar shall not be used. All flange jointing material unless specified, shall be subjected to the approval of the Owner / Owner's Representative.

Socket welded connections shall be used on oil piping services less than 50 mm nominal size. The use of socket welded connections on other piping services shall be subjected to the approval of the Owner / Owner's Representative and restricted to the areas where the temperature or pressure cycling or severe vibration is not expected to occur or where the service may not accelerate crevice corrosion.

Screwed connections shall only be used on galvanised pipes for air services and only when the pipe is less than 50 mm nominal size. In case of threaded joints in piping, all screw threads shall be of the ISO metric form and the diameter and pitch of thread for all bolts, studs and nuts shall conform to the ISO standards. Threaded joints are used in galvanised steel pipes only. Threaded joints, which are to be seal- welded shall be made up without the use of any joint compound or sealing tape. Threaded joints, which are not to be seal- welded shall be made leak-tight by use of suitable joint compound. Backing off of the make-up threaded joints to facilitate fit-up to alignment is not permitted.

At all points where pipes pass through concrete floors or brick or other walls, suitable floor collars or wall boxes are to be provided and fixed. The floor collars shall have raised curbs of suitable height, which shall not be less than 75 mm. The wall boxes shall be flush fitting and be of neat design and approved finish.

The Contract shall include fixing of all necessary components for the protection against weather of such holes in an approved manner. Where pipes pass through roofs, the pipe collar shall stand up less than 200 mm above the top of the roof and hood shall shroud it to within 25 mm of the finished roof level. After the collars, boxes or other fittings been fixed in position, the floors, walls and structures shall be made good by the Contractor.

If service pipes run adjacent to each other, they are, wherever possible, to pass through a box. Where pipes of varying bore pass through a common box, a neat plate cover shall be provided between the pipes and the box. In the case of flanged pipework, boxes shall be large enough to permit the passage of the flange.

Where pipes are laid in covered trenches this Contract shall include for the supply and fixing of all the necessary pipe supports, clamps, packing and fixings, etc.

During erection the Contractor shall be responsible for providing temporary trench covers for the protection of the pipes in the trench and for the safety and convenience of his employees and those of other contractors working or having normal access in the vicinity of trench areas.

The Contractor shall be responsible for maintaining the trenches clean and dry, and shall hand over same to the Owner in clean and dry condition at the time of taking over of plant.

5.4.0 Cleaning, Packing and Handling of Piping Systems

The Contractor shall take all necessary precautions to ensure that the interior of all piping is kept clean during erection and free from any injurious matter.

All piping except water and air piping shall be chemically cleaned, pickled and purged with an air blast to clean the pipe inner surface. The outside of all pipes shall also be cleaned similarly. Carbon steel and ferritic alloys piping shall be cleaned after hot working or heat treatment. Cleaning shall be accomplished by either of the following methods.

- a) Degreasing making use of alkalis
- b) Pickling in hot sulphuric acid along with suitable inhibitor, followed by washing in cold and hot water.



- c) Cleaning by means of power driven wire brushes. The brushes shall be of the same material as the metal being cleaned. Both inside and outside surfaces shall be cleaned.
- d) Grit-blasting the inner and outer surfaces using silicon carbide or steel shots. All grit shall be subsequently removed.

After cleaning (by any of the above methods), the pipes shall be protected by means of an outdoor preservative. All pipes shall be capped using plugs or plastic caps. All bevels, threads, flange faces and other sealing surfaces shall be suitably protected with wood or plastic to prevent damage to these surfaces.

Suitable connections shall be made, where necessary, on all pipe runs to facilitate the removal of dirt and debris and the cleaning of each pipe run in accordance with the requirements specified elsewhere.

All steam piping to turbines shall be blown through with steam in accordance with the Inspection and Testing Requirements. The Contractor shall install and subsequently remove any temporary piping, fittings, supports or instrumentation required to carry out the blowing through operation. The terminals of piping being blown through shall be adequately fixed in order to take the resultant thrusts. The anchor, whether temporary or permanent, shall be designed to take the thrust and any loads imposed on the building steelwork and shall receive the prior approval of the Owner / owner's Representative. Target plates shall be used to ascertain that the system is rid of impurities.

5.5.0 Testing of Piping Systems

The following tests shall be conducted in the piping systems to check for cracks and the welding joint quality.

5.5.1 Hydrostatic Test

All pipework shall be tested hydraulically to at least 1.5 times the design pressure for at least 2 hours. After the hydraulic test, a leak test with air to 1.1 time the design pressure for at least 24 hours shall be performed.

The hydrostatic test of the pipe work shall be carried out with skids isolated from the pipe work. Skids shall be tested separately before installation and connection to pipe work.

The hydrostatic test pressure shall not be applied until the piping system and the testing medium have reached thermal equilibrium.

During the tests, hydrostatic pressure shall be monitored and corrections shall be made to compensate for thermal expansion or contraction. By this procedure, the test pressure shall be kept within specified test pressure. All joints are visually examined for leakage during the test.

Tested systems shall be vented and drained immediately upon successful completion of the test.

All stainless steel lines are emptied and dried immediately after hydrostatic tests are completed. To avoid the possibility of pitting due to chlorine contents in water, demineralised or otherwise suitably treated water shall be used as the testing medium.

5.5.2 Pneumatic Test

Pneumatic testing of a piping system is done



- i) When the piping system is so designed that it cannot be filled with water or other liquid testing medium.
- ii) When the piping system is to be used in services where traces of the testing medium cannot be tolerated.
- iii) When the piping system cannot be completely drained and dried out.
- iv) When hydrostatic testing would contaminate, or adversely affect chemical handled during the process.
- v) When the testing fluid would affect or damage internal lining.

Pneumatic tests shall meet the following requirements:

- Air test shall be performed with clean, dry air. The source shall be equipped with appropriate pressure relief valves and gauges. The pneumatic test pressure shall not be less than 1.2 or more than 1.5 times the design pressure of the piping system.
- No repair welding shall be performed on a pressurised system.

5.5.3 Radiographic Test

Radiographic inspection shall be carried out in accordance with the requirements of ANSI B31.1 and ASME V for checking piping weld quality.

Random radiography shall be carried out in accordance with ASME V Article 2 for all full penetration butt welds. Weld repairs made as a result of radiographic examination shall be radiographed after welding. Repairing a particular area more than two times is not permitted and the component shall be rejected. Prior approval shall be obtained from the Owner / Owner's Representative before taking up major weld repairs (When depth of repair exceeds 20% of thickness or 25 mm whichever is smaller). Mapping of major weld repairs is also required.

All welds shall be subject to 100% non destructive testing.

Radiography shall be carried out as follows:

- i) For piping 2½ inch NB or smaller, a single elliptical exposure which encompasses the entire weld circumference.
- ii) For piping 3 inch NB or larger, the double-wall-single-image technique shall be used with at least three exposures at 120° to each other.

The radiographic film recording shall be performed in accordance with the ASTM E94-77. The Radiographic Procedures and Standards of Acceptability shall be in accordance with ASME V and as specified in the appropriate design requirements:

- Gamma isotope double wall IR-192.
- Film used shall be fine-grained, a high contrast, direct type.
- Intensifying screen shall be 'lead'.
- Image quality indicators shall be of the wire type (DIN 54109) selected to give the required level of sensitivity.

6.0.0 GUIDELINES FOR SELECTION AND ERECTION OF VALVES

6.1.0 Scope of Specification

This specification covers the guidelines for selection of valves and technical requirements for materials, installation and tests of general and special purpose valves, valve drives and related accessories. General-purpose valves include gate, globe, piston lift check, swing



check, butterfly, plug, Ball and Diaphragm valves. Valve drives include pneumatic (diaphragm and cylinder), electric (motor and solenoid) actuators and hydraulic.

6.2.0 Valve Selection Criteria

Valve selection criteria based on mode of flow regulation is given below.

Type of valve	On-Off	Throttling	Diverting (Directional Change)
Globe – Straight/Angle/Oblique pattern	Yes	Yes	No
Globe – Multiport pattern	No	No	Yes
Piston	Yes	Yes	No
Parallel Gate – Conventional/Conduit/Knife	Yes	No	No
Wedge gate – with bottom cavity	Yes	No	No
Wedge gate – without bottom cavity (rubber seated)	Yes	Moderate	No
Plug – Non lubricated/Eccentric plug	Yes	Moderate	Yes
Plug – Lubricated/Lift plug	Yes	No	Yes
Ball	Yes	Moderate	Yes
Butterfly	Yes	Yes	No
Pinch	Yes	Yes	No
Diaphragm – weir type	Yes	Yes	No
Diaphragm – straight through	Yes	Moderate	No

Following is the valve selection criteria based on the fluid properties.

Type	Liquid			Special Applications
	Neutral (water, oil etc)	Corrosive (Acid, alkaline etc)	Slurry	
Globe – Straight pattern	Yes	No	No	
Globe – Angle pattern & Oblique pattern	Yes	No	No	
Globe – Multiport pattern	Yes	No	No	
Piston	Yes	No	No	
Parallel Gate - Conventional	Yes	No	No	Less pressure drop
Parallel Gate – Conduit gate	Yes	No	No	Water with sludge or debris



Type	Liquid			Special Applications
	Neutral (water, oil etc)	Corrosive (Acid, alkaline etc)	Slurry	
Parallel Gate – Knife gate	Yes	No	No	
Wedge gate – with bottom cavity	Yes	No	No	
Wedge gate – without bottom cavity (rubber seated)	Yes	Yes	No	
Plug – Lubricated & Non lubricated	Yes	Yes	No	
Plug – Eccentric/Lift plug	Yes	Yes	Yes	
Ball	Yes	Yes	No	
Butterfly	Yes	Yes	No	
Pinch	Yes	Yes	Yes	Powder as the nature of fluid
Diaphragm – weir type/ Straight through	Yes	Yes	Yes	No

For reasons of plant standardization the Contractor shall standardize the valves, to reduce number of types and manufacturers to a minimum. Installation and testing of the valves shall be in accordance with the applicable standards. The requirement of this clause shall apply if they are more stringent than the approved standards.

All valves shall be suitable for the media and for the service conditions and those performing similar duties shall be interchangeable. All valves must meet maximum design demands for pressure and temperature of the piping system.

If the media handled are polluted, the shut off devices used in discharge lines (e.g. drains on vessels) and possibly also in vent lines should consist of gate valves.

The maximum permissible forces for actuation handwheels are 300 N for wheels with diameter up to 400 mm and 600 N for larger diameters. Differential pressures requiring higher forces for actuation of handwheels shall entail fitting the valve with gears. For calculation of the gears or all other actuators the design pressures shall be taken as differential pressures. Large valves that are frequently operated or hard to operate manually shall be motorized.

Valves that are required to be motor operated shall be provided with hand operated equipment for closing and opening of the valves during power failure and shall have a suitable arrangement for de-coupling when the valves are being motor operated.

Gear operator shall be of totally enclosed. Bevel gear in grease case with grease nipples for gate and globe valves and totally enclosed helical worm gear in grease case with grease nipples for ball, plug and butterfly valves.

Where required, valve spindles shall be lengthened so that the hand-wheel is at a minimum height of one metre above the level of the floor. Where necessary they shall be provided with



headstocks and pedestals of rigid construction. The actuation of valves by means of chain drives is not permissible.

On all valves where the hand wheels are liable to be dangerously hot to touch thermal insulation shall be provided on the ring and spokes.

All valves shall be closed by rotating the handwheel in clock wise direction when looking at the face of the hand wheel. The face of each handwheel shall be clearly marked 'open and 'shut', with arrows indicating the direction of rotation to which each term refers.

Plastic or bakelite valve handwheels shall not be accepted. Valves with solid handwheels are not acceptable since all valves must be capable of being locked by means of a chain and padlock in the open and closed position.

All valves must be suitable for outdoor installation with due consideration of the special climate and environmental conditions at the site.

Unless otherwise agreed, all valves shall be fitted with the spindle in the vertical position. Eye bolts shall be provided where necessary to facilitate handling heavy valves or parts of valves.

Valves of sizes NB 50 and above shall be provided with position indications.

Fire safe valves shall be supplied with antistatic devices.

Materials used must confirm to the applicable standards. Materials for screws, bolts and nuts must have the operating temperature limits closely observed.

All valves of the relevant pipe work systems must be suitable for pickling.

For cold water lines ductile iron shall be allowed. In no case shall grey cast iron be allowed.

Unless otherwise required by virtue of the valve's function, bodies shall have an internal cross section corresponding to the nominal diameter of the connection.

Integral bypass arrangement for gate valves shall be provided wherever necessary. In that case, bypass valve shall be a globe valve and bypass attachment to main valve body shall not be screwed. The integral bypass valve shall also be motorized if the connected main valve is provided with motor actuator.

Gate valves and swing check valves of the H.P. piping systems shall be equipped with self-sealing lid covers. Gate valves with self-sealing lid covers shall be equipped with a safety device at the body. If discs are used they must be capable of being dismantled and changed under operating conditions.

Connecting flanges shall be in accordance with the applicable standards with regard to both the connection dimensions and the minimum thickness of the material.

The transition from the flat rear surface of the flange (nut contact faces) to where the welding begins must have no sharp-edged machined grooves.

The spindle must be made in one piece: the length of thread must be such that the threaded bush is fully engaged in any position of the moving part. The connection between the spindle and the cone must be sufficiently flexible. For H.P. globe valves and globe valves for throttling purposes of NB 50 or less the spindle and cone must be made in one piece.

In case of metallic sealing elements there must be difference in hardness between the body seat and the sealing element, the sealing element having the higher hardness values.

All globe valves shall be equipped with throttling cones with parabolic characteristics.



Each valve shall be marked on the body with the material diameter, the nominal pressure, type of valve and an arrow showing the flow direction whenever only one is possible.

No traps which incorporates internal screens or check valves shall be used unless specifically required by the specifications or approved by the Owner.

Condensate drainers shall be of the ball-float type.

For safety valves, pressure relief valves, bursting discs and other safety devices against excess pressure the directives of appendix II of the code ANSI B31. 1: 'New Mandatory Rules for the design of Safety Valve Installations' shall apply as well as requirements of Indian Boiler Regulations (IBR) wherever applicable.

6.3.0 Requirements of General Purpose Valves

a) Gate and Globe Valves

All gate and globe valves, except bronze body valves, shall be screwed outside and yoke designed with rising stems. Bronze body valves shall have union type bonnets and rising stems.

Bonnets joints shall be of the bolted, flanged type for class rating upto 600#. Pressure seal bonnets shall be provided for class rating above 600#. The bypass shall be integral with the main valve and shall be of welded connection.

Valves shall be provided with back-seating construction and shall be suitable for re-packing at full pressure with the valve in the open position. Gate valves for pressure above 40 bar shall have double wedge type discs. Globe valves shall have plug type discs. All valves shall have replaceable seat rings.

b) Check valve

Check valves shall be designed for mounting in horizontal or vertical piping runs. Check valve shall be of a non slam type with a swing disc and, in special cases, of the tilting disc type or guided piston lift type used upto 2". Check valves are placed in line with a gate valve or a globe valve where guaranteed tightness is required. As far as possible, mounting check valves in vertical position to be avoided.

c) Butterfly valves

Butterfly Valves shall be used in place of gate or globe valves for low-pressure liquid or gas service upto 300# class rating. Valves are to be designed for minimum pressure loss when open and capable to withstand the full pressure of the line when closed and cause minimum vibration when used for throttling of flow.

- Butterfly valve Up to 100NB shall be without gear, above 100NB to 500NB shall be gear operated and above 500NB shall be motor (electrically) operated.

d) Ball Valves

Ball valves may be used for low pressure liquid / air service. Each ball valve shall be provided with an operating lever.

e) Instrument Root Valves

Instrument shut-off valves shall be Globe type construction, no bonnet, outside screw, rising stem, with vent plugs and flanged or socket weld ends.



6.4.0 Requirements of Special Purpose Valves

Special purpose valves include valves operated with motor, pneumatic and solenoid actuators. These valves are mainly meant for remote operation in critical controls of fluid pressure, flow and temperature. The special valves shall have provision for hand operating gear.

a) Motor operated valves:

Electrically operated valves are preferred for non-safeguarding service. Local operation shall be provided on all valves. Every selector switch shall be lockable in "local" or "remote" or "hand" positions and each shall be provided with a padlock and two keys. Valve motors shall be supplied from the 400 V, 3-phase system.

Electric actuators shall have torque-limiting devices effective throughout full travel, the torque at which these operate being readily adjusted, and travel limit switches for controls and also for the operation of remote indicating lights.

The speed of operation of all power-operated valves is to be selected to suit the operating conditions of the system and to minimise pressure surges. Actuators shall have adequate power and control systems to operate the valves accurately under all system operating conditions.

All motorized valves shall be equipped with four limit switches, for automatic control and position indication purposes. Two torque switches are equipped, one for acting in the opening direction and the other in the closing direction. Limit switches shall not be used as mechanical stops. The materials of the limit switches shall be corrosion resistant to chemicals present in the plant environment by hermetically sealed snap acting single pole double throw type, able to switch faultlessly 125 V DC/24V DC/ 230V AC.

b) Pneumatic actuated valves:

Pneumatic actuators may be of the following types:

- Spring opposed diaphragm motor type
- Spring less opposed diaphragm motor type
- Piston operated type

Air actuators shall be designed to produce the required stem forces with supply air pressures of 5.5 - 7 bar (g). Piston actuators shall be used where stem forces dictate their use.

Diaphragms shall be of moulded rubber, neoprene or other suitable materials and diaphragm housings shall be of pressed steel construction.

Piston actuators use cast pistons and cylinders with O-ring seals. Air cylinders are manufactured in accordance with BS 4862 or approved equivalent.

The cylinders, unless otherwise specified, shall be required to be supplied with protective gaiters - bellows type to protect the piston rod seals. Cylinder seal materials are to be selected by considering higher ambient temperatures.

c) Solenoid actuated valves:

Solenoid coils are rated at 125 V DC for continuous energizing and designed to operate satisfactorily within 0.80 to 1.1 of rated DC voltage and in 55°C ambient temperature.

Solenoid valves shall operate on the "ON-OFF" principle. The use of economy resistors is not allowed. Solenoids shall be installed in a vertical orientation.

d) Safety and relief valves:

Safety & safety relief valves are provided to relieve the pressure in excess of the design pressure building up in the system.

All relief valves are direct spring loaded, angle body types of a design suitable for their respective operating conditions. Relief valves for compressed air, steam services shall be of the "safety" type. Relief valves for water or oil shall be of the liquid relief type having a slow opening and closing action. All relief valves shall be arranged for field adjustment of the set pressure and provided with lifting levers.

e) Control valves:

Control valves are meant for regulating pressure, temperature & flow parameters in the system. Control valve stations are generally designed with a gate valve at its upstream and downstream with a globe vent valve and a globe type bypass valve. Manual bypass valve is provided where manipulation can provide satisfactory control or where it is required for the safe plant shutdown following failure of the control valve. Bypass valves are not provided in cases where manual control cannot sensibly be achieved.

Trim of control valves shall be designed to avoid erosion, excessive noise and vibration while handling flashing condensate.

Control valves shall have stainless steel stems, guide bushing, inner valves, seat rings, stem lock pins and stuffing box parts hardened with stellite or other equivalent seating surfaces.

Flow control valves shall be especially designed to meet high pressure drop applications with stainless steel stems, stellite, or other equivalent hardening, seats and discs.

Control valves shall be fitted with approved indicators, showing accurately the amount of valve opening, and shall have electric position transmitters with 4-20 mA output equivalents to 0-100% opening. All valve seats and faces shall be renewable and be made from materials that are corrosion and wear resistant. Noise levels for control valves shall be restricted to 85 dBA at 1 m.

f) Pressure reducing valves:

Pressure reducing valves shall be designed for perfectly stable, quiet and non-vibratory operation over its full range and shall be suitable for continuous duty at the operating temperature.

Incase of electrical or hydraulic valve operator is provided, on failure of the operating mechanism, the valve shall not close automatically and the valve opening shall be readily adjustable by hand. A pressure relief valve shall be provided at the discharge of each reducing valve, capable of discharging the maximum flow of the reducing valve without build-up of pressure.

Pressure & Temperature gauges shall be provided upstream and downstream of each reducing valve and this valve is operated by sensing the downstream pressure with the set pressure.

6.5.0 General requirements of installation of valves

All regularly operated isolation valves and control valves shall be accessible from a permanent floor or access platform. For operator convenience, valves shall have 1.0 m clear approach space. The stems of all valves for outdoor service shall have weatherproof protection covers of approved construction.



Sufficient overhead access and clearance shall be provided to enable the valve internals to be withdrawn and also for the complete valve to be removed by means of lifting tackle if necessary. Pipe work systems shall be designed and supported so that valves can be isolated for maintenance purposes without shut down of the system whenever feasible and practical.

Unless otherwise specified, manually operated gate, globe, or butterfly valves shall be hand wheel operated and plug valves or ball valves shall be wrench-operated. Manual gear operators shall be provided, as required, depending on the size and pressure rating of the valve. All gear operators shall be of the totally enclosed type, self-locking, with position indicators. All valves shall be equipped with a locking facility, which permits locking in the open or closed position.

All valves shall be fitted with indicators such that it may be readily seen whether the valves are open or shut, and the extent of opening. In case, the valves fitted with extended stems, indicators shall be provided both on the valve and at the extended stem hand wheel. Where remote indication is required, the valves shall be equipped with limit switches mounted on the valves for electrical signal of valve positions "open" and "shut" or position 0 to 100% as required.

Valves and related accessories shall be subjected to hydrostatic testing and seat leak testing as per the requirement of the applicable codes and valve pressure classes as per B16.34 / API 598 / BS 5146. All motor actuators shall be supplied with type and routine test reports.

The shut off valves in the vent line from the safety valves shall be locked open by a approved master key system.

All isolation valves shall be designed to withstand the differential pressure across them when closed.

The drains from each filter separator and other liquid drainage points shall be fitted with a non-return valve and manual isolating valve. The drains shall be grouped and connected to a common drain header leading to the condensate tank.

Vents and thermal reliefs shall discharge to the vent system. The capacity and the design of the vent system shall be as per the recommendations of API standards.

Whenever there is a risk of pressure above design point safety valves shall be provided.

7.0.0 MATERIAL REQUIREMENTS FOR PIPING COMPONENTS AND VALVES

The main materials and special requirements specified under this title shall be seen as the minimum requirement.

The following guideline represents minimum requirements. In case of intended deviations 'Deviation from Enquiry Documents' applies.

7.1.0 Piping Material Specifications

SL NO	SERVICE	SIZE	PIPE	FITTINGS	FLANGES	GASKETS	END JOINT
1	HP steam system – HP Steam to steam turbine, HP steam upto	<= 50 NB	ASTM A335 P91	ASTM A182 F91	ASTM A182 F91-	Spiral wound	Socket welded
		> 50 NB	ASTM	ASTM A234	ASTM	Spiral	Butt



SL NO	SERVICE	SIZE	PIPE	FITTINGS	FLANGES	GASKETS	END JOINT
	PRDS		A335 P91	WP91	A182 F91-	wound	welded
2	Steam Temperature above 550° C & upto 605 ° C	<= 50 NB	ASTM A335 P91	ASTM A182 F91	ASTM A182 F91-	Spiral wound	Socket welded
		> 50 NB	ASTM A335 P91	ASTM A234 WP91	ASTM A182 F91-	Spiral wound	Butt welded
3	Steam Temperature above 500 and upto 550° C	<= 50 NB	ASTM A335 P22	ASTM A182 F22	ASTM A182 F22	Spiral wound	Socket welded
		> 50 NB	ASTM A335 P22	ASTM A234 WP22	ASTM A182 F22	Spiral wound	Butt welded
4	Steam Temperature above 400 and upto 499° C	<= 50 NB	ASTM A335 P11	ASTM A182 F11	ASTM A182 F11	Spiral Wound SS316	Socket Welded
		> 50 NB	ASTM A335 P11	ASTM A234 WP11	ASTM A182 F11	Spiral Wound SS316	Butt welded
5	Temperature below 400° C (LP steam system, Auxiliary steam system, Fuel oil, Feed water, Condensate CEP suction, Nitrogen Filling)	<= 50 NB	ASTM A106 Gr B	ASTM A105	ASTM A105	Spiral Wound SS316	Socket Welded
		> 50 NB	ASTM A106 Gr B	ASTM A234 WPB	ASTM A105	Spiral Wound SS316	Butt welded
6	DM water distribution system/ Portable water system & LP chemical dosing system	<= 50 NB	ASTM A312 TP 316L	ASTM A182 Gr F316L	ASTM A182 Gr F316L	EPDM/ Teflon	Socket Welded
		> 50 NB	ASTM A312 TP 316L	A 403 Gr WP316L	ASTM A182 Gr F316L	EPDM/ Teflon	Butt welded
7	Closed cycle cooling water system	<= 50 NB	ASTM A53 Gr B ERW / IS1239 part I Heavy ERW	ASTM A105/IS1 239 Part II	ASTM A105	EPDM/ Teflon	Socket Welded
		Above 50 NB and upto 450 NB	ASTM A 53 Gr B ERW / IS1239 part I Heavy ERW upto 150NB & IS3589	ASTM A234 WPB/IS1 239 Part II up to 150NB	ASTM A105	EPDM/ Teflon	Butt welded



SL NO	SERVICE	SIZE	PIPE	FITTINGS	FLANGES	GASKETS	END JOINT
			ERW above 150NB				
		Above 450 NB	ASTM A134-A283 Gr C ERW / IS 3589	Same as parent pipe	ASTM A105 / IS2062 Plate fabricated	EPDM/ Teflon	Butt welded
8	Instrument Air system	<= 50 NB	ASTM A53 Gr. B (ERW)/ IS1239 Part I Heavy ERW Galvanized	ASTM A105/IS1239 Part II Galvanized	ASTM A105 Galvanized	EPDM/ Teflon	Threaded
		> 50 NB	ASTM A53 Gr. B/IS1239 ERW Part I Heavy up to 150NB Galvanized	ASTM A234 WPB / IS 1239 Part II up to 150NB Galvanized	ASTM A105 Galvanized	EPDM/ Teflon	Threaded
9	Service air / service water	<= 50 NB	ASTM A53 Gr B ERW/ IS1239 Part I Heavy ERW	ASTM A105/IS1239 Part II	ASTM A105	EPDM/ Teflon	Socket Welded
		> 50 NB & Upto 450 NB	ASTM A53 Gr B ERW/IS1239 ERW Part I up to 150NB.	ASTM A234 WPB/ IS 1239 Part II up to 150NB	ASTM A105	EPDM/ Teflon	Butt welded
		450 NB & Above	ASTM A134-A283 Gr C ERW	ASTM A234 WPB	Plate fabricated from MS IS 2062 Plate	EPDM/ Teflon	Butt welded
10	Lube Oil, Waste oil and Control / Hydraulic Oil (Upstream of Filter) / LDO & HFO	<= 50 NB	ASTM A106 Gr B	ASTM A105	ASTM A105	Spiral Wound SS316	Socket Welded
		> 50 NB	ASTM A106 Gr B	ASTM A234 WPB	ASTM A105	Spiral Wound SS316	Butt welded
11	Lube Oil, Waste oil and Control / Hydraulic Oil (Downstream of Filter)	<= 50 NB	ASTM A312 TP316	ASTM A182 Gr F316L	ASTM A182 Gr F316L	Spiral Wound SS316	Socket Welded
		> 50 NB	ASTM A312 TP316	ASTM A403 GRWP316	ASTM A182 Gr F316L	Spiral Wound SS316	Butt welded
12	Sea water intake and outfall / CT	All	HDPE	HDPE	HDPE With Backing Ring	EPDM	Fusion welded



SL NO	SERVICE	SIZE	PIPE	FITTINGS	FLANGES	GASKETS	END JOINT
	Makeup and Desal plant feed water/ ash recovery water Actual piping MOC shall be referred from the respective section. Accordingly Bidder shall consider.						
13	Sea water intake and outfall / CT Makeup and Desalplant feed water/Auxiliary cooling water system/ Low and High Pressure Sea water Actual piping MOC shall be referred from the respective section. Accordingly Bidder shall consider.	All	GRP	GRP	GRP	-	Butt and Wrap for Aboveground / Bell and Spigot for Below ground.
14	Condenser cooling water system	<= 50 NB	ASTM A312 TP 316 L	ASTM A182 Gr F316L	ASTM A182 Gr F316L	EPDM/ Teflon	Socket Welded
		Above 50 NB (including Above ground CW pipe)	IS1239 part I, ERW, Heavy, glass flake coating (1 mm) / ASTM A312 TP 316 L upto 150NB & IS3589 fabricated from IS 2062 ,with Polyurethane	ASTM A234 WPB glass flake coating (1 mm) up to 350NB and fabricated from parent pipe with	ASTM A105 up to 150 glass flake coating (1 mm) up to up to 350NB and fabricated from IS2062 Plate with Polyurethane lined 400NB and	EPDM/ Teflon	Butt welded



SL NO	SERVICE	SIZE	PIPE	FITTINGS	FLANGES	GASKETS	END JOINT
			lined inside 150NB and Above	Polyurethane lined inside 400NB and Above	Above		
		Above 900 NB (below ground)	IS3589 fabricated from IS 2062 with corrocoat or polyurea coating of 1500 microns DFT and Outside of pipes shall be provided with 250 mm thick RCC encasement	- -	-	-	-
15	Chemical lines in Desalination plant.	ALL	CPVC	-	-	-	-

Note: At the welding joints, corrocoat coating shall be applied after welding.

7.2.0 Valve Material Specifications

SL. NO.	SERVICE	SIZE	BODY/BONNET	DISC	STEM	HAND WHEEL	VALVE ENDS
1	HP steam system – HP Steam to steam turbine, HP steam upto PRDS	>65NB < 50 NB	ASTM A182 Gr. F91 ASTM A182 Gr.F91	ASTM A182 Gr. F91 ASTM A182 Gr F91	ASTM A182 Gr. F6a ASTM A182 Gr.F6a	ASTM A47 Gr. 32510 ASTM A47 Gr.32510	BUTT WELDED. SOCKET WELDED
2	Steam Temperature above 550° C & upto 605 ° C	>65NB < 50 NB	ASTM A217 C12A/ ASTM A182 Gr.F91	ASTM A182 Gr. F91 ASTM A182 Gr F91	ASTM A182 Gr. F6a ASTM A182 Gr.F6a	ASTM A47 Gr. 32510 ASTM A47 Gr.32510	BUTT WELDED. SOCKET WELDED
3	STEAM LINES (TEMP >500 °C AND <550 °C)	>65NB < 50 NB	ASTM A217 WC9/ ASTM A217 C12A ASTM A182 Gr.F22	ASTM A217 WC9/ ASTM A217 C-12A ASTM A182 Gr F22	ASTM A182 Gr. F6a ASTM A182 Gr.F6a	ASTM A47 Gr. 32510 ASTM A47 Gr.32510	BUTT WELDED. SOCKET WELDED
4	STEAM LINES (TEMP>400 °C AND <499 °C)	>65NB < 50 NB	ASTM A217 WC6 ASTM	ASTM A217 WC6 ASTM	ASTM A182 Gr. F6a ASTM A182	ASTM A47 Gr. 32510 ASTM A47	BUTT WELDED. SOCKET



SL. NO.	SERVICE	SIZE	BODY/ BONNET	DISC	STEM	HAND WHEEL	VALVE ENDS
			A182 Gr.F11	A182 Gr F11	Gr.F6a	Gr.32510	WELDED
5	LP steam system, Auxiliary steam system, Fuel oil, Feed water, Condensate CEP suction, Nitrogen Filling	>65NB < 50 NB	ASTM A216 Gr WCB ASTM 105	ASTM A216 Gr WCB ASTM A182 Gr F6a	ASTM A182 Gr F6a ASTM A182 Gr F6a	ASTM A47 Gr 32510 ASTM A47 Gr 32510	BUTT WELDED SOCKET WELDED
6.	Lube Oil, Waste oil and Control / Hydraulic Oil (Upstream of Filter) / LDO & HFO	>65NB < 50 NB	ASTM A216 Gr WCB ASTM A105	ASTM A216 Gr WCB ASTM A 182 Gr. F6a	ASTM A479 Type 410-2 ASTM A479 Type 410-2	ASTM A47 Gr 32510 ASTM A47 Gr 32510	BUTT WELDED SOCKET WELDED
7.	Lube Oil, Waste oil and Control / Hydraulic Oil (Downstream of Filter)	>65NB <50NB	ASTM A 351 CF3M ASTM A 182 F 316 L	ASTM A 351 CF3M ASTM A 182 F 316 L	ASTM A479 Type 410-2 ASTM A479 Type 410-2	ASTM A47 GR. 32510 ASTM A47 GR. 32510	BUTT WELDED SOCKET WELDED
8.	INSTRUMENT AIR	>65NB < 50 NB	A216 Gr. WCB GALV. A105 GALV.	A351 Gr. CF 8M SS316	ASTM A479 Type 410-2 ASTM A479 Type 410-2	ASTM A47 GR. 32510 ASTM A47 GR. 32510	FLANGED RAISED FACE SCREWED
9	SERVICE AIR SERVICE WATER	>65NB < 50 NB	A216 Gr. WCB A105.	ASTM A216 Gr WCB ASTM A 182 Gr. F6a	ASTM A479 Type 410-2 ASTM A479 Type 410-2	ASTM A47 GR. 32510 ASTM A47 GR. 32510	FLANGED RAISED FACE SOCKET WELDED
10	SEA WATER	>65NB < 50 NB	A 439 Gr.D2 - NI RESIST A182 F316L	A 439 Gr.D2 - NI RESIST A182 F316L	DUPLEX SS DUPLEX SS	ASTM A47 GR. 32510 ASTM A47 GR. 32510	FLANGED RAISED FACE SOCKET WELDED
11	Condenser cooling water system	>600NB	CI-IS 210 FG-260 or ASTM A-216 CLB or Fabricated steel as per ASTM A-515 Gr. 60/80 / IS:2062 Gr. B or	CI-IS 210 FG-260 or ASTM A-216 CLB or Fabricated steel as per ASTM A-515 Gr. 60/80 / IS:2062 Gr.or	DUPLEX SS		



SL. NO.	SERVICE	SIZE	BODY/ BONNET	DISC	STEM	HAND WHEEL	VALVE ENDS
		>65NB UP TO 600NB	equivalent. Fully ebonite lined A 439 Gr.D2 - NI RESIST	equivalent. Fully ebonite lined A 439 Gr.D2 - NI RESIST	DUPLEX SS	ASTM A47 GR. 32510	FLANGED RAISED FACE
		< 50 NB	A182 F316L	A182 F316L	DUPLEX SS	ASTM A47 GR. 32510	SOCKET WELDED
12	DM Water / DMCW/ CCCW / Potable water /LP chemical dosing system	>65NB < 50 NB	ASTM A 351 CF3M ASTM A 182 F316L	ASTM A 351 CF3M ASTM A182 F316L	ASTM A479 Type 410-2 ASTM A479 Type 410-2	ASTM A47 Gr 32510 ASTM A47 Gr 32510	FLANGED RAISED FACE SOCKET WELDED

Piping and valve specification also given in the respective package section. In case of contradiction between the respective package section and the piping section, superior of the respective package section and the piping section shall be provided.

8.0.0 BURIED PIPING

8.1.0 Excavation for Pipe Trenches

The trench shall be cut true to the line leveled with the help of sight rails provided at every 30 m, at change of direction, gradient and at any suitable distance as directed by the Owner.

If the trench is excavated below the required level indicated in the drawing, the extra depth shall be filled with concrete or approved equivalent material as directed by the Owner.

The trench shall be excavated so as to provide an average cover of 1500 mm or equal to the diameter of the largest pipe to be laid in the trench unless otherwise shown in drawings. The average cover shall be reckoned from top of the pipe of the largest diameter to be laid in the trench, to the finished grade. The width of the trench, shall be sufficient to give free working space on each side of the pipe. The free working space shall conform to IS:783. Generally it shall not be less than 150 mm on either side or 1/3 of dia of pipe whichever is greater.

No excavated material shall be deposited within 1.5 meters from the excavated trench.

The dredged material shall be disposed off shore as per the regulations for sea water intake piping

In case of road cutting, all material i.e. metal, bricks, etc. shall be taken out carefully and kept separately for reuse and road work shall be redone up to the original level prior to cutting the road with the excavated road materials after laying & testing of the pipeline. The Contractor shall provide suitable signs and barricades to prevent accidents. Contractor shall also provide reasonable bypass when a road is cut for laying pipeline. The dykes affected due to laying of the pipes, shall be redone conforming to the original specifications by the Contractor.



During excavation if some obstacle is met with, same shall be reported to the Owner and dealt with as instructed by him.

The Contractor shall dewater, shore or do whatever might be required to excavate the trench, install the pipe in it and backfill the trench, in accordance with the specifications. Dewatering shall be done in advance of the laying of the pipe to allow adequate inspection of padding of the bottom if required and dewatering shall be continued throughout during laying of the pipe and backfilling of the trench.

In muddy/slushy ground, the bed shall be provided with a layer of a sand or lean concrete as directed by the Owner.

The trench shall follow the gradient of pipeline as specified in the drawing. The Contractor shall keep the trench in good condition, until the pipe is laid and tested. All materials to shore the trench in order to prevent caving are to be furnished and removed by the Contractor.

In case pipe is lowered in caved trench and back-filled before being inspected by the Owner, the Contractor shall re-excavate the trench for inspection and backfill it.

8.2.0 Sand bedding:-

Sand bedding of adequate thickness with fine sand to be provided as per AWWA M11

8.3.0 Corrosion Protection Tape coating

Materials

All underground steel pipes shall be protected with external corrosion Protection Tape.

Coating shall be coal tar based tape coating materials confirming to AWWA C203. Tape shall be coal tar component supported on fabric of organic / inorganic fibres. The fibre shall be thoroughly coated and completely covered on both sides with coal tar component. The tape shall be supplied in standard width and rolls shall be wound on hollow cores of standard diameter. The material shall have enough mechanical strength and dimension stability. As far as possible the fabric shall be thin, flexible, uniform and composed of glass fibres in an open structure bonded with a suitable inert material compatible with coal tar.

The primer shall be a coal-tar or suitable resin product. The primer shall consist of chlorinated rubber synthetic plasticizer and solvents. These primers shall be suitably compounded to produce a liquid coating which may be applied by brushing or spraying and which shall produce effective bond between the metal and subsequent coating of coal tar tape. Primer should not contain benzol or other toxic and/or highly volatile solvents, added pigments or inert fillers or other substances and shall show no tendency to settle out in containers.

Where the soil is corrosive in nature, Cathodic protection shall be given. If soil resistivity is greater than 5000 ohm-cm, cathodic protection is generally not required

Application Procedure

Cleaning, blasting and protection after blasting

Before the metal is blast cleaned, all oil and grease on the surfaces shall be thoroughly removed by flushing with a suitable solvent (such as xylene or 1,1,1 trichloroethane) and wiping with clean rags. The use of dirty or oily rags or dirty solvent shall not be permitted. All foreign matter not removable by blast cleaning shall be removed by suitable means. Blast cleaning operations shall remove all rust, scale and other impurities from the surface, exposing base material, presenting a greyish matte appearance. Slight shadows, strata or discoloration caused by rust stains or mill scale oxides need not be removed. Blasted



surfaces that rust before a priming coat has been applied shall be cleaned of all rust by buffing or wire brushing, or shall be reblasted. Adequate air separators shall be used to effectively remove all oil and free moisture from the air supply to the blaster.

After being cleaned, the pipe shall be protected from and be maintained free of oil, grease and dirt that might fall on the pipe before it has received its coal tar tape. During blast cleaning, any pipe found to show pits shall be set aside immediately, pending examination by the Owner for acceptance, reconditioning or rejection.

Priming and Application of coal tar tape

All blasted surfaces shall be primed immediately following blasting and cleaning. The surfaces be dry at the time the primer is applied and no primer shall be applied during rain unless the pipe to be primed is protected from the weather by suitable housing.

The use of coal tar primer that has become fouled with foreign substance or has thickened through evaporation of the solvent oil shall not be permitted. The application of primer shall be hand brushing, spraying or other suitable means and shall be in accordance with instructions for application, as supplied by the manufacturer. The apparatus to be used for application of the primer shall be acceptable to the Owner. Spray gun apparatus to be used shall include a mechanically agitated pressure pot and an air separator that shall remove all oil and free moisture from the air supply.

After application, the primer coat shall be uniform and free from floods, runs, sags, drips, holidays or bare spots. Any bare spots or holidays shall be recoated with an additional application of primer. All runs, sags, floods or drips shall be removed by scraping and cleaning, and the cleaned area shall be retouched or remedied by reblasting and repriming. Suitable measures shall be taken to protect the wet primer from contact with rain, fog, mist, spray, dust or other foreign matter until completely hardened and tape applied.

The minimum and maximum drying times of the primer or the period between application of primer and application of coal tar tape, shall be in accordance with instructions issued by the manufacturer.

If the coal tar tape is not applied within the allowed maximum time after priming, the pipe shall be reprimed with an additional light coat of primer or the entire prime coat shall be removed by reblasting and the pipe reprimed.

The cleaning and priming operation may be carried out in the Contractor's workshop or on site. The entire pipe length shall be cleaned but the ends of the pipes shall be left without coating for a distance of 230 mm for joints, which shall be coated and wrapped manually on site after laying, welding and testing the pipes.

Tape application should follow as soon as the primed surface is tacky. Tape shall be wrapped in accordance with the manufacturer's recommendation in a manner that shall meet the adhesion and holiday detection requirement. In no case the overlap per single wrap is less than 12.5 mm. Two coats of coal tar tape coating shall be applied. A suitable primer as per manufacturer's recommendation shall be applied between the wraps. Air pockets or bubbles between the pipe and tapes or between tapes are to be avoided and tape shall be in perfect contact with the primed steel.

8.4.0 Laying of Underground Piping

General

After prefabrication, coating and trenching, the Contractor shall lay the underground piping in accordance with the following clauses and as per the approved piping arrangement drawings.



The Contractor shall be responsible for correct layout and gradient of the line.

Lowering & Laying

The pipes shall be lowered either by mechanical methods or by hand when the trench is ready and bottom of the trench is graded as per required pipe laying conditions and specifications.

By machine

The shop coated pipe, already transported to the pipe laying site/convenient length of pipe assembly coated and wrapped near the trench after hydrostatic testing shall be placed on clean square cut skids suitably spaced so as to keep the pipe away from touching the ground. The pipe may be lowered down in the trench by the launcher cranes, with sufficient care to protect the coating of the pipeline. Bare cables, chains hooks etc. shall not be permitted to come in contact with the coating.

At tie in welds and other places, the Contractor shall clean, prime, coat and wrap manually. Also short sections of pipelines which are impracticable to shop treat may be hand treated but only on the prior written approval of the Owner.

By Hand

The pipe may be lowered with the help of tripods and chain pulleys blocks into the trench immediately after the coating. However if in the opinion of the Owner that the temperature condition do not allow direct lowering, then the pipe shall be set down on clean square cut skids. The skids shall be so spaced as to keep the pipe away from touching the ground.

Method & Time of lowering pipe

Under favourable temperature, conditions and using methods which shall not damage coating, the pipe may be lowered into the trench.

Pipe previously set on skids, because of unfavourable temperature conditions shall be lowered into the trench normally in the cool of the morning and only when the temperature of the pipe is below the softening point of the coating materials.

All skid marks and other places of damages shall be thoroughly examined to ensure proper patching where necessary, before the pipe is finally lowered into the trench.

Handling of Coated Pipes

Coated pipes shall not be placed in trench until cave in plugs, hard clods, stones, skids, welding rods etc. have been removed there from. Where the trench has a hard or jagged bottom, sufficient fine dirt or sand shall be placed therein, before the pipe is lowered.

Coated pipe shall not be handled or moved by means of cable or chains or by prying with skids or bars. It shall be tied and lowered by using lowering belts of a standard width and designs for the size of pipe being handled.

Coated pipe shall not be dragged along the ground or otherwise handled in a manner that shall be detrimental to the coating.

Lining up & Welding

The ends of the pipe line shall be kept securely closed to prevent entry of any foreign material/ moisture after lowering into the trench.

Before making joints the pipe shall be carefully laid so as to be perfectly aligned in both plan and profile and the end closures provided shall be removed.



Tie-in shall be made in the coolness of the morning or when the ambient temperature is not exceeding 29°C or softening temperature of the coating material whichever is less. All bevelling, aligning and welding shall be in accordance with the welding specifications.

Free access shall be provided for the welding of the circumferential joints by increasing the width and depth of the trench at these points. There should be no obstruction to the welder from any side so that a good welded joint is obtained.

8.5.0 Draining

All lines and equipment shall be completely drained after the hydrostatic test of a system has been completed. High point vents shall be open to prevent excessive vacuum and permit complete draining.

If it becomes necessary to leave a system filled with the testing medium for any abnormal length of time, suitable arrangement such as venting shall be made to provide for possible liquid expansion with change in ambient temperature.

8.6.0 Backfilling

After testing and inspection of the pipeline to the entire satisfaction of the Owner, the trench shall be backfilled with the same material as the pipe bed above the top of the pipe. No trench shall be backfilled without the approval of Owner.

Backfilling with the excavated material shall be done in layers of 200 mm, well watered and rammed to avoid any settling afterwards.

The Contractor shall place soil over the trench to such a height as to provide adequately for future settlement of the trench backfill.

If due to exigencies of the work, some portion of the pipeline is backfilled without approval of the Owner, the Owner shall have the right to order uncovering of the pipe for examination.

The backfill material shall be free from stone pieces.

Surplus excavated soil or rubbish material shall be removed by the Contractor to a place designated by the Owner.

When the trench has been dug through roads all backfill shall be thoroughly compacted. In certain cases, special compaction methods may be required by the Owner. This shall be done by the Contractor and part of the EPC work.

When the trench has been dug through unlined ditches the backfill shall be thoroughly compacted in 150 mm layers for a distance of 1.50 m beyond the outside banks of the ditch on either side. The banks of the ditch shall also be compacted in 150 mm layers.

After the roads have been already graded, if they are trenched or otherwise disturbed by the Contractor during laying of the pipelines. The Contractor shall restore the road to its original level and condition. In the event, the Contractor is required to place extra fill, gravel, or other special material it shall be borne by him and shall part of the EPC work.

8.7.0 Clean up of Surroundings

As soon as the backfill is completed, the Contractor shall immediately clean up the adjoining area by removing all surplus and defective material and dispose of all refuse such as spurs, sheet iron, and broken skids etc. to the complete satisfaction of the Owner.



8.8.0 Thrust blocks should be provided at all direction changes for GRP/HDPE Buried pipes .

9.0.0 DOCUMENTATION

9.1.0 Drawings, Data / Documents To Be Submitted Along With Offer

9.1.1 Completely filled up technical schedules and data sheets of tender documents

9.1.2 Details of similar job executed in last five years

9.1.3 Mandatory spares

9.1.4 Start up and commissioning spares

9.1.5 3 years Operation and maintenance spares

9.1.6 Special Tools and tackles for erection & maintenance

9.2.0 Drawings, Data / Documents to be furnished by the successful Bidder

9.2.1 Piping specification for Supply and erection

9.2.2 QAP for shop and field works

9.2.3 Piping general arrangement drawings

9.2.4 Stress analysis report

9.2.5 Isometric drawings

9.2.6 Datasheets and GA drawings for valves and piping specialties

9.2.7 Specification for Pipe supports and stress analysis.

9.2.8 Specification for insulation

9.2.9 Pipe Thickness calculation

9.3.0 Any other drawings required for review during the detailed engineering stage, same shall also be submitted by contractor.

**VOLUME II****SUB-SECTION - 2.21****THERMAL INSULATION****1.0.0 GENERAL**

This section is intended to provide the scope, design, constructional and functional requirements of thermal insulation for piping, valves, fittings and equipments for the purpose of heat conservation, temperature maintenance, process stabilization, personnel protection.

2.0.0 SCOPE OF SUPPLY

Thermal insulation

Marine grade aluminum Cladding material & Other Accessories materials.

Cladding sheet, all other ancillary materials i.e. Wires, Straps, Zinc coated Screws, Wire netting, Joint sealing compound, Ceramic mill boards, MS flats, Lugs, Bolts & Nuts etc. shall be of commercial quality.

3.0.0 DESIGN REQUIREMENTS**3.1.0 Insulation Material**

Thermal insulation shall be required for all hot piping and equipment with fluid temperature greater than 60°C. and for piping and equipment for the following cases:

- Conservation Energy and thereby increase system thermal efficiency.
- Maintaining the process temperature.
- Personnel protection
- Prevention of condensation.

Piping and equipment shall be insulated with Mineral (Rock) wool material conforming as per the relevant code & provided as below:

Mineral (Rock) Wool material of density 150kg/m³ shall be provided for piping and Fittings.

Mineral (Rock) wool material of density 100kg /m³ shall be provided for Valve Boxes and Equipments.

Insulation material shall be finally covered with cladding material.

Bidder shall calculate the insulation thickness based on the selected Insulation material and the same will be subjected to owner approval during detailed engineering.

3.2.0 Cladding material & Other Accessories materials

Cladding of Marine grade aluminum shall be required for piping and equipment for the following purpose:

- Cladding over hot thermal insulation to protect insulation surface against moisture in air or rain, to prevent physical damages etc.



Insulation material shall have backup stainless steel hexagonal wire netting for interface temperature greater than 400 °C & galvanised steel for interface temperatures less than & equal to 400°C. The insulation shall be backed with hexagonal wire mesh on one side.

Insulation material shall be wrapped and held in place using binding and lacing wires. The binding and lacing wires shall be of stainless steel material for interface temperature greater than 400°C & galvanised steel for interface temperatures less than & equal to 400°C.

Insulation supporting arrangements for vertical piping and equipments shall be provided.

The straps for securing Aluminium cladding sheet shall be of Aluminium material.

4.0.0 CONSTRUCTION REQUIREMENT

4.1.0 Construction requirement of Insulation

Insulation work on piping and equipment shall be done after the system has been completely tested, cleared and cleaned of loose scale, rust, grease etc. and after application of primer.

Insulation materials shall be dry. If the materials become wet after application, they shall be dried or replaced before weather proofing work.

When applying cold insulating materials, care shall be taken to ensure that the material is applied at the recommended applied density.

When applying multi-layer material for cold insulation all joints shall be staggered and each layer shall be separately secured in place. Unless otherwise specified, at least the final two layers shall be provided with a suitable vapour barrier where the operating temperatures are above 0°C.

For cold insulation, the lugs or other insulation supports used shall not be more than 75 percent of the total insulation thickness used in order not to puncture the vapour barrier.

Sampling lines shall be insulated. Controllers and instruments which are located indoors, together with tubing connected there to, shall not be insulated.

4.1.1 Piping

The Insulation material shall be properly butted to each other so that the fibres are interlocked at all longitudinal and horizontal joints.

All joints, gaps shall be densely filled with loose mineral wool. The mattresses shall be securely laced together at all joints with GI tie wires.

Where pipe work is being insulated, the valves and flanges shall be covered with removable box type insulation and a separate width of aluminium jacket shall be used over the insulation. The removable covers shall be secured in place by means of bands with quick release clips.

A small hole to act as a leakage indicator shall be formed in flange lagging.

Steam traced lines shall be insulated with a provision to accommodate one 15 NB steam trace line. Tracing union loops located outside the insulation shall be wrapped with 25 mm width, 3mm thick standard insulation tape and weather proofed.

For horizontal surface the longitudinal joints shall always be either at the bottom or on sides. When more than one layer of insulation is required the circumferential joints shall be staggered by at least 50 mm.



Bends shall be insulated in the same manner as straight pipe except that the insulation shall be applied in mitred segments to conform to the contour of the bend.

Expansion joints properly filled with loose mineral wool shall be included to allow movement and expansion of the pipe without producing random tracking of insulation.

In the case of the greater insulation thickness (atleast from 60mm upwards) spacer shall be provided to ensure a uniform insulating thickness on all sides and a perfect circular shape of the sheet metal jacket.

4.1.2 Equipment

For vertical surfaces of vessels and equipment, the insulation material shall be laced together along all joints and to the support rings immediately above them. This shall be further secured by 20 mm wide 23 SWG, horizontal aluminium bands at about max 1 meter pitch. For dished ends of vessels, the insulation shall be secured by readily tensioned 20 mm wide 23 SWG marine grade aluminum bands fixed centrally to a wire ring at the outer ends to band round the body of vessel.

For insulation of equipment, supports of same metal as vessel, projecting to a point not more than half the thickness of the insulating materials shall be welded to the vessel to support the vertical insulation. The support shall be uniformly pitched at 500 mm. A support shall be located above each vessel flange at a sufficient distance above the flange bolts to allow for their easy removal.

Small cylindrical surfaces are insulated with mattress section. The edges of each mattress shall be butt jointed closely together, in order to eliminate gaps and secured with GI strap bands of 15 mm wide, 0.5 mm at intervals of 250 mm. The mats to be stitched together at the horizontal joint using 0.7 mm thick GI wire.

If the insulation is in several layers, joints shall be staggered. Each layer must be secured separately.

For Equipment / Pressure vessel nozzles including man holes, hand holes and their covers, line flanges, valves and other fittings, if any, shall be insulated with removable metal jacketed sections. The jackets shall permit removal and replacement of these parts without causing damage to the insulation.

4.2.0 Construction of Cladding

All joints of the cladding shall be bent true to shape, properly grooved and overlapped (min 25 mm) and neatly screwed with self tapping rust proof screws of size M4 x 12 mm. The self tapping screws shall be cadmium plated and shall be flat or round headed. In addition, to these screws the sheet metal joints shall be sealed with bituminous mastic or equivalent joining compound.

The application of the cladding such that the vapour barrier of the cold insulation shall be effective and prevent moisture migration into the body of the insulation which will cause deterioration in the insulation value, physical damage to the insulation and corrosion of the cold surface.

During application of the vapour seal over cold insulation, special care is to be taken that it shall be carried down over all exposed edges of the insulation.



ANNEX – 2.21.1

SPECIFIED DESIGN DATA

Description	Unit	Data
General		
Ambient temperature	°C	40
Surface Velocity	m/sec.	1
Emissivity of the Cladding material	-	0.2
Insulation surface temperature	°C	60
Operating temperature for Pipe / Equipment	°C	MCR condition
Thermal conductivity	W/mk	As per standard.
Insulation Material		
Insulation Material		Mineral (Rock) wool.
Type		
Preformed pipe sections		Shall be used for pipes & fittings.
Slabs or Mattress		Shall be used for Valve Boxes and Equipments.
Density of Insulation material		
Preformed pipe sections	kg/m ³	140
Slabs or Mattress	kg/m ³	100
Cladding Material		
Cladding material		Marine grade aluminium
Thickness of Cladding material for Pipes, Fittings, Valve Boxes and Equipments.	SWG (mm)	20 (0.91) SWG for piping having outside diameter over insulation 450 mm and above and for all equipments & 22(0.71)SWG for piping having outside diameter over insulation less than 450 mm.
Finishing Cement		
Type of material		Lightly bonded Mineral wool
Density	kg/m ³	1100

**VOLUME II****SUB-SECTION 2.22****WORKSHOP, ROAD WEIGH BRIDGE, CHEMICAL LABORATORY,
STORES AND DIESEL BUNK****1.0.0 GENERAL**

This section is intended to provide the scope, design, constructional and technical requirements for workshop, chemical laboratory, stores, diesel bunk and road weigh bridge.

2.0.0 SCOPE OF SUPPLY**2.1.0 Workshop, Chemical laboratory and Stores**

The workshop, chemical laboratory and stores shall be complete in every respect & suitable for satisfactory operation of the power plant.

The list of minimum equipment to be supplied is furnished in this specification. The sizes of machines / equipment and their capacity shall be selected by the Contractor based on the requirement specific to the equipment and systems being proposed by them.

Maintenance tools and tackles as required for the various machines, commissioning spares for various machines as applicable, first fill lubricant / coolant for each equipment shall be provided.

2.2.0 Road Weigh Bridge

Two (2) no. of complete weigh bridge platform pit-less type with load cells, digital weight indicator and totaliser.

The weigh bridge shall be tested for full capacity and certified to be accurate before received at the site. After erection at site, contractor shall arrange for the inspection of the weigh bridge by the Inspector of weights and measures and get the weigh bridge stamped by him. The contractor shall pay the requisite fees for such first stamping. The requisite test loads for stamping shall also be arranged by the contractor.

All necessary cables from load cells up to digital weight indicator, totaliser and printer.

All other accessories and limits required to complete the weighing system.

3.0.0 DESIGN AND CONSTRUCTIONAL REQUIREMENTS**3.1.0 Workshop**

The various components of workshop machine shall be capable of easy installation and removal / replacement.

The noise and vibration from machinery shall be minimized and not be greater than that from high quality modern plant of comparable size.

Special attention shall be paid to the appropriate regulations for accident prevention. It must be assumed that in the operation of the machines even inexperienced personnel shall be satisfactorily protected. All equipment and machines with moving, hot or electrically energized



parts shall be provided with reliable protective equipment. Where necessary, erection openings / access shall be provided.

Suitable safety interlocks, limit switches for longitudinal travel and cross traverse of saddles and emergency brakes shall be provided as required. Emergency brake control shall be easily approachable to the operator.

The machines, tools and equipment will be in accordance with ISO standards as well as accident prevention regulations.

The dimensions of the workshop and stores shall be mainly based on the size of the equipment to be handled, the number of people working in the workshop and store and the quantity of spare parts to be stored.

Minimum 1500 mm clearance shall be maintained between the individual machines / equipments.

The various machinery, plant and equipment shall be so designed and arranged as to present a functional and pleasing appearance.

3.1.1 Equipment - Workshop

Sl. No.	Equipment	Specification	Accessories	Qty
1.	Heavy duty lathe	900 mm SOB, 2000 mm DBC. other parameters of the machine shall be as per manufacturer's standard	Square tool post, two (2) nos. dead centers, rotating center, quick change tool post with set of tool holder, 3 jaw self centering chuck, complete coolant system, oil gun & oil can, rear splash guard, steady rest and follow rest, one set (10 nos.) of carbide turning tools (standard), work light without bulb, chip tray, longitudinal stop.	1
2.	General Duty Lathe	600 mm SOB, 1500 mm DBC. other parameters of the machine shall be as per manufacturer's standard		1
3.	Shaper	Stroke-610 mm, other parameters of the machine shall be as per manufacturer's standard	Crank handle, tool holder attachment, Ram length adjustment control, one (1) no. high speed steel (HSS) cutting tool, machine vice, pulleys & v-belts as required, electric motor, starter, automotive lubricating pump, machine lamp without bulb.	1
4.	Slotting machine	Stroke - 300 mm, other parameters of the machine shall be as per manufacturer's standard	Complete coolant system / equipment, lighting equipment, 3 jaw self centering chuck of diameter 300 mm with back plate (steel body).	1
5.	Universal milling machine	Table - 1600 mm X 300 mm, other parameters of	Complete coolant equip. work light without bulb,	1



Sl. No.	Equipment	Specification	Accessories	Qty
		the machine shall be as per manufacturer's standard	indexing head. One(1) no. high speed steel milling cutter.	
6.	Radial drilling machine	Capacity drilling in steel 50 mm diameter, Radius of drilling arm : 1500 mm, other parameters of the machine shall be as per manufacturer's standard	Box table (500 mm X 500 mm X 500 mm), complete coolant equipment with pump, motor, piping etc., work light without bulb	1
7.	Pedestal drill	16 mm diameter in steel, size of table – 600 mm x 600 mm	-	1
8.	Grinder	600 mm wheel diameter. Double wheel pedestal grinder	Eye protection shield, tool rest bracket, adjustable tool rest, One coarse grinding wheel and one fine grinding wheel, machine lamp.	1
9.	Tube bending machine	1/2" to 4" NB, other parameters of the machine shall be as per manufacturer's standard	Formers of different sizes suiting machine capacity.	1
10.	Power hacksaw	Job diameter - 225 mm, other parameters of the machine shall be as per manufacturer's standard	One (1) no. hacksaw blade, machine lamp without bulb.	1
11.	A/C welding machine	Current range - 60 to 400 Amps, AC Welding Transformer, other parameters of the machine shall be as per manufacturer's standard	Welding cable with electrode holder (5 metres length), Earthing cable assembly (5 metres), Protective helmet with glass, pair of hand gloves, chisel, wire brush, Ammeter - voltmeter attachment	2
12.	D/C welding machine	MG set, current range : 35 – 320 Amps, Rectifier welding sets other parameters of the machine shall be as per manufacturer's standard	Welding cable with electrode holder (5 metres length), Earthing cable assembly (5 metres), Protective helmet with glass, pair of hand gloves, chisel, wire brush.	1
13.	Argon Arc welding set	Max continuous welding current @ 60% duty cycle 170 amps, welding current range: 5 to 220 Amps.	-	2
14.	Soldering iron	25 Watts, 250 Volts	-	4
15.	Welding tables	Size - 750 mm (length) X 500 mm (width) X 1000 mm (Height)	-	3
16.	Pneumatic hammer	As per manufacturer standard.	-	1
17.	Work benches	Carpenter type work bench, size – 750 mm x 500 mm x 1000 mm height	-	6



Sl. No.	Equipment	Specification	Accessories	Qty
18.	Fitter vice	Size – 150 mm.	-	6
19.	Marking-off table	Size – 2000mm x 2000 mm, material of construction – cast iron.	-	1
20.	Portable screens	Fabricated screen, size 6 ft high and 8 ft length	-	
21.	Corrugating rollers	Size 900mm	-	1
22.	Industrial Vacuum cleaner.	As per manufacturer standard.	-	
23.	Set of Measuring tools			1 set for each measuring tool
a)	Vernier Calliper	Size 0 to 300mm, least count 0.02mm.	-	
b)	Vernier depth guage	Size 0 to 300mm, least count 0.02mm.	-	
c)	Inside calliper	0 to 150mm.	-	
d)	Outside calliper	0 to 150mm.	-	
e)	Inside Micrometer	Size 0 to 25mm, least count 0.01mm.	-	
f)	Outside Micrometer	Size 0 to 150mm, 0.01mm accuracy.	-	
g)	Dial guage with magnetic stand.	Size 0 to 10mm, least count 0.01mm	-	
h)	V block	100 mm x 45 mm x 60 mm	-	
i)	Snap Gauges	As per manufacturer standard.	-	
j)	Feeler Gauges	As per manufacturer standard.	-	
k)	Thread Pitch Gauges	NPT, Metric- As per manufacturer standard.	-	
l)	Slip Gauge Block set	As per manufacturer standard.	-	
m)	Precision Level	As per manufacturer standard.	-	
n)	Steel measuring tape	5m long.	-	
o)	Steel Rule	150 mm , 300 mm, 600 mm, 1000mm	-	
24.	General Tool			
a)	Screw drivers	Dimension & Blade length (mm)- 3.2x0.5x200; 4.3x0.6x200; 5x0.6x125; 5x0.8x200.	-	1
b)	Double ended spanners (mm x mm)	10x11; 12x13; 14x15; 16x17; 18x19; 20x22; 21x23; 24x26; 24x27; 25x28; 30x32.	-	1



Sl. No.	Equipment	Specification	Accessories	Qty
c)	Hammer Set	Ball Peen Hammer in 1 lb, 2 Lbs, Mallet Hammer 1 Lbs, Wooden Hammer	-	1
		Sledge Hammer		1
		10 Lbs Sledge Hammer		1
d)	Hack Saw frame with blades	As per manufacturer standard.	-	1
e)	Socket set	1/2" Sq Drive socket in size mm (10, 12, 14, 16, 18, 20, 22, 24, 26, 28 30,32)	-	1
f)	Precision Level	As per manufacturer standard.	-	1
g)	File set	Flat- 100,150,200,250 mm Round file - 150 mm Half Round file - 200 mm, 250 mm	-	10
h)	Pipe Cutter	1/2" – 2"	-	1
i)	Long nose plier	170 mm(L)	-	1
j)	Round nose plier	25 mm(L)	-	1
k)	Universal Plier & Cutter Plier	As per manufacturer standard.	-	1
l)	Cir Clip Plier (Inside / Outside)	As per manufacturer standard.	-	1
m)	Pipe wrench	Each - 0-3/4", 1 1/2", 0-2 1/2	-	1
n)	Right angle	12" Size	-	1
o)	Chisel Set	Flat Chisel of 1/2", 3/4", 1" tip size	-	1
p)	Bearing Puller set	Universal Puller Twin Grip of 6" opening size - 1	-	1
		Puller triple grip of 8" opening size -1 No.	-	1
q)	Centre Punch	As per manufacturer standard.	-	1
r)	Gasket Punch set	Punches of various sizes 6, 8, 10, 12, 16, 20, 22, 24 mm in a case.	-	1
s)	Hand Lamps, without Bulbs , Sockets , Plugs &Cables	As per manufacturer standard.	-	1
t)	Box for above tools	As per manufacturer standard.	-	1



3.2.0 Stores Requirements

- Open storage area along with necessary storage stand/ brackets
- Heavy part storage racks suitable for wooden pallet stacking.
- Wooden Pallet
- Pallet stacking & reclaiming fork lift electrically operated with all accessories and electric charger system.
- Small parts & consumables storage racks along with bins of various sizes.
- Air conditioned storage area with racks & bins for storage of electronic cards.
- Bin card storage cabinets along with bin cards.
- Chemical storage shed with necessary safety measures.
- Necessary fire fighting & fire alarm system along with ventilation system for the stores.
- An interchangeability chart for various standard parts/ consumables.
- Necessary computer, software etc. with net working for issue, receipt, purchase office & coding operations.

3.3.0 List of Chemical Laboratory Equipments

The list of minimum equipment to be supplied for Chemical Laboratory of the Power Plant for the purpose of conducting routine tests on water, lube oil and gas are given below:

3.3.1 Lab Equipments for Water Analysis:

A Bench Top pH Meter

Type : Bench Top model - 2 Nos.
Range : 0 - 14.00
Resolution : 0.001/0.0/0.1
Relative accuracy : ± 0.005 slope 80 to 120%
With auto buffer recognition, 3 point calibration

The instrument shall be supplied with certified calibration solution / pH buffer tablets.

Equipment shall be supplied with calibration certificate.

B Portable pH Meter

Portable Model : 1 Nos.
Range : 0 -14.00
Resolution : 0.01 pH
Relative accuracy : ± 0.01 pH, slope 80 to 120%

The instrument shall be supplied with certified calibration solution I pH buffer tablets.

Equipment shall be supplied with calibration certificate.

C Bench top conductivity meter

1.0 Type : Direct reading digital

2.0 Design Data



- 2.1 Range : 0 to 20.00, 200.0, 2000 μ S/cm
0 to 20.00, 200.0 ms/cm.
2.2 Resolution : 0.05% full scale
2.3 Accuracy ± 1 % full scale within each range, ± 0.1 μ S/cm in the lowest range
2.4 Temperature compensation: Automatic from 0 to 120°C.

The conductivity meter shall be complete with cells for the above range specified.

Equipment shall be supplied with calibration certificate.

D Portable Conductivity Meter

Portable model of the following specification may also included in the supply.

- Range : 0 to 199.9; 0 to 1999 μ S/cm; 0 to 19.99 ms/cm.
Resolution : 0.1, 1 μ S/cm : 0.01 ms/cm
Accuracy : ± 1 %

E Spectrophotometer- Double Beam

One double beam Spectrophotometer of the following. specification shall be considered.

- Double beam
spectrophotometer : 1 No
Range : 190 to 1100 nm
Band width : 4nm
Wave length resolution : 0.1 nm
Wave length calibration : Automatic
Wave length accuracy : ± 1 nm
Stray light : <0.3% T@ 220 & 340 nm
Photometric range : 0 to 3.0 Abs
Read out mode : Transmittance, Absorbance, concentration .

The equipment shall be supplied with other accessories required for normal operation and voltage stabilizer along with the main instrument.

F Jar Test Apparatus

Type: Flocculator with Multiple stirring machine equipped with a variable speed drive

Stirrer: Four stainless steel stirrer paddles with an arrangement to vary the speed of each stirrer independently over a range of 6-60 RPM. The length of the paddles shall be such that at the max. speed of 60 RPM the tip velocity shall not exceed 600 mm / sec.

Speed control: Step less speed control through Rheostat or energy regulator

- Speed measuring device
Type : Tachometer
Range : Rpm 0-100
Accuracy : Rpm 1
Smallest division : Rpm 1
Power supply : 240V,50Hz 1 PH, AC

- Flocculator : Shall be" fitted with a fractional horse power motor and shall take jar or breaker of 1 litre capacity. It shall also have in illuminated arrangement for observing floc formation by providing a light source under the base & a hole of approximately 25MW at the base for directing the light beam.



Equipment shall be supplied with calibration certificate.

G Turbidity Meter

Measurement : Nephelometric
Range : 0.001 NTU for a range of 0.000 - 0.999,
0.01 NTU for range 0.00 to 9.99,
0.1 NTU for a range 0.0 to 99.9,
1 NTU for 0 to 1000 NTU.

Accuracy : $\pm 2\%$ reading or ± 0.01 NTU.

The instrument shall be supplied with 0.02, 10, 100, 1000 NTU standards for calibration and two empty cuvettes.

H Residual Chlorine Meter

Chlorine, F & T
Method : DPD (50-100 Test);
Range : 0.02 to 2.00 & 0.1 to 8.0 mg/l
Pocket colorimeter with LCD display; backlit & silicon detector

I DO2 Meter

Purpose : A dissolved oxygen meter is used to measure the amount of oxygen present in a unit volume of water.

Description : The DO2 Meter shall essentially consist of, but not be limited to the following parts:

- a) Self-stirring BOD probe & Kit
- b) 5ft Cable Assembly(data logging & printer cables)
- c) RS232 infrared adaptor communication
- d) Cap membrane kit (6 each) which includes electrolyte.
- e) Digital LCD display
- f) Battery

The portable oxygen meter should be able to measure:

- a) Oxygen range : 0.01 mg/l - 2000 mg/l
- b) Resolution : 0.01 mg/l
- c) Temperature range : 0 – 50 deg C
- d) Automatic air pressure compensation
- e) Automatic temperature compensation
- f) Correction for salinity

Equipment shall be supplied with calibration certificate.

J Flame Photometer

Purpose : For determination of sodium, potassium and calcium in solution by flame photometry

Description : The flame photometer shall essentially consist of, but not be limited to the following parts:

- (1) An atomiser and burner



- (2) Pressure regulating devices (Needle valves) and gauges for fuel and air or oxygen.
- (3) An optional system consisting of suitable light dispersing and filtering devices capable of preventing excessive interference from light of wave lengths other than that being measured.
- (4) Photo sensitive detector/indicating device.
Burner Type: Suitable for Liquefied Petroleum Gas (LPG)
Range : Full scale deflection should be guaranteed for 2PPM of sodium, 5 ppm of potassium 20 ppm of calcium
Accuracy : $\pm 1\%$
Accessories : (1) Interference filters for sodium, potassium and calcium
(2) Oil free air compressor
- Power Supply : 240V, 50 Hz, 1 phase AC unaffected by voltage fluctuation of $\pm 10\%$.
- Limits of Detection : Na ≤ 0.2 ppm, K ≤ 0.1 ppm, the instrument consists the following features in addition.
Electronic flame failure detection, fine and coarse sensitivity controls

Equipment shall be supplied with calibration certificate.

K Magnetic Stirrer

- Purpose : Laboratory use
- Capacity : 3 (Min.) litres
- Description
- Case : Die cast aluminium
- Top plate : Glass coated stainless steel
- Size of the plate : Square plate 180 x 180 mm (Min.) I Round plate 180 mm dia (Min.)
- Speed control : Stepless speed controlled upto to 1200 RPM
- Stirrer type : Teflon coated stirring round bars
- Size : 7.9 mm (dia) x 13 mm (L)
7.9 mm, (dia) x 25 mm (L)
7.9 mm (dia) X 38 mm (L)
- Quantity : 3 Nos. i.e., one each of the size indicated above.

Equipment shall be supplied with calibration certificate.

L Hydrometer

- Purpose : To measure Specific gravity of liquids
- Temperature : 0 to 80 degree C
- Range of measurement : 0 to 2

Materials of Construction

Bulbs and stems: Chemically resistant glass

**Description**

- i) Instrument shall have double scale.
- ii) The bulbs and stems shall be streamlined so that hydrometer reaches without trapping air bubbles setting point

3.3.2 Lab Equipments for Coal Analysis:**A Muffle Furnace**

Table top design, short heating up and low outer wall temperatures via the use of high grade ceramic fiber material in the multi layer composite insulation. With electronic analog controller and digital analog temperature display, thermo couple PtRh-Pt, low noise solid state.

Temperature range	:	upto 1200 °C
Accuracy	:	±3 Deg C
Nos	:	2

Equipment shall be supplied with calibration certificate.

B Ordinary Oven

Purpose	:	Drying Laboratory Glassware
Nos	:	2
Type	:	Electrically heated and double walled with a facility for digital temperature facility
Design data		
Thickness of insulation	:	50 mm (min.)
Material of insulation	:	Glass wool
Heating element		
Material	:	Ni-Cr Ribbon
Control	:	Thermostatic
Temperature range	:	30-250 deg C
Accuracy	:	±1 Deg C

Equipment shall be supplied with calibration certificate.

C Sieve Shaker

Purpose	:	For grading of samples of pulverised fuels

These equipment shall be motorized with rotary gyrator motion and tapping motion for 20 cm test sieves with set of siever. A timer of 0 to 60 mins shall be included as a part of this instrument.

Equipment shall be supplied with calibration certificate.

D Grinder

Purpose	:	Preparation of coal samples for testing
Type	:	Roll crusher or coffee mill type
Capacity	:	20 kg/hr.
Input size	:	5-6 mm
Output size	:	650 - 750 micron
Holding capacity	:	7 kg

Grinder shall be fully enclosed and shall have an enclosed hopper and receptacles
Equipment shall be supplied with calibration certificate.

**E Stop Watch**

Beveled movement with two hands with range 30 minutes & resolution:1/5seconds

Type	:	hand held, Non magnetic.
Resolution	:	1/5 of second
Reset facility	:	required
Recording period	:	0-30 minutes with a 60 second sweep

F Bomb Calorimeter

Automatic calorimeter consists of controller, measuring cell, integrated cooler decomposition vessel and accessory kit. As per ASTM and DIN.

Method	:	Isoperibol
Range	:	6000 to 15000 BTU / Lb for a 1 gram sample
Precision	:	$\leq 0.05\%$ RSD
Resolution	:	1 BTU/lb, 0.1 Cal/g.

Corrections acid or % nitrogen, fuse wire, sulfur, moisture, spiking ash and hydrogen.

Temp measuring resolution 0.0001 ° C

The consumables required for 1000 analysis and other accessories required for normal operation may be supplied along with the main instruments.

Equipment shall be supplied with calibration certificate.

G Top Pan Balance

Capacity	:	3200 grams
Minimum display	:	0.1 grams
Standard deviation	:	≤ 0.06 g
Linearity:	:	± 0.1 mg.
Nos	:	2

The above balance may be supplied with the certified weight box with traceability certificate.

H Analytical Single Pan Balance

Fully automatic internal calibration

Maximum capacity	:	81/210 grams
Readability	:	0.01/0.1 mg
Repeatability	:	0.02/0.1 mg
Linearity	:	$\pm 0.031 \pm 0.2$ mg
Nos	:	2

The above balance may be supplied with the certified weight box with traceability certificate.

I Vacuum Oven

Type	:	Infra red moisture analyzer
Method	:	Heating by infrared rays, determination of weight loss.



Sample weight maximum: 30 grams
Measuring accuracy : 0.05%
Measuring range : 0 to 100%
Readability : 0.01 %
Temperature range : up to 160 °C
Equipment shall be supplied with calibration certificate

J Jaw Crusher

Purpose : Preparation of Coal
Capability desired : Crushing from hard rock to coal
Input size : 125 (Max. for high capacity) .
50 & less for medium capacity
Output size : 12.5 (Min. for high capacity)
3.2 (Min. for medium capacity)
Crushing capacity : 1000 kg/hr. for high capacity
250 kg/hr. for medium capacity

The crushers shall be supplied complete with rotary screen, tight and loose pulleys, belt, motor and accessories including feeding hopper all assembled and mounted. .

Equipment shall be supplied with calibration certificate.

K Set of sieves, Cover & Receiver

Sieve frame shall be made of brass 200 mm diameter, 50 mm height above the wire cloth and shall be drawn from one piece without seam.

Cover and receiver shall be of stainless steel 200 mm diameter for use with the above sieve.

A set of test of sieves 10 Nos of various size as per IS 460

Equipment shall be supplied with. calibration certificate.

3.3.3 Lab Equipments for Oil Analysis:

A Redwood Viscometer

Purpose

The instrument is required to measure the viscosity of lubricating, transformer and fuel oils having their viscosity not less than 30 seconds and not more than 2000 seconds as per IP70.

Description

The viscometer shall essentially consist of :

- a) A cylindrical, heavily silver-plated, brass cup provided with an agate jet in the base. The oil cup shall be surrounded by a loose cylinder provided with vanes for stirring the liquid bath. The bath shall be cylindrical and provided with a tap for emptying and a side tub for heating with an electric heating element applied to the walls but not to the under side of the bath. An auto- transformer (Regavolt) shall be supplied to control the temperature.

The agate jet may be closed by means of a metal ball attached to a stiff wire, which can be removed and suspended from the thermometer support during the run.

A wire attached internally near the top of the side of the cup shall indicate the level to which the sample must be adjusted .

Thermometer Conforming to IP 70/62

- i) IP 8 C Range : 0 to 44 deg C
- ii) IP 9 C Range : 37.8 to 82 deg C



A certificate of accuracy from the manufacturer shall be supplied with each thermometer.

- a) Flash - Capacity 50 - 0.06 ml. At 20 deg C
- b) Thermometer clip
- c) Oil cup cover
- d) Iron stand with leveling screws to support and align the bath firmly
- e) Screen painted white inside and having an opening 9 cm. in width from the top to the bottom.
- f) Level - a circular level, sensitive to 0.20 mounted on a brass plate to fit the upper end of the oil cup and slotted to accommodate the vertical rod and the valve stem.
- g) Wooden stand.
- h) Ball valve receiving flask, heating bath with stirrer and electrical heating

B Heating Mantle

Type: Heating elements completely embedded in nonflammable fabric. Mantle shall be capable of accommodating round-bottomed flasks of 500 to 1000 ml. Capacity.

Temperature inside mantle	: Upto 400 deg.C
Temperature control accuracy:	±2 deg.C.
Power rating	: 0.35 to 0.45 kW
Power supply	: 240V, 50 Hz, 1 phase, AC
Accessories	: a) Suitable built-in temperature control unit b) Pilot indicating lamp c) Thermocouple and temperature indicator

Equipment shall be supplied with calibration certificate

C Cannon Fenske Viscometer with water bath

As per ASTM D445

Cannon Fenske reverse flow type Viscometer (factory certified) for opaque liquid of size 75, 100, 150, 200, 300, 350, 400, 450, 500 one each.

D Pensky Marten Flashpoint Apparatus(Electrically Heated)

Purpose : The equipment supplied shall be suitable in all respects for determination of flash point (closed and open cup) by the method as laid down under of IS.1448 Part-1 /IP 3A ASTM 0925B/IP 144B Part-1 /IS.120

Description : The equipment general shall consist of but not be limited to (1) Cup (2) Lid (3) Electric heater (4)

Thermometers (5) Clip to convert the equipment for open cup determination (6) Oil test jet. The equipment shall be suitable for operation on 240 V 50 Hz, 1 -Phase AC power supply

- 1. Cup : Conforming to dimensions laid down in IS and equipped with devices for locating the position of lid on the cup and the cup in the stove. A handle attached permanently to the flange of the cup shall be provided .
- 2. Lid : Lid shall include the following parts: Stirring Devices: conforming to Para 3.1.2 (a) of IS -1448 P-21 Cover Proper: conforming to para 3.1.2 (b) IS Shutter: conforming to' para 3:1.2 (c) of IS Flame Exposure Device : conforming to para 3.7.2 .(d) of IS. It shall contain gas test jet.
- 3. Stove : The stove consist of the following parts.
 - a) Air bath conforming to para 3.1.3 (a) of IS. The air bath shall be electrically heated.
 - b) Top Plate: conforming to para 3.1.1 (b) of IS



4. Thermometers : Cemented into the collar

a) If 15c Low range: 7°C to 11.00°C one each

b) If 16 C high range: 9.0°C to 370°C

The thermometers shall comply in all respects 10 para 3.1.4 of method F:21 of IS1448. Over and above being cemented into the collar. each thermometer shall contain a projected ring so that it can rest on the collar in such a way that the bottom of the bulb is 44.4 mm below the level of the rim of the cup which will correspond to the level of the lower surface of the portion of the lid inside the rim.

Each thermometer shall be provided with a certificate of accuracy from the manufacturer of the thermometer.

Clip for open cup: A clip shall be supplied to convert the apparatus for determination of flash point by open cup method.

Oil Test Jet: A Oil test jet shall be provided with necessary accessory to fit on the lid as an alternative to gas test jet in case of non- availability of gas cylinder.

E Potentiometric Titration Apparatus

Karl J Fisher Moisture

Titration with the following specification shall be considered for determining the moisture in oil samples.

Titration Method : KF coulometric
Titration speed : Low current 2 mg / min, High current 20 mg/min
Moisture range : 1 ppm to 100% H₂O
Precision : 0.3 % at 1 mg H₂O
End point potential: Fixed
Background correction : automatic
Result presentation: ppm - % - mg.

Two liters of chemical required for analysis also shall be supplied along with the main instrument.

Equipment shall be supplied with calibration certificate .

F Centrifuge for Oil Analysis

Purpose : To determine the amount of water and sediment in oil used in power stations

Description/Details

The apparatus supplied shall conform to the latest editions of BS:2882 and IP 75 and shall be complete in all respects.

The apparatus shall, essentially consist of a centrifuge capable of whirling a minimum of four (4) filled centrifuge tubes at a controlled speed. The centrifuge shall have a diameter of swing of 38 to 45 cms measured from tip to tip of the rotating tubes and shall permit the use of cone shaped tubes. The centrifuge shall be enclosed by a metal shield or case strong enough to eliminate danger in case of occurrence of breakage. The diameter of the metal shield/case shall not be less than 48 cms.

The centrifuge motor shall be :

(a) Of flame proof design



- (b) Without slip ring, commutator or centrifugal. Starting switch
- (c) Effectively isolated from the bowl

Each tube shall have a capacity of 100 ml and shall be of glass.

The buckets shall be suitable for accommodating the tubes described and shall conform in all respects to the various provisions of IP 75

The apparatus shall operate on 240V, 50 Hz single phase supply.

Equipment shall be supplied with calibration certificate

G Dean & Stork Apparatus

The apparatus shall consist of 10ml graduated receiver with 19/26 outer joint and 24/29 inner joint, 500 ml round bottom flask with 24/29 outer joint, Leibig condenser of 200mm length with 19/26 joints and spray tubes. The apparatus supplied shall comply in all respects to IS: 1448 (Part-1) method P:40.

H Portable Pressure and Vacuum Pump for Oil Analysis

Neoprene diaphragm based oil-free, teflon coated head, portable AC powered vacuum pump for Lab use operating on 230V / 50 Hz.

- Accessories
- :(a) Cellulose nitrate membrane filter dia 47mm, pore size 0.45 um
Qty- 4Packets (each packet having 100 filters)
 - (b) 2 nos. stainless steel filter holder for vacuum filtering of aqueous liquids with clamp,
 - (c) 2 nos. of vacuum flask with complete accessories

3.3.4 Orsat Apparatus for Flue Gas Analysis

For measurement of carbon dioxide, carbon monoxide & oxygen in furnace flue gases; the apparatus should include:-

- (a) Leveling bottle with 250ml capacity
- (b) 100ml gas burette with graduation of 0-50ml in side of 0.2ml division with outer jacket
- (c) 3 absorption pipette of 100ml capacity (Two filled with glass tube and one with copper spiral & glass tubes)
- (d) 3 test manifold
- (e) Calcium chloride & rubber bellow

The above items from a to e shall be fitted in Good quality wooden cabinet with front & rear sliding doors with lifting handle-1Nos

Accessories

- (a) Three test manifold & rubber bellow : 6 Nos
- (b) Absorption pipette with glass tube : 6 Nos
- (c) 100ml gas burette with outer jacket : 6 Nos
- (d) Leveling bottle cap. 250 ml : 6 Nos

3.3.5 Standard Lab Equipments:

A Dry & Wet Bulb Thermometer

Wet & dry thermometers mounted on a case boxed with spare wick and related humidity tables. Thermometer shall have readings in both deg C and F.

Temperature range: 10 to 50 deg C & 0 to 120 F.



Graduations	:	every 2 deg F.
Material	:	Boro Silicate Glass
Medium	:	Mercury
Length	:	10" Min

Equipment shall be supplied with calibration certificate .

B Barometer

The Contractor shall furnish precision aneroid barometers of dial size 6 inches (150 mm). The barometers shall have a range of 600 to 800 mm Hg with resolution = 1mm Hg and accuracy ± 1 mm Hg temperature range -5 to 55°C

Range	:	600 – 800mm Hg
Mounting	:	Wall mounting
Dial size	:	150mm
Auxiliary indicator	:	Required
to record the previous value		
External adjustment:		Required
Screw		

C Dew Point Meter

The Dew point meter shall be used for measuring moisture in instrument air, service air, hydrogen etc. The Contractor shall furnish calibration accuracy guarded glass column to measure a range of moisture from (-) 100 to (+) 30deg. Cel. The meter shall be accurate and readable to within 0.1deg.C as minimum.

Standard range	:	(-) 100 to (+) 30deg. Cel
Resolution	:	0.1deg. C)
Accuracy	:	± 2 deg C

D Water Bath

Purpose: Laboratory use

Temperature range: 5 deg. Centigrade above ambient to 90°C

Accuracy : $60^{\circ}\text{C} \pm 1^{\circ}\text{C}$

Construction Features:

Body	:	
Type	:	Double walled
Material	:	Inner wall - stainless steel
Dimension	:	35 cm x 25 cm x 10 cm (Min.)
Facilities desired	:	a) Thermostatic temperature control b) Built in constant level arrangement c) With cover plate to accommodate 4 viscometers of canon fenske, thermostat with digital temperature setting and reading

Equipment shall be supplied with calibration certificate.

E BOD Incubator

Capacity	:	220 lit
Refrigerant	:	R 134a
Heating power	:	150W
Cooling power	:	200W
Temperature range	:	5°C to 50°C
Accuracy	:	$\pm 1^{\circ}\text{C}$
Temperature Display	:	3 digits LED
Temperature rising	:	Digital keypad



Temperature control : Automatic microprocessor based
Temperature sensor : PT 100
Supply voltage : 240V, 50Hz
Ambient temperature : 0 - 50°C

Double-walled inside anodized Aluminium and outside Mild steel sheet painted in epoxy powder coating with 'L' shape thermometer and two air circulation fans.

F Microscope Trinocular with Standard Accessories

Range - 40 X - 400X

Detachable Trinocular tube 360° rotatable, 30° inclined Dioptre compensation, Interpupillary distance adjustment

Sample size - Up to 15mm diameter and up to 5mm thick

G Lab Refrigerator

Type: Standard laboratory model

Quantity: 2Nos (One for storage of chemicals and other for storage of samples)

Capacity: 300 & 265 Lts resp.

H Digital Density Meter

The density meter calibrated at 20°C within the range 600–1200 shall be supplied.

I Moisture Analyzer

Range : 10ppm to 100% with appropriate sample size
Display readability : 0.001 g
Temperature Setting : 40° - 160°C in one degree increments
Temperature Control : Temperature sensor, +/- 5°C
Temperature Steps : One
End of Analysis Mode : time-out
Units of Results : % moisture, % solid, % moisture dry, weight loss
Display : Liquid crystal display
Integrated Printer : None (optional external printer)
Connector for column printer : Socket connector for 24 column printer

J Wet & Dry Hygrometers

Humidity

Range : 10 – 100%
Accuracy : 1.0%
Resolution : ± 5%

Temperature

Range : 0 – 55 °C
Resolution : 0.1°C
Accuracy : ±1°C
Sensor type : Capacitance



3.3.6 Laboratory Furniture

A WORKING TABLE

The bench top shall be made of marine plywood with thickness 30 mm to which tiles are to be bonded with Polyurethane or Epoxy compound. The area joined with acid resistant cement. The Tiles are of shell white colour shed in matte finish. The tiles will be of the ceramic material having reputed make of size 10"x10" with minimum thickness of 5mm

Dimension: D= 750 mm & Top Height-900mm with 3 nos corner SS sink
L=450mm D= 350mm H= 170mm

Total Running Length= 43 meters

B MODULAR UNDER BENCH STORAGE UNIT:

20 SWG steel with epoxy coated Storage unit. Each unit shall be comprising of one drawer with lock arrangement. Cup-board with adjustable shelves, lock system and door shall be with Auto lock hinge.

Dimension : D=550 mm, H=750 mm, W=850 mm

Total Quantity : 48 nos

C WALL MOUNTED CHEMICAL STORAGE UNIT

The unit shall have horizontal sliding glass door which run smoothly in plastic channels or aluminum channel with epoxy powder coated. The sliding lass will be 5 mm thick safety glass. Two no shelves are to be provided. Shelves & periphery of cabinet will be made of 20 SWG CRCA with epoxy powder coating.

Dimension: D=350 mm, L=900 mm ,H=600 mm

Total Quantity= 20 nos

D ANTI VIBRATION TABLE

Top shall be finished in black granite. The units are to be placed on tabular pedestals & are made of best quality steel. The instrument tables are to be supplied with two electric outlet and two drawer for storage, Anti-vibration table made out of 20 SWG CRCA sheet (out-Table). The inner table will be made out of 40x40 CRCA tube with pre casted RCC slab 500mmx700mm weighing 80 Kg. will be placed over rubber pads to take care of vibration.
Dimension: L=1650 mm D=750 mm, H=750mm

Total Quantity= 2 nos

E EIGHT CABINET ISLAND ASSEMBLY WITH ELEVATED SHELVES & SIDE SINK

To be equipped with 3 way water faucets. The top bench shall be designed as per Sr No 1
Dimension: L= 5800 mm W=1500 mm

Height to counter top 900mm

Height to top Shelves 1500mm

Elevated Shelves shall be made out of 20 SWG CRCA sheet.

D=300mm H=650mm L=5100mm

**F FOUR CABINET ISLAND ASSEMBLY WITH ELEVATED SHELVES AND SIDE SINK**

Top bench shall be as per Sr no 6
Dimension: L=4000, W=1500 mm
Height to counter top 900 mm
Height to top Shelves 1500mm
Elevated Shelves shall be made out of 20 SWG CRCA sheet .
D=300mm H=650mm L=3300mm
SS Sink size L=450mm W=350mm H= 170mm

G WORKING DESK

Working desk will have under bench storage module made out of 20 SWG CRCA sheet. The table top shall be melanin white colour. The door and shutter should have full recessed handles. The shutter should have concealed hinges and locking arrangement.
Dimension: L= 1350 mm,D= 750 mm,H=750 mm

Total Quantity= 4 nos

H STEEL RACKS

18 SWG CRCA Slotted angles steel racks with anti rusting paint
Dimension: L=1050 mm,D= 450mm, H=2100 mm

Total Quantity= 6 nos

I Laboratory Working Chair, with adjustable height arrangement. The base shall have five arms with castor wheels.

Total Quantity= 6 nos

J Revolving Stool – top made of S.S. circular type of 250 mm dia. Height shall be 450 mm to 600 mm adjustable.

Total Quantity= 6 nos

3.4.0 Road Weigh Bridge

The Electronic Weigh Bridge shall be suitable for weighing loaded Road Trucks and Trailers and for 24 hours of operation per day.

The weigh bridge shall be capable of withstanding dynamic loads imparted by the vehicle movement and braking.

The weigh bridge shall calibrate automatically the variation due to rains and other errors.

The weigh bridge equipment shall be electronic load cell with micro processor based type.

The weigh bridge shall be suitable for operation during rainy season.

Sensing equipment for positioning of road vehicles shall be provided.

3.4.1 Equipment – Road Weigh Bridge

SL.NO.	Description	Data
I	GENERAL	
1.0.	Weigh bridge type	Pit less type microprocessor based Road Weigh



SL.NO.	Description	Data
		Bridge
2.0.	Quantity	Two (2) no.
3.0.	Codes and Standards	IS: 1432 - General requirements for weighing instruments IS: 1436 - Weigh Bridge- Specification. IS : 9281 - Specification for Electronic Weighing Systems - Part 2 Methods of Measurements IS: 9777 - Data sheet for selection of weigh bridges for bulk handling equipment. Load Cells- Organisation International Monetary League(OIML) standard
4.0.	Weighing capacity - Gross	60MT capacity - Stores. 100MT capacity – Silo area
5.0.	Platform size	18000 x 3000 mm
6.0.	Platform MOC	Anti skid steel
7.0.	No. of trucks / trailers for weighment	Minimum 200 trucks / tractor trailers per day.
8.0.	Type of trucks / trailers for weighment	All type
9.0.	Maximum safe over load protection	150% of rated capacity.
10.0.	Maximum load for mechanical damage	300% of rated capacity.
11.0.	Standards for load cells	OIML (Organisation international monetary league)
12.0.	Load cells type	Rocker pin (Compression type) / Shear beam type
13.0.	Load cell protection	IP 68 and tested by a national test house and also have overload parameters.
14.0.	Number of load cells per weigh bridge	Minimum 6 Nos. Each with rating of maximum safe over load capacity. Suitable compensation must be built for temperature variation.
14.1.	Accuracy required	$\pm 0.05\%$
14.2.	Repeatability	$< \pm 0.010\%$ FSO
15.0.	Resolution	10 kg
16.0.	Indicator	kg or tone
17.0.	Totaliser	Yes, minimum 6 digit type to be provided in the weight indicator.
18.0.	Weighing equipment	Desk top type and compact should be suitable for dusty, hot, humid conditions without an air conditioner.
19.0.	Digital weight indicator	Atleast 20 mm high character display for backlit LCD display.
20.0.	Display modes	Weight and 16 mm for messages with a) Indicate weight b) Indicate calibration – Calibration to be



SL.NO.	Description	Data
		checked automatically every 5 minutes.
21.0.	Display of key board entered values	10 mm high characters
22.0.	Protection	From electro magnetic and radio interference
23.0.	Auto calibration	Calibrations check facility to be provided.
24.0.	Digital filtering system	To ensure correct weighment when weighing oscillatory loads.
25.0.	Annunciators	To indicate over capacity.
26.0.	Push button balance	To weigh $\pm 1/4$ of a scale interval of 200
27.0.	Front panel controls	For balance, lamp test, semi auto tare, cancel tare and key board enable
28.0.	Automatic, manual tare and zero facility	To be provided in digital weight indicator Provision for interfacing with a PC & printer
29.0.	Weighment & printouts	1. Name of the contractor 2. Date and Time 3. Serial Number 4. Product Code 5. Customer Code 6. Truck Registration Number 7. First (Gross) Weight (I) 8. Second (Tare) Weight (II) 9. Net (pay load) Weight (III) 10. LxBxH (m) Weigh slip after every weighment (i.e) I & II weighments. Real time clock required to provide date and time to printer. Facility for totalising the different material received.
30.0.	Control Room	Air conditioned
31.0.	Side post and post marking at entry and exit of weigh platform	Required
32.0.	Painting of Weigh bridge	Surface preparation : Degreasing and Mech. Cleaning with wire brushing and machine brushing as per St2. Primer: Two (2) coats of HB Zinc Phosphate (alkyd Medium as per IS:2074, DFT:35-40 microns per coat. Finish Paint: Two (2) coats of synthetic enamel (alkyd med) as per IS: 2932, DFT: 20-25 microns per coat. Total DFT:110 – 130 microns Final Colour of Paint: As per manufacturer's standard
II	VIDEO DISPLAY UNIT	
1.0	Operator's Station (PC based)	One (1) no for each Weigh Bridge
2.0	Processor	Core 2 Duo or better
3.0	Hard drive	320GB
4.0	System Memory	2GB
5.0	DVD Drive	DVD Read & Writer



SL.NO.	Description	Data
6.0	Operating system	WIN 2007 or higher
7.0	Graphic accelerator	8MB (Minimum)
8.0	Communication ports	04 nos. (min.) with two pen drive and other ports as required
9.0	Monitor	TFT Type
10.0	Screen diagonal	21" flat
11.0	Resolution	1024 X 768 or better
12.0	Degree of protection	IP-30
13.0	External Controls	Brightness, contrast, Horizontal /Vertical amplification & shift
14.0	Keyboard	One (1) no for each weigh bridge
15.0	Mouse	One (1) no for each weigh bridge
16.0	UPS	One (1) no for each weigh bridge with a power backup facility of 1 Hr for the total system.
17.0	Printer	One (1) no for each weigh bridge – DOT MATRIX PRINTER – 136 Column

Note:

1. The dimensions with GA drawing shall be submitted further after awarding the same.
2. Facility for auto calibration to be provided.

3.5.0 Miscellaneous

1. No. diesel bunk with tank of capacity 12 KL and metered filling facility to be provided near stores and all the approval and license to be arranged by the contractor.

3.6.0 List of Chemicals:

SL.NO.	List of Chemicals	Quantity
I	GENERAL	
1.	Acetic acid glacial, AE/GR/ER/ grade in bottles of 2.5 lts	7.5Lts
2.	Acetone AE/GR/ER grade - in bottle of 2.5 lts	10 lts
3.	Alpha naphthol sulphonic acid E/GR/ER grade 0 in 25 gms pack	200 gms
4.	Alkali blue indicator - in 100gms pack	100 gms
5.	Ammonia solution about 25% pure sp.gr. AR/GR/ER grade in 2.5 lts pack	25 lts
6.	Ammonia buffer solution in 500 ml pack	20 lts
7.	Ammonia chloride AE/GRIER grade in 500 gms pack	6kg
8.	Ammonia molybdate excellar grade	20kg
9.	Ammonia purpurate (mureide) indicator in 5	40gms



SL.NO.	List of Chemicals	Quantity
	gms pack	
10.	Anhydrous calcium chloride fused AR/GR/ER gr	20gms
11.	Amylum soluble AR/GR/ER grade in. 500 gms pack	2kg
12.	Aluminium for estimation of aluminium AR/GR/ER gr	20gms
13.	Barium chloride AR/GR/ER grade in 500 gms pack	4 kg
14.	Benzene AR/GR/ER grade in bottles of 2.5 lts	10 lts
15.	Bromocresol (indicator) green in 5 gms of 2.5 lts	20 gms
16.	Bromocresol (indicator) purple in 5 gms pack	10 gms
17.	Carbon tetrachloride LR grade in 500 ml pack	10 gms
18.	Calgon(indicator) for hardness determination in 5 gms pack	20gms
19.	Chlorotex reagent for determination of chlorine content in 100 ml pack	3 lts
20.	Citric acid AR/GR/GR grade	20 kg
21.	Concentrated nitric acid (concentration 69 to 72%) AR/GR/ER grade	10. lts
22.	Cobaltus chloride AR/GR/ER grade	2kg
23.	Copper sulphate AR/GR/ER grade in 500 gms pack	3kg
24.	,Dextrose (D glucose) AR/GR/ER grade in 500 g'ms pack	4kg
25.	Dipotassium hydrogen orthophosphate AR/GR/ER grade in 500 gms pack	2 kg
26.	EDTA solution 0.02 N in 500 ml pack	12lts
27.	Erichrms black T (solochrome black) indicate in 25 gms pack	200 gms
28.	Ethylene diamine tetra acetic Cilcid AR/GR/ER grade in 100 gms pack	2kg
29.	Ferric chloride anhydrous AR/GR/ER grade in 500 gms pack	2kg
30.	Ferrous ammonia sulphate AR/GR/ER grade in 500gms pack	3kg
31.	Fusion mixture AR/GR/ER grade in 500 ml	2 kg
32.	Glycerol AR/GR/ER grade - in 2.5 lts pack	10 lts
33.	Hexamine in 500 gms pack	1kg
34.	Hydrochloric acid AR/GR/ER grade sp.gr.1.18 in 2.5 lts pack	40 lts
35.	Hydrazine sulphate in 500 gms pack	1kg
36.	Hydrofluoric acid AR/GR/ER grade 48% in 500 ml pack	3 lts
37.	Hydrogen per oxide purified 30% AR/GR/ER grade in 100 gms pack	4 lts
38.	Hydroxyl amine hydrochloride AR/GR/ER grade in 100 gms pack	2kg
39.	Indige carmine (indicator) in 25 gms	200 gms



SL.NO.	List of Chemicals	Quantity
40.	Iodine resublimed in 100 gms pack	800 gms
41.	Lead nitrate AR/GR/ER grade in 500 gms pack	1kg
42.	Manganous chloride AR/GR/ER grade in 500 gms pack	1kg
43.	Mercury AR/GR/ER grade in 250 gms pack	3kg
44.	Mercuric chloride AR/GR/ER grade in 250 gms pack	2kg
45.	Methanol AR/GR/ER grade in 500 ml pack	30 lts
46.	Methyl" orange indicator in 50 gms pack	500gms
47.	Methyl ted indicator in 50 ml pack	100 gms
48.	N.T Nappthyl ethylene diamine dithydrochicride in 10 gms pack	20 gms
49.	Oxalic acid AR/GR/ER grade purified in 500 gms pack	3 kg
50.	Ortho phenanthrolein - in 5 gms pack	50 gms
51.	Para dimethyl amino benzal dehyde in 100 gms pack	500 gms
52.	Perchloric acid AR/GR/ER grade in 500 ml pack	4lts
53.	Phenolphthalein powder in 50 gms pack	500 gms
54.	pH indicator paper wide range in boxes of booklet range 2 to 10.5	20 boxes
55.	Potassium chromate AR/GR/ER grade in 500 gms pack	2kg
56.	Potassium dichromate AR/GR/ER grade in"500 gms pack	2.5 kg
57.	Potassium chloride purified AR/GR/ER grade in 500 gms pack	3kg
58.	Potassium hydroxide pure pellets in 500 gms pack	20kg
59.	Potassium iodide AR/GR/ER grade in 100 gms pack	6 kg
60.	Potassium nitrate purified in 500 gms pack	2kg
61.	Potassium pemanganants purified in 500 gms	2kg
62.	Potassium metabisulphite in 500 gms pack	10 kg
63.	Pyrogallol (QuaJigens) in 100 gms pack	2kg
64.	Silica gel indicating type	2 kgk
65.	Silver nitrate pure AR/GR/ER grade in 100 gms pack	500 gms



SL.NO.	List of Chemicals	Quantity
66.	Silicone grease in 100 gms pack	1 kg
67.	Sodium acetate AR/GR/ER grade in 500 gms pack	3 kg
68.	Sodium carbonate anhydrous AR/GR/ER grade in 500 gms pack	2 kg
69.	Sodium carbonate anhydrous AR/GR/ER grade in 500 gms pack	2 kg
70.	Sodium hydroxide pellets purified AR/GR/ER grade in 500 gsm	10 kg
71.	Sodium chloride crystal pure AR/GR/ER Grade in 500 gms pack	4 kg
72.	Sodium diethyl dithe carbomate in 100 gms pack	500 gms
73.	Sodium nitrate	500 gms
74.	Sodium thiosulphate AR/GR/ER grade in 500 gms pack	3 kg
75.	Sodium potassium tartarate AR/GR/ER grade in 500 gms pack	2 kg
76.	Sodium sulphate AR/GR/ER grade in 500 gms pack	2 kg
77.	Sulphuric acid AR/GR/ER grade sp. gravity 1.84 in 2.5 lts pack	25 lts
78.	Sulphasalicylic acid AR/GR/ER grade in 500 gms pack	1 kg
79.	Sulphanilic acid in 100 gms pack	500 gms
80.	Tin granule in 250 gms pack	500 gms
81.	Toluene rectified in 500 ml bottles	10 lts.
82.	Universal indicator in 100 ml bottles	11 lts
83.	Xylene rectified in 2.5 lts pack	15 lts
84.	Xylenol orange indicator in 5 gms pack	40 gms
85.	Zinc granule reagent grade	1 kg
86.	Filter paper whattman make sheets, packed in boxes of 100 sheets	8 boxes
87.	Filter paper whattman make	
	15 cm dia No. 40 size	6 boxes
	15 cm dia No.41 size	6 boxes
	15 cm dia No. 42 size	6 boxes
88.	Ortho Phosphoric acid	5 liters
89.	Sodium Nitrite AR	1 kg



SL.NO.	List of Chemicals	Quantity
90.	Calcium Acetate AR	500 grams
91.	Sulphanilenide AR	500 grams
92.	pH Buffer Tables 4,7,9,2,10	5 packs each of 10 tables.
93.	Calcium chloride AR	1 kg
94.	Thorium Nitrate AR	250 grams
95.	Potassium Bromate	500 grams
96.	Potassium Bromide	500 grms

3.7.0 List of Glass Wares and accessories

- 1 Bottle reagent plain narrow mouth with inter changeable flat head stopper corning Make : Borsil ® of vensil.

Sl.No.	Capacity	Approximate Odxheight (mm)	Size of interchangeable	Quantity (Nos.)
1	125	54 x 120	19/26	12
2	250	64 x 147	19/26	24
3	500	80 x 172	24/29	24
4	1000	104 x 200	29/32	24
5	2000	129 x 265	34/35	12

- 2 Bottle reagent amber narrow mouth with interchangeable flat head stopper corning (B) make : Borosil ® or Vensil

Sl.No.	Capacity (ml)	Approximate total height (mm)	Quantity (Nos.)
1	125	120	12
2	250	147	12
3	500	172	12
4	1000	200	12

- 3 Bottles weighing with coining ® make : Borosil ® or Vensil

Sl.No.	Capacity	Quantity (Nos)
1	25	6
2	40	6
3	50	6
4	60	6

- 4 Bottles dropping with 9.5 ml dropper make : Borosil ® or Vensil

Sl.No.	Capacity (ml)	Quantity (Nos)
1	50	6
2	100	6

- 5 Bottles dropping clear glass T.R. pattern with slotted ground glass stopped make : Borosil ® or Vensil

Sl.No.	Capacity (ml)	Quantity (Nos)
1	50	6
2	100	6



- 6 Bottles dropping amber glass T.R. pattern with slotted ground glass stopped make : Borosil ® or Vensil

Sl.No.	Capacity (ml)	Quantity (Nos)
1	50	6
2	100	6

- 7 Bottle gas washing complete with interchangeable stopper coming ® make: Borosil ® or Vensil.

Sl.No.	Capacity	Size of interchangeable stopper (mm)	Quantity (Nos.)
1	125	29/32	12
2	250	29/32	12
3	500	29/32	12

- 8 Bottle gas wash complete with interchangeable stopper coming ® make : Borosil ® or Vensil

Sl.No.	Capacity	Quantity (Nos)
1	500	6
2	1000	6

- 9 Bottles, relative density, accuracy as per IS:5717-1970 with capillary bore, interchangeable stopper coming (R) or Vensil

Sl. No.	Capacity	Tolerance	Maximum body Dia x Height (mm)	Size of interchangeable stopper (mm)	Quantity (Nos.)
1	25	2	30 x 56	10/19	6
2	30	2	48 x 66	10/19	6
3					
4					
5					

- 10 Beaker, made of Boresil ® or Vensil glass with spout coming ®

Sl.No.	Capacity (ml)	Approx size (mm) OD x Height	Quantity (Nos.)
1	50	42 x 55	24
2	100	50 x 72	24
3	250	68 x 95	24
4	400	77 x 105	24
5	600	90 x 120	12



- 11 Burets made of corning glass straight moulded with stop cock PTFE with capillary outlet, graduation on 0.1 ml class B of IS:1997 with works certificate. Make: Boresil ® or Vensil.

Sl.No.	Capacity (ml)	Graduation interval (ml)	Tolerance $\pm$ (ml)	Approx. total height (mm)	Quantity (Nos.)
1	50	0.1	0.05	780	12
2	100	0.2	0.10	830	12

- 12 Pipettes volumetric with one bulb accuracy as per Class B of IS:4162 (1985 reaffirmed 1991) with works certificate make: Boresil ® or vensil.

Sl.No.	Capacity (ml)	Tolerance (+%)	Quantity (Nos.)
1	10	0.02	12
2	25	0.03	24

- 13 Pipettes (Mehr type) accuracy as per class B of IS:4162-1967 with works certificate make : Boresil ® or vensil.

Sl.No.	Capacity (ml)	Graduation interval (ml)	Tolerance (ml)	Quantity (Nos.)
1	1	0.01	0.006	12
2	1	0.1	0.006	12
3	2	0.02	0.01	12
4	2	0.1	0.01	12
5	5	0.02	0.01	24
6	5	0.1	0.05	24
7	10	0.1	0.05	24

- 14 Funnels, filtering boresil glass with long stem make : Boresil ® or Vensil.

Sl.No.	Dia (mm)	Quantity (Nos)
1	75	24
2	100	24

- 15 Funnels, filtering boresil glass with short stem make : Boresil ® or Vensil.

Sl.No.	Dia (mm)	Quantity (Nos)
1	150	12
2	200	12

- 16 Funnels, separating with stop cock and interchangeable stopper, globe shapes coming (8) make : Boresil ® or Vensil.

Sl.No.	Capacity (ml)	Stopper size	Quantity (Nos)
1	250	19/20	12
2	500	24/25	6

- 17 Flasks, separating with stop cock and interchangeable stopper, globe shape comings ® Make : Boresil ® or Vensil.

Sl.No.	Capacity (ml)	Approximate OD x Height (mm)	Approximate Neck OD (mm)	Quantity (Nos.)
1	150	72 x 124	24	12



Sl.No.	Capacity (ml)	Approximate OD x Height (mm)	Approximate Neck OD (mm)	Quantity (Nos.)
2	250	85 x 1459	24	24
3	300	104 x 176	34	24
4	100	131 x 220	42	6

- 18 Flasks volumetric Boreasil glass with ground glass stopper accuracy as per Class B, IS:915 (1975, re-affirmed 1991) make : Boreasil ® or Vensil.

Sl.No.	Capacity (ml)	Tolerance (ml)	Interchangeable stopper size (mmø)	Quantity (Nos.)
1	50	0.06	10/15	24
2	100	0.10	14/15	24
3	250	0.15	14/15	12
4	500	0.25	19/20	6
5	1000	0.40	19/20	6

- 19 Cylinder, boresil glass with spout, graduated in 0.1 ml make : Boreasil ®

Sl.No.	Capacity (ml)	Graduation (ml)	Tolerance (mm)	Quantity (Nos.)
1	25	0.5	0.25	12
2	50	1.0	0.5	12
3	100	1.0	0.5	12
4	250	2.0	1.0	6
5	500	5.0	2.5	6
6	1000	10.0	5.0	6

- 20 Dishes (Petril, crystallising coming ® make : Boreasil ® or Vensil

Sl.No.	Approximate OD x Height (mm)	Quantity (Nos)
1	100 x 50	6
2	150 x 75	6
3	190 x 108	6

- 21 Dishes, evaporating flat bottom with pour out coming ® make : Boreasil ® or Vensil.

Sl.No.	Approximate OD x Height (mm)	Quantity (Nos)
1	80 x 45	12
2	150 x 75	6
3	190 x 108	6

- 22 Desicoator-scheibler glass with knob, cover and porcelain plate make: Boreasil (R) or Vensil. .

Sl.No.	Internal dia (mm)	Quantity (Nos)
1	250	4
2	150 x 75	6
3	190 x 108	6

- 23 Distillation trap with Graharrh condenser, interchangeable stopper coming ® for determination of moisture in coal by distillation process as per ASTM D95 and ASTM E 123



Sl.No.	Capacity (ml)	Quantity (nos)
1	5	6
2	10	6
3	25	6

24

Sl.No.	Glass Tubing – Tube size	Quantity (nos)
1	4 mm bore	5
2	5 mm bore	5

25

Sl.No.	Glass Rod – Rod size	Quantity (nos)
1	33 mm dia	5
2	5 mm dia	5
3	10 mm dia	5

26 Glass cover circular swallow type with ground glass.

Sl.No.	Dia (mm)	Quantity (nos)
1	100	12
2	150	12

27 Porcelain mortar with pastel. The pastel fitted with wooden handle.

Sl.No.	Mortar Dia (mm)	Quantity (nos)
1	150	6

28 Agati Morter and Pastel

Sl.No.	Dia (mm)	Quantity (nos)
1	8	3

29

Sl.No.	Porcelain tiles glazed sizeq	Quantity (nos)
1	6" x 6"	24

30 Porcelain crucibles with lid for temperature upto 1200 deg.C.

Sl.No.	Capacity (ml)	Quantity (nos)
1	50	12

31 Porcelain disc filtering perforated dia 2 mm – 12 nos.

32 Polyethene reagent bottles with wide mouth

Sl.No.	Capacity (ml)	Quantity (nos)
1	100	24
2	250	24
3	500	24
4	1000	24



33 Polyethene reagent bottles with narrow mouth

Sl.No.	Capacity (ml)	Quantity (nos)
1	100	24
2	250	24
3	500	24
4	1000	24

34 Polyethene carbuoys with washer attached lid.

Sl.No.	Capacity (ltr)	Quantity (nos)
1	1.0	12
2	2.5	24
3	5.0	24
4	10.0	12
5	20.0	12

35 Polyethene buckets

Sl.No.	Capacity (ml)	Quantity (nos)
1	10	12
2	15	12

36 Polyethene wash bottles

Sl.No.	Capacity (ml)	Quantity (nos)
1	100	12

37 Polyethene beakers

Sl.No.	Capacity (ml)	Quantity (nos)
1	250	12
2	500	12
3	1000	12
4	2000	12

38 Polyethene tubing in rolls of 30 meter

Sl.No.	Size ID/OD (mm)	Quantity (nos)
1	3/5	1
2	5/7	1
3	6/8	2
4	8/10	2
5	10/12	2

39 Aspirator bottles made of polyethne with plastic screw in cap, handle and stop cock.

Sl.No.	Capacity (ml)	Quantity (nos)
1	500	6

40 Bottle alikathene sequeeze with jet

Sl.No.	Capacity (ml)	Quantity (nos)
1	500	12



- 41 PVC tray rigid with handle

Sl.No.	Approximate size (mm)	Quantity (nos)
1	450x300x15	12

- 42 Rubber bladder

Sl.No.	Size (inches)	Quantity (nos)
1	5	24

- 43 Rubber tubing (pressure) in rolls of 30 meters.

Sl.No.	Inside dia (mm)	Outside dia (mm)
1	5	10
2	8	15
3	10	15

- 44 Rubber tubing thickness 1 to 2 m rolls of 30 mtrs

Sl.No.	Outside dia (mm)	Quantity (rolls)
1	5	1
2	6	1
3	7	1
4	8	1

- 45 Tubes Nessler with graduation at 25 ml & 50 ml

Sl.No.	Capacity (ml)	Quantity (nos)
1	100	36

- 46 Test tube borosil glass thick walled

Sl.No.	Capacity (ml)	Quantity (nos)
1	50	24
2	100	24

47	Test tube holder	12 nos.
48	Test tube stand, wooden, polished with 6 holes and 6 pegs for holding test tubes	12 nos.
49	Triped stand	6 nos.
50	Bung rubber assorted size between 5 and 20 mm dia set consisting of 10 – numbers	1 set ech
51	Spatula polished and flexible with this rounded ends, length 100 mm width 15 mm	12 nos.
52	Scoop, made of SS, length 60 mm	12 nos.
53	Burette clamp metallic base with supporting rod and spring type holders for two burettes	12 nos.
54	Funnel holder wooden, for	12 nos.



	two funnels, opening diameter 50 mm	
55	Pipette stand, polythene to hold 12 pipettes, 6 on either size horizontally	12 nos.
56	Tongs SS (Stainless steel) with flattened and curved tip length 400 mm	12 nos.
57	Tongs blackened steel with flattened and curved tip length 400 mm	4 nos.
58	Glass cutter	1 no.
59	Redwood viscosity flask 50 ml	4 nos.
60	Brush round form made of camel hair in quill holder	12 nos.
61	Wire gauge made of galvanized iron, square mesh, and asbestos centre net size 150 x 159 mm	6 nos.
62	Cork boring machines for boring holes in cork and compressed rubber corks complete with set of nickel plated steel borers of 3 to 25 mm dia 2 nos. each.	1 no.
63	Platinum crucibles with lid. – capacity 30 ml, depth 30 mm inside dia 10 mm total weight approximate 30 gms inclusive of lid	3 nos.
64	Platinum dishes with crucibles type lid capacity 100 ml depth 30 mm, inside dia 75 mm, total wt. approx 60 gms inclusive of lid.	1 no.
65	Stopwatch in metal body for 1 hour duration	2 nos.
66	Spirit lamp	2 nos.
67	Dean & stork apparatus for determination of moisture in coal (round bottom flask capacity 500 ml, condenser & receiver 25 ml full set.	3 nos.

The following additional glass ware and accessories shall also be included in the list.

Sl.No.	Name	Capacity	Quantity
1	Burette	25 ml	6 Nos.
2	Burette	10 ml	6 Nos.
3	Pipettes on bulb	20 ml	12 Nos.
4	Measuring cylinder stoppered	50 ml	6 Nos.
5	Measuring cylinder stoppered	100 ml	6 Nos.
6	Iodine flask with l/c stopper	250 ml	6 Nos.
7	Iodine flask with l/c stopper	500 ml	6 Nos.
8	Asbestos gloves		6 pairs



Sl.No.	Name	Capacity	Quantity
7	Rubber Gloves Acid / Alkali proof		12 pairs
8	China dish	250 ml	12 Nos
9	China dish	100 ml	12 Nos.
10	Tissue paper		100 rolls
11	Bucker funnel	75 mm dia	3 Nos.
12	Aspirator bottle – Glass	250 ml	6 Nos.
13	Suction below		12 Nos.
14	Polythene beaker	100 ml	12 Nos.
15	Polythene trough		3 Nos.



VOLUME II

SUB-SECTION 2.23

INSPECTION AND TESTING AT MANUFACTURER'S WORKS

1.0.0 GENERAL

This section is intended to provide the scope, functional requirements for Inspection and Testing of various mechanical equipment, material, parts, and workmanship of the Plant during manufacture, to demonstrate compliance with specification, codes and standards and to ensure overall reliability of plant operation and performance.

2.0.0 INSPECTION AND TESTING REQUIREMENTS

The equipment to be supplied under this Contract shall be subject to works' inspections and workshop tests.

The Bidder shall issue a quality assurance programme, indicating the kind and extent of inspections and tests to be carried out on plant components. These inspections and tests shall prove whether the equipment fulfils the requirements of the Contract in view of

- Design & functional requirement of equipment/system
- safety conditions
- consideration of the applied standards and regulations
- execution of workmanship
- Conformity with the present state of modern technology.

2.1.0 Material tests

Test specimens shall be taken in accordance with the relevant standards and codes. Dimensions shall be adequate for the purpose intended and the test specimen shall accompany the component through all phases of the heat treatment. Before cutting or otherwise removing the test specimens, these shall be permanently banded together with the forgings, castings or components which they represent and, if requested, in the presence of the Owner's Engineer. Except where expressly otherwise approved, all test specimens shall be machined to the dimensions specified in the relevant standards and codes. Steel castings and forgings, in all cases; be annealed before the test specimens are withdrawn.

Chemical analysis and mechanical properties of the material concerned shall also be submitted.

All casting components shall be tested for compliance with the relevant standards and codes and shall be suitable for the purpose for which the castings are to be used. The chemical analysis and mechanical properties of the material tested shall be provided by the Bidder. The results obtained from these material tests shall be in compliance with the values contained in the relevant standards and codes and with the figures quoted in the relevant sections of the Contract, X-ray examination and ultrasonic examination of circumferential, longitudinal, nozzle welded joints, stiffening rings, etc., shall be carried out by the Bidder in compliance with the standards under which the relevant equipment will be designed.

All castings and forgings of critical components of the equipments viz ST, BFP, CEP, CW pumps etc, pressure vessels, alloy & stainless steel material shall be subjected to X-ray and/or ultrasonic tests before the start of machining procedures, in order to detect defects as early as possible and to replace in time defective parts, thus avoiding undue delay in the manufacture and delivery of plant components. After partial machining in the Bidder's workshop, further tests may be performed. No repair welding machining of castings and forgings of major components shall be carried out without prior inspection and confirmation by



the Owner's Engineer. In case of a rejection, written and certified notice must be given to the Owner/ Owner's Engineer, indicating also measures undertaken by the Bidder in order to cope with the requirements of the Contract.

Major steel forgings

Purchase specifications shall clearly state the quality and inspection requirements and should include, but not be limited to:

- a) chemical composition range
- b) heat treatment
- c) mechanical test specimen locations
- d) mechanical properties
- e) magnetic properties (when applicable)
- f) non-destructive testing
 - methods and procedures
 - stage and extent of application
 - recordable indication size
 - allowable indication size
- g) thermal stability test (HP and reheat turbine shafts only)

Each forging shall be suitably marked with an identification number which shall be transferred throughout all machining stages. The identification number shall be indicated on all documents relating to the forging.

Repair welding will not be permitted on rotating parts and on other components the proposal will be subject to approval by the Owner's Representative.

Rotor forgings

The profile of forgings at the stage of final ultrasonic inspection should be such as to minimize the regions where complete coverage is not possible.

Ultrasonic indications should be measured by the equivalent flat bottomed hole or AVG (DGS) method.

The toughness of rim and core (where applicable) material shall be evaluated by testing Charpy V impact specimens over a range of temperatures and thus determining the 50% fibrosity fracture appearance temperature.

Allowable indication size and material toughness are interdependent design related criteria and the Bidder must be prepared, if requested by the Owner's Representative, to justify his proposals by reference to fracture mechanics calculations.

Bores, when provided, shall be magnetic particle inspected and a suitable intrascope used for examination.

Major steel castings

Purchase specifications shall clearly state the quality and inspection requirements and should include:

- a) chemical composition range
- b) heat treatment
- c) mechanical test specimen locations
- d) mechanical properties
- e) non-destructive testing
 - methods and procedures



- stage and extent of application
- recordable indication size
- allowable indication size
- f) other tests
- g) standard weld repair procedure.

Each casting shall be identified by hand stamped or cast-on reference numbers which shall be Indicated on all documents relating to the casting.

Non-destructive testing

Minimum requirements are as follows:

- a) Crack detection of critical areas of castings which in the case of castings to operate at high temperature or high pressure shall consist of 100% of all accessible areas. Magnetic particle inspection shall be used for ferritic steel castings.
- b) Ultrasonic inspection of all surfaces of castings to operate at high temperature or high pressure.
- c) Ultrasonic thickness check of critical areas.
- d) Radiographic examination adjacent to future butt weld regions (Acceptance Standard Level 1 of ASTM E446 or E186 as appropriate).
- e) Radiographic examination shall also be used to assist in defining defects indicated by ultrasonic inspection.

In addition to being applied as necessary quality control on as cast items, inspections outlined in a) and b) above shall be applied to the finally heat treated casting.

Prior to non-destructive testing all surfaces shall be satisfactorily prepared and visually examined.

Repair welding

Unacceptable defects observed by visual examination or indicated by nondestructive testing shall be excavated by chipping or thermal gauging and grinding and their complete removal proved by crack detection.

In the case of excavations which penetrate more than 25 mm or 50% of the wall thickness or cover more than 10,000 mm² area the Owner's Representative written approval of the proposed repair must be obtained.

Only welders qualified by performance tests on similar cast materials shall be used.

On completion of repair welded areas shall be ground smooth and carefully blended into the surrounding material. The repaired areas shall be surface crack detected, magnetic particle inspection being used for ferritic steel castings and in addition ultrasonic inspection shall be used on castings to operate at high temperature or high pressure.

Steel plates and sections

The following requirements, which may be supplementary to the applicable material standards, shall be considered when selecting material grades:

- impact testing of plate or sections over 50 mm thick (impact requirements to be dependent on application)
- ultrasonic testing of plate where the presence of non-metallics may interfere with the interpretation of ultrasonic testing of future welds



- ultrasonic testing and through thickness ductility measurement, where the application involves the risk of lamellar tearing in the material at regions of high restraint (e. g. at set-on nozzle locations or cruciform joints)
- ultrasonic testing clad materials to detect lack of bonding (proposed rectification procedures shall be submitted for the approval of the Owner's Representative).

Reinforced thermosetting resin pipes

Checks shall be made on all raw materials to ensure that they comply with the relevant ASTM Standard.

All deliveries of resin shall be checked for consistency by viscosity and reactivity. Any resins deviating from the manufacturer's published figures shall not be used.

Testing of reinforced thermosetting resin pipes:

- Long term hoop strength (type test for pressure pipes only)

In accordance with ASTM D2992 Procedure B with the exception that the test results shall be extrapolated to determine the stress which the pipe can withstand for a period of 60 years without failure. The lower 95% confidence limit at 60 years shall also be calculated.

- Hydraulic test

100% of the pipes shall be subjected to an internal hydraulic pressure test at the manufacturer's works prior to delivery. The test shall be applied to a pressure equal to 1.5 times the maximum working pressure stated for each classification of pipe. The test pressure shall be applied for a minimum period of 5 minutes without signs of leakage.

- In addition to the above the first pipe and every thirtieth thereafter of each class and diameter shall be maintained at test pressure for a minimum of 4 hours without signs of leakage.

Each pipe and fitting shall be subjected to an internal low pressure air test at the manufacturer's works prior to delivery. The test pressure shall be an overpressure of 0.1 bar and this shall be applied for a minimum period of 5 minutes without signs of leakage or distress. Fittings which are of mitred construction shall be manufactured from pipes which have successfully passed the tests defined above.

- Dimensions

The dimensions and tolerances of all pipes shall be determined in accordance with ASTM-D 2122 Stiffness

A minimum of one pipe for every 30 pipes manufactured shall be tested for stiffness in accordance with ASTM-D 2412 "Method of Test for External Loading Properties of Plastic Pipe by Parallel Plate Loading". A minimum of one pipe of each class and diameter of pipe shall be tested.

Longitudinal and hoop tensile strength. The tensile strength properties of a minimum of one pipe for every 100 pipes manufactured shall be measured in accordance with ASTM-D 638. A minimum of one pipe of each class and diameter of pipe shall be tested.



- Cure

Curing, to be tested by the Barcol Hardness test determined in accordance with ASTM-D 2583 standard: 100 % of the produced pieces. Minimum acceptable hardness is 90% of the value recommended by the resin manufacturer of the particular resin used, when non-reinforced. The sample pipe shall also withstand a commercial acetone test on the internal portion of the laminate.

- Loss on ignition

A minimum of one pipe for every 30 pipes manufactured shall be tested in accordance with ASTM-D 2584 "Standard Method of Test for Ignition Loss of Cured Reinforced Resins".

- Joint tests

A minimum of two pipes in every 100 pipes manufactured shall be jointed and tested in accordance with the requirements of section 7.2 of ASTM-D 3262.

- Visual inspection

Each pipe and fitting shall be subjected to a complete visual inspection before shipment in accordance with ASTM-D 2563.

- Vacuum test

Vacuum test of pipe shall be carried out for each diameter once at beginning of production. The vacuum to be applied shall be equivalent to the condition which occurs during full vacuum. The corresponding derated vacuum for this test shall be proved by the pipe manufacturer.

- Failure of tests on completed pipes

In the event of a specimen not fulfilling the minimum requirements for strain corrosion resistance, all pipes of that class and diameter which have been manufactured shall be rejected and shall be replaced entirely.

Any pipe or fitting which fails any of the quality control tests which are to be carried out on each and every pipe or fitting shall be rejected. In the event of any pipe failing any of the remaining tests outlined above that pipe shall be rejected and the relevant test shall be carried out on a further ten pipes of that class and diameter. If any one of these ten pipes fails then the manufacture of pipes of that class and diameter shall cease and the Owner reserves the right to reject all the pipes of that class and diameter.

Thermal insulating materials

Materials shall be tested for bulk density, specific heat, compressive strength, fire resistance under pressure, service temperature limit in accordance with VDI 2055 or equivalent standards.

Workshop manufacturing and pre-assembly

All workshop fabricated components and parts of the plant shall, to the fullest practical extent, be formed, machined, fitted, welded, stress-relieved, X-rayed, adjusted, tested, cleaned and painted. The equipment shall be pre-assembled in the workshop of the Bidder or his sub-supplier to the maximum possible extent, then dismantled only as far as required for safe and proper shipment, in order to keep erection work on site to a



minimum. Equipment and parts shall be marked, labelled or otherwise identified to facilitate assembly and erection on site. Marks and labels shall be fixed in such a manner so that deformation or obliteration shall not occur during shipment, storage and erection on site.

2.2.0 Manufacturing tests

2.2.1 Welding

Welding procedures shall be qualified in accordance with the requirements of the construction code/specification for the item of plant concerned and in the case of critical plant items the tests shall be witnessed by an internationally recognised inspection authority.

Welders shall be qualified in accordance with the requirements of the construction code/specification for the item of plant concerned for all types/positions of welding he may perform.

A system of positively identifying the work of each welder shall be maintained and any welder whose work is the subject of multiple rejections shall be required to undergo a requalification test. Any welder failing the retest may, at the discretion of the Owner's Representative be disqualified from further welding on items under this contract.

Welded fabrications shall be stress relieved when specified by the applicable standard or for dimensional stabilisation prior to machining.

Copies of temperature charts referenced with load items shall be included in the test certification supplied for the relevant items.

All welds shall be visually examined and shall be of smooth contour, free from cracks, undercut and other significant defects. Wherever possible the interior of tubes etc. shall be examined using a suitable optical device where necessary.

Fillet welds shall be checked for size using suitable gauges which shall be available for use on request by the Owner's Representative during an inspection visit.

Non-destructive examination of pressure and vacuum containment welds

Welds shall be non-destructively tested in accordance with the construction standard applicable to the item of plant. In addition the requirements of the **following Table 1** shall be observed. This table shall also apply in cases where the standards used for design and construction of an item of plant does not specify the quality requirements for welds. Fault limitations to be subject of agreement with the Owner's Representative prior to fabrication.

Table 1 : Non-Destructive Testing

Type of Steel	Design Factor (shell)	Wall thickness (mm)	Inside diam. (mm)	Type and Extent of Non-Destructive Testing			Remarks
				Butt	Nozzle	Fillet	
C and C-Mn steels with C content not exceeding 0.25%	≤ 0.85	≤ 10	all	-	-	-	Only applicable to: Atmospheric systems (excluded systems, which handle chemicals, toxics or flammable media).



Type of Steel	Design Factor (shell)	Wall thickness (mm)	Inside diam. (mm)	Type and Extent of Non-Destructive Testing			Remarks
				Butt	Nozzle	Fillet	
		≤	all	10% R	-	-	
		> 40	all	100% R	10% M	10% M	
	> 0.85	≤ 40	≤ 100	10% R	-	-	
			> 100	100% R	10% M	10% M	
		> 40	all	100% R	100% M	100% M	Test before stress relief
C-Mn steels with C content 0.25 to 0.35% and C 1/2 Mo steels		≤ 30	all	10% R	10% M	10% M	Applicable below 50 bar
	all	> 30	all	100% R	100% M	100% M	Test before stress relief
Low alloy steels except CrMoV and 2 CrMo	all	all	all	100% R	100% U	100% M	Test before stress relief
CrMoV and 2CrMo steels and 12% Cr ferritic/ martensitic steels	all	all	≤ 100 > 100	100% R 100% R* 100% U	100% M 100% M 100% U	100% M 100% M	Test before stress relief Test before stress relief
* Radiographic examination may be omitted if done on as-welded joint							
Austenitic Stainless Steels	≤ 0.85	≤ 15	all	-	-	-	Not applicable to: Butt welds made from one side only Operating temperatures exceeding 200 °C
		≤ 30	all	10% R	-	-	
		> 30	all	10% R	10% D	10% D	
			≤ 100	10% R	-	-	
	> 0.85	≤ 30					
			> 100	100% R	10% D	10% D	
		> 30	all	100% R	100% D	100% D	

Legend: R = Radiographic examination
U = Ultrasonic examination
M = Magnetic particle examination
D = Dye penetrant examination

Note:

- Where 10% examinations are shown for pipe work under 100 mm diam bore this shall be the circumference of 10% of the welds by each welder selected at random with a minimum of one per welder.
- Where 10% examinations are shown for vessels or large diameter pipework this shall be 10% of each weld length and must include all intersections of longitudinal and circumferential welds.
- Where partial examinations reveal rejectable defects, adjacent welds or areas of weld shall be examined. In the event of rejectable defects being found welds shall be subject to 100% examination.
- Welds in clad materials shall be tested in accordance with the requirements of the base material and the surface of the overlaid welds shall be dye penetrant tested throughout their length.



Non-destructive examination of structural welds

Welds shall be non-destructively tested in accordance with the construction standard applicable to the item of plant. Where appropriate, the following requirements shall also be observed:

Magnetic particle testing of the tension side welds In major fabricated girders and sections.

Ultrasonic examination of heavily restrained welds (e. g. cruciform joints) where there is a risk of lamellar tearing in the parent material.

Weld repairs

Unacceptable defects observed by visual examination or indicated by nondestructive testing shall be completely removed by chipping or thermal gouging and grinding. The resulting excavation shall be crack detected prior to rewelding.

Details of the original defects and repair shall be recorded.

Repaired welds shall be subjected as a minimum requirement to the same inspection requirements as the original welds and test records should indicate that a repaired weld is referred to.

2.2.2 Pressure testing

All items subjected in service to internal pressure or vacuum shall, unless otherwise agreed, be pressure tested in the manufacturer's works and prior to any internal or external coating.

Hydrostatic testing

All pressure vessels, inserts or other parts of such vessels, which are subject to an internal pressure or vacuum during operation shall undergo a hydraulic or other approved test. Unless otherwise stated in the specification, the test pressure shall be maintained for a sufficient period to permit complete examination by the inspector.

Should it be necessary to carry out repair welding on stress-relieved equipment, it must undergo a stress-relieving process again with prior approval of the Owner's Representative. In all such cases, the hydraulic test must be repeated.

Particular attention must be paid to the temperature of water used for hydraulic testing which shall not be less than 20°C. Prior to testing, metal temperatures shall also not be less than 20°C. Where pressure parts 600 mm in diameter and above are being tested, the hydraulic pressure shall be raised to the test pressure in stages, during which the item shall be examined and all defects rectified before the full test pressure is reached.

Suitable water shall be used as the test media unless otherwise agreed and test pressures shall be in accordance with the applicable construction standard but if none is specified then the test pressure shall be 1.5 times the design pressure but not less than an overpressure of 3.5 bar. Test pressure of vacuum containment items shall be agreed with the Owner's Representative.

The test pressure shall be maintained for sufficient time to permit complete visual examination of all surfaces and joints and in no cases less than specified in the applicable construction standard.

The chloride content of water used for testing austenitic stainless steel items shall not exceed 30 ppm unless immediate flushing with water of this quality is done after the test.



Pneumatic testing

The Bidder shall apply pneumatic testing in cases where hydrostatic testing is impractical or undesirable. Safety precautions, test pressures/ duration and degree of prior non-destructive examination of the subject items shall be agreed with the Owner's Representative.

Pneumatic or gas leak testing supplementary to hydraulic testing shall be applied in appropriate cases where specified by the applicable construction standard.

2.2.3 Testing of corrosion protection

Surface coatings

Following tests have to be performed before, during and after coating:

- visual inspection of blasted surfaces according to DIN 55928 part 4, annex 1
- checking of coating material
- measurement of air humidity, air temperature and coating area temperature (determination of dew point)
- visual inspection of coating
- checking of dryfilm thickness (DFT)
- checking of adhesion.

Galvanised zinc coatings

Surfaces shall be visually inspected. Bare patches, lumps blisters or inclusions of foreign matter shall be cause for rejection.

Zinc coating thickness shall be determined non-destructively in accordance with DIN 50981 or coulometrically in accordance with DIN 50932. For coatings with a weight exceeding 900 g/m² the coulometric test method specified in DIN 50932 shall be used.

Hard rubber linings

Surfaces shall be visually inspected. Uneven surfaces, splits, blisters or inclusion of foreign matter shall be cause for rejection.

The thickness of linings shall be measured in accordance with VDI Standard 2539 or equivalent. A tolerance of + 10% is permitted for rubber coatings of 3 mm nominal thickness.

Hardness tests shall prove compliance with the rubber manufacturers standards.

The absence of pores shall be proved by the induction sparking test method. The potential used shall be 5,000 Volts for each mm of thickness plus an additional 5,000 Volts (i. e. potential of 20,000 Volts for 3 mm thick lining).

2.3.0 Mechanical equipment

2.3.1 Rotating units

Balance testing of rotating units

Each rotating unit shall be first statically balanced and then dynamically balanced (in the case of impellers this shall be done before and after mounting of the service rotor shaft). A check balance of items that have undergone overspeed test shall also be made.



Vibration testing of rotating units

The vibration characteristics of rotating units shall be measured during performance tests. Locations of measurement and standards to be achieved shall, on request, be subject to agreement by the Owner's Representative.

2.3.2 Steam turbine

The turbines shall be completely assembled with their control, stop and governing valves on a suitable erection rig at the manufacturer's works and shall be carefully inspected and measured for manufacture and assembly tolerances. Functional tests shall be performed on the safety equipment.

Important items of turbine control equipment which cannot be adequately tested during the main tests shall be separately bench tested.

Furthermore testing shall comprise:

- balancing and overspeed test of the assembled rotor
- measurement of radial clearances
- assembling inspection.
- Bearing oil temperature rise
- Vibration levels over the operating speed range
- AOP cut-in and cut-out pressures
- Check for assembly clearance after the test

2.3.3 Steam Generator

As per the requirement of IBR / ASME

2.3.4 Pumps

Running tests and performance tests shall be conducted on all pumps:

Performance tests shall be conducted through the full operation range of the pump to closed valve conditions. Graphs indicating flow/head, flow/power absorbed, flow/efficiency, flow/NPSH and speed shall be produced.

The lubricating oil used in the test shall be of the same brand and grade as that recommended by the manufacturer for service use.

Bearing oil temperature rise and Vibration levels over the operating speed range shall be measured and shall be as per the standard.

Dismantling of the pump for visual examination of parts for damage following test shall be done when required by the inspection standard, when considered necessary by the manufacturer, or when requested by the Owner's representative witnessing the running or performance tests. Replacement of parts following test shall necessitate repeat testing.

Job motor shall be used for testing the BFP, CEP CW, ACW booster and CCW pumps.

NPSH test shall be performed for BFP and CEP pumps. For vertical pumps minimum submergence test shall be conducted.

For all the pumps in the plant, the Testing and acceptance std shall be IS 5120/HIS/PTC code. However no negative tolerance is allowed for Flow, Head, Shut off head & Efficiency at Guarantee point. However positive tolerance of 3% on Heat at Guarantee point and 5% on shut off head is permitted.

**2.3.5 Fan**

All fans shall be tested in accordance with the BS 848 part 1 and other applicable standards.

The particular test procedure to be applied to each type of fan shall be agreed with the Owner. The tests shall be conducted strictly to the requirements of the agreed test procedure so that all points on the performance curves are within agreed tolerances.

2.3.6 Deaerator, Condenser and Plate heat Exchanger

- Hydro Test as per ASME sec VIII , Div 1
- Air test / hydrostatic test of tube to tube sheet joints for condenser.

2.3.7 Gate, Globe, Regulating and Check valves

- As per IBR / ASME
- Shell Hydro test
- Seat leakage test as per BS 6755 part 1 Rate A with Air test & Hydro test.

2.3.8 Control Valve, Pneumatic block valve and PRDS

- As per IBR / ASME
- Shell hydro test as per ASME 16.34
- Seat leakage test , Actuator chamber leakage test, as per ASME 16.104
- Operation test (calibration , Hysteresis)
- Flow characteristics test

2.3.9 Butter Fly valves

- Shell hydro test & Disc strength test as per BS 5155
- Seat leakage test BS 5155
- Open & close operation check for more than 14 “ valve
- Flow characteristics test

2.3.10 Air compressors

Air compressors shall be tested in accordance with the requirements of BS 1571, class C.1 part 1, ISO 1217, ASME PTC-9 or similar standards. Any request for deviation from the test conditions shall be accompanied by the manufacturers' proposals for the adjustment of the correction factors contained in the standard.

No Tolerance on guaranteed values of energy consumption, volumetric efficiency, air drier capacity, dew point of air, is allowed.

2.3.11 Air Drying Plant

Leakage test, Auto sequential test, operating time for regeneration cycle, Dew point test

Performance test for the air dryer shall be conducted at site to prove the following parameters:

- a) Rated dew point temperature
- b) No spikes in the dew point temperature during changeover from one tower to the other in the dryer

2.3.12 Cranes and hoists

Where size permits cranes and hoists shall be completely assembled at the manufacturer's works and functional tests including load, speed, deflection etc shall be load conducted.



2.3.13 Fire fighting system

All testing requirement as per TAC / NFPA.

The stand post assembly along with the hydrant valve (valve being open and outlet closed) shall be pressure tested at a hydrostatic pressure of 21 Kg/cm² to detect any leakage through defects of casting.

Flow test shall be conducted on the hydrant valves. The flow through valves shall not be less than 900 Litres/min.

Leak tightness test of the valve seat shall be conducted at a hydrostatic test pressure of 14 Kg/cm²(g).

2.3.14 HVAC

a) Chiller

Each chiller shall undergo a series of factory tests to ensure that the vacuum section is leak tight and meets the manufacturer's strict quality control standards. The chiller-heater shall be covered with helium charged bell and the vacuum section shall be evacuated. The leakage rate shall be measured by a helium mass spectrometer.

Performance Tests

All chiller units shall be performance tested at the manufacturer's work. During the test reading shall be taken for various parameters like

- Chilled water inlet/outlet temperatures
- Capacity
- Steam consumption (for absorption chiller)
- Power consumption
- Cooling water inlet / outlet temperatures.
- Vibration & noise level.
- Temperature rise of lubricating oil.

Pressure Tests

A standard Pressure test shall be conducted on the evaporator, refrigerant piping, condenser and steam line as per code. In Shell and tube heat exchangers, Water side and refrigerant side shall be hydraulic and pneumatic pressure tested respectively. The compressors shall be pressure tested pneumatically at 1.5 times the design pressure. Pressure build up test and leak back test shall also be carried for the compressor as per the applicable standards.

b) Air Handling Unit

Visual and dimensional check shall be done for quality workmanship and completeness of each section and component and their assembly. The cooling coils shall be pressure tested (hydraulic for chilled water, pneumatic for direct expansion type) for minimum 1.5 times the design pressure.

Performance Tests

All Air handling units shall be performance tested at the manufacturer's work. During the test reading shall be taken for various parameters like

- Air flow rate and static pressure developed by the air handling fan.
- Cooling capacity of the cooling coil.



- Noise level at specified distance from the unit and Vibration.
- Power consumption.
- Leak tightness for the assembled unit.
- Smooth operation and responsiveness of the face and bypass damper.

c) Cooling Tower

All testing as per ATC-105 : Acceptance test code for water cooling towers

2.3.15 Water treatment plants

Functional tests on completed individual equipment shall include:

- Pumps performance test
- Interlock and protection panels.

2.3.16 Hangers & Supports

All shop tests shall be conducted in accordance with ANSI standards and other applicable codes/standards.

Each Constant load hanger shall be tested before delivery to ensure that the variation in supporting capacity provided through specified range does not exceed 5%.

Each variable load spring hangers shall be tested before delivery for its spring stiffness.



VOLUME II
SUB-SECTION 2.24
GENERAL MECHANICAL REQUIREMENTS

1.0.0 GENERAL

This section covers the general mechanical requirements of all other sections of this specification and shall be complied with in every respect unless otherwise stated or agreed by the Owner.

2.0.0 CASTINGS AND FORGINGS

The quality requirements of approved international other national standards shall be taken as the minimum requirements.

Cast iron is not to be used for any part of equipment which is in tension or which is subjected to impact, or to a working temperature exceeding 100°C unless specifically approved by the Owner. Materials for iron castings shall comply with approved international or national standards.

All forgings are to be manufactured from basic electric steel or fully killed acid open-hearth steel. Consideration shall be given to the use of vacuum-degassed steels in appropriate cases.

Forgings shall be free of cracks externally or internally, extensive non-metallic inclusions and surface defects which cannot be removed by subsequent machining.

Each forging shall be suitably branded with an identification number which shall be transferred throughout all final machining stages. The identification number shall be marked on all documents and test certificates relative to the forging.

3.0.0 PUMPS

The following represents general requirements for pumps Intended for various services and the same shall be read in conjunction with the requirement specified elsewhere in the detailed mechanical specification.

General

All pumps shall be so designed that they are suitable for continuous operation and outdoor condition unless otherwise specified.

Pumps installed for parallel operation or as standby sets are to be of the same design, i.e. interchangeable.

Standard-type pumps with suitable characteristics shall be used wherever practical. Only proven makes and models are to be supplied. All accessories and the overall design of pump sets are to be such that they are suitable for automatic operation as planned for the relevant systems.

All pumps shall comply with the latest applicable recommendations of Hydraulic Institute Standards (U.S.A) or approved equivalents.



Pump types

Centrifugal pumps shall be used wherever possible.

Rotary-type positive displacement pumps will be accepted for handling fuel oil/sludge handling etc., and reciprocating pumps shall be used for chemical dosing and metering purposes

The pumps shall have a continuously rising head (upto shut-off) characteristics with the minimum shut-off head of 110% but not exceeding 125% of the head at best efficiency point for the rated impeller.

The pump shall be designed to have best efficiency between the rated and normal point. However in no case the rated point should be beyond 115 % of the best efficiency point. Moreover the minimum continuous stable flow shall not be less than 20 % of the best efficiency point.

The Contractor shall note that the pump characteristics as obtained during the performance testing of pump shall not deviate from the characteristic furnished during tender stage particularly with regard to the operating point and shut off head and steepness of the curve beyond the duty point.

Miscellaneous pumps / General Service pump shall have flow & head margins of 10% & 15% respectively.

The pump shall be capable of meeting the actual requirement for continuous operation at 47.5 Hz.

The equipment shall be made suitable for outdoor installation. Weather/environmental conditions under which the equipment must operate are specified in the 'Project Data'. However, for the Owner's guidance, the Contractor shall list in the proposal any special protection that the Owner is required to arrange.

Pump shall be capable of automatic start up from stand still condition with discharge valve fully open. Motor shall be selected according to the above requirement.

Difference in flows handled by the two pumps when operating the parallel shall not be more than 5% of the flow through any one pump.

The impeller shall be of non-overloading type.

A hardness difference of 50 BHN minimum shall be maintained between the impeller ring and wearing ring, inter-stage bushing and spacer sleeve and balancing and spacer sleeve and Balancing disc/piston and counter balancing disc.

Mechanical seal of shall be provided at both ends of the shaft of pump for DM water/Feedwater/Condensate/oil application.

The maximum temperature rise of bearings shall not exceed as per standard over ambient temperature.

All major rotating components shall be dynamically balanced. The assembled rotors shall be dynamically balanced.

The tender shall also demonstrate that the pump can operate at the quoted minimum continuous stable flow without exceeding the vibration limits as stipulated in HIS.



Pump-motor set shall run smooth without undue noise and vibration. The limits of vibrations shall be applicable with maximum wearing clearances.

Acceptance of the forced lubrication system shall be subjected to the approval by the Owner. In case forced oil lubrication is recommended the lubrication system shall include shaft driven lube oil pump and lube oil plant with interconnecting piping and controls. Acceptable peak to peak vibration limits shall generally be guided by HIS.

The drive motor rating shall be selected such that a minimum margin of 25% upto 18.5KW, 15% for 22-55KW, 10% for above 75 KW is available over the pump input power required at the rated duty point. However, motor rating shall not be less than the maximum power required by the pump at any point on the curve including the run-off condition. All motors shall be energy efficient type with efficiency not less than 94%.

4.0.0 CORROSION ALLOWANCES

Corrosion allowances of minimum 1.6 mm shall be considered for carbon steel pipes. For vessels of carbon steel construction a corrosion allowance of 3 mm shall be considered.

5.0.0 PIPING AND APPURTENANCES

All the skid mounted equipment piping wherever specified shall be in fully assembled condition. Piping shall be duly supported on the base plate and terminated with ANSI flange at the edge of the base plate towards suction. Piping shall be properly tagged with metallic strips.

In mechanical seal cooler cooling water shall be used on shell side. Tube shall be made of SS304. Shell shall be of carbon steel. Tubes used for cooling bearing housing shall be of SS 304.

Forced oil lubrication when used shall have all supply lines in stainless steel and return lines in carbon steel.

The technical and design features of each is elaborated in a separate section.

6.0.0 SUCTION STRAINER

Strainer shall be provided on suction line of each pump. Generally Basket type strainer is preferred. The clear area of strainer shall be five times the inlet cross sectional area of the connecting piping. Strainers shall be constructed of 16 gauge perforated stainless steel plates (304 grade) and shall be lined with stainless steel (316 grade) screen.

The design pressure for strainers shall corresponding to maximum system pressure envisaged during the worst operating condition

The pressure drop across the strainers at rated flow under 100% cleaned condition and 50% clogged condition shall not exceed 0.1 kg/cm² (max.) and 0.15 kg/cm² (max.) respectively.

The strainer shall be so designed that they all capable of sustaining the differential pressure at rated design flow and 50% clogged condition.

Strainer body and cover shall be of ASTM A216 Gr.WCB or equivalent. The area of the strainer shall be atleast five (5) times the inlet cross sectional area of the connected piping. The MOC of mesh shall be SS:316 / SS:304.



7.0.0 WELDING

All welding / cutting / rework on IBR piping shall be strictly done as per IBR code.

All welding process shall be of standard and internationally agreed type and designation free from all unproven innovative or development features

All costs for inspection and testing including any additional tests required by the Engineer shall be deemed to be included in the Contract Price. Any additional inspection and testing required by the Engineer shall be performed promptly and no claims for consequent delay or disruption of the work will be considered.

The procedure to be followed in production welding of all parts of the vessel including main seam, circumferential seams, and branches shall be provided in detail by the Contractor for the Engineer's approval.

Welding, post weld heat treatment and other non-destructive testing shall be conducted by Contractor as required by the ASME and as instructed by the Owner. Procedures of all welding, welder qualification and treatment of welding defects, pre/post welding heat treatment, NDT shall be performed after welding as per ASME and Testing requirement shall be approved by the Owner. The Contractor shall arrange suitable stress relieving equipment with automatic recording device.

All necessary radiography as per applicable code shall be included in the scope of work of the Contractor.

Approval of the welding procedure etc., shall not relieve the Contractor of his responsibility for correct welding, electrodes and for minimising distortion in the finished structure.

All welders and welding operators shall be qualified for the work and shall hold current welder's qualification certificates in accordance with the latest editions of ASME Sec. IX and IBR.

For welding on site, the Contractor shall provide drying ovens in sufficient number to permit the correct storage of electrodes for 48 hours before use. Drying ovens shall preferably be heated by electric means and shall have automatic heat controls and visual temperature indication. The storage temperature for electrodes shall be as stated by the manufacturer but in the case of low hydrogen electrodes shall not be less than 100 °C. The re-baking of low hydrogen electrodes shall be strictly in accordance with the manufacturer's recommendations.

Welds of stainless or special steel with steel which is not stainless must be made in a manner which ensures that the stainless steel or special steels do not lose their corrosion-resistant or other special properties.

Welded seams shall not be painted before inspection; in case of necessity, only colorless coating may be used.

All controls, examinations and tests corresponding to these specifications, shall be performed by the supplier, without detriment to the Owner's inspection right to verify and control them on their part or to repeat them if they deem it is necessary.

The supplier shall keep 'welding records' for all pressure pipes with a qualified welding method, as well as for condensers, deaerators, water pipes, pressure vessels and other important weldings. He shall record on them, after every working day, the number of weldings executed during the day, their location, identification of welders, measured preheating temperature (if any) and other information of interest.



The Inspector shall be notified at regular site meetings at least 2 days prior to the commencement of any assembly or fabrication work.

All control protocols, such as of the qualifications of welders and methods, of evaluation of X-rays, of magnaflux examinations, as well as the x-ray films, shall be submitted to the Owner's inspection for their approval.

Qualification of welders

The standard to be applied for the qualification of welders shall be approved by the Owner. Welders shall be qualified according to the section IX of the before mentioned ASME standard. The inspector of the Owner has the right to attend during the qualification tests. Tests with unsatisfactory results made by a welder under qualification may be repeated by him doubling the number of tests. For the welders acceptance each of the repetition tests has to be satisfactory. The supplier shall keep a 'registry of welders' on which he shall record systematically: qualifications, part of the supply on which they intervene, major faults and comments.

Qualification of methods

The variables to be considered in defining the weldings subjected to special qualification of method shall be agreed upon with the Owner. Stipulations in Q-11, section IX, of the mentioned ASME standard, shall govern for this purposes.

Control of executed weldings

Unless otherwise agreed or unless other contractual stipulations exist, the section VIII, point UW 51 of the ASME standards, shall apply for 100 % x-ray controls, and the point UW 52 for x-ray sampling examinations, excepting from the last the indications about porosity which shall be agreed upon separately.

The Contractor shall have at the works site all necessary equipments and facilities to perform control, like portable x-ray equipments, radioactive isotope equipments, x-ray laboratory, magnaflux equipment, dye check penetrants and developers, fluorescent power and ultraviolet lamp to verify the watertightness of expanded tubes. The Contractor's personnel shall include a specialist and the auxiliary workers necessary to execute the controls.

8.0.0 LUBRICATION

Lubricated elements shall have a safety reserve against occasional lubricating deficiencies or their retaining capacity should be such as to operate without damage even if delays occur during maintenance periods. As far as possible, lubrication of the given element in the machine should be done with the same lubricant under all climatic conditions (winter and summer) and furthermore, a limited number of different types of lubricants should be required for the different parts of the equipment. Lubrication oil and grease of any brand shall be easily obtained on the local market in India.

Centralized lubrication systems should be provided that includes purification of the main lubricant considering centrifugal or static filter type.

Lubricant deposits such as those on bearings, accumulation tanks, etc., should be easily accessible, simple to clean and to control their level and it should be possible to empty their contents.

The required lubricant characteristics shall be stated, also indicating the trade name for the products.



9.0.0 VESSELS, TANKS AND HEAT EXCHANGER

All pressure vessels shall be designed in accordance with ASME Boiler and Pressure Vessel, Section VIII Unfired Pressure Vessels. All butt welds shall be subject to 100% radiography test and all other welds shall be subject to 100% non destructive testing. Other standards the Contractor intend to use are to prior approval of the Owner. All flanged connections to pressure vessels shall conform to at least pressure class 150. Threaded connections shall conform to pressure class 3000.

All connections shall match for pipe instrumentation, drains and relief valves. All bolt holes must straddle the centre line of nozzles. Access stairways and handrails necessary for safe operation and easy maintenance shall be provided. Corrosion allowance shall be considered.

If any degree of vacuum may occur the pressure vessel or tank shall be designed for full vacuum even if vacuum breakers are installed.

The items listed below shall be provided as a minimum.

- 1 manhole (minimum nominal bore 600 mm) for vessels of 1.0 meter diameter and above
- 2 handholes (minimum size 200 mm) for vessels below 1.0 meter diameter
- 2 spare nozzles
- 1 drain nozzle

Manhole covers shall be provided with davit.

The saddle and reinforcing plates welded to the vessel shall be of the same material as the vessel shell or head. Insulated vertical vessels and tanks shall be furnished with insulation supports or clips.

Tanks

Unless otherwise specified, tanks used for the storage, lubricating oil, raw water, make-up water, condensate, chemicals, etc. and tanks used for mixing and agitation shall be of welded construction, manufactured from mild steel plates of accepted quality and thickness in accordance with the approved relevant standards.

All welds shall be continuous, including welds around internal stays, stiffeners and supports (see also Article "Welding" of this Section V).

All large tanks shall have at least two manholes each of 600 mm inner diameter complete with covers of the bolted type, fitted with a davit for easy handling.

All tank nozzles shall be provided with flanges, if not otherwise specified.

Nozzles shall be provided where necessary for the fitting of instruments, level controllers and piping.

Internal and external protection painting of the tanks shall be performed according to the requirements of this Contract.

Arrangements shall be made for the blanking-off or removal of all valves or pipe connections during sand-blasting and painting to prevent the ingress of sand or other matter. The protective process shall be applied also to any ferrous or non-ferrous parts mounted inside the tanks.



Heat exchanger

Heat exchangers are to be designed, manufactured and erected in accordance with the applicable standards.

Only proven products shall be delivered. No cast iron components are permitted.

It must be possible to install and remove the heat exchangers without undue difficulty. Lifting lugs and eyes and other special tackle shall be provided to permit easy handling.

Tubular heat exchangers or plate and frame type heat exchangers are acceptable. Where necessary the tubes are to be protected by impact shields. An adequate number of visual inspection ports is to be provided in critical areas to facilitate condition monitoring.

Unless otherwise specified, all heat exchanger tubes and casings must be designed to withstand 1.2 times the zero flow pressure of the relevant pump at cold conditions, or 1.2 times of the maximum positive operating pressure, as applicable. The minimum design pressure is 6 bar, and the design shall be proof against full vacuum. The test pressure must be 1.5 times the design pressure.

The heat exchangers shall be designed for the maximum temperature incurred plus 20 K.

Heat exchangers must be capable of continuous unrestricted operation with up to 10% of plugged tubes, and a corresponding factor of conservatism of at least this amount must be used in the design of the heat transfer areas.

Considerable importance will be attached to the ease of cleaning the heat exchangers.

Where any heat exchanger part in contact with liquid can be isolated, and there is a possibility of being heated from the other side, safety valves are to be provided for pressure relief.

Pipes from drains, vents and safety valves are to be grouped together, and routed to easily observable points equipped with covered funnels or to the flash tanks.

The overall design and conception of the heat exchangers and accessories is to be such that they are suitable for the degree of automation envisaged for the individual system.

**VOLUME II****SUB-SECTION 2.25****CLEANING, PROTECTIVE COATING AND PAINTING****1.0.0 GENERAL**

This specification covers the general requirements related to the cleaning protective coating and painting of equipment, components and systems that are covered under main equipment / system specifications for 2x660 MW Supercritical Thermal Power Plant. The components and/or equipment shall be mechanically and /or chemically cleaned during the following stages of the Contract.

- Cleaning in workshop
- Cleaning before painting and/or corrosion protection (application of prime coat)
- Cleaning before erection and during installation.

Cleaning of fabricated component items shall be carried out after fabrication and final heat treatment or welding at manufacturer's works or at site, as appropriate. No paint shall be applied surfaces within 75 mm of field welded connections. These surfaces shall be coated with a consumable preservative and marked.

For cleaning in workshop and before painting, mechanical cleaning by power tool and scrapping with steel wire brushes shall be adopted to clear the surfaces. However, in certain locations where power tool cleaning cannot be carried out, hand scrapping may be permitted with steel wire brushes and/or abrasive paper. Cleaning with solvents shall be resorted to only in such areas where other methods specified above have not achieved the desired results. Cleaning with solvents shall be adopted only after written approval of the Owner / Engineer.

Machined surfaces shall be protected during the cleaning operations.

In the event of the surfaces not being cleaned to the Owner's satisfaction, such parts of the cleaning procedures or agreed alternatives as are deemed necessary to overcome the deficiencies shall be carried out at the supplier's sole expense.

For reclining small areas, hand cleaning by wire brushing may be permitted.

2.0.0 CODES AND STANDARDS

Painting of equipment shall be carried out as per the Codes indicated below and shall conform to the relevant IS Code for the material and workmanship.

The following codes and standards shall be followed for the surface preparation, surface protection and painting works.

IS: 5	Colors for ready mixed paints and enamels.
IS: 101	Methods of test for ready mixed paints and enamels.
IS: 104	Ready mixed paint, brushing, Zinc Chrome, priming.
IS: 158	Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water and heat resisting.
IS: 161	Heat resistant paints
IS: 1303	Glossary of terms relating to paints.
IS: 1477	Code of practice for painting of ferrous metals in buildings (Parts I & II).
IS: 2074	Specifications for ready mixed paint, Air drying, red oxide zinc chrome priming.
IS: 2338	Code of practice for finishing of wood and wood based materials: Parts 2 schedules.



IS: 2339	Aluminum paint for general purposes, in dual container.
IS: 2395	Code of practice for painting of concrete, masonry and plaster surfaces: Part 2 schedules.
IS: 2524	Code of practice for painting of non-ferrous metals in buildings (Parts I & II).
IS: 2932	Specification for enamel, synthetic, exterior (a) undercoating, (b) Finishing
IS: 3140	Code of practice for painting asbestos cement building products.
IS: 6158	Recommended practice for design safeguarding against Embrittlement of hot dip Galvanized Iron & steel products.
IS: 6159	Recommended practice for design & fabrication of Iron & steel products prior to Galvanizing & metal spraying.
IS: 6278	Code of practice for white washing and Color - Washing.
IS: 10221	Code of practice for coating & wrapping of underground mild steel pipelines.
IS: 33	Inorganic pigments and extenders for paints –Methods of sampling & test.
IS: 13183	Aluminum paint, Heat resistant - specifications.
IS: 144	Specification for ready mixed paint brushing, petrol resisting, Air drying for Interior paints of tanks and containers, Red oxide.
IS: 9954	Pictorial surface preparation standards for painting of steel surfaces.
IS: 11883	Specification for Ready Mixed Paint, Air Drying, Red Oxide Priming for metals.
IS: 9404	Color code for identification of pipelines used in the Thermal Power Plants.
IS: 12744	Specification for Ready Mixed Paint, Air Drying, Red Oxide-Zinc Phosphate Priming.
BS: 2015	Glossary of paint selected terms.
BS: 5252	Final coat color.
BS: 7079A1/S1	Specification for rust grades and preparation grades of uncoated substrates after overall removal of previous coating.
BS: 7079A2	Preparations grades of previously coated steel substrates.
BS: 7079GrC	Surface roughness characteristics of blast cleaned steel substrates.
BS: 7079GrD	Methods for surface preparation.
BS-4232	Surface Finish of Blast cleaned steel for painting.
ASTM	American Standard for Testing Material.
ASTM A 780	Standard practice for repair of damaged galvanized coatings.
AWWA	American Water Works Association.
ASA-A-13.1-1981	Scheme for identification of piping system (American National Standard Institution).
DIN	Deutshes Institute for Normung
SIS-055900-1967	Surface preparation standards for painting steel surfaces. (Swedish standard Institution)
SSPC-SP	Preparation Specifications (Steel structures painting council, U.S.A.).
	National Association of Corrosion Engineers, U.S.A. (NACE).



3.0.0 SCOPE OF WORK AND GENERAL REQUIREMENTS

This specification covers the surface preparation, method of application and material to be used for all coating of equipment, steel structures and piping. Steel material subjected to surface preparation on shop/site shall have minimum requirements in accordance with Rust Grade B (SSPC/SSPM Volume-2).

Coating materials according to SSPC, EN ISO, ASTM, BIS or DIN standards, shall be used. The paint shall comply with applicable laws, regulations, ordinances etc., of the local authority, state or the nation pertains to the work. The materials shall be matched with each other so that they are compatible. Coatings deviating this specification shall be subject to approval.

Standards of surface preparation and painting shall give a time to first maintenance of minimum 10 years.

The paint to be applied shall be approved by Owner.

All paints & paint material used shall be procured from approved manufacturers. Paint shall be supplied in manufacturers original containers with the description of content, specification No., colour, ref no, date of manufacture, shelf life expiry date & pot life.

The paint manufacturers shall provide coating system data sheet for each coating system to be used containing the following information

- a. Surface preparations
- b. Film thickness (min and max)
- c. Min and max recoating intervals at relevant temperatures
- d. Mixing ratio, thinner details and coating repair systems

The sample for testing the paint being used may be taken by the Owner at any time.

In general Shop fabricated equipment will be delivered to the site coated with a shop applied system or the manufacturer's standard finish in accordance with the requirements of this specification.

For equipment that has received shop prime coat, all touch-up prime coat and additional coats shall be applied in accordance with the coating schedule. It is responsibility of the vendor to ensure compatibility between shop and field applied paint systems.

Necessary precautions shall be provided to all equipment, structures to protect other surfaces from abrasive blasting, coating over spray and spatter. Damage to other surfaces or equipment shall be repaired by the vendor.

The Contractor shall submit the following for review and approval by the Owner:

- a. Manufacturer's recommended paint scheme for the project
- b. Latest published product & instructions for application data,
- c. Procedures for surface preparation and application.
- d. Pre qualification for equipments and blasting materials, product, procedure and personnel qualifications for the paint and painting systems.
- e. Painting repair procedures

Painting records shall contain:

- Equipment/components/location painted
- Date of painting
- Paint details such as specification No, colour, date of manufacture, shelf life, expiry date
- Application equipments



- Ambient conditions at the time of painting
- Surface temperature
- Drying time between coating, DFT and number of coatings
- Appropriate work plan for painting.

The supply of all necessary equipments, weather protection, and scaffolding for painting to ensure work is carried out in accordance with the specification and agreed programme.

Maintenance of the paint work until completion of the contract, this shall include repair of any damaged areas caused by third party.

Disposal of painting waste resulting from painting, shall comply with applicable laws, regulations, ordinances etc., of the local authority, state or the nation pertains to the work and coating materials.

It is a mandatory requirement that all operatives working to this procedure take full cognizance and implement necessary safety precautions.

4.0.0 CLEANING AT MANUFACTURER'S WORKS

Mechanical cleaning shall preferably be carried out by abrasive blasting. The Owner is prepared to consider alternative methods such as chemical cleaning provided they achieve the necessary surface condition.

In case of chemical cleaning, the detailed procedure for chemical cleaning as well as the system for which chemical cleaning is required shall be submitted by the contractor for Owner's approval. The procedure shall comprise of pre-treatment and acid treatment to achieve cleanliness equivalent to that specified for mechanical cleaning.

Surface condition:

The Metal surfaces shall be clean and free of mil scale, rust, dirt, grease and any other deleterious matter.

Where metal surfaces are to be painted the surface profiles shall conform to the painting specification requirements.

Where this does not apply, surfaces shall have a surface texture not coarser than Grade 80 abrasive paper.

Abrasives:

Abrasives containing silica, silicates or slag residues shall not be used for water/steam side surfaces of plant except for cleaning sand castings, where hydro blasting may be employed.

For austenitic materials only, abrasives containing 98% or more of alumina, Al_2O_3 , shall be used.

Removal of abrasive and debris:

After cleaning, abrasive and debris shall be thoroughly removed for components.

5.0.0 PROTECTION AT MANUFACTURER'S WORKS

As soon as all items have been cleaned and within four hours of the subsequent drying, they shall be given suitable anti-corrosion protection.



All water, air and steam side surfaces shall be protected by the application of approved water soluble corrosion inhibitors, or vapor phase inhibitors that can be subsequently removed by site water washing or steam blowing.

The gas side of steam generating plant items shall be protected by the application of temporary protective that do not require to be removed before commissioning, but which are removed during initial firing.

The rate of application of volatile corrosion inhibitors shall be at least 10 grams per square meter or 35 grams per cubic metre, whichever is the greater, except for pipes up to 300 mm diameter for which the minimum application rates shall be 5 grams per square metre.

Immediately after the protective treatment has been applied all vessels and pipes shall be suitably sealed off by discs or caps or approved alternatives to prevent ingress from the surroundings. Cylindrical plugs shall not be driven into the ends of pipes. These protective covers shall not be removed until immediately before final connection is made to the associated equipment.

6.0.0 WEATHER CONDITIONS

Painting shall be done only when the surface temperature is above 5°C. Surface temperature must be at least 3°C above dew point to ensure that condensation does not occur on the surface.

Reasonable protection against precipitation and seawater spray shall be exercised for the painting of outdoor parts.

Precautions shall also be taken against solar radiation to ensure that the specified dry film thickness of priming or finish coats is obtained.

Any prime coat exposed to excess humidity, rain, dust etc., before drying, shall be permitted to dry and the damaged area of primer shall be removed and the surface prepared and primed again.

Sheltered or unventilated horizontal surfaces on which dew may collect require more protection, and to achieve this additional top coat of paint shall be applied.

The temperature quoted as “normal” in the “Paint System Tables” refers to the average local climatic conditions.

7.0.0 SURFACE PREPARATION

In preparing any surface to be coated, all loose paint, dirt, grease, rust, scale, weld slag or spatter or any other extraneous material shall be removed and defects repaired, so as to obtain a clean, dry, even surface to receive the priming or finishing coat (s) as called for in the painting schedules. Sharp edges should be rounded, especially when tank linings have to be applied.

All machined surfaces, including flange faces, shall be suitably covered to prevent damage during surface preparation.

All surfaces should be blast cleaned whenever possible.

**Surface preparation methods:**

Bare steel surfaces should be prepared by one of the methods described below in order of preference and in accordance with Swedish Standard SIS 05 59 00 or Steel Structures Painting Council, SSPC, Vis 1, or DIN 55928, section 4.

The relative humidity level should not be more than 60% & the steel surface temperature at least 3° C above the dew point during dry blast cleaning operations.

a. White metal blast cleaning Sa 3 or SSPC - SP 5

Sa 3 Blast cleaning to bare metal. Mill scale, rust and foreign matter must be removed completely. Subsequently, the surface is cleaned with vacuum cleaner, clean dry compressed air or a clean brush. It must then have a uniform metallic color and correspond in appearance to the prints designated Sa 3.

b. Near white metal blast cleaning Sa 2 1/2 or SSPC - SP 10

Sa 2 1/2. very thorough blast cleaning. Mill scale, rust and foreign matter shall be removed to the extent that the only traces remaining are slight imperfections in the form of spots or stripes. Subsequently, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It must then correspond in appearance to the prints designated Sa 2 1/2.

Mechanical cleaning should only be used when procedures (a) and (b) are not practicable.

c. Near white metal blast cleaning P Sa 2 1/2 DIN 55928

Very thorough blast cleaning. Very adhesive coatings remain. From all other surface mill scale and rust are to be removed to such an extent that the only traces remaining are slight imperfections in the form of spots or stripes. Further treatments see Sub b).

The adhesivity of residual coatings in the transition zone has to be tested even after the application of the primer.

d. Very thorough mechanical scraping and wire brushing St 3

St 3 very thorough scraping and wire-brushing - machine brushing - grinding - etc. are to be preferred. Surface preparation as for St 2. But much more thoroughly. After the removal of dust, the surface must have a pronounced metallic sheen and correspond to the prints designated St. 3.

e. Thorough scraping and wire brushing St 2

St 2 Thorough scraping and wire-brushing - machine brushing - grinding - etc. The treatment shall remove loose mill scale, rust and foreign matter. Subsequently, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It should then have a faint metallic sheen. The appearance must correspond to the prints designated St 2.

f. Air Blasting with Non-Metallic Abrasives Powder

Whenever the "Duplex"-process is to be applied (hot dip galvanising followed by painting), prepare the hot dip galvanised surface by water washing to remove flux residues and careful air blasting with non-metallic abrasive powder. Use an abrasive with grain size from 0.1 to 0.5 mm, at a greatly reduced air pressure, max. 2 bar (g) (28 psig).

This procedure also applies to stainless steel and aluminium surfaces to be coated.



Surface preparation methods	SIS 055900	DIN 55928 Part-4	BS 4232 only for blasting	SSPC-Vis
Blasting acc to item (a),(b),(c),	Sa 3		First quality	White metal SP 5
Blasting acc to item (b)	Sa 2 1/2		Second quality	near White SP 10
Blasting acc to item (c)	Sa 2		Third quality	Commercial blast SP 6
Hand/or power tool derusting acc to item (e)	St 2		--	Hand tool cleaning SP 2
acc to items (d) and (e)	St 3		--	Power tool cleaning SP 3
Flame jet cleaning		F1	--	Flame cleaning SP 4
Pickling		Be	--	Pickling

Steel structures to be blast cleaned have to be free of pitting and other severely corroded places in accordance with B.S. 4232 and SIS 055900.

The abrasives used for blast-cleaning shall be graded flint, grit, shot or silica sand and shall be such that they will produce an average keying profile on the blast-cleaned surface of not more than 40 microns.

An air pressure of 7 bar g at the nozzle shall be used.

After blast-cleaning, all accumulated grit, dust, etc., must be removed leaving the surface clean, dry and free of mill scale, rust grease and other foreign matter.

In the event of rusting after completion of the surface preparation, the surface must be cleaned again in the manner specified.

Oil, grease, soil, cement, salts, acids or other corrosive chemicals shall be cleaned from steel surfaces, by the use of solvents, emulsions or cleaning compounds. The final wiping shall be with clean solvent and clean rags or brushes. There shall be no detrimental residue left on the surface.

Primed areas which suffer damage must be spot blasted on site to a degree of cleanliness Sa 2 1/2 before, touching up.

Protective coating must be applied as quickly as possible after the completion of surface preparation no matter what cleaning method has been used.

No blast-cleaned surface shall be allowed to remain uncoated overnight.

Steel work protected by shop primer after arrival on site must be cleaned of salt, sand, oil etc. Before the first coat of paint is applied on site. Shop primer damaged during transport must be rectified by blast-cleaning and coating before application of the site coats.

Wood surfaces shall be sanded clean. All nail holes shall be puttied and sanded before priming.

Concrete: If a protective coating is required, concrete shall be allowed to cure before painting.



8.0.0 PREPARATION OF COATING MATERIALS

All containers shall remain un-opened until required for use.

Primers and paints which have livered, gelled or otherwise deteriorated shall not be used.

The oldest primer or paint of each kind shall be used first.

All ingredients in any container shall be thoroughly mixed before use, and shall be agitated frequently during application to keep the primer in suspension.

Primer or paint mixed in the original container shall not be transferred until all settled pigment is incorporated into the body of liquid.

Mixing in open containers shall be done in a well ventilated area.

Primer or paint shall be mixed in a manner ensuring the breakdown of all lumps, complete dispersion of pigment and uniform composition.

Two-component primers shall be mixed in accordance with the manufacturer's instructions. Thinners shall not be added to primers or paints unless necessary for proper application according to the manufacturer's instructions. When use of thinners is permitted, it must be added to the primer or paint during mixing.

8.1.0 Primer Paint

After the surface is prepared, one coat of suitable primer shall be applied. After this first coat is dried up completely, second coat of primer shall be applied.

Primer shall be applied by brushing to ensure a continuous film without 'holidays'. The dry film thickness of each coat shall be as specified in the Annex- ANNEX 25.1.2 -Paint System of this specification.

The primer should be worked by brush application to cover the crevices, corners, sharp edges etc. in the presence of inspector.

The shades of successive coats should be slightly different in color in order to ensure application of individual coats, the thickness of each coat and complete coverage should be checked as per specification approved by Engineer before application of successive coats.

The contractor shall provide standard thickness measurement instrument with appropriate range(s) for measuring.

Elko meter for measuring the Dry film thickness of each coat, surface profile gauge for checking of surface profile in case of sand blasting. Holiday detectors and pinhole detectors for checking the painted surface discontinuities should be provided by the contractor.

The contractor shall make arrangements for paint manufacturer to provide expert technical service at site as and when required free of cost and without any obligation to the Owner, as it would be in the interest of the manufacturer to ensure that both surface preparation and application are carried out as per their recommendations.

Final inspection shall include measurement of paint dry film thickness, check of finish and workmanship.

8.2.0 Rub down and Touch Up of Primer

The shop coated surfaces shall be rubbed down thoroughly with emery paper to remove all dust, rust and other foreign matters, washed, degreased, then cleaned with warm fresh water and air dried.



The portions, from where the shop coat has peeled off, shall be touched up and allowed to dry before applying a coat of primer.

The compatibility between shop coat and field primer shall be ascertained from the paint manufacturer. In case degreasing with white spirit is not effective, the surface shall be finally wiped clean with aromatic solvent like xylol or light naphtha.

8.3.0 Non Compatible Shop Coat Primer

- a) The compatibility of finishing coat shall be confirmed from the paint manufacturer. In the event of use of primer such as zinc rich epoxy, inorganic zinc silicate etc., the paint system shall depend on condition of shop coat. If the shop coat is in satisfactory condition showing no major defect, the shop coat shall not be removed. The touch up primer and finishing coat(s) shall be identified for application by Engineer. Shop coated (coated with primer & finishing coat) equipment shall not be repainted unless paint is damaged.
- b) Shop primed equipment and surfaces shall only be 'spot cleaned' in damaged areas by means of power tool brush cleaning or hand tool cleaning and then spot primed before applying one coat of field primer unless otherwise specified. If shop primer is not compatible with field primer then shop coated primer shall be completely removed before application of selected paint system for particular environment. For package units/equipment, shop primer shall be as per the paint system given for particular environment.
- c) In case of existing paint, compatibility between finishing coat and new selected finish coat shall be ascertained before application of finish coat. In case, the coat is selected for upgrading existing alkyd coating to high performance coating then, surface preparation shall be by manual/mechanical means to remove loose rust, peeled off/damaged paint, but sound old coating need not be removed. It shall be touched with suitable primer wherever it has peeled off before application of tie coat. The tie coat shall be applied after 7 days of curing of the primer. If, new paint system is not suitable to upgrade existing coating then complete paint shall be removed by mechanical or blast cleaning before application of new coating system.

8.4.0 Finish Paint

Suitable Finish paints as per the schedule shall be applied for the jobs. The color/shade shall be as approved by the Owner. After cleaning the dust on the dried up primer, first coat of finished paint shall be applied. After this first coat dries up hard, the surface is wet scrubbed cutting down to a smooth finish and ensuring that at no place the first coat is completely removed. After applying second coat, allowing the water to get evaporated completely, third finish coat of finish paint may be applied(if applicable).

9.0.0 STEEL STRUCTURES PAINTING

Generally, all steel structures shall receive two primer coats and two finish coats of painting. First coat of primer shall be given in shop after fabrication before dispatch to erection site after surface preparation as described below. The second coat of primer shall be applied (if required) after erection and final alignment of the erected structures. Two finish coats shall also be applied after erection.

Steel surface which is to painted shall be cleaned off dust and grease and the heavier layers of rust shall be removed by chipping to grade ST-2 as per SIS05-5900 or as per IS: 1477 (part -I) prior to actual surface preparation. Suitable primer of required DFT shall be applied as specified in the Paint system of this document- Annex-25.1.1.

Suitable finish paint of required DFT shall be applied as specified in the Paint system of this document- Annex-25.1.1. The undercoat and finish coat shall be of different tint to distinguish



the same from finish paint. All paints shall be of approved brand and shade as per the Owner's requirement.

Joints to be site welded shall have no paint applied within 100 mm of welding zone. Similarly where Friction grip fasteners are to be used no painting shall be provided. On completion of the joint the surfaces shall receive the paint as specified.

Surfaces inaccessible after assembly shall receive two coats of primer prior to assembly. Surfaces inaccessible after erection including top surfaces of floor beams supporting gratings or chequered plate shall receive one additional coat of finish paint over and above number of coats specified before erection. Portion of steel member embedded / to be encased in concrete shall not be painted.

10.0.0 PAINT MATERIALS

The paints shall conform to the specifications given in this Annex and class - 1 quality in the products range of any of the following manufacturers:

- a. Asian Paints (India) Ltd.
- b. Bombay Paints
- c. Berger Paints India Ltd.,
- d. Good lass Nerolac Paints Ltd.,
- e. Garware Paints
- f. Jenson & Nicholson
- g. Shalimar Paints
- h. Equivalent other country manufacturer after prior approval of Owner.

11.0.0 STORAGE

All paints and painting material shall be stored only in rooms to Engineer's approval. All necessary precautions shall be taken to prevent fire. The storage building shall preferably be separated from adjacent buildings. A signboard bearing the words "PAINT STORAGE - NO NAKED LIGHT - HIGHLY INFLAMMABLE - DANGER - NO SMOKING" shall be clearly displayed outside. All paints shall be stored in the safest manner so that no container rolls down and causes accidents. The shelf life of the paints shall be ensured so that the paint materials are not in storage and use after the date of expiry.

12.0.0 APPLICATION

Health and safety of work

The supplier has to check all painting work to be carried out according to the specification of the paint supplier further to all relevant prescriptions and regulations concerning the health and safety of work.

The paint supplier has to present a written specification including at least the flash point of the paints, ventilation requirements, handling precautions such as inhalation, eye and skin protection, and first aid procedure, storage requirements, spill or leak procedure, fire precaution, waste disposal.

Methods

Quality of the surface to be painted or coated has to be tested acc. to DIN 55928 and DIN 8202.

Temporary corrosion protections are to be completely removed prior to applying the definite one, in acc. with DIN 55928.



All prime coatings shall be applied by brush or airless spray or a combination of these methods, as approved by the coating manufacturer.

All doors, windows, stairways, handrails (if painted), bolts, flanges and equipment supports shall be finish painted by brush.

Spray guns should not be used outside in windy weather or near surfaces of a contrasting colour unless the latter is properly protected.

All cold-spray painting shall be done using standard equipment in accordance with accepted standards and methods.

Care has to be taken not to connect spraying devices for nitro and backelite paints simultaneously to oil based paints.

Paint applied to items that are not being painted shall be removed at the supplier's expense, leaving the surface clean, unstained and undamaged.

Dry film thickness (DFT)

To the maximum extent practicable the coats shall be applied as a continuous film of uniform thickness and free of pores. Overspray, skips, runs, sags and drips should be avoided. The different coats shall not be of the same colour.

For a composite paint or coating system consisting of several coats, the total DFT must be at least equal to the sum of the minimal DFT's for the individual coats. If, the paint system does not have the required minimum DFT those areas should be marked & repainted. If the occurrence of those areas is high, the complete surface must be repainted. It is also critically important to check the DFT of primers and intermediate coats and to correct them where necessary.

For paintings based on Zinc silicate the DFT is limited as well on minimum DFT as on maximum (150µm) because of the risk of mud cracking.

Consumption of paints

Has to be evaluated according to DIN 53220. The paints shall be tested as per IS - 101.

Each coat of paint shall be allowed to harden before the next is applied. For epoxy paint the hardening time normally is 12-14 hours. Suppliers' recommendations regarding hardening time of epoxy paints must be followed.

Particular attention must be paid to full film thickness at edges.

The minimum total dry film thickness of the paint systems shall be as recommended in the **Annex 25.1.2**. The DFT is given in microns (millionths of a metre).

13.0.0 PROTECTIVE COATINGS AND PAINT SYSTEMS

The colour coding for identification of pipelines should comply with IS-2379 & IS -9404.

The type and number of protective coats for any item requiring painting are to be in accordance with DIN 55928 and are to be at least of a quality as shown in the attached Annex-25.1.1- Paint System.

Alternative to the Annex-25.1.1- Paint System specified, are to be presented on the schedule Departure from Specification, as indicated elsewhere.



Generally, all parts shall receive the specified prime coat (s) at the supplier's works to ensure that no corrosion occurs during transport to the site and storage at the site.

Parts which cannot be damaged during transport shall receive the full number of coats.

Types of Substrate, Base metal:

- Ferrous (Surface Temperature during operation < 120° C, EN ISO 12944:1998)

To this group belongs carbon steel, low alloyed steel & high alloyed steel. All paint systems are inevitable for corrosion protection.

- Hot dip galvanized surfaces.

Hot dip galvanized surfaces do require painting in a wet, industrial, chemicals and/or marine environment

- SS (EN ISO 12944:1998 conditionally applicable)

In general, SS surfaces do not require painting unless in a chemical and/or marine environment. In case of chemical and/or marine environments determination of whether or not the surface requires painting depends on the chemical content of the base metal.

The following formula applies:

$$W = Cr + 3.3 \times Mo + 22.45 N_2$$

If $W < 23$, then the surface has to be painted.

If $W < 28$ & $W > 23$, then the surface to be painted if splash contact with the media (i.e. sea) is possible. This may also occur if there is a strong wind carrying drops to the surface.

If $W > 28$, then the surface need not be painted.

- Aluminium

By default such surfaces/components will not be painted. Exceptions are architectural/aesthetic reasons and high corrosive conditions, which shall be evaluated separately depending on aluminum alloys.

14.0.0 GALVANIZING

Galvanizing works shall conform in all respect to B.S. 729, B.S. 3083 and B.S.C.P. 2008 and to DIN 50976 whatever requires the higher quality and shall be performed by the hot dip process, unless otherwise specified.

It is essential that details of steel members and assemblies which are to be hot-dip galvanized should be designed in accordance with B.S 4479.

Vent-holes and drain-holes should be provided to avoid high internal pressures and air-locks during immersion, which may cause explosions, and to ensure that molten zinc is not retained in pockets during withdrawal.

Careful cleaning of welds is necessary before welded assemblies are dipped. The welds and the surrounding metal should be cleaned separately, preferably be blast-cleaning, because the usual preliminary pickling cannot be relied on to remove the welding slag.

All defects of the steel surface including cracks, surface laminations, laps and folds shall be removed in accordance with B.S. 4360. All drilling, cutting, welding, forming and final



fabrication of unit members and assemblies shall be completed, where feasible, before the structures are galvanized. The surface of the steelwork to be galvanized shall be free from paint, oil, grease and similar contaminants in accordance with DIN 55928, part 4 and DIN 50976. The weight of zinc coating per unit area has to be noted in the manufacturing documents in accordance with DIN 50976.

The minimum average coating weight shall be as specified in Table 1 of B.S. 729 or Table 2, DIN 50976, whatever requires higher quality.

Structural steel items shall be initially grit-blasted to B.S. 4232, second quality, (Sa 21/2) or by pickling in a bath and the minimum average coating weight on steel sections 5 mm thick and over shall be 610 g/m^2 (DFT = 85μ).

On removal from the galvanizing bath, the resultant coating shall be smooth, continuous, free from gross surface imperfections such as bare spots, lumps, blisters and inclusions of flux, ash or dross.

Galvanized contact surfaces to be joined by high-tensile friction-grip bolts shall be roughened before assembly so that the required slip factor (defined in B.S. 3294, part 1 and B.S. 4604, part 1) is achieved. Care shall be taken to ensure that the roughening is confined to the area of the mating faces.

Bolts, nuts and washers, including general grade high-tensile friction grip bolts (referred to in B.S. 3139, and B.S.4395 part 1) shall be hot dip galvanized and subsequently centrifuged (according to B.S. 729). Nuts shall be tapped up to 0.4 mm oversize after galvanizing and the threads oiled to permit the nuts to be finger-turned on the bolt for the full depth of the nut. No lubricant, applied to the projecting threads of galvanized high-tensile friction-grip bolt after the bolt has been inserted through the steelwork, must be allowed to come into contact with the mating faces of the steelwork,. A local remelting of the galvanized parts to achieve the nuts to be finger turned on the bolt is possible in accordance with DIN 50976.

Protected slings must be used for offloading and erection. Galvanized work which is to be stored at the works or on site shall be stacked so as to provide adequate ventilation to all surfaces to avoid wet storage staining (white rust).

Small areas of the galvanized coating damaged in any way shall be restored in accordance with DIN 55928, part A and DIN 50976 by:

- Cleaning the area of any weld slag rust and other impurities and by thorough wire brushing to give a metallic clean surface.
- Application of suitable number of coats of zinc-rich paint containing more than 90 % w/w of zinc in dried film. The dry film thickness shall exceed at least 50 % the thickness of the desired galvanization. In case of application of a low melting point zinc alloy repair rod, the rods shall be in accordance with DIN1707, the thickness of the alloy shall be at least as of the desired galvanization.

The restored area is not to exceed 1 % of the galvanized surface.

Surface restoration of parts in contact with drinking water is not allowed and the quality of the galvanization is to be in accordance with DIN 2444.

After fixing, bolt heads, washers and nuts shall receive two coats of zinc-rich paint. Connections between galvanized surfaces and copper, copper alloy or aluminum surfaces shall be protected by suitable preferably hydrophobe tape wrappings to the owner's approval.



15.0.0 SPRAYED METAL COATINGS

Corrosion protection may be also achieved by spraying of suitable metals as zinc and/or aluminum on the surfaces of structures. For special cases tin, copper, lead can be used as well. Methods of surface preparation have to conform to B.S. 2569 or to DIN 8567. A proper treatment of the surface followed by an immediate spraying is to apply to ensure adhesion of the sprayed metal. The surface has to be clean, free of impurities, rust, mill scale and rough enough to have binding properties to ensure good enticulation with the sprayed layer. Suitable roughness can be achieved by blast cleaning acc. to BS 4232 or DIN 8567. Welds are to be cleaned and prepared with special care. All surfaces to be treated have to be dry and accessible.

Application of coatings, requirements for thickness, adhesion, composition of coating metals, and subsequent treatment have to conform to BS 2569, DIN 8565 and 8567.

Testing of the spray coated layers are to be carried out in accordance with DIN 8565.

The contractor has to specify the type, composition and thickness of the sprayed metal and of the sealing coating according to DIN 8565 including the corresponding warranties and tests if, sprayed metal coating will be applied.

Safety of work:

All precautions connected with this type of application of corrosion protection have to be in accordance with German regulation DVS 2307, page 1. 2.

Sprayed, unfused coating of metals and metallic compounds applied by combustion gas flame, plasma arc, detonation and similar processes, and the preparation of components, spraying techniques, sealing, finishing and inspection shall be according to B.S. 4761.

The hot galvanized surface has to be cleaned before the application of the coats to remove corrosion products, dirt, dust, grease.

The cleaning can be achieved by

- brush off
- washing with 1 - 1.5 % ammonia water with up to 0.1 % detergent added and followed by wet grinding to turn the foam to grey color,
- steam blasting.

16.0.0 WARNING NOTES / SIGNALS

This Instruction serves the identification of the coated surfaces that are received from shop in assembled condition / module wise.

The warning note shall prevent any possible damage to the coated surfaces during transportation / assembly at site.

Eg.: Welding work OR Heat treatment work on the outside of coated or lined surfaces is prohibited.

17.0.0 COLOUR CODE FOR PIPING

- a. The colour code scheme is intended for identification of the individual group of the pipeline. The system of colour coding consists of a ground colour and colour bands superimposed on it. The colour coding for the identification of pipelines shall comply with **Annex – 25.1.1** of this specification.



Ground Colour shall be applied throughout the entire length for un insulated pipes. For insulated pipes, on the metal cladding or on the pipes of material such as non-ferrous metals, austenitic stainless steel etc., ground colour coating of minimum 2m length or of adequate length not to be mistaken as colour band shall be applied at places requiring colour bands. Colour band(s) shall be applied at the following location.

- i. At battery limit points
 - ii. Intersection points & change of direction points in piping ways.
 - iii. Other points, such as midway of each piping way, near valves, junction joints of service appliances, walls, on either side of pipe culverts.
 - iv. For long stretch/yard piping at 50 M interval.
 - v. At start and terminating points.
- b. Flow direction shall be indicated by an arrow in the location stated above and as directed by Engineer. Colors of arrows shall be black or white and in contrast to the color on which they are superimposed. The size of the arrows shall confirm to IS:2379. Product names shall be marked at pump inlet, outlet and battery limit in a suitable size as approved by Engineer. As a rule minimum width of color band shall conform to 75 mm up to 300 NB and to 100 mm over 350 NB. Whenever it is required by the Engineer to indicate that a pipeline carries a hazardous material, a hazard marking of diagonal stripes of red and golden yellow as per IS:2379 shall be painted on the ground color.
- c. All uninsulated piping systems, hangers and supports shall have two coats of suitable primer coats and with suitable finish paints as per Annex 25.1.2 Painting system. Shades shall be as per IS 5 or as indicated by Owner /Engineer. Service of the pipe/line designations shall be painted on all pipes at visible locations.

18.0.0 IDENTIFICATION OF VESSELS, PIPING ETC.

Equipment number shall be stenciled in black or white on each vessel, column, equipment and machinery after painting.

Line number in black or white shall be stenciled on all the pipelines of more than one location as directed by Engineer; size of letters printed shall be 150 mm (high) for column & vessels. 50 mm (high) for pump compressor and other machinery and shall be as per IS: 9404 for piping. The storage tanks shall be marked as detailed in the respective drawing.

19.0.0 INSPECTION AND TESTING

- a) All painting materials including primers and thinners brought to site for application shall be procured directly from manufacturer as per specifications and shall be accompanied by manufacturer's test certificates. Paint formulations without certificates are not acceptable. Engineer at his discretion, may call for tests for paint formulations. Contractor shall arrange to have such tests performed including batch wise test of wet paints for physical & chemical analysis. All costs thereof shall be borne by the contractor. The paints shall be tested as per IS: 101 / equivalent international standard and approved by the Owner.
- b) The painting work shall be subject to inspection by Engineer at all times. In particular, following stage wise inspection shall be performed and contractor shall offer the work for inspection and approval of every stage before proceeding with the next stage. The record of inspection shall be maintained in the registers. Stages of inspection shall be surface preparation, primer application and each coat of paint. In addition to above, record shall include type of shop primer already applied on equipment e.g. red oxide zinc chromate or zinc phosphate or Silicate primer etc.



- c) Any defect noticed during the various stages of inspection shall be rectified by the contractor to the entire satisfaction of Engineer before proceeding further. Irrespective of the inspection, repair and approval at intermediate stages of work, contractor shall be responsible for making good of any defects found during final inspection/guarantee period/defect liability period as defined in general condition of contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat and extra coat of paint shall be applied to make-up the DFT specified without any extra coat to the Owner.

20.0.0 GUARANTEE

The contractor shall guarantee that the chemical and physical properties of paint materials used are in accordance with the specifications contained herein/to be provided during execution of work. The contractor shall produce test reports from the manufacturer regarding the quality of the particular batch of paint supplied. The Engineer shall have the right to test wet samples of paint at random for quality of the same. Batch test reports of the manufacturer's for each batch of paints supplied shall be made available by the contractor.



ANNEX-25.1.1

STANDARD FINAL COLOUR OF EQUIPMENT AND PIPING

1.0.0 STANDARD COLOUR CODE FOR MECHANICAL EQUIPMENT

Sl. No.	Description	Ground Colour
A	CLOSED COOLING WATER SYSTEM	
1	Closed cooling water pumps	Sea Green
2	Plate heat exchanger	Sea Green
3	Closed Cycle cooling Water (CCCW) pumps	Sea Green
4	CCCW Expansion tank	Sea Green
5	CCCW chemical dosing tank	Sea Green
B	WATER TREATMENT PLANT	
1	Raw water	
a	Raw water pump	Sea Green
b	Clarifier	Sea Green
c	- Raw / Fire water storage tank	Sea Green
d	DM plant supply pump	Sea Green
e	Filter air blower	Sea Green
f	Filter back wash pump	Sea Green
g	Lime slaking tank & agitator	Sea Green
h	Lime slurry transfer pump	Sea Green
i	Lime solution tank	Sea Green
j	Lime solution dosing pump	Sea Green
k	Alum solution tank	Sea Green
l	Alum solution metering pump	Sea Green
m	Polyelectrolyte solution tank	Sea Green
n	Polyelectrolyte solution metering pump	Sea Green
o	Sludge feed pump	Sea Green
p	Filter press	Sea Green
q	Service water tank for DM building	Sea Green
r	Service water tank for control annex	Sea Green
2	Demineralization system	
a	Activated carbon filter	Sea Green
b	Cation exchanger	Sea Green
c	Anion exchanger	Sea Green
d	Degasser tower	Sea Green
e	Air blower for degasser tower	Sea Green
f	Strong base anion exchanger	Sea Green
g	Degassed water transfer pump	Sea Green
h	Strong base anion exchanger	Sea Green
i	Mixed bed polisher	Sea Green
j	Air blower for mixed bed polisher	Sea Green
k	DM Water Storage tank	Sea Green
l	DM water transfer pump	Sea Green
m	Acid unloading cum transfer pump	Dark Admiralty Grey
n	Bulk acid storage tank	Dark Admiralty Grey
o	Acid measuring tank for SAC	Dark Admiralty Grey
p	Acid measuring tank for MB	Dark Admiralty Grey
q	Regeneration water pump	Dark Admiralty Grey
r	Caustic Lye unloading cum transfer pump	Dark Violet
s	Bulk caustic storage tank	Dark Violet
t	Caustic regeneration tank & agitator	Dark Violet



Sl. No.	Description	Ground Colour
u	Caustic solution filter	Dark Violet
v	Caustic dilution tank for SBA/WBA	Dark Violet
w	Caustic dilution tank for MB	Dark Violet
x	Caustic pump for regeneration for WBA/SBA	Dark Violet
y	Waste water recirculation cum disposal pump	Sea Green
C	CRANE & HOIST	
1	Power house EOT crane	Canary Yellow
2	CW pump house EOT crane	Canary Yellow
D	COMPRESSED AIR PLANT	
1	Air compressor	Sky Blue
2	Compressed air dryer	Sky Blue
3	Air receiver	Sky Blue
E	Chemical Dosing	
1	Hydrazine preparation tank	Dark Admiralty Grey
2	Ammonia preparation tank	Dark Admiralty Grey
3	Hydrazine & ammonia dosing tank	Dark Admiralty Grey
4	Hydrazine & ammonia dosing pump	Dark Admiralty Grey
5	Phosphate preparation tank	Dark Admiralty Grey
6	Phosphate dosing tank	Dark Admiralty Grey
7	Phosphate dosing pump	Dark Admiralty Grey
8	Sampling system	Dark Admiralty Grey
F	FIRE PROTECTION SYSTEM	
1	Diesel engine driven pump	Fire Red
2	Fuel tank for diesel engine driven pump	Fire Red
3	Main hydrant pump (Electrical)	Fire Red
4	Jockey pump	Fire Red
5	Fire Water Storage tank	Fire Red
6	CO2 cylinder	Fire Red
G	FUEL OIL SYSTEM	
1	Fuel oil pumps skid	Light Brown
2	Fuel oil Storage tank	Light Brown
3	Fuel oil strainer	Light Brown
H	ASH DISPOSAL SYSTEM	
1	Ash transmitting vessel	Aluminium
I	AIR CONDITIONING AND VENTILATION SYSTEM	
1	Refrigerant compressor	Sky Blue
2	Chilled / condenser pumps	Sea Green
3	Condenser water pipe	Sea Green
4	Fans	Grey

Notes:

1. This color code basically refers to IS:2379 for piping with necessary modifications
2. For any item left out, color coding will be decided after Owner's approval.

**2.0.0 STANDARD COLOUR CODE FOR ELECTRICAL EQUIPMENT**

	Description	Colour	Colour No.
1	Generator	Two undercoats of high quality epoxy based primer followed by two coats of epoxy painting	
2	Generator circuit breaker	-	RAL 7032
	a) Outdoor		
	b) Indoor	Glossy white	-
3	Transformers	Pebble grey	RAL 7032
4	Bus ducts	Pebble grey	RAL 7032
5	Junction boxes.	Pebble grey	RAL 7032
6	HT/LT Switchboards, Distribution boards, Control & Relay panels		
	a) Indoor	Pebble grey	RAL 7032
	b) Outdoor	Pebble grey	RAL 7032
7	UPS Panel, charger panels	Pebble grey	RAL 7032
8	DG Alternator	Onan Green	-
9	NGR	Pebble grey	RAL 7032
10	Motor	Pebble grey	RAL 7032
11	Lighting fittings	As per manufacturer's standard	As per manufacturer's standard
12	Cable trays	Galvanized	
13	Elevator	Red oxide primer paint	

1. For interior coating, manufacturer's standard can be adopted subject to Owner's approval.
2. All panels that are to be erected at CCR floor shall be painted using RAL 7032 (exterior colour). All Electrical, C&I, Fire alarm or any other panel shall have this colour.



3.0.0 COLOUR CODING FOR IDENTIFICATION OF PIPELINES USED IN THERMAL POWER PLANTS

Sl.No	Medium	Ground Shade		Band Shade		Remarks
		Color	Color No. as per IS:5	Color	Color No. as per IS:5	
1	Water system					
a)	Untreated or raw / service	Sea green	217	White	-	White is not included in IS - 5-2007
b)	Treated/dematerialized	Sea green	217	Light orange	557	
c)	Condensate	Sea green	217	Light brown	410	
d)	Potable water	Sea green	217	French blue	166	
e)	RO water	Sea green	217	Light orange	557	
f)	Service & clarified water	Sea green	217	French blue	166	
2	Steam system					
a)	Auxiliary steam	Aluminum	-	Signal red	537	with aluminum
3	Air system					
a)	Instrument	Sky Blue	101	White	-	White not included in IS- 5 - 2007
b)	Service/Plant	Sky Blue	101	White	-	
c)	Vacuum pipes	Sky Blue	101	Black	-	
4	Gas system					
a)	Hydrogen	Canary yellow	309	Signal red	537	White is not included in
b)	Chlorine	Canary yellow	309	Dark violet	796	
c)	Carbon dioxide	Canary yellow	309	Light grey	631	
d)	Oxygen	Canary yellow	309	White	218	
5	Oils					



Sl.No	Medium	Ground Shade		Band Shade		Remarks
		Color	Color No. as per IS:5	Color	Color No. as per IS:5	
a)	LDO/HFO	Light brown	410	Brilliant green	221	
b)	Transformer oil	Light brown	410	Light orange	557	
6	Chemical feed					
a)	Acid piping (in water treatment plant)	Dark admiralty grey	632	Signal red	537	Hazard mark is given
b)	Alkali Piping (in water treatment plant)	Dark violet	796	Golden yellow	356	Hazard mark is given
7	Fire services	Fire red	536	-	-	-
8	Effluent pipes	Black	-	-	-	-

4.0.0 COLOUR CODE FOR STRUCTURAL STEEL

SL. NO	ITEM/SERVICE	COLOR	COLOR No. as per IS:5
1	Gantry girder & monorail	Brilliant green	221
2	Gantry girder & monorail stopper	Signal red	537
3	Building structural steel columns brackets, beams bracings, roof truss, purloin, side grit, louvers, stringers	Dark admiralty grey	632
4	Pipe rack structure & trestle	Dark admiralty grey	632
5	Chequered plate (Plain Face)	Black	-
6	Grating	Black	-
7	Ladder	Dark admiralty grey	632
8	Hand railing Hand rail	Signal red	537
9	Middle rail	Signal red	537
10	Toe Plate	Signal red	537
11	Vertical post	Black	-
12	Structural steel for Silo	Smoke grey	692



Notes

1. Covering capacity and DFT depends on method of application. Covering capacity specified above is theoretical. Allowing the losses during application, min specified DFT shall be maintained.
2. All primers and finish coats shall be cold cured and air dried unless otherwise specified.
3. All paints shall conform to relevant Indian Standard and shall be applied in accordance with manufacturer's instructions for surface preparation, intervals, curing and application. The surface preparation, quality and workmanship shall be ensured.
4. Technical data sheets for all paints shall be supplied at the time of submission of quotations.
5. In case of use of epoxy tie coat, manufacturer shall demonstrate satisfactory test for inter coat adhesion. In case of limited availability of epoxy tie coat, alternate system may be used taking into consideration the service requirement of the system.
6. Contractor will submit the final colour shade for all equipments & piping under his scope for final approval by client / consultant.



ANNEX 25.1.2 PAINTING SYSTEMS						
Cleaning, Protective Coating and Painting - Systems designed as per ISO 12944 with service life of 10 yrs.						
Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
Structural Steel work, piping (Oil + Water), tanks outside surface, transmission towers cranes, steel floors, galleries, stairways, Outdoor.	< 130 Deg	SA 2 1/2	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1	75
			Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)
			Mid coat	1	2 pack High build High Solid Lamellar MIO based Epoxy Mid coat.	200
			Finish	1	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of at least 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	350
Structural Steelwork, piping, indoor and outdoor	130 to 200 Deg	SA 2 1/2	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75
			Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)
			Sealer	1	Single pack Heat Resistant Silicon Acrylic Finish paint.	25
			Finish	2	Single pack Heat Resistant Silicon Acrylic Finish paint.	25
					Total	150
Alternative -2		SA 2 1/2	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75
				1	Single pack Moisture Cured, Inorganic Silicate based heat resisting finish up to 400 Deg - Grey shade./ white/ Aluminium.	50
			Finish	1		50
					Total	175
Alternative-3			Finish	1	Single pack Heat Resistant Silicon Acrylic Finish paint. - either Aviation White/ Aviation Orange.	80
					Total	155
Structural Steel work Piping, Un-insulated	200 to 400	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs	75



ANNEX 25.1.2 PAINTING SYSTEMS						
Cleaning, Protective Coating and Painting - Systems designed as per ISO 12944 with service life of 10 yrs.						
Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
Carbon Steel Indoor and Outdoor	Deg C.				/ 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	
			Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level 2.	(75)
			Finish	2	Heat Resisting Silicon Aluminium Paint. VS to be min 28%.	20
					Total	115
Carbon steel surfaces subjected to temperature up to 400 °C. But Under Thermal Insulation.	< 400 °C	Power tool cleaning to St 2 /3		2	Red-oxide Zinc phosphate primer to IS 12744	30
						60
Components coming in the gas path (other than Coils), including water walls, SH panels, SH Headers, Hot air ducts etc.		Power tool cleaning		2	Red-oxide Zinc phosphate primer to IS 12744	30
						60
Structural Steel work, Piping (Oil + water) , Tanks Indoor.	<130 Deg.C	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75
			Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)
			Mid coat	2	2 pack High build High Solid Lamellar MIO based Epoxy Mid coat.	100
			Finish	2	Two component Polyamide Cured Epoxy Coating.	25
					Total	325
Structural Steel work in the battery rooms, chlorination plant and	Ambient	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance	75



ANNEX 25.1.2 PAINTING SYSTEMS						
Cleaning, Protective Coating and Painting - Systems designed as per ISO 12944 with service life of 10 yrs.						
Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
water treatment plant, (extremely aggressive atmosphere)					specifications for SSPC Paint 20 , Level 1	
			Touch up		Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)
			Mid coat	1	Two component, high build rust encapsulating, aluminium pigmented modified epoxy coating.	125
			Finish	1	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%	150
					Total	350
Steel Tanks inside Surface (Total) for Oil Storage	Normal	SA 2.5	Primer	1	Two component high build amine cured epoxy Primer with zinc phosphate pigment.	75
			Finish	2	Two component Self priming High Build Polyamine adduct cured epoxy coating.	125
					Total	325
Alternative-1			Finish	3	Two component Self priming High Build Polyamine adduct cured epoxy coating. (No primer required. Self priming coating post blasting)	125
					Total	375
Alternative-2			Finish	2	Two component High build high solid Solvent free epoxy coating - certified by CFTRI for Potable water usage. (Primer same as above)	150
					Total	300
Steel Tanks inside Surface (Total) for Water Storage (Potable and Distilled Water)	Ambient	SA 3	Primer	1	Two component high build polyamide cured zinc phosphate Primer	75
			Finish	2	Two component Self priming High Build Polyamine adduct cured epoxy coating - certified by CFTRI for Potable water usage.	125
					Total	325
Alternative 1			Finish	2	Two component High build high solid Solvent free epoxy coating - certified by CFTRI for Potable water usage. (No primer required. Self priming coating post blasting)	200
					Total	400
Steelwork immersed in	< 60	SA 3	Primer	1	Two component High Build High Solid Rapid Curing Epoxy	75



ANNEX 25.1.2 PAINTING SYSTEMS						
Cleaning, Protective Coating and Painting - Systems designed as per ISO 12944 with service life of 10 yrs.						
Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
seawater such as inlet/ outlet structures, dolphins, sheet piling	Deg C				Zinc Phosphate Primer.	
			Finish	1	Two component High build High Solid Modified Epoxy coating.	500
					Total	575
			Wherever TAR based product is not to be recommended.			
			Finish	1	Two component High build High Solid Modified Epoxy coating	500
					Total	500
			Finish	1	Two component High build High Solid Modified Epoxy coating with Glass Flake.	500
					Total	500
Alternative 1						
Cast Iron Water pipelines - Outside surface, buried in Soil	< 60 Deg C	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1	75
			Finish	2	Polyamide Cured Coal Tar Epoxy, Vs min 65% black.	200
					Total	475
Alternate-1			Finish	1	Two component High build High Solid Modified Epoxy coating	500
Alternate -2			Finish	1	Two component High build High Solid Modified Epoxy coating with Glass Flake	500
Steel Pipes - Inside surfaces such as cooling water lines.	< 60 Deg C	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75
			Finish	2	Coal Tar Epoxy, Vs min 65% black.	225
					Total	525
Water Pipelines - Outside Surface, Indoor	< 60 Deg C	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75
			Touch	1	Two component Zinc rich Primer meeting performance and	(75)



ANNEX 25.1.2 PAINTING SYSTEMS						
Cleaning, Protective Coating and Painting - Systems designed as per ISO 12944 with service life of 10 yrs.						
Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
			up		compositional specifications of SSPC Paint 20 Level2	
			Finish	2	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%	100
					Total	275
Oil pipelines - Outside surface, above ground	< 100 Deg C	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75
			Touch up		Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)
			Mid coat	2	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%	100
			Finish	1	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of at least 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	350
Pumps, Motors, Turbine, Claddings, Steam Turbine Condenser, Indoor	Up to 90 Deg	SA 2.5	Primer	1	Catalysed Zn rich Primer with a VS of 60% min, complying to SSPC Paint 20 level 2.	75
			Finish	2	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%.	100
					Total	275
Alternative 1		SA 2.5	Primer	1	Catalysed Zn rich Primer with a VS of 60% min, complying to SSPC Paint 20 level 2.	75
			Mid coat	1	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%.	100
			Finish	2	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of at least 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	250
Heat Exchangers - Inside Surface.	Up to 60 Deg	SA 2.5	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75
			Finish	2	Coal Tar Epoxy, Vs min 65% black.	200



ANNEX 25.1.2 PAINTING SYSTEMS						
Cleaning, Protective Coating and Painting - Systems designed as per ISO 12944 with service life of 10 yrs.						
Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
					Total	475
Heat exchanger Coils coming in the gas path . (Eco, SH, RH coils & Loose tubes etc.)		Power tool cleaning			One coat of dip-coat paint -Red-oxide Zinc phosphate primer	35
Instrument panels, Electrical cubicles and similar steel sheet – indoor (Can be used on Aluminium, steel, stainless steel and galvanized substrates.)	Ambient	Oil grease and contaminants must be removed	Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	75
			Mid coat	1	Two component High Build Surface Tolerant Epoxy coating pigmented with Aluminium and Lamellar Micaceous iron oxide	100
			Top coat	1	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%	100
					Total	275
Instrument panels, Electrical cubicles and similar steel sheet – outdoor (Can be used on Aluminium, steel, stainless steel and galvanized substrates.)	Ambient	Oil grease and contaminants must be removed	Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	100
			Mid coat	1	Two component High Build Surface Tolerant Epoxy coating pigmented with Aluminium and Lamellar Micaceous iron oxide.	150
			Top coat	1	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of atleast 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	325
Substrate, base metal: Carbon steel, HDG acc ISO 1461 Or. Equiv. Non Insulated. - Outdoor	<120 Deg	Air blasting with Nonmetallic abrasive Powder	Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)
			Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	50
			Mid coat	1	Two component High Build Surface Tolerant Epoxy coating pigmented with Aluminium and Lamellar Micaceous iron oxide	150



ANNEX 25.1.2 PAINTING SYSTEMS						
Cleaning, Protective Coating and Painting - Systems designed as per ISO 12944 with service life of 10 yrs.						
Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
			Finish	1	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of atleast 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	275
Substrate, base metal: Carbon steel, HDG acc ISO 1461 Or. Equiv. Non Insulated.- Indoor	<120 Deg	Air blasting with Nonmetall ic abrasive Powder	Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level 2.	75
			Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	125
			Finish	1	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%.	100
					Total	225
			For Outdoor Application			
			Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)
			Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	125
			Finish	1	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of at least 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	200
			For Indoor Application			
Substrate, Stainless Steel - Non insulated.	< 120 Deg	Air blasting with Nonmetall ic abrasive Powder	Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	125
			Finish	1	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%	100
					Total	225
			For Outdoor Application			
			Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	125
			Finish	1	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of atleast 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	200
Applicable for Water -				For Indoor Application		



ANNEX 25.1.2 PAINTING SYSTEMS						
Cleaning, Protective Coating and Painting - Systems designed as per ISO 12944 with service life of 10 yrs.						
Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
Water Cooled heat Exchangers like Condensers, Flash box, Water - Water coolers etc. For Outdoor installations in corrosive atmosphere - like Chemical/ Marine.	< 120 Deg	Air blasting with Nonmetallic abrasive Powder	Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	75
			Top coat	2	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%.	100
					Total	275
			For Outdoor Application			
			Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	125
			Mid coat	1	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%.	100
			Top coat	1	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of at least 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	300

**PAINTING SPECIFICATION FOR CIVIL BUILDINGS – COASTAL**

S.No.	Location	Description
1	Metal and Timber Joinery	Two component high build, self priming, rust encapsulating, modified epoxy coating. Min VS 80%.
2	All Ceiling	Oil bound distemper (Office rooms) White Washing - all areas.
3	Internal wall surfaces	Oil Bound distemper
4	Control room/office	Acrylic Emulsion.
5	External faces of walls	Cement based Water proof paint
6	Walls of battery room and other acid/alkali spillage areas	1. Primer -1 coat of 50 microns - Two pack Polyamide Epoxy Primer with Zinc phosphate Pigment for concrete application. Min VS 48%. 2. Top coat - 1 coat of 125 microns - Two component self priming, high build polyamine adduct cured epoxy coating having excellent chemical resistance. Min VS 60%.
7	Cooling Tower External	
	a. Steel sections	i) Blasting to SA 2.5 ii) 1 x 75 microns - Inorganic Zinc Silicate as per SSPC Paint 20 Level 2. iii) 1 x 150 microns –Two components high build epoxy intermediate pigmented with lamellar micaceous iron oxide. Min VS 65%. iv) 1 x 75 microns - Two component high solids, Glossy, Acrylic Aliphatic Polyurethane paint, Min VS of 57%, Gloss retention of 90% after exposure to 2000 hrs under QUV B 313 lamp
	b. Concrete sections	1. 1 x 50 microns - Epoxy Polyamide Primer 2. 1x 500 microns-Two components high build high solid, engineered epoxy coating. Min VS 87%. - Typical dft - 500 microns per coat. Condensation as per IS 101 - 9000 hrs, Salt spray as per ASTM G 85 - 8000 hrs.
8	Chimney external	i) 1 x 50 microns Concrete Epoxy Polyamide primer followed by ii) 2 Coats of 50 microns of Acrylic Aliphatic Polyurethane paint



Tamil Nadu Generation and Distribution Corporation Ltd.

2 X 660 MW Udangudi Supercritical Thermal Power Project - Stage - 1

TENDER ENQUIRY DOCUMENT FOR EPC CONTRACT

[BID SPECIFICATION NO.SE/C/UP/EE/E/OT NO.01/2015-16]

VOLUME - II SECTION - 3 DETAILED TECHNICAL SPECIFICATION ELECTRICAL

FICHTNER Consulting Engineers (India) Private Limited
Chennai, India



INDEX

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SECTION-3.1: GENERAL

1.0.0 INTENT OF SPECIFICATION

This specification covers the requirements of electrical system and equipment for efficient and trouble-free operation of the proposed power project.

It is not the intent to specify completely herein all details of design, manufacture & installation. However, the equipment shall conform in all respects to high standards of design engineering and workmanship and shall be capable of performing satisfactorily in continuous commercial operation up to specified guarantee period.

The general terms and conditions, instruction to Bidder/Contractors and other attachments referred to elsewhere be hereby made part of the technical specification. The Bidder's offer shall conform to all requirements stipulated in the specification.

Deviations, if any, shall be brought out very clearly on deviation sheet enclosed with the Tender document only. Otherwise, it will be construed that the Bidder's offer is in line with what has been stated / asked for in this specification.

2.0.0 SCOPE OF WORK

2.1.0 The scope of work shall cover design, engineering, manufacture, assembly and testing at works, packing, dispatch and transportation to site including transit insurance, erection testing and commissioning of the complete electrical system for the power project. Major equipment and systems are listed below and are further detailed in subsequent sections of this specification :

- 1) Generators and its auxiliaries
- 2) Excitation system for generators
- 3) Neutral grounding equipment for generators
- 4) Surge arrester and voltage transformer cubicle for generators
- 5) Isolated phase busduct for generators
- 6) Protection panel for generator and transformers
- 7) Control panel for generators
- 8) Generator circuit breakers
- 9) Generator transformers
- 10) Spare Generator transformer
- 11) Bus reactors
- 12) Unit transformers
- 13) Station transformers
- 14) Standby Maintenance transformer
- 15) 400 kV gas insulated indoor switchyard (GIS) including all control, metering & protection panels, substation automation system, communication system etc.
- 16) 400 kV outdoor equipment for GIS switchyard (Such as GIS busduct, SF6 Air Bushing, lightning arrester, CVTs, etc.)
- 17) Switchyard communication system equipment at power plant switchyard end of transmission lines.
- 18) 11 kV & 6.6 kV segregated phase busduct
- 19) Neutral grounding resistors for 11 kV system
- 20) Neutral grounding resistors for 6.6 kV system
- 21) Unit auxiliary transformers



- 22) Station auxiliary transformers
- 23) Auxiliary transformers for CHP, AHP, and Sea water intake etc.
- 24) Dry type LV service transformers
- 25) 33 kV switchgear
- 26) 11 kV switchgear
- 27) 6.6 kV Switchgear
- 28) 33kV, 11kV and 6.6kV VCB Isolation Panels
- 29) Bus transfer panels
- 30) Electrical monitoring system (EMS)
- 31) Integrated energy management system (IEMS)
- 32) Tariff metering panels
- 33) 415 V switchgear
- 34) DC distribution boards (220 V, 48 V & 24 V)
- 35) 415 V Non segregated phase busduct
- 36) Batteries and Chargers (220 V, 48 V & 24 V)
- 37) Uninterrupted power supply system (UPS)
- 38) Diesel generator set
- 39) HT Power cables
- 40) LT Power and control cables
- 41) Trailing cables
- 42) Cable trays, Bolted (Unistrut) type supports, fittings and accessories
- 43) Cabling accessories (cable glands, lugs, ferrules, terminations, joints, clamps etc.)
- 44) Fire stop sealing system for cable penetrations
- 45) Illumination system
- 46) HT Motors
- 47) LT Motors
- 48) DC Motors
- 49) Electric actuators with integral starters
- 50) Passenger cum goods elevators
- 51) Rack & Pinion type elevators
- 52) Telephone system
- 53) Public address system
- 54) Wireless paging system
- 55) Electrical lab equipment
- 56) Construction power supply system
- 57) Earthing system
- 58) Lightning protection system
- 59) Variable frequency drive system
- 60) Electrical equipment for ESP
- 61) Work stations, large video screen, Multi-function printers, laptops etc.
- 62) Furniture for all workstations and printers
- 63) Test bench, Steel Almirah, Storage Cabinets and Furniture for all Lab equipment
- 64) Safety items
- 65) Any other equipment as required to complete the system

2.2.0 Equipment / items not specifically mentioned in the specification but which are required for successful operation and maintenance of the power project in all respects, consistent with the best engineering practices are deemed to be included in the scope of supply.



2.3.0 The scope of supply shall also include the following:

- Consumables (such as transformer oil, fuses, bulbs, lub oil, electrolyte for battery, SF6 gas, fuel oil for DG set etc.), till COD of power plant.
- Spare parts required for successful commissioning. Bidder shall furnish the list along with tender.
- Mandatory spares for 3 years Operation & Maintenance (O&M) as listed in Section-1 of Volume-II.
- Special tools and tackles for Operation & Maintenance (O&M) as listed in Annex – 3.1.1.
- Training of Owner's personnel for operation and maintenance of various equipment and system as specified elsewhere.

2.4.0 O&M spares and special tools & tackles being purchased by the Owner in this tender shall not be used during the commissioning of the equipment.

3.0.0 GENERAL REQUIREMENTS

2.1.0 All the materials and equipment furnished for permanent installation in the work shall be new, unused, and undamaged. Asbestos containing materials are not allowed.

2.2.0 The Contractor shall establish 'KKS Codification' system, to provide consistent numbering throughout the Power project.

3.3.0 The Contractor shall be responsible for the selection and design of all equipment and materials which shall provide the best coordinated performance of the overall power station in all operating modes which shall also include "islanding" mode of operation.

3.4.0 The construction of electrical enclosures located in hazardous areas shall be of a type designated as suitable for the environment in which they are located. Hazardous area equipment list shall be specified with zone & temperature class specification.

3.5.0 Electrical equipment such as motors, push button stations, lighting fixtures, junction boxes located in areas such as fuel oil handling areas, hydrogen gas handling area, hydrogen generation plant, coal dust areas etc. shall be provided with flameproof type enclosures as per relevant standards.

3.6.0 The Contractor shall be fully responsible for carrying out all co-ordination & liaison work as may be required with Electrical Inspector, Factory Inspector & other statutory bodies for implementation of the work. The application on behalf of the Owner for submission to the Electrical Inspector & other statutory bodies along with the copies of drawings complete in all respects shall be done by the Contractor and approval shall be taken well ahead of time so that the actual commissioning of equipment is not delayed for want of inspection and approval by the Inspector & statutory bodies. The Contractor shall arrange the actual inspection work by the Electrical Inspector.

3.7.0 List of codes and standards to be complied with for various equipment/systems in subsequent sections of this specification. The standards shall be latest publication (including amendments) as on date of bid submission. All the equipment and accessories shall also conform to the requirements of latest editions including amendments of the following:

- Indian Electricity Act and rules framed there-under
- Fire insurance regulations
- Regulations laid down by the office of the Chief Electrical Inspector to Government
- CEA guidelines / regulations
- CERC regulations / TNERC regulations
- CBIP manual on substations



- CBIP manual on Transformers
 - CBIP manual on Busduct
 - CBIP manual on Earthing of AC power systems
 - Guidelines of tariff advisory committee (TAC)
 - Regulations of Central pollution control board
 - CEA manual on transmission planning criteria
 - Factory Act
 - Lift Act
 - Any other regulations laid down by the local authorities
- 3.8.0 All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at site. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing.
- 3.9.0 All electrical equipment meant for indoor installation shall be stored in indoor stores having controlled atmosphere, till moved to its place of installation. Outdoor equipment shall be covered and stored in leveled, clean, fenced outdoor yard. All sensitive electric/electronic parts shall be covered with plastic / polythene covers to prevent ingress of humidity. All equipment during storage shall be protected against damage due to acts of nature or accidents. The storage instructions of the equipment manufacturer and Owner shall be strictly adhered to.
- 3.10.0 Bidder shall guarantee that system engineered and equipment offered shall meet the requirements as stipulated in this specification and as confirmed by them in technical data sheets.
- 3.11.0 Bidder shall furnish vendor list for all the items along with the bid for evaluation. "Makes" of all electrical equipment and accessories are subject to prior approval by the Owner.
- 3.12.0 Similar equipment and components shall be of same make. Equipment of same type and rating shall be interchangeable.
- 3.13.0 All manufacturers' guarantees for all bought out items & equipment shall be made available to the Owner and shall be valid for the entire liability period. If such guarantees are not issued by manufacturer, the Contractor shall guarantee the bought out items for the entire defects liability period along with his guarantee for the project as a whole.
- 3.14.0 If the completed plant or any portion thereof supplied by Contractor at any time before or after installation is found to be defective or not conforming to specification or if it fails to fulfill the requirement of the contract, the Owner may reject the same. In such an event, the Contractor shall replace the same to the satisfaction of the Owner, without affecting the committed milestones and without any cost implication to the Owner.
- 3.15.0 In the event of failure of any particular equipment which fails more than three times during the guarantee period, the Contractor shall replace that equipment with another equivalent make as approved by Owner, at his own cost. Manufacturer's / Contractor's guarantee, as mentioned for such replaced equipment shall also be made available to the Owner and shall be kept valid at least for one year from the date of last replacement at site.
- 3.16.0 In case of any discrepancy among other technical sections and / or the drawings enclosed, the most stringent one shall prevail.
- 3.17.0 Technical specification for various equipment and system are covered in the following sections of this specification.
- Section -3.2 : Generator
- Section-3.3 : 400 kV GIS Switchyard
- Section -3.4 : Power Transformers & Bus Reactor



Section-3.5	:	Dry Type LV Transformers
Section-3.6	:	Busduct
Section-3.7	:	Generator Circuit Breaker
Section-3.8	:	HV Switchgear
Section-3.9	:	Neutral Grounding Resistors
Section-3.10	:	LV Switchgear
Section-3.11	:	Control And Relay Panel For Generator And Transformers
Section-3.12	:	Electrical Control Monitoring System
Section-3.13	:	Battery Charger
Section-3.14	:	Battery
Section-3.15	:	Uninterrupted Power Supply System
Section-3.16	:	Motors
Section-3.17	:	Electrical Actuators
Section-3.18	:	Diesel Generator Set
Section-3.19	:	Elevators
Section-3.20	:	Chimney Elevator
Section-3.21	:	Public Address System
Section-3.22	:	Telephone System
Section-3.23	:	Illumination System
Section -3.24	:	Cables
Section-3.25	:	Cable Trays, Supports & Accessories
Section-3.26	:	Cabling Accessories
Section-3.27	:	Fire Stop System
Section-3.28	:	Earthing & Lightning Protection System
Section-3.29	:	Installation
Section-3.30	:	Variable frequency drive system (VFDS)
Section -3.31	:	ESP Electrical equipment
Section-3.32	:	Electrical Lab Equipment
Section -3.33	:	Construction Power

4.0.0 SYSTEM DESIGN

- 4.1.0 Each generator shall be connected to the 400 kV switchyard through a generator transformer via generator circuit breaker using isolated phase bus duct. Power shall be evacuated from the 400 kV switchyard through required line feeders. Start-up power shall be drawn from 400 kV switchyard through generator transformers and Unit transformers and station transformer.
- 4.2.0 Auxiliary power supply is envisaged at 11 kV, 6.6 kV & 415 V level. For each unit, Unit transformers and station transformer shall be provided. The power supply for Unit transformers and station transformer shall be tapped from the main run of the isolated phase bus duct between generator circuit breaker and generator transformer.
- 4.3.0 Standby maintenance transformer shall be provided to derive start-up power for the "unit" whenever required. It shall also feed power for the Unit switchgear / Station switchgear during failure / shut down of any Unit transformer/Station transformer. All the loads pertaining to balance of plant facilities shall be fed from station bus connected to station transformers. Power for Standby maintenance transformer shall be drawn from 400 kV level and stepped down to 11 kV. Power for external coal handling system shall be derived from station transformers.



- 4.4.0 Auxiliary transformers shall be provided to derive 6.6 kV, 33 kV power supply for various systems. LV service transformers shall be provided to derive 415 V supply.
- 4.5.0 During total blackout condition, Diesel Generator (DG) set shall feed essential loads, for safe shut down of units. One number DG set shall be provided for each unit. One common standby DG set of identical rating shall be provided common for two units.
- 4.6.0 To provide uninterrupted power supply to DCS, respective control system and other control panels, a dedicated 230 V AC UPS system shall be provided for each unit. Similarly for all auxiliary plants, switchyard etc., to feed essential loads, 230 V UPS system shall be provided in respective areas.
- 4.7.0 To feed essential loads of main plant, such as the emergency oil pumps, control supply to switchgear / panels, emergency DC lighting etc., 220 V DC supply backed by DC batteries shall be provided for each unit. Similarly for all auxiliary plants, switchyard etc., to feed essential loads, 220 V DC system shall be provided in respective areas.
- 4.8.0 For the purpose of design of electrical equipment / systems (which are air cooled), an ambient temperature of 50°C and relative humidity of 95% shall be considered. The equipment shall be suitable for operation in a highly polluted and saline environment. However, equipment in air conditioned areas shall be suitable for design temperature of 35°C.
- 4.9.0 To feed external coal handling system 2 Nos. each 25 MVA rated feeders shall be provided at 33 kV switchgear located, at Sea water intake electrical room near plant boundary.
- 4.10.0 To feed Flue gas desulphurization (FGD) system in future, 16 MVA power shall be considered in sizing 11 kV Unit switchgears and Unit transformers. One no. 16 MVA feeder shall be provided in each 11 kV Unit switchgear-1A, 1B, 2A & 2B.
- 4.11.0 To feed colony, two numbers, 5 MVA rated feeders shall be considered in 11 kV standby switchboard-1A and 1B.
- 4.12.0 4 Nos. of 415 V, DOL starter feeders shall be considered in station MCC for Owner's use (to feed water pumps for colony).
- 4.13.0 In 415 V system of Ash water recovery pump house, additional load of 500 kVA for future use shall be considered while sizing the transformer and 2 nos. 1000 Amp feeders shall be provided in PCC.
- 4.14.0 Voltage levels shall be considered as follows:
- | | |
|---|---|
| Power evacuation and Startup power | : 400 kV ($\pm 5\%$), 3 phase, 3 wire, 50 Hz, effectively earthed. |
| Generation voltage | : Manufacturer's standard voltage, 3 phase, 50 Hz |
| HT supply for external CHP | : 33 kV ($\pm 10\%$), 3 phase, 3 wire, 50 Hz, solidly earthed |
| HT auxiliary supply | : 11 kV ($\pm 10\%$) & 6.6 kV ($\pm 10\%$), 3 phase, 3 wire, 50 Hz, earthed through resistance. |
| LT auxiliary supply | : 415 V ($\pm 10\%$), 3 phase, 4 wire, solidly earthed. |
| LT emergency supply | : 415 V ($\pm 10\%$), 3 phase, 4 wire, solidly earthed. |
| DC supply | : 220 V (+10% & -15%), DC, 2 wire, unearthed. |
| UPS supply | : 230 V ($\pm 10\%$), 1 phase, 2 wire, 50 Hz, AC |
| Communication system DC supply | : 48 V (+10% & -15%), DC, 2 wire, +ve pole earthed. |
| Control supply for MCC feeders | : 110 V AC, 1 phase, 2 wire |
| Permissible frequency variation | : +3% to - 5% |
| Combined variation of voltage & frequency | : 10% |

**Voltage level for AC motors**

Up to 0.2 kW	: 230 V, 1 phase, 50 Hz
Above 0.2 kW up to 200 kW voltage	: 415 V, 3 phase, 50 Hz
Above 200 kW & up to 2000 kW	: 6.6 kV, 3 phase, 50 Hz
Above 2000 kW	: 11 kV, 3 phase, 50 Hz

- 4.15.0 Auxiliary power supply system and its equipment shall be designed in such a way that the main equipment and auxiliaries are not endangered under all conditions. Transformer voltage ratios, type of tap changers and tap ranges, impedances and tolerances thereon, shall be so optimized that the auxiliary system voltages under various grid and loading conditions are always within permissible limits and equipment are not subjected to unacceptable voltages during operation and starting of motors.
- 4.16.0 The vector groups of the generator transformers, Unit transformers, station transformers, standby maintenance transformer, and auxiliary transformers shall be so selected that the paralleling at 11 kV and 6.6 kV buses shall be possible. Further, the vector group of other LV service transformers shall have identical vector groups.
- 4.17.0 The three phase symmetrical short circuit ratings of the switchgear and equipment at different voltage levels shall be not less than the following values:

Sl. No.	Voltage level	Symmetrical Short time withstand current	Dynamic withstand current
a)	400 kV	63 kA for 1 second	163 kAp
b)	33 kV	25 kA for 3 second	63 kAp
c)	11 kV	50 kA for 3 second	125 kAp
d)	6.6 kV	31.5 kA for 3 second	80 kAp
e)	415 V	65 kA / 50 kA for 1 second	137 kAp / 105 kAp

- 4.18.0 System neutral earthing shall be as follows:

- Generator neutral shall be earthed through distribution transformer and secondary resistor to limit the earth fault current to about 15 A.
- 400 kV system neutral shall be solidly earthed.
- 11 kV system shall be earthed through resistance to limit the earth fault current to 300 A.
- 6.6 kV system shall be earthed through resistance to limit the earth fault current to 300 A.
- 33 kV system neutral shall be solidly earthed.
- 415 V system neutral shall be solidly earthed.
- 220 V DC system unearthed.
- 48 V DC system positive pole earthed.
- 24 V DC system negative pole earthed.

- 4.19.0 Automatic bus transfer system (consisting of fast transfer, in phase transfer, residual voltage transfer, parallel transfer) shall be provided at 11 kV Unit switchgear. All other Switchgear shall be provided with auto changeover facility between incomers and bus coupler.
- 4.20.0 Auxiliary transformers and Service transformers, as required, shall be provided to meet the demand at various voltage levels of auxiliary power systems, with the criteria that each switchgear / power control centre shall be fed by 2X100% transformers / feeders. The auxiliary



transformers / service transformers shall be designed to carry the maximum expected load of both bus sections.

- 4.21.0 Main plant electrical system shall be controlled and monitored from plant DCS. Electrical system of auxiliary plants (such as CHP, AHP, WTP, Desal plant, water intake system, Fuel oil system, Fire water system, etc.) shall also be controlled and monitored from respective control system. Further the entire plant electrical system shall be monitored from SCADA based electrical monitoring system EMS).
- 4.22.0 A dedicated substation automation system (SAS) for Switchyard shall be provided for the switchyard control and monitoring. SAS shall also be integrated with plant DCS and EMS system, to monitor switchyard parameters & status. Status of all the breakers, isolators, earth switches shall be supervised. All protective relays alarm and trip signals shall be monitored in SAS. Other details of the SAS are given in switchyard section.
- 4.23.0 The SAS system and EMS system shall be designed so that the failure of any single component, processor, link or device shall not render system unavailable and accordingly necessary redundancy at every level shall be provided.
- 4.24.0 In the GIS switchyard, necessary communication equipment shall be provided to transmit the required data & signals of the power station to Regional / State Load Dispatch Centre and Transmission Company. RTU's and other necessary equipment shall be provided.
- 4.25.0 All the work stations, laptops, Multi-function printers etc. shall be of commercial grade, and shall be of high end version having all state of art features and latest model of that year being installed. Make and model no. of offered equipment shall be subject to Owner's approval.
- 4.26.0 The visual display unit (VDU) for all workstations shall be 24" LED display unit. The unit shall have a minimum resolution of 1280X1024 pixels and the screen shall be reflection protected.
- 4.27.0 System study shall be carried out using authenticated validated software of latest version. The system study shall include the following for the entire project including power evacuation system:
- Load flow study
 - Short circuit study during steady state and transient condition.
 - Voltage drop study during steady state and transient condition.
 - System study during Islanding / Grid disturbance.
 - Insulation co-ordination study.
 - Motor acceleration study
 - Relay setting coordination study.
 - Power System Stability (PSS) studies

The Contractor shall carry out the detailed computer studies considering single machine with infinite bus so as to confirm the suitability of the Turbine generator and its excitation system in the grid for maintaining the power system stability under dynamic and transient conditions and tune the PSS parameters at site for all the machines. The data pertaining to grid shall be discussed and finalised between Owner and the Contractor during detail engineering.

5.0.0 LAYOUT ASPECTS

- 5.1.0 In the Power house building, AB bay & BC bay and central control building shall be utilized to accommodate Electrical and C&I equipment of the Main Plant. Cable spreader room shall be provided for each Electrical room, Control room and Control equipment room.
- 5.2.0 11 kV Unit switchgear, 11 kV Station switchgear, 11 kV Standby switchgear, 6.6 kV Unit auxiliary switchgear, 6.6 kV Station auxiliary switchgear, 415 V Power Control Centres (PCC), dry type transformers and Motor Control Centres (MCC) of main plant, Emergency Switchgear,



- Ventilation MCC, Air condition MCC, AC & DC distribution boards of main plant, main plant battery & charger, main plant UPS etc. shall be located in the electrical rooms of Power house building.
- 5.3.0 The batteries shall be located in a separate ventilated room. For lead acid batteries, acid resistant protective treatment shall be proposed for the battery room floor and on the wall surfaces. An eye wash basin shall be provided in each battery room.
- 5.4.0 Transformer yard shall be located adjacent to A row of the power house building. Generator transformers, Unit transformers, Station transformers, Standby maintenance transformer, Unit auxiliary transformers, ECHS Auxiliary Transformers and station auxiliary transformers shall be located in the transformer yard.
- 5.5.0 All the switchgears, Battery rooms, Equipment rooms etc., of both units shall be mirror image to other TG building.
- 5.6.0 All BTG related Switchgear rooms shall have Air Conditioned operator room and have direct access from TG Building Lifts.
- 5.7.0 400 kV GIS Substation shall be located in front of the transformer yard. Overhead lines from the switchyard shall be tied to a separate gantry structure positioned near respective transformers, to facilitate tap off connection to generator transformers and standby maintenance transformers. Bus reactors shall be located in the switchyard.
- 5.8.0 Fencing shall be provided around outdoor switch yard, transformer yard. Auxiliary transformers and service transformers in off-site areas shall also have suitable fence as per IE rules.
- 5.9.0 The following minimum clearance shall be maintained for various switchgear installed in a room:

S. No.	Description	Clearance in mm
1)	Between HT switchgear front face and any other panel front face	2500
2)	Between HT switchgear front face and wall/structure	2000
3)	Between HT switchgear rear face and wall/structure/obstacle	1000
4)	Between LT switchgear (drawout type) front face and any other LT panel front face	2000
5)	Between LT switchgear (drawout type) front face and wall/structure	1500
6)	Between LT panel (fixed type)/ control panel front face and any other panel front face	1500
7)	Between LT panel (fixed type) front face and wall/structure	1000
8)	Side spacing between HT switchgear and other panel	2000
9)	Side spacing between HT switchgear and wall	2000 + 1 future panel space
10)	Side spacing between LT switchgear / panels	1000
11)	Side spacing between LT switchgear / panels and wall	1000+ 1 future panel space
12)	Clearance between rows of batteries	1000
13)	Space in front of Dry type transformer	3000
14)	Between Dry type transformer rear face and wall/structure	1500



S. No.	Description	Clearance in mm
15)	Space on sides of Dry type transformer	1000
16)	Space on sides of Power transformers	1500
17)	Space around GIS equipment	5000

5.10.0 Cable spreader room shall be provided for all the electrical room and control rooms and control equipment rooms for the various buildings and areas:

- Main plant turbine building
- Central control building
- Switchyard control building
- ESP control building
- Ash handling plant
- Coal handling plant
- CW water Pump House
- Water treatment plant
- RO & DM Plant
- Out fall sea water pump house
- Fuel Oil Pump House
- In electrical rooms of other buildings, cable trenches with less than 1.0 Mtr depth from the finished floor of respective building can be considered, adequately protecting from water ingress from outdoor trenches.

5.11.0 For interplant cabling overhead cable racks on steel structure shall be provided. For transformer yard and outdoor switchyard cabling can be in RCC cable trenches.

5.12.0 Where ever cable trenches are provided suitable slope shall be maintained and it is connected to sump. Sump shall be provided with sump pump with auto control. Cables shall not be routed in the coal conveyor gallery. A separate cable gallery shall be provided with walkway along the conveyor gallery.

5.13.0 The Minimum ground clearance from bottom of cable trays shall be Minimum 6 metres for road crossings etc., and other area shall be Minimum 2.5 metres. The Cable trays shall be of vertical formation. All electrical rooms and cable spreader rooms shall have minimum of two doors and the doors shall be fire rated for 2 hours. Cable spreader room height shall be atleast 3.5 metre.

5.14.0 All busduct entry shall be from top only. Unless otherwise specified, all incomers from LV service transformers rated 750 kVA & above to PCC shall be through non-segregated phase bus duct (NSPB). For lesser ratings, the same may be of bus duct or cable based on the layout.

5.15.0 All the LV service transformers shall be dry type, located indoor.

5.16.0 For Generator transformers, Unit transformers, Station transformers, Stand by maintenance transformers and Unit auxiliary transformers and any other transformer more than 20 MVA located in transformer yard, rail track shall be extended from transformer foundation and taken into the service bay of turbine building. Where rails cross the fencing, fencing shall be made of removable type to facilitate transport of transformer.

5.17.0 For Generator transformers, rail track shall be interconnected such that spare Generator transformer can be moved to the location of the any other generator transformer within a short duration. This rail track shall be independent of main road.

5.18.0 Where oil capacity of the transformer (individual or aggregate) is >2300 litres and <5000 litres, firewall wall shall be provided unless equipment / building are located at clear distance of 6 metre.

5.19.0 Where oil capacity of the individual transformer is >5000 liters, separating fire wall shall be provided as per TAC norms, unless equipment or building are located at clear distance of not less than the following:



5000 to 10000 liters	8 Metre
>10000 to 20000 liters	10 Metre
>20000 to 30000 liters	12.5 Metre
>30000 liters	15 Metre

- 5.20.0 Masonry fire walls shall be minimum 345 mm thick and RCC firewall shall be minimum 200 mm thick. The fire wall shall extend 600 mm beyond the transformer's outer periphery on either side. The height of the fire walls shall be 600 mm above the height of the transformer.
- 5.21.0 Transformers shall be provided with oil collection pit (soak pit) at the bottom, if oil in one transformer exceeds 2275 litres and the soak pit shall be sized to hold total quantity of oil.
- 5.22.0 If oil in one transformer is 9000 litres or more, in addition to soak pit, a separate burnt oil pit sized to accommodate 110% of the volume of oil of the largest transformer, shall be provided which should be located at more than 5 metres from the transformer to drain the oil away from the soak pit. The soak pit below the transformer shall accommodate atleast 1/3rd of the oil of that transformer.
- 5.23.0 In the transformer yard, burnt oil pit can be common for all the transformers of respective Unit and shall be sized for the largest transformer oil quantity and soak pits of all other transformers in the yard shall be terminated at common burnt oil pit.
- 5.24.0 Transformer Oil Filter Plant shall be housed in a Building.
- 5.25.0 Drain pipes of Generator transformers and standby transformers in the transformer yard shall be extended up to burnt oil pit and shall be provided with additional isolation valve, in addition to the drain valve provided at transformer end. Drain valve at transformer end shall normally be open and isolation valve at burnt oil pit shall remain closed. In case of any major fault in the transformer, oil can be drained to the pit by opening valve at burnt oil pit. The Drain Valve shall be housed in a covered room.
- 5.26.0 Transformer soak pit shall be filled with gravel. Burnt oil pit shall be of totally covered RCC construction with ladder, man hole, steel cover for man hole, pumping arrangement for dewatering the pit etc.
- 5.27.0 Fire barriers or Fire stops shall be provided for all cable penetrations in cable spreader rooms and for cables passed through wall and floor. Fire barriers and fire stops shall be fire rated for at least 2 hours.
- 5.28.0 All electrical rooms including GIS building shall be provided with epoxy flooring.
- 5.29.0 Switchyard control building shall have two floor construction with the following rooms, which are further detailed in the Civil section:
- Airconditioned Control room
 - Airconditioned room for Relay panels
 - Battery room
 - Air conditioned room for UPS & Battery chargers
 - Airconditioned Data room
 - Airconditioned Communication room
 - LV Switchgear room
 - Airconditioned Engineering Room
 - Airconditioned Tariff metering room
 - Cable spreader room
 - Airconditioned Maintenance engineers room (15metreX5metre)
 - Store cum tool room in ground floor
 - Airconditioned Mini Conference Room (5 metreX5metre)
 - Toilet (Men & Women)
 - Pantry Room
 - Room for HVAC
 - The required furnitures such as Chairs, Tables, Almirahs shall be provided.



- 5.30.0 All electrical buildings shall have two floor construction with the following rooms , which are further detailed in the Civil section:
- Electrical room
 - Battery room
 - Airconditioned Control room
 - Cable spreader room
 - Airconditioned Maintenance engineers room (5 metreX5metre)
 - Store cum tool room in ground floor
 - Toilet (Men & Women)
 - Pantry Room
 - AHU Room
 - The required furnitures such as Chairs, Tables, Almirahs shall be provided.
- 5.31.0 In each electrical room of main plant building, operator cubicle with fan and furniture shall be provided.
- 5.32.0 All the electrical rooms shall be provided with 3 metre X 3 metre size rolling shutter. Electrical equipment layout in the room shall enable replacement of indoor transformer at a later date, without obstructing structures/equipment. Suitable clear corridor for equipment movement shall be envisaged.
- 5.33.0 Workstation for generator disturbance recorder, work station for relay parameterization, work station for energy audit metering will be located in electrical engineer room in central control building.
- 5.34.0 EMS workstations for Unit-1, Unit-2 and station shall be located in central control room along with DCS workstation

6.0.0 QUALITY ASSURANCE & INSPECTION

- 6.1.0 All materials, components and equipment covered under this specification shall be procured, manufactured, erected, tested, and commissioned at all the stages, as per approved Quality Plan.
- 6.2.0 The Contractor shall adopt suitable quality assurance program to ensure that the equipment and services under the scope of Contract, whether manufactured or performed within the Contractor's works or at his sub-Contractor's premises or at the Owner's site or at any other place of work are in accordance with the specification. Such program shall be outlined by the Contractor and shall be finally accepted by the Owner / authorized representative after discussion. The quality assurance (QA) program shall be generally in line with ISO standards.
- 6.3.0 Manufacturing Quality Plan (MQP) shall detail out for all the components and equipment, various tests and inspections to be carried out as per the requirements of this specification and standards mentioned therein, quality practices and procedures followed by Contractor's and sub-Contractor's quality control organization, the relevant reference documents, acceptance norms etc. during all stages of manufacturing including raw material procurement, in-process manufacturing, assembly and final testing and performance testing. The quality plans shall be submitted to Owner for approval for all the equipment listed under scope of work.
- 6.4.0 Field Quality Plan (FQP) shall detail out the quality practices, procedures etc. to be followed by the Contractor's 'site quality control organization', during various stages of site activities starting from receipt of materials and equipment at site, storage at site, internal transport, erection, testing and commissioning for all the equipment.
- 6.5.0 The Contractor shall carry out all tests and inspections required to establish that the items and equipment conform to the requirements of the specification and relevant codes and standards specified in the specification, and also as per the approved quality plans. Tests shall be performed in the presence of Owner's representative, if so desired by the Owner. For all spares



and replacement items, the quality requirements for the supply of main equipment shall be applicable.

- 6.6.0 Quality audit / surveillance / approval of the test results and inspection and acceptance of material shall not, however, prejudice the right of the Owner to reject the equipment if it does not comply with the specification when erected or does not give complete satisfaction in service. Also they shall not limit the liabilities and responsibilities of the Contractor in ensuring complete conformance of the materials and equipment supplied to relevant specification, standards, data sheet, drawing etc.
- 6.7.0 The Contractor whose equipment are offered should have designed, manufactured, tested and supplied the same for the specified system voltage and which are in satisfactory operation for at least five (5) years as on date of bid opening. Type test certificates for test conducted on similar rating shall be furnished.
- 6.8.0 Equipment offered shall be of type tested and proven type. In case type test reports are not found to be meeting the specification requirements, Contractor shall conduct; all such type tests according to the relevant standards at his cost and the Owner will not absorb such cost.
- 6.9.0 Tests shall be carried out for all the equipment as per applicable standards as stated in the various sections of this specification. Copies of certified reports of all tests carried out at the works shall be furnished. The equipment shall be dispatched from works, only after receipt of Owner's written approval of the test reports.
- 6.10.0 Makes of all equipment and components shall be subject to Owner's approval without any cost implication.

7.0.0 TENDER DRAWINGS

All drawings, schedules and annexure appended to this specification shall form part of the specification. These drawings are meant to give a general idea to the Bidder / Contractor. No information / data shown / not shown in these drawings shall be construed to relieve the Contractor of his responsibility to carry out the work as per this specification. **The following drawings are enclosed in Section-7 of Volume-II.**

- 1) Main single line diagram for auxiliary power distribution
- 2) Single line diagram for 400 kV GIS Switchyard
- 3) 400 kV GIS Switchyard Single line diagram for metering & protection
- 4) Single line diagram for typical protection of generator & transformers
- 5) Single line diagram for HT Unit switchgear – 1A/2A
- 6) Single line diagram for HT Unit switchgear – 1B/2B
- 7) Single line diagram for HT standby switchgear – 1A/1B
- 8) Single line diagram for HT station switchgear – 1 and 2
- 9) Single line diagram for HT Unit auxiliary switchgear -1/2
- 10) Single line diagram for HT station auxiliary switchgear
- 11) Single line diagram for HT sea water intake switchgear
- 12) Single line diagram for HT CHP switchgear
- 13) Single line diagram for HT AHP switchgear
- 14) Single line diagram for 33kV HT switchgear
- 15) Schematic diagram for DC system
- 16) Schematic diagram for UPS system
- 17) Typical energy metering scheme at each voltage level
- 18) 400 kV GIS switchyard substation automation system
- 19) Electrical monitoring system and integrated energy management system for Power Plant
- 20) Block diagram of communication system



- 21) Block diagram of Public addressing system
- 22) Details of Cable trays & accessories
- 23) Details of Bolted type cable tray support details
- 24) Cable tray installation details
- 25) 400 kV GIS Switchyard layout
- 26) Typical control scheme for HT switchgear auxiliary transformer feeder
- 27) Typical control scheme for HT switchgear LV service transformer feeder (dry type)
- 28) Typical control scheme for HT Switchgear motor Feeder (≤ 2000 kW)
- 29) Typical control scheme for HT Switchgear motor Feeder (> 2000 kW)

8.0.0 PACKING & DELIVERY

The Contractor shall arrange transportation of all equipment from the point of manufacture to the Site. The arrangements shall include, but not be limited to, hiring adequate capacity of Wagon, determination of routes, determination of required permits, payment of required taxes and duties, and notification to the Owner.

9.0.0 DRAWINGS & DOCUMENTS

The drawings and documents need to be submitted along with the Bid are listed in Section-1 of Volume-II the tender specification.

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Master document list
- Main single line diagram
- Design basis report for electrical system
- Control and metering philosophy for electrical system
- Logic diagrams for various switchgear
- KKS numbering for electrical system
- Hazardous area classification
- Sizing Calculation for all Transformers, GCB, NGT, NGR, IPBD, SPBD, NSPBD, Cables, Emergency DG Set, UPS System, Battery and Battery Chargers, Power Station Earthing, lighting, GIS Switchyard and CT and VT.
- System study reports
- Relay setting calculation for complete system
- List of make or vendors
- Spares list
- List of Special tools
- Quality plan
- All other drawings and documents as listed in various sections of this specification.

The successful bidder shall furnish schedule for submission of drawings and documents listed in various sections of this specification, within 60 days of award of contract.

**ANNEX -3.1.1 : SPECIAL TOOLS & TACKLES FOR ELECTRICAL**

Sl. No.	Description	Unit	Quantity
1.	Special tools for Generator		
a)	Rotor assembly and disassembly tool	No.	1
b)	Protection ring assembly and disassembly tool	No.	1
c)	Ring key dismantling tool	No.	1
d)	Wind guide ring assembly and disassembly tool	No.	1
e)	Bearing assembly and disassembly tool	No.	1
f)	Seal pad pedestal, intermediate ring assembly and disassembly tool	No.	1
g)	Cooler assembly and disassembly tool	No.	1
h)	Outlet line sleeve assembly and disassembly tool	No.	1
i)	Sealant injection tool	No.	1
j)	Inner end cap , wind guide ring hoisting tool	No.	1
k)	End cap hoisting tool	No.	1
l)	Portable gas analyser for H ₂ , CO ₂ and O ₂	No.	1
2.	Special tools for transformers		
a)	Hydraulic jacks suitable for the largest transformer.	Nos.	4
b)	Mobile High vacuum oil filtration plant of capacity 6000 LPH with accessories like oil hoses etc.	No.	1
c)	Portable high capacity two stage vacuum pump unit for evacuation of large transformers up to 0.001 torr.	No.	1
d)	Portable dry air supply unit, capacity-300 cft/Min, outlet Pressure- 5 Kg / sq.cm, dew point of air better than -30 degree centigrade.	No.	1
e)	Portable three phase transformer turns ratio tester: Range 0-2000, Accuracy- 0.1 %	No.	1
f)	Transformer winding resistance range 2 milliohm - 19.99 ohms, Current Range- 1 A, 5 A, 10 A, Resolution- 1 milliohm Accuracy- 0.2 %, Power-230 V AC, 50 Hz	No.	1
g)	Oil BDV Measurement Kit – Automatic oil testing unit for checking BDV of transformer oil up to 80 KV.	No.	1
h)	Oil tan delta and resistivity measurement kit – Suitable for measurement of volume resistivity, di-electric constant, watt loss, loss factor with elevated temperature read out for transformer oil.	No.	1
i)	Nitrogen Dew point measurement instrument	No.	1
j)	On line moisture removal system (one set for each 3-phase GT bank)	sets	2
k)	Off line portable DGA kit of GE Hydran / Kelmann / Doble make	No.	1
l)	Oil tanker, wheel mounted, 10 kL capacity	No.	1



Sl. No.	Description	Unit	Quantity
3.	Special tools for GIS switchyard		
a)	Leakage current analyzer for Surge Arrester	No.	1
b)	Relay test kit (Numerical)	No.	1
c)	CT and PT Test kit	No.	1
d)	CB analyzer	No.	1
e)	Hand crank for various GIS mechanisms	No.	1
f)	Digital manometer	No.	1
g)	Temperature metering set	No.	1
h)	Relief valve manometer with coupling elements	No.	1
i)	Filling handle	No.	1
j)	A wheeled maintenance device with pressure vessel, vacuum pump and all required gauges and fittings for the service of the GIS switchgear	No.	1
k)	Spring charging hand crank for CB mechanism	No.	1
l)	Gas re-filling and evacuating DILO plant MEGA series	No.	1
m)	980 kg SF6 gas additional storage tank	No.	1
n)	Gas distribution system	No.	1
o)	DILO pipe extension	No.	1
p)	10 m length DILO pipes	No.	1
q)	120 cu.m vacuum pump with maintenance kit	No.	1
r)	Dew point measuring device	No.	1
s)	Portable partial discharge monitoring equipment	No.	1
t)	Portable SF6 gas leakage detector	No.	1
4.	Special tools for HT Switchgear		
a)	Earthing trucks for bus earthing of each voltage rating	Nos.	2
b)	Earthing trucks for cable earthing of each voltage rating	Nos.	2
c)	Breaker Trolleys of each type	Nos.	2
d)	Spanner sets	Nos.	2
5.	Special tools for LT Switchgear	Nos.	2
a)	Breaker Trolleys	Nos.	2
b)	Spanner sets	Nos.	2
6.	Special tools for Battery	Nos.	
a)	Battery Impedance Measurement Kit	Nos.	2
b)	Electronic Battery loading Kit (Torkel Kit/Equivalent) of suitable rating	Nos.	2
c)	Capacity measurement kit (AH integrator for discharge measurement)	Nos.	2
d)	DC Tongue tester suitable for measuring current up to DC 800 A & DC voltage measurement up to 500 V.	Nos.	4



Sl. No.	Description	Unit	Quantity
e)	Portable cell charging unit – suitable for charging 12 cells at 400 A (24 V, 400 A - voltage shall be adjusted up to 220 V with corresponding decrease in current rating)	Nos.	2
7.	Special tools for Telephone system		
a)	Dial testers for DC pulsing and telephone instruments.	Nos.	2
b)	Line-man hand-held telephone sets with DC pulsing and DTMF switch able with built in ringer unit and crocodile clip.	Nos.	3
c)	Krone tools	Set	1
d)	Digital Multimeter	Nos.	2
e)	Special type screw driver set	Set	1
f)	Long nose pliers	Nos.	2
g)	Cutting pliers	Nos.	2
8.	Special tools for GCB		
a)	Lifting equipment necessary to permit removal of one pole or the complete circuit-breaker	No.	1
9.	Portable Aluminium Ladders of various sizes for lamp replacement	Nos.	3
10.	Hand held label printer	Nos.	2
11.	Crimping Tools hand operated	Nos.	5
12.	Crimping Tools Power operated	Nos.	5
13.	Tools kit box, each containing the following items. Make and model of tool shall be subject to Owner's approval.	Set	5
a)	Offset screwdriver		
b)	Insulated screw driver		
c)	Jeweler's screwdriver set		
d)	Pen-type burnisher		
e)	Jeweler's file set		
f)	Push/pull spring hook		
g)	Nut driver set		
h)	Spring tension gauge		
i)	Box wrench, 3/8 and 1/16 inch		
j)	Holding screw driver, 4 – in blade		
k)	Holding screw driver, 3 – in blade		
l)	Hemostat		
m)	Beryllium putty knife		
n)	Thickness gauge, 25- blade		
o)	Spring bender, 90 degree		



Sl. No.	Description	Unit	Quantity
p)	Curved fine-point tweezers		
q)	Fine-point tweezers		
r)	Antistatic, double ended aligner, plastic tip		
s)	Antistatic, double-ended aligner, metal tip		
t)	Folding hex key set		
u)	Flat-nose plier		
v)	Electrician's knife		
w)	Electrician's scissors		
x)	Double-ended holding screwdriver		
y)	Chain-nose plier		
z)	Multipurpose crimper		
aa)	Offset ratchet		
bb)	screwdriver		
cc)	Brush, noncorrosive Beryllium screwdriver		
dd)	Armature stop bender		
ee)	Adjustable wrench		
ff)	Diagonal plier		
gg)	Metric folding hex key set		
hh)	Beryllium screwdriver		
ii)	Magnet cleaner blade		
jj)	Wire stripper		
kk)	Open ended wrench set		
ll)	Spring bender, horizontal slots		
mm)	Adjusting tool, 90 degree		
nn)	Pocket screwdriver, slotted, 1/8 x 2 inch		



SECTION -3.2: GENERATOR

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of Generator, excitation system and associated auxiliary systems.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) Generator
- b) Exciter and Digital Automatic Voltage Regulator (DAVR)
- c) Gas system
- d) Seal oil system Stator water cooling system
- e) Generator instrumentation
- f) Various monitoring system
- g) Various detectors
- h) Surge Protection and Voltage Transformer (SPVT) Cubicle
- i) Neutral Grounding Transformer (NGT) Cubicle
- j) Commissioning spares and consumables
- k) Mandatory spares
- l) Tools & tackles
- m) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS/IEC standards including amendments, except where modified and / or supplemented by this specification. Some of the applicable standards are listed below:

a) IS/IEC 60034-1	Rotating electrical machines- Rating and performance.
b) IS/IEC 60034-3	Rotating electrical machines- Specific requirements for synchronous generators driven by steam turbines or combustion gas turbines
c) IS/IEC 60034-4	Rotating electrical machines- Methods for determining synchronous machine quantities from tests
d) IS/IEC 60034-5	Rotating electrical machines- Degree of protection
e) IS/IEC 60034-8	Rotating electrical machines- Terminal marking and direction of rotation
f) IS/IEC 60034-9	Rotating electrical machines- Noise limit
g) IS/IEC 60034-14	Rotating electrical machines- Mechanical vibration
h) IS/IEC 60034-16	Rotating electrical machines- Excitation system

4.0.0 DESIGN CRITERIA

- 4.1.0 The synchronous generator shall be totally enclosed, three phase, two pole, cylindrical rotor, wye connected directly driven by the steam turbine at 3000 rpm. The efficiency of generator shall be more than 98% at rated load.
- 4.2.0 The turbine-generator shall be connected to the utility network through generator transformer via generator circuit breaker. The generator shall be capable of operating alone, in parallel with other generators and / or with utility grid. The generator and associated system offered by the



Contractor shall be capable of 'islanding' when there is a grid disturbance and continue to supply the 'House loads' continuously.

4.3.0 Generating unit shall meet the requirements of CERC's grid code and TNERC's grid code.

4.4.0 Generator winding shall be class 'F' insulated. Generator shall be capable of delivering continuously the rated power with winding temperature rise limited to Class 'B' temperature range at rated voltage, frequency, power factor and at rated cooling water temperatures and rated gas pressure.

4.5.0 Generator and its excitation system shall have capability to at least match the declared maximum continuous rated output of the associated steam turbine (for the secondary cooling water temperature of 39 degree C) at all power factors between 0.85 lagging and 0.95 leading with +3% to -5% frequency variation, terminal voltage variation of +/-5% as per IEC-60034-3 and combined voltage & frequency variation of 5%. It shall be ensured that when the Generator is working at this capability and cooling water temperature is 39 degree C, no part of the Generator shall attain a temperature in excess of the temperature limits specified for Thermal Class 130(B) insulation as per IEC-60034.

4.6.0 Also the generator and its excitation system shall be capable of continuous stable operation without any excessive temperature rise at the peak output of the associated steam turbine under VWO and HP heaters out conditions, etc. as available for the secondary cooling water temperature of 39 degree C at all power factors between 0.85 lagging and 0.95 leading with +3% to -5% frequency variation, terminal voltage variation of +/-5% and combined voltage & frequency variation of 5%. Temperature of different parts may exceed those permissible for Thermal Class130 (B) insulation under such operating conditions, but shall be lower than those permissible for Thermal Class155 (F) insulation as per IEC-60034.

4.7.0 Generators shall be able to satisfy transmission load reactive requirements under all reasonable anticipated operating conditions. If required by Grid, the plant should be able to meet the reactive requirements so long as the same is within the load capacity curve.

4.8.0 The surge arresters and surge protection capacitors shall limit transient over voltage waves and ensure that generator turn and ground insulation shall not be subjected to excessive electrical stress.

4.9.0 The noise (sound) power level emitted by the generator as measured one (1) metre from the surface of the generator and at 1.5 metre height above floor level shall be limited to 85 dB(A) with suitable sound proof enclosure if required.

4.10.0 The generator shall be designed with water cooled for stator winding, direct hydrogen cooled for rotor winding and stator core. In the event of one cooler being out of service, the generator shall be capable of carrying at least two thirds rated load continuously without exceeding class B temperature limits.

4.11.0 Phase and neutral terminals brought out for connection to isolated phase bus duct.

4.12.0 Generator shall be capable of delivering rated output under following operational conditions:

- i. Voltage variation ($\pm$) 5% of rated value at rated power and rated power factor (as per IEC-60034-3).
- ii. Frequency variation (-) 5 to (+) 3% of 50Hz at rated power and rated power factor (as per IEC-60034-3).
- iii. Combined voltage and frequency variation 5% (absolute sum).
- iv. Power factor variation 0.85 (lag) to 0.95 (lead).



- v. Operation under unbalanced load: As specified in IEC 60034 -1.
- vi. Operation under unsymmetrical short circuit $I_2^2 t$ (where I_2 and t are negative sequence current in p.u. and time in seconds respectively) to be as per IEC 60034 – 1.
- vii. Voltage waveform Total harmonic distortion (THD) to be within limits specified in IEC-60034-1.
- viii. Short circuit withstanding capacity: Capable of withstanding of 3-phase short circuit at the generator terminals when operating at rated MVA and power factor with 5% over voltage for a period of not less than 3 seconds.
- ix. Special operating conditions: Capable of withstanding the electrical, mechanical and thermal stresses developed during fast reclosing of high voltage line, transmission line switching, out of step operation and out of phase synchronization etc.
- x. Line charging capability (MVAR): Not less than 30% of the rated MVA at zero power factor leading.
- xi. Generator neutral earthing: Non-effectively earthed neutral system. Neutral to be earthed through a distribution transformer loaded with a resistor. The core design to permit the flow of earth fault current of at least 15A for 1 second without major any core damage.
- xii. Impulse level and surge protection: Impulse level as per IEC-60034, Pt.15 or as mutually agreed between Manufacturer and the Purchaser. Surge arrestor of suitable rating to be provided for the surge protection of the generator winding. The surge capacitors also to be included.

5.0.0 CONSTRUCTIONAL FEATURES

5.1.0 Generator

- 5.1.1 The stator housing shall be of totally enclosed gas tight construction, having sufficient mechanical strength and rigidity to withstand internal hydrogen explosion without any damage. Degree of protection shall be IP-54.
- 5.1.2 The dimensions of the generator stator body shall be within the maximum permissible rail / road transportation dimensions within the country taking into account the special wagons available/being made available for transporting such heavy oversized consignment.
- 5.1.3 Stator Core material shall be high permeability, low loss, cold rolled silicon sheet steel. The stator winding shall consist of three phase, double layer, short chorded, bar type winding having two parallel paths. The elementary conductors shall be Roebel transposed in the slot portion. Winding Insulation shall be epoxy thermo-setting type and rated for Class 'F' insulation. Adequate semiconducting protection shall be provided on the winding and slots to avoid partial discharges.
- 5.1.4 Winding shall be star connected. Three (3) phase and the three (3) neutral terminals shall be brought out. All stator terminal lead connections inside the generator shall be suitably supported to contain vibration. The overhang portion of the winding shall be of winding suitably braced and supported so as to withstand 3 phase short circuit at its terminals as stipulated in IS/IEC-60034 when the machine is operating at rated MVA, power factor and permissible maximum over voltage. Bushing shall be housed in stator frame in a non-magnetic steel terminal box. Terminal connector shall be silver coated copper for connection to the busduct through flexible.



- 5.1.5 Rotor shall be machined from single alloy steel forging to give the required mechanical, metallurgical and magnetic characteristics. Rotor Winding conductor coils shall be made of hard drawn silver bearing copper and the insulation shall be epoxy glass based material rated for class 'F' insulation.
- 5.1.6 Self-aligning type sleeve bearings either mounted on separate pedestals or on the end shields shall be provided. The bearing housings as well as bearing shells shall be of split construction. The bearing shells shall be lined with tin based Babbitt metal. The hydrostatic jacking arrangement shall be provided in line with turbine bearings. At least one of the bearings shall be suitably insulated. Arrangements shall be provided to measure the insulation of the generator bearing while the machine is in operation.
- 5.1.7 Redundant pick-ups/ transducers shall be provided for bearing metal temperature, bearing drain oil temperature and bearing vibration.
- 5.1.8 The entire generator bearing pedestal shall have vibration pickups in X-Y directions and connected to VMS as detailed in C&I specification (Section-4 of Volume-II).
- 5.1.9 For rotor earthing, brush shall be provided. For shaft voltage monitoring earthing brushes shall be provided at the turbine end bearing pedestal. It should be possible to increase the brush pressure while generator is working.
- 5.1.10 Shaft voltage monitoring system complete with all software and hardware will be provided as per Manufacturer's proven practice integrating with DCS system.
- 5.1.11 An on-line rotor winding temperature monitoring system complete with all software and hardware will be provided as per Manufacturer's proven practice integrating with DCS system.
- 5.1.12 Earthing brushes shall be provided at the turbine end bearing pedestal. It should be possible to increase the brush pressure while Generator is working.
- 5.1.13 Hydrogen Coolers shall be provided with 10% excess tubes. Cooler tubes shall be corrosion resistant with integral fins and arranged in the stator casing so as to avoid the direct fall of water during leakage, if any, on the winding insulation.
- 5.1.14 Generator drying arrangement complete with all accessories and controls to enable drying out operation of the generator with hot air circulation shall be provided.
- 5.1.15 The following detectors shall be provided for the generator. All these remote detectors shall be connected to Unit DCS. Resistance temperature detectors (RTD) shall be provided as stated below, located at points where highest temperature is likely to occur during operation. In case simplex RTDs are provided in place of duplex, they shall be double of those specified.
- Twenty four (24) numbers duplex RTD uniformly distributed along the circumference of the stator and located at the hottest possible zones.
 - Twenty four (24) numbers duplex RTD for stator core out of which twelve (12) shall be located in the end zones where maximum temperatures are expected.
 - Two (2) numbers duplex RTD per H₂ gas cooler section for measurement of inlet and outlet gas temperature.
 - Two (2) numbers duplex RTD per H₂ gas cooler section for measurement of inlet and outlet water temperature.
 - Two (2) numbers duplex RTD per bearing for measurement of Babbitt metal and drain oil temperature.
 - One (1) numbers duplex RTD per bearing for measurement of drain oil temperature.
 - One (1) numbers duplex RTD for primary water inlet and three (3) detectors for primary water outlet for stator winding.
 - Four (4) numbers duplex RTD installed appropriately inside the generator for measurement of cold H₂ gas.



- Four (4) numbers duplex RTD installed appropriately inside the generator for measurement of hot H₂ gas.
- One (1) number Temperature indicator per H₂ gas cooler section in the pipe lines for measurement of inlet and outlet gas temperature.
- One (1) number Temperature indicator per H₂ gas cooler section in the pipe lines for measurement of inlet and outlet water temperature
- Generator casing temperature indicator with vibration absorbent and temperature element for remote.

All the process based interlocks, annunciations and protections for generator & auxiliaries (like seal oil system, stator water system, etc.,) shall be integrated in unit DCS.

5.2.0 Generator Auxiliaries

5.2.1 The following monitoring systems shall be provided for the generator.

- a) On line water temperature monitoring for individual stator winding bars, complete with all software and hardware required to detect any abnormalities in the temperature at any given generator operating point and shall be sensitive to generator loads, header flows, pressure, etc.
- b) Vibration monitoring system comprising six (6) numbers of optical sensor type vibration pickups at each end of overhang portion of the winding, symmetrically located around the periphery with connection to Turbine Supervisory system for vibration monitoring and analysis. Additionally, six numbers optical sensors shall be supplied for future use.
- c) Liquid leakage detector at all the low level points inside the generator casing including end shields along with provisions of indication and alarm during leakage of liquid in generator in case of water cooled machine.
- d) Online Partial Discharge (PD) monitoring system permanently connected with independent sensing unit for each generator, along with necessary terminal equipment and software.
- e) Online harmonic monitor and analyzer.

5.2.2 Gas System

- a) Each generator shall be furnished with hydrogen and carbon dioxide gas supply system including hydrogen gas manifold and CO₂ gas manifold, CO₂ heating system, gas cylinders, hydrogen pressure regulator, interconnecting piping, fittings, valves, gauges, thermometers, pressure transmitters and other instruments, control panels, etc.
- b) Number of gas cylinders shall be equal to total requirement for one start up and one shut down of a unit plus those required to be connected on manifolds of all units plus total requirements for seven days consumption of all units. Adequate spare cylinders shall also be provided.
- c) Purity of hydrogen from 97-99%.
- d) Seamless steel tubes shall be used for valve piping. Valves shall be of glandless diaphragm type, wherever possible.
- e) During purging, filling and emergency operating conditions, the gases shall be expelled to the atmosphere (outside the Turbine building) through a manually operated vent valve.
- f) Hydrogen safety relief valve shall be provided at hydrogen manifold
- g) Refrigeration type driers 2X 100% duties, to maintain the hydrogen inside the machine dry shall be provided. All timer logics and temperature controls shall be carried out in the DCS for H₂ Gas drying system.



- h) At standstill, a suitable hot air blowing system complete with blower, heater and thermostatic control etc. shall be provided to prevent condensation during long shut down.
- i) On line dew point monitoring system shall be provided across the inlet and outlet lines to the drying system along with alarm/annunciation in case of high moisture content in the generator casing hydrogen.
- j) Thermal conductivity type gas analyzer (microprocessor based) shall be provided to continuously analyse the gas discharged from the casing during purging and shall also analyse samples of the casing hydrogen during normal operation.
- k) Portable gas analyser for H₂, CO₂ and O₂ (Already listed under 'Special tools & tackles-Annexure-3.1.1) shall be provided for supervision of the gas purging operation.
- l) The local control panel shall be provided complete with all control, indications, instruments etc. and shall be interfaced with DCS for complete operation. The following instruments shall be provided.
 - o Pressure indicator for the pressure of hydrogen in the hydrogen manifold.
 - o Pressure indicator / local gauge for gas pressure inside the generator.
 - o Gas purity indicator.
 - o Temperature indicator for hot and cold hydrogen inside casing.
 - o Dew point indicator for casing hydrogen across drier inlet and outlet lines
 - o Measurement of %H₂, %CO₂ and %O₂

All the signals available at Local control panel shall also be available at DCS including the following:

- o On line dew point indication and alarms from the monitoring system
 - o On line thermal conductivity
- m) Zener protection and explosive proof circuits shall be employed in hydrogen gas circuit remote measurements.
 - n) Redundant H₂ gas pressure transmitters for generator casing pressure shall be provided and shall be connected to Unit DCS.
 - o) H₂ gas pressure transmitter shall be provided at the hydrogen gas manifold Also H₂ gas pressure transmitter at generator entry level and shall be connected to Unit DCS.
 - p) Provision of H₂ make up flow meter with switching logic for CO₂ and H₂.
 - q) During the transportation and storage the machine/stator coil shall be kept under nitrogen atmosphere..

5.2.3 Seal Oil System

- a) A complete seal oil supply and control system including AC and DC motor operated pump sets, cooler, filters, pressure regulators, oil tanks, degasification tanks, regulating and control valves, gauges, thermometers and other instruments, interconnecting piping including hangers and supports, valves and control panel complete with all interlocking relays shall be provided.
- b) Blowers for venting out hydrogen gas liberated from oil shall be provided suitably mounted at places where such gas accumulation is likely to occur.
- c) 2X100% AC motor driven pumps and 1X100% DC motor driven pump shall be provided.
- d) During short time emergency which may arise due to non-availability of both AC & DC pumps, unit may be tripped and seal oil supply for such coasting down period shall be from a suitable arrangement from lubrication oil system or a damper tank.
- e) Seamless steel piping shall be used in the system.
- f) The seal oil pressure shall be maintained at a pressure suitably in excess of the generator casing hydrogen pressure. The seal oil system shall be so designed that it is possible to



run the machine at no load in air medium at a slightly positive air pressure without any modification in the system.

- g) 2X100% duty seal oil coolers shall be provided with temperature element at inlet and outlet of coolant and oil. These coolers shall be shell and tube plate type suitable for using demineralized (DM) water of condensate quality. Seal oil coolers shall be designed to have 15% excess tube plate surface area over and above designed tube surface area required for the rated load conditions while maintaining the design pressure drop on cooling water side.
- h) Suitable filters of 2X100% duty shall be provided. It shall be possible to carry out cleaning and maintenance of any cooler and filter when the machine is in operation.
- i) The system shall be controlled as part of turbine control system at control room. In addition to the remote control and monitoring, local control and monitoring for this system shall be realized in the local panel mounted near these systems.
- j) Suitable filter shall be provided in the lub oil line to seal oil system to remove dust from entering seals when AC seal oil pump / DC seal oil pump fails to operate.
- k) The local control panel shall be provided complete with all controls, instruments, indications, process interlocks and protection etc. and shall be interfaced with DCS for complete operation.
- l) Redundant seal oil and H₂ gas differential pressure remote measurement shall be installed in individual impulse lines and connected to DCS in addition to the local differential pressure gauge. The DM water seal pots shall be provided in these Seal oil/H₂ gas DP measurements.
- m) All the seal oil tanks connected with generator shall be provided with high and low (for protection) adequate (for interlock) level switches.
- n) The process interlocks, annunciations and protection of seal oil system shall be in Unit DCS.
- o) Seal oil pressure transmitters shall be provided at the pump level and at the seal oil outlet at seal oil skid. Pressure Gauge shall be provided at seal oil inlet to the generator
- p) Duplex RTDs at inlet and outlet seal oil coolers, seal oil pressure transmitters at pump level and at the generator level shall be provided in addition to other process requirement.
- q) The local panel shall not comprise of any process interlocks and protection.

5.2.4 Stator Water Cooling System

Cooling shall be provided with a closed loop stator water cooling system. The stator water pressures shall be maintained suitably less than the generator casing hydrogen pressure. The system shall be provided with the following.

- a) Primary water tank mounted suitably on anti- vibration pads. The empty space in primary water tank shall be with vacuum created by vacuum pump or filled with Nitrogen gas.
- b) Make-up water for primary water system shall be tapped off from condensate extraction pump discharge header and from DM water makeup line to the condenser. The level in the tank shall be maintained by means of suitable valves in the make-up line. The expansion tank level transmitter shall be of radar type or ultrasonic type.
- c) The primary water tanks shall be provided with radar type level transmitters to ascertain the water level and low & very low level switches shall also be provided. Level control shall be envisaged in DCS.
- d) 2X100% capacity water to water heat exchanger shall be designed to accept secondary DM water (condensate quality). The exchanger shall be designed to have 10% excess tube surface area over and above the designed surface area required for the rated load condition while maintaining the design pressure drop on cooling water side.



- e) 2X100% capacity fine wire mesh filters with magnet bars of unlimited life for removal of all magnetic particles.
- f) 2X100% capacity AC motor driven Circulating water pumps.
- g) Mixed bed demineralizer (MBD) of adequate capacity to maintain the required quality of water shall be provided. The MBD shall remain continuously in service in order to retain high purity of stator cooling water with its associated electrical resistivity.
- h) The inlet and outlet lines of mixed bed demineralized shall have conductivity analyzers with LCD digital display and these signals are to be connected to unit DCS.
- i) Conductivity of DM water shall be measured before and after generator stator winding and shall be analysed in DCS to provide necessary annunciation.
- j) Stator water pressure transmitters at pump level and at generator level shall be provided.
- k) Stator water flow very low trip (2 out of 3) shall be derived in Unit DCS using the signals from three DP/DP vortex type transmitters. Three independent DP impulse lines shall be drawn from the orifice plate/ Flow sensor with double isolation. Local flow indicator shall also be installed for field monitoring. Additionally 100% sensors shall be supplied for future use.
- l) DP across strainer measurement shall be provided at local and remote.
- m) One online PH meter with local LCD display shall be provided in the stator water line.
- n) On line conductivity measurement of stator water (Trip through two out of three logic).
- o) On line stator water flow indicator (Trip through two out of three logic).
- p) Set of conductivity meters in the main water circuit and after the demineraliser.
- q) Set of flow switches (at least two nos.) to monitor low distillate condition and flow transmitters/ meters for primary water to stator winding and main bushing, make up water etc.
- r) Dual pressure switch for auto starting of stator water pumps.
- s) Sets of pressure gauges at the inlet and outlet of stator water filters, differential pressure switches for the filters, differential pressure gauge across stator winding and pressure transmitters as required.
- t) Set of resistance temperature detectors, local indicators for primary water before and after the Generator winding, bushing and cooler.
- u) Duplex RTDs shall be provided to give signals for high temperatures.
- v) Alkalising unit to maintain PH value of water within acceptable limit.

The local control panel shall be provided complete with all controls, instruments, indications, process interlocks and protection etc. shall be interfaced with DCS for complete operation.

5.3.0 Generator Excitation System

- 5.3.1 A complete generator excitation and voltage regulating system shall be provided with the generator. **The system shall be Brushless Excitation System or Static excitation system along with Digital Automatic Voltage Regulator.** The excitation system offered shall be of proven design and shall have a satisfactory field service record on machines of similar size and construction incorporating the type of excitation.
- 5.3.2 Excitation system shall have matching characteristics suitable for satisfactory parallel operation with other generators in the plant.



- 5.3.3 Necessary inputs and interface equipment shall be provided with generator excitation and automatic voltage regulator for hooking up with turbine automatic run up system and electro hydraulic governing system.
- 5.3.4 When the generator is subjected to a sudden loss of rated output at rated power factor, the system shall be capable of restoring the voltage of within 2% of the nominal preset value within negligible time, so as not to initiate the protection equipment.
- 5.3.5 The excitation system shall have 2X100% channels including complete power converters, controls and independent DAVRs., Each shall be equipped for 'Auto Operation' with the facility for selecting either channel in 'Auto' or 'Manual' mode.
- 5.3.6 Each excitation system channel shall be designed to continuously carry currents of at least 10% above the field current requirement at generator MCR condition and higher currents for short time duty.
- 5.3.7 Excitation system < 0.5 sec response time as per IEEE 421 A
- 5.3.8 Excitation response ratio > 2
- 5.3.9 Excitation system ceiling voltage > 1.5 times rated load excitation voltage.
- 5.3.10 Each excitation system channel shall be capable of supplying without damage to any of the components, the field forcing voltage and current of the system for a period of 10 seconds without exceeding the limits of temperature for rectifier junction and heat sink.
- 5.3.11 The excitation system shall be designed in such a manner that due to any fault in DAVR firing circuit pulse transformer, rectifying elements in any channel etc. excitation system shall be available with its full capacity. All rectifying elements shall have over voltage and short circuit protection.
- 5.3.12 Pulse transmission & control path to each convertor bridge shall be independent and daisy chain topology is not acceptable.
- 5.3.13 Built-in provision to perform off-line simulation tests on excitation system shall be provided.
- 5.3.14 All the control and converter panels of excitation system shall be housed in a dust free air conditioned room.
- 5.3.15 Necessary arrangement for monitoring rotor winding temperature shall be provided and shall be interfaced with DCS.
- 5.3.16 For brushless excitation system necessary slip rings / brushes shall be provided for detecting an earth fault in field winding. Separate slip rings with associated brushes shall be provided for shaft earthing. The system shall be interfaced with DCS.
- 5.3.17 The excitation system shall be designed for field forcing capability of maximum 200% exciter voltage corresponding to the generator MCR output at rated power factor for less than 10 seconds even for close in faults on high voltage outgoing lines or bolted faults at generator terminals.
- 5.3.18 The excitation system shall be rated to continuously carry current at least 10% above the rated generator field current requirement and the ceiling voltage shall be 160% of the normal required voltage.
- 5.3.19 The rectifier bridges shall have 'N+2' redundancy where N is the number of bridges required to deliver rated excitation current and 'N+1' number of bridges shall deliver the ceiling voltage/current



- 5.3.20 Suitable on line diode monitoring system shall be provided.
- 5.3.21 The excitation system shall be provided with power system stabilizer (PSS) for achieving the dynamic stability of the system under most stringent conditions of operation in the phase of disturbance created by short circuits conditions, load rejections, switching on/ off of transmission lines.
- 5.3.22 The power system stabilizer should have adoptable settings, which should automatically adjust to system reactance. The system should provide automatic and continuous measurement of system reactance and power system stabilizer setting must continually adjust itself for any changes in the system reactance so as to provide required dynamic stability margins.
- 5.3.23 The power system stabilizer in conjunction with the excitation system shall be adjustable to provide damping torque to the machine system and limit the oscillation in the range of 0.1 to 3 Hz. Equipment required for the generation of the control signal to the stabilizer shall be furnished as part of stabilizer. The power system stabilizer parameters shall be co-ordinated with the parameters of the turbine-Generator and the excitation system such that the loading capability of the Generator can be fully utilized.
- 5.3.24 PSS shall be adaptive to varying operating conditions with features to compute optimum stabilising signal along with suitable scheme for identifying external reactance of the generator. Facility for remote manual switch off-on along with indication shall be incorporated. Automatic supervision and blocking/switch off facility along with indications, etc. shall also be provided.
- 5.3.25 There shall be provision for doing open circuit test and short circuit test with all protection in force and slow excitation from DCS.

5.4.0 Brushless Excitation System

- 5.4.1 The brushless excitation system shall consist of :
- a) Permanent Magnet Generator (PMG) type pilot exciter.
 - b) Rectifier unit for PMG
 - c) Brushless main exciter
 - d) Rotating rectifier unit
 - e) Regulator cubicle
 - f) Complete instrumentation and protection system.
 - g) Inter-connecting cables between different components of the system
- 5.4.2 The pilot exciter shall be revolving field, salient pole, permanent magnet high frequency type. The armature shall be stationary 3 phases feeding current to the rectifier assembly and excitation control equipment. The rotor shall be magnetised and stabilised to give stable magnetization characteristic during operation. The stator winding insulation shall be of thermal class 'F' insulation.
- 5.4.3 Main exciter
- Armature shall be of rotating armature, 3-phases, star connected, feeding current to the rotating diodes mounted on the exciter shaft. The armature core shall be made from silicon sheet lamination to reduce eddy losses and shall be suitably varnished on both sides. The exciter shall be totally enclosed, self-support ventilated, frame supported on the generator foundation having journal bearings. Integrally mounted air to water heat exchangers, designed for DM water shall be provided. The stator and rotor winding insulation shall be of thermal class 'F' with the temperature rise limited to class B limits. Rotor winding retaining ring shall be made up of stress corrosion resistant material.



5.4.4 Rotating rectifier assembly

The rectifier assembly made of silicon diodes shall be arranged as two distinct rings with opposite polarity diodes on respective rings. The diodes shall be connected in a conventional three arm full wave rectifier bridge. Rectifier assembly shall have one complete bridge as redundant. Diodes shall be cooled by forced air circulation by means of fans mounted on the main exciter. Each diode shall be provided with a fuse together with visual indication in the event of diode failure. The output from the rectifier shall be fed to the generator field through the bore of the rotor shaft and necessary plug in type of shaft connection. The axial copper connector shall be designed such that it shall be possible to disconnect this connector at the point where the exciter shaft couples to the generator so that, if necessary, the generator and exciter can be tested individually.

5.4.5 Instrumentation and protection of the system shall generally include the following:

- Suitable twin resistance temperature detectors for measuring hot and cold air temperature of exciter with necessary provisions for protection tripping/interlocks.
- Dial type thermometer for measuring the inlet and outlet temperature of water to the air coolers.
- Pressure gauges at the inlet and outlet of water to air coolers.
- Instruments and devices for the measurement of rotor winding temperature.
- Stroboscope or suitable alternative device for detection of faulty rotating diode element.
- Suitable arrangement for exciter field suppression.
- A pair of auxiliary slip rings to give access to the rotor circuit allowing an earth fault detector circuit to be connected.

5.5.0 Static excitation system

5.5.1 If static excitation system is offered, it shall be of proven design and shall have a satisfactory field service record on machines of similar size and construction incorporating the type of excitation. The excitation system shall have matching characteristics suitable for satisfactory parallel operation with other generator.

5.5.2 The system shall conform to the requirements of excitation, stated in the above clauses.

5.5.3 The excitation system shall consist of:

- a) Rectifier transformer
- b) Regulator cubicle
- c) Thyristor convertor cubicles along with firing controls.
- d) DC excitation cubicle housing field circuit breaker, main field flashing device and an over voltage protection.
- e) Interconnecting cables/ bus bars between different equipment/panels of the system.

5.5.4 Rectifier Transformer shall be Indoor, epoxy moulded dry type, 3 phase step down transformer with class 'F' insulation, limiting temperature rise to 'B' limits, housed in sheet steel enclosure, complete with flanges and terminal lugs for connection to the generator terminals through isolated phase bus ducts. It shall withstand through fault current for the time duration equal to de-excitation time of the generator field current for such faults under AVR/manual operation. A set of CTs to be provided in the primary of rectifier transformer for overload protection. Hot spot temperature measurement in each limb of the transformer along with indication as well as alarm and trip contacts shall be provided.

5.5.5 All required protection along with current transformers for metering and protection shall be provided for excitation transformer. Static energy meter with trivector measurement shall be provided at incomer of excitation transformer.

5.5.6 Power thyristor convertor shall be fully controlled three phase, full wave bridge type facilitating fast and high ceiling performance. The thyristors shall be selectively protected against over-



loads by ultra high speed fuses. Suitable lamps indication shall also be provided to indicate the defective 'thyristor'. Gate Firing Circuit The firing circuit shall have the following essential features :

- a) It shall produce a gate pulse for every thyristor once in a cycle.
- b) It shall be able to shift the gate pulse in the time over a range of about 150 electrical degrees under a signal from the regulator.
- c) It shall provide a linear relationship between the regulating inputs volts and rectifier output.
- d) The firing circuit shall have negligible time lag.
- e) It shall fire the thyristors correctly for any situation of input voltage, depression or unbalance coupled with high or low field currents

5.5.7 There shall be a pulse transformer between the individual gates of the parallel connected thyristors and between the main current circuit and the control circuit. Their amplitudes shall be depending upon the trigger characteristics, approximately +3 to +20V peak against cathode.

5.5.8 The initial field flashing shall be from the station's 415 V auxiliary AC supply. Suitable rectifier filters, etc. required for converting this AC supply to the required DC supply shall be housed in the excitation system cubicle. Suitable protection interlock with desired time delay shall be provided so that when the AC terminal voltage of the generator is built up to the required level for the main excitation rectifier system to take over, the field flashing circuit is switched off. In case the main excitation system fails to take over after a predetermined time of field flashing, the field breaker should trip automatically. An annunciation for field flashing failure/main field breaker trip due to field flashing failure shall be incorporated. All the components of field flashing system shall be continuously rated irrespective of its short time duty requirement.

5.5.9 Field breaker shall be of DC, multipole, air break type, suitable for operation from local panel as well as from remote. The breaker shall have arc quenching arrangement for both the main poles as well as the discharge contacts. Breaker shall be designed to carry currents for continuous as well as short time duty of the excitation system. Breaking current capacity of the breaker shall match with the fault level at the output DC bus. Discharge contacts shall be rated to discharge the field energy corresponding to the highest field current which may come during its entire operating range. The breaker shall be complete with control switches, indication lamps, local/remote selector switch, etc. The discharge resistor shall be non-inductive for quick discharge of inductive energy and thereby controlling the voltage across the field. Optional Separate breakers for field application and suppression may also be considered if it is Vendor's standard arrangement. Suitable interlock shall be provided to prevent closing of the field breaker unless the regulator reference signal is at/near the minimum setting and minimum machine speed of 95% is attained. Adequate number of normally open and normally closed field circuit breaker auxiliary contact for remote position indication and interlocking with generator and field flashing circuit shall be provided. DC busbar link, to interchange DC +ve & -ve power supply to avoid non uniform wear and tear, shall be provided in the field breaker cubicle.

5.5.10 A suitable brush-gear with brush assembly, in a well ventilated enclosure shall be provided. Collector rings Insulated helically grooved, alloy steel collector rings shrunk on the rotor. For cooling the slip rings, if required, suitable fans shall be provided either on the collector rings or on the rotor shaft adjacent to it. Brush shall be located only on the upper two third periphery of collector rings. The brushes shall be staggered along the length of collector ring to avoid any non uniform ring wear. Access doors shall be provided to enable replacement and inspection windows shall be provided for inspection of brushes while the machine is in operation. Brush holders shall be constant pressure type which can be adjusted as per requirement. Suitable insulation shall be provided to prevent passage of current through pressure device.

5.6.0 Digital Automatic Voltage Regulators (DAVR)

5.6.1 Digital automatic voltage regulators shall be of microprocessor based numerical type, as per manufacturer's standard and having negligible dead band suitable for a large interconnected



system. Two numbers fully equipped automatic channels shall be provided. Either channel shall be capable of being the main or standby. Either channel shall be capable of being selected as manual also. DAVR Characteristics shall include the following:

- a) Auto control range: $\pm 10\%$ of rated terminal voltage in all modes for voltage level adjustments of generator operation.
- b) Frequency range of operation: 47.5 to 51.5 Hz
- c) Accuracy at which generator voltage to be held: better than 0.5% of the set value over the whole load range of the machine.
- d) Range of transformer drop compensation: 0 to 15%
- e) Max. change in generator: Less than 0.5% voltage when DAVR is transferred from auto to manual under all conditions of excitation.
- f) Manual control range: 70% of no load to 110% full load excitation.

5.6.2 Voltage regulator shall have the following technical features.

- a) Maximum and minimum excitation limiter.
- b) Channel reference microprocessor controlled.
- c) Ramp generation circuit to enable gradual rise of reference signal applied to the circuit to avoid sudden voltage build up.
- d) Suitable feedback proportional to transformer compensation drop to be provided for compensation
- e) A rotor angle limiter to keep the angle between the direct axis of the machine and network vector within the set reference value as determined by stability, by adjusting the excitation.
- f) Stator current limiter to act immediately in under-excited range. The time delay in overexcited range shall enable a temporary overloading of the machine.
- g) Rotor current limiter to act with time delay, so that the regulation dynamics are not impaired in case of a fault.
- h) Voltage/frequency (V/Hz) limiter to limit the ratio of generator voltage and frequency at all operating conditions to such a value that the maximum generator transformer core flux density does not exceed the value specified.
- i) It shall be fail safe such that loss of control supply shall not lead to outage of the excitation system.

5.6.3 Automatic changeover shall be possible in case of trouble in the running from Auto-1 to Auto-2 or channel. vice versa

5.6.4 Automatic change over shall be possible from 'Auto' to 'Manual' in case of :

- Generator protection circuit operation i.e. after field forcing and over excitation condition with a time delay.
- Loss of terminal voltage feedback by way of any of the VT fuse blowing up
- Faulty over excitation condition.
- Loss of automatic channel reference signal
- Power supply failure in the automatic channel
- Manual intervention

5.6.5 The offered DES shall be based on state-of-the-art digital technology. It shall be of continuous rating and accurate. It shall be characterized by fine regulation, high speed response, robust construction, on-line integration with other system like DCS, Non dead-band type and with self monitoring and diagnostics. All accessories mounted in a suitable panel shall be provided. The digital automatic voltage regulators shall be capable of working over the whole load and voltage range of the turbo generator. The System shall be equipped with a HMI system with event logging, fault logging, disturbance recording, parameter monitoring and trending. The HMI shall



work in a Microsoft Windows based computing environment. The HMI hardware shall be made of off the shelf' computing hardware. No proprietary computers, monitors and networking equipments shall be utilized.

The DAVR should consist of two independent Automatic channels with built in backup manual channels and standalone field current regulator. The DAVR shall be redundant in all aspects, including controllers, I/O Systems etc.

The DAVR should have dedicated controller for each channel such as Auto-I and Auto-II of redundant design.

These two independent channels shall perform with one acting as Master and the other as slave.

The Master / slave option shall be selectable either way.

A surge free switch over to standby channel shall be achieved on failure of the active channel, which follows the master controller.

Whenever there is only one channel healthy out of two in service the auto to manual mode shall take over automatically without surge in case of fault in the auto mode.

Selection by the operator for DES operation between channels i.e.master / slave and selection of the mode i.e. Auto/manual shall be possible from remote as well as from local regulator panel.

All the external signals shall be connected with input module and these are interfaced to the controller.

All the output signals shall be connected with output module and these are interfaced to the controller.

Necessary auxiliary relays, auxiliary contactors, control fuses (HRC), transducers, MCB's and selector switches shall be provided as per the control and logic scheme.

Power converter shall have

- (a) Draw out design
- (b) Safe test position for on-line repair and function tests.
- (c) Removal/replacement of the power parts with a module trolley.

Limiters and Compensators

Complete limiter functions shall be dual redundant, incorporated in the controller set. The limiters circuit and compensation circuit shall be available in the Digital AVR system with programmable setting over a wide range are as listed below. The setting values shall be possible to set from local control panel and remote control station (PC) / laptop.

Limiter

Maximum stator current limiter (Lag / Lead)

Under excitation limiter

Maximum Rotor current limiter

Load angle limiter

Over fluxing (Volt / Hz) limiter

Minimum number of Thyristor bridge limiter for limiting the field current in proportion to the number of Thyristor Bridge available.

Adaptive Power system stabilizer (PSS).

**Compensation and other accessories**

Voltage regulation
Active power compensation
Reactive power compensation
Resistive and reactive line drop compensation
Power factor control
Reactive power control
Acceptance of command from paralleling Device/Synchronizer
Maximum Auto reference value setting
Minimum manual reference value setting for separate excitation and normal start.

Protection schemes and interlocks

Rotor over voltage protection for positive and negative poles.
Excitation Transformer over current Instantaneous and delayed (50/51) protection with latest version of Numerical protection Relay.
Two stage microprocessor based Excitation Transformer over temperature protection shall be provided.
Minimum number of active Thyristor bridge protection.
Excessive ceiling duration protection.
Thyristor converter bridge supervising scheme with equipment and protection.
Channel changeover scheme and protection interlocks.
Control supply, synchronizing supply and Regulation supply supervision scheme and Protection.
Field flashing contactor closing, Tripping scheme and protection interlocks.
Field Breaker closing, Tripping scheme and protection interlocks.
Auto reference value supervision scheme and interlocks.
Manual references value supervision scheme and interlocks.
Pulse supervision scheme shall be provided at initial pulse generator and up to final pulse amplification stage.
voltage supervision scheme and protection.
Pulse blocking and pulse releasing scheme and interlock shall be provided during initial voltage buildup.
Pulse inversion scheme shall be provided.
Any other protections which are essential to safeguard the system shall be provided.

Metering:

Individual thyristor current monitoring system shall be provided to monitor the number of working Thyristor i.e. arm wise at the DES panels.

The rotor winding temperature shall be calculated based on on-line field winding resistance. The calculated temperature shall be available as a proportional milliamps signal as an input to a recorder in central control room for display. Reputed make eight channel microprocessor based LED display chart less recorder shall be supplied along with the panel. The offered recorder shall accept (4-20) & (0- 20) mA analog input signals (Universal).

All the indication meters both analog and digital shall have accuracy class of 0.5% or better. Reputed make dedicated analog / Digital meters shall be provided in DES panels and in UCB to display the various critical parameters of the system as follows

HMI and Control Station:

The DES shall be provided with a two numbers (2 Nos.) of excitation control terminals of the latest version for local and a remote display, monitoring and control. In addition, a desktop engineering station networked to the DES with suitable software shall be provided for the



maintenance engineer for the monitoring, controlling, parameter setting, tuning and simulating the DES. A portable engineering station in a Laptop PC shall also be provided. Suitable licenses for the utilization of all the features of proprietary software package shall be provided for the excitation control terminals and for the desktop/laptop engineering stations.

DVR operation shall be possible in both auto mode and manual mode from Central Control room, DES Panel and remote HMI Station.

The local control panel shall be of microprocessor based LED / LCD display unit. It should be possible to interface with the controller via communication cable.

On line parameter monitoring, event logging, fault logging, parameter settings and operation of DES shall be available. The HMI station shall provide real time display and trending of the measured and derived parameters of the DES. The HMI shall also provide real time display of the operating point of the generator in the performance capability display. It shall be possible to set, monitor and tune all the control parameters from the HMI station through the engineering software of the offered control system.

The offered system should have a facility of interfacing with unit DCS. The operation of DES shall be possible from operating station of DCS. Necessary interfacing hardware and software shall be supplied by the bidder

- a) Selection of operation control auto & manual with indication
- b) Field breaker ON /OFF control with indications.
- c) Selection of operation control from UCB, DCS and DES panel.
- d) Reference value (Generator voltage) set point control in auto mode increase and decrease with enable.
- e) Indication at min and max set points in auto mode.
- f) Field current set point control in manual mode increase/decrease with enable.
- g) Indication at minimum & maximum set points in manual mode.
- h) Indication for the limiters in action.
- i) Indication for adoptive power system stabilizer operation.
- j) Indication for field flashing ON / OFF.
- k) Indication for field breaker closing coil healthy.
- l) Indication for the field breaker trip coil healthy and field breaker trip circuit healthy for post and pre closing conditions.
- m) Indication of the system readiness before the start up.
- n) A center zero balance indicator to indicate the channel difference signal.
- o) Generator field current indicator.
- p) Rotor winding temperature recorder.
- q) Generator field breaker/exciter field breaker control & instrumentation.
- r) Auto and manual channel control of excitation level.
- t) Field flashing (for Static Excitation System) and field forcing condition indications.

All indication lamps shall be of LED type.

Alarm

The alarm conditions shall be grouped into three categories.

- a) Common stage I Alarm (less serious)
- b) Common stage II Alarm (serious)
- c) Common stage III Alarm (trip)

All the alarm categories with the designated identity of the abnormal equipments shall be annunciated at the local and CCR.

All alarms shall be of latched type and control only is reset manually.



The potential free output contacts of the above three alarms categories shall be available at the interface terminals for further connection in future

5.7.0 Surge Protection and Voltage Transformer (SPVT) Cubicle

- a) The system shall protect the generator and potential transformers from voltage surges. This system also senses voltage for metering, relaying, and automatic voltage regulation. The SPVT cubicle shall consist of the following major components:-
- Surge capacitors for each phase.
 - Rotating machine surge arresters for each phase.
 - A minimum of two sets of three voltage transformers.
- b) The surge capacitors, rotating machine surge arresters, and voltage transformers that connect to the main isolated phase bus duct and shall be enclosed in the surge protection and potential transformer cabinet. Three separate compartments, one for each phase and each separated from the other by grounded metal barriers to maintain the integrity of the isolated phase bus duct, shall be provided. Capacitors, surge arresters, and potential transformers shall be connected phase-to-ground. Potential transformers shall be fused on both the primary and secondary sides. Potential transformers shall be connected wye-wye and open delta with the neutral of the primary and secondary windings grounded.
- c) The system shall be designed for maximum generator output at any voltage from 95 to 105 percent of rated voltage and a phase-to-ground fault on the connected equipment.
- d) The Potential transformers ratio shall be generator rated voltage / $\sqrt{3}$: 110 V/ $\sqrt{3}$. The burden and accuracy class of the potential transformers shall be co-ordinated with the requirements of the generator control and protection system, requirements of generator excitation system and turbine governing system.
- e) The SPVT cubicle shall be provided separately for each phase and shall be metal clad, dust and vermin proof, free standing, dead front assemblies housing VTs, surge capacitor, surge arrester, fuses on LV side of VT etc. SPVT cubicle shall be fabricated from cold rolled sheet steel for minimum 2 mm thick suitably reinforced to ensure structural rigidity. The degree of protection for SPVT cubicle shall be IP 55.
- f) Each SPVT cubicle shall have seal off bushing at the terminations of tap-off busduct to cubicle.
- g) Surge arrester shall be gapless type, hermetically sealed, connected between line and ground, specifically suitable for generator.
- h) A discharge counter shall be provided for each surge arrester. The discharge counter register shall be visible without having to open the compartment door.
- i) Mineral oil filled / askarel filled surge capacitor shall not be acceptable.
- j) The voltage transformer shall be epoxy cast resin type conforming to IS: 3156.
- k) The voltage transformer along with secondary fuses shall be mounted on draw out type carriage. Suitable guide slots and stops shall be provided to ensure easy withdrawal and positioning. The fixed and draw out contacts of voltage transformer primary shall be tinned or silver plated.

5.8.0 Neutral Grounding Transformer (NGT) Cubicle

- a) The neutral point of a generator shall be earthed to facilitate protection of the stator winding and associated system. Earthing shall also prevent damaging transient overvoltage in the



event of an arcing earth fault or Ferro resonance. For generators, impedance in the form of transformer shall be inserted in the stator earthing connection to limit the magnitude of earth fault current.

- b) The secondary winding of earthing transformer shall be loaded with a resistor of a value which, when referred through the transformer ratio, will pass the chosen short-time earth-fault current. The resistor shall prevent the production of high transient over-voltage in the event of an arcing earth fault, which it does by discharging the bound charge in the circuit capacitance. For this reason, the resistive component of fault current should not be less than the residual capacitance current.
- c) It is important that the earthing transformer never becomes saturated; otherwise a very undesirable condition of ferro resonance may occur. The normal rise of the generated voltage above the rated value caused by a sudden loss of load or by field forcing must be considered, as well as flux doubling in the transformer due to the point-on-wave of voltage application.
- d) The transformer and resistor shall be located in separate enclosure adjacent to each other. The cubicles shall have hinged access doors capable of being locked. The cubicles shall be fabricated from cold rolled sheet steel of minimum 2 mm thickness suitably reinforced to ensure that structural rigidity. Degree of protection for neutral grounding transformer cubicle shall be IP 54. Degree of protection for loading resistor shall be IP 31.
- e) The neutral grounding transformer shall be completely assembled, wired and connected to the neutral bus tap through seal off bushing.
- f) The neutral grounding transformer shall be dry type, natural air cooled, single phase connected between generator neutral and ground.
- g) The loading resistor shall be formed of non-aging, corrosion resistant steel, provided with necessary insulations.
- h) All alarm, protection and indication leads shall be wired up to terminal blocks that shall be mounted in a dust tight enclosure suitable for flush mounting and having a fully hinged cover with lock.

5.9.0 Technical Parameters

SL No.	DESCRIPTION	UNITS	DATA
I	GENERATOR		
1	Rated active power		660 MW, 776 MVA
2	Rated terminal voltage	kV	As per manufacturer's standard
3	Rated frequency	Hz	50
4	Rated Power factor	Cos ϕ	0.85
5	Power factor operating range	Cos ϕ	0.85 lag to 0.95 lead
6	Applicable standard	-	IEC60034
7	Protection class for enclosure	-	IP54
8	Type of Cooling		
	a) Stator Winding		Water
	b) Stator Core		Hydrogen



SL No.	DESCRIPTION	UNITS	DATA
	c) Rotor		Hydrogen
9	Number of phases	-	3
10	Rated speed	rpm	3000
11	Efficiencies at rated voltage frequency and power factor at maximum capability	%	> 98%
12	Short circuit withstand Duration	Sec	3
13	Type of excitation system	-	Brushless excitation system with PMG/Static Excitation System
II	SPVT CUBICLE		
1	Surge Arrester		
	a) Type		Gapless type for rotating machine protection
	d) Nominal discharge current		10 kA
	e) Power frequency spark over voltage		2U+1 kV and BIL of 4U+5 kV (peak), where U is the line to line voltage
2	Voltage Transformer		
	a) Type		Epoxy cast resin drawout
	b) Primary Winding connection		Grounded Wye
	c) Secondary Winding connection		Grounded Wye / Grounded Wye / Open delta
	d) Insulation class		Class E or better
	e) VA Burden		Minimum 100 VA
	f) Accuracy class for protection		3P
	g) Accuracy class for DAVR / EHG / Synchronization and other measurements		0.5
	h) Accuracy class for Acceptance testing, energy accounting and audit meters		0.2S
III	NGT CUBICLE		
1	Neutral grounding transformer		
	a) Type		Cast resin insulated self-cooled
	b) Insulation class		Class F or better
	c) Maximum temperature rise		90°C rise above ambient 50°C
2	Neutral grounding resistor		
	a) Type		Grid type stainless steel
	b) Duty (time rating)		5 minutes
	c) Maximum temperature rise		300°C rise above ambient 50°C

6.0.0 TESTS

6.1.0 Equipment offered shall be of type tested and proven type. Type test reports shall be furnished for generator and exciter.



6.2.0 Tests as listed below shall be carried out at works as per applicable standards. Copies of test reports shall be furnished for approval.

6.2.1 Routine tests on each generator

- 1) Measurement of insulation resistance before high voltage test
- 2) Determination of generator open circuit characteristics.
- 3) No load saturation test
- 4) Stator Phase Sequence Checking.
- 5) Voltage Balance Test
- 6) Measurement of mechanical losses.
- 7) No load heat run & short circuit heat run test at rated hydrogen pressure and with one cooler out of service
- 8) Determination of short circuit characteristics.
- 9) Measurement of core losses at the rated voltage and frequency.
- 10) Measurement of Zero sequence & Negative impedance
- 11) Determination of direct axis synchronous reactance & SCR.
- 12) Equivalent heat runs to determine temperature rises comprising of an open circuit run at 110% of the rated stator voltage followed by a short circuit run at the rated stator current.
- 13) Determination of generator efficiency by the separation of losses at 100%, 80% and 60% load.
- 14) AC high voltage test of stator winding and stator terminal bushings after heat run test.
- 15) Measurement of rotor winding impedance at standstill and rated speed
- 16) Measurement of rotor and stator winding resistance.
- 17) AC high voltage testing of the field windings after the heat run test, with the rotor revolving at 3000 rpm and also with the stationary rotor.
- 18) High voltage testing of resistance temperature detectors after the heat run test.
- 19) Measurement of the insulation resistance after the high voltage test.
- 20) Calculation of the temperature rise of the stator and the rotor.
- 21) Retardation test.
- 22) Measurement of phase to neutral and phase to phase capacitance of all the three phases of the stator and the rotor and calculation of the equivalent generator capacitance as viewed from the generator terminals; also the measurement of the capacitance between the complete winding and the body and the dissipation factor.
- 23) Hydrogen leakage test.
- 24) Partial discharge test.
- 25) Measurement of -ve phase sequence impedance.
- 26) Measurement of zero sequence reactance.
- 27) Residual voltage measurement.
- 28) Phase sequence.
- 29) Shaft voltage
- 30) Vibrations
- 31) Mechanical inspection.
- 32) Measurement of bearing vibrations.
- 33) Over speed test.
- 34) Hydraulic test on coolers.
- 35) Hydraulic tests on machine housings.
- 36) Rotor balance.
- 37) Hydraulic test of stator winding
- 38) Pneumatic test of stator winding
- 39) Rotor purge test



- 40) DPT & UT of bearings, seals and fans
- 41) CC bolt leak test on rotor
- 42) Tests on RTDs
- 43) Core flux test / ELCID test
- 44) NFT test on stator overhang portion

6.2.2 Electrical Tests on DAVR

- 1) Accuracy test.
- 2) Sensitivity test.
- 3) Response ratio test.
- 4) High voltage test.
- 5) Performance test at reduced supply voltage.
- 6) Performance test of all limiters and PSS.
- 7) Impulse input response test.
- 8) Manual channel following auto channel test.
- 9) Range of voltage adjustment test for both auto and manual channels.
- 10) Output test.
- 11) IR test.

6.2.3 Tests on excitation system

- 1) Characteristics check on amplifiers and associated circuitry
- 2) Simulated tests on excitation and DAVR circuits to demonstrate control, response, discrimination and excitation limit features.
- 3) Function and HV test on field breakers.
- 4) High voltage and insulation tests
- 5) Rotor over voltage tests (FAT)
- 6) Thermal withstand test (full load test) for all Thyristor converters (FAT)
- 7) N-2 redundancy test (FAT)
- 8) Thyristor bridge current sharing test at full load (FAT)
- 9) PSS simulation test (SAT)

6.2.4 Type tests for static excitation system

- 1) All type and special tests on excitation transformer as per IS-11171.
- 2) Type tests on field breaker as per IEEE/ANSI C-37-18.
- 3) Temperature rise test of converter panel at MCR rating. Ceiling duty condition of excitation system shall also be demonstrated.
- 4) If busducts are used, the same shall be tested for material. One section shall be tested for temperature rise, dynamic and short time current test, degree of protection test and one minute power frequency high voltage withstand test as per IS:8084.
- 5) Test for estimating the discharging capability of the field discharge resistors in succession for at least two discharges.

6.2.5 Type test reports shall be submitted for the following:

- 1) Converter panel :
 - (i) Input & output surge withstand capability test
 - (ii) Soak test for Electronic module.
- 2) Degree of protection test for Excitation system panels.
- 3) Type tests on thyristors as per relevant International Standards.



6.2.6 Routine tests for static excitation system

- 1) Checking of wiring and cable continuity.
- 2) IR value of complete wiring circuit with all equipments mounted on the panels.
- 3) The high potential test of 2.0 KV for one minute shall be tested on all panels.
- 4) Functional check on electronic modules by simulation.
- 5) Routine test according to relevant standards such as control sequence interlocks as per scheme.
- 6) Lamp Load Test / Water-Rheostat Test on thyristor bridges.
- 7) The offered system should have the built-in off-line test facility to check pulse and control signal thoroughness up to power converter terminals.
- 8) There shall not be any hardware modification required in offered system to carry out slow excitation (separate excitation) during generator OC / SC tests. Changing over from self to separate excitation shall be user-friendly and time saving while doing SC / OC tests for Generator system.
- 10) Online-Offline Test/Simulation facility shall be available to check the functionality of PSS and limiters.

6.3.0 Tests as listed below shall be carried out at site as per applicable standards. Copies of test reports shall be furnished for approval.

6.3.1 Field tests on each generator

- 1) Measurement of the insulation resistance of the stator and rotor windings to the frame and between phases, after drying out the machine, and measurement of the polarisation index
- 2) Measurement of the DC resistance of all windings and embedded temperature detectors
- 3) Measurement of the insulation resistance of bearings
- 4) Capacitance measurement and dissipation factor between the winding and body
- 5) Measurement of rotor impedance at standstill and at rated speed
- 6) Open circuit and short circuit tests
- 7) Measurement of temperature rise at the rated load
- 8) Performance capability of the machine
- 9) Line charging capacity
- 10) Short circuit tests
- 11) Hydrogen leakage test
- 12) Vibration test
- 13) Over speed test
- 14) Hydraulic tests on coolers
- 15) Bearing and shaft current test
- 16) Load throw-off tests
- 17) Rotor Purge Test
- 18) Pneumatic Tests of Stator Winding
- 19) Tests on DAVR
- 20) Core flux test / ELCID test

6.3.2 Field tests static excitation system

Tests on the assembled DES panels shall include, but not be limited to, those listed herein.

- 1) Accuracy test
- 2) Sensitivity test
- 3) Response ratio test
- 4) 2% step test
- 5) Performance test at reduced supply voltage
- 6) Ability of the regulator to maintain voltage under steady load conditions from zero to maximum continuous over voltage rating.
- 7) Performance test of all limiters
- 8) Impulse input response test



- 9) Test for Auto-slave tracking the Auto-master channel and Auto changeover.
- 10) Test for manual mode following Auto mode and Auto changeover to manual.
- 11) Ranges of voltage adjustment test for both Auto and manual mode.
- 12) Thyristor bridge load test
- 13) Functional tests of sub-systems
- 14) Output wave form analysis
- 15) Total harmonic distortion measurements
- 16) All integrated functional tests.

7.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Technical data sheet
- General arrangement and section drawing of generator
- Stator transport outline drawing
- Rotor package transport drawing
- Characteristic curve drawing
- Power capability diagram
- Negative sequence withstand current curve
- Excitation system principle block diagram
- Temperature measuring element layout drawing
- Generator and excitation generator terminal connection terminal board layout drawing
- Generator line side and neutral side drawing
- Stator cooling water and electricity connection diagram
- Rotor pulling through and installation method
- Generator stator cooling water system diagram
- Generator H₂ system diagram
- Generator seal oil system diagram
- Generator load distribution drawing
- Generator installation drawing
- Excitation scheme drawing
- Excitation installation drawing
- General arrangement and section drawing of NGT
- General arrangement and section drawing of SPVT cubicle
- General arrangement and section drawing of DAVR/excitation cubicle
- Technical particulars of auxiliary system
- P&I diagram of auxiliary system
- Sizing Calculation for CT, NGT, NGR & SPVT
- Foundation Plan & loading details
- Erection and commissioning procedures
- Operation and maintenance manual
- Test reports
- Manufacturing quality plan
- Field quality plan

SECTION-3.3: 400 kV GIS SWITCHYARD

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of 400 kV GIS switchyard.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) 400 kV, gas insulated switchgear comprising circuit breakers, isolators, earth switches, current transformers voltage transformers, local control cubicle, etc.
- b) 400 kV outdoor CVT
- c) 400 kV lightning arresters
- d) 400 kV bus post insulators
- e) 400 kV GIS busduct
- f) OPGW communication
- g) Relay panels
- h) Substation Automation System (SAS) with work station and furniture
- i) Tariff metering panels.
- j) 400 kV insulator strings and hardware, conductors, aluminum tubes, bus bar materials, clamps & connectors, shield wires, connectors etc.
- k) Bay marshaling kiosks, Junction boxes
- l) Overhead line connection between generator transformers, Bus reactors and standby transformers and GIS Switchyard.
- m) SF6 gas cylinders
- n) Gantries and structures
- o) Commissioning spares and consumables
- p) Mandatory spares
- q) Tools & tackles
- r) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS/IEC standards including amendments, except where modified and / or supplemented by this specification. Some of the applicable standards are listed below:

a)	IEC 62271-203	Gas Insulated metal-enclosed switchgear for rated voltages above 52 KV
b)	IEC 60376	New sulphur hexafluoride
c)	IEC 62271-1	High-voltage switchgear and control gear - Common specification
d)	IEC 62271-100	High voltage alternating current circuit breakers
e)	IEC 62271-102	Alternating current disconnectors(isolate) and earthing switches
f)	IEC 61869-2	Additional requirements for current transformers
g)	IEC 61869-3	Additional requirements for inductive voltage transformers
h)	IEC 60137	Bushings for alternating voltages above 1000 V
i)	IEC 61639	Direct connection between power transformers and gas insulated metal enclosed switchgear for rated voltages of 72.5 kV and above
j)	IEEE C37.122.1	Guide for Gas-Insulated Substations



k)	IEC 61869-5	Additional requirements for capacitive voltage transformers
l)	IEC 60358	Coupling capacitors and capacitor dividers
m)	IEEE 1138	IEEE standard for testing and performance for optical ground wire (OPGW) for use on electric utility power lines.
n)	IEC 60794-4	Optical fiber cables
o)	IS 3070-3	Lightning arresters for alternating current systems – Metal oxide lightning arresters without gaps
p)	IEC 60099-4	Metal oxide surge arresters without gaps
q)	IEC 61850	Communication network and systems in substations
r)	IEC 60255	Electrical Relays
s)	IEC 60359	Expression of the performance of electrical & electronic measuring equipment
t)	IEC 60447	Basic and safety principles for man machine interface (MMI) – Actuating principles
u)	ANSI C37.2	Manual and automatic station control, supervisory and associated telemetering equipment
v)	IS 14697	Specification for AC static transformer operated watt-hour and var-hour meters, Class 0.2S and 0.5
w)	IEC 62053 -61	Electricity metering equipment
x)	IEEE 693	Recommended practice for seismic design of substation.
y)	IEEE 80	IEEE Guide for safety in AC substation grounding

4.0.0 DESIGN ASPECTS

4.1.0 GIS Switchyard shall have three single phase construction, **one and half breaker arrangement** (D-type) having the following bays.

- Two numbers Generator transformer (GT) bays
- One number Standby maintenance transformer bay
- Four numbers Line bays
- Two numbers Bus reactor bays
- Two numbers Bus VT bays
- One number spare bay (fully equipped)
- Bus sectionalizing isolator for each bus
- Two numbers spare bay (Unequipped)

4.2.0 **400 kV GIS switchyard Single Line Diagram is attached in Section-7 of Volume-II.**

4.3.0 Two line feeders of double circuit tower should not be fed from same diameter/same bus. Line feeder and GT feeder shall be fed from the same diameter.

4.4.0 The gas insulated bus duct enclosures shall be of aluminum alloy material. The following equipment shall be located in the SF6 insulated enclosure.

- Circuit breakers
- Disconnectors
- Earth switches
- Current transformers
- Voltage transformers

4.5.0 GIS equipment shall be free standing, metal enclosed, sectionalized with gas tight barriers between sections or compartments, self-supporting, SF6 gas insulated, with single phase encapsulated made out of aluminium enclosures.



- 4.6.0 The gas sections/ compartments shall be arranged so that extension in future can be made at any end without any cutting / welding, drilling on the operational / existing bay/ equipment. Future extension shall be accessible without any shut down of operating bays.
- 4.7.0 Unless specified otherwise, at least 10 % margin shall be considered in equipment sizing over and above the calculated load current / fault current / power requirements.
- 4.8.0 The GIS sizing shall be based on design ambient temperature of 50°C and design relative humidity of 95% maximum. Temperature rise of current carrying parts shall be limited to the values stipulated in IEC-60694, under rated current and the climatic conditions at site. The temperature rise for accessible enclosure shall not exceed 20°C over an ambient temperature of 50°C.
- 4.9.0 Current rating of the busduct shall be same as that of the circuit breaker rating in the circuit.
- 4.10.0 The GIS enclosures shall be suitable to withstand an internal flash over without burn through for a period of 0.3 sec. The GIS Enclosures shall be suitably designed to withstand a fault for a period of back up protection relay to clear the fault (i.e. for approximately 0.3 sec for 63 kA minimum).
- 4.11.0 SF6 gas pressure loss within each gas filled compartment individually as well as complete installation shall not be more than 0.5% per year.
- 4.12.0 GIS shall be modular having:
- Fail safe inter and intra bay inter locking scheme
 - Interchangeability of similar parts
 - Gas density switch for each isolated section / module
- 4.13.0 GIS shall be subdivided into the following separately monitored zones:
- Each SF6 / air bushing termination (line / Generator / Transformer / Reactor) with its associated disconnecter and high speed earthing switch
 - Each circuit-breaker, including its associated CTs
 - Each Voltage transformers for bus bars
 - Each Bus bar low speed earthing switch along with its associated disconnecter
- 4.14.0 The arrangement shall be single-phase enclosed. The assembly shall consist of completely separate pressurized sections designed to minimize the risk of damage to personnel or adjacent sections in the event of a failure occurring within the equipment. Rupture diaphragms shall be provided to prevent the enclosures from uncontrolled bursting and suitable deflectors provide protection for the operating personnel.
- 4.15.0 A separate, free-standing Local Control Cubicle (LCC) shall be provided for each GIS bay. The LCC shall contain devices required for the operation and monitoring of the circuit breaker, Disconnector & earthing switch. It shall include necessary motor protection devices, Interlocking relays, time relays, coupler relays for the remote control, alarm indicator, terminal Blocks, etc. On the front of the local control cubicle, a mimic diagram depicting all control switches, position indicator for the control shall be provided.
- 4.16.0 The enclosure shall be of continuous design and shall be provided with high frequency earthing arrangement as specified in IEEE- 80.**
- 4.17.0 The enclosure shall be sized for carrying induced current equal to the rated current of the bus. The conductor and the enclosure shall form the concentric pair with effective shielding of the field internal to the enclosure.



- 4.18.0 The enclosure shall be designed to practically eliminate the external electromagnetic field and thereby electro-dynamic stresses even under short circuit conditions. The Average Intensity of electromagnetic field shall not be more than 50 micro tesla.
- 4.19.0 Current transformers, voltage transformers and tariff meters shall meet the requirements of the Electricity Regulatory Commission / Transmission Utility.
- 4.20.0 Gas insulated switchyard shall be located in front of transformer yard of power plant. The sequence of bays shall be so arranged that the maximum horizontal angle of deviation of the incoming power and shielding conductors does not exceed 30°. Similarly the point of anchoring on incoming towers shall be such that the vertical angle of deviation is limited to 30° from horizontal plane.
- 4.21.0 Separate storage facility for empty SF6 gas cylinders and filled SF6 cylinders with chain & lock arrangement shall be provided in the GIS building.
- 4.22.0 GIS building shall be provided with required electrically operated overhead crane, ventilation system, Air Conditioning, fire alarm and firefighting system.

5.0.0 CIRCUIT BREAKER

- 5.1.0 Circuit breakers shall be of sulphur hexafluoride (SF6) type and shall use SF6 gas for both insulation and arc quenching. It shall be high speed, single and three phase reclosing, with operating sequence and timing as specified. SF6 Circuit breakers shall comprise metal enclosed breaker poles (Puffer type). The Circuit breakers shall be horizontal mounted and shall withstand the forces imposed during earthquake.
- 5.2.0 Circuit breakers shall be of class C2-M2 as per IEC. The circuit breakers shall be capable of performing their duties without opening resistors. Specifically, they shall be capable of the following:
- Interrupting the steady state and transient magnetizing current of power transformers.
 - Interrupting line / cable charging current as per IEC without use of opening resistors.
 - Clearing short line faults (kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.
 - Breaking 25% of the rated fault current at twice rated voltage under phase opposition condition.
- 5.3.0 The breakers shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energization of lines with trapped charges.
- 5.4.0 For all line feeders pre insertion resistor (PIR) shall be provided. Further, switching controllers shall be provided in circuit breakers used for switching shunt reactors for lines / buses and transformers. The switching controller shall enable the optimization of switching behavior.
- 5.5.0 Circuit breaker shall have spring charged mechanism or hydraulic operated mechanism.
- 5.6.0 Necessary ports/Sensors/suitable means for using portable tools and tackles shall be provided
- 5.7.0 Auto-reclosing relay shall be provided for auto reclosing of 1 pole / 3 pole operations as specified. The breaker shall be suitable for single phase and three phase auto-reclosing.
- 5.8.0 Each breaker pole shall be provided with two independent tripping circuits, pressure switches and tripping coils each fed from separate DC sources and connected to different set of protective relays. SF6 lockout logic shall be fail safe.



5.9.0 The total break time shall not be exceeded under any of the following duties:

- Test duties T10, T30, T60, T100 (with TRV as per IEC- 62271-100)
- Short line fault L90, L75 (with TRV as per IEC-62271-100)
- The total break time of the breaker shall not be exceeded under combined variation of the trip coil voltage (70-110%), pneumatic/hydraulic pressure and SF6 gas pressure etc.
- The values guaranteed shall be supported with the type test reports.

6.0.0 ISOLATOR

6.1.0 Isolators shall be Indoor, gas insulated, single-pole, 3-phase, group operated type, off-load break type, installed in the GIS to provide electrical isolation of the circuit breakers, transformers, shunt reactor, bus and transmission lines. The Isolators shall be operated by electric motor rated for 220 V DC supply and shall be equipped with a manual operating mechanism or with hand cranks for emergency use. Isolators shall be with mechanical endurance class M1.

6.2.0 Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the systems in their closed position. They shall be constructed such that they do not open under influence of short circuit current.

6.3.0 Isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated interlocking conditions are met. All these interlocks shall be of failsafe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within a variation range as stipulated.

6.4.0 The isolator shall be capable of making / breaking normal currents when no significant change in voltage occurs across the terminals of each pole of isolator on account of make / break operation.

6.5.0 Isolators shall be fitted with an optical indicator per pole located between pole & driving rod so that open or closed contacts of the isolator are visible from floor level.

6.6.0 The disconnecting switches shall be arranged in such a way that all the three phases operate simultaneously. All the parts of the operating mechanism shall be able to withstand starting torque of the motor mechanism without damage until the motor overload protection operates.

7.0.0 MAINTENANCE EARTH SWITCHES

7.1.0 Maintenance Earth switches shall form an integral part of the isolator. Earth switches shall be only locally operated from the local control cubicle. The maintenance earth switches shall be constructionally interlocked with the isolator so that the maintenance earth switches can be operated only when the isolator and circuit breaker is open and vice versa. The constructional interlocks shall be built in the construction of isolator and shall be in addition to the electrical interlocks. Locking facility shall be provided for both close and open position.

7.2.0 The earth switch shall have three poles, group operated, with one motor operated mechanism per three poles and additionally with an emergency manual operation using operating handles or hand cranks. Once initiated, the motor mechanism shall complete an open or close operation without requiring the initiating contact to be held closed. Maintenance earth switch should be able to carry the same fault current as like Isolators and shall withstand dynamic stresses.

7.3.0 The earth switch shall also comply with the requirements of IEC-601129, in respect of induced current switching duty as defined for Class-B Earth switches.



- 7.4.0 Maintenance earth switch shall be provided with indicators on each pole for visual inspection of each switch contact position.
- 7.5.0 Main grounding connections on each earth switch shall be rated to carry the full short circuit rating of the switch for 1 sec. and shall be equipped with a silver plated terminal connector suitable for steel strap of adequate rating for connection to the grounding grid.

8.0.0 FAST ACTING EARTH SWITCHES

- 8.1.0 Fast acting earth switches shall be used to earth insulated sections of installation to protect personnel during overhaul assembly and at each busbar all external connecting feeders like overhead lines, transformer connections, HV cables. These switches shall be located at the beginning of the feeder bay modules and shall be of high speed, make proof type and used to discharge the respective charging currents, in addition to their safety function. These switches shall be capable of interrupting the inductive currents and to withstand the associated TRV.
- 8.2.0 Fast acting Earth switches shall include the complete operating mechanism and auxiliary contacts. Fast acting Earth switches shall be locally operated from the local control cubicle as well as from remote through selection facility. These fast acting earth switches shall be electrically interlocked with their associated circuit breakers & isolators so that the grounding switches cannot be closed if the circuit breaker & isolators are closed.
- 8.3.0 Fast acting Earth switches shall be constructionally interlocked with their associated circuit breaker such that the grounding switches cannot be closed if the circuit breakers are closed. The grounding switches shall be required to close before the isolator switches are opened in order to dissipate the trapped charges, when the lines are taken out of service for maintenance, etc. The constructional interlocks shall be built in construction of isolator and shall be in addition to the electrical interlocks. Locking facility shall be provided for both close and open position.
- 8.4.0 Fast acting earth switch shall be single pole operated, with one motor operated mechanism per single pole and additionally with an emergency manual operation using operating handles or hand cranks. These shall be fitted with a stored energy closing system to provide fault making capability. Once initiated, the motor mechanism shall complete an open or close operation without requiring the initiating contact to be held closed. Maintenance earth switch should be able to carry the same fault current as its peak withstands current rating.
- 8.5.0 Fast acting earth switch shall also comply with the requirements of IEC - 622271-102 in general and IEC-601129, in respect of induced current switching duty as defined for Class-B Earth switches.
- 8.6.0 Fast acting earth switch shall be provided with indicators on each pole for visual inspection of each switch contact position.

9.0.0 CURRENT TRANSFORMERS

- 9.1.0 The current transformers shall be of metal enclosed, inductive type, nonresistant and shall be contained in their own-SF6 compartment, separated from other parts of installation. The transformers shall be effectively shielded against high frequency electromagnetic transients. Short time rating of CTs shall be not less than that of the associated switchgear.
- 9.2.0 Gas insulated current transformers, shall be used for protective relaying and metering with fully distributed secondary windings. The CT's shall have multi core with multi ratio, which shall be changeable by means of taps on the secondary side. The secondary leads shall be brought out into the secondary terminal box.
- 9.3.0 The secondary windings shall be air insulated and mounted inside the metal enclosure. All CTs shall have effective electromagnetic shields to protect against high frequency transients.



- 9.4.0 Different ratios specified shall be achieved by secondary taps only and primary reconnection shall not be accepted.
- 9.5.0 Current transformer's guaranteed burdens and accuracy class shall be simultaneous for all cores. Current transformer, characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 10% to 100% of rated current in case of metering CTs and up to the accuracy limit factor / knee point voltage in case of relaying CTs. For differential protection and REF protection, PS class CT shall be provided and for overcurrent protection 5P20 class shall be provided.
- 9.6.0 Current transformers shall be suitable for high speed auto reclosing.
- 9.7.0 The rated extended primary current shall be 150% at highest ratio and 200% at ratios other than highest ratios. The transformer shall be able to sustain full line to line voltage without saturation of transformer. The accuracy class shall be at maximum tap.

10.0.0 VOLTAGE TRANSFORMER

- 10.1.0 Voltage transformer shall be of electromagnetic inductive type fully encapsulated in GIS, single phase unit, constructed and tested in accordance with IEC 60044-02. VT gas compartment shall be segregated from the adjacent GIS compartments so that VT housing shall be grounded to the GIS enclosure. The damping device, which should be permanently connected to one of the secondary windings, should be capable of suppressing the ferro-resonance oscillations.
- 10.2.0 The electromagnetic unit comprising compensating reactor, intermediate transformer and protective and damping devices should have separate terminal box with all the secondary terminals brought out.
- 10.3.0 The VT gas compartment shall be isolated from the adjacent gas compartments with separate gas supervision. If the VT gas compartment is connected to the line isolator gas compartment. A non-return valve shall be provided to avoid entering of any decomposed gas from the isolator gas compartment to the VT gas compartment. Bus VTs shall be located in a separate bay module on the bus and connected phase to ground to the phase buses.
- 10.4.0 The bus VT's shall be connected through hand operated isolators, which are to be provided with lock facilities and locks.

11.0.0 LOCAL CONTROL CUBICLE (LCC)

- 11.1.0 For each bay, a separate local control cubicle including gas monitoring kiosk shall be provided which shall be installed in respective bay for local control & monitoring. The LCC shall be equipped with suitable hardware & software for remote control operation.
- 11.2.0 The LCC shall contain necessary devices for the operation and monitoring of the GIS apparatuses. On the front of the LCC, mimic diagram depicting all controls, indications and metering shall be provided.
- 11.3.0 All control and interlock functions shall be configured in LCC.
- 11.4.0 Required alarms and indications shall be provided in LCC. Alarm circuit shall not respond to faults for momentary conditions.
- 11.5.0 LCC shall be of simplex type design. It shall consist of CRCA sheet steel of minimum 2 mm thickness and shall provide a degree of protection not less than IP 31. Panels shall be free standing, floor-mounting type. All doors and removable covers of panels shall be gasketed all around. Anti-vibration pads shall be placed between panel and base frame. Cable entries to the panels shall be from the bottom.

**12.0.0 GIS ENCLOSURE**

- 12.1.0 SF6 Busducts shall be of aluminium alloy, modular, single phase encapsulated. Homogeneous epoxy resin insulator shall be used to support the conductors inside the enclosures. Metal bellow type compensators with adjustable tensions shall be provided, wherever required.
- 12.2.0 The bus enclosure should be sectionalized in a manner that maintenance work on any bus disconnector can be carried out by isolating and evacuating the small effected section and not the entire bus. The enclosure sub-divided into individual arc and gas proof compartments for ;
- Busbar section with associated busbar disconnector.
 - Circuit breaker
 - Line disconnectors
- 12.3.0 Adequate provision shall be made to allow for the thermal expansion of the conductors and of differential thermal expansion between the conductors and the enclosures. The bellows shall be metallic.
- 12.4.0 The enclosure shall be designed for the mechanical and thermal loads to which it is subjected in service. The enclosure shall be manufactured and tested according to the pressure vessel code. Each enclosure has to be tested as a routine test at 1.5 times the design pressure for one minute. The bursting strength of aluminium castings shall be at least 5 times the design pressure and the same shall be tested as a type test on each type of enclosure.

13.0.0 GIS GROUNDING

Refer 'Earthing' Section.

14.0.0 GIS AUXILIARY EQUIPMENT**14.1.0 Gas to Air Bushing**

The Connection between overhead line and SF6 gas equipment shall be done using 'gas to air' bushing. This bushing shall be made out of composite insulator like Silicon rubber. The internal insulation of the bushings can be a resin impregnated paper winding (RIP) or compressed SF₆-gas. The internal and external electrical field of the bushings shall be controlled by capacitive grading body or by grading shields. Bushing shall have Creepage distance of 31 mm/kV and shall be suitable for outdoor mounting on steel structure.

14.2.0 SF6 Gas properties

The SF6 gas shall conform to IEC-60376, IEC-60376A & IEC-60376B. The gas shall be suitable in all respects for use in the switchgear under all operating conditions. High pressure cylinder in which SF6 gas is supplied & stored at site shall comply with the requirements of IS: 4379 & IS 7311.

14.3.0 Pressure relief device

Pressure relief devices shall be provided in the gas sections to protect the main gas enclosures from damage or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electrical fault arcs (preferably in downward direction). Each gas-filled compartment shall be equipped with filters, density switches, filling valve and safety diaphragm. Each gas compartment shall be fitted with separate non-return valve connectors for evacuating & filling the gas and checking the gas pressure etc.

Portable Partial Discharge (PD) monitoring system (Already listed under 'Special tools & tackles-Annexure-3.1.1) shall be provided for detecting different types of defects in GIS, such as particles, loose shields and PD as well as for detection of PDs in other of equipment like CTs, PTs, Gas busduct, etc. with hot sticks. PD monitoring equipment shall be suitable for



measuring the PD in charged GIS condition with bandwidth in the order of 10 KHz - 500 KHz, with selection for intermediate bandwidths.

- 14.4.0 **SF6 Gas processing Unit:** SF6 processing unit suitable for evacuating, liquefying, evaporating, filling, drying and purifying SF6 gas shall be provided.
- 14.5.0 **SF6 Gas Monitoring Devices and Alarm circuits:** Dial type temperature compensated gas density or density monitoring devices associated pressure gauge shall be provided. The devices shall provide continuous & automatic monitoring of the state of the gas & a separate device shall be provided for each gas compartment so the each compartment shall be monitored simultaneously.
- 14.6.0 **Gas Supply System:** SF6 gas necessary for filing & putting into operation the complete switchgear installation shall be supplied. In addition, 10% of total gas requirement shall be supplied in separate cylinders as spare requirement.
- 14.7.0 **Dew Point Meter** (Already listed under 'Special tools & tackles-Annexure-3.1.1) : This Dew point meter shall be portable and suitable for measuring the dew point of SF6 gas in the Circuit breaker.
- 14.8.0 **Portable SF6 gas leakage detector** (Already listed under 'Special tools & tackles-Annexure-3.1.1): SF6 gas leakage detector shall be provided with a rubber suction bulb, DC dry cell battery operated.

15.0.0 CAPACITIVE VOLTAGE TRANSFORMER

- 15.1.0 Capacitive voltage transformer (CVT) shall be capacitor voltage divider type with electromagnetic unit, suitable for outdoor service. CVT shall be used for metering and protection.
- 15.2.0 The accuracy class specified shall be maintained throughout the entire burden range on all the windings without any adjustments during operation. CVT's guaranteed burdens and accuracy class shall be simultaneous for all cores.
- 15.3.0 A protective surge arrester shall be provided to prevent breakdown of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor / primary winding, tuning reactor / RF choke etc. due to short circuit in transformer secondary. CVT shall be provided with test cap for measurement of capacitance and loss factor.
- 15.4.0 Insulating oil in CVT shall be EHV grade conforming to IS 335. Bushing / insulator for CVT shall be one piece without any metallic flange joint.

16.0.0 LIGHTNING ARRESTERS

- 16.1.0 Lightning arresters shall be provided for all the line feeders, transformer feeders and reactor bays. Lightning arresters shall be of hermetically sealed units, self-supporting construction, suitable for mounting on outdoor steel support structures.
- 16.2.0 The lightning arresters shall be of heavy duty station class and gapless type without any series or shunt gaps. The lightning arresters shall be capable of discharging over-voltages occurring during switching of unloaded transformers, reactors and long lines.
- 16.3.0 Lightning arrester shall be capable discharging energy equivalent to specified class on two successive operations, as required by relevant standards. The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.
- 16.4.0 The non-linear blocks shall be of sintered metal oxide material. The lightning arresters shall be fitted with pressure relief devices suitable for preventing shattering of porcelain housing and providing path for flow of rated fault currents in the event of arrester failure. Seals shall be



provided in such a way that these are always effectively maintained even when discharging rated lightning current.

- 16.5.0 Arresters shall be complete with insulating base having provision for bolting to flat surface of structure. On insulating base, ground terminal bracket shall be provided. Line terminal and ground terminal shall be of stainless steel.
- 16.6.0 Each single pole unit shall be provided with discharge counter and leakage current meters mounted in sheet steel enclosure of IP 55 degree of protection. The reading of milli-ammeter and counters shall be visible through an inspection glass panel. XLPE insulated copper conductor of adequate size and length shall be used for connecting discharge counter terminal and lightning arrester earth terminal. Bypass copper shunts shall also be provided for bypassing the discharging counter for removal / maintenance of counter. The supporting structure for lightning arrester shall be provided with a mounting pad, for fixing discharge counters and leakage current meters.
- 16.7.0 Grading / corona rings and intermediate ring of hot dip galvanized steel shall be provided on each arrester unit.

17.0.0 COMMUNICATION

17.1.0 Optical fiber communication

- 17.1.1 The fiber optic communication network shall support the voice & data communication requirements of GIS switchyard . The fiber optic network shall be based on the Synchronous Digital Hierarchy (SDH). Optical fiber communication system shall include all required equipment including the following:
- Terminal box
 - Fiber optic approach cable (single mode fiber)
 - Fibre optic distribution panel
 - Termination Equipment Subsystems
 - Network Management System
 - Cables and Cabling
 - Equipment Cabinets
 - ADM type OLTE
 - Primary mux
 - Cross connect multiplexer
 - Digital protection coupler with E1 interface
- 17.1.2 A fiber optic approach cable (armoured) shall be provided to connect Overhead Fibre Optic Cable (OPGW-Single mode communication) between the final in line splice enclosure on the gantry / tower forming the termination of the fiber cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building.
- 17.1.3 Approach cable shall contain fibres with identical optical/ physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), fiber support/bedding structure, core wrap/bedding, and an overall impervious jacket.
- 17.1.4 Fibre Optic Distribution Panels (FODP) shall be designed to provide protection for fiber splicing of pre-connectorized pigtails and to accommodate connectorized termination and coupling of the fiber cables. All FODPs shall be of corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Ground lugs shall be provided on all FODPs and properly grounded. The FODP shall meet ingress protection class IP55 specification.
- 17.1.5 Transmission equipment shall have SDH equipment comprising common cards, Cross-connect/control cards, Optical base card, Power supply cards, optical card, tributary card,



power cabling, other ,hardware & accessories including sub-racks, patch cords, DDF,etc. fully equipped.

- 17.1.6 Termination equipment shall have primary multiplexer (comprising Subscriber Line Interface Cards, common cards, Power supply cards, power cabling, other ,hardware & accessories including sub-racks, etc. fully equipped), Insert Multiplexer(comprising Subscriber Line Interface Cards, common cards, Power supply cards, power cabling, other ,hardware & accessories including sub-racks, etc. fully equipped) and Digital Access Cross Connect Switch (DACS).
- 17.1.7 Network management system shall comprise required hardware, software, workstation, Multi function printer etc.
- 17.1.8 Fiber Optic (FO) cables shall be primary coated single mode fiber, filled, loose tubes, assembled around the central strength member, filled core, metallic moisture barrier, polyethylene sheathed optical fibre telecommunication cables, complying with National and International Standard Specifications. For outdoor application, it shall be armoured type.
- 17.1.9 EPABX for OPGW shall be of state of the art equipment specially designed for the application. The requirements of EPABX are covered in separate section titled 'Communication System'.

18.0.0 RELAY PANELS

- 18.1.0 All main protective relays shall be of fully numerical type. The relays shall have features for continuous monitoring of all the components and power supply and healthy indication lamps. Any failure may be indicated with external alarm. The relays shall have programmable output relays to configure trip and other alarm functions. The communication protocol shall be as per IEC 61850. Relays shall be of latest design, high end latest model.
- 18.2.0 All the protection relays shall be numerical type provided with communication port to facilitate interfacing with Substation Automation system (SAS). It shall be possible to carry out / modify settings of relays from SAS. Necessary software shall be loaded in SAS.
- 18.3.0 For all the numerical relays and disturbance recorder, time synchronizing signal shall be derived from main plant GPS signal equipment. Type of clock signal format shall be coordinated.
- 18.4.0 Separate relay panels shall be provided for each feeder, bus coupler and busbar protection.
- 18.5.0 Line protection
- a) The line protection panel shall consist of following relays and protection schemes, in two separate groups.
- Main-I numerical distance protection scheme
 - Main-II numerical distance protection scheme of different hardware platform and different make from that of main –I
 - Directional inverse definite minimum time (IDMT) type earth fault relay
 - Two stage over voltage protection
 - Auto-reclosing (single phase and three phase)
 - Distance to fault locator
 - Synchronizing check relay
- b) Each distance protection of non switched 5 zone having separate measurements for all the phase & earth faults with selectable characteristic shall have following features:
- Distance protection
 - Carrier communication logic for distance protection.
 - Switch On To Fault (SOTF).



- Power swing detection.
 - Fuse failure detection.
 - Over current stub protection
 - Over-Voltage protection
 - Directional earth fault protection
 - Directional over current protection
 - Negative sequence protection for alarm and indication.
 - Fault locator
 - Disturbance recorder
 - Extensive self-supervision
 - IEC 61850 communication protocol
- c) Each group of line protection shall have separate lockout relays with supervision.
- d) Line differential relays shall be provided for shorter line lengths.
- e) Line differential protection shall be considered for lines having OPGW network.
- f) Phasor Measurement Unit (PMU) shall be provided for feeders as per the requirement of grid authority.
- g) For line feeders, synchronizing socket shall be provided in the relay panel, for manual synchronizing through synchronizing trolley.

18.6.0 Reactor Protection

Reactors shall be provided with the following protections through numerical multifunction protection relay:

- Differential protection
- Restricted earth fault protection
- Backup overcurrent and earth fault protection
- Backup impedance protection
- Extensive self-supervision
- IEC 61850 communication protocol

Other protections such as Buchholz, oil / winding temperature, pressure relief device, low oil level alarm etc. shall also be provided through independent auxiliary relays to energize the master trip relays.

18.7.0 Generator transformer feeder protection

Generator transformer protection shall be provided in a separate panel as covered in the '**Relay panel**' section. In the switchyard relay panel, feeder protections shall be provided through numerical relay and shall have following features:

- Backup phase overcurrent protection.
- Backup ground fault protection.
- Extensive self-supervision
- Breaker-pole discrepancy
- IEC 61850 communication protocol

18.8.0 Standby maintenance transformer protection

Standby maintenance transformer shall be provided with the following protections through numerical multifunction protection relays.



- Differential protection, restricted earth fault protection (LV side) and standby earth fault protection (LV side) shall be grouped in one relay.
- Restricted earth fault protection (HV side), backup phase over current protection (HV side), standby earth fault protection (HV side) and over fluxing protection shall be grouped in other relay.

Other transformer protections such as Buchholz, oil / winding temperature, pressure relief device, low oil alarm, OLTC surge protection etc. shall also be provided through independent auxiliary relays to energize the master trip relays.

18.9.0 Bus Bar Protection

Fully duplicated bus bar protection shall be provided for each bus. The bus bar protection relay shall be distributed numerical type. The scheme shall comprise bay unit for each feeder and a central unit. The bay unit shall measure three phase current in each bay and communicate to central unit through fiber optic cable. Bus bar protection relay shall have the following features:

- Low-impedance busbar protection
- High functional reliability with stabilized differential current directional current comparison
- High through-fault stability even in case of CT saturation
- No switching of CT circuits
- Flexible solutions at system extension
- Extensive self-supervision
- Breaker-failure protection
- End fault protection
- Definite time overcurrent protection
- Inbuilt Check Zone
- IEC 61850 communication protocol

18.10.0 Relay panels shall be of simplex type with front glass door. It shall consist of CRCA sheet steel with thickness not less than 2 mm for weight bearing members and 1.6 mm for enclosures and shall provide a degree of protection not less than IP 31. Panels shall be free standing, floor-mounting type.

18.11.0 The relay panels shall be provided with two numbers of 220 V DC feeders in loop-in / loop-out fashion. Each feeder shall be fed from separate section of DC board. 220 V DC supply shall be distributed to various circuits with necessary MCBs, Voltage monitoring relays, indication lamps, diode connections etc. Manual selection scheme shall be provided to feed the DC supply to the DC bus from either supply.

18.12.0 The synchronizing trolley shall be provided for manual synchronizing. It shall be complete with double voltmeter, double frequency meter, synchroscope, reversing VT, lamp for bright lamp synchronization etc.,

18.13.0 **Single Line Diagram for protection of GIS Switchyard is enclosed in Section-7 of volume-II.**

19.0.0 DISTURBANCE RECORDER (DR)

Disturbance recorder shall record analogue values of currents and voltages as well as open / closed positions of relay contacts and breakers during system disturbances. The disturbance recorder shall comprise of distributed individual acquisition units, one for each feeder and an evaluation unit common for the whole GIS Switchyard. The acquisition units shall acquire the disturbance data for the pre-fault, fault and post-fault periods and transfer them to the evaluation unit automatically. Necessary hardware and software shall be supplied for the on-line transfer of data from acquisition unit to the evaluation unit. The acquisition units shall have the following features:



- Microprocessor based
- Atleast 8 nos. analogue channels
- Atleast 32 nos. digital channels
- Minimum pre-fault memory >200 ms
- Minimum post-fault memory >2s
- Storage of up to 100 disturbance records in non-volatile memory
- Event resolution of 1 ms or less
- Time display
- Data output in COMTRADE format (IEEE standard – common format for transient data exchange)
- Communication through IEC 61850 standard protocol
- Interface to Substation automation system
- Software along with interface port for transferring the data automatically from local evaluation unit to a remote station and receiving the same at remote station through OPGW / VSAT / leased line.
- The system shall be in synchronism with GPS system

The evaluation unit shall consist of the latest Workstation including a large high resolution color monitor, mouse, keyboard and high speed color printer. Evaluation software for the analysis and evaluation of recorded data shall be provided and shall run on the operating platform of the PC.

20.0.0 SUBSTATION AUTOMATION SYSTEM (SAS)

- 20.1.0 The SAS shall comprise full station and bay control, monitoring and communication functions and shall provide all functions required for the safe and reliable operation of the GIS Switchyard. SAS shall be based on a decentralized architecture and on a concept of bay oriented, distributed intelligence. The SAS shall conform to IEC 61850 standards. The SAS layout shall be structured in station level and bay level.

Architecture diagram of Substation automation system is enclosed in Section-7 of Volume II.

- 20.2.0 The SAS shall be state-of-the-art and shall follow the latest engineering practice. It shall ensure long term compatibility requirements and continuity of equipment supply and safety of the operating staff.
- 20.3.0 The SAS architecture shall be flexible to allow for future extension of GIS Switchyard bays. During such extension, normal operation of the existing GIS Switchyard shall be unaffected and system shall not require a shutdown.
- 20.4.0 The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable.
- 20.5.0 Each component and equipment should have been established for reliability. The minimum target reliability of each piece of equipment like each electronic module/card, power supply, peripheral etc. shall be established by the Bidder considering its failure rates/meantime between failures (MTBF), meantime to repair (MTTR), such that the availability of the complete system is assured.
- 20.6.0 The Bidder shall submit Reliability and maintainability values including detailed calculation for the overall system availability along with all assumptions for each device/equipment/system module as per IEEE standard-P-1046 or equivalent.
- 20.7.0 Self-monitoring of single components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance and any



failures shall be alarmed to the operator. on-line testing routines for various subsystems shall be provided. All the modules shall be hot swappable.

20.8.0 System self-supervision shall be used for supervising and monitoring the system. It shall provide status information of hardware and software, as well as picture functions for the supervision of system objects.

20.9.0 The support from OEM on supply of spare modules for SAS shall be for 15 years from the date of COD.

20.10.0 All the software to cater to all control / operation / communication with relays / data acquisition of the electrical system shall be provided. The Contractor shall provide all software licenses for all the software being used in the SAS. The license shall be valid for the life cycle. The license shall not be hardware. In case of anti-virus software, the license shall include regular updates until the end of warranty and 1 year annual maintenance contract (AMC) period. Any defect in the software, which may arise during life time of the system shall be fixed at no cost to the Owner.

20.11.0 All software versions shall be the latest official releases as on the day of shipment from works and shall include all software updates released up to that date. The Contractor shall inform the Owner about software updates / new releases that would be taking place after the system is commissioned.

20.12.0 The entire station shall be controlled and supervised from HMI. Operation of any equipment can be typically initiated from various control levels. However, clear control priorities shall prevent initiation of operation from more than one control level. The priority shall always on the lowest enabled control level.

20.13.0 For SAS, time synchronizing signal shall be derived from main plant GPS signal equipment. Type of clock signal format shall be coordinated.

20.14.0 The SAS shall contain the following main functional parts:

- a) Redundant station controllers
- b) Bay control & monitoring unit for each bay
- c) Ethernet switch for station controllers
- d) Ethernet switch fault tolerant ring architecture) for each bay
- e) Dual redundant communication bus at station level and at BCU level
- f) Dual redundant communication between intelligent electronic devices (IEDs) and Ethernet switches
- g) Ethernet switch for tariff meters
- h) Dual redundant bi-directional communication link between SAS and remote workstation in main plant control room
- i) Dual redundant bi-directional communication link & gateway for remote load dispatch centre (RLDC)
- j) Dual redundant bi-directional communication link & gateway for power plant DCS
- k) Dual redundant bi-directional communication link & gateway for power plant electrical monitoring system (EMS)
- l) Communication link for protection relays
- m) Two numbers operator workstations in hot standby mode in switchyard control room.
- n) One number engineering workstation in switchyard control room.
- o) One number Large video screen
- p) One number multi-function color laser jet Multi function printer (A3 paper)
- q) One number multi-function color laser jet Multi function printer (A4 paper)
- r) One number dot matrix Multi function printer (A3 paper)
- s) One number operator workstation located in main plant control room



- t) One number multi-function color laser jet Multi function printer (A4 paper) located in main plant control room
- u) Workstation for disturbance recorder
- v) Workstation for tariff metering
- w) Furniture for all workstations and printers

20.15.0 The control hierarchy level shall be as follows:

- Level 0 : GIS Switchyard equipment
- Level 1 : Bay control unit
- Level 2 : Station level (HMI)
- Level 3 : Remote DCS / generator control panel (for GT CB & Tie CB)

20.16.0 At station level, the entire station shall be controlled and supervised from the station HMI. At bay level, the IEDs shall provide all bay level functions like control, monitoring etc. Each bay control IED shall be independent of the others and its functioning is not affected by any fault occurring in any of the other bay control units of the station.

20.17.0 The data exchange among bay level IEDs, and between bay level and station level take place via the dual fiber optic inter-bay bus according to IEC 61850-8-1 standard. One Ethernet switch shall be provided for each bay. The connection from each IED to the switch shall be by a dual fiber optic link. The Ethernet switches shall be connected in a dual redundant fault tolerant ring.

20.18.0 Station level HMI shall include graphic screens, special user functions such as station single line diagram, overviews, control of circuit breakers and isolators, alarm lists and event lists, logging of historical data for trends and reports.

20.19.0 The communication infrastructure shall consist of a fiber optic, managed, switched Ethernet LAN in a dual fault tolerant ring configuration. One Ethernet switch shall be provided in each protection panels with the IED's connected to the switch using fiber optic cables. Ethernet switches shall be provided with spare capacity of not less than 50%.

20.20.0 A Workstation with Windows operating system (latest version) along with the disturbance evaluation software shall be provided as the DR workstation. The application server shall automatically download the DR data from the IEDs. The downloading of DR data can also be done manually on operator's request. The disturbance waveforms shall be printed on the color laser Multi function printer.

20.21.0 Main server and standby servers and workstation servers shall be of industrial grade and state of the art. The server shall be capable of performing all functions of the entire switchyard including future requirements. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. The capacity of hard disk shall be selected such that the following requirements shall occupy less than 50% of disk space:

- Redundant storage of all analogue data (at 15 minute interval) and digital data including alarm, event and trend data for 45 days
- Storage of all necessary software
- 1 Tera byte space for Owner's use

Main server and standby servers shall be rack mounted.

20.22.0 Ethernet switch shall be of industrial grade. The main features of the ethernet switches shall include:

- High speed (1Gbps) operation
- Glass fiber optic cables with MTRJ connectors
- Dual redundant power supplies for increased network availability



- Designed for harsh environment (IEC:61850-3 requirements for use in electrical substations)
- Full compliance with IEEE:802.3 and IEEE:802.3u Ethernet standards for universal interoperability
- Enhanced rapid spanning tree (IEEE:802.1w) for fault tolerance with fast recovery times (<5 ms)
- Virtual LAN (IEEE:802.1Q) for traffic segregation
- SNMP for network management
- SNTP for time synchronization of the Ethernet switches

20.23.0 The SAS shall support simultaneous communications with remote control centre as well as regional load dispatch centre (RLDC). The SAS shall simultaneously respond to independent scans and commands from the two centers. The SAS shall support the use of different communication data exchange rate, scanning cycle and / or communication protocol to each centre.

20.24.0 SAS shall communicate (bidirectional communication) with DCS and Electrical monitoring system (EMS) of power plant for monitoring GIS Switchyard equipment. There shall be no control of GIS Switchyard equipment from DCS/EMS. The extent of information required from SAS shall be determined during detailed design. However, as a minimum, the position of each equipment required for the display of active mimic diagram, common alarms for each feeder, status of breakers / isolators / earth switches, voltages for bus bars and circuits, active power and reactive power for each circuit etc. shall be available. Required hardware and software shall be provided for communication between SAS and plant DCS/EMS.

20.25.0 BCUs shall be of modular construction and equipped for the delivered inputs / outputs plus 20% spare capacity. Each BCU shall include two redundant interfaces to station controller. BCUs shall provide control and protection functions, each function being a separate independent element within the unit. BCUs shall include logic function and sequences. BCU shall be located in relay panels of respective bays. A separate control switch (TNC) spring return type with pistol grip handle for each breaker shall be provided in the SAS pnels housing the BCU to facilitate manual operation. The BCU and other IEDs shall have redundant power supply modules.

20.26.0 Station controller and Ethernet switches shall be located in a separate panel. Panel shall be of simplex type design. It shall consist of CRCA sheet steel with thickness not less than 2 mm for weight bearing elements and 1.6 mm for others and shall provide a degree of protection not less than IP-31. Panels shall be free standing, floor-mounting type. All doors, removable covers and panels shall be gasketed all around. Anti-vibration pads shall be placed between panel and base frame. Cable entries to the panels shall be from the bottom.

20.27.0 The station level hardware shall consist of main and redundant servers and switched ethernet communication infrastructure etc. Server main and standby servers as well as workstation servers shall be of industrial grade and state of the art. The server shall be capable of performing all functions of the entire GIS Switchyard including future requirements.

20.28.0 The visual display unit (VDU) for all workstations shall be 24" TFT monitor. The unit shall have a minimum resolution of 1280X1024 pixels and the screen shall be reflection protected. Large video screen shall be 84".

20.29.0 The user interface shall be based on WINDOWS concepts with graphics and facility for panning, scrolling, zooming, de-clustering etc. Operation shall be by a user friendly function keyboard and optical mouse.

The updating times on the operator station under normal and calm conditions in the substation shall be as follows:

- Exchange of display (first reaction) < 1 s
- Presentation of a binary change in the process display < 0.5 s



- Presentation of an analogue change in the process display < 1 s
- From order to process output < 0.5 s
- From order to updating the display < 1.5 s

20.30.0 Dot matrix printer shall be robust and suitable for operation with a minimum of 132 characters per line. One dot matrix printer shall be exclusively used for hourly log printing. Laser printer shall serve as a color hard copy device to copy diagrams from color monitor for documentation and graphic diagram development functions. Minimum seven colors shall be provided. All reports and graphics shall be printed on laser printer. All printers shall be continuously on-line. Failure of any printer shall be indicated on the station HMI.

20.31.0 Network management system (NMS) software shall be provided for following management functions:

- a) Configuration Management
- b) Fault Management
- c) Performance Monitoring
- d) Network switch management

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR workstation and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall:

- Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
- Maintain a graphical display of SAS connectivity and device status.
- Issue alarms when error conditions occurs
- Provide facility to add and delete addresses and links

20.32.0 Substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the Owner. During such event, normal operation of the existing substation shall be unaffected and system shall not require a shutdown. The Bidder shall provide all necessary software tools along with source codes to perform configuration for additional bays/equipment in future.

20.33.0 The Substation Automation System shall have the capability to support simultaneous communications with multiple independent remote master stations.. It shall have communication ports as follows:

- Two ports for Remote Control Center (Type of port will be firmed up during detail engineering).
- Ethernet port for DCS and EMS on OPC link server supporting data access
- Two ports for Regional System Coordination Center (RSCC) (Type of port will be firmed up during detail engineering).

20.34.0 The communication interface to the SAS shall allow scanning and control of the defined points within the substation automation system independently for each control centre. The substation automation system shall simultaneously respond to independent scans and commands from remote control centers. The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control centre. Also, each control center's data scan and control commands may be different for different data points within the substation automation system's database.

20.35.0 The SAS system shall provide acoustic alarm during abnormalities.

20.36.0 The Vendor shall provide training for operation, maintenance and programming of SAS and shall provide all necessary training material.



20.37.0 Where fiber optic cables are used, 20% spare fibers (minimum of six) shall be provided in each cable.

20.38.0 Ergonomically designed, modular furniture required in switchyard control room for server, Operator console table, Chair, Printer Table, Office Furniture, etc. with suitable dimension according to Control Room size shall be supplied with the system.

21.0.0 TARIFF METERING

21.1.0 Tariff meters shall meet the requirements of the respective State Electricity Regulatory Commission. The meters shall be 3-phase, 4 wire, and 0.2S accuracy class electronic tri-vector energy meters with ABT compatibility. Following tariff meters shall be provided:

- a) Main meter and check meter for each EHV line
- b) Standby meter on EHV side of each generator transformer
- c) Standby meter on EHV side of each standby maintenance transformer
- d) Energy meter for reactor

21.2.0 Tariff metering panel shall be provided to accommodate tariff meters. Number of panels shall be as follows:

- a) One panel for every two lines
- b) One panel for generator transformer-1 & 2
- c) One panel for standby maintenance transformer
- d) One panel for other energy meters

21.3.0 **Drawing for 'Typical energy metering scheme at each voltage level' is attached in Section-7 of volume-II.**

21.4.0 The panel shall be made of cold rolled sheet steel of thickness not less than 2 mm. The panel shall have glass door. Degree of protection shall be at least IP 31. The panel shall be complete with door limit switch operated cubicle lighting, 5 Amp switched power socket, space heater, terminal block, panel earth bus, body earth pads, sealing arrangement etc.

21.5.0 The main meter and the check meter shall be connected to same core of CT and VT. The energy meters shall be capable of receiving periodic time synchronization signals via proper on-line system. The meter time shall be in synchronism with GPS system.

21.6.0 The accuracy class of main meter and check meter shall be 0.2S. The accuracy class of standby meters shall also be 0.2S accuracy class.

21.7.0 The accuracy class of current transformers (CTs) and voltage transformers (VTs) shall not be inferior to that of associated meters.

21.8.0 The meter shall be immune to external influences like magnetic induction, vibration, electrostatic discharge, switching transients, surge voltages, oblique suspension, and harmonics and necessary tests shall be carried out in accordance with relevant standard.

21.9.0 The meters shall safely withstand the usual fluctuations arising during faults etc. as per IS 14697. The immunity to external magnetic field shall be strictly as per CBIP recommendations.

21.10.0 Lead cables of CTs and VTs shall be of sufficient cross-section for reducing voltage drop to minimum between end connections (connection between cable lead end and CT / VT terminal as well as between cable lead end and meter terminal). No joints shall be allowed in lead cables. The burden on metering cores of CTs and VTs including burden of lead cable and meters connected thereto shall not exceed rated burden.



- 21.11.0 The meter must perform four quadrant measurements. The interface meters suitable for ABT shall be electronic/digital type, composite meters, self-contained for measurement of active and reactive energy, and other parameters. The meters shall be suitable for being connected directly to VTs having a rated secondary line-to-line voltage of 110 V and to CTs having rated secondary current of 1A. The reference frequency shall be 50 Hz.
- 21.12.0 The active energy (watt-hour) measurement shall be carried out on 3-phase 4-wire principle with accuracy as per class 0.2S of IEC-60687 / IEC-62053-22. The VAR and reactive energy measurement shall also be on 3 phase 4 wire principle with accuracy as per class 0.2 of IEC 62053-22 or better.
- 21.13.0 The meter shall be compatible with time of the day (TOD) tariff. For TOD tariff, meter shall have the provision to define maximum eight (8) TOD registers for different energies.
- 21.14.0 The meter shall continuously monitor and calculate the average demand in kVA during the integration period and maximum out of these shall be stored along with date and time in the meter's memory. The integration period shall be programmable for 15/30/60 minutes on real time basis on block / sliding window principle that shall also be programmable. The meter shall also display maximum demand (MD) reset count. The MD resetting shall be possible in any of the following ways:
- a) Automatic reset on a predetermined date and time of the month
 - b) Resetting through a hand held terminal or computer capable of communicating with the meter with password protection
- 21.15.0 Meters shall be suitable for working under balanced / unbalanced loads at all power factor. The display shall indicate direct values without having to apply any multiplying factor.
- 21.16.0 The meter shall also store the apparent energy (import and export) and cumulative energy. Registers of the same shall be made available on display as well as base computer software (BCS).
- 21.17.0 The meters shall have following facilities:
- a) Communication port: RS 485, RS 232 & front optical port & Ethernet port.
 - b) Load survey capability
 - c) Missing potential indication in case of failure of potential at the meter incoming terminal.
 - d) Provision for telemetering using common protocol
 - e) Provision for collection of data by meter reading instrument (MRI)
 - f) Provision for time synchronizing facility from external clock. Provision for correcting real time by MRI
 - g) Sliding integration window/block integration
 - h) Real time clock
 - i) Non-volatile memory for 35 days
 - j) Test output device in the form of a pulse indicator accessible from the front and capable of being monitored by suitable testing equipment
 - k) CT/VT error compensation
- 21.18.0 The active energy (watt-hour) meter shall display on demand the export / import energy during 15 minutes block.
- 21.19.0 Further the meter shall continuously integrate and display on demand the export / import cumulative active energy sent out / in from / to the GIS Switchyard bus bars up to that time in export and import register. The cumulative energy reading at each midnight shall be stored in the meter memory in respective registers. There shall be separate register for export and import.



21.20.0 The reactive energy (VARh) meter shall store the values in different registers as below:

- Above 103% voltage: reactive energy import & export
- Below 97% voltage: reactive energy import & export
- Reactive energy import with active energy import
- Reactive energy import with active energy export

21.21.0 The accuracy of the meter shall not be affected by harmonics circulating in the system of magnitudes within permissible limits stipulated by CEA Grid Standards and Regulations. The meter shall indicate and record the total resultant quantities of fundamental frequency and harmonics or alternatively the meter shall record fundamental frequency quantities and harmonics related quantities (such as MWh, MVAh and MVARh) separately. Only fundamental frequency values shall be used for billing purpose.

21.22.0 It shall be possible to store previous minimum 45 days data regarding energy consumed (15 minutes blocks), demand and frequency. That is load survey is needed for the demand and energy consumed in every MD integration time cycle (15 min). The demand to be recorded in the load survey shall match with the recorded in display parameters. The demand and energy consumed as discussed shall be recorded separately under energy import / energy export within a 15 minutes time block. It shall be possible to down load and view parameters and load survey data on computers and obtain full details of demand and consumption in statement form and also in graphic form.

Necessary software for various programmable features to obtain various details shall be provided by the supplier. The software shall include provision for load survey graphic presentation and other reports generation in BCS from the data collected from the meter through meter reading.

22.0.0 TECHNICAL PARAMETERS OF GIS SWITCHYARD

Sl. No.	Description	Data
1.	General:	
a)	Nominal system voltage	400 kV (rms)
b)	Highest system voltage	420 kV (rms)
c)	System Neutral	Solidly grounded
d)	Design ambient temperature	50 degree C
e)	Lightning impulse withstand voltage	1425 kV (peak)
f)	Switching impulse withstand voltage	1050 kV (peak)
g)	Power frequency withstand voltage (dry)	630 kV (rms)
h)	Short time current and duration	63 kA for 1 sec.
i)	Internal arc withstand capability	63 kA for 1 sec
j)	Bus bar rating	4000 A
k)	Phase to Phase clearance for air insulation	4000 mm(for conductor –conductor configuration) 4200 mm(for rod– conductor configuration)
l)	Phase to earth clearances for air insulation	3500 mm (min.)
m)	Sectional clearance for air insulation	6500 mm (min.)
n)	Creepage distance for outdoor	31 mm/kV
o)	Bay width for outdoor	27 m



Sl. No.	Description	Data
2.	Circuit Breaker:	
a)	Rated current	As required
b)	Symmetrical interrupting capability	63 kA for 1 sec
c)	Dynamic rating	163 kA (peak)
d)	Closing resistors	For line breakers
e)	Temperature rise	As per IEC
f)	Operating duty	O-0.3 sec-CO-3 min-CO
g)	Total break time (maximum)	40 ms
h)	Total make time (maximum)	90 ms
i)	First pole to clear factor	1.3
j)	TRV	As per IEC
3.	Rated current of Isolator	As required
4.	Current Transformer	
a)	Temperature rise	As per IEC 61869
b)	Radio interference voltage at $1.1 U_n/\sqrt{3}$ and frequency range 0.5 to 2 MHz	1000 microvolts
c)	Power frequency withstand voltage, secondary	3 kV
d)	Partial discharge level	10 Pico coulombs
5.	Capacitive Voltage Transformer:	
a)	Temperature rise	As per IEC 61869
b)	Power frequency withstand voltage for secondary winding	3 kV
c)	Rated power factor	0.8 lag
d)	Coefficient of earthing	<0.8
e)	Rated voltage factor	1.2 Continuous & 1.5 for 30 secs.
f)	Capacitance for carrier coupling (pf)	8800
g)	Accuracy class for tariff metering	0.2
h)	Accuracy class for other metering	0.5
i)	Accuracy for protection core	3P
6.	Lightning Arrester:	
a)	Arrester rated voltage	390 kV
b)	Type of arrester	Metal oxide, gapless
c)	Nominal discharge current	20 kA of 8/20 micro second wave
d)	Minimum discharge capability	8 kJ / kV
e)	Continuous operating voltage.	303 kV (RMS)
f)	Max. switching surge residual voltage at 1 kA Min. switching surge residual voltage at 1 kA	730 kVp 780 kVp
g)	Max. residual voltage at discharge current	850 kV (peak) at 20 kA
h)	Max. steep current impulse residual voltage	925 kV(peak) at 20 kA
i)	Long duration discharge class (IEC)	4/5



Sl. No.	Description	Data
j)	High current short duration test value (4/10 micro second wave)	163 kA(peak)
k)	Low current long duration test value	As per IEC

23.0.0 TESTS

23.1.0 The equipment offered shall be of type tested and proven type. Type test reports shall be submitted for review. All routine and acceptance tests in accordance with the latest version of applicable standard shall be conducted for all the equipment.

23.2.0 Every functional unit shall be routine tested by the manufacturer at the manufacturer's works according to IEC standards. Each transport unit shall be routine tested. This includes gas tightness tests of all gas compartments, mechanical and dielectric tests of all components not yet tested as functional unit.

23.3.0 The tests shall be carried out for GIS enclosure, Circuit breaker, disconnectors and earthing switches, SF6/Air bushings, current transformers, voltage transformer and local control cubicle as per IEC.

23.4.0 The following tests shall be performed at Site, among others:

- Check to verify that the installed switchgear complies with the specification
- Functional testing of all apparatus
- Inspection of electric wiring and interlocks
- Gas leak testing
- Measurement of gas humidity
- Dielectric test
- Measurement of contact resistances

23.5.0 Following routine tests shall be carried out for CVT.

- h) Verification of terminal markings and polarity
- i) Power frequency dry withstand tests on primary windings
- j) Power frequency dry withstand tests on secondary windings
- k) Determination of errors and other characteristics
- l) Measurement of insulation resistance
- m) Oil leakage test
- n) Measurement of capacitance
- o) Partial discharge measurement
- p) Measurement of tan delta
- q) Over voltage inter-turn test

23.6.0 Following tests shall be carried out for lightning arrester

23.6.1 Routine Tests

- Measurement of reference voltage
- Residual voltage test of arrester unit
- Partial discharge test
- Current distribution test
- Leakage check
- Verticality check on completely assembled surge arresters

23.6.2 Acceptance Tests

- Measurement of power frequency reference voltage of the arrester units



- Lightning impulse residual voltage on arrester units
- Partial discharge test
- Thermal stability test on three sections
- Watt loss test
- Aging & energy capability test on blocks

23.7 Site tests

23.7.1 The various commissioning checks / tests to be carried out on the various equipment shall be in accordance with applicable standards and equipment supplier's recommendation.

23.7.2 The following tests shall be carried out before and during erection, testing and commissioning:

- Check for physical damage
- Visual examination of zinc coating / plating
- Check from name plate that all items are as per specification
- Check tightness of all bolts, clamps and connecting terminals using torque wrenches
- For oil filled equipment, check for oil leakage. Also check oil level and top up wherever necessary
- Check ground connections for quality of weld and application of zinc rich paint over weld joint of galvanized surfaces
- Check cleanliness of insulator and bushings
- Check for surface finish of grading rings (corona control ring)
- Electrical clearance check
- Testing of torque by torque wrenches on all bus bar power connectors and other accessories
- Millivolt drop test on all power connectors
- Sag and tension check on conductors
- Millivolt drop test on all joints
- Dye penetration test and radiography test on 10% sample basis on weld joints
- Test check on 5% sample joints after cutting the weld piece to observe any voids etc.
- Visual examination for finish, damage, creepage distance etc. for insulators
- All checks and tests specified by manufacturers in their drawings and manuals as well as all tests specified in the relevant code of erection

23.7.3 All equipment and accessories included in the scope of this contract shall be tested at site after installation during commissioning. The tests and pre-commissioning checks shall include but not limited to the following:

a) Circuit Breaker

- Insulation resistance of each pole
- Breaker closing and opening time including PIR time if applicable
- Slow and power closing operation and opening
- Trip free and anti-pumping operation
- Minimum pickup voltage of coils
- Dynamic contact resistance measurement
- Functional checking of control circuits interlocks, tripping through protective relays and auto-reclose operation
- Operation from SAS
- Insulation resistance of control circuits, motor etc.
- Resistance of closing and tripping coils
- SF6 gas leakage check
- Dew point measurement
- Calibration of pressure switches and gas density monitor
- Protection against pole discrepancy



- Wiring continuity check
- Capacitance and tan delta measurement of grading capacitors

b) Isolator and Earth Switch.

- Insulation resistance of each pole
- Manual / remote and electrical operation and interlocks
- Insulation resistance of control circuits and motors
- Earth connections
- Contact resistance
- Proper alignment so as to minimize to the extent possible the vibration during operation
- Measurement of operating torque for isolator and earth switch
- Resistance of operating and interlocks coils
- Functional check of the control schematic and electrical and mechanical interlocks
- Alignment of limit switches

c) Current Transformers

- Insulation resistance test for primary (if applicable) and secondary winding
- Polarity test
- Ratio identification test
- Primary injection of current
- Magnetising current characteristics test
- Secondary winding resistance measurement
- Measurement of capacitance and tan delta of main insulation

d) Voltage Transformers

- Insulation resistance test for primary (if applicable) and secondary winding
- Ratio test
- Phasing test
- Back charging
- Dielectric test of oil (wherever applicable)
- Secondary winding resistance measurement
- Capacitance and tan delta measurement of capacitor stacks (for capacitive voltage transformer)

e) Lightning Arrester

- Leakage current measurement
- Resistance of earth connection
- Counter operation
- Earth continuity
- IR measurement of stacks

f) Earthing

- Check soil resistivity
- Check continuity of grid wires
- Check earth resistance of the entire grid as well as various sections of the same
- Check for weld joint and application of zinc rich paint on galvanised surfaces
- Carry out dip test on earth conductor prior to use
- Check earth pit resistance



23.7.4 The following tests shall be carried out on Relay Panels & metering panel

a) Cubicle Wiring

- Completeness of wiring is as per relevant drawings.
- Completeness of all interconnections between panels shall
- Insulation resistance of all the wires with respect to earth
- Functional checking of all control circuit e.g. closing, tripping interlock, supervision and alarm circuit including proper functioning of component/ equipment
- Check terminations and connections
- Gap sealing and cable bunching

b) Relays

- Check internal wiring
- Insulation resistance between all terminals and body
- Insulation resistance between AC and DC terminals
- Check operating characteristics by secondary injection
- Check minimum pick up voltage of DC coils
- Check operation of electrical/ mechanical targets
- Check CT connections with particular reference to their polarities for differential type relays
- Relay settings
- Test communication link

c) Meters

- Insulation resistance of all insulated portions
- Check CT and VT connections with particular reference to their polarities for power type meter
- Check calibration certificate

d) General

- Wiring check in conformity with schematics.
- Insulation check.
- Primary injection test.
- Secondary injection test.
- On load test.
- DC sequential test.

23.7.5 The following tests shall be carried out on **Substation Automation System**

- Check name plate details according to the specification
- Check for physical damage
- Check earth connection and earth continuity
- Check for correct CT/PT terminals
- Functionally check for all control circuits
- Check connections and wiring
- Megger all terminals to body
- Test BCUs and their settings
- Test communication links
- Carry out functional check
- Loop testing of all measurement signals and control loops
- Test protection interlocks
- Carry out cable continuity checks



- Carry out functionality of all displays and alarms
- Check operation of VDUs
- Check operation of printers
- Check functioning of all software

24.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Design basis report for switchyard
- Technical data sheet
- Overall GIS Switchyard layout – plan & section including roads & drains
- GIS building layout
- Single line diagram
- Protection and metering diagram
- Synchronizing scheme diagram
- Calculations for sag tension, short circuit forces, cantilever strength of all equipment etc.
- Spacer span design calculations
- Bus bar and conductor sizing calculations
- CT / VT sizing calculations
- Sizing calculations for various other equipment
- Block interlock diagram for breakers and isolators
- Control and protection schematics
- Tariff metering scheme
- Substation automation system (SAS) architecture
- I/O List, display for substation automation system
- Wiring diagrams
- Relay co-ordination and setting calculation
- General arrangement drawings of various equipment'
- Equipment layout for GIS Switchyard control building
- Gas schematic diagrams
- Gas system installation procedures & gas handling procedures
- Electrical and physical clearance diagrams
- Erection key diagram
- Detailed erection and commissioning procedure
- Test procedures
- Type test certificates for all equipment
- Sub vendor list
- Manufacturing quality plan
- Field quality plan
- O&M manual



SECTION -3.4: POWER TRANSFORMERS & BUS REACTOR

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of EHV power transformers, bus reactor and auxiliary power transformers.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) Six numbers 400 kV class single phase generator transformers.
- b) One number 400 kV class spare single phase generator transformer
- c) One number 400 kV class three phase standby maintenance transformer
- d) Two numbers 125 MVAR 400 kV class three phase bus reactor
- e) Four numbers Unit transformers
- f) Two numbers Station transformers
- g) Four numbers 11/6.9 kV rated Unit auxiliary transformers
- h) Two numbers 11/6.9 kV rated Station auxiliary transformers
- i) Two numbers 11/6.9 kV rated AHP auxiliary transformers
- j) Two numbers 11/6.9 kV rated Sea water intake transformers
- k) Two numbers 11/34.5 kV rated External coal handling transformers
- l) Transformers as required for the system
- m) On line dissolved gas analyzer for all generator transformers and standby maintenance transformers
- n) EHV Neutral formation for single phase generator transformers along with CT neutral box.
- o) Online partial discharge measurement equipment for all the generator transformers, standby maintenance transformer, Unit transformers and station transformers of Unit-1.
- p) Online partial discharge measurement equipment for all the Generator transformers, Unit transformers and station transformers of Unit-2.
- q) Nitrogen injection system for transformers
- r) Commissioning spares and consumables
- s) Mandatory spares
- t) Tools & tackles
- u) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Indian Standards, IEC publications and any other standards of latest edition including amendments, except where modified and /or supplemented by this specification.

- a) IS 12463 : Inhibited mineral insulating oil
- b) IS 2026 : Specification for Power Transformers (All parts)
- c) IS 2099 : Specification For Bushings for Alternating voltages above 1000 V
- d) IS 3347 : Dimension for porcelain transformer bushings
- e) IS 3639 : Specification For Fittings and accessories for Power Transformers
- f) IS 4257 : Porcelain Bushings for Transformers
- g) IS 10028 : Code of practice for selection, installation and maintenance of transformers.
- h) IS-2705 : Specification for Current Transformers



- i) IS 8478 : Application Guide for On Load Tap changers.
- j) IS 10561 : Application Guide for Power Transformers.
- k) IEC 60076 : Power Transformers General (Part 1)
- l) IEC 60076 : Power Transformers Temperature rise (Part 2)
- m) IEC 60076 : Power Transformers Insulation levels, dielectric tests and external clearances in air (Part 3)
- n) IEC 60076 : Power Transformers Guide to the lightning impulse and switching impulse testing – Power transformers (Part 4)
- o) and reactors
- p) IEC 60076 : Power Transformers Ability to withstand short circuit (Part 5)
- q) IEC 60076 : Reactors 1 (Part 6)
- r) IEC 60076 : Loading guide for oil-immersed power transformers (Part 7)
- s) IEC 60076 : Power Transformers Application guide (Part 8)
- t) IEC 60076 : Power Transformers Determination of sound levels (Part 10)
- u) IEC 60076 : Power Transformers Determination of sound levels – Application guide (Part 10-1)
- v) IS 5553 : Reactors Specification (Part 2)
- w) CBIP Manual on Transformers

3.0.0 DESIGN CRITERIA

- 3.1.0 The transformer shall be designed for exceptional circumstances arising due to sudden disconnection of the load and shall be capable of operating at approximately 125% of normal rated voltage for a period of not exceeding one minute and 140% of normal rated voltage for a period of 5 seconds and 110% of normal rated voltage for continuous duration.
- 3.2.0 The transformer shall be capable of operating without injurious heating at rated output at any tap position, provided the voltage corresponding to that tap does not vary by more than $\pm 10\%$ of rated voltage. The winding including the tapping arrangement shall be designed such that the electromagnetic balance is maintained between HV and LV windings at all voltage ratios.
- 3.3.0 The transformers shall be capable of delivering the rated output at any particular tap continuously without exceeding the specified temperature limits under the following operating conditions.
 - Voltage variation of $\pm 10\%$ of rated voltage of that particular tap.
 - Frequency variation of $+3\%$ - 5% of rated frequency.
 - Combined voltage and frequency variation not exceeding the rated v/f ratio by 10%.
- 3.4.0 The transformers shall be suitable for outdoor installation in a hot, saline, humid and tropical climate. They shall be capable of operating continuously at their rated outputs without exceeding specified temperature limits.
- 3.5.0 All the power transformers shall be mineral oil filled. The temperature rise of top oil (by thermometer method) shall not exceed 50°C over an ambient temperature of 50°C and Temperature rise of winding (by resistance method) shall not exceed 55°C over an ambient temperature of 50°C . Hot spot temperature based on maximum yearly weighted average temperature shall not exceed 98°C .
- 3.6.0 The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that at 110 per cent continuous over-voltage condition it does not exceed 1.9 Tesla.



- 3.7.0 The transformers shall withstand, without injurious heating 125% over fluxing for a period of one (1) minute and 140% over fluxing for a period of five (5) seconds. (Over fluxing caused by combined voltage and frequency fluctuations).
- 3.8.0 The transformers shall be free from annoying hum and vibration when it is in operation, even at 110% rated voltage.
- 3.9.0 The transformers shall be designed with particular attention to the suppression of maximum harmonic voltage, especially the third and fifth so as to minimize interference with communication circuit.
- 3.10.0 The transformers shall be capable of withstanding without injury, the thermal & magnetic stresses caused by faults on any of the winding /through faults with full voltage maintained on other winding for the specified duration.
- 3.11.0 Bushing CTs shall be rated for short circuit withstand duration of 1 second.
- 3.12.0 The transformer and all its accessories including CTs etc. shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for the specified duration.
- 3.13.0 The transformers shall be capable of being loaded in accordance with IS: 6600/IEC-600354. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.
- 3.14.0 In case of radiator banks, the transformer shall be capable of operating continuously under natural cooled condition up to the specified load. The forced cooling equipment shall come into operation by pre-set contacts of winding temperature indicator and the transformer shall operate as a forced cooling unit. Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without the calculated winding hot spot temperature exceeding 140°C. Further, cooling shall be so designed that during total failure of cooling fans and oil pumps of one radiator bank, the transformer shall be able to operate at full load for at least ten (10) minutes without the calculated winding hot spot temperature exceeding 115°C.
- 3.15.0 The noise level of transformer, when energized at normal voltage and frequency with fans and pumps running shall not exceed, when measured under standard conditions, the values specified in NEMA standard publication TR-1.
- 3.16.0 Transformer tank shall be dispatched filled with oil or pure dry inert Nitrogen gas. In case the tank is filled with inert gas the temperature and pressure at the time of gas filling shall be marked on a tag. A graph showing pressure vs. temperature shall be attached for reading pressures at different temperatures. Necessary valve, two stage pressure regulators, filled up Nitrogen cylinder etc. along with other accessories required shall be provided with the tank for intermittent replenishment during transportation.
- 3.17.0 It shall be ensured that the moisture content measured at 'manufacturing works' during testing is not exceeded at site during commissioning
- 3.18.0 Impact recorder/indicator shall be provided to monitor the impact experienced by the transformer during transport.
- 3.19.0 **Generator transformers (GT)**

In addition to the above requirements, GT sizing shall take care of the following:

- a) Generator transformer shall be used to connect to EHV network to evacuate power. The transformer shall be adequately sized for the stringent operating condition. It shall be rated



to evacuate full power of the generator with valve wide open condition at 95% operating voltage, when unit/station auxiliaries are not powered directly by generating source. Accordingly, GT shall be sized for 110% of maximum continuous rating MVA of generator.

- b) One number of single phase spare GT shall be provided common for both units, in the transformer yard. The spare GT shall be stored as per manufacturer's recommendation. Manufacturer's recommendation for long time storage shall be based on the actual installation executed by him. If the manufacturer recommends continuous charging during storage, suitable power feeding arrangement shall be provided in the switchgear for the same.
- c) The transformer shall be provided with off circuit tap changer. For tap changer, potential free contacts of GT Tap position shall be provided for remote communication to RLDC.
- d) The transformers shall be provided with 2X60% radiator banks.

3.20.0 Standby maintenance transformers

- a) The transformer shall be used to connect to EHV network to draw startup power
- b) The transformer shall be standby to Unit transformer and Station transformers. It shall be rated to backup one unit transformer and station transformer together, or two unit transformers together at any time.
- c) The transformers shall be provided with 2X50% radiator banks. The transformer shall be provided with on load tap changer. Each radiator bank shall have one spare fan.

3.21.0 Bus reactor

- a) Reactor shall be designed for exceptional circumstances arising due to sudden fluctuation in supply voltage. The reactor shall be provided with radiator banks.
- b) The crest value of the third harmonic component in phase current not to exceed 3% of the crest value of fundamental when reactor is energised at rated voltage with sinusoidal wave form.

3.22.0 Unit Transformer (UT)

- a) Transformer shall be used to connect to Generator supply and EHV network to draw auxiliary power to feed Unit auxiliaries.
- b) 2x50% rated Unit transformer shall be provided for each Unit. UT shall be two winding type.
- c) Each UT shall be sized to feed the following loads and shall have a design margin of 10%:
 - Loads connected to Unit switchgear
 - Power requirement for FGD as specified
 - Additional load imposed on the largest rated outgoing feeder due to bus supply changeover at downstream switchgear.
- d) The transformers shall be provided with 2X60% radiator banks. The transformer shall be provided with on load tap changer.

3.23.0 Station Transformer (ST)

- a) Transformer shall be connected to IPBD busduct tap off, to draw auxiliary power to feed station auxiliaries.
- e) 2x50% rated Station transformer shall be provided for the plant. ST shall be two winding type.



- f) Each ST shall be sized to feed the following loads and shall have a design margin of 10%:
 - Loads connected to station switchgear
 - Power requirement for external coal handling as specified
 - Additional load imposed on the largest rated outgoing feeder due to bus supply changeover at downstream switchgear.
- b) The transformers shall be provided with 2X60% radiator banks. The transformer shall be provided with on load tap changer.

3.24.0 Auxiliary transformers

- a) Required numbers of auxiliary transformers for supplying BTG auxiliaries, CHP auxiliaries, AHP auxiliaries, Sea water intake auxiliaries, etc. shall be provided.
- b) For each switchgear, 2X100% rated transformers shall be considered.
- c) Transformer shall be two winding type, sized to feed the following loads and shall have a design margin of 10%:
 - 100% load connected on both the bus sections of switchgear
- d) The transformers shall be provided with 2X50% radiator banks.

3.25.0 Efficiency

Efficiency of the transformers shall be not less than the following at 0.85 PF at full load:

- 99.7% : Generator Transformer
- 99.5% : Unit transformer / Standby maintenance transformer / Station transformers
- 99.0% : Auxiliary transformers

The loss figures quoted by the bidders shall be taken in to account for Bid evaluation at the rates indicated in commercial section.

Contractor shall guarantee losses and efficiency figures of each transformer during detail engineering. During testing, if the losses exceed the guaranteed value, penalty shall be applied for at the rates indicated in general technical specification. If the losses exceed the guaranteed value by 10% or more, the transformers may be rejected by the Owner.

4.0.0 CONSTRUCTIONAL FEATURES

4.1.0 Tank

- a) The tank shall be of welded construction and fabricated from tested quality low carbon steel of adequate thickness. After completion of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.
- b) The tank shall be of bell type with bolted joint at about 500 mm above the bottom of tank. In case the joint is welded it shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise of the joint.
- c) The tank shall be provided with :
 - Lifting lugs suitable for lifting the equipment complete with oil.



- A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks.
 - Suitable haulage holes.
- d) The tank shall be designed in such a way that it can be mounted on the plinth directly.
- e) The base of each tank shall be so designed that it shall be possible to move the complete transformer unit by skidding in any direction without injury when using plates or rails.
- f) The tank cover shall preferably be sloped to prevent retention of rainwater and shall not distort when lifted.
- g) At least two adequately sized inspection openings one at each end of the tank, shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.
- h) The tank covers shall be fitted with pockets at the position of maximum oil temperature for bulbs of oil and winding temperature indicators. It shall be possible to remove these bulbs without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.
- i) Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.
- j) All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression.
- k) Ladder with safety device for access to the top of transformer tank shall be provided.

4.2.0 Core

- a) The core shall be constructed from high grade, non-ageing, cold rolled, super grain oriented, and silicon steel laminations. CRGO Silicon steel shall be HI-B grade or equivalent.
- b) The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating.
- c) For EHV power transformers the insulation of core to tank, clamp to tank and core to clamp plates shall be able to withstand a voltage of 10 kV (rms) for 1 minute in air.
- d) The core shall be boltless type. Insulation of core to clamp plates shall be able to withstand a voltage of 10 kV (rms) for 1 minute for EHV transformers and 2 kV (rms) for 1 minute for other transformers.
- e) For EHV power transformers, in order to ensure prevention of multiple core earthing, core isolation test at 10 kV for 1 minute shall be done during pre-commissioning stage. To facilitate above, the core & core earthing has to be done outside the tank with suitable bushing.
- f) The core and coil assembly shall be dried in vacuum pressure of less than 0.5 mm of Hg. Then the core and coil shall be immediately impregnated with oil to ensure the elimination of moisture with in the insulation.



- g) Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.
- h) Each core lamination shall be insulated with a material that shall not deteriorate due to pressure and hot oil.
- i) The supporting frame work of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of tank through drain valve or cause trapping of air during oil filling.
- j) Adequate lifting lugs shall be provided to enable the core and windings to be lifted.
- k) Air core reactance shall be not less than 20% to be discussed

4.3.0 Windings

- a) Conductors shall be of electrolytic grade copper, free from scales and burrs.
- b) The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and be non-catalytic and chemically inactive in transformer oil during service. It shall be class-A or better.
- c) Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.
- d) The coils shall be made up, shaped and braced to provide for expansion and contraction due to temperature changes.
- e) The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalize the distribution of currents and temperature along the winding.
- f) The end turns of the high voltage windings shall have reinforced insulation to take care of the voltage surges likely to occur during the switching or other abnormal conditions.
- g) No corona discharge shall result on the winding upon testing the transformer for induced voltage test as specified in IS.

4.4.0 Conservator & Oil Preservation System

- a) Main conservator shall have constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture, and shall be fitted with magnetic oil level gauge with low oil level potential free contacts and view glass indicator.
- b) Oil preservation system shall be air cell type for transformers rated 10 MVA and above. Air cell used shall be made of nitrile rubber reinforced with nylon cloth suitable for operating continuously at 100°C.
- c) The conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to 100°C.
- d) Conservator shall be positioned so as not to obstruct any electrical connection to transformer. The connection of air cell to the top of the conservator shall be by air proof seal preventing entrance of air into the conservator.



- e) The conservator shall be able to withstand the vacuum during installation/maintenance periods. In addition provision shall be kept to isolate the conservator from the main tank when the latter is under vacuum by providing a vacuum sealing valve or other suitable means in the pipe connecting main tank with the conservator.
- f) The Conservator shall be fitted with 2X100% dehydrating filter breather. The breathers shall be connected in parallel to the pipe emanating from the conservator. Passage of air shall be through Silica gel. Silica gel shall be isolated from atmosphere by an oil seal. Breather shall be mounted not more than 1200 mm above rail top level. To minimize the ingress of moisture, multiple breathers of identical size shall be connected in series for main tank conservator.

4.5.0 Pressure Relief Device

Adequate number of pressure relief devices shall be provided at suitable locations. These shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to equipment. The device shall operate at a static pressure less than the hydraulic test pressure of the transformer tank. It shall be mounted directly on the tank. One set of electrically insulated contacts shall be provided for alarm/tripping. Discharge of pressure relief device shall be properly taken through pipes and directed away from the transformer/other equipment and this shall be prevented from spraying on the tank.

4.6.0 Buchholz Relay

Buchholz relay shall be double float type. Any gas evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper/stainless steel tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling with the transformer in service. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure.

4.7.0 Oil Temperature Indicators (OTI)

Transformers shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device shall be provided in the OTI. A temperature sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to the OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read atleast every 2°C. Accuracy class of OTI shall be 1.5% or better.

The OTI shall also be provided with in built variable resistor for connecting it to transducers for remote monitoring of the temperature at DCS. The transducers shall be provided with dual outputs of 4-20 mA signal and shall be mounted in the cooler control cubicle.

4.8.0 Winding Temperature Indicator (WTI)

- a) A device for measuring the hot spot temperature of HV winding shall be provided. For transformers rated 50 MVA and above, WTI shall be provided for LV winding also.
- b) It shall comprise the following:
 - Temperature sensing element.
 - Image coil.
 - Auxiliary CTs, if required to match the image coil.
 - 150 mm dia local indicating instrument with maximum reading pointer and two adjustable electrically independent, ungrounded contacts (one for high winding temperature alarm and one for trip) besides that required for control of cooling equipment,. Temperature indicator dials shall have linear gradations to clearly read at least every 2°C. Accuracy class of WTI shall be 1.5% or better.



- Calibration device.
- c) Signal transmitter (RTD) shall provide signal for remote winding temperature (RWTI) and also separate signal for recording winding temperature at remote 'DCS system'. RTD shall be duplex platinum with nominal resistance of 100 ohms at zero degree centigrade. RTD shall be three wire ungrounded system.
- d) The WTI shall also be provided with in built variable resistor for connecting it to transducers for remote monitoring of the temperature. The transducers shall be provided with dual outputs of 4-20 mA signal and shall be mounted in the cooler control cubicle.

4.9.0 Axles and Wheels

- a) The transformers shall be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track. Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer. The rail track gauge shall be 1676 mm.
- b) To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation. All Wheels shall be detachable and shall be made of cast iron and steel as required.
- c) Wheels shall be arranged so that they can be turned through an angle of 90° when tank is jacked up clear of the rails or floor.

4.10.0 Bushings and Current Transformers

- a) Bushing for voltage rated 72.5 kV and above shall be of the oil filled condenser type. 36 kV bushing shall be solid porcelain or oil communicating type.
- b) Oil filled condenser bushing with silicon RTV coating shall be provided with the following fittings.
 - Oil level gauge.
 - Oil filling plug and drain valve if not hermetically sealed.
 - Tap for capacitance and tan delta test.(tan delta monitoring)
- c) Alternatively, Resin Impregnated condenser type bushing shall be provided with tap for capacitance and tan delta test.(tan delta monitoring).
- d) The CT shall be cast resin type, with Class E insulation or better, secondary leads of CTs shall be wired up to marshaling box. The secondary terminals of the CT shall have provisions for shorting. CT shall not be mounted inside transformer.
- e) Bushings of identical rating shall be interchangeable.
- f) Porcelain used in bushing manufacture shall be homogenous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.
- g) Clamps and fittings shall be of hot dip galvanised steel. The design of connectors/clamps shall ensure corona free operation at the maximum rated voltage.
- h) Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.
- i) No arcing horns shall be provided on the bushings.



- j) The terminal marking and their physical position shall be as per IS: 2026.

4.11.0 Neutral Earthing Arrangement

- a) For solidly grounded system, the neutral terminal of the transformer shall be brought to the ground level by a tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to galvanised steel flats connected to grounding mat.
- b) For non-effectively grounded system, the neutral terminal shall be brought to cable box provided with transformer.
- c) In case of bank of three single phase transformers, HV neutral shall be formed by interconnecting HV terminals through sleeved copper bars, supported on porcelain insulators. For earth fault protection, cast resin CTs shall be provided in suitable enclosure after forming neutral.

4.12.0 Cable Box

Where required, a dust tight air insulated type cable box with IP: 55 protection shall be provided for terminating the cables. Inspection cover for fixed portion of cable box shall be provided. Handles for lifting cable box shall be provided. Gland plate for single core cable termination shall be of Aluminium. The cable box shall have Pressure Relief Diaphragm (PRD).

4.13.0 Cooling equipment

4.13.1 Radiator Cooling

- a) Each radiator bank shall have its own cooling fans, shut off valves at the top and bottom (80 mm size), lifting lugs, top and bottom oil filling valves, air release plug at the top, a drain and sampling valve and thermometer pocket fitted with captive screw cap on the inlet and outlet. OFAF cooled transformers shall have, in addition, 2 x 100% oil pumps and oil flow indicator. In case of failure of the running pump the standby pump shall come in immediate operation. Radiators shall be designed to avoid pockets in which moisture may collect and shall withstand pressure tests.
- b) Atleast one number extra cooling fan or 20% capacity standby fans (whichever is higher) shall be provided with each radiator bank.

4.14.0 Valves

- a) All valves up to and including 100 mm shall be of gun metal or of cast steel/cast iron. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.
- b) Suitable means shall be provided for locking the valves in the open and close positions.
- c) Each valve shall be provided with the indicator to show clearly the position of the valve.
- d) All valves flanges shall have machined faces.
- e) All valves in oil line shall be suitable for continuous operation with transformer oil at 100 degree C.



- f) The oil sampling point for main tank shall have two identical valves to be put in series .Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.
- g) A valve or other suitable means shall be provided to fix the on-line dissolved gas monitoring system to facilitate continuous dissolved gas analysis. The location & size of the same shall be finalised during detail engineering stage.
- h) After testing, inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil resisting paint/varnish with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint of a shade (preferably red or yellow) distinct and different from that of main tank surface. Outside surface except gasket setting surface of butterfly valves shall be painted with two coats of red oxide zinc chromate followed by two coats of fully glossy finishing paint.
- i) All hardware used shall be cadmium plated / electro galvanised.

4.15.0 Cooler Control Cabinet

- a) The cooler control cabinet shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired up to the terminal board in the cooler control cabinet. All the necessary terminals for remote connection to shall be wired up to the cooler control cabinet.
- b) The temperature indicators shall be so mounted that the dials are about 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.
- c) Two auxiliary power supplies, 415 volt, three phase four (4) wire shall be provided at cooler control cabinet for power circuit. All loads shall be fed by one of the two feeders through an electrically interlocked automatic transfer switch housed in the cooler control cabinet. Design features of the transfer switch shall include the following :
 - Provision for the selection of one of the feeder as normal source and other as standby.
 - Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay to standby sources.
 - Indication to be provided at cooler control cabinet for failure of normal source and for transfer to standby source and also for failure to transfer.
 - Automatic re-transfer to normal source without any intentional time delay following re-energization of the normal source.
 - Both the transfer and the re-transfers shall be dead transfers and AC feeders shall not be paralleled at any time.
 - Auto changeover shall be blocked if short circuit protective device is operated on internal fault.
- d) Necessary isolating switches and MPCB/MCB shall be provided.
- e) For cooler control circuit, control supply shall be 110 V AC. For Cooler Control circuit, Control supply shall be derive by two set of control transformers 415/110 V located in each of the Transformer cooler control cabinet. In case of GT banks Manual Bypass arrangement for control supply shall also be provided such that for the pump & fan can continue to work in-case of loss of control supply.
- f) The cooler control cabinet shall have IP 55 degree of protection.
- g) Following lamp indications shall be provided in cooler control cabinet as a minimum.



- Control supply failure
 - Power supply failure
 - Fan failure.
 - Pump failure.
 - Cooler control on 'Manual/Auto/Remote manual'.
 - Overload trip for fans/pumps
 - Any other indication as required.
- h) Two set of potential free initiating contact for the following signals shall be wired independently to the terminal blocks of cooler control cabinet, for connecting to protection Panel and DCS system:
- Control Supply failure.
 - Power Supply failure.
 - Fan failure.
 - Cooler control on 'Manual/Auto/Remote manual'.
 - Overload trip for fans / pumps
 - Cooling pump failure
 - No oil flow/reverse oil flow for pumps.
 - Buchholz relay Alarm/Trip
 - Winding Temperature Indicator Alarm/Trip
 - Oil Temperature Indicator Alarm/Trip
 - Pressure Relief Valve Operated (Trip).
 - Main tank Oil level low Alarm
 - Any other contacts as required.

4.16.0 OFF Circuit tap changer

OFF-Circuit taps with the range from +5.0% to -5.0% insteps of 2.5% shall be provided on HV side of the transformer, where specified. The operating handle shall be brought out of the tank enclosure and provided with a hand wheel so that it can be operated conveniently from ground level. The operating handle shall be locked at any tap position. The design shall be such that the lock cannot be inserted unless the contacts are correctly engaged. The cranking device shall be removable, mechanical stops shall be provided to prevent cranking beyond the required level. All contacts shall be silver plated and shall be held under strong contact pressure to ensure low contact drop and avoid pitting. A warning plate indicating "For de-energized operation only" shall be fitted. The mechanism shall be provided with a mechanical tap position indicator. The direction of rotation for tap raise /lower operation shall be marked. No. of revolution of the operating handle for one tap change shall also be marked.

4.17.0 On Load Tap Changer (OLTC)

- a) The OLTC gear shall be designed to complete successfully tap changes for the maximum current to which transformer can be loaded. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.
- b) Oil, in compartments which house the making and breaking contacts of the OLTC shall not mix with oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. An oil surge relay shall be installed in the above pipe. The conservator shall be provided with oil level gauge and all fitments and accessories as required.
- c) Oil filled compartments shall be provided with filling plug, drain valve with plug, air release vent, oil sampling device, inspection opening with gasket and bolted with lifting handles.



- d) The OLTC shall be provided with the Local - Manual / Local - Electrical / Remote - Electrical modes of operation. The electrical operation shall be performed through a Raise / Off / Lower control switch. When the manual operating gear is in use, it shall not be possible to operate electric drive.
- e) Diverter switch, motor drive mechanism and selector switches shall be provided as per IS-10028. All electrical control switches and local operating gear shall be clearly labeled in suitable manner to indicate the direction of tap changing.
- f) A local tap changer cubicle shall be provided for housing motor drive mechanism for OLTC mounted on the tank of the transformer. The cubicle shall be fabricated with minimum 2 mm thick sheet steel complete with all wiring, MCBs, cubicle illumination lamps, anti-condensation heater with thermostatic control switch, gland plate etc. Local/ Remote selector switches shall be mounted inside the cubicle. The cubicle shall conform to IP55 degree of protection. The cubicle shall include the following as a minimum:
- Driving motor (squirrel cage totally enclosed type).
 - Electrically and mechanically interlocked reversing contactors.
 - MCCB/MPCB with integral short circuit and thermal overload protection.
 - Raise / Off / Lower control switch
 - Remote / Local selector switch lockable in 'Remote' position.
 - Mechanical tap position indicator showing rated tap voltage against each position and resettable maximum and minimum indicators.
 - Limit switches to prevent motor over-travel in either direction in addition to mechanical stops.
 - Brake or clutch to permit only one tap change at a time on manual operation.
 - Emergency manual operating devices (hand crank or hand wheel).
 - Operation counter.
 - Space heaters with MCB.
 - Cubicle lamp with door switch and MCB.
 - Gaskets and hinged door with locking arrangement.
 - Terminal blocks, internal wiring, earthing terminals and double compression cable glands for power and control cables.
 - Necessary relays, contactors, current transformers etc.
 - Control supply transformer, if applicable.
 - Any other feature as required.
- g) The following electrical control features shall be provided:
- Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position. In case of failure of external power supply during tap change, adequate means shall be provided to safeguard the transformer and its auxiliary equipment.
 - Only one tap change from each tap change impulse even if the control switches or push button is maintained in the operated position.
 - Cut-off of electrical control when manual control is resorted to.
 - Cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.
 - Cut-off of electrical control when it tends to operate the tap beyond its extreme position.
 - Voltage regulation relay shall be used for regulating the secondary voltage of power transformer with OLTC. The required dead band settings shall be set by setting the nominal value and lower and upper level values shall be set independently
 - Operation of raise control shall be automatically inhibited when the voltage falls below the specified under voltage limit.
 - Any other feature as required.



4.18.0 Numerical Tap Changer Control

The Numerical Tap Changer-cum Transformer Monitoring Unit (NTCMU) shall be provided housed in transformer relay panel. The remote tap changer-cum transformer monitoring unit shall comprise of the following:

- a. Raise / off / lower control
- b. Tap position indicator (On LCD display)
- c. Remote transformer winding temperature indication (On LCD display)
- d. Remote transformer oil temperature indication (On LCD display)
- e. Voltage sensing relay
- f. Voltage regulation relay (DAVR) for Auto operation
- g. Auto/Manual Selection
- h. Necessary auxiliary relays
- i. Necessary analog/binary inputs
- j. LED indications for :
 - Tap change in progress
 - OLTC Mechanism stuck
 - AC supply fail
 - Oil surge relay Alarm/Trip
 - Control supply healthy
 - Lower limit reached
 - Upper limit reached
 - Any other feature/control/annunciation as required.

The Unit shall communicate with DCS for control and indication.

4.19.0 Wiring and Terminal Blocks

- a) All control cabinets, marshaling boxes, etc. shall be fully wired at the factory to ensure proper functioning of the control, protection and interlock schemes. All contacts including spare contacts of switches, relays and other devices shall be wired up to the terminal block. The inter-connection cables shall not touch transformer body to avoid heating.
- b) Wiring shall be done with flexible 650 V grade XLPE cables with stranded copper conductor of minimum size 2.5 sq.mm. Not more than two wires shall be connected to a terminal. Wiring shall be identified at both ends with ferrules bearing wire numbers as per approved drawing. Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.
- c) Terminal blocks shall be of 650 V grade suitable for terminating required cable size. Terminals for CT secondary shall have provision for shorting & earthing. Not more than two wires shall be connected to any terminal. 20% spare terminals shall be provided.
- d) All devices and terminals blocks within the panel shall have identification numbers as per schematic diagram.
- e) The marshaling box shall have degree of protection of IP 55.

4.20.0 Earthing Terminals

- a) Two earthing pads (each complete with two nos. holes, M10 bolts, plain and spring washers) suitable for connection to galvanised steel earthing flat shall be provided each at position close to earth of the two diagonally opposite bottom corners of the tank.
- b) Two earthing terminals shall also be provided on cooler, cooler control cabinet and any other equipment mounted separately.



4.21.0 Insulating Oil

The insulating oil shall be EHV grade, inhibited type mineral oil, and shall conform to all parameters specified in IS/IEC standard, while tested at Supplier's premises. The transformer and all associated oil filled equipment shall normally be supplied along with the first filling of oil and 10 percent excess quantity of oil shall also be supplied in non-returnable drums. The Contractor shall furnish test certificates from the Supplier against their acceptance norms, prior to dispatch of oil from refinery to site.

4.22.0 On line Dissolved Gas Analyser (DGA)

On-line dissolved gas analyzer shall be provided for EHV power transformers (Generator transformers and Standby maintenance transformer).

It shall be GE Hydran / Kelmann / Doble make . It shall be microprocessor based, complete with extraction unit with oil pump, detection unit, sampling control unit & software. The system shall be communicated to EMS, which shall be loaded with the DGA software.

On-Line dissolved Gas Analysis shall provide automatic on-line analysis of nine (9) gases (Oxygen-O₂, Nitrogen -N₂, Hydrogen-H₂, Carbon monoxide-CO, Carbon dioxide-CO₂, Methane -CH₄, Ethane-C₂H₆, Ethylene -C₂H₄, Acetylene-C₂H₂) which shall be carried out in two steps, identical with a laboratory procedure ensuring a high accuracy and reliability:

- Degassing of the oil sample through vacuum extraction (according to IEC 60567) or any other method.
- DGA through gas chromatography with Thermal Conductivity Detector (TCD), Flame Ionization Detector (FID) and Methanizer or by Photo Acoustic Spectroscopy.

The whole system shall be controlled by a micro-processor. The intervals of the analysis can be defined by the operator. All results shall be displayed in ppm with a high sensitivity (0.1 ppm for certain hydro-carbons). Additionally all other operating conditions shall be stored in a data-base. The data shall be transmitted to a remote computer located in the control room. The integrated alarm function can be triggered on specific gas levels, defined trends and the interruption of the power supply. A visually effective traffic light system shall provide status indication. The whole system shall be installed in controlled environment housing.

The system shall be robust and suitable for operation in substation environment. Input oil temperature up to 100 degree Celsius. Input power supply shall be 230 V 50 Hz AC.

4.23.0 On line partial discharge (PD) measurement

The on line partial discharge measurement system shall be envisaged for assessing the condition of transformers in the field. By monitoring the in-service partial discharge, the insulation performance and bushing healthiness shall be reliability assessed over time and corrective action be taken before a failure occurs.

It shall be based on Ultra high frequency (UHF) technology, equipped with the following devices:

- UHF sensors that can be either mounted through tank hatches or inserted through an oil drain valve
- UHF central control unit
- UHF pulse generator
- PD evaluation server
- PD analyses software



- Ethernet switch
- Connecting cables & accessories
- Additional 100% sensors for future use

4.24.0 Nitrogen injection system

Generator transformers, Standby maintenance transformer, Station transformers Unit transformers and all transformers rated above 20 MVA shall be provided with a dedicated Nitrogen Injection system for prevention against the transformer explosion which shall use nitrogen as quenching medium. The system shall prevent transformer oil tank explosion / fire in case of internal / external cause. In the event of fire by external causes it shall accomplish its role as fire preventer and extinguisher without employing water or carbon dioxide. Fire shall be extinguished within reasonable with time (not more than 3 minutes so as not to harm the transformer) of system activation and within 30 seconds (maximum) of commencement of nitrogen injection. The system shall be time tested and proven type for similar rating of transformers. The system shall be fool-proof. The system shall have control cubicle, regulating valves, pipe connections, nitrogen cylinders, detectors, automatic control and manual control etc.

4.25.0 Each Transformer shall be supplied with the following accessories as applicable

The fittings listed are only indicative and other fittings which generally are required for satisfactory operation of the transformer are deemed to be included. The transformer fittings and accessories shall be of reputed make and shall be subject to approval of the Owner.

- 1) Conservator for main tank with oil filling hole and cap, isolating valves, drain valve, sump valve, magnetic oil level gauge with low level alarm contacts.
- 2) Pressure relief devices with alarm/trip contacts.
- 3) Air cell type Oil preservation system complete with accessories
- 4) Buchholz relay with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm and trip contacts.
- 5) 150 mm dial magnetic oil level gauge with low level alarm contact.
- 6) Oil view glass
- 7) Thermometer pockets with mercury in glass thermometer (0-120 °C)
- 8) Winding temperature indicator for HV winding with alarm and trip contacts.
- 9) Winding temperature indicator for LV winding with alarm and trip contacts.
- 10) Signal transmitter for remote HV-WTI and LV-WTI.
- 11) Remote winding temperature indicators for HV winding & LV winding.
- 12) Remote oil temperature indicators.
- 13) RTD for remote oil temperature indicators.
- 14) 150 mm dial oil temperature indicator with alarm and trip contacts.
- 15) Drain valve with locking arrangement at transformer end
- 16) Drain valve at burnt oil pit end with interconnecting pipe from transformer drain valve
- 17) Set of Sample valves (top and bottom)
- 18) Oil flow indicator with alarm contacts with each oil pump
- 19) Set of Filter valves (top and bottom) with locking arrangement at bottom valve.
- 20) Shut-off valves on both sides of oil pumps.
- 21) Set of Silica gel breather with oil seal
- 22) Rating plate and terminal marking plate.
- 23) Valve Schedule plate.



- 24) Do's & Don'ts plate.
- 25) Cooler control cabinet.
- 26) All cabling between transformer and cabinet.
- 27) Set of Air relief devices
- 28) Ladder with safety device for access to the top of transformer tank.
- 29) HV bushings
- 30) LV bushings busduct adaptor
- 31) LV Neutral bushing with cable box
- 32) Current transformers
- 33) Inspection covers
- 34) Cover lifting eyes, lifting lugs, jacking pads, towing holes, etc.
- 35) Protected type mercury or alcohol in glass thermometer.
- 36) Flanged bi-directional wheels
- 37) Radiator banks complete with fans, valves, etc.
- 38) Drain valves/plugs for pipe work
- 39) On load tap changer.
- 40) Numerical tap changer control unit
- 41) Off circuit tap changer

4.26.0 Painting

- (a) Painting shall be carried out as per 'CBIP Manual on Transformers'.
- (b) External and internal surfaces of all transformer tanks and chambers and other fabricated steel items shall be cleaned of scale, rust and surface dirt by blast cleaning. Inside of all oil filled chambers and tanks, hot oil resistant varnish on white epoxy paint shall be applied. Two coats of epoxy zinc phosphate or zinc chromate primer topped with two coats of aliphatic glossy paint finish shall be applied. One intermediate coat of high build micaceous iron oxide shall also be applied. Total dry film thickness shall be 150-180 microns. All interior surfaces of chambers that are in contact with oil shall have atleast three coats of paint.
- (c) The finish shade on external surface shall be of shade number 631 of IS: 5. One coat of additional paint shall be given at site over all external surfaces after erection.

5.0.0 TESTS

All tests shall be carried out using its own accessories and parts which shall be supplied along with the transformer. Tests shall be conducted on transformer as per IS: 2026/ IEC-60076/CBIP Manual.

Short circuit tests certificates for test conducted earlier on transformers of similar type and rating shall be furnished for the Owner's review.

5.1.0 Routine Tests

Following routine tests shall be conducted on each transformer:

- a) Measurement of winding resistance at all taps
- b) Measurement of voltage ratio at all taps, polarity and check of phase displacement
- c) Measurement of impedance voltage / short circuit impedance (principal tapping) and load loss.



- d) Measurement of no load loss and current.
- e) Measurement of insulation resistance.
- f) Switching impulse withstand voltage test , transformer winding $U_m > 72.5$ kV
- g) Lightning impulse withstand voltage test, transformer winding $U_m > 72.5$ kV
- h) Separate source withstand voltage test.
- i) Induced AC Over voltage withstand test
- j) Tests on on-load tap changers
- k) Leakage test on tank, conservator and radiator during fabrication
- l) Oil pressure test

5.2.0 Type Tests

Following type tests shall be conducted on one transformer of each type and each rating:

- a) Temperature rise Test with dissolved gas analysis test before and after.
- b) Lightning impulse withstand voltage test, transformer winding $U_m \leq 72.5$ kV
- c) Vacuum test during tank fabrication
- d) Pressure test on Transformer.
- e) Degree of protection for Cooler control cabinet

5.3.0 Special Tests

Following Special tests shall be conducted on one transformer of each type and each rating:

- a) Lightning impulse test on neutral terminal (Where neutral is resistance grounded)
- b) Long duration induced AC voltage test for transformer winding $72.5 \text{ kV} < U_m \leq 170 \text{ kV}$.
- c) Short circuit withstand test (If valid type test report is not available for the specified rating)
- d) Measurement of zero-sequence impedance of three-phase transformers.
- e) Measurement of Acoustic noise level
- f) Measurement of the harmonics of the no-load current.
- g) Measurement of the power taken by the fan and oil pump motors.
- h) Test with lightning impulse chopped on the tail.
- i) Determination of capacitance and dissipation factor between windings-to-earth, and between windings.
- j) Determination of transient voltage transfer characteristics.
- k) SFRA test before dispatch and after installation at site.

5.4.0 Additional Tests

Following additional tests shall also be carried out on each transformer:

- a) Magnetic circuit isolation test
- b) Determination of capacitances and dissipation for condenser bushings > 72.5 kV
- c) Magnetic balance test on three phase transformer
- d) Dissolved gas analysis before and after temperature rise test
- e) Frequency response analysis test
- f) Measurement of magnetization current at low voltage
- g) Tests on oil
- h) Oil pressure test on completely assembled transformer
- i) Dew point measurement before dispatching.

Insulating oil shall be tested for BDV & moisture content as follows, at manufacturer's works (oil sample shall be drawn before and after heat run test):

- BDV 60 kV (min.)
- Moisture content 15 ppm

5.5.0 Site tests

5.5.1 The following tests shall be conducted at site on each transformer.

- a) Dew point measurement
- b) Winding resistance measurement
- c) Verification of vector group and polarity
- d) Measurement of voltage ratio test
- e) Measurement of magnetization current
- f) Magnetic balance test on 3 phase transformer
- g) Magnetic circuit isolation test
- h) Measurement of short circuit resistance at low voltage
- i) Insulation resistance measurement
- j) Measurement of capacitance and dissipation factor between windings-to-earth, and between windings.
- k) Dissolved gas analysis test
- l) Tests oil filled in transformer
- m) Measurement of tan delta for bushings

5.5.2 The following checks shall be conducted at site on each transformer.

- a) Colour of silicagel in breather
- b) Oil level in the breather housing, conservator tanks, radiators, condenser bushing etc.
- c) Bushing for conformity of connection to the lines etc. and tan delta test for bushing
- d) Operation of protection devices and alarms:
 - Buchholz relay
 - Excessive winding temperature
 - Excessive oil temperature
 - Low oil flow
 - Low oil level indication
- e) Resistance of all windings on all steps of the tap changer.
- f) Insulation resistance of the following:
 - Control wiring
 - Cooling system motor and control
 - Main windings
 - Tap changer motor and control
 - Tank and turret mounted CTs
 - Core and clamp
 - Core to earth
 - Core clamp to earth
 - Core to core clamp
- g) The following checks shall also be carried out:
 - Direction and overload setting of cooling accessories
 - Earthing of main tank, marshaling box, tap changer driving gear, pump and fan motor etc.
 - Neutral earthing
 - Calibration of WTI and OTI
 - Earthing of bushing test tap
 - Connection of WTI CT
 - Tightness of CT secondary connection and shorting of unused CTs
 - All valves for their correct opening and close sequence



- h) Test on tank/ turret mounted CTs
 - IR value between secondary winding & earth and between windings
 - Secondary resistance
 - Polarity
 - Ratio test
 - Magnetization current
- i) Test on cooler fan and pump
 - IR Value
 - Starting current
 - Running current
- j) Continuously observation of the transformer operation at no load for 24 hours with respect to voltage, no load current, temperature rise and noise.
- k) Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.

6.0.0 TECHNICAL PARAMETERS

6.1.0 Technical parameters of Generator transformers are as follows:

Sl. No.	Description	Unit	Data
1.	Rating (maximum)	MVA	3X275 MVA
2.	Construction	Nos.	3 nos. single phase units for each Generator
3.	Voltage Ratio (HV / LV)	KV	420/sqrt(3)/22*
4.	Vector group		YNd1
5.	OFAF Rating of 1 phase unit	MVA	275 MVA
6.	ONAF Rating of 1 phase unit	MVA	220 MVA
7.	ONAN Rating of 1 phase unit	MVA	165 MVA
8.	Bi-directional power flow	Yes / No	Yes
9.	Temperature rise above 50 °C ambient Temperature		
a)	In oil by thermometer measurement	°C	50
b)	In winding by resistance method	°C	55
10.	HV Side fault level	kA	63
11.	Short circuit withstand duration	Sec	3
12.	Impulse withstand level		
a)	HV side	KV	1425
b)	LV side	KV	170
13.	One minute Power frequency withstand voltage		
a)	HV side	KV	630
b)	LV side	KV	As per standards, for the generator voltage
c)	HV Neutral	KV	70
14.	Connections		
a)	HV side		Star
b)	LV side		Delta



Sl. No.	Description	Unit	Data
15.	System earthing		
a)	HV side		Solidly grounded
b)	LV side		-
16.	Terminal arrangement		
a)	HV side		Overhead line
b)	LV side		IPB
c)	HV Neutral side		Ground conductor
17.	Bushings creepage distance		31 mm /kV
18.	Tap Changer		
a)	Type		OCTC
b)	Tap provided on		HV side
c)	Range of taps	%	+5% to -5% in steps of 2.5%

* As per generator manufacturer's practice

6.2.0 Technical Parameters of Standby maintenance transformers are as follows:

Sl. No.	Description	Unit	Data
1)	Rating (maximum)	MVA	As required
2)	No. of windings		Three
3)	Voltage Ratio (HV / LV1/LV2)	KV	400/11.5/11.5
4)	Vector group		YNyn0yn0
5)	Type of cooling		ONAN/ONAF
6)	ONAN Rating	MVA	(60% of ONAF Rating)
7)	ONAF Rating	MVA	100%
8)	Bi-directional power flow	Yes / No	No
9)	Temperature rise above 50 °C ambient Temperature		
	In oil by thermometer measurement	°C	50
	In winding by resistance method	°C	55
10)	HV Side fault level	kA	63
11)	Short circuit withstand duration	Sec	3
12)	Switching Impulse withstand voltage on HV side		1050
13)	Impulse withstand level		
	HV side	KV	1300
	LV side	KV	75
14)	One minute Power frequency withstand voltage		
	HV side	KV	630
	LV side	KV	28
	HV Neutral	KV	70
	LV Neutral	KV	20
15)	Connections		



Sl. No.	Description	Unit	Data
	HV side		Star
	LV-1 side		Star
	LV-2 side		Star
16)	System earthing		
	HV side		Solidly grounded
	LV side		NGR grounding medium resistance
17)	Terminal arrangement		
	HV side		Overhead line
	LV1 side		SPB
	LV2 side		SPB
	LV Neutral side		Cable Box
	HV Neutral side		Ground conductor
18)	Bushings creepage distance		31 mm/kV
19)	Tap Changer		
	Type		OLTC
	Tap provided on		HV side
	Range of taps	%	±10% in steps of 1.25%
	Mode of operation		Local Manual, Local Electrical, Remote Electrical, Auto Mode

6.3.0 Technical parameters of Bus reactors are as follows:

Sl. No.	Description	Unit	Data
1.	Rating	MVAR	125 MVAR
2.	HV Side Voltage level		420 kV
3.	Frequency & Variation		50 Hz, +3%, -5%
4.	HV Side fault level	kA	63
5.	Short circuit withstand duration	Sec	3
6.	Type of cooling		ONAN
7.	Lightning Impulse withstand level(1.2/50 micro sec) , Phase	KVp	1300
8.	Switching surge impulse voltage, Phase	KVp	1050
9.	Ratio of zero sequence reactance to positive reactance (X0/X1)		Between 0.9 & 1.0.
10.	Range of constant impedance		Up to 1.5 p.u. voltage
11.	Harmonic content in phase current		
12.	Permissible current unbalance among different phases		+ 2%



Sl. No.	Description	Unit	Data
13.	Lightning Impulse withstand level(1.2/50 micro sec), Neutral	KVp	550
14.	Switching surge impulse voltage, Neutral	KVp	230
15.	System earthing		
a)	HV side		Solidly grounded
16.	Terminal arrangement		
a)	HV side		Overhead line
b)	HV Neutral side		Ground conductor
17.	Phase Bushings		
a)	Rated Voltage	kV	420
b)	Bushings Creepage distance		31 mm /kV
c)	Lightning Impulse withstand level(1.2/50 micro sec) , Phase	KVp	1425
d)	Switching surge impulse voltage, Phase	KVp	1050
e)	One minute Power frequency withstand voltage	kV	630
18.	Neutral Bushings		
a)	Rated Voltage	kV	145
b)	Bushings Creepage distance		31 mm /kV
c)	Lightning Impulse withstand level(1.2/50 micro sec) , Phase	KVp	650
d)	One minute Power frequency withstand voltage	kV	275

6.4.0 Technical Parameters of Unit transformers are as follows:

Sl. No.	Description	Unit	Data
1.	Voltage Ratio (HV / LV)	kV	22*/11.5
2.	Vector group		Dyn11
3.	Service		Outdoor
4.	Type of cooling		ONAN/ONAF
5.	ONAN Rating	MVA	80%
6.	ONAF Rating	MVA	100%
7.	Bi-directional power flow	Yes / No	No
8.	Short circuit withstand duration	Sec	3
9.	Impulse withstand level		
a)	HV side	kVp	170
b)	LV side	kVp	75
10.	One minute Power frequency withstand voltage		



Sl. No.	Description	Unit	Data
a)	HV side	kV	70
b)	LV side	kV	28
c)	LV Neutral	kV	20
11.	System earthing		
b)	LV side		Resistance grounded limited to 300 A for 5min.
12.	Terminal arrangement		
a)	HV side		IPB
b)	LV side		SPB
d)	LV Neutral side		Cable Box
13.	Bushings Creepage distance		20 mm /kV
14.	Tap Changer		
a)	Type		OLTC
b)	Tap provided on		HV side
c)	Range of taps	%	+/- 10% in steps of 1.25%
d)	Mode of operation		Local Manual/Auto, Remote Manual/ Auto Mode

6.5.0 Technical Parameters of Station transformers are as follows:

Sl. No.	Description	Unit	Data
1.	Rating	Nos.	As required
2.	Voltage Ratio (HV / LV1/LV2)	kV	22*/11.5
3.	Vector group		Dyn11
4.	Service		Outdoor
5.	Type of cooling		ONAN/ONAF
6.	ONAN Rating	MVA	80 %
7.	ONAF Rating	MVA	100%
8.	Bi-directional power flow	Yes / No	No
9.	Short circuit withstand duration	Sec	3
10.	Impulse withstand level		
a)	HV side (generator side)	kVp	170
b)	LV side (11.5 kV)	kVp	75
11.	One minute Power frequency withstand voltage		
a)	HV side	kV	70
b)	11 kV side	kV	28



Sl. No.	Description	Unit	Data
d)	11 kV Neutral	kV	20
12.	System earthing		
b)	11 kV side		Resistance grounded limited to 300 A for 5min.
13.	Terminal arrangement		
a)	HV side		IPB
b)	LV side		SPB
c)	LV Neutral side		Cable Box
14.	Bushings (in cable box/busduct) Creepage distance		20 mm /kV
15.	Outdoor Bushings Creepage distance		31 mm /kV
16.	Tap Changer		
a)	Type		OLTC
b)	Tap provided on		HV side
c)	Range of taps	%	+/- 10% in steps of 1.25%
d)	Mode of operation		Local Manual/Auto, Remote Manual/ Auto Mode

6.6.0 Technical Parameters of Oil filled HV auxiliary Transformers are as follows:

Sl. No.	Description	Unit	Data
1.	Service		Outdoor
2.	Type		Oil filled, two winding
3.	Nominal system voltage (HV / LV)	kV	11/6.9 kV
4.	Vector group		Dyn1
5.	Type of cooling		ONAN
6.	Impulse withstand level		
a)	11 kV	kVp	75
b)	6.6 kV	kVp	60
7.	One minute Power frequency withstand voltage		
a)	11 kV	kV	28
b)	6.6 kV	kV	20
8.	Connections		
a)	HV side		Delta
b)	LV side		Star
9.	Parallel operation of transformer		-
a)	HV side		



Sl. No.	Description	Unit	Data
b)	LV side		Resistance grounded limited to 300 for 5min.
10.	Terminal arrangement		
a)	HV side		Cable Box
a)	LV side		Cable Box/Busduct
c)	LV Neutral side		Cable box
11.	Bushings		
a)	Indoor Bushings Creepage distance		20 mm /kV
12.	Tap Changer		
a)	Type		OCTC
b)	Tap provided on		HV side
c)	Range of taps	%	+5% to –5% in steps of 2.5%
13.	Short circuit withstand duration	Sec	2

6.7.0 Technical Parameters of Oil filled External CHP Transformers are as follows:

Sl. No.	Description	Unit	Data
1.	Service		Outdoor
2.	Type		Oil filled, two winding
3.	Nominal system voltage (HV / LV)	kV	11/34.5 kV
4.	Vector group		Dyn1
5.	Type of cooling		ONAN/ONAF
6.	Impulse withstand level		
a)	11 kV	kVp	75
b)	33 kV	kVp	170
7.	One minute Power frequency withstand voltage		
a)	11 kV	kV	28
b)	33 kV	kV	70
8.	Connections		
a)	HV side		Delta
b)	LV side		Star
9.	Parallel operation of transformer		-
a)	HV side		
b)	LV side		Solidly grounded
10.	Terminal arrangement		
a)	HV side		Cable Box



Sl. No.	Description	Unit	Data
a)	LV side		Cable Box
c)	LV Neutral side		Cable box
11.	Bushings		
a)	Indoor Bushings Creepage distance		20 mm /kV
12.	Tap Changer		
a)	Type		OCTC
b)	Tap provided on		HV side
c)	Range of taps	%	+5% to –5% in steps of 2.5%
13.	Short circuit withstand duration	Sec	2

7.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Technical data sheet
- Sizing calculation for transformers
- List of deliverable items & packing list.
- General Arrangement drawing of transformer and reactor.
- Parts list
- General Arrangement drawing and scheme drawing for Cooler cabinet
- General Arrangement drawing and scheme drawing for numerical tap changer control unit
- HV/LV bushing arrangement
- HV neutral & LV neutral Terminal arrangement
- Over fluxing curve
- Particulars of on-line dissolved gas analyzer
- Catalogues/drawings for bought out items.
- Transport /Shipping dimension drawing
- Foundation Plan & loading details
- Properties of transformer oil
- Valve diagram plate and list of valves indicating material & size.
- Name plate details
- Design calculations for short circuit withstand capability (Thermal & Dynamic force).
- Painting & surface preparation procedure.
- Test procedure for testing at shop and site.
- Catalogues / drawings / leaflets for all items
- Erection and commissioning procedures
- Operation and maintenance manual
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.5: DRY TYPE LOW VOLTAGE (LV) SERVICE TRANSFORMERS

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of dry type LV service transformers.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) 11 / 0.433 kV rated dry type transformers for power house building.
- b) 11 / 0.433 kV rated dry type transformers for ESP auxiliary supply.
- c) 11 / 0.433 kV rated dry type transformers for Auxiliary plants.
- d) 11 / 0.433 kV rated dry type transformers for non-plant buildings.
- e) 11 / 0.433 kV rated dry type transformers for WTP, Fuel oil, CW and other auxiliary plants.
- f) 6.6 / 0.433 kV rated dry type transformers for CHP, AHP, WTP, Sea water intake, and other auxiliary plants.
- g) Static excitation transformer
- h) Commissioning spares and consumables
- i) Mandatory spares
- j) Tools & tackles
- k) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Indian Standards, IEC publications and any other standards of latest edition including amendments, except where modified and /or supplemented by this specification.

- a) IS 2099 : Specification for bushings for alternating voltages above 1000V
- b) IS 3347 : Dimension for porcelain transformer bushings
- c) IS 3639 : Specification for fittings and accessories for power transformers
- d) IS 4257 : Porcelain bushings for transformers
- e) IS 10028 : Code of practice for selection, installation and maintenance of transformers.
- f) IS 2705 : Specification for current transformers
- g) IS 10561 : Application guide for power transformers.
- h) IS 11171 : Specification for dry-type power transformers
- i) CBIP Manual on transformers

4.0.0 DESIGN REQUIREMENTS

- 4.1.0 Transformers shall be designed with maximum temperature rise of 90°C over design ambient of 50°C. The core and other associated parts shall also be limited to the same value of temperature rise as for the windings.
- 4.2.0 Required numbers of service transformers for supplying 415 V loads of entire plant shall be provided. For each switchgear, 2X100% rated transformers shall be considered. Each transformer shall be rated to meet the loads connected on both the bus sections of switchgear with 10% design margin. The rating of transformers shall be between 630 kVA and 2500 kVA.



- 4.3.0 For each mechanical system, separate set of service transformers shall be provided. Loads of two systems shall not be fed from the same transformer.
- 4.4.0 The transformers shall be capable of delivering the rated output at any particular tap continuously without exceeding the specified temperature limits under the following operating conditions.
- Voltage variation of $\pm 10\%$ of rated voltage of that particular tap.
 - Frequency variation of $+3\%$ -5% of rated frequency.
 - Combined voltage and frequency variation of 10% (absolute sum).
 - Minimum ambient temperature specified in the specification
- 4.5.0 The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 per cent continuous over-voltage condition it does not exceed 1.67 Tesla.
- 4.6.0 Transformers shall withstand, without injurious heating 125% over fluxing for a period of one (1) minute and 140% over fluxing for a period of five (5) seconds. (Over fluxing caused by combined voltage and frequency fluctuations).
- 4.7.0 Transformers shall be capable of operating at 125% rated voltage for a period of one (1) minute and 140% rated voltage for a period of ten (10) seconds due to sudden load throw off.
- 4.8.0 The transformers shall be free from annoying hum and vibration when it is in operation, even at 110% rated voltage.
- 4.9.0 The transformers shall be designed with particular attention to the suppression of maximum harmonic voltage, especially the third and fifth so as to minimize interference with communication circuit.
- 4.10.0 The transformers shall be capable of withstanding without injury, the thermal & magnetic stresses caused by faults on any of the winding /through faults with full voltage maintained on other winding for a period of 2 seconds. Bushing CT shall be rated for the same fault current for a duration of 1 second.
- 4.11.0 The transformers shall be capable of being loaded in accordance with IS: 6600/IEC-600354. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.
- 4.12.0 The noise level of transformer, when energized at normal voltage and frequency with fans running shall not exceed, when measured under standard conditions, the values specified in NEMA standard publication TR-1.
- 4.13.0 Efficiency of the transformers shall be in the range of 98.25 to 98.75% at 0.8 PF at full load for various ratings between 500 kVA and 2500 kVA.

5.0.0 CONSTRUCTIONAL FEATURES

- 5.1.0 Dry type transformers shall be Vacuum pressure impregnated type (VPI) or encapsulated type.

5.2.0 Core & Windings

Windings shall be fully uniformly insulated. The high voltage and the low voltage coils shall be wound with high conductivity copper conductors and the insulation shall be done by Vacuum pressure impregnation process. Coils shall be separated by a uniform air space that permits free circulation of cooling air between the coils. Windings shall be properly sized, insulated and



supported for the voltages and currents to be encountered in operation, including short circuits. Insulation shall be class –H and temperature rise shall be limited to class F.

5.3.0 Core

The transformer core shall consist of thin, individually insulated sheets of high permeability, cold rolled grain-oriented, non-aging silicone steel. They shall be miter-corner-cut without burs, to provide a cross section most nearly resembling the circular cross-section. Laminations shall be cut and stacked utilizing step-lap construction to reduce losses and sound. Designed flux density shall be kept well below saturation.

The assembled core shall be braced with heavy structural steel angle or channel to apply uniform clamping forces across the entire width, top and bottom. The core shall be protected from corrosion with high temperature rated rust-resistant coating.

5.4.0 Core and Coil Assembly

Construction shall consist of separate high and low voltage coils for each phase, mounted coaxially, with high/low air space between coils adequate for the rated voltage potentials. Coils shall be mounted concentrically and supported in place on the transformer core so as to restrain movement in shipping and in service. Each coil shall be supported on epoxy blocks, top and bottom, with resilient pads to retain the coils while permitting thermal expansion under loading. The core-and-coil assembly shall be designed and manufactured to withstand without damage the short circuit testing. All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration or short circuit stresses.

5.5.0 Bus

All bus work shall be designed to withstand maximum short circuit stresses when connected to a supply system having a specified fault capacity, and to meet all test voltage requirements, without audible or visible corona.

Low voltage bus shall be high conductivity copper. Connections of coil windings to bus shall be brazed or welded using shielded arc techniques. Connection and terminal bolting surfaces shall be tin or silver-plated. Bolted connections shall include spring washers to maintain bolted surface pressure. All bus shall be sized to for the amperes involved and maximum specified ambient temperatures.

High voltage bus shall be high conductivity copper. It shall be supported by glazed porcelain insulators for surge strength. It shall have bolt-connected joint and terminal surfaces tin or silver-plated. High voltage leads shall be bus or flexible, insulated cable with suitable terminations. Taps shall have flexible cable or solid copper links or jumpers.

Ground bus shall be copper bus or aluminium extending the full length of the enclosure. It shall have provisions to mount appropriate terminal connections for external grounding.

5.6.0 Enclosure

The enclosure shall be a ventilated enclosure for indoor use and be designed to provide adequate ventilation for the transformer. Protection of enclosure shall be atleast IP 33. Screens shall be perforated sheet steel type. Mesh size shall be such that lizard, rats etc. cannot enter inside the enclosure.

Double leaf access shall be provided with concealed hinge and neoprene gaskets for easy access to HV links and also for withdrawal of core and coil assembly if required. The enclosure shall be of CRCA sheet steel with a minimum thickness of 2 mm while the roof and vertical supports shall be formed from minimum 3 mm thick sheet steel. The enclosure shall be



adequately reinforced to ensure rigidity so as to permit transportation of transformer within enclosure.

The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized adequately. Each transformer shall be provided with one set of bi directional rollers for rolling the transformer parallel to either centre line.

5.7.0 Base

The transformer base shall be a separate rigid steel construction capable of supporting the core and coil assembly and enclosure. Construction shall include provisions for lifting as well as for jacking and skidding or rolling in both directions. Lifting provisions shall be designed for lifting the transformer and the core-and-coil assembly, separately or together.

5.8.0 Temperature Indicators

For measuring temperature in the winding PT-100 Resistance temperature detectors shall be embedded in all three phases in LV windings. Potential free alarm and trip contacts shall be provided in to operate alarm and trip circuits. Four channel temperature scanner & local winding temperature indicator for winding temperature measurement shall be provided in the marshaling box. The same shall be hooked up to DCS/EMS.

5.9.0 Off Circuit Tap Changer

- a) Off circuit taps as specified shall be provided on the high voltage winding.
- b) The transformer shall be capable of operation at its rated kVA on any tap provided the voltage does not vary by more than 10% of the rated voltage corresponding to the tap.
- c) The winding including the tapping arrangement shall be designed to maintain electromagnetic balance between HV and LV windings at all voltage ratios.
- d) The tap change switch shall be three phase, hand operated for simultaneous switching of similar taps on the three phases by operating on external hand wheel.
- e) The tap changing shall be possible without disturbing the transformer in any way except de-energizing.
- f) Arrangement shall be made for securing and locking the tap changer in any of the working positions, and it shall not be possible for setting or locking it in any intermediate position. An indicating device shall be provided to show the tap in use.
- g) Cranking device for manual operation of the off circuit tap changing gear shall be removable and suitable for operation by a man standing on ground level. The mechanism shall be complete with the following:-
 - Mechanical tap position indicator which shall be clearly visible from near the transformer.
 - Mechanical stops to prevent over cranking of the mechanism beyond the extreme tap positions.
 - Manual operating mechanism shall be labeled to show direction of operation for raising the secondary voltage and vice versa.
 - A warning plate indicating "The switch shall be operated only when the transformer has been de-energised" shall be fitted.

5.10.0 Safety Interlock

For all dry type transformers following safety interlocks shall be provided:



- a) A safety interlock to ensure that the enclosure door can be opened only when transformer is de energized.
- b) Safety limit switches operated by door handle for tripping HV breaker.

5.11.0 Limit Switches

Minimum 4 Nos. limit switches shall be provided for transformer enclosure door interlock. Each Limit switch shall have 1 NO & 1 NC contact. All NO contacts of limit switch shall be connected series and NC contacts shall be connected parallel. Limit switch shall be used for HT Circuit breaker tripping and HT Circuit breaker closing permissive.

5.12.0 Bushings

- a) All bushings shall be homogenous, non-porous porcelain type, uniformly glazed and free from blisters, burns and other defects complete with suitable terminal connectors of adequate capacity..
- b) Bushings located indoor can be epoxy-molded types.
- c) Clamps and fittings of steel or malleable cast iron shall be galvanised.
- d) Bushing location shall provide adequate phase and ground clearances.
- e) For indoor bushing, creepage distance shall be 20 mm/KV.

5.13.0 Cable Box

- a) A dust tight air insulated type cable box with IP: 55 protection shall be provided for terminating the cables with termination kit.
- b) Inspection cover for fixed portion of cable box shall be provided. Handles for lifting cable box shall be provided.
- c) Gland plate for single core cable termination shall be of Aluminium.
- d) The cable box shall have Pressure Relief Diaphragm (PRD).

5.14.0 Busduct Termination

For busduct termination a flanged throat or equivalent connection shall be provided with IP 55 degree of protection to suit the busduct. The busduct shall be non-phase segregated type. Busduct terminals and flange shall be coordinated with bus duct size. The arrangement shall be such as to permit removal of the transformer and core / coil assembly without dismantling the bus duct installation. Necessary flexible shall be provided to connect the bushing terminals to the busbar.

5.15.0 Neutral Terminals

- a) Two Nos. neutral terminals shall be provided on LV side. One neutral terminal shall be part of phase connection arrangement busduct throat/ LV cable-box (as applicable). Other neutral terminal shall be brought to the transformer bottom for connection to station earth by means of earthing bar of copper / Aluminium, supported on insulators mounted on transformer body.
- b) Neutral bushing CT shall be provided for protection. CTs shall be cast resin type. CT shall be located as per protection requirement.



5.16.0 Marshaling Box

- a) The marshaling box shall be fabricated using sheet steel of at least 2 mm thickness.
- b) Marshaling box shall be complete with all internal wiring and identification ferrules, cables, conduits required for wiring between marshaling box and instruments on transformer.
- c) The marshaling box shall be provided with thermostatically controlled space heaters and shall have IP: 54 degree of protection.
- d) CT terminals shall be with shorting and disconnecting facility.
- e) Cable gland plate shall be of removable type.
- f) The marshaling box shall have MCB for incoming power supply.
- g) Marshaling box shall have seven channel temperature scanner & local winding temperature indicator for winding temperature measurement. Terminal block shall be provided in the marshaling box to connect cabling between RTD's and Temperature scanner. The temperature scanner unit shall continuously monitor the winding temperature and shall be provided with auxiliary relays with potential free contacts for alarm and trip.

5.17.0 Wiring

- All control, alarm and indication devices provided with the transformer shall be wired up to the terminal blocks.
- Wiring shall be done with 1100 V grade XLPE insulated FRLS wires in conduit or XLPE insulated armoured FRLS cable. Minimum wire size shall be 2.5 sq.mm. stranded copper for control & 4 sq.mm. stranded copper for CTs. Not more than two wires shall be connected to a terminal. 20% spare terminals shall be provided.
- All devices and terminal blocks within the marshaling box shall be identified by symbols corresponding to those used in applicable schematic or wiring diagrams. Each wire shall be ferruled by plastic tube with indelible ink print at both end having terminal block no. terminal no. as per approved schematic or wiring diagrams.

5.18.0 Name plate

Each transformer shall be provided with a rating name plate. Plates shall be stainless steel material fitted in a visible position. Name plates shall be of white non-hygroscopic material with engraved black lettering.

6.0.0 PAINTING

All the fabricated surfaces shall be pretreated by degreasing, de-rusting and chemically cleaned prior to application of epoxy resin red oxide primer to give a dry film thickness of 50 microns. The finishing paint shall be half gloss based on an epoxy based. The paint shall be applied in two coats to give a minimum dry film thickness of not less than 50 microns. The final paint shade of external surface of shall be RAL 7035.

7.0.0 TESTS

7.1.0 Offered rating and type of transformer should have type tested.

7.2.0 Type tests/ Routine tests / Special tests / Acceptance tests shall be conducted as per standards and test reports shall be submitted for review.



7.3.0 The following type tests shall be conducted one on each rating of transformer

- Measurement of winding resistance
- Measurement of voltage ratio and check of phase displacement
- Measurement of impedance voltage, short circuit impedance (principal tapping) and load loss.
- Measurement of no load loss and current.
- Separate source voltage withstand test
- Induced overvoltage withstand test
- Lightning impulse test
- Temperature rise Test.

7.4.0 Following routine tests shall be conducted on each transformer

- Measurement of voltage ratio and check of phase displacement
- Measurement of impedance voltage / short circuit impedance (principal tapping) and load loss.
- Measurement of no load loss and current.
- Separate source voltage withstand test
- Induced overvoltage withstand test

7.5.0 Following Special tests shall be conducted on each rating of transformer

- Short circuit withstand test
- Partial discharge measurement
- Measurement of Acoustic noise level
- Degree of protection test.

7.6.0 The following tests/ checks shall be conducted at site. Any other tests/checks as per the manufacturer's recommendation shall also be carried out

- Resistance measurement of windings
- Ratio test
- Vector group test
- Tap changer test
- Temperature indicator test
- Marshaling kiosk test
- Magnetizing current test
- Earthing connections continuity test
- CT polarity check

8.0.0 TECHNICAL PARAMETERS OF DRY TYPE TRANSFORMERS

Sl. No.	Description	Unit	Data
1.	Service		Indoor
2.	Type		Dry type, two winding
3.	No. of Phase		Three
4.	Frequency	Hz	50
5.	No. of windings		Two
6.	Nominal system voltage (HV / LV)	kV	11/0.433 6.6/0.433



Sl. No.	Description	Unit	Data
7.	Vector group		Dyn1
8.	Type of cooling		AN
9.	Impulse withstand level		
a)	HV side	kV	75
10.	One minute Power frequency withstand voltage		
a)	11 side	kV	28
a)	6.6 side	kV	20
b)	LV side	kV	3
11.	Connections		
a)	HV side		Delta
b)	LV side		Star
12.	Neutral Earthing		
a)	HV side		
b)	LV side		Solidly grounded
13.	Terminal arrangement		
a)	HV side		Cable Box
b)	LV side		Busduct
a)	LV Neutral side		Ground conductor
14.	Bushings		
a)	Indoor Bushings Creepage distance		20 mm /kV
15.	Tap Changer		
a)	Type		OCTC
b)	Tap provided on		HV side
c)	Range of taps	%	+5% to –5% in steps of 2.5%
16.	Short circuit withstand duration	Sec	2

9.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Transformer sizing calculation
- Technical data sheet
- Dimensional General Arrangement drawing of transformer.
- Parts list
- Bushing / Terminal arrangement
- Cable box details
- Busduct termination arrangement
- Catalogues/drawings for bought out items.
- Transport /Shipping dimension drawing



- Foundation Plan & loading details
- Name plate details
- Design calculations for short circuit withstand capability.
- Erection and commissioning procedures
- Operation and maintenance manual
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.6: BUSDUCT

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of Isolated phase busduct, segregated phase busduct, Non segregated phase busduct associated equipment.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) Isolated phase busduct (IPBD) between generator and generator circuit breaker.
- b) Isolated phase busduct (IPBD) between generator circuit breaker and generator transformer including delta connections and tap offs.
- c) Current transformers for IPBD
- d) Isolated phase busduct (IPBD) between generator and NGT including required CTs
- e) 11 kV Segregated phase busduct (SPBD) between Unit transformer / Station transformer and respective switchgear
- f) 11 kV Segregated phase busduct (SPBD) between standby maintenance transformer and respective switchgear
- g) 11 kV Segregated phase busduct (SPBD) between switchgears
- h) 6.6 kV Segregated phase busduct (SPBD) between Auxiliary transformer and respective Switchgear
- i) 415 V Non segregated phase busduct (NSPBD) between transformer and power control centres
- j) AC & DC busduct for Static excitation system (if applicable)
- k) Air pressurization equipment for IPBD
- l) Hot air blowing equipment for IPBD
- m) Galvanised steel support structures
- n) Shorting links for IPBD
- o) Commissioning spares and consumables
- p) Mandatory spares
- q) Tools & tackles
- r) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Indian Standards, IEC publications and any other standards of latest edition including amendments, except where modified and /or supplemented by this specification.

a) IEC: 60529	Degree of protection provided by enclosures (IP code).
b) IS: 2099	Bushings for alternating voltage above 1000 volts.
c) IS: 2705	Current transformers.
d) IS: 3156	Voltage transformers.
e) IS: 4759	Hot-dip zinc coatings on structural steel and other allied products.
f) IS: 5082	Wrought aluminum and aluminum alloy bars, rods, tubes and sections for electrical purposes.
g) IS: 8084	Interconnecting bus bars for AC voltage above 1 kV up to and including 36 kV.



- h) IS: 9431 Indoor post insulators of organic material for systems with nominal voltages greater than 1000 volts up to and including 300 kV.
- i) IEEE: 32 Neutral grounding devices.
- j) IEC: 60076-11 Dry type power transformers.
- k) ANSI C37.20 Metal enclosed low voltage power circuit breaker switchgear.
- l) ANSI C37.23 Metal-enclosed bus and calculating losses in isolated phase bus.
- m) ANSI C37.24 Evaluating the effect of solar radiation on outdoor metal enclosed switchgear
- n) CBIP manual on busduct

4.0.0 TECHNICAL REQUIREMENTS

- 4.1.0 The bus ducts shall be installed partially indoor and partially outdoor in a hot, humid and tropical atmosphere.
- 4.2.0 All the equipment and its components shall be designed for design ambient temperature of 50°C.
- 4.3.0 The bus duct shall be natural air cooled. Degree of protection shall be IP-55 and shall be dust tight.
- 4.4.0 Positive air pressurization arrangement shall be provided for the isolated phase bus duct to prevent dust ingress.
- 4.5.0 For steam turbine generator, IPBD shall be sized to evacuate whole generated power at valve wide open (VWO) condition continuously, without exceeding the specified temperature limits. A design margin of 10% shall be considered further.
- 4.6.0 If Static excitation system is offered, Tapoff IPBD from Main IPBD for Excitation transformers, Non Segregated phase busduct (NPSBD) between Excitation Transformers and Exciter Panels, DC Busduct between Exciter Panels and generator Exciter shall be provided.
- 4.7.0 SPBD and NSPBD busduct of transformers shall be rated to carry name plate power rating of the associated transformers continuously, without exceeding the specified temperature limits. A design margin of 10% shall be considered further.
- 4.8.0 SPBD busduct between the switchgear shall be sized to carry continuously for maximum power flow with 10% design margin, without exceeding the specified temperature limits.
- 4.9.0 The continuous rating of the busduct shall be such that the rated current can be delivered without exceeding the following temperature as per IS 8084, with no canopy for outdoor portion.
 - Maximum temperature of bus conductor with silver plated /welded joint: 105°C
 - Maximum temperature of bus conductor with plain bolted joint: 90°C
 - Maximum temperature of bus enclosure: 80°C.

Losses in the conductor shall be limited to such a value that the temperature rise of the conductor does not exceed the specified values.

For the portion of the bus-duct installed outdoor and exposed to direct sun-rays, the effect of solar heat shall also be considered in the determination of temperature rise.

- 4.10.0 The busduct shall be suitable for continuous operation at maximum system voltage and shall be adequately sized to withstand short circuit current rating specified short circuit forces due to momentary current. Temperature of busduct shall not exceed 250 degree C, while carrying the specified short circuit current when fault occurs, at operating temperature.



- 4.11.0 The Busduct and auxiliary equipment shall be capable of withstanding the mechanical forces and thermal stresses of the short-circuit currents without any damage or deterioration of material. Bus conductor support insulator span shall be chosen considering minimum safety of 2.5 for cantilever strength under short circuit condition.
- 4.12.0 The busduct and supporting structures shall be designed and constructed so as to withstand without damage the horizontal/ vertical ground accelerations due to seismic. The outdoor section shall withstand the wind loading as indicated.
- 4.13.0 The bus conductors and inner surface of enclosure shall be coated with matte black paint to facilitate heat dissipation.
- 4.14.0 The portion of bus duct at the transformer end shall be subject to vibration. Suitable means shall be provided to isolate the transformer vibration from rest of the bus structure/bus duct.
- 4.15.0 Bolted rigid joints provided as disconnecting links and to facilitate removal of CTs shall be of the same materials as the bus conductor.

4.16.0 Bus Conductor

- a) The Bus Conductor shall be of high conductivity, painted aluminum alloy, supported on insulators.
- b) The bus conductor shall be designed for welded connections except at equipment terminations, bolted disconnect links, and bolted flexible. Flexible connections shall be provided between bus sections to allow for expansion and contraction of the conductor. Flexible connections shall also be provided at all equipment terminations.
- c) All connection hardware shall be nonmagnetic and shall have high corrosion resistance
- d) All busbar shall be colour coded as per IS. Phase identification painting shall be done at every joint.

4.17.0 Bus Enclosure

- a) Filtered drain tapping with dual stop cocks shall be provided for drainage of condensate at the lowest point and at such other locations where accumulation of condensate can be expected. In particular a drain valve shall be provided at the lowest point of transformer end termination.
- b) All outdoor bus-enclosures shall be so designed and constructed as to prevent accumulation of rain water on top sheet. Local rain hood shall be provided at all flanged joints coming in the outside portion of the busduct.
- c) Suitable inspection openings shall be provided for access to support insulators, bus joints, transformer terminals, equipment terminals etc. All inspection openings shall have reliable sealing arrangement with neoprene gaskets. Bolted type inspection covers shall be provided to provide access to the busbar joints and insulators.
- d) The enclosure cross section, connecting member between enclosure sections, flexible and rigid joints and shorting links between phase enclosures shall be adequate to allow the flow of longitudinal current required for the rated continuous current of the bus without overheating.



4.18.0 Insulators

- a) Insulator shall be interchangeable, high creep, high strength, wet process, fine glazed porcelain or good quality epoxy resin insulators.
- b) Insulator shall be mounted in such a way so as to permit easy removal or replacement without disassembly of the bus. The insulator mounting plate shall be designed for cantilever loading to withstand the short circuit force.
- c) The conductor shall be fastened on the insulator through fixed and sliding joints so as to allow conductor expansion or contraction without straining the insulator. Positive contact shall be made between end caps of the supporting insulators and the conductors.
- d) Additional support insulators shall be provided at bend and at tap offs for withstanding all possible forces.

4.19.0 Connections , Disconnecting links, Terminations and Shorting Link

- a) Expansion joints made of aluminium/copper laminated connections shall be provided wherever deemed necessary, to take care of thermal expansions and contractions of the bus bars under normal operating conditions.
- b) All matching flanges, gaskets, fittings, hardware vibration pads and supports required for termination of the bus duct at generator, transformers and other equipment shall be furnished. Flexible connections both for conductor and enclosure shall be furnished for the following:
 - i. At all equipment termination to take care for misalignment up to 25 mm in all directions.
 - ii. Between bus duct supported from building steel and that supported by turbine foundation to prevent transmission vibrations.
- c) The equipment terminal connections shall be readily accessible and shall provide sufficient air gap for safe isolation during electrical testing.
- d) If the material of bus conductor and that of the equipment terminal is different, then suitable bi-metallic connectors shall be provided by the bidder.

4.20.0 Supporting Structures

- a) Bus duct shall generally be supported from ground in outdoor areas and from ceiling/floor in indoor areas. However, same shall be firmed up as per the actual site conditions during detail engineering.
- b) All supporting structure required for hanging and/or supporting the complete bus duct shall be furnished. These shall include all members, indoor/outdoor posts, bolts, shims, base plates, hangers, brackets, bracings and hardware.
- c) For the design of structures, loads such as dead load due to equipment and structure, Wind load on structures, seismic loads, and short circuit forces shall be considered.
- d) All bus ducts shall be adequately supported and braced to successfully withstand normal operation, vibrations, thermal expansion, short circuit forces and all specified design loads.
- e) Supports shall be designed to provide tolerance of 12 mm in the horizontal and vertical directions.



- f) Arrangement of support steel work shall be such as to prevent heating of structures caused by circulating currents.
- g) Hinges of all inspection covers shall be strapped across with flexible earth connections.
- h) Support structure and busduct shall be designed in such a way that after opening the terminals, the transformer can be removed along the rail track without fouling/dismantling busduct support structure. It shall be ensured that No load is transferred on associated transformers and switchgear.
- i) All steel members shall be suitably surface treated and hot-dip galvanized after fabrication. All hardware shall be of high strength steel with weather resistant finish. Thickness of galvanizing shall be not less than 610 gm/sq.m.

4.21.0 Isolated phase busduct

- 4.21.1 The IPBD shall serve as an interconnection between generator and its associated generator circuit breaker, generator transformer, Unit transformers, station transformer, NGT and SPVT cubicle. IPBD shall also cover the bushing CT's of the Generator.
- 4.21.2 The bus duct shall be isolated phase, continuous (bonded enclosure). IPBD shall be rated for short circuit duration of 3 seconds.
- 4.21.3 The material of the conductor shall be aluminium alloy. All contact surfaces shall be silver plated. The bus enclosure shall be made of non-magnetic material such as aluminium alloy. Each phase shall be enclosed in a weather proof, dust tight, non-magnetic metal (aluminum alloy) enclosure. The enclosure shall be designed for welded connection.
- 4.21.4 The portion of the bus duct at the generator end shall be subject to vibrations. Bus duct enclosure shall not be bolted with generator. A slit of 10–20 mm shall be kept between enclosure and generator flange. Suitable covering shall be provided on the slit to allow escape of hydrogen and avoid dust entry inside the common chamber.
- 4.21.5 Suitable wall frame assembly without seal-off bushing shall be provided for the busduct at locations where the busduct passes through building wall. The wall frame shall be fabricated out of aluminium.
- 4.21.6 Flexible laminated copper connections shall be provided at the terminals of Generator, generator circuit breaker, generator transformer, Unit transformers, station transformer, SPVT cubicle and neutral earthing cubicle.
- 4.21.7 Seal off bushings shall be provided at the generator end of the bus duct (to prevent migration of hydrogen into the bus duct) and tap off to transformers, SPVT cubicles and neutral grounding transformer (NGT) cubicle.
- 4.21.8 To prevent ingress of foreign matter into the bus duct enclosure during plant shut down or maintenance, aluminum end caps shall be provided for the following locations:
 - Generator transformer end
 - Unit transformer end
 - Station transformer end
- 4.21.9 Apart from the disconnecting links at interconnection/equipment connections, bus duct shall be provided with pre-fabricated shorting link having rating equal to continuous rated current of busduct main run to for drying out / short circuit test. Shorting links shall be provided for the following locations:
 - Generator end, as near to the generator terminals (It can be provided as part of GCB)



- Generator transformer end, as near to the GT flange as possible
- Unit transformer end and Station transformer end on-line side after 87T
- Both sides of the neoprene or EPDM rubber or metallic expansion bellows
- Any other section, where it is felt that it is not properly bonded and the induced currents may not have a continuous path

4.21.10 Pre-fabricated shorting links rated same as the continuous amperage of bus duct main run and shall be furnished complete with all hardware for connections. The links shall be suitable for shorting bus conductors/enclosures of three (3) phases. The links shall be so designed with flexible connections that the bus insulators shall not be unduly stressed due to expansion / contraction during dry out or short circuit tests.

4.21.11 Rubber bellows shall be provided at the bus duct terminations such as, SPVT, UAT, ST and GT.

4.21.12 The electrically continuous bus enclosure shall be used as the grounding bus. All parts of the bus enclosure, supporting structure and equipment frames shall be grounded to earthing mat. Duplicate bolted type ground pads shall be provided to accommodate adequately sized galvanized steel flats, wherever isolated phase bus duct terminates.

4.21.13 Air pressuring Equipment

- a) Air pressurization of entire bus duct installation shall be provided to keep pressure inside the bus duct 20 to 100 mm water column above atmospheric pressure by clean dry air. To prevent condensation, the design shall be based on dew point of -25° C.
- b) In order to avoid any accidental overpressure the unit shall be equipped with safety valves calibrated to open the circuit at about at about 2-3 times the design pressure. All materials shall be designed to withstand more than twice the safety valve set pressure.
- c) A tee-connection with non-return valve and isolation valve, pressure reducer shall be provided for a standby connection to station compressed air supply header.
- d) Complete arrangement for pressurization of bus duct shall be provided, located indoor, including compressor, drier, dust filters, safety valves, controls, indication and alarms for failure of pressurization and excessive leakage. Air drying plants shall have 2X100% redundancy. The degree of protection for control panel shall be IP-52. Control panel shall be provided accommodating starters and control systems for compressor and drier.
- e) Air leakage rate shall not exceed 3% of the total enclosure volume per hour.
- f) In addition to the above system, one additional inlet flange at air dryer unit for receiving instrument air from the 'main plant air compressor' as standby arrangement and suitable pressure reducer shall be provided by the Contractor.

4.21.14 Hot Air Blowing Equipment

- a) To avoid condensation of moisture inside busduct during shutdown of the generator, suitable facility for blowing hot air inside the bus enclosure shall be provided.
- b) Hot air blowing system shall be of open loop type, capable of blowing hot air simultaneously in the indoor and outdoor portions of the duct.
- c) One set of portable hot air blowing equipment mounted on trolley complete with motorized blowers, heaters, starters, thermostat, hose connections, piping, valves, control and instruments, control panel, cable tray / conduit, cable / cable accessories and all equipment and accessories as required for the system shall be provided for each Unit.



- d) A control cabinet shall be furnished with wired control and monitoring devices, indicating lights etc. Auxiliary contacts shall be provided for remote ON / OFF indication of hot air blowing operation.
- e) Ambient air shall be drawn in through inlet damper and dry air filter and forced through thermostat controllers. Hot air shall be distributed by a set of properly sized ducts and dampers to the indoor and outdoor portion of the busduct. Hot air shall be let from busduct through suitably directed outlet provided at each equipment termination.
- f) The system shall be put in operation only before start-up and shall be sized complete the drying operation in about 2 hours. Once the drying up is complete, the system shall be shut down. The dampers and hot air outlets are to be kept closed when the system is not in operation.
- g) Heaters shall be adequately rated to warm up the busduct from the specified minimum ambient temperature to temperature of 70 degree C in 2 hours' time.

4.21.15 Current Transformers (CTs)

- a) The current transformers shall be epoxy cast-resin, single core ring type conforming to IS:2705. It shall be mounted within the bus duct enclosure and suitable for operation at an ambient temperature existing within the bus duct enclosure which may be in range of 90 degree C to 100 degree C. Mounting arrangement of CT shall be so designed so as to avoid equalizing connections between live conductor and CT inner surface.
- b) CT secondary leads shall be brought out through non-magnetic metallic conduits to a marshaling box with degree of protection IP-55. The box shall be provided with removable aluminum gland plate. The facility for shorting and grounding shall be provided at the terminal blocks. CT terminal shall be stud type with shorting link.
- c) Bolted rigid joints provided as disconnecting links and to facilitate removal of CTs shall be of the aluminium alloy material.

4.22.0 Segregated phase busduct

- 4.22.1 11kV Segregated phase duct (SPB) shall serve as interconnection between the Unit switchgear / station switchgear / standby switchgear / Unit transformers / station transformers / standby transformer. The busduct shall have three phase conductors. The busduct shall be rated for ungrounded system.
- 4.22.2 6.6kV Segregated phase duct (SPB) shall serve as interconnection between the respective switchgear to Auxlairy Transformers. The busduct shall have three phase conductors. The busduct shall be rated for ungrounded system. In other locations, based on layout requirments busducts shall be provided which will be decided during detail engineering.
- 4.22.3 The busduct shall be natural air-cooled type. The enclosure shall have a degree of protection of IP 55 weather proof. The bus ducts shall be suitable for installation in outdoor in a hot, humid and tropical atmosphere.
- 4.22.4 Wall frame assembly with weather and fire proof seal-off bushing shall be provided for the busduct at locations where the busduct passes through building wall. The seal shall be such as to prevent interchange of air between either sides of busduct portions. Flexible connectors shall be provided on both sides of wall bushings. The wall frame shall be fabricated out of aluminium angles and sheet suitable for grouting in the wall. It shall be provided with flanges on both sides to receive the busduct flanges. Seal-off bushings shall be dry non-hygroscopic, porcelain/epoxy type. All plates, anchors and hardware required for fixing the frame, shall be furnished. The



bushing shall withstand the maximum short circuit forces under short-circuit condition. Fireproof barrier/sealing shall have a minimum fire rating of three (3) hours.

- 4.22.5 The enclosure shall be of aluminum alloy. Minimum thickness of enclosure shall be 3 mm. Metallic barriers of minimum 2 mm thick aluminum sheet shall be provided to have complete phase segregation inside the enclosure. The aluminum sheet shall be welded on a frame work made up of aluminum angles.
- 4.22.6 The bus conductor shall be of high conductivity aluminum alloy.
- 4.22.7 All outdoor bus-enclosures shall be so designed and constructed as to prevent accumulation of rain water on top sheet. Local rain hood shall be provided at all flanged joints coming in the outside portion of the busduct.
- 4.22.8 Silicagel breathers shall be provided both in indoor and outdoor portions of bus duct for absorption of moisture. It shall be Perspex glass type. Number of silica gel breathers shall be provided based on the length of bus duct.
- 4.22.9 Filtered drains for drainage of condensate shall be provided at the lowest points and at such locations where accumulation of condensate can be expected.
- 4.22.10 Space heater shall be provided, preferably located near to each insulator at suitable intervals with thermostat control to avoid moisture condensation within bus-duct.
- 4.22.11 All matching flanges, seal-off bushings, gaskets, fittings, hardware and supports required for termination of the bus duct at the switchgear, transformers and other equipment shall be furnished.
- 4.22.12 Flexible connections both for conductor and enclosure shall be furnished to withstand vibration, expansion/ contraction at:
- At all equipment termination to provide for misalignment up to 25 mm in all directions.
 - Between the busduct portions supported from building steel to prevent transmission of vibration.
 - Between the bus sections to allow for expansion and contraction of the conductor and enclosure.
- 4.22.13 At transformer end flexible connections shall be of copper and at switchgear end it can be aluminium or copper flexible based on the busbar material at switchgear end which shall be firmed up during detail engineering.,
- 4.22.14 2 numbers 50 x 6 mm aluminium flat shall run as earthing conductor parallel to busduct, along the enclosure suitably clamped. This ground conductor shall be connected to plant earth grid at either end of busduct. Ground pad shall be bolted type complete with suitable tapped holes, bolts and washers. Bus enclosure, supporting structures and equipment frames shall be bonded to the above ground bus.
- 4.23.0 **Non segregated phase busduct**
- 4.23.1 Non phase segregated phase bus duct (NSPB) shall serve as interconnection between the 415 V switchgear and service transformers. The busduct shall have three phases and neutral conductor. Size of the neutral bus conductor shall be not less than 50% of size of the phase conductor. The busduct shall be rated for 415 V, grounded system.
- 4.23.2 The busduct shall be natural air-cooled type. The enclosure shall have a degree of protection of IP 55 weather proof. The bus ducts shall be suitable for installation in outdoor in a hot, humid and tropical atmosphere.
- 4.23.3 The portion of bus duct at the transformer end shall be subject to vibration. Suitable means shall be provided to isolate the transformer vibration from rest of the bus structure/bus duct.



- 4.23.4 Wall frame assembly with weather and fire proof seal-off bushing shall be provided for the busduct at locations where the busduct passes through building wall. The bushing shall withstand the maximum short circuit forces under short-circuit condition. Fireproof barrier/sealing shall have a minimum fire rating of three (3) hours.
- 4.23.5 The bus conductor shall be of high conductivity aluminum alloy.
- 4.23.6 The enclosure material for NSPBD shall be of non-magnetic material of aluminium alloy.
- 4.23.7 Phase to earth clearance shall be not less than 19 mm and phase to phase clearance shall be not less than 25 mm.
- 4.23.8 Silicagel breathers shall be provided both in indoor and outdoor portions of bus duct for absorption of moisture. It shall be perspex glass type.
- 4.23.9 Bus support insulators shall be of FRP sheet insulators. The support shall be designed for cantilever loading to withstand the short circuit force.
- 4.23.10 Space heater shall be provided at suitable intervals with thermostat control to avoid moisture condensation within busduct.
- 4.23.11 2 numbers 50 x 10 mm aluminium flat shall run as earthing conductor parallel to busduct, along the enclosure suitably clamped. This ground conductor shall be connected to plant earth grid at either end of busduct.
- 4.24.0 **Painting**
- a) All the fabricated surfaces shall be pretreated by degreasing, de-rusting and chemically cleaned prior to application of epoxy resin red oxide primer to give a dry film thickness of 50 microns.
 - b) The inside of busduct enclosure shall be treated with black matte paint. The inside of cubicles shall be off white.
 - c) The finishing paint shall be half gloss based on an epoxy based. The paint shall be applied in two coats to give a minimum dry film thickness of not less than 50 microns.
 - d) The final paint shade of external surface of busduct shall match with associated equipment.
 - e) All the support structures shall be hot dip galvanized. All hardware shall be galvanized or cadmium plated.

5.0.0 TESTS

- 5.1.0 All components shall be tested as per applicable standard. Test reports shall be furnished for approval. All materials used in manufacture of various components shall be of tested quality and shall conform to relevant standards/specification.
- 5.2.0 Inspection and tests shall be performed in the field in accordance with the requirements and recommendations of respective standards and the local regulation. Testing shall include a comprehensive demonstration of all safety devices, interlocks and controls.

**5.3.0 Following tests shall be conducted on busduct as per IS 8084.****5.3.1 Type Tests**

- a) Impulse voltage test.
- b) Temperature rise test.
- c) Short time current test (Valid type test report carried out similar rating of busduct in the last 5 years shall be submitted for review).
- d) Power frequency voltage withstand test (wet).
- e) Degree of protection test (Water tightness test and air tightness test).
- f) Mill volt drop test as per IS 5561.

5.3.2 Routine Test

- a) Power frequency withstand voltage withstand test (dry).
- b) Insulation resistance test if applicable.
- c) Visual inspection and verification of dimensions.

5.3.3 Site tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

- Power frequency voltage withstand test
- Air leakage test
- Water tightness test on outdoor portion of bus-duct
- Insulation resistant measurement of equipment and all wiring
- Milli-volt drop

6.0.0 TECHNICAL PARAMETERS**6.1.0 IPBD**

Sl. No.	Description	Unit	Data
1)	Type		Isolated Phase Busduct
2)	Service		Indoor/Outdoor
3)	Reference Standard		IS 8084
4)	Short circuit duration	kA/sec	3
5)	Material		
	a)Bus conductor		Aluminium alloy
	b)Bus enclosure		Aluminium alloy
6)	Degree of protection		IP 55
7)	Maximum Temperature of Bus bars at continuous full load rating for Silver plated bolted joints / welded joints		105°C
8)	Maximum temperature of enclosure		80°C

6.2.0 Segregated Phase Busduct

Sl. No.	Description	Unit	Data	Data
1)	Type		Segregated Phase Busduct	Segregated Phase Busduct
2)	Service		Indoor/Outdoor	Indoor/Outdoor



Sl. No.	Description	Unit	Data	Data
3)	Rated Voltage	V	11000 V +/- 10%	6600V +/- 10%
4)	Insulation level			
	a) 1 min dry power frequency withstand	kV(rms)	28	20
	b) Impulse withstand	kV(peak)	75	60
5)	Short circuit duration	sec	3	3
6)	Degree of protection		IP 55	IP 55
7)	Material			
	a) Bus conductor		Aluminium alloy	Aluminium alloy
	b) Bus enclosure		Aluminium alloy	Aluminium alloy
8)	Short-time current	kA rms	50	31.5
9)	Dynamic withstand current rating	kAp	125	80

6.3.0 Non phase segregated phase busduct

Sl. No.	Item Description	Units	Data
1.	Type of installation		Indoor
2.	Type of busduct		Non segregated bus duct, Three phase and Neutral.
3.	Reference Standard		IS 8084
4.	Rated system voltage	V	415 +/- 10%
5.	Short circuit rating and duration	kA / sec	65kA/1Sec 50kA/1 Sec
6.	Material of conductor		Aluminium
7.	Material of Enclosure		Aluminium
8.	Degree of Protection		IP:55
9.	Minimum clearance		
10.	Phase to Phase	mm	25
11.	Phase to Earth/Neutral	mm	19
12.	One minute power frequency withstand voltage	kV	2.5
13.	Short-time current for 1 sec.	kA rms	50/65
14.	Dynamic withstand current rating	kAp	105/137

7.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Technical data sheets.
- Busduct sizing calculation
- GA and busduct layout and sectional details.
- Termination detail at equipment of both sides.
- Wall frame assembly drawing.
- Hot air blowing equipment drawing.
- Air pressurization equipment details.
- Particulars of CT.
- Scheme diagram and GA for space heater DB.
- Scheme for space heater circuit.
- Foundation plan and fixing details.



- Temperature rise calculation.
- Short circuit force withstand calculation.
- Structural calculations.
- GA and Fabrication drawings for supports.
- CT / VT sizing calculation
- Catalogues / drawings / leaflets for all items
- Erection and commissioning procedures
- Operation and maintenance manual
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.7: GENERATOR CIRCUIT BREAKER

1.0.0 INTENT OF SPECIFICATION

This section covers the technical requirements of Generator circuit breaker (GCB).

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following for each GCB:

- a) Circuit breaker with disconnecter for series isolation on Transformer side.
- b) Grounding switches fitted both sides of unit and to all three phases.
- c) Voltage transformers on transformer side.
- d) Voltage transformers on generator side.
- e) Surge arrestor with surge counter on transformer side
- f) Surge capacitor on either side of circuit breaker
- g) Supporting structures and suitable platform.
- h) Operating mechanism
- i) Local control cubicle.
- j) A switched (motor operated) short circuiting connection between the power circuit breaker and the series disconnecter for maintenance and protection checking on generator side.
- k) A motor operated grounding link for the above short circuiting connection.
- l) Commissioning spares and consumables
- m) Mandatory spares
- n) Tools & tackles
- o) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Indian / IEC Standards, except where modified and /or supplemented by this specification.

- a) IEEE C37.013 : AC Generator Circuit Breaker Rated on a Symmetrical Current Basis
- b) IEC 62271-1 : High voltage switchgear and control gear – Common specification
- c) IEC 62271-100 : High Voltage Alternating Current Circuit Breaker
- d) IEC 62271-200 : AC Metal Clad Switchgear and Control Gear for Rated Voltage above 1kV up to and Including 52 kV
- e) IEC 62271-300 : Seismic Qualification of Alternating Current Circuit-Breakers
- f) IEC 62271-304 : Design Classes for Indoor Enclosed Switchgear and Control gear For Rated Voltages Above 1kV up to and including 52 kV To Be Used In Severe Climatic Conditions
- g) IEC 62271- 102 : Alternating Current Disconnectors and Earthing Switches.
- h) IEC 60376 : Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment
- i) IEC-60099 : Non-linear resistor type gapped surge arrestor for AC systems
- j) IEC 60267 : Guide to testing of circuit breakers with respect to out of phase switching
- k) IEC 60282 : High voltage fuses



- l) IEC 60358 : Surge Capacitor

4.0.0 DESIGN REQUIREMENTS

- 4.1.0 GCB shall be provided for each generator in the turbine building. GCB shall be installed between the generator and generator transformer located in a hot, humid and tropical climate.
- 4.2.0 The voltage class of the Generator circuit breaker shall be same as that of the generator.
- 4.3.0 Ambient temperature prevailing inside the equipment while carrying rated current, when the outside air ambient temperature is 50 degree C shall be considered as design ambient temperature for sizing the equipment/device/bus rating. Temperature rise shall be as per applicable IEC/IEEE standards.
- 4.4.0 For steam turbine generators, continuous current rating and interrupting current of the GCB shall be selected considering the generated power evacuation at valve wide open (VWO) condition.. A 10% margin shall be considered for both continuous current and interrupting current and rounded off to the next higher standard rating
- 4.5.0 The contractor shall ensure that GCB satisfies all requirements of IEEE C37.013.
- 4.6.0 The GCB shall be with an operating duty of CO-30 min-CO for short circuit current and O-3min-CO-3 min-CO for load current.
- 4.7.0 GCB shall be used for the following:
- Synchronising the generator to the system
 - Connecting and disconnecting the generator from the system under out-of phase conditions.
 - Connecting the generator to the system under fault conditions i.e. switch on to fault
 - Interrupting load and fault current from network and generator source within the interrupting capability specified.
 - House load operation while isolated from grid i.e. with the generator transformer HV breaker in open position.
 - Transferred surges from HV side of generator transformer
- 4.8.0 The main current carrying parts shall be able to carry the rated current continuously without exceeding the temperatures specified in IEEE C37.013.
- 4.9.0 The short time current rating of the GCB shall be decided considering higher of the short circuit current contribution from generator or the short circuit current contribution from EHV system through generator transformer and contribution of HV auxiliary system through Unit transformers.
- 4.10.0 The connections and GCB shall be designed to withstand full $\frac{1}{2}$ cycle instantaneous and asymmetrical peak maximum currents under short circuit fault conditions. The connections & GCB shall be rated to carry the full unrestricted fault current for 3 seconds
- 4.11.0 Momentary current rating shall be calculated based on X/R ratio of EHV system, HV system and generator.
- 4.12.0 The breaker shall meet the transient recovery voltage (TRV) requirements specified in IEEE C37.013 for system source faults and generator source faults. The applicable values shall be adjusted for 50 Hz operation.



- 4.13.0 The breaker shall also be capable of withstanding and interrupting the out-of-phase switching currents and inherent TRV conditions required in accordance with IEEE C37.013 (adjusted for 50 Hz operation).
- 4.14.0 The breaker shall be capable of interrupting its rated interrupting current after trip coil has been energised within the specified time.
- 4.15.0 The following factors shall be taken into account while selecting the ratings and interlock schemes for the GCB:
- Synchronizing requirements of the generator
 - Transferred surges from HV side of generator transformer.
 - Load rejection from full load and rated power factor and house load operation while isolated from grid i.e. with the generator transformer EHV breaker in open position.
 - Connecting and disconnecting the generator from the system under out-of phase conditions.
 - Interrupting load and fault currents from network / auxiliary system and generator sources
 - Connecting the generator to the system under fault conditions i.e. switching on to fault.
 - Design ambient temperature.
- 4.16.0 During normal condition, when grid power is available, the generator shall be started with GCB in open position and synchronizing shall be done at the GCB. However, during grid disturbance, generator shall be running with GCB in closed position on house load (generator transformer EHV breaker in open position) and subsequently, generator shall be synchronized with grid through EHV breaker. Necessary scheme and interlocks shall be provided in GCB.
- 4.17.0 The contractor shall submit calculations indicating continuous current rating, short circuit breaking current, DC component of breaking current, making current etc. of GCB for approval. The calculations shall be based on IEEE C37.013.
- 4.18.0 The GCB shall be based on IEEE C37.013 which shall be tested with a test circuit time constant of 133 milli-second based on which the peak and asymmetrical break short circuit multiplying factors shall apply:-
- $\frac{1}{2}$ cycle (10 milli-second at 50 Hz) peak making short circuit current duty shall be 2.7 times the GCB symmetrical ac short circuit rms current rating
 - 50 milli-second break short circuit current duty shall be 1.39 times the GCB symmetrical ac short circuit rms current rating
- 4.19.0 The GCB with its main contacts open and insulating gas at atmospheric pressure must be capable of withstanding an out-of-phase voltage across the terminals with the phase angle between two voltages varying continuously. This shall be in line with the requirements given in the IEEE standard C37.013
- 4.20.0 SF6 circuit-breakers shall not incorporate components which are liable to deterioration or likely to create undesirable chemical action when in contact with the by-products of arcing or other substances likely to be encountered under service conditions. Precautions to minimise the presence of moisture and SF6 decomposition products shall be incorporated.
- 4.21.0 Static and moving gas seals shall be designed to prevent the leakage of gas or ingress of moisture throughout the service life of the interrupting module.
- 4.22.0 The enclosure of the module shall be strong enough to withstand the internal pressures generated when switching and shall incorporate an over pressure relief device for safe discharge of any excess pressure that may arise in service.
- 4.23.0 Interrupters incorporating separate main and arcing contacts shall be arranged such that any re-ignitions or restrikes always occur in the arcing zone between the arcing contacts.



- 4.24.0 Where the design is such that leakage could cause gas pressure to fall below that at which the specified insulating and interrupting capacities can be maintained, gas pressure monitoring devices shall be incorporated to provide an alarm and block operation.
- 4.25.0 GCB movement during short circuit shall be restricted so as to limit the stresses on GCB support insulators within their capabilities.
- 4.26.0 Support structure shall be designed to withstand the dynamic as well as static load of the GCB.
- 4.27.0 The circuit breakers shall be designed for natural air cooling in general. Where forced cooling is adopted, it shall be subject to Owner's approval. For forced cooling arrangement, 2X100% rated cooling fans shall be provided.
- 4.28.0 In place of active cooling (e.g.forced air cooling), passive cooling by means of a heat pipe cooling system can be offered, provided the cooling system is proven one and is in successful operation for the past three years. Details of passive cooling method shall be furnished along with the offer.

5.0.0 CONSTRUCTION REQUIREMENTS

- 5.1.0 GCB shall be SF₆ type, metal-clad design having electrically operated circuit breakers. SF₆ gas shall be used both as its arc-extinguishing medium as well as for internal insulation. It shall be provided with three pole gang operation and anti-pumping feature.
- 5.2.0 GCB shall be provided in single phase enclosures, all fully assembled on a common frame with operating mechanisms, supervisory and control equipment.
- 5.3.0 GCB shall be installed indoor in the turbine building and connected to Generator busduct (Isolated Phase) on both sides. GCB shall be placed such that it is in line with the isolated phase bus duct (IPBD) to / from generator and generator transformer.
- 5.4.0 Connections to the generator phase bus ducts shall be adaptable and removable by means of flexible copper braid or laminated conductors with bolted fixings and all necessary equipment and accessories for the connections including flexible, bolted joints, plate adapters, etc. shall be supplied.
- 5.5.0 GCB enclosure shall be non-magnetic aluminium alloy, minimum flux, and isolated phase type with degree of protection IP-55.
- 5.6.0 The phase spacing shall be selected to suit the generator busduct spacing.
- 5.7.0 The current path of the system shall be connected to the busbar current path by bolted flexible, laminated or stranded connectors. In order to avoid detrimental tensile stresses to the terminals, resulting from electro-dynamic forces of a short-circuit current; the flexible connectors must be supported adequately.
- 5.8.0 The phase enclosures shall be designed to carry the induced reverse current, flowing through the isolated phase busbar enclosures. Thus the external magnetic field and its influence to the equipment shall be minimised. The phase enclosure shall be welded onto the busbar enclosure, ensuring continuity of the phase enclosure characteristics. In order to avoid pollution due to ingress of dust and/or moisture, the phase enclosures shall be made airtight to withstand also a small internal overpressure.
- 5.9.0 Windows shall be provided in the phase enclosures near to the disconnector and earthing switches to allow visually checking of the position of each of them.
- 5.10.0 Insulators shall be of high strength, fine glazed porcelain or epoxy resin type.
- 5.11.0 As the breaking capacity of an SF₆ circuit-breaker and the dielectric withstand level across its open contacts is dependent upon the density of the SF₆-gas, it shall be monitored. The density of the gas in the circuit-breaker chamber shall be compared with the density of the gas in a sealed reference gas volume.

5.12.0 When the gas density drops below the specified value, the density monitor shall signal the loss of SF6-gas in several steps. SF6 gas monitor for each phase shall be provided. Necessary interlocks are to be arranged to prevent breaker operation on fall of SF6 gas density. SF6 density monitoring, alarm on low density and close & Trip blocking on very low density shall be provided. SF6 gas lockout logic shall be fail safe.

5.13.0 Disconnectors

- a) The generator circuit-breaker shall be fitted with an off-load series disconnector to permit maintenance of the generator circuit when the generator transformer / Unit transformer / station transformer circuits are energised.
- b) The line disconnector shall be of a telescopic unit type with a sliding tubular contact, with its hinged point on the transformer side and with an operating mechanism that operates through a mechanical linkage of all three poles. The isolating gap of the disconnector shall be in air at atmospheric pressure and a window shall be provided in the GCB enclosure to allow visual checking of its position.
- c) The disconnector operating mechanism, operated by a 3-phase motor, shall be of a heavy-duty construction type and shall be designed to complete its normal travel to either "open" or "close" position, once started, without holding the control switch continuously in that position. It means that stopping the travel between fully open and closed position is not acceptable.
- d) Interlocking shall be available to allow different operation modes to be selected. Mechanically driven semaphore shall be provided for signaling close / open-position. A crank handle shall be provided for manual operation in case of emergency.
- e) The operating mechanism shall be independent of the circuit-breaker and earthing switch operating mechanisms and in addition to the normal local electrical open / close control facilities the mechanism shall also be provided with manual operation facilities for emergency and maintenance purposes. Mechanical open/closed status indications shall also be provided.
- f) The disconnector shall be interlocked such that it cannot be opened or closed unless the circuit-breaker is open and viewing windows shall be provided in the equipment enclosures to facilitate direct observation of the disconnector position and confirmation of the isolating distance.

5.14.0 Earth switch

- a) Earthing switches shall be fitted on both sides of the circuit-breaker to permit maintenance of both the generator circuit and/or the generator transformer and Unit transformer / station transformer circuits.
- b) The GCB earth switches shall be of blade type, air insulated, gang operated with motor drive, with their hinged point connected to earth and shall be integrated together with the GCB and disconnector into each of the single phase tubular aluminum enclosure, forming a straight section in the run of the isolated phase bus. The earth switches shall be peak fault making type with suitable peak fault making duty.
- c) The earthing switches operation shall be interlocked with the GCB and disconnector.
- d) The control of the earthing switches including the interlocking circuits shall be accommodated in the GCB system control cubicle. A local / remote switch and push-buttons for local control shall be provided.



- e) The GCB earth switch operating mechanism, operated by a 3-phase motor, shall be of a heavy-duty construction type and shall be designed to complete its normal travel to either "open" or "close" position, once started, without holding the control switch continuously in that position. Stopping the travel between fully open and closed position is not acceptable.
- f) Interlocking system shall be provided to allow different modes of operation to be selected. Mechanically driven semaphore shall be provided for signaling close/open position. A crank handle shall be provided for manual operation in case of emergency.
- g) The operating mechanism shall be independent of the circuit-breaker and disconnector operating mechanisms and in addition to the normal local electrical open/close control facilities the mechanism shall also be provided with manual operation facilities for emergency and maintenance purposes. Mechanical open/closed status indications shall also be provided.
- h) The earthing switches shall be interlocked such that they cannot be opened or closed unless the circuit-breaker and its disconnector are open and viewing windows shall be provided in the equipment enclosures to facilitate direct observation of the earth switch position. Interlocking shall also be provided to prevent the operation of the earthing switches unless the relevant remote switching devices are open (disconnectors) or withdrawn into the test position (circuit-breakers).

5.15.0 Short circuiting switch

- a) Electrically operated short-circuiting switch shall be provided. The short-circuiting switch shall be provided between the circuit-breaker and the disconnector of the system on generator side. The short-circuiting switch and its connection between phases shall be developed to expedite the testing and adjustment of the plant protection system.
- b) Closure of the switch shall establish an unearthed three phase short-circuit, which then can be switched to the generator terminals by closure of the circuit-breaker. The closing of the earthing switch shall be motor operated (local/remote switch in position local) while the generator shall be de-excited.

5.16.0 Surge capacitor and Surge arrester

- a) Heavy duty class gapless metal oxide surge arrester shall be provided on each phase on each side of the GCB inside the enclosure. The surge arrester and rate of rise limiting RC surge suppressor shall provide protection against over voltages for both the generator and the connected transformers.
- b) Arrester shall be heavy duty with low protection level offering high protection margins suitable for operation in high resistance ineffectively/unearthed system and shall be pollution resistant, maintenance free with stable characteristic suitable for operation without thermal breakdown in the GCB enclosure panel under specified ambient conditions.
- c) The surge arrester shall be suitable for maximum system voltage specified with transient over voltage due to earth fault for up to 10 second withstand.
- d) Creepage and energy discharge capability shall be sufficient to withstand the environment conditions specified and the high site ambient temperatures at which the switchgear shall be suitable for operation.
- e) The nominal discharge current shall be based on the maximum surge discharge conditions during maximum surge voltage.
- f) The surge capacitors shall be of a metal-housed type and use synthetic aromatic oil as dielectric. The surge capacitors shall be mounted on the generator side and transformer



side in each phase of the GCB system unit to provide additional protection for the equipment connected to the generator bus bar against over voltages and to limit the rate-of-rise of the transient recovery voltage.

5.17.0 Current transformer

- a) The current transformers shall be of a single-phase ring core type and shall be fitted at one or both ends of the GCB enclosure. The CTs shall be accessible through the removable top cover of the GCB enclosure. The secondary windings shall be wired to terminal blocks in the GCB control cubicle.
- b) The current transformers shall have a basic impulse level and a power frequency withstand level as specified for the system.
- c) The current transformers shall have the following accuracies:
 - Metering Class 0.2S
 - Over-current & earth fault protection Class 5P
 - Differential protection Class PS
- d) The rated output shall match the requirements of the equipment connected. CT shall be rated for 120% of the full load rating. The secondary current rating shall be 1 A or 5 A as per protection requirement.
- e) Facilities shall be provided which allow primary injection testing of the current transformers with the minimum disturbance to the GCB.

5.18.0 Voltage transformer

- a) Single-phase Voltage transformers (VTs) as required for electrical protection, metering and measuring, synchronization and ferro-resonance protection shall be provided.
- b) The GCB voltage transformers shall be of a single-phase ring core type and shall be fitted at one or both ends of the GCB system enclosure.
- c) Secondary windings of voltage transformers shall be electrically protected. The voltage transformers could be provided with two or three (3) secondary windings as required.
- d) The VTs shall be accessible through the removable top cover of the GCB system unit enclosures. The secondary windings shall be wired to terminal blocks in the GCB control cubicle.
- e) The VTs shall have a basic impulse level and a power frequency withstand level as specified for the system.
- f) The voltage transformer secondary circuits shall be complete themselves and shall be earthed at one point only. A separate earth link shall be provided for each secondary winding and shall be situated at the transformer but earthing shall be in the relay or control building. The primary winding shall be earthed at the transformer.
- g) The VTs shall have primary fuses.
- h) The preferred secondary voltage shall be 110 V. VTs shall be so designed that saturation of the VT cores does not occur when $\sqrt{3}$ times normal voltage is applied to each winding. In this respect the rated voltage factor for the VTs, shall be selected dependent on the system earthing.



- i) Voltage Transformers (VT) for different functions shall have following accuracy class.
 - For tariff metering, accuracy class shall be class 0.2
 - For general instruments / Measuring, accuracy class shall be class 0.5.
 - For protection, accuracy class shall be class 3P.
- j) Protection VT shall be provided with an additional open delta secondary winding, for the circuit neutral point displacement protection. These VT shall be of 3 phase winding with 5 limbed core or alternatively shall be based on 3 single phase winding VT. The Broken delta winding shall be loaded with ferro-resonance damping resistor for VT on the transformer side of the GCB.
- k) One side of the low voltage winding of single phase voltage transformers and the star point of three phase voltage transformers shall be earthed via an earthing link.

5.19.0 Operating Mechanism

- a) The circuit-breaker operating mechanism shall be of the stored energy type, and shall have a capacity which is sufficient to perform an open-close-open (O-C-O) duty without replenishment from any external source. No closing operation shall be possible without sufficient stored energy in the mechanism to open the circuit breaker again. The operating/drive mechanism shall be trip-free as defined in IEC/IS standards and shall have anti-pumping features. Circuit-breaker operating mechanisms shall be 3 pole gang operated
- b) The electrical motor operated spring charge mechanism shall be provided for the GCB, complete with all control equipment. .
- c) Electrical as well as mechanical lock-outs shall be incorporated in each circuit-breaker to prevent operation whenever gas pressure or driving mechanism spring pressure, etc. are less than the set values for satisfactory operation of the circuit breaker or in case of any endangering irregularity. An alarm feature for local and remote indication of falling gas pressure shall be incorporated. SF6 gas lockout logic shall be fail safe.
- d) A direct acting mechanical trip via an emergency push button shall be provided on each circuit-breaker.
- e) Mechanically operated indicator shall be provided to show whether the circuit-breaker is open or closed. The position and gas pressure indicators shall be easily visible from the operator standing location. Mechanical or electrical operation counters shall be provided with all operating mechanism.

5.20.0 Interlocking

- a) Circuit-breakers, disconnectors and earthing switches shall be provided with an approved interlocking system which shall ensure safe operation for personnel and equipment under all service conditions.
- b) Electrical interlocks shall be hard wired fail safe design and shall function so as to interrupt the operating supply and shall also include for emergency hand operation.
- c) Failure of the electrical supply or its restoration shall not produce or permit faulty operation.
- d) Mechanical interlocks shall be provided between disconnectors and associated earthing switches to prevent coincident closure.



- e) Under normal operating conditions and when selected for remote operation the circuit-breakers shall be closed by their respective synchronising systems and electrical interlocks shall be provided to prevent the closing of circuit-breakers on to live connections unless the incoming and running voltages are equal and in synchronism.
- f) Interlocking shall also be provided such that except under maintenance conditions, it shall not be possible to close the circuit-breaker unless the respective series disconnector and HV circuit-breaker are closed.
- g) Simultaneous operation from local and remote shall be prevented by the provision of a Local/Off/Remote Selector Switch key operated with the key withdrawable in the remote position only. Except for the circuit-breaker all other equipment shall be operated locally.
- h) A system of hard wired safety interlocks shall be provided by means of auxiliary contacts on all necessary remote equipment so as to prevent
 - Closing of disconnectors unless all relevant earthing switches are open
 - Closing of earthing switches unless all relevant disconnectors are open and all relevant HV and LV circuit-breakers withdrawn into the test position.

Back reporting contacts for the status of the circuit-breaker, disconnectors and earthing switches shall be provided so as to enable the interlocking of the remote equipment. In other words, the interlocking philosophy implemented shall be a visible break fail safe interlocking philosophy throughout.

- i) To address situations where the power supply for motorised devices is not available a separate key interlocking system shall be provided to facilitate the local emergency manual operation of each item of equipment together with a key diagram and operating chart which shall be mounted on the front of the local control kiosk.

5.21.0 GCB Control Cubicle features

- a) The GCB control cubicle shall be of sheet enclosed dust and vermin proof simplex type. The enclosure shall be made out of aluminium alloy / cold rolled sheet steel of 2 mm thick. The panel enclosure shall provide a degree of protection not less than IP55. All doors and openings shall be provided with neoprene gaskets.
- b) The cubicle shall be suitable to be installed on base frame supplied in one piece along with foundation bolts. Adequate holes shall be provided at the bottom of all the panels for their installation on base frame. Anti-vibration pad of 25 mm thick shall be provided between base frame and panel through its entire width on the front/rear side.
- a) All control and supervisory apparatuses shall be mounted in the control cubicle. The following control and indicating facilities shall be provided as a minimum:
 - A local mimic with the electrical single line GCB diagram of the system.
 - Local - Off - Remote key operated selector switch.
 - Local electrical opening and closing facilities.
 - Remote electrical opening and closing facilities via interposing relays.
 - Mechanical open and closed indication facilities.
 - DC close and trip coils and an additional D.C. trip coil per pole.
 - Gas pressure meter for each SF6 filled compartment
 - Operations counter.
 - Alarm table with first up facility.
 - Lamp test push-button.
 - Indications
 - Alarms



6.0.0 PAINTING

Painting shall be carried out by approved process. After preparation of the under surface, all the equipment shall be painted with epoxy based paint by powder coating. The final thickness of paint film shall not be less than 85 microns. Final shade shall be RAL-7035. Support structures shall be hot dip galvanized.

7.0.0 TESTS

7.1.0 All the equipment supplied shall be of type tested quality. The performance of the generator circuit-breaker system should have been fully tested in accordance to the standard IEEE C37.013 with regard to the interrupting capability.

7.2.0 Further type tests should have been carried out with all of the related components within the system to prove continuous current capability, dielectric strength, long term endurance, noise level etc. and verify the liability and compliance with the requirements of the relevant IEC-standards. Type test reports for the following shall be submitted for review by the Owner.

- a. Rated dielectric strength tests
 - (i) Rated low frequency withstand voltage dry test.
 - (ii) Rated full wave impulse withstand voltage test.
- b. Short circuit rating and transient recovery voltage tests
 - (i) Test for rated symmetrical short circuit current interrupting capability, duty cycle and rated transient recovery voltage parameters.
 - (ii) Test for rated closing, latching and short time current carrying capability.
 - (iii) Test for rated Generator source asymmetrical short circuit interrupting capability.
- c. Load current switching test
- d. Out of phase switching current tests
- e. Rated excitation current switching tests.
- f. Type tests and oscillographic test records for closing and tripping timings for generator circuit breaker of the rating offered.
- g. Rated continuous current carrying tests
- h. Mechanical endurance life tests.
- i. Noise level tests.

7.3.0 All acceptable & routine tests as per IEC-60056 and IEEE C37.013a-2007 standards shall be conducted on all the equipment/components of each of the generator circuit breaker. The tests shall include the following:

- a) Design and visual checks
- b) Dielectric tests on the main circuit
- c) Dielectric tests on auxiliary and control circuits
- d) Measurements of the resistance of the main circuit
- e) Mechanical operation tests
- f) Timing tests and recording the switching times and movement of breaker contacts
- g) Functional tests of individual components
- h) Leakage test of phase enclosures
- i) SF6-gas leakage test.

7.4.0 Site tests

All site tests shall be carried out to prove the circuit breaker installation and integrity. Site tests shall be carried out in accordance with IEEE C37.013. The tests shall include the following:

- a) Leakage tests
- b) Gauge tests
- c) Stored energy system tests
- d) Electrical resistance of current path tests (circuit breaker and isolator)
- e) Clearance and mechanical adjustment check tests



- f) Timing tests (using each trip coil separately)
- g) Normal frequency withstand voltage withstand tests.
- h) Functional tests of circuit breaker and isolator / earth switch including checks of interlocks, indications etc.
- i) Ratio and polarity checks for VTs

8.0.0 GCB TECHNICAL PARAMETERS

Sl. No.	Description	Unit	Data
1.0	General		
a)	Material of enclosure for GCB		Aluminium alloy
b)	Degree of Protection of the enclosure		IP 55
c)	Material of enclosure for control cubicle		Aluminium alloy
d)	Rated Lighting Impulse Withstand Voltage to earth, between poles and across open switching device	kV, peak	170
e)	Rated One(1) minute power-frequency Withstand voltage to earth, between poles and across open switching device	kV, sym, rms	70
2.0	GENERATOR CIRCUIT BREAKER		
a)	Applied Standard		IEEE 37.013
b)	Rated short circuit withstand time	Sec	3
c)	Interrupting media		SF6
d)	Rated Operating Sequence		CO-30 min-CO (Short Circuit duty) O-3min-CO-3min-CO (Load current duty)
e)	Interrupting Time	m. Sec	≤ 50
f)	Closing Time	m. Sec	≤ 100
g)	No.of trip coil		2
h)	Mechanism		Hydraulic Spring, 3pole gang operated
i)	Type of Cooling		Natural
3.0	DISCONNECTING SWITCH		
a)	Type		Tubular Telescopic Unit
b)	Applied Standard		IEC 62271-102
c)	Rated short circuit withstand time	Sec	3
d)	Operating Method		Three pole ganged motor operated
4.0	EARTHING SWITCH		
a)	Type		Blade type with the hinge point connected to the enclosure



Sl. No.	Description	Unit	Data
b)	Applied Standard		IEC 62271-102
c)	Rated short circuit withstand time	Sec	3
d)	Operating Method		Motorized
6.0	VOLTAGE TRANSFORMERS		
a)	Service		Inside GCB enclosure
b)	Applied Standard		IEC 61869
c)	Insulation		epoxy resin insulation, Class F
7.0	SURGE ARRESTOR		
a)	Service		Transformer Side
b)	Applied Standard		IEC 60099-4
c)	Rated discharge current (Wave 8/20 μ s)	kA	20 kA peak
d)	Mounting Details		Inside enclosure , transformer side
8.0	SURGE CAPACITOR		
a)	Applied Standard		IEC 60358
b)	Mounting Details		Inside GCB Enclosure

9.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Technical data sheet
- Equipment layout of GCB
- General arrangement and section drawing of GCB
- General arrangement and section drawing of local control cubicle
- Single line diagram & Schematic wiring diagrams
- Sizing Calculation for GCB
- GCB cooling method
- Short circuit withstand calculation for GCB (Thermal & dynamic)
- Design calculation for support structure
- Foundation Plan & loading details
- Catalogues / drawings / leaflets for all items
- Erection and commissioning procedures
- Operation and maintenance manual
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.8: HIGH VOLTAGE (HV) SWITCHGEAR

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of High voltage switchgear (11 kV / 6.6 kV / 33 kV).

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following. Quantity of switchgear shall be as per system requirement.

- a) 11 kV Unit switchgear
- b) 11 kV Station switchgear
- c) 11 kV standby switchgear
- d) 6.6 kV Unit auxiliary switchgear
- e) 6.6 kV Station auxiliary switchgear
- f) 6.6 kV CHP auxiliary switchgear
- g) 6.6 kV AHP auxiliary switchgear
- h) 6.6 kV Sea water intake switchgear
- i) 33 kV VCB isolation panel at switchgear room of power house building (for feeding external coal handling system)
- j) 33 kV switchgear at switchgear room of sea water intake pump house for feeding external coal handling system
- k) 11 kV VCB isolation panel for the transformers which are located 1 kM away from main plant building.
- l) 6.6 kV VCB isolation panel for the transformers which are located 1 kM away from main plant building.
- m) 6.6 kV load break switch for the stacker reclaimer installed near cable reeling drum.
- n) Bus transfer panel for 11 kV Unit switchgear
- o) Commissioning spares and consumables
- p) Mandatory spares
- q) Tools & tackles
- r) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Indian / IEC Standards, except where modified and /or supplemented by this specification.

a) IS: 2705	Current transformers -Specification (Part I to IV)
b) IS: 3156	Specification for Voltage transformers (Part I to IV)
c) IS: 3231	Electrical relays for power system protection.
d) IS: 3427	A.C. Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV.
e) IS: 5578	Guide for marking of insulated conductors
f) IS: 6005	Code of practice for phosphate of iron and steel
g) IS: 9385	HV fuses
h) IS: 9431	Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 Volts up to and including 300 kV
i) IS: 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals.



- j) IS: 13118 Specification for high voltage alternating current circuit breakers
- k) IS: 12729 Switchgear & Control gear for voltages exceeding 1000 V –General requirements.
- l) IS: 10624 High voltage fuse-links for motor circuit applications
- m) IS: 9920 High Voltage Switches for Rated Voltages above 1 kV and less than 52 kV
- n) IS: 14666 High voltage alternating current switch fuse combinations.
- o) IS: 12534 Application guide for the selection of high voltage fuses for transformer circuit applications
- p) IEC 62271- 200 High-voltage switchgear and control gear
- q) IEC-62271-100 High-voltage switchgear and control gear - alternating current circuit breakers.
- r) IEC-62271-106 High-voltage switchgear and control gear - Part 106: Alternating current contactors, contactor-based controllers and motor-starters
- s) IEC-60099 Non-linear resistor type gapped surge arrester for AC systems
- t) IEC- 62271-102 High-voltage switchgear and control gear – Alternating current disconnectors and earthing switches

4.0.0 DESIGN REQUIREMENTS

4.1.0 Design ambient air temperature shall be considered as 50°C for sizing the electrical equipment and relative humidity of 95% maximum.

4.2.0 Power supply voltage shall be considered as follows:

- Motors rated > 0.2 kW and up to 200 kW : 415 V, 50 Hz, 3 Phase
- Motors rated up to 0.2 kW : 240 V, 50 Hz, Single Phase
- Panel lighting & Space Heater : 240 V, 50 Hz, Single Phase
- Control Supply : 220 V DC
- Motors rated > 2000 kW : 11 kV, 50 Hz, 3 Phase
- Motors rated > 200 kW and up to 2000 kW : 6.6 kV, 50 Hz, 3 Phase
- For external coal handling : 33 kV, 50 Hz, 3 Phase
- For colony : 11 kV, 50 Hz, 3 Phase

4.3.0 Insulation level

- One minute Power Frequency withstand voltage for 6.6 kV : 20 kV (rms)
- 1.2/50 Micro sec, impulse withstand voltage for 6.6 kV : 60 kV (peak)
- One minute Power Frequency withstand voltage for 11 kV : 28 kV (rms)
- 1.2/50 Micro sec, impulse withstand voltage for 11 kV : 75 kV (peak)
- One minute Power Frequency withstand voltage for 33 kV : 70 kV (rms)
- 1.2/50 Micro sec, impulse withstand voltage for 33 kV : 170 kV (peak)

4.4.0 Short circuit withstand rating shall be not less than the following:

- 11 kV Switchgear : 50 kA for 3 second
- 6.6 kV Switchgear : 31.5 kA for 3 second
- 33 kV Switchgear : 25 kA for 3 second



4.5.0 Internal arc withstand rating shall be not less than the following:

- 11 kV Switchgear : 50 kA for 0.5 second
- 6.6 kV Switchgear : 31.5 kA for 0.5 second
- 33 kV Switchgear : 25 kA for 0.5 second

4.6.0 Current Rating:

4.6.1 Ambient temperature prevailing inside the switchgear while carrying rated current, when the outside air ambient temperature is 50° Celsius shall be considered as Design ambient temperature for sizing the equipment/device/bus rating. Temperature rise shall be as per applicable IEC/IS standards. A design margin of not less than 10% shall be considered for sizing various devices.

4.6.2 For the Switchgears having two bus sections, each bus section & incomer shall be rated for load requirements of both the bus sections for continuous current rating.

4.6.3 Dummy cubicles with horizontal bus bars, power, control and annunciation cable running through the panel, if necessary, to avoid beam interfering with cable openings and to facilitate easy maintenance shall be provided.

4.7.0 Control supply and space heater supply:

- a) For all the feeders control supply voltage shall be 220 V DC. For each Switchgear, 2 Nos. 220 V DC control supply shall be provided. Suitable diode shall be provided to derive control supply through diode auctioneering.
- b) For each switchgear, 240 V AC supply shall be provided for auxiliary supply. For each panel space heater, cubicle lamp & socket, rated for 240 V AC supply shall be provided. Thermostatically controlled space heaters shall be provided separately to keep the ambient temperature under control inside the enclosure to prevent condensation. The heaters shall be located such that wiring, buses and control devices do not get overheated.

4.8.0 Controls:

- a) HV Switchgears shall have Vacuum circuit breakers for incomer, bus coupler, Tie and all outgoing feeders.
- b) All feeders shall be controlled from DCS / respective control system and from the switchgear. All the protection and safety interlocks shall be hardwired in the Switchgear itself.
- c) The incomer modules shall be interlocked with their upstream breaker such that they can be closed only when upstream breaker is closed and trip automatically when upstream breaker is tripped.
- d) All HT switchgear panels shall be provided with pad lock and key arrangement with key rack located in Unit control room/ respective offsite area control room.
- e) When required, Synchronizing of supplies at 11 kV Switchgears shall be carried out from Bus Transfer Panel and DCS.
- f) Local / Remote selection shall be provided in switchgear. Local selection is envisaged for local operation from Switchgear. Remote selection shall enable starting from DCS/ PLC. Local trial start of Motor is envisaged from Local push button station also.
- g) All analog signals, digital signals shall be grouped at one place in each panel for cabling to remote DCS / EMS/ respective control system / Bus Transfer Scheme panel (BTS).



- h) All hardware/software required for interfacing with the DCS system shall be supplied by the Contractor.
- i) To feed external coal handling system, 33 kV supply is envisaged, which shall be derived from 11 kV Station switchgear through 11/34.5 kV transformer, 33 kV VCB isolation panels shall be located in the power house building and 33 kV switchgear locating at Electrical room of sea water intake pump house for further routing to external coal handling system.
- j) Local start push button shall be hardwired to DCS/ respective control system so as to check the process permissive for starting the fans/pumps, whereas local stop push button shall be directly hard wired to concerned switch gear for tripping. One more status contact for latched condition of stop push button shall be hard wired to DCS/ respective control system for necessary alarming.
- k) Controls envisaged for various Switchgears are as follows:

Sl. No.	Feeders	Controlled From	Method of Supply Changeover
1	Unit switchgear		
	Incomer and tie from standby transformer	Bus Transfer Scheme (BTS)	Fast /In phase / Slow / parallel supply changeover
	Incomer and tie from standby transformer	DCS	Manual dead bus / live bus changeover through synchronizing
	Outgoing Motor feeder	DCS/LPB	
	Other outgoing feeder	DCS	
2	Station Switchgear		
	Incomer	DCS	Manual dead bus / live bus changeover through synchronizing
	Tie from Station	DCS	Auto changeover & Manual live bus changeover through synchronizing
	Tie to Unit	DCS	
	Outgoing Motor feeder	DCS/LPB	
	Other outgoing feeder	DCS	
3	6.6 kV Unit auxiliary switchgear		
	Incomer	DCS	Manual live bus changeover
	Tie	DCS	Auto changeover & Manual live bus changeover through synchronizing
	Outgoing Motor feeder	DCS/LPB	
4	6.6 kV Station auxiliary switchgear		
	Incomer	DCS	Manual live bus changeover
	Bus coupler	DCS	Auto changeover & Manual live bus changeover through synchronizing
	Outgoing Motor feeder	DCS/LPB	
	Other outgoing feeder	DCS	
5	CHP / AHP / Sea water intake auxiliary Switchgear		
	Incomer	Respective control system	Manual live bus changeover
	Bus coupler	Respective	Auto changeover & Manual live



Sl. No.	Feeders	Controlled From	Method of Supply Changeover
		control system	bus changeover through synchronizing
	Outgoing Motor feeder	Respective control system/LPB	
	Other outgoing feeder	Respective control system	
6	33 kV ECHP switchgear		
	Incomer	DCS	Manual live bus changeover
	Bus coupler	DCS	Auto changeover & Manual live bus changeover through synchronizing
	Other outgoing feeder	DCS	

4.9.0 **Typical single line diagram for various HT switchboards are enclosed in Section-7 of volume-II.**

4.10.0 In each bus section 20% spare feeders shall be provided covering various types and ranges of outgoing feeders. One feeder of largest rated motor and one feeder of largest rated transformer shall be provided as minimum in each switchgear. Spare feeders shall be completely wired up.

4.11.0 20% of control terminals in each feeder shall be provided as spare subject to a minimum of 2 terminals.

5.0.0 TECHNICAL REQUIREMENTS

5.1.0 Switchgear Construction

5.1.1 The switchgear shall have a single front, single tier, fully compartmentalized, drawout type, metal clad construction complying with clause No. 3.109.1 of IEC-62271 part 200, comprising of a row of free standing floor mounted panels. Each circuit shall have a separate vertical panel with distinct compartments for circuit breaker truck, cable termination, main busbar and auxiliary control devices. The adjacent panels shall be completely separated by steel sheets except in busbar compartments where insulated barriers shall be provided to segregate adjacent panels.

5.1.2 The circuit breakers and bus VTs shall be mounted on withdrawable trucks which shall roll out horizontally from service position to isolated position.

5.1.3 The trucks shall have distinct Service, Test / Isolated positions. It shall be possible to close the breaker compartment door in Isolated position also, so that the switchgear retains its specified degree of protection. While switchgear designs with doors for breaker compartments would be preferred, standard designs of reputed switchgear manufacturer's where the truck front serves as the compartment cover may also be considered, provided the breaker compartment is completely sealed from all other compartments and retains the IP-4X degree of protection in the Isolated position.

5.1.4 The switchgear assembly shall be dust, moisture, rodent and vermin proof with the truck in any position Service, Test / Isolated or removed, and all doors and covers closed. All doors, removable covers and glass windows shall have gaskets all round with synthetic rubber or neoprene gaskets.



- 5.1.5 Circuit breakers, LV compartments, busbar chamber & cable termination chamber etc. shall be housed in separate compartment within the cubicle. The design shall be such that failure of one equipment shall not affect the adjacent units.
- 5.1.6 The VT/ relay compartments shall have degree of protection not less than IP:52 in accordance with IS:13947. However, remaining compartments can have a degree of protection of IP: 4X. No louvers/opening shall be provided on the top of the panel. All other louvers if provided, shall have very fine brass or GI mesh screen. Tight fitting gasket/gaskets are to be provided at all openings in relay compartment.
- 5.1.7 Enclosure shall be constructed with rolled steel sections and cold rolled steel sheets of at least 2.0 mm thickness, Gland plates of minimum 3 mm thick, shall be made out of hot rolled or cold rolled steel sheets and for single core cables, it shall be nonmagnetic material.
- 5.1.8 The switchgear shall be cooled by natural air flow and forced cooling shall not be accepted.
- 5.1.9 Total height of the switchgear panels shall not exceed 2500 mm. The height of switches, push buttons and other hand operated devices shall not exceed 1800 mm and shall not be less than 700 mm from bottom of the panel base. All relays, meters, indicating lamps, switches etc. shall be flush mounted on the respective cubicle front door.
- 5.1.10 Safety shutters complying with IEC-62271 part 200 shall be provided to cover up the fixed high voltage contacts on busbar and cable sides when the truck is moved to TEST and ISOLATE position. The shutters shall move automatically, through a linkage with the movement of the truck. Pressure relief device shall be provided for each HV compartment to vent out safely the gases produced in case of fault.
- 5.1.11 The switchgear shall have the facility of extension on both sides.
- 5.1.12 Similar equipment and components shall be of same make. Equipment of same type and rating shall be interchangeable..

5.1.13 Internal arc withstand requirements

- a) The HV switchgear shall be arc resistant type and it shall also be effective during the process of inserting the switching devices and/or VT's into the service position or withdrawing the switching devices and / or VTs into the test position.
- b) The switchgear, as per IEC-62271-200, shall be:
- Designed to provide loss of service continuity classification LSC2B-PM
 - Internally arc tested front, lateral and rear (FLR) i.e. IAC A FLR for an arc fault current as specified to meet the requirements of Annex A IEC 62271-200 (criteria 1 to 5)
- c) The segregation shall be designed to prevent arcs, smoke and/or vaporized metal from going directly or indirectly from one compartment to another so as to prevent the fault or its effects spreading to other compartments.
- d) Compartmenting shall be such that maintenance can be carried out safely on one (1) circuit with other adjacent circuits still in service.
- e) HV switchgear shall comply with IEC 60298 with regards to mechanical strength in the event of internal arc.
- f) The arc detection system shall be of the light sensitive/current sensitive type and shall detect and isolate only the faulted bus section of the switchgear so that healthy bus section continues to operate satisfactorily. The fitting of the arc detection system does not nullify any of the switchgear type tests. Preferences shall be for an arc detection system which indicates the location of the fault.



5.2.0 Bus and Bus Taps

- 5.2.1 The main buses and connections shall be of high conductivity Copper / Aluminium alloy sized for specified current ratings with maximum temperature limited to 90°C and 105°C for silver plated joints. The busbars shall be designed for specified short circuit rating.
- 5.2.2 All bus connections/joints shall be silver plated. Adequate contact pressure shall be ensured by means of two bolts connection with plain and spring washers and lock nuts. Bimetallic connectors shall be furnished for connections between dissimilar metals.
- 5.2.3 Busbar insulators shall be epoxy cast resin type designed to withstand stresses due to maximum short circuit current. Bus insulator shall be flame-retardant, non- hygroscopic track resistant type with high creepage surface. This shall be of non-carbonizing material such as epoxy bonded Fiberglass etc.
- 5.2.4 Busbars and connection shall be fully insulated for working voltage with adequate phase/ground clearances. Insulating sleeves for busbars and cast-resin shrouds for joints shall be provided. Cross section of the main horizontal busbar shall be uniform throughout the switchgear and continuous in one transport unit. All buses and connection shall be supported and braced to withstand stresses due to maximum short circuit current and also to take care of any thermal expansion.
- 5.2.5 Busbars shall be colour coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from front of the switchgear assembly. However, where busduct termination is envisaged, sequence of R,Y,B shall match with the R,Y,B sequence of equipment on the other end of busduct.
- 5.2.6 The busbar chamber shall be without seal off bushing between the panels, However, Bus chamber shall be totally enclosed & separated from all other chambers and shall be provided with epoxy case seal-off bushings through which the buses shall pass so as to prevent fire from bus chamber to other chambers.

5.3.0 Circuit Breaker

- 5.3.1 The circuit breakers shall be of Vacuum type. They shall comprise of three separate, identical single pole interrupting units, operated through a common shaft by a sturdy operating mechanism.
- 5.3.2 Surge arrestor shall be provided for each motor/ dry type transformer feeders.
- 5.3.3 Circuit breaker shall be restrike free, stored energy operated and trip free type. Motor wound closing spring charging shall only be acceptable. An anti-pumping relay shall be provided for each breaker, even if it has built-in mechanical anti-pumping features.
- 5.3.4 Trip circuit supervision shall be provided for all feeders to monitor the circuit breaker trip circuit both in pre-trip and post trip conditions.
- 5.3.5 Close circuit supervision shall be provided for all Incomers, Tie/ bus-coupler breakers to monitor the circuit breaker close coil in both pre trip and post trip conditions.
- 5.3.6 Self-reset type lockout relay to be provided on Bus PT panel for under voltage tripping of the motor feeders.
- 5.3.7 Each breaker feeder shall be provided with the following as a minimum:
- Anti-pumping relay
 - Motor charged spring operating mechanism with spring charged limit switches & required number of contacts.



- Manual spring charging facility
- Mechanical indication for spring charged condition
- Mechanical indication for circuit breaker ON / OFF status and circuit breaker positions (SERVICE / TEST/ ISOLATED) each with having required number of contacts for interlocks.
- Closing coil and tripping coil
- CTs for protection
- Mechanical ON / OFF provision of circuit breaker
- Circuit breaker operation counter
- Position of earth switch (as applicable)
- Phase barriers
- Shutter assembly

5.3.8 Mechanical / Electrical interlocks shall be provided to prevent mal-operation.

5.4.0 Load break switch

5.4.1 11 kV / 6.6 kV load break switch shall be located in outdoor sheet steel cubicle. The switch shall be triple pole, single throw, gang operated, air / SF6 insulated type complete with HRC fuse, shunt trip coil, etc. The switch shall be rated for 50 kA for 11 kV and 31.5 for 6.6 kV for 1 second short circuit rating. The switch and its cubicle shall be of type tested and proven design.

5.5.0 Current Transformer (CT)

5.5.1 The CTs shall be mounted on the switchgear stationary parts. The CTs shall be of cast resin, bar primary type and of Class B or better insulation. CT secondary current shall be 1 Amp.

5.5.2 CTs shall be rated for switchgear fault level for 1 sec and conforming to accuracy class mentioned below :-

- Class PS for differential relaying and REF protection
- Class 5P20 for other relaying
- Class 0.5 for energy accounting and audit meters with ISF < 5
- Class 0.5 for metering with ISF < 5

5.5.3 Separate cores shall be provided for metering and protection applications. Core balance CT and associated relay combination shall be such as to ensure a pick up sensitivity of 10 A primary ground fault current for all the outgoing feeders.

5.6.0 Voltage Transformer (VT)

5.6.1 Voltage transformer shall be cast-resin, draw-out type. Bus VT shall be mounted on adopter panel of bus coupler or shall be provided in separate panel. Line VT shall be mounted on the breaker carriage itself / below the breaker compartment. Separate cores shall be used for metering and protection. Voltage Transformer shall be cast-resin, draw-out type. Voltage Transformer mounted on breaker carriage is not acceptable. Over voltage factor shall be considered resistance grounded system as 120% for continuous duty and 190% for 8 hours.

5.6.2 Accuracy class of the voltage transformer shall be Class 3P for protection and Class 0.5 for metering .

5.6.3 High voltage windings of voltage transformer shall be protected by current limiting fuses. The voltage transformer and fuses shall be completely disconnected and visibly grounded in fully draw-out position. Automatic shutters shall be for safety purpose to avoid accidental access to live parts on VT withdrawal and entry of rodents. Low voltage side MCB's shall be provided.

5.6.4 Fuse failure relay on voltage balance principle shall be provided for all Bus VT's for monitoring the healthiness of primary fuse/secondary MCBs. For line VT's fuse failure relay shall be



provided on the secondary side of the voltage transformers to monitor failure of MCBs. The relay shall initiate alarm and block the tripping etc., which shall operate in case of VT fuse/MCB failure.

- 5.6.5 VTs shall be provided with one open delta winding with provision for harmonic suppression arrangement.

5.7.0 Relays

- 5.7.1 Each breaker module shall be provided with multifunction numerical relay for protection.

- 5.7.2 Relays in protective circuits shall be flush mounted on panel front with connections from the inside. They shall have transparent and dust tight covers removable from the front. They shall either have built-in test facilities.

- 5.7.3 The Numerical relays shall have built in protection, control, metering, monitoring, and communication facility. The Numerical relays shall be networked through Ethernet switch, Gateway/Data Concentrators and shall be further integrated with SCADA based electrical monitoring system (for monitoring, measuring, fault data analysis & relay parameterization).

- 5.7.4 All the numerical relays shall have two communication ports; local front port communication to laptop and a second port (RJ45/Fiber optic) on IEC 61850 to communicate with the data concentrator through LAN and Ethernet switches.

- 5.7.5 The successful bidder shall be fully responsible for selection of appropriate relay to provide optimum protection and discrimination of various circuits and equipment including the safety of the devices.

- 5.7.6 All hardware and licensed software required for communication of relays, parameterization, down load / analysis of fault data from relays and interfacing the relays with the DCS/EMS system shall be supplied by the Contractor complete with set of cables, accessories, etc.

- 5.7.7 All relays and timers shall be rated for control supply voltage of 220 V DC and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used. Interrogation voltage for the binary inputs shall be suitably selected to ensure avoidance of mal operation due to stray voltages.

- 5.7.8 Failure of a control or auxiliary supply and de-energisation of a relay shall not initiate any circuit breaker operation. All relays shall withstand a minimum test voltage of 2 kV AC rms for one minute.

- 5.7.9 Relays shall have separate output for individual functionality and the master trip shall be software configurable in case of multi output relays. Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping.

- 5.7.10 All the protective relays shall have inbuilt lock-out (86) facility with manual reset. For transformer feeders, a separate lockout relay shall be provided with manual reset. Each circuit breaker feeder shall be provided with, protective relay trip circuit supervision relay, necessary auxiliary relays, timers, etc. to meet circuit requirements. In addition self-reset type lockout relay to be provided on Bus PT Panel for under voltage tripping the motor feeders.

- 5.7.11 Lock out relay function contacts shall only be provided for protection trip & reset status for use in close and trip interlocks of the circuit breaker.

- 5.7.12 Comprehensive single numerical relay shall have provision of both current and voltage inputs. The overcurrent relay shall have provision for 3 nos. CT input for phase fault and 1 CT input for earth fault and 1 CT input for CBCT. Relay shall be suitable for both residually connected CT



input as well as CBCT input. The voltage-operated relay shall have provision for 3 PT inputs. Relays shall be suitable for CT secondary current of 1 A / 5 A selectable at site. Relays used in incomers and bus couplers shall have provision of two sets of voltage signal inputs for the purpose of synchronization.

- 5.7.13 All CT and PT terminals shall be provided as fixed type terminals on the relay to avoid any hazard due to loose connection leading to CT opening or any other loose connection. In no circumstances Plug In type connectors shall be used for CT/ PT connections.
- 5.7.14 All numerical relay shall have key pad / keys to allow relay settings from relay front. All hand reset relays shall have reset button on the relay front. Relay to be self or hand reset shall be software selectable. Manual resetting shall be possible from remote.
- 5.7.15 Relays shall have suitable output contact for breaker failure protection.
- 5.7.16 Relays shall have self-diagnostic feature with self-check for power failure, programmable routines, memory and main CPU failures.
- 5.7.17 Relays shall have at least two sets or groups of two different sets of adaptable settings. Relays shall have multiple IEC/ ANSI programmable characteristics.
- 5.7.18 For breaker control from DCS/Respective control system, hardwired potential free contacts shall be provided from DCS/Respective control system, to the numerical relays.
- 5.7.19 Schematics requiring auxiliary relays /timers for protection function shall be a part of numerical relay. The number of auxiliary relay and timer function for protection function shall be provided as required. Auxiliary relays for interlocking purpose shall be of self-reset type.
- 5.7.20 Bus no volt condition shall be configured to a output contact of the relay of all incomers
- 5.7.21 Timer functions shall be programmable for on/off delays.
- 5.7.22 The numerical relay shall be able to provide supervisory functions such as trip circuit monitoring, circuit breaker state monitoring, PT and CT supervisions and recording facilities with Post fault analysis.
- 5.7.23 The numerical processor shall be capable of measuring and storing values of a wide range of quantities, all events, faults and disturbance recordings with a time stamping using the internal real time clock. Battery backup for real time clock in the event of power supply failure shall be provided.
- 5.7.24 150 time tagged events/ records should be able to store with time stamping last 5 faults storage including the indication, protection operated , fault location relay and operating time, currents, voltage and time. All Setting parameters, Fault data, waveforms & event logs shall be stored in Non-volatile memory only.
- 5.7.25 Diagnostics Automatic testing, power on diagnostics with continuous monitoring to ensure high degree of reliability shall be provided. The results of the self-reset functions shall be stored in battery back memory. Test features such as examination of input quantities, status of digital inputs and relay outputs shall be shall be available on the user interface
- 5.7.26 The alarm/status of each individual protection function and trip operation shall be communicated to Data concentrator/DCS/Respective control system. The numerical relay system shall have built-in features/hardware interface to provide such inputs to Data concentrator / DCS/Respective control system for analog/digital.
- 5.7.27 Sequence of events shall have 1 ms resolution at device level.



- 5.7.28 Measurement accuracy shall be 1 % for RMS Current and voltage.
- 5.7.29 It shall be possible to carryout open / close operation of breakers from a laptop by interfacing from the relay front port (RS232) during initial commissioning.
- 5.7.30 Relay shall be suitable to accept both AC & DC supplies with 110 V AC or 220 V DC with tolerance of 80% to 120 % of rated voltage
- 5.7.31 Relay shall be immune to capacitance effect due to long length of connected control cables. Any external hardware, if required for avoiding mal operation of the relay due to cable capacitance shall be included as a standard feature. All IOs shall have optical isolation. Analog inputs shall be protected against switching surges, harmonics etc.
- 5.7.32 No separate earth bus shall be required for the relays. It shall be possible to connect the relay earth to the common earth bus in the switchgear panel which shall be connected to the plant earth mat.
- 5.7.33 Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.
- 5.7.34 Make of relays shall be Alstom/ABB/Siemens/Schneider/SEL/GE.
- 5.7.35 Relays shall be rated for operation on 110 V VT secondary voltage.
- 5.7.36 Auxiliary supply voltage for Relays, meters and transducers shall be 220 V DC.
- 5.7.37 The switchgear shall be provided with DC fail relay and DC fail indication lamp for each DC control supply incomer.
- 5.7.38 Breaker auxiliary contacts used for interlocking purposes shall be multiplied using electrically latched relay.
- 5.7.39 Numerical relay shall have the following features
- a) At least two group of settings
 - b) Min. no of LEDs - 10
 - c) LCD Screen
 - d) Front key pad for Parameter / Navigation.
 - e) In built lockout function with front key resetting.
 - f) EMC Compatible.
 - g) No adopter / Convertor is acceptable.
 - h) At least 10 disturbance recorder
 - i) At least 5 Fault recorder
 - j) Event recording at least 50
 - k) Unlimited logic gates
 - l) In-built timers
 - m) Freely programmable DI / DO.
 - n) In built CB control function with interlocking.
 - o) Goose messaging for inter tripping command and interlocking in addition to hardware interlocking.
 - p) Non -Volatile memory with battery backup or suitable arrangement
 - q) Time synchronization
 - r) self-diagnosis
- 5.7.40 Earth fault protection relay shall initiate tripping of associate breaker.
- 5.7.41 Requirements of protection functions of various feeders shall include the following. The same shall be achieved using numerical relays:



- a) Incomer feeder from Unit transformers and Station transformers:
- IDMT & DMT overcurrent protection (50/51)
 - IDMT & DMT earth fault protection (50N/51N)
 - Under voltage protection (27)
 - Breaker fail protection (60BF)
 - Check Synchronizing function (25C)
- b) Incomer feeder from HV transformers:
- IDMT & DMT overcurrent protection (50/51)
 - IDMT & DMT earth fault protection (50N/51N)
 - Under voltage protection (27)
 - IDMT & DMT standby earth fault protection (50NS/51NS)
 - Restricted earth fault protection (64R)
 - Breaker fail protection (60BF)
 - Check Synchronizing function (25C)
- c) Incomer feeder (Direct from upstream switchgear):
- IDMT & DMT overcurrent protection (50/51)
 - IDMT & DMT earth fault protection (50N/51N)
 - Under voltage protection (27)
 - Breaker fail protection (60BF)
 - Check Synchronizing function (25C)
- d) Tie feeder:
- IDMT & DMT overcurrent protection (50/51)
 - IDMT & DMT earth fault protection (50N/51N)
 - Under voltage protection (27)
 - Breaker fail protection (60BF)
 - Check Synchronizing function (25C)
 - Instantaneous earth fault protection through CBCT (50N) for cable feeders only
- e) Bus Coupler feeder
- IDMT & DMT overcurrent protection (50/51)
 - IDMT & DMT earth fault protection (50N/51N)
 - Breaker fail protection (60BF)
 - Check Synchronizing function (25C)
- f) For Outgoing transformer feeders.
- Short circuit protection (50)
 - IDMT & DMT overcurrent protection (50/51)
 - IDMT & DMT earth fault protection (50N/51N)
 - Breaker fail protection (60BF)
 - Instantaneous earth fault protection through CBCT (50 N).
 - Restricted earth fault protection (64)
 - Differential protection (87) for Transformers rated 5 MVA and above

Self-reset auxiliary relays with hand reset flag indicator shall be provided for contact multiplication of the following:

- Transformer Buchholz alarm and trip contacts.
- Transformer winding temperature indicator alarm and trip contacts.
- Transformer oil temperature indicator alarm and trip contacts.
- Transformer pressure relief trip contacts.
- Transformer oil level low alarm contacts.



- g) For Outgoing feeders.
- IDMT & DMT overcurrent protection (50/51)
 - IDMT & DMT earth fault protection (50N/51N)
 - Breaker fail protection (60BF)
 - Instantaneous earth fault protection through CBCT (50 N).
- h) Motor feeders.
- Short circuit protection (50)
 - IDMT & DMT overcurrent protection (50/51)
 - IDMT & DMT earth fault protection (50N/51N)
 - Breaker fail protection (60BF)
 - Instantaneous earth fault protection through CBCT (50 N).
 - Differential protection (87) for motors rated above 1000 kW
 - Electronic over load protection (49)
 - Negative sequence protection (46)
 - Phase reversal protection (46 R)
 - Restart inhibit with startup counter (37)
 - Locked rotor protection (48-LR)
 - Under current protection (66)
- i) Bus PT shall have the following protections.
- Under voltage relay
 - Fuse failure relay
 - No voltage relay.
- j) Line PT shall have the following protections.
- Fuse failure relay
 - Under voltage relay

5.8.0 Control and Interlocks

- 5.8.1 The circuit breaker will normally be controlled from DCS/Respective control system. The control switch located on the switchgear / relay would normally be used only for testing of circuit breaker in TEST position.
- 5.8.2 The incomer modules shall be interlocked with their upstream breaker such that they can be closed only when upstream breaker is closed and trip automatically when upstream breaker is tripped.
- 5.8.3 The circuit-breaker shall have three distinct positions as follows:
- 'Service' both power and control contacts connected.
 - 'Test' Power contacts isolated, control contacts connected.
 - 'Isolated' both power and control contacts isolated.
- 5.8.4 Circuit breaker control switches shall be 3-position spring return to 'neutral' from both close and trip positions. They shall have 'Pistol Grip' handle. The contacts shall be of silver plated, air break type. The continuous current and breaking capacity of the contacts shall be adequate for the duty involved.
- 5.8.5 'Red', 'Green' and 'Amber' indication lamps shall be provided on the panel to indicate breaker 'Close', 'Open' and 'Auto-Trip' position. In addition to above, mechanical indicator shall be provided which shall be clearly visible to the operator standing in front of the panel.



- 5.8.6 Indication lamps to show the circuit-breaker 'Service' and 'Test' positions shall be provided. Further additional indication lamps shall be provided as per scheme requirement.
- 5.8.7 Indication lamps shall be of the panel mounting, LED type. The lamps shall have escutcheon plates marked with its function, wherever necessary. Lamps shall have translucent lamp-covers as warranted by the application.
- 5.8.8 Facilities shall be provided for mechanical tripping of the breaker and for manual charging of the stored energy mechanism for a complete duty cycle, in an emergency. These facilities shall be accessible only after opening the compartment door.
- 5.8.9 The control / interlock schemes for various types of feeders shall be commensurate with their application. Contact multiplication, if necessary to meet the above contact requirement, shall be done through electrical reset latch relay.
- 5.8.10 Potential free contacts for indications /alarms /SOE points shall be provided in each Breaker panel for remote panel/DCS/Respective control system which shall include the following:
- Potential free contacts for remote DCS for Breaker on, Breaker off, Breaker in remote, Breaker in service, Ready to start, lock out relay operation, Trip circuit trouble, PT fuse failure, switchgear disturbed, relay fault etc.
 - Potential free contacts for interfacing with Bus transfer panels and other upstream/downstream breakers.
 - For Transformer feeders, potential free contacts for remote DCS for OTI alarm, WTI alarm, Buchholz alarm, Oil level low alarm, OTI Trip, WTI Trip, Buchholz relay trip, Pressure relief device operated etc.
 - For each PT panel, potential free contacts for remote DCS for Bus under voltage relay operated, Bus PT fuse failed, DC supply failed, Bus PT not in service etc.
- 5.9.0 **Meters**
- 5.9.1 For incomers & Tie feeders following Meters and transducers shall be provided:
- Current transducer on 'Y' phase
 - Voltage transducer on 'Y-B' phase
 - 1.0S class energy accounting and audit meters
 - 1.0 class Multi-Function Meter.
- 5.9.2 For outgoing transformer feeders following Meters and transducers shall be provided:
- Current transducer on 'Y' phase
 - 1.0S class Energy meter
 - 1.0 class Multi-Function Meter.
- 5.9.3 For outgoing feeders following Meters and transducers shall be provided:
- Current transducer on 'Y' phase
 - 1.0 class Multi-Function Meter.
- 5.9.4 For outgoing motor feeders following Meters and transducers shall be provided:
- Current transducer on 'Y' phase
 - 1.0S class Energy accounting and audit meter
 - 1.0 class Analog meter on 'Y' phase
- 5.9.5 For Bus Coupler following Meters and transducers shall be provided:
- Current transducer on 'Y' phase
 - 1.0 class Multi-Function Meter.



5.9.6 For Bus VT following Meters and transducers shall be provided:

- 1.0 class Digital Voltmeter, measuring all three phases
- Voltage transducer on three phases

5.9.7 Energy accounting and audit meters shall meet CEA regulation. It shall be integrated with integrated energy management system. The energy audit meters shall be suitable for measurement, recording and display of cumulative active energy with date and time. It shall have data storage capacity for at least 35 days in a non-volatile memory. It shall have facility to download the parameters through meter reading instruments as well as remote transmission of data over communication network. It shall also have the facility to measure, record and display the following parameters. All parameters excluding instantaneous electrical parameters shall also be stored in memory.

- (a) Apparent power
- (b) Phase wise kilowatt at peak KVA
- (c) Phase wise KVA(reactive) at peak KVA
- (d) Phase wise voltage at peak KVA
- (e) Power down time
- (f) Average power factor
- (g) Line currents
- (h) Phase voltages
- (i) Date and time
- (j) Tamper events

5.9.8 Digital Multifunction Meters shall be provided with bright LED/LCD display for local indication and shall be provided with communication port suitable for communicating on MODBUS protocol to EMS/DCS. It shall display various parameters like 3 phase currents, voltages, PF, MD, KW, KVA, etc. for local indication and shall be provided with minimum 8 nos. of user programmable registers for communicating any of the displayed parameters to the remote.

5.9.9 For motor feeder, analog ammeter with accuracy class 1.0, of 96x96 sq.mm square with 240° scale. Shall be provided. It shall have cramped scale above 2 times to 8 times the rated current for indicating the starting current.

5.9.10 Transducers shall be of dual output type, class 0.5, 4-20 mA DC linear output & 750 ohm load.

5.10.0 Surge arrestor

The surge arrestors shall be provided for all motor/ dry transformer feeders to limit the switching over voltages to 2.2PU. The surge arrestors shall be metal oxide, gapped or gap less type generally in accordance with IEC 60099- 1 and suitable for indoor duty. These shall be mounted within the switchgear cubicle between line and earth, preferably in the cable compartment. Surge arrestor selected shall be suitable for non-effectively earthed system and rating shall be in such a way that the value of steep fronted switching over voltage generated at the switchgear terminals shall be limited to the requirements of feeding equipment.

5.11.0 Earthing and Earthing Devices

5.11.1 Aluminium or copper earthing bus shall be provided at the bottom and shall extend throughout the length of each switchgear. It shall be bolted to the framework of each panel and each breaker earthing contact bar.

5.11.2 The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault currents to earth without exceeding the allowable temperature rise.

5.11.3 All joint splices to the earth bus shall be made through atleast two bolts and taps by proper lug and bolt connection.



- 5.11.4 The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions i.e. Service, Test and Isolated as well as throughout the intermediate travel. The truck shall also get and remain earthed when the control plug is connected irrespective of its position.
- 5.11.5 All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth by independent stranded copper wires of suitable size.
- 5.11.6 VT and CT secondary neutral point earthing shall be at one place only on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit may be removed without disturbing the earthing of other circuits.
- 5.11.7 Separate earthing trucks shall be provided for maintenance work. These trucks shall be suitable for earthing the switchgear busbar as well as outgoing/ incoming cables or bus ducts. The trucks shall have a voltage transformer and an interlock to prevent earthing of any live connection. The earthing trucks shall in addition have a visual and audible annunciation to warn the operator against earthing of live connections.
- 5.11.8 Built-in earthing facilities for the busbar and outgoing/ incoming connections are also acceptable. The inbuilt earthing switches shall have provision for short circuiting and earthing a circuit intended to be earthed. These switches shall be quick making type, independent of the action of the operator and shall be suitable for operation from the front of the switchgear panel. These switches shall have facility for padlocking in the earthed condition.
- 5.11.9 Interlocks shall be provided to prevent :
- Closing of the earthing switch if the associated circuit breaker truck is in Service position.
 - Insertion of the breaker truck to Service position if earthing switch is in closed position.
 - Closing of the earth switch on a live connection. Three (3) nos. voltage capacitive dividers shall be provided on each phase of the section intended for and three (3) nos. "RED" neon lamps/ LEDs connected to these on the panel front for visual indication.
- 5.11.10 The earthing device shall have the short circuit withstand capability equal to that of associated switchgear panel. 4 NO + 4 NC of auxiliary contacts of the earthing device shall be provided for interlocking purpose.
- 5.11.11 All hinged doors shall be earthed through flexible earthing braid.

6.0.0 BUS TRANSFER SCHEME (BTS) PANEL

- 6.1.0 Bus transfer scheme (BTS) panel shall be provided for each Unit switchgear. Make of 'BTS panel' shall be subject to Owner's approval.
- 6.2.0 Unit switchgear shall comprise one incomer from Unit transformer which is a normal source, supplying power when the unit is running and a tie feeder from standby maintenance transformer, to supply station power.
- 6.3.0 During unit startup, Unit switchgear will be energised from grid supply through generator transformer (GCB in open condition). On stabilizing generator supply, generator will be synchronized with grid by closing GCB.
- 6.4.0 Alternatively, during unit startup power will be drawn from grid through standby maintenance transformer and auxiliary switchgear will be energised by closing tie feeder. On stabilization of generator supply, changeover is envisaged between incomer and tie feeder of Unit switchgear. The changeover of these two sources shall be from the BTS. Following changeovers/transfers are envisaged during plant operation:



- a. **Station to Unit Transfer:** During plant start, Unit switchgear will be energized through tie feeder. After stabilizing generation, incomer breaker will be closed by the operator through manual planned changeover and the tie breaker will be tripped through BTS.
- b. **Unit to Station Transfer under following conditions:**
- Manual planned transfer during normal operation of the unit (in case Unit transformer is to be taken out from service).
 - Protective transfer shall be initiated automatically on operation of Master trip relay of the Unit.
 - Auto transfer during under voltage, bus under frequency or high df / dt by continuously monitoring the system parameters.
- 6.5.0 Microprocessor based numerical automatic fast changeover scheme for changeover of supply shall be provided. The closure of the station supply breaker shall be supervised by a synchro-check relay permanently connected to and energized by the secondary voltages of the station and unit bus PT. The high-speed transfer shall be completed within 40 milliseconds. If the phase angle difference between the two sources exceeds the predetermined setting of the synchro-check relay, which shall not exceed 20 degree, an automatic "slow dead" transfer shall be made. To facilitate fast bus transfer operation, closing and opening operation time difference shall be limited to 02 cycles (40 ms)
- 6.6.0 Bus transfers shall be attempted in the following modes as per the guidelines of IEEE-666 standard.
- Fast transfer
 - In phase transfer
 - Slow (Residual voltage) transfer
 - Parallel fast transfer
- 6.7.0 BTS shall have the following features:
- a) It shall be designed to be completely automatic, self-checking and built in testing mode to ensure highest degree of reliability.
 - b) It shall monitor and prevent continuous paralleling of two sources.
 - c) Manual transfer shall be initiated from the front of the panel.
 - d) While transferring the bus from one source to another, continuity of supply to motor or other auxiliaries shall be ensured.
 - e) In case of BTS trouble or control supply failure, it should not affect the switchgear system. No tripping of breakers shall be initiated under such cases.
 - f) The BTS shall perform several system checks to determine the transfer system readiness. It shall not allow the transfer to be initiated if any of the system check condition is not satisfied.
 - g) During emergency, fully manual changeover facility will be utilized for which following facilities shall be provided
 - Voltages Shall be read from relay display
 - Synchronizing permissive LED shall be glowed
 - Closing command wired to the relay will actuate the output command from the relay for breaker closing
 - h) BTS shall be provided with following features:
 - Output contact shall be suitable rated to be wired directly in closing and tripping circuits
 - It should have enough DI/DO for status monitoring on continuous basis to ensure operation readiness.
 - It shall allow manual bus transfer from local / remote.
 - It shall be communicable with EMS / DCS.



- 6.8.0 On line testing mode shall be incorporated in the BTS. Test mode IN / OUT selection shall be provided on the front interface. During test mode, BTS shall check all interlocks to ascertain this operation. If any of the interlock fails, shall be detected in the test mode and shall be indicated. On actuation of test transfer, the tripping and closing contacts shall be asserted as per actual system conditions, but shall not actually triggers the transfer. The display of change status of breaker in test mode shall be indicated on the interface. After completion of test operation, the test mode shall get automatically disconnected.
- 6.9.0 BTS shall be provided with one USB port at the front for connecting to Laptop and one port on IEC 61850 protocols at the rear for communication through Ethernet switch/data concentrator to DCS and Engineering workstation (for fault diagnosis and analysis and relay parameterization).
- 6.10.0 BTS shall record every transfer event, which can be uploaded to the PC. The system quantities like phase difference between bus voltage and new source, magnitude of vectorial difference between bus voltage and new source, voltage magnitudes and frequency all at the instant of closing of new source breaker and breaker closing and tripping timings shall be available.
- 6.11.0 BTS shall be blocked under following conditions:
- BTS shall continuously perform self-test and in the event of failure of this test, the BTS shall be blocked.
 - On initiation of commands to breaker through BTS, if breaker fails to close or open then BTS shall blocked. If old source breaker fails to trip and new source breaker closes, then to avoid paralleling, the new breaker shall trip.
 - When desired bus transfer request does not result in desired bus transfer operation, BTS shall block.
 - In case of fault in Unit switchgear.
- 6.12.0 Potential free contact shall be provided to annunciate BTS trouble in DCS/EMS.
- 6.13.0 BTS shall be put into non readiness under following conditions:
- a) If any of the unit incomer breaker / tie breaker on station board / tie breaker on Unit board taken out of service position. The BTS shall continuously monitor the service position of these breakers the same shall be indicated in BTS.
 - b) If the status of NO and NC contacts of the above breaker are not consistent with each other. The BTS shall continuously monitor the breaker status error condition shall be detected and indicated.
 - c) Failure of unit incomer line side PT, station PT and Unit switchgear bus PT (Not in service position / PT fuse failure).
 - d) Non availability of DC voltage across the closing and tripping command contacts/ tripping coil/ Closing coil for the unit incomer breaker, tie breaker and tie breaker on station board feeding unit board. BTS shall continuously monitor the above.
 - e) Operation of Master trip relay of unit incomer breaker, tie breaker and tie breaker on station board feeding unit board.
 - f) If the new source voltage is unhealthy. BTS shall continuously monitor the voltage magnitude of the new source for under voltage and over voltage setting of PT inputs.
- 6.14.0 BTS panel enclosure shall be free standing type and shall be fabricated from rigid welded structure frame completely covered by cold rolled sheet metal enclosure of minimum thickness 2 mm. The cable entry shall be from bottom. The enclosure shall be dust and vermin proof confirming to IP-42.
- 6.15.0 The BTS panel shall have menu base with screen and push buttons on the front face for transfer operations. It shall give all information on the screen like transfer mode, BTS IN / OUT condition, Previous transfer log, Breaker status, BTS ready / not ready with the status of all conditions required for BTS ready state, BTS blocked / not blocked conditions with all conditions required for BTS with manual reset, BTS test IN/OUT status etc.



- 6.16.0 The BTS IN / OUT selection shall be provided in the Panel. When the BTS is out, both the source breaker shall be operative from switchgear or remote Electrical control panel. The provision shall be made such that, when the DC supply of the BTS is off, then BTS shall be in out condition irrespective of selection. When transfer shall be initiated, the selection shall be BTS IN. During BTS transfer the closing positive and negative of the breaker shall be through BTS panel, for tripping of the breaker, the switchgear supply shall be used.
- 6.17.0 The following annunciations shall be provided in the LED display
- BTS ready
 - BTS in test mode (During this selection, BTS ready indication shall blink)
 - BTS IN
 - UT feeding bus (Unit breaker ON)
 - Station feeding bus (Station breaker and tie breaker on station board ON)
 - Previous transfer OK
 - BTS not ready
 - BTS blocked
 - Unit motors tripped
- 6.18.0 The digital, programmable, seven segment panel meters shall be provided on the front of the panel. The meters shall include but not limited to the following :
- Unit voltage (Unit incomer line side secondary line voltage)
 - Station voltage (Station board voltage)
 - Station frequency
 - Bus voltage
 - Bus frequency
 - New source bus (Phase difference between new source and bus)
 - New source bus (Magnitude of phasor difference between new source and bus)

7.0.0 PAINTING

Painting shall be carried out by approved process. After preparation of the under surface the equipment shall be painted with epoxy based paint by powder coating. The final thickness of paint film on steel shall not be less than 85 microns. Final shade shall be RAL-7035.

8.0.0 TESTS

- 8.1.0 All the equipment supplied shall be of type tested quality. Type test reports shall be submitted for Switchgear panel and breaker of each voltage class and current rating as per IS 12729:
- 8.2.0 The Switchgear panel and circuit breaker shall be subjected to the routine test in accordance with the relevant Indian / IEC Standards. Factory acceptance tests shall be carried out (FAT) for bus transfer panel.
- 8.3.0 Type test reports for the following shall be submitted for Switchgear panel of each voltage class and current rating as per IS 12729:
- Dielectric tests including Lightning impulse withstand test, Power frequency withstand test, switching impulse test, partial discharge test, artificial pollution test, Power frequency withstand test on auxiliary and control circuits.
 - Radio interference voltage tests
 - Temperature rise test
 - Measurement of resistance of the main circuit
 - Short time withstand current and peak withstand current test



8.4.0 Type test reports for the following shall be submitted for Circuit breaker / Contactor of each voltage class and current rating as per applicable standard.

8.5.0 For circuit breaker, the list of type tests shall include the following as per IS 13118:

- Dielectric tests
- Radio interference voltage test
- Measurement of the resistance of the main circuit
- Temperature-rise tests
- Short-time withstand current and peak withstand current tests
- Verification of the Protection
- Tightness tests
- Electromagnetic compatibility tests
- Mechanical and environmental tests including Mechanical operation test
- Short-circuit current making and breaking tests
- Capacitive current switching tests
- Magnetising and inductive current switching tests

8.6.0 Routine Tests

8.6.1 The Switchgear panel shall be subjected to the routine test in accordance with the relevant Indian / IEC Standards. The tests shall include the following.

- Power frequency voltage dry test on the main circuit.
- Voltage test on control and auxiliary circuits.
- Measurement of resistance of the main circuit.
- Mechanical operating tests

8.6.2 The circuit breakers, Contactors, Switches, voltage transformers and current transformers shall be subjected to the routine test in accordance with the relevant Indian / IEC Standards.

8.6.3 For circuit breaker, the list of routine tests shall include the following as per IS 13118:

- Dielectric tests on the main circuit
- Dielectric tests on the control circuit & auxiliary circuit
- Measurement of the resistance of the main circuit
- Mechanical operating tests
- Tightness tests
- Design and visual checks

8.7.0 Site Tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

- a) General
- Check name plate details according to specification
 - Check for physical damage
 - Check tightness of all bolts, clamps and connecting terminals
 - Check earth connections
 - Check cleanliness of insulators and bushings
 - Check heaters are provided
 - HV test on complete switchgear with CT and breaker/ contactor in position
 - Check all moving parts are properly lubricated



- Check for alignment of busbars with the insulators to ensure alignment and fitness of insulators
 - Check for interchangeability of breakers/ contactors
 - Check continuity and IR value of space heater
 - Check earth continuity for the complete switchgear board
- b) Circuit Breaker/ Contactors
- Check alignment of trucks for free movement
 - Check correct operation of shutters
 - Check slow closing operation (if provided)
 - Check control wiring for correctness of connections, continuity and IR values
 - Manual operation of breakers completely assembled
 - Power closing/ opening operation, manually and electrically at extreme condition of control supply voltage
 - Closing and tripping time
 - Trip free and anti-pumping operation
 - IR values, resistance and minimum pick up voltage of coils
 - Simultaneous closing of all the three phases
 - Check electrical and mechanical interlocks provided
 - Checks on spring charging motor, correct operation of limit switches and time of charging
 - Check SF6 pressure/ vacuum (as applicable)
 - All functional checks
- c) Current Transformers
- Insulation resistance between windings and winding terminals to body
 - Polarity tests
 - Ratio identification checking of all ratios on all cores by primary
 - injection of current
 - Magnetisation characteristics and secondary winding resistance
 - Spare CT cores to be shorted to earth
- d) Voltage Transformers
- Insulation resistance test
 - Ratio test on all cores
 - Polarity test
 - Line connections as per connection diagram
- e) Cubicle Wiring
- Check all switch developments
 - It should be made sure that the wiring is as per relevant drawings. All interconnections between panels shall similarly be checked
 - All the wires shall be meggered to earth
 - Functional checking of all control circuit e.g. closing, tripping interlock, supervision and alarm circuit including proper functioning of component/ equipment
 - Check terminations and connections
 - Wire ducting
 - Gap sealing and cable bunching
- f) Relays
- Check internal wiring
 - Insulation resistance between all terminals and body
 - Insulation resistance between AC to DC terminals
 - Check operating characteristics by secondary injection
 - Check minimum pick up voltage of DC coils
 - Check operation of electrical/ mechanical targets



- Check CT connections with particular reference to their polarities for differential type relays
 - Relay settings
- g) Meters
- Insulation resistance of all insulated portions
 - Check CT and VT connections with particular reference to their polarities for power type meter

9.0.0 TECHNICAL PARAMETERS

Sl.No.	Description	Unit	11 kV switchgear	6.6 kV switchgear	33 kV switchgear
1.0	Switchgear				
a)	Type		Metal clad, Indoor	Metal clad, Indoor	Metal clad, Indoor
b)	Type of cooling		Natural air cooled	Natural air cooled	Natural air cooled
c)	Rated Voltage (normal / max)	kV	11/12	6.6 / 7.2	33/36
d)	Short circuit withstand current rating	kA rms	50	31.5	25
e)	Peak withstand current rating	kAp	125	80	63
f)	Short-time rating for 3 Sec. duration	kA rms	50	31.5	25
g)	Internal arc withstand rating for 0.5 Sec. duration	kA rms	50	31.5	25
h)	Impulse withstand voltage	kVp	75	60	170
i)	One minute power frequency with stand voltage	kV rms	28	20	70
j)	Degree of protection for breaker, cable, busbar compartment		IP4X	IP4X	IP54
k)	Degree of protection for isolator				IP54
l)	Degree of protection for relay & meter compartment		IP52	IP52	IP54
2.0	Circuit breaker				
a)	Type		VCB	VCB	VCB
b)	No. of poles		3	3	3
c)	Rated operating duty		O-3min-CO-3min-CO	O-3min-CO-3min-CO	O-3min-CO-3min-CO
d)	Short-time current for 3 sec (minimum)	kA rms	50	31.5	25
e)	Rated short circuit breaking current(min)	kA rms	50	31.5	25
f)	Rated short circuit making current (min)	kAp	125	80	63
g)	Control supply voltage				
	• Closing coil & spring charging motor	V	220 V DC (80-110%)	220 V DC (80-110%)	220 V DC (80-110%)
	• Tripping coil	V	220 V DC (70-110%)	220 V DC (70-110%)	220 V DC (70-110%)



Sl.No.	Description	Unit	11 kV switchgear	6.6 kV switchgear	33 kV switchgear
6.0	Busbar				
a)	Short-time current for 3 sec. (min)	kA rms	50	31.5	25
d)	Dynamic withstand current rating (min)	kAp	125	80	63
b)	Temperature rise of over design ambient of 50°C • Bus bars • Silver plated joints		40 °C 55°C	40 °C 55°C	40 °C 55°C

10.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Technical data sheet
- Feeder list for each switchgear
- General arrangement and section drawing
- Single line diagram & Schematic wiring diagrams
- Metering and protection drawing
- Sizing Calculation for busbar
- Short circuit withstand calculation for busbar (Thermal & dynamic)
- Component list & Bill of Quantities for all the boards
- Panel cutout details
- Foundation Plan & loading details
- Erection and commissioning procedures
- CT / VT sizing calculation
- Relay setting calculation
- Catalogues / drawings / leaflets for all items
- Erection and commissioning procedures
- Operation and maintenance manual
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.9: NEUTRAL GROUNDING RESISTORS

1.0.0 INTENT OF SPECIFICATION

This specification covers requirements of neutral grounding resistors for 11 kV and 6.6 kV system.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) NGR for Unit transformers
- b) NGR for Station transformers
- c) NGR for Standby maintenance transformer
- d) NGR for Unit auxiliary transformers
- e) NGR for Station auxiliary transformers
- f) NGR for CHP auxiliary transformers
- g) NGR for AHP auxiliary transformers
- h) NGR for Sea Water Intake transformers
- i) Galvanised support structures
- j) Commissioning spares and consumables
- k) Mandatory spares
- l) Tools & tackles
- m) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Standards, except where modified and /or supplemented by this specification.

- IEEE-32 : Neutral grounding resistors

4.0.0 TECHNICAL REQUIREMENTS

- 4.1.0 Neutral grounding resistors shall be used to ground neutral of high voltage transformers.
- 4.2.0 The NGR rating shall be based on an ambient temperature of 50 Degree C. The short time current rating of the NGR shall be such that it can allow about 300 A current for 5 minutes without exceeding the temperature rise of 300°C over 50°C ambient.
- 4.3.0 DC resistance shall not vary by more than +10% of the rated value at design ambient temperature. DC resistance at maximum temperature specified shall not be more than +15% of the rated value.
- 4.4.0 The NGR shall be natural air-cooled type. The resistor shall be made of stainless steel grid.
- 4.5.0 The NGR shall be suitable for outdoor installation in a hot, humid and tropical atmosphere.
- 4.6.0 One end of the resistor shall be connected to neutral side of the transformer through suitable cable box and other end shall be connected to earth pit through bushing and galvanised steel busbar.
- 4.7.0 The material of resistor shall be non-inductive and made of non-magnetic material of punched stainless steel. The resistor shall be of dry type and maintenance free. The resistors shall be



designed to carry high currents at high temperatures without deterioration and with relatively small change in its resistance value. The operation of the resistor shall not be affected by moisture or fine dust or sand. All element connections shall be bolted type to ensure stable resistance value throughout the life of Unit.

- 4.8.0 The resistor shall be enclosed in Aluminium enclosure of not less than 2 mm, having degree of protection of IP 55. The enclosure shall have suitable hood or sloped roof on top for rain protection. The NGR shall be complete with support insulators and interposing insulators for resistor.
- 4.9.0 For NGR, the enclosure shall have cable box with bushing for receiving neutral cable.
- 4.10.0 Cable box shall be provided with Bolted type removable aluminium gland plate for fixing cable glands. Cable box shall be suitable for receiving termination kits. In case of bus connections bushing with all accessories shall be supplied.
- 4.11.0 A low voltage bushing and stud shall be provided through the enclosure wall for the resistor earth connection. The low voltage bushing shall be suitable for receiving 2 numbers of 50X6 mm Galvanized steel flat. The cubicle shall be complete with mounting brackets, lifting hook etc.
- 4.12.0 The NGR cubicle shall be mounted on an insulated pedestal.
- 4.13.0 The enclosure shall be provided with a space heater & thermostat. Suitable terminal block shall be provided to receive 240 V AC supply and distribute the same to space heater through MCB. Door switch operated Illuminating lamp & socket shall be provided
- 4.14.0 Support structure shall be of hot dip galvanized standard steel section. Height of support structure shall be not less than 1 metre. For the design of structures, loads such as Dead load due to equipment and structure, Wind load on structures, Seismic loads, Short circuit forces shall be considered. All supporting structures shall be furnished including members, bolts, shims, base plates, brackets, bracings and hardware. All steel members shall be suitably surface treated and hot-dip galvanized after fabrication. All hardware shall be of high strength steel with weather resistant finish. Thickness of galvanizing shall be not less than 610 gm/sq.m.
- 4.15.0 The NGR shall be provided with tropical finish to prevent fungus growth. All the fabricated surfaces shall be pretreated by degreasing, de-rusting and chemically cleaned prior to application of synthetic resin red oxide primer to give a dry film thickness of 20-40 microns. The finishing paint shall be epoxy based. The paint shall be applied in two coats to give a minimum dry film thickness of not less than 50 microns. Final shade shall be 631 (light grey) of IS 5. All hardware shall be galvanized or cadmium plated.

5.0.0 INSPECTION & TESTING

NGR shall be inspected and tested as per the applicable standards and approved Quality Plan.

5.1.0 Following tests shall be conducted on NGR Cubicle

5.1.1 Type Tests

- Impulse Voltage test
- Temperature rise test
- Power frequency voltage withstand test
- Degree of Protection Test

5.1.2 Routine Tests

- Resistance Measurements



- Dielectric Tests
- Temperature rise tests
- Visual inspection and verification of dimensions
- Insulation resistance measurement
- One minute power frequency high voltage test
- Operational Check

5.1.3 Site Tests

- Power frequency voltage withstand test at 80% of routine test voltage.
- Insulation resistance test for enclosure circuit
- Measurement of DC resistance
- Physical check

6.0.0 TECHNICAL PARAMETER OF NGR

Sl. No.	Item Description	Units	Data for NGR for 11 kV system	Data for NGR for 6.6 kV system
1	Service		Outdoor	Outdoor
2	Applicable standard		IEEE: 32	IEEE: 32
3	Rated Current	A	300 A for 5 minutes	300 A for 5 minutes
4	Resistance of complete assembly	Ohms	22.13	13.28
5	Rated line Voltage	V	11500	6900
6	Rated Phase to Neutral voltage	V	6639	3984
7	Insulation level			
	a) 1 min dry power frequency withstand	kV(rms)	28	20
	b) Impulse withstand	kV(peak)	75	60
8	Material			
	a) Resistance		Punched grid Stainless steel strip type	Punched grid Stainless steel strip type
	b) Enclosure		Aluminium	Aluminium
9	Degree of protection		IP 55 Weather proof	IP 55 Weather proof
10	Enclosure Finish - Interior & Exterior surface		Epoxy, Shade 631 to IS: 5	Epoxy, Shade 631 to IS: 5
11	Cooling		Natural cooling	Natural cooling
12	Maximum permissible Temperature	°C	350°C	350°C
13	Type of support structure		Galvanized steel	Galvanized steel



7.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Technical data sheet
- General arrangement and section drawing
- Sizing Calculation
- Erection and commissioning procedures
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.10: LOW VOLTAGE (LV) SWITCHGEAR

1.0.0 INTENT OF SPECIFICATION

This section covers the technical requirements of low voltage switchgear.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) 415 V, AC intelligent Power control centres (PCC) for units, station, auxiliary plant and non plant buildings.
- b) 415 V, AC intelligent Motor control centres (MCC) for units, station, auxiliary plant and non plant buildings.
- c) 415 V, AC distribution boards for units, station, auxiliary plant and non plant buildings.
- d) 415 V, AC Emergency PCC and emergency MCC for each unit.
- e) 220 V DC distribution boards for units, station and auxiliary plants.
- f) 415 V heater control panels for electrical heat tracing of fuel pipe lines
- g) Local starters for units, station and auxiliary plants.
- h) Local panels for units, station and auxiliary plants.
- i) Local push button stations for various units, station and auxiliary plants.
- j) Commissioning spares and consumables
- k) Mandatory spares
- l) Tools & tackles
- m) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS/IEC standards including amendments, if any, except where modified and/or supplemented by this specification. Some of the applicable standards are listed below:

a) IS 8623	Specification for low voltage switchgear and control gear Assemblies
b) IS 10118	Code of practice for selection, installation and maintenance of switchgear and control gear
c) IS/IEC 60715	Dimensions of low-voltage switchgear and control gear - standardized mounting on rails of mechanical support of electrical devices in switchgear and control gear installations
d) IS 12021	Specification for control transformers for switchgear and control gear for voltages not exceeding 1000 V
e) IS 13032	Miniature circuit breaker boards for voltages not exceeding 1000 V
f) IS/IEC60947	Specification for low voltage switchgear and control gear
g) IS 694	Specification for PVC insulated cables for working voltage up to and including 1100 V
h) IS 5	Colour for ready mixed paints and enamels
i) IS 14372	Specification for volt-ampere hour meters for full power factor range
j) IS 14415	Specification for volt-ampere hour meters for restricted power factor range
k) IS 1248	Direct acting indicating analogue electrical measuring instruments and their accessories



- l) IS 2705 Specification for current transformers
- m) IS 3156 Specification for voltage transformers
- n) IS 3231 Specification for electrical relays for power system protection
- o) IS 6005 Code of practice for phosphate of iron and steel
- p) IS 11353 Guide for uniform system of marking and identification of conductors and apparatus terminals
- q) IS/IEC 60529 Degrees of protection provided by enclosures (IP code)

- r) IEC 60439 Low voltage switchgear and control gear assemblies
- s) IEC 60947 Low voltage switchgear and control gear
- t) IEC/TR 61641 Enclosed low-voltage switchgear and control gear assemblies – Guide for testing under conditions of arcing due to internal fault

4.0.0 TECHNICAL REQUIREMENTS

4.1.0 Power supply voltage shall be considered as follows:

- Motors rated > 0.2 kW and up to 200 kW : 415 V, 50 Hz, 3 Phase
- Motors rated up to 0.2 kW : 240 V, 50 Hz, Single Phase
- Panel lighting & Space Heater : 240 V, 50 Hz, Single Phase
- Control Supply : 220 V DC

4.2.0 Current Rating

- 4.2.1 Ambient temperature prevailing inside the switchgear while carrying rated current, when the outside air ambient temperature is 50°C shall be considered as design ambient temperature for sizing the equipment/device/bus rating. Continuous current rating shall be such that the temperature does not exceed 90°C. For silver plated joints the temperature shall not exceed 105°C.
- 4.2.2 The continuous current rating of the feeders shall be based on the name plate current rating of the connected equipment with 10% margin at design ambient condition, rounded off to next higher standard rating unless specified otherwise.
- 4.2.3 The continuous current rating of the incomers/tie feeders/main bus bars of PCC shall be based on the name plate rating of the upstream transformer with 10% margin at design ambient condition, rounded off to next higher standard rating unless specified otherwise.
- 4.2.4 The continuous current rating of the incomers/tie feeders/main bus bars of other switchgear shall be based on the continuous current rating of the all the connected loads with 10% margin at design ambient condition, rounded off to next higher standard rating unless specified otherwise.
- 4.2.5 For switchgear having two bus sections, each bus section, bus coupler and incomer shall be rated for the combined load requirements of both the bus sections.
- 4.2.6 Similar equipment and components shall be of same make. Equipment / Module of same type and rating shall be interchangeable.
- 4.2.7 The design of the LV Switchgear shall include all devices required for remote control & monitoring from DCS. It shall be monitored from the EMS system also.
- 4.2.8 The power control centres and motor control centres shall be intelligent type.



4.3.0 Protection

- 4.3.1 The Contractor shall be responsible for selection of protective devices so as to provide optimum protection and discrimination of various circuits and equipment including the safety of the devices. For motor feeders, coordination of overload relay and MPCB/MCCB with the thermal characteristics of the motor shall be ensured.
- 4.3.2 MCCB / MPCB, contactor and Electronic overload relay for motor feeders shall meet type-2 coordination as per applicable standard.
- 4.3.3 The incomer modules shall be interlocked with their upstream breaker such that they can be closed only when upstream breaker is closed and trip automatically when upstream breaker is tripped.
- 4.3.4 Each breaker module shall be provided with multifunction numerical relay for protection. Relays shall have built in protection, control & metering and communication modules suitable for IEC-61850 protocol.

4.4.0 Control

- 4.4.1 Incomers and bus coupler of PCCs shall have air circuit breaker (ACB). PCC refers to LV switchgear connected to load center transformer which consists of outgoing power feeders and outgoing motors feeders.
- 4.4.2 Outgoing feeders of PCC shall be controlled by ACB / moulded case circuit breakers (MCCBs) depending on their ratings / applications.
- 4.4.3 Incomers and bus couplers of MCCs shall be breaker controlled. Outgoing feeders of MCCs shall be controlled by MCCBs / Motor protection circuit breakers (MPCBs) and contactors depending on their ratings / applications.
- 4.4.4 Feeders rated above 630 A shall be controlled by ACBs, unless specified otherwise. Feeders rated up to 630 A may be controlled by MCCBs. However ACB shall be used for 400 A and 630 A feeders where auto changeover is envisaged at incomer / bus coupler.
- 4.4.5 ACBs shall be used for motor feeders rated above 125 kW for direct-on-line (DOL) starting.
- 4.4.6 MCCB/MPCB Contactor starter units shall be used for motor feeders rated up to 125 kW for DOL starting.
- 4.4.7 Feeders of 415 V PCC/MCC shall be controlled from DCS or Respective control system and Local Push Button (LPB) Station as per scheme requirement.
- 4.4.8 Remote selection shall enable control from DCS/Respective control system.
- 4.4.9 The control/interlock schemes for various types of feeders shall be commensurate with their applications.
- 4.4.10 Local start push button shall be hardwired to DCS/Respective control system so as to check the process permissive for starting the drives, whereas local stop push button shall be directly hard wired to concerned switch gear for tripping.

4.5.0 Changeover Scheme

- 4.5.1 All PCCs and ACB operated MCCs shall be normally operated with the bus coupler breaker open. Auto-changeover facility shall be provided such that if there is a prolonged under voltage on any one of the bus sections, the respective incoming breaker shall trip and the bus coupler breaker shall close, provided on the other bus section is healthy. This auto-changeover shall be



blocked if the incoming breaker had tripped either on a bus fault or manually. Changeover back to the normal source of supply shall be done manually.

- 4.5.2 Planned changeover facility shall be provided for PCC and ACB operated MCC. When planned outage of one of the normal incoming supplies is required, the respective incomers shall be tripped automatically after the bus coupler breaker is closed manually through synchro-check relay. For this purpose, a trip selection shall be provided in DCS/Respective control system for selecting the incomer to be tripped. Thus, depending on the selection made incomer A or incomer B shall be tripped once bus coupler breaker is closed manually, thus maintaining continuity of supply. A timer for annunciation of the running breaker failing to trip within a pre-set time, (i.e. if the two sources remain paralleled for more than a pre-set time) shall be provided. When the normal supply is to be brought back into operation, the incomer breaker shall be closed through synchro-check relay whereupon the bus section breaker shall trip automatically. All hardware required for meeting the functional requirements stated above, shall be included.

4.6.0 Emergency MCC

- 4.6.1 Emergency MCC to supply power to important emergency loads/motors for safe shut-down of unit shall be provided for each unit. It shall have two bus sections (A&B) with a bus coupler. Bus section-A shall have two incomers, one from Unit PCC and the other from emergency PCC. Bus section-B shall have one incomer from station PCC. All the incomer breakers in the emergency MCC shall be 4 Pole. Bus coupler shall be normally closed.
- 4.6.2 In case of failure of unit supply to the Emergency MCC, the station supply shall be switched ON automatically and in case of total failure of AC supply of the power station, the supply from emergency PCC shall be switched ON automatically.
- 4.6.3 DG PCC shall have two incomers, one incomer fed from respective Unit DG set and second incomer fed from standby DG set. In case of failure of unit DG set, the stand-by DG set shall be switched ON.
- 4.6.4 All service like essential motors for safe shutdown of the unit, UPS incomers, battery charger AC supply, lighting, etc. shall be connected to this MCC. DG supply shall be extended to emergency MCC in less than 15 sec from loss of power.
- 4.6.5 On restoration of normal supply, the changeover of DG supply to normal supply at Emergency MCC shall be done with synchronizing facility to avoid interruption of supply.
- 4.6.6 For DG paralleling / load testing, separate breaker shall be provided in main plant AC MCC & Emergency MCC. Load test of DG set can be carried out using connected loads on the AC MCC switchgear.

4.7.0 Essential Service Modules

During auto changeover of the supply, the contactors in the affected bus would have dropped off. The services, which shall be restarted immediately without time lapse to keep unit running, are considered essential service. (For e.g. seal oil pumps, lube oil pumps, auxiliary cooling water pumps etc.) Such auxiliaries shall restart automatically without any action by the operator after an auto change over. These modules shall have additional hardware like timer, aux contactors and associated circuitry in the module or shall have restart feature programmed in DCS. Such essential services shall be identified during the detailed engineering stage and suitable module / scheme shall be provided.

The modules of some of the critical application motors like barring gear motor, air heater motor, lube oil pump, jacking oil pump etc. irrespective of their kW rating shall be provided with a CT, ammeter and a current transducer with remote metering in DCS.



5.0.0 CONSTRUCTIONAL FEATURES

5.1.0 General

- 5.1.1 PCC/MCC/DB shall be metal enclosed, indoor, floor mounted and free standing type. Switchgear frames, load bearing members, doors and covers and gland plates shall be fabricated using CRCA sheet steel. The thickness of sheet shall be not less than 1.6 mm for non-load bearing members and 2.0 mm for load bearing members. Gland plate thickness shall be minimum 3.0 mm.
- 5.1.2 PCC / MCC shall be drawout type and distribution boards can be fixed type with compartmentalized construction.
- 5.1.3 Suitable synthetic rubber gaskets shall be provided to make switchgear completely dust-proof and vermin-proof with a degree of protection of IP 52 for all switchgear. However, degree of protection for bus bar chamber where the bus bar is rated above 1600 A can be IP 42.
- 5.1.4 All switchgear shall be compartmentalized (conforming to Form 4b of IEC 60439-1) with uniform height not exceeding 2450 mm. Module size of switchgear shall not be less than 200 mm.
- 5.1.5 The switchgear shall be arc proof tested. In the event of an internal fault in a functional unit, the damage shall be confined to that unit alone, so that the busbar system and all other functional units remain fit for further service. Switchgear assemblies shall comply with IEC 61641 with regard to internal arc testing.
- 5.1.6 The arrangement of feeders in the switchgear shall take into consideration the number and size of cables required for the feeders. Incomer and bus section ACB shall be limited to one per panel. ACB outgoing feeders shall be limited to two per panel for ratings up to 1000 A. For ratings 1250 A and above, the number of outgoing feeders shall be limited to one per panel.
- 5.1.7 Bus duct entry shall be from top and cable entry shall be from bottom for PCCs/MCCs/DBs. Switchgear shall be divided into distinct vertical sections (panels), each comprising of the following compartments:
- Main bus bar compartment
 - Switchgear/feeder compartment
 - Cable alley of at least 300 mm width
 - Auxiliary bus bar compartment
 - Control compartment for relays for ACB feeder
- 5.1.8 Switchgear shall be of modular design, consisting of modules, segregated into single or multi-tier compartments. Each module shall be placed in individual compartment. All module grouped together shall form the complete switchgear. Completed switchgear shall be of flush-fronted design having a neat appearance and shall be readily extensible.
- Door shall be provided at the front of each compartment to give full access to all the components and the compartment.
- Switchgear covers (including doors without interlock) shall be bolted type and shall be designed to give access to individual circuits without exposing other circuits, which may be live. Alternatively, circuits exposed by the removal of the cover shall be individually shrouded.
- 5.1.9 The switchgear shall be designed to prevent contact with live parts both within the modules and in the cable alley. Following are the minimum segregations to be provided amongst the different parts of the switchgear:

- a) Main horizontal bus bar chamber and vertical bus bar chamber



- b) Between different modules
- c) Between modules and cable chamber
- d) Between auxiliary bus bars and the rest of the switchgear
- e) Between vertical bus bars and modules

All insulating materials used as partitions guards and shrouds shall be non-hygroscopic and flame retardant.

5.1.10 Interlock between compartment door and modules shall be provided such that the door cannot be opened without switching off the power supply to the module. Defeat interlock shall be provided for the module comprising of MCCB/MPCB as a means of isolation, such that it is possible to open the door with device ON and the module in 'SERVICE' position. The following shall apply under these conditions:

- a) It shall not be possible to close the door till the interlock has been reinstated
- b) Attempted withdrawal of the module under such conditions shall be cautioned against by providing warning label affixed at an appropriate place

5.1.11 Switchgear shall be equipped with thermostatically controlled space heaters in each panel (separate for front and rear in case of double front panels having separate cable alleys) so as to maintain interior temperature 5°C above the ambient. They shall have MCB for protection.

5.1.12 All LT switchgear modules shall be provided with lock and Key arrangement with key rack located in respective control room.

5.1.13 At least 20% of feeder modules covering the range of motors/ outgoing feeders used subject to minimum of one module in each bus section shall be provided as spare. Spare modules shall be completely wired up.

5.1.14 20% of control terminals in each module shall be provided as spare subject to a minimum of 2 terminals.

5.2.0 Feeder Modules

5.2.1 Drawout modules shall have the following features:

- a) Withdrawal of module shall be possible without disconnecting wires.
- b) Drawout units of similar type and rating shall be interchangeable.
- c) Secondary connections to the drawout module shall be through self-aligning and self-isolating contacts. In case of circuit breakers, easily disconnecting type plug and socket shall be acceptable in place of self-aligning and self-isolating type contacts.
- d) With the drawout module fully removed from its housing, live parts exposed shall either be finger proof or shall have means to shroud them totally to prevent contact. Suitable add-on type shrouds shall be provided where automatic shutters or in-built shrouds are not provided.

5.2.2 All single front switchgear shall be provided with single leaf, hinged or bolted covers at the rear. The bolts shall be of captive type. The covers shall be provided with 'DANGER' labels.

5.2.3 Drawout modules shall have distinct 'SERVICE' and 'TEST' positions. The equipment pertaining to a drawout type module shall be mounted on a fully withdrawable chassis, which can be drawn out without having to unscrew any wire or cable connection. Suitable arrangement with cradle/rollers and guides shall be provided for smooth movement of the chassis.

5.2.4 Each switchgear shall be provided with removable type gland plate, which shall cover the entire cable alley. For all single core cables, gland plate shall be of non-magnetic material.



5.2.5 The arrangement of the feeders shall ensure that operating handle of the switch/breaker shall be above 350 mm but below 1800 mm from finished floor level.

5.3.0 Bus Bars and Insulators

5.3.1 Each PCC/MCC/DB shall be provided with three phase bus bars and one neutral bus bar. DC distribution boards shall have two bus bars.

5.3.2 Bus bars (including neutral bus bar) shall be capable of carrying the short time current for the duration as specified, without any damage. Current carrying capacity of neutral bus bar shall be minimum half that of the phase bus bar.

5.3.3 For double front type of board, separate vertical bus bars for each front shall be used.

5.3.4 All bus bars shall be made of high conductivity copper/aluminium alloy. They shall be supported on insulators of material such as fiber reinforced polyester or epoxy cast resin.

5.3.5 Minimum air clearance for horizontal and vertical bus bar termination shall be 25 mm between phases and 20 mm between phase and earth. For all other components the clearance shall be 10 mm minimum.

5.3.6 All bus bars shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength insulators. All bus bar joints shall be provided with high tensile steel bolts, Bellevue/spring washers and nuts. All bus bars and bus taps shall have HRPVC sleeves, colour coded as follows:

- Red, yellow & blue for R, Y & B phases respectively
- Black for neutral
- Grey & white for positive and negative respectively

5.3.7 All horizontal and vertical bus bars and joints shall be covered by insulating shrouds.

5.3.8 Contact surfaces at all joints shall be silver plated or properly cleaned and anti-oxide grease applied to ensure an efficient and trouble free connection. In case of dissimilar metal connections (copper to aluminium), proper treatment shall be given to minimize bimetallic effect. All such joints shall be silver/tin plated or suitable bimetallic washers shall be provided.

5.3.9 Auxiliary bus bars each of minimum 25 sq.mm thick electrolytic tough pitch copper shall be provided for the following applications.

- 240 V AC supply for panel space heater/motor space heater/panel illumination
- 220 V DC control supply for breaker tripping and closing, spring charging motors, indication circuits
- 110 V AC control supply for contactor operated motor starter control circuits as applicable

5.4.0 Control Supply and Space Heater Supply

5.4.1 PCC and ACB operated MCC shall have redundant 220 V DC control supply and shall have diode auctioneering. Each panel shall receive control supply through bus wires tapped off from auxiliary copper bus bar through MCBs provided in the respective panel. It shall be possible to isolate any panel without disturbing the power supply to other panels. Each sub-circuit shall have separate MCB.

5.4.2 An under voltage relay to monitor control supply shall be provided. A contact of the relay shall be wired to the terminal for external use. Control Supply Failed' indication shall be provided.

5.4.3 PCC/MCC shall derive 110 V AC control supply through 2X100% rated 415 /110 V transformer and shall be provided with changeover arrangement. Changeover shall be blocked for control



bus bar fault. The control transformers shall be of insulation class 'B' or better. The sizing of control transformers shall be carried out considering the load of power contactors, auxiliary contactors, indicating lamps and other equipment including remote auxiliary relays and lamps in the circuit with 20% design margin. One pole of secondary winding shall be earthed.

- 5.4.4 For PCC and MCC 240 V AC Space heater supply shall be derived from 415/230 V control supply transformer located one in each bus section. Necessary MCB to isolate and distribute the supply shall be provided. For DB, 240 V AC space heater supply can be derived from incoming supply itself.
- 5.4.5 All motors rated 30 kW and above shall be provided with power supply for space heater. Circuit for motor space heater shall be wired through auxiliary NC contact of breaker/contactors and MCB.
- 5.4.6 Each panel of PCC/MCC/DB shall be equipped with the following as required:
- Thermostatically controlled space heater(s).
 - Illumination lamp with door switch
 - 5 Amp 3 pin socket with MCB protection.

5.5.0 Air Circuit Breakers

- 5.5.1 Air circuit breakers shall be stored energy, trip free, air break and horizontal drawout type and shall have fault making and breaking capacities as specified. There shall be 'SERVICE', 'TEST' and 'ISOLATED' positions for the breakers. In 'TEST' position the circuit breaker shall be capable of being tested for operation without energizing the power circuits i.e. the power contacts shall be disconnected, while the control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the 'SERVICE', 'TEST' or 'ISOLATED' position. It shall be possible to close the door in 'TEST' position.
- 5.5.2 Breakers of different ratings shall not be interchangeable. Front fascia cut-outs for all ratings of breakers shall be identical.
- 5.5.3 The spring charging mechanism of the circuit breaker shall be motor operated. The close/trip control switch shall be interlocked to trip before close. The closing and tripping circuits shall be self-opening on completion of their respective functions irrespective of the position of the control switch. Manual closing devices shall also be provided. The circuit breaker shall be electrically and mechanically trip free. For all circuit breakers electrical anti-pumping device shall be provided.
- 5.5.4 The fixed portion of the circuit breaker shall have rail arrangement over which the chassis can move smoothly. Proper mechanical indication shall be provided for the three positions ('SERVICE', 'TEST' and 'ISOLATED') without opening the compartment door. It shall be possible to bring the circuit breaker to isolated position with the help of external lever without opening the compartment door. The circuit breaker can be padlocked in OFF position with door interlock defeat facility.
- 5.5.5 The following interlocks shall be provided on the circuit breaker:
- It shall not be possible to withdraw the circuit breaker from the service position with the contacts of the breaker closed
 - It shall not be possible to close the circuit breaker unless any one of the three positions is located
 - It shall not be possible to open the compartment door when the circuit breaker is ON



5.5.6 It shall not be possible to close the breaker under following conditions:

- Stored energy mechanism is not charged
- Shunt release is energized
- OFF push button is locked in OFF position

5.5.7 The circuit breaker shall be provided with mechanical ON/OFF, 'TRIP', 'SPRING CHARGED/DISCHARGED', 'READY TO CLOSE' and breaker position indications and mechanical trip push button. An operating handle shall also be provided to charge the spring manually.

5.5.8 The circuit breaker shall be provided with automatic safety shutters, so that before the breaker reaches 'ISOLATED' position the main isolating contacts are completely shrouded. In the drawout condition, it shall be possible to inspect the breaker fixed contacts condition by lifting the shutters.

5.5.9 When the circuit breaker compartment door is open, it shall not be possible to touch the live parts. All removable covers protecting live parts shall be clearly labeled with warning notices reading 'LIVE PARTS. ISOLATE ELSEWHERE BEFORE REMOVING COVER'. It shall be possible to readily remove the arc chutes for routine inspection of the contacts with the circuit breaker in the withdrawn position. Contact erosion indicator shall be provided on moving contacts of breaker for visual indication of contact life.

5.5.10 Each breaker feeder shall be provided with the following:

- An anti-pumping relay
- Motor charged spring operating mechanism
- Manual spring charging and manual closing mechanism
- Mechanical indication of spring charge
- Mechanical position indicator (to show whether the breaker is in the 'ON' or 'OFF' positions and in the 'SERVICE', 'TEST' or 'ISOLATED' positions)
- Closing coil
- Shunt trip coil
- CTs for protection
- Manual trip push button
- Phase barriers
- Shutter assembly
- Door interlock kit
- Operation counter
- Intelligent control unit

5.5.11 The closing coil and spring charging motor shall operate satisfactorily for all values of control supply voltage between 80% and 110% of the rated voltage. But, the shunt trip coil shall be designed such that it shall operate satisfactorily for all values of control supply voltage between 70% and 110% of the rated voltage. One open-close-open operation of the circuit breaker shall be possible after failure of power supply to motor.

5.5.12 Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit-breaker module in a cubicle. The trolley shall be such that the topmost breaker module can be withdrawn on the trolley and can be lowered for maintenance purpose. Also, it shall be such that all types, sizes and ratings of breakers can be withdrawn / inserted in the switchgear.

5.6.0 Contactor Starter Unit

5.6.1 All motors rated up to 125 kW shall be controlled by direct-on-line contactor starters. MPCB shall be used for motor feeders rated up to 15 kW. For feeders rated above 15 kW and up to 125 kW, MCCB shall be used. The starting circuit shall consist of the following:



- Isolating device (MCCB/MPCB)
- Contactor as main means of starting and stopping of motor
- A short circuit protective device (Inbuilt feature of MPCB/MCCB)
- Electronic overload protection relay with current display unit & built-in single phasing prevention feature
- CT operated numerical relay for motor feeders rated 75 kW and above
- Intelligent control unit

5.6.2 Withdrawable contactor starter units shall be provided with means for mechanically indicating the 'SERVICE' and other positions.

5.7.0 Moulded case Circuit Breakers (MCCB) / Motor Protection Circuit Breakers (MPCB)

5.7.1 MCCBs shall be of three / four pole construction for panel mounting. The MCCBs shall be provided with front operating handles and mechanical ON / OFF indicators.

5.7.2 MCCB shall be provided with spring assisted quick-make, quick-break, current limiting type manually operated trip free mechanism, mechanical ON/OFF/TRIP position indicators, thermal tripping devices of inverse characteristics, instantaneous short circuit tripping devices and necessary auxiliary and alarm contacts. The MCCB module shall be provided with service, test and isolated position. The thermal and short circuit tripping device shall be adjustable type.

5.7.3 The MPCB's shall be in general similar to that of MCCB's in all the features mentioned above.

5.7.4 MCCBs/MPCBs shall be provided with overload thermal release setting range of 50% to 100% of rated current and adjustable short circuit magnetic release of 5 to 10 times rated current.

5.7.5 MCCBs/MPCBs shall be capable of withstanding the thermal stresses caused by overloads and locked rotor currents of values associated with protective relay settings of the motor starting equipment and the mechanical stress caused by the peak short circuit current of value associated with the switchgear rating. The maximum tripping time under short circuit shall not exceed 20 m. Second. When used for motor circuit, shunt trip devices shall be provided and the let through power of controlling MCCB/MPCB shall be lower than the respective contactor, Contactor and overload relays shall be selected so as to withstand the let-through energy of the connected MCCB/MPCB in the feeder and consequent thermal and dynamic effects. All power feeder module MCCBs shall be equipped with earth fault release.

5.7.6 The DC circuits shall be provided with DC rated MCCB / MCBs.

5.7.7 MCCBs/MPCBs shall have following accessories and features:

- a) Shunt trip release
- b) Under voltage release
- c) Auxiliary contact for ON/OFF/ trip position
- d) Fault signaling contact
- e) Insulation shields to isolate the connection between each pole
- f) Finger protection plate to prevent accidental contact
- g) The compartment door shall be interlocked with handle of MCCB/MPCB.

5.8.0 Control and Selector Switches

5.8.1 All circuit breaker operating switches shall be of the pistol grip type, spring return to neutral and lockable in that position. The trip, neutral and close positions shall be clearly indicated.

5.8.2 Ammeter and voltmeter selector switches shall have four stay put positions with adequate number of contacts for 3 phase 4 wire system. These shall have oval handles. Ammeter



selector switches shall have make before break type contacts to prevent open circuiting of CT secondary

5.8.3 Local/Remote selector switch shall be provided as per control requirement.

5.9.0 Contactors

5.9.1 Contactors shall be of air break, electromagnetic type rated for uninterrupted duty. Contactors shall be double-break, non-gravity type and their main contacts shall be silver faced copper. Direct-on-line contactors shall be of utilization category AC3. Full voltage reversing starters shall comprise of forward and reverse contactors mechanically and electrically interlocked with each other. These contactors shall be of utilization category AC4. DC contactor shall be of utilization category DC3. The contactor rating shall be chosen to provide type-2 discrimination. However, the minimum rating shall be 16 A.

5.9.2 Electronic over load relay shall have selectable setting, self-powered, ambient temperature compensated, sensitive to phase loss/unbalance, trip free mechanism, with trip indication, test and stop function, current display etc. Type-2 coordination shall be ensured between MCCB/MPCB, contactor and overload relay.

5.10.0 Miniature Circuit Breaker (MCB)

MCB shall be rated for atleast 10 kA short circuit rating. It shall be quick make, quick break, and independent manual type with trip free feature. MCB shall have overcurrent protection, ON/OFF position indicators and auxiliary contact block for ON/OFF/Trip positions.

5.11.0 Instrument Transformers

All current and voltage transformers shall be completely encapsulated, cast resin insulated type suitable for continuous operation at the temperature prevailing inside the switchgear enclosure, when the switchgear is operating at its rated condition and the specified ambient temperature. The class of insulation shall be 'B' or better.

Current Transformers shall be cast-resin type with 1 A secondary. Separate cores shall be used for metering and protection. Accuracy class of the current transformers shall be class 5P20 for relaying and Class 0.5 and ISF<5 for metering.

Voltage transformers shall be cast-resin drawout type and shall have an accuracy class of 0.5/3P for metering & protection. Voltage transformer mounted on breaker carriage is not acceptable. It shall have a continuous voltage factor of 1.2 with short time over voltage factor of 1.5 for 30 seconds. The VT shall be provided with MCCB on the primary side and MCBs on secondary side.

5.12.0 Relays and Timers

5.12.1 Relays and timers in protective circuits shall be flush mounted on panel front with connections from the inside. They shall have transparent and dust tight covers removable from the front. They shall either have built-in test facilities, or shall be provided with necessary test blocks and test switches located immediately below each relay.

5.12.2 Relays shall have lock-out facility with manual reset. Each circuit breaker feeder shall be provided with separate latched lockout relay (86), trip circuit supervision relay, necessary auxiliary relays, timers, etc. to meet circuit requirements. In addition self-reset type lockout relay to be provided on Bus PT Panel for Under voltage tripping the motor feeders.

5.12.3 Lock out relay contacts shall only be provided for protection trip & reset status for use in close and trip interlocks of the circuit breaker.



- 5.12.4 Auxiliary supply voltage for relays and transducers shall be 220 V DC. Relays shall be capable of satisfactory continuous operation between 80-120% of the rated voltage.
- 5.12.5 Failure of a control or auxiliary supply and de-energisation of a relay shall not initiate any circuit breaker operation. All relays shall withstand a minimum test voltage of 2 KV AC Rms for one minute.
- 5.12.6 The relays shall have provision of both current and voltage inputs. The current operated relay shall have provision for 5 sets of CT inputs, 3 nos. for phase fault and 1 CT input for earth fault & 1 CT input for CBCT. Relay shall be suitable for both residually connected CT input as well as CBCT input. Relays shall be suitable for CT secondary current of 1 A / 5 A selectable at site. The voltage-operated relay shall have provision for 3 PT inputs. Relays shall be rated for operation on 110 V, VT secondary voltage. Relays used in Incomers and bus couplers shall have provision of two sets of voltage signal inputs for the purpose of synchronization.
- 5.12.7 All CT and PT terminals shall be provided as fixed type terminals on the relay to avoid any hazard due to loose connection leading to CT opening or any other loose connection. In no circumstances Plug In type connectors shall be used for CT/ PT connections.
- 5.12.8 All numerical relays shall have key pad / keys to allow relay settings from relay front. All hand reset relays shall have reset button on the relay front. Relay to be self or hand reset shall be software selectable. Manual resetting shall be possible from remote. Relays shall have suitable output contact for breaker failure protection.
- 5.12.9 Relays shall have self-diagnostic feature with self-check for power failure, programmable routines, memory and main CPU failures.
- 5.12.10 The numerical relay shall be able to provide supervisory functions such as, circuit breaker state monitoring, PT and CT supervisions and recording facilities with Post fault analysis
- 5.12.11 The numerical processor shall be capable of measuring and storing values of a wide range of quantities, all events, faults and disturbance recordings with a time stamping using the internal real time clock. Battery backup for real time clock in the event of power supply failure shall be provided.
- 5.12.12 Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping.
- 5.12.13 Numerical relays shall be capable of storing Minimum of 150 time tagged events/ records with time stamping. The numerical relays shall be able to store last 5 faults including the indication, waveforms, protection operated, fault location relay and operating time, currents, voltage and time. All Setting parameters, Fault data, waveforms & event logs shall be stored in Non-volatile memory only.
- 5.12.14 Sequence of events shall have 1 ms resolution at device level.
- 5.12.15 Measurement accuracy shall be 1 % for RMS Current and voltage.
- 5.12.16 Relay shall be immune to capacitance effect due to long length of connected control cables. Any external hardware, if required for avoiding mal operation of the relay due to cable capacitance shall be included as a standard feature. All IOs shall have optical isolation. Analog inputs shall be protected against switching surges, harmonics etc.
- 5.12.17 The alarm/status of each individual protection function and trip operation shall be communicated to DCS/Respective control system. The numerical relay system shall have built-in features/hardware interface to provide such inputs to Respective control system for analog/digital values.



- 5.12.18 Relays shall have at least two sets or groups of two different sets of adaptable settings. Relays shall have multiple IEC/ ANSI programmable characteristics.
- 5.12.19 Numerical relays shall have two level pass word protections, one for read only and other for authorization for modifying the setting etc.
- 5.12.20 Timer functions shall be programmable for on/off delays.
- 5.12.21 The protective relays shall have at least 10 nos. potential free contacts (Programmable) Auxiliary relays shall have contacts as required. Relay output contacts shall be suitable for directly wiring in the breaker closing and trip circuit operating from 220 V DC control voltage.
- 5.12.22 Making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used. Interrogation voltage for the binary inputs shall be suitably selected to ensure avoidance of mal operation due to stray voltages.
- 5.12.23 No separate earth bus shall be required for the relays. It shall be possible to connect the relay earth to the common earth bus in the switchgear panel which shall be connected to the plant earth mat.
- 5.12.24 All protective relays shall be latest numerical type, having following features/functions:
- Protection functions as required
 - IEC IDMT characteristics
 - Measurements
 - Event/fault/disturbance recording
 - Binary input/output relays as required
 - LEDs to indicate status of the relay
 - LCD display for measurements, settings, faults etc.
 - Key pad on the front of the relay
 - Communication ports for transmitting settings, measurements, alarms, faults, events, disturbance records to DCS/Respective control system/SAS (Substation Automation System)
 - Communication port for software setting/access measurements/maintenance/fault analysis
 - Self-monitoring
- 5.12.25 All protective relays shall be latest numerical type with one USB port at the front for connecting to Laptop and one port (RJ45/FO port) at rear suitable for communication on IEC 61850 protocols.
- 5.12.26 The Numerical relays shall be networked through Ethernet switch, Gateway/Data Concentrators and shall be further integrated with SCADA based electrical monitoring system (for monitoring, measuring, fault data analysis & relay parameterization).
- 5.12.27 All necessary hardware including Managed Ethernet switches, accessories and licensed software shall be supplied by the vendor.
- 5.12.28 Ethernet switches shall be 'substation hardened' and shall comply with IEC61850-3 for communications and environment requirements. The Ethernet switches shall be of managed type with two (2) no. of fibre optic cable ports for ring network and Fourteen/Sixteen of Copper ports to achieve the LAN configuration. These switches shall be mounted inside the switchgear Panel.
- 5.12.29 The switchgear shall be provided with DC fail relay and DC fail indication lamp.
- 5.12.30 Breaker auxiliary contacts used for interlocking purposes shall be multiplied using electrically latched relay.



5.12.31 Protection relays shall include, protection functions but not limited to the following:

- a) Incomer feeder from transformers:
 - IDMT & DMT overcurrent protection (50/51)
 - IDMT & DMT Earth fault protection (50N/51N)
 - Under voltage relay (27)
- b) Normal Incomer feeder (Direct from Upstream switchgear):
 - IDMT & DMT overcurrent protection (50/51)
 - IDMT & DMT Earth fault protection (50N/51N)
 - Under voltage relay (27)
- c) Bus Coupler feeder:
 - IDMT & DMT overcurrent protection (50/51)
 - IDMT & DMT Earth fault protection (50N/51N)
 - Check Synchronizing relay (25C)
- d) Outgoing ACB operated Motor feeder:
 - IDMT & DMT overcurrent protection (50/51)
 - IDMT & DMT Earth fault protection (50N/51N)
 - Over load (49)
 - Negative sequence (46)
 - Phase Reversal (46 R)
 - Restart inhibit with startup counter (37)
 - Locked rotor (48-LR)
 - Under current (66)
- e) Other Outgoing feeder:
 - IDMT & DMT overcurrent protection (50/51)
 - IDMT & DMT Earth fault protection (50N/51N)
- f) Bus PT:
 - 3 phase Under voltage relay

5.13.0 Indicating Instruments

5.13.1 All indicating instruments and meters shall be capable of carrying continuously their full load currents and full voltage across their coils. They shall not be damaged by the passage of fault currents or the existence of over voltage on the primary side of their instrument transformers for the maximum permitted duration of fault conditions which may occur during normal operation. All instruments and meters shall be back connected.

5.13.2 Meters and transducers for 415 Volts PCCs

For incomers feeders following Meters and transducers shall be provided:

- Current transducer on 'Y' phase
- Voltage transducer on 'Y-B' phase
- 1.0S class energy accounting and audit meter
- 1.0 class digital multi-function meter

For Bus Coupler following Meters and transducers shall be provided:

- Current transducer on 'Y' phase
- 1.0 class digital multi-function meter



For ACB outgoing feeders following Meters and transducers shall be provided:

- Current transducer on 'Y' phase
- 1.0 class digital multi-function meter

For ACB motor feeders following Meters and transducers shall be provided:

- Current transducer on 'Y' phase
- 1.0 class Analog meter on 'Y' phase

For contactor motor feeders 15 kW & above following Meters and transducers shall be provided:

- Current transducer on 'Y' phase
- 1.0 class Analog meter on 'Y' phase
- Electronic overload relay with current display in switchgear.

For contactor motor feeders less than 15 kW following Meters and transducers shall be provided:

- Electronic overload relay with current display in switchgear.

For Bus PT following Meters and transducers shall be provided:

- Digital Voltmeter measuring all three phases
- Voltage transducer on three phases
- Power factor transducer

5.13.3 Meters and Transducers for 415 Volts MCCs

For incomers feeders following Meters and transducers shall be provided:

- Current transducer on 'Y' phase
- Voltage transducer on 'Y-B' phase
- 1.0 class digital multi-function Meter.

For Bus Coupler following Meters and transducers shall be provided:

- Current transducer on 'Y' phase
- 1.0 class digital multi-function Meter.

For Bus PT following Meters and transducers shall be provided:

- Digital Voltmeter measuring all three phases
- Voltage transducer on three phases

For contactor motor feeders 15 kW & above following Meters and transducers shall be provided:

- Current transducer on 'Y' phase
- 1.0 class Analog meter on 'Y' phase
- Electronic overload relay with current display in switchgear.

For contactor motor feeders less than 15 kW following Meters and transducers shall be provided:

- Electronic overload relay with current display in switchgear.

5.13.4 Meters and Transducers for 415 Volts DBs

For incomers feeders following Meters shall be provided:

- Digital voltmeter measuring all three phases
- Digital ammeter measuring all three phases

For Bus PT following Meters shall be provided:

- Digital Voltmeter measuring all three phases

5.13.5 Energy accounting and audit meters shall meet CEA regulation. It shall be integrated with integrated energy management system. The energy audit meters shall be suitable for measurement, recording and display of cumulative active energy with date and time. It shall



have data storage capacity for at least 35 days in a non-volatile memory. It shall have facility to download the parameters through meter reading instruments as well as remote transmission of data over communication network. It shall also have the facility to measure, record and display the following parameters. All parameters excluding instantaneous electrical parameters shall also be stored in memory.

- (a) Apparent power
- (b) Phase wise kilowatt at peak KVA
- (c) Phase wise KVA(reactive) at peak KVA
- (d) Phase wise voltage at peak KVA
- (e) Power down time
- (f) Average power factor
- (g) Line currents
- (h) Phase voltages
- (i) Date and time
- (j) Tamper events

5.13.6 Digital Multifunction Meters shall be provided with bright LED/LCD display for local indication and shall be provided with communication port suitable for communicating on MODBUS protocol to EMS/DCS. It shall display various parameters like 3 phase currents, voltages, PF, MD, KW, KVA, etc. for local indication and shall be provided with minimum 8 nos. of user programmable registers for communicating any of the displayed parameters to the remote.

5.13.7 For motor feeder, analog ammeter with accuracy class 1.0, of 96x96 sq.mm square with 240° scale. Shall be provided. It shall have cramped scale above 2 times to 8 times the rated current for indicating the starting current.

5.13.8 Transducers shall be of dual output type, class 0.5, 4-20 mA DC linear output & 750 ohm load.

5.13.9 Transducers shall be provided in all the buses so that algebraic summation in electrical system shall be Zero.

5.14.0 Push Buttons

5.14.1 Push buttons shall be of heavy duty, spring return and push-to-actuate type. Their contacts shall be rated to make, continuously carry and break 10 A at 240 V AC and 1 A (inductive) at 220 V DC.

5.14.2 All push buttons shall have two nos. NO and two nos. NC contacts, unless specified otherwise. The contact faces shall be of silver alloy. All push buttons shall be provided with integral escutcheon plates marked with their functions.

5.14.3 The colour of the button shall be as follows:

- Green for motor START and breaker CLOSE
- Red for motor STOP and breaker OPEN
- Black for valve/damper OPEN/CLOSE commands
- Black for all annunciation functions, overloads, reset and miscellaneous commands

5.14.4 All push buttons on panels shall be located in such a way that red push buttons shall always be to the left of green push buttons. All emergency push buttons shall have mushroom knobs.



5.15.0 Indicating Lamps

5.15.1 Indicating lamps shall be of the panel mounting clustered LED type. The lamps shall have escutcheon plates marked with their functions, wherever necessary. Bulbs and lamp covers shall be easily replaceable from the front of the cubicles. Low Voltage Glow Prevention (LVGP) feature shall be provided for indicating lamps. Lamps shall have translucent lamp covers of the following colour, as warranted by the application :

- Red for motor ON, valve/damper OPEN and breaker CLOSE
- Green for motor OFF, valve/damper CLOSE and breaker OPEN
- Amber for TRIP
- Blue for 'SERVICE' position indications
- White for all healthy conditions (e.g. control supply, lockout relay healthy, spring charged condition etc.)
- White for 'TEST' position indications
- Red, yellow, blue for R, Y and B phases respectively

5.15.2 Indicating lamps shall be located just above the associated push button/control switch. Red lamps shall invariably be located to the right of green lamps. When associated with push buttons, red lamps shall be directly above the green push button and green lamp shall be directly above the red push button.

5.15.3 All indicating lamps shall be suitable for continuous operation at 85% to 110% of their rated voltage.

5.15.4 For incomer and bus, indicating lamps for R, Y and B phases shall be provided.

5.16.0 Wiring

5.16.1 Wiring shall be by 1100 volt grade multi-stranded PVC insulated copper wire having a cross-sectional area of not less than 1.5 sq.mm. All connections from CT leads up to instruments, relays and terminal board shall be made by copper wires of minimum 2.5 sq.mm size. The cables shall be tested for flammability test as per applicable standards and shall also withstand service temperature without deterioration.

All wiring shall use the colour codes specified below:

• 3 phase AC connections	Red, yellow & blue for R, Y & B phases respectively
• 1 phase AC connections	Red and black for phase and neutral respectively
• DC connections	Grey & white for positive and negative respectively
• Earth connection	Yellow-Green

5.16.2 Wiring shall be run mostly clear of all metal parts in insulated cleats, properly routed and neatly bunched. However, PVC wire holders and channels shall be preferred for running of wiring. Where wiring passes from one compartment to another, the aperture shall be 'bushed' to prevent damage of wires against sheet metal edges. Bushes may comprise of good quality rubber grommets.

5.16.3 Where single phase conductors are associated with the 3 phase system from which they are derived, the phase conductor shall use the same colour as the phase from which it is derived.

5.16.4 Inter-module bus wires shall be kept separate from all other wiring. AC or DC terminations shall be grouped function-wise as far as possible and labels of the function shall be affixed.

5.16.5 Terminal boards shall have separate terminals for incoming and outgoing wires with not more than two wires connected to any one terminal. Terminal boards shall be mounted vertically at the side of the cubicle or in horizontal rows and properly spaced to have clean wiring



arrangement, adequate access for putting ferrules, making terminations etc. It shall be possible to read the ferrule numbers when the wiring is complete. Where terminals may be live when the equipment is isolated from the main supply, these shall be clearly marked on the panel.

- 5.16.6 Extra flexible wires shall be used for wiring to devices mounted on moving parts such as hinged doors. The wire bunches from the panel inside to the doors shall be properly sleeved or taped. All internal wiring terminations shall be made with solder less crimping type heavy duty tinned copper lugs. Insulation sleeves shall be provided over the exposed parts of lugs.
- 5.16.7 Engraved core identification plastic ferrules marked to correspond with panel wiring diagrams shall be fitted at both ends of each wire.
- 5.16.8 Control terminal blocks shall be of 650 V grade, rated for 10 A and in one piece molding. It shall be complete with insulating barriers, clip-on type terminals and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. Terminal blocks for CT and VT secondary leads shall be provided with test links and isolating facilities. CT secondary leads shall be provided with short circuiting and earthing facilities.
- 5.16.9 In all the panels, at least 20% spare terminals for external connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks.
- 5.16.10 All interlocks shall be hardwired in the switchgear itself.
- 5.16.11 The wiring shall be complete in all aspects so as to ensure proper functioning of control, protection and interlocking scheme. All the wiring shall be complete up to terminal blocks on the side of each unit/module.
- 5.16.12 Adjacent rows of terminal blocks shall be spaced not less than 100 mm apart.
- 5.16.13 The terminal blocks shall be mounted inside the module (and not in cable way) in a manner so as to provide easy access to terminals and to enable ferrule numbers to be read without difficulty.
- 5.16.14 All inter-panel wiring shall be carried out within the switchgear before dispatching the panel.
- 5.16.15 A typed circuit directory, card holder and card with clear plastic covering shall be provided on the inside of each cabinet door. The directory card shall provide space to identify each circuit in the panel board. An electronic copy of the circuit directory shall be provided to the Owner.

5.17.0 Cable/Busduct Termination

- a) PMCC/MCC/DB shall be designed for cable entry from the bottom. Sufficient space shall be provided for ease of termination and connection. Add-on panels shall be considered for cables, if any.
- b) Cable termination compartment and arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded aluminium conductor, XLPE insulated, armoured and FRLS PVC sheathed cables.
- c) Sufficient space and support arrangement shall be provided in the cubicles to accommodate cables.
- d) Cables shall be PVC insulated, armoured, extruded FRLS PVC overall sheathed with 2.5 sq.mm for control & current circuits and 1.5 sq.mm for voltage circuits and PVC insulated, armoured, extruded FRLS PVC overall sheathed with stranded copper / aluminium conductor for power circuits.
- e) All provisions and accessories shall be furnished for termination and connection of cables, including removable gland plates, cable supports, crimp type tinned copper lugs, brass compression glands with tapped washer and terminals blocks.



- f) The gland plates and supporting arrangement for 1/C power cable shall be such as to minimize flow of eddy current.
- g) For all DG sets & service transformers rated 1000 KVA and above shall be connected through bus ducts to the respective switchgear panel. Busduct entry shall be from the top.

5.18.0 Name plates and labels

5.18.1 Nameplates shall be of 3 ply laminate with black lettering on white background. The following shall be provided with nameplates/warning labels as described below:

- Main name plate for PCC/MCC/DB on front and back sides
- All incomers and outgoing feeders indicating description, rating, equipment no., feeder no., etc.
- All door mounted components
- Panel numbers on front and rear
- Warning labels for interlocks

All name plates shall be fastened by means of screws to the panel.

Danger labels shall be provided for the following:

- MCC as per statutory regulations
- Bus bar chamber
- Cable alley housing live terminals

5.18.2 Name plate or polyester adhesive stickers shall be provided inside the panel for all equipment (lamps, push buttons, switches, relays, auxiliary contactors etc.) mounted on the switchgear.

5.18.3 Special warning plates, one each on each front of a shipping section, shall be provided on removable covers of doors giving access to cable terminals and bus bars. Special warning labels shall be provided inside the switchgear also, wherever considered necessary. Identification tags shall be provided inside the panels matching with those shown on the circuit diagram.

5.18.4 All major components such as breakers, switches, contactors, CTs etc. shall be provided with labels indicating their ratings.

5.18.5 For single front switchgears, similar panel and board identification labels shall be provided at the rear also.

5.19.0 Earthing

5.19.1 Two earth terminals shall be provided on each switch cubicle, at the rear side. An earth bar of at least 50 x 10 mm aluminium shall be fixed to these terminals. The earth bar shall be electrically continuous and shall run the full extent of each board. This earth bar shall be on the same side as the cable entry and shall be extended on both sides of the panel.

5.19.2 Each unit shall be constructed to ensure satisfactory electrical continuity between all metal parts not intended to be alive and earth terminals of the unit. Suitable holes with bolts and nuts shall be provided at each end of earth bar of switchgear for connection to a main earthing grid.

5.19.3 The earth bar shall be accessible in each cable entering compartment either directly or through a branch extension to earth the cable armour and shields. 10 mm diameter holes shall be drilled and hardware for connection provided through the earth bus.

5.19.4 The cores of transformer (bus voltage transformer, control transformer, heating transformer etc.) shall also be earthed through copper wire. Doors shall have a copper wire for earth



connection to fixed unit. VT and CT secondary neutral point earthing shall be at one place only on the terminal block.

- 5.19.5 All non-current carrying metal work of the switchgear/panel shall be effectively bonded to the earth bus. All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth bus by independent stranded copper wires of size not less than 2.5 sq.mm. Insulation colour code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors and soldering shall not be acceptable. All hinged doors shall be earthed through flexible earthing braid.

5.20.0 Wall Mounted Distribution Boards

- 5.20.1 Wall mounted distribution boards shall be metal enclosed, suitable for outdoor mounting on wall or steel structures with suitable hood on the top. The enclosure shall be cold rolled sheet steel of at least 1.6 mm thickness. Gland plate shall be of 2 mm thick. The board shall be dust and vermin-proof and shall have a degree of protection of IP-55. MCB/motor protection circuit breaker (MPCB) shall be rated for 10 kA short circuit rating. MPCB shall have adjustable overload setting and short circuit release.

- 5.20.2 Wall mounted distribution boards shall comprise the following as a minimum:

- Adequately rated TPN MCB isolator as incomer
- 3 phase & neutral bus bar
- Required number of TPN/SP MCBs or MPCBs with contactor and start/stop PBs for outgoing feeders
- R,Y, B indicating lamps (LED)

5.21.0 Local Motor Starters

- 5.21.1 Local motor starters shall be metal enclosed, suitable for outdoor mounting on wall or steel structures with suitable hood on top. The enclosure shall be cold rolled sheet steel of at least 1.6 mm thickness. The local motor starters shall be dust and vermin-proof and shall have a degree of protection of IP-55.

- 5.21.2 Local motor starters shall comprise of the following:

- A 3-pole contactor, mechanically latched type
- Start push button, coloured green
- Stop push button, coloured red
- 'ON' indicating lamp
- Electronic overload relay with single phasing protection

5.22.0 Local Push Button (LPB) Stations

- 5.22.1 The local push buttons station enclosure shall be with hood on top suitable for outdoor mounting on wall or steel structures. The enclosure shall be provided with a protective guard, to avoid inadvertent operation of push buttons. The local push button stations shall be dust and vermin-proof and shall have a degree of protection of IP-55 as per IS 13947.

- 5.22.2 LPB shall be of following types:

- Type-A: With Stop Push Button in FRP enclosure
- Type-B: With Start & Stop Push Buttons in FRP enclosure
- Type-C: With Forward, Reverse & Stop Push Buttons in FRP enclosure
- Type-D: With Stop Push Button in flame-proof enclosure
- Type-E: With Start & Stop Push Buttons in flame-proof enclosure
- Type-F: With Forward, Reverse & Stop Push Buttons in flame-proof enclosure



- 5.22.3 Push buttons shall be with two NO and two NC contacts. Emergency stop push buttons shall be mushroom, latched type. Start push button shall be self-reset type.

6.0.0 PAINTING

Painting shall be carried out by approved process. After preparation of the under surface the equipment shall be painted with epoxy based paint by powder coating. The final thickness of paint film on sheet steel shall not be less than 85 microns. Final shade shall be RAL-7035.

7.0.0 TESTS

- 7.1.0 All tests shall be conducted as per relevant IS/IEC standards and shall be performed in the presence of Owner's representative, if so desired by the Owner. All equipment/components/materials shall be of type tested and proven type.

- 7.2.0 Type test reports shall be submitted for switchgear panel and breaker of each current rating as per applicable standard. The switchgear panel shall be subjected to routine tests in accordance with the relevant IS/IEC standards. Test reports shall be submitted to the Owner for approval.

7.3.0 Type Tests

- 7.3.1 Type test reports for the following shall be submitted for switchgear panel of each current rating:

- Power frequency withstand test on power circuit and auxiliary and control circuits
- Temperature rise test
- Measurement of resistance of the main circuit
- Short time withstand current and peak withstand current test
- Degree of protection test

- 7.3.2 Type test reports shall be submitted for circuit breaker as per applicable standard by the Bidder for Owner's review. The list of type tests shall include the following:

- Dielectric tests
- Measurement of the resistance of the main circuit
- Temperature rise tests
- Short time withstand current and peak withstand current tests
- Electromagnetic compatibility tests
- Mechanical and environmental tests including mechanical operation test
- Short circuit current making and breaking tests
- Mechanical endurance test
- Electrical endurance test

- 7.3.3 The contactors, relays, switches, breakers, local push buttons, local motor starters, instruments, VTs, CTs and control transformers shall be subjected to type tests in accordance with the relevant IS/IEC standards.

7.4.0 Routine Tests

- 7.4.1 The switchgear panel shall be subjected to routine tests in accordance with the relevant IS/IEC standards. The tests shall include the following:

- Power frequency voltage dry test on the main circuit
- Voltage test on control and auxiliary circuits
- Measurement of resistance of the main circuit
- Mechanical operating tests



7.4.2 The circuit breakers, contactors, switches, local push buttons, local motor starters, VTs, CTs and control transformers shall be subjected to routine tests in accordance with the relevant IS/IEC standards. Routine test reports shall be furnished by the Vendor for Owner's review.

7.4.3 For circuit breaker, the list of routine tests shall include the following:

- Dielectric tests on the main circuit
- Dielectric tests on the control circuit & auxiliary circuit
- Measurement of the resistance of the main circuit
- Mechanical operating tests
- Design and visual checks

7.5.0 Site Tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

a) General

- Check name plate details according to specification
- Check for physical damage
- Check tightness of all bolts, clamps and connecting terminals
- Check earth connections
- Check cleanliness of insulators and bushings
- Check heaters are provided
- HV test on complete switchgear with CT and breaker/ contactor in position
- Check all moving parts are properly lubricated
- Check for alignment of busbar with the insulators to ensure alignment and fitness of insulators
- Check for interchange ability of breakers/ contactors
- Check continuity and IR value of space heater
- Check earth continuity for the complete switchgear board

b) Circuit Breaker/ Contactors

- Check alignment of trucks for free movement
- Check correct operation of shutters
- Check slow closing operation (if provided)
- Check control wiring for correctness of connections, continuity and IR values
- Manual operation of breakers completely assembled
- Power closing/ opening operation, manually and electrically at extreme condition of control supply voltage
- Closing and tripping time
- Trip free and anti-pumping operation
- IR values, resistance and minimum pick up voltage of coils
- Simultaneous closing of all the three phases
- Check electrical and mechanical interlocks provided
- Checks on spring charging motor, correct operation of limit switches and time of charging
- Check SF6 pressure/ vacuum (as applicable)
- All functional checks

c) Current Transformers

- Insulation resistance between windings and winding terminals to body
- Polarity tests
- Ratio identification checking of all ratios on all cores by primary injection of current
- Magnetisation characteristics and secondary winding resistance
- Spare CT cores, if any to be shorted and earthed



d) Voltage Transformers

- Insulation resistance test
- Ratio test on all cores
- Polarity test
- Line connections as per connection diagram

e) Cubicle Wiring

- Check all switch developments
- It should be made sure that the wiring is as per relevant drawings. All interconnections between panels shall similarly be checked
- Insulation resistance of all wires with respect to earth
- Functional checking of all control circuit e.g. closing, tripping interlock, supervision and alarm circuit including proper functioning of component/ equipment
- Check terminations and connections
- Wire ducting
- Gap sealing and cable bunching

f) Relays

- Check internal wiring
- Insulation resistance between all terminals and body
- Insulation resistance between AC and DC terminals
- Check operating characteristics by secondary injection
- Check minimum pick up voltage of DC coils
- Check operation of electrical/ mechanical targets
- Check CT connections with particular reference to their polarities for differential type relays
- Relay settings

g) Meters

- Insulation resistance of all insulated portions
- Check CT and VT connections with particular reference to their polarities for power type meter

8.0.0 TECHNICAL PARAMETERS OF LV SWITCHGEAR

Sloe.	Description	Unit	Parameters
1.0	LV Switchgear – General		
a)	Type		Metal clad, Form 4b
b)	Type of cooling		Natural air cooled
c)	One minute power frequency withstand voltage • Main circuit • Auxiliary circuit	kV kV	2.5 2.0
d)	Rated voltage	V	415 ±10%, 3 phase, 4 wire
2.0	PCC/MCC		
a)	Short circuit withstand current rating for switchgear fed from 2500 kVA transformer		65 kA (rms) for 1 sec & 137 kA (peak)
b)	Short circuit withstand current rating for all other switchgear		50 kA (rms) for 1 sec & 105 kA (peak)
c)	Degree of protection of switchgear with modules in service and all doors closed		IP-52



Sloe.	Description	Unit	Parameters
d)	Degree of protection for bus bar chambers (above 1600 A)		IP-42
3.0	AC Distribution Board		
a)	Short circuit withstand current rating	kA	50 kA (rms) for 1 sec 105 kA (peak)
b)	Degree of protection		IP-52
4.0	Air Circuit Breaker		
a)	Type		ACB
b)	No. of poles		TPN/TP/4P
c)	Short circuit performance category		P2
d)	Rated operating duty		O-3min-CO-3min-CO
e)	Short time current for 1 sec. for 2500 kVA transformer	kA(rms)	65
f)	Rated short circuit breaking current for 2500 kVA transformer	kA(rms)	65
g)	Rated short circuit making current for 2500 kVA transformer	kA(peak)	137
h)	Short time current for 1 sec. for all other breakers	kA(rms)	50
i)	Rated short circuit breaking current for all other breakers	kA(rms)	50
j)	Rated short circuit making current for all other breakers	kA(peak)	105
k)	Control supply voltage • Closing coil, spring charging motor • Tripping coil	V	220 V DC, (80-110%) 220 V DC, (70-110%)
4.0	Moulded Case Circuit Breaker (MCCB)		
a)	No. of poles		TPN/TP
b)	Short time current for 1 sec.	kA(rms)	50/65
c)	Rated short circuit breaking current	kA(rms)	50/65
d)	Rated short circuit making current	kA(peak)	105/137
e)	Overload release setting		Yes
f)	Short circuit release setting		Yes
g)	Undervoltage release		Yes
h)	Shunt trip		Yes
4.0	Motor Protection Circuit Breaker (MPCB)		
a)	No. of poles		TP
b)	Rated short circuit breaking current	kA(rms)	50/65
c)	Overload release setting		Yes
d)	Short circuit release setting		Yes



Sloe.	Description	Unit	Parameters
e)	Undervoltage release		Yes
f)	Shunt trip		Yes
5.0	Bus Bar		
a)	Temperature rise over design ambient of 50°C (i) Bus bars (ii) Silver plated joints		40°C 55°C
b)	Short-time current for PCC with incomer from 2500 kVA transformer	kA	65 kA (rms) for 1 sec with 137 kA (peak) dynamic rating
c)	Short-time current for other PCC/MCC/DB	kA	50 kA (rms) for 1 sec with 105 kA (peak) dynamic rating
d)	Bus bar clearance in air (minimum) • Phase to phase • Phase to earth	mm mm	25 20

9.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Technical data sheet
- General arrangement and section drawing
- Single line diagram & Schematic wiring diagrams
- Sizing Calculation for busbar
- Short circuit withstand calculation for busbar (Thermal & dynamic)
- Component list & Bill of Quantities for all the boards
- Panel cutout details
- Foundation Plan & loading details
- Erection and commissioning procedures
- CT / VT sizing calculation
- Relay setting calculation
- Catalogues / drawings / leaflets for all items
- Operation and maintenance manual
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan

**SECTION-3.11: CONTROL AND RELAY PANEL FOR GENERATOR AND TRANSFORMERS****1.0.0 INTENT OF SPECIFICATION**

This section covers the requirements of control and relay panel for generator and transformers.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) Relay panel for generator transformer of Unit-1
- b) Relay panel for Unit transformers of Unit-1
- c) Relay panel for standby maintenance transformer (Part of Switchyard relay panel)
- d) Relay panel for station transformer-1
- e) Relay panel for generator of Unit-1
- f) Control panel for generator of Unit-1
- g) Relay panel for generator transformer of Unit-2
- h) Relay panel for Unit transformers of Unit-2
- i) Relay panel for station transformer-2
- j) Relay panel for generator of Unit-2
- k) Control panel for generator of Unit-2
- l) Relay testing kit
- m) Laptop (latest configuration) loaded with necessary software for relay testing
- n) Commissioning spares and consumables
- o) Mandatory spares
- p) Tools & tackles
- q) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC standards including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards are listed below:

a) IEC 60255	Electrical relays
b) IEC 60359	Expression of the performance of electrical & electronic measuring equipment
c) IS 3231	Electrical relays for power system protection
d) IS 3842	Electrical relay for AC systems
e) IS 13032	AC Miniature circuit breaker boards for voltages not exceeding 1kV
f) IS 13703	Low voltage fuses
g) IS 694	PVC insulated cables
h) IS 6005	Code of practice for phosphate of iron and steel

4.0.0 TECHNICAL REQUIREMENTS**4.1.0 Single Line Diagram for protection of generator and transformer is enclosed in Section-7 of Volume-II.****4.2.0 Generator transformer protection****4.2.1 Generator transformer relay panel shall comprise the following:**



- Set of main protection relays for generator transformer(s)
 - Set of auxiliary relays for alarm / trip signals from generator transformer(s)
 - DC / AC power supply arrangement
 - Other auxiliaries
- 4.2.2 For generator transformers redundant two numbers multifunction numerical relay shall be provided. The following protection functions shall be distributed among two relays.
- GT differential protection (87GT)
 - HV Restricted earth fault protection (64R)
 - Backup non-directional over current protection (51GT)
 - Short circuit protection (50GT)
 - Over fluxing protection (99GT) on HV
 - Backup earth fault protection (51 NGT)
 - Pole discrepancy protection for single pole breakers of GT
 - Start-up earth fault protection for GT LV winding and UT HV winding (64T). The relay shall be connected across open delta of VT provided in GCB enclosure
- 4.2.3 Overall differential protection (87OA) protection covering Generator / GCB, Generator Bus duct, generator transformer & overhead line shall also be provided.
- 4.2.4 Auxiliary relays for the following alarm / trip conditions shall be provided for generator transformer:
- HV winding temperature alarm
 - LV winding temperature alarm
 - Oil temperature alarm
 - Buchholz alarm
 - HV winding temperature trip
 - LV winding temperature trip
 - Oil temperature trip
 - Buchholz trip
 - PRV –A operated
 - PRV –B operated
 - Sudden pressure relay operated
 - Low oil level alarm
 - Oil flow low
 - Pump over load trip
 - Fan over load trip
 - Power supply fail
 - Control supply fail
 - Fire signal
 - One set of each of the above auxiliary relays for trip and alarms functions shall be hooked up to numerical relays for SCADA communication.
 - The trip auxiliary relays contacts shall energize the lock out relays directly.
- Note: In case of single phase construction, three set of above mentioned auxiliary relays shall be provided for a bank of three single phase transformers.
- 4.2.5 The following auxiliary relays shall also be provided:
- Three phase trip relays
 - Auxiliary relays, timers and multiplication relays as per scheme requirement
 - Supervision relay for each lockout relay
 - AC & DC control supply monitoring relays
- 4.2.6 Trip contacts of class-A, class-B and class-C trips shall be grouped individually and shall be routed to lock out relays of generator relay panel.



- GT differential protection, overall differential protection, restricted earth fault protection, backup earth fault protection, over fluxing protection, transformer PRV trip & buchholz trip & WTI trip, fire protection trip are considered under class-A trip.
- Transformer OTI trip & overload trip are considered under class-B trip.

4.2.7 In the relay panel, trip contacts shall be provided for tripping of the following:

- R phase, Y phase, B phase coils of trip coil-1 of EHV GT main breaker
- R phase, Y phase, B phase coils of trip coil-2 of EHV GT tie breaker

4.3.0 Unit transformers & Station auxiliary transformer protection

4.3.1 Separate transformer relay panels shall be provided for Unit transformers and station auxiliary transformer of each unit.

4.3.2 Relay panel for each transformer shall comprise the following:

- Set of protection relays for each transformer
- Set of auxiliary relays for alarm / trip signals from each transformer
- One electronic energy accounting and audit meter for each transformer
- Transducers for current, MW and MVAR measurement of each transformer
- DC / AC power supply arrangement
- Other auxiliaries

4.3.3 The protection shall be divided into two groups. Complete protection of the equipment shall be fully available even if either of the groups is not available.

4.3.4 The following protections shall be provided for each transformer. For each group, separate lockout relay shall be provided.

Relay Group-1

- Differential protection (87)
- Backup earth fault protection (51N)
- Restricted earth fault protection for LV winding (64 LV)

Relay Group-2

- Restricted earth fault protection (64)
- Phase over current backup protection (50 & 51)
- In case of station auxiliary transformer, the backup Earth Fault protection (51N) shall be provided on HV and LV neutral.

4.3.5 Auxiliary relays for the following alarm / trip conditions shall be provided for each transformer:

- Winding temperature alarm
- Oil temperature alarm
- Buchholz alarm
- Winding temperature trip
- Oil temperature trip
- Buchholz trip
- PRV operated
- Low oil level alarm
- Sudden pressure relay operated
- OLTC surge protection
- Power supply fail
- Control supply fail



- Cooler fail
- Tap changer trouble
- OLTC stuck
- Fire signal
- 2 nos. spare auxiliary relays for future use
- One set of each of the above trip and alarm relays contact shall be hooked up to numerical relay for SCADA communication.
- The trip auxiliary relay contacts shall directly energize the lockout relay.

4.3.6 The following auxiliary relays shall also be provided:

- Auxiliary relays, timers and multiplication relays as per scheme requirement
- Supervision relay for each lockout relay
- AC & DC control supply monitoring relays

4.3.7 Relays shall be provided with self-reset contacts except for the trip lockout, which shall have contacts with manual reset feature.

4.3.8 Relay panel shall have provision for locating 'Numerical tap changer unit' for the Unit transformers and Station auxiliary transformers. Necessary hardware and wiring interface shall be provided.

4.3.9 Trip contacts of class-A, class-B and class-C trips shall be grouped individually and shall also be routed to lock out relays of generator relay panel.

- Transformer differential protection, restricted earth fault protection, backup earth fault protection, transformer PRV trip & buchholz trip & WTI trip, fire protection trip are considered under class-A trip.
- Transformer OTI trip & overload trip are considered under class-B trip.

4.4.0 Generator protection

4.4.1 Two sets of independent, redundant numerical generator protection systems (Group-1 & Group-2) shall be provided for each generator. The protection relay functions shall be grouped in two groups each with separate CT and VT inputs, trip channel and trip device. Each independent numerical generator protection systems shall include main and back-up protection functions.

4.4.2 One group shall be receiving all AC and DC signals from one set of devices and the other from another set of devices. Similarly, these two groups shall derive DC supply from two separate feeders. However, the relays in each group shall be tripping the circuit breaker through both trip coils I & II. Monitoring devices such as supervision of DC supplies, supervision of protective relays, supervision of trip relays, CT and PT supervision and supervision of both trip circuits shall be provided.

4.4.3 The earth fault detection principle shall be of low frequency injection method. It shall not be harmonic distribution type.

4.4.4 Each set of protection system shall comprise the following protection functions. For each group, separate relay panel shall be provided.

- Generator Differential Protection (87G)
- Voltage Restrained Over current Protection (51VG)
- Back-up Impedance Protection (21G) (two stage)
- Stator Earth Fault 95% & 100% Protection (64G1, 64G2) (100% stator Earth Fault protection shall be low frequency injection)
- Generator Back up Earth Fault (Open Delta) Protection
- Stator Inter-turn Fault Protection (95G)
- Negative Phase Sequence Over current Protection (two stages)(46G)



- Overload Protection (49G)
- Over/Under Voltage Protection (59/27G) (two stages)
- Over/Under Frequency Protection (81G) (two stages)
- Loss of Excitation Protection (40G) (two stages)
- Reverse Power Protection (32G)
- Low Forward Power Protection (37G)
- Generator Out Of Step Protection (78G)
- Over Excitation Protection (61G) (two stages)
- Generator Back-energization protection (51BEG)
- Generator Rotor Earth Fault Protection (64F1, 64F2) (two stages)
- Startup/Shutdown Protection (59G)
- Dead machine relay (61 B).
- Islanding protection schemes to isolate power plant from grid for disturbances in the grid.
- Local breaker back up protection (50 LBB) with its own trip relay.
- Generator O/L alarm
- Generator VT fuse fail
- Neutral point displacement protection
- Voltage unbalance protection

4.4.5 Generator Lockout Relays shall be provided in each group. The relays shall have adequate contacts for CB trip and interlock with other equipment. The relays shall provide trip/interlock signals to the following equipment:

- Switchyard circuit breakers
- Unit transformer and station auxiliary transformer circuit breakers
- Generator field circuit breaker
- Generator circuit breaker
- DAVR
- Turbine ETS
- EHT GT breaker trip coil 1 & 2 supervision relays shall be provided in GRP or the supervision of trip wires from GRP to Swyd relay panel / GT Breaker shall be provided in GRP.
- Others necessary equipment

4.4.6 Trip contacts of class-A, class-B and class-C trips shall be grouped individually and shall also be routed to respective lock out relays.

4.4.7 Trip lockout relays and interlocking relays shall have contacts with manual reset feature. All the alarm signal contacts shall be output from protection panel to DCS and generator fault recorder. Each contact to DCS shall be independence from each other. The lock out relays shall be provided with necessary supervision relays.

4.4.8 The unit protections shall be classified to initiate the following three classes of tripping:

- a) Class-A trip mode for critical electrical faults in the generator, generator transformer and Unit transformer systems. In this mode of tripping, for faults in the GT and UT, the unit is directly tripped by simultaneously shutting down the turbine and opening the GT HV circuit breaker and UT LV side circuit breaker along with tripping of the excitation system and GCB.
- b) Class-B trip mode for non-critical electrical faults in the generator system. In this mode of tripping, the turbine is shut down first and the generator is tripped subsequently by reverse power and low forward power relays by opening the GT HV circuit breaker and tripping of the excitation system. This mode of tripping is adopted for all mechanical faults and non-critical electrical faults.



c) Class-C trip mode for abnormal operating conditions and system disturbances.

In this mode of tripping, the generator is isolated from the power system by tripping the GT HV circuit breaker for faults beyond the generator system. In this case, the unit continues to run with HP-LP bypass system and supplies the auxiliary loads. Resynchronization after Class C tripping at EHV level shall be of Auto-Synchronizing type.

4.4.9 Disturbance Recorder (DR)

One no. microprocessor based Disturbance Recorder (DR) shall be provided for **each generator** to record graphic form of instantaneous values of voltage and current in all three phases and neutral, open and closed positions of relay contacts and breaker during disturbances. It shall have the facility for slow and fast scan to record transient and dynamic performance of the system. Both slow and fast scan to record transient and dynamic performance of the system. The slow scan facility shall be provided with the following minimum features:

- The input shall be MW, MVAR, field voltage, frequency and generator terminal voltage etc. Any transducers, if required for interfacing, shall be provided.
- It shall be suitable to record the frequency excursions and response of generator field and governor control on system fluctuations.
- It shall have options to select the scan rate in the range having a minimum of 10 Hz suitable to facilitate capture of low frequency waveforms in the range of 0.5 – 3 Hz.
- The non-volatile memory shall be suitable for recording for a minimum of 15 minute at scan rate corresponding to selected pre-fault zone of recording.

The fast scan facility shall be provided with the following minimum features:

- The input shall be voltages and current etc. Any transducers, if required for interfacing, shall be provided.
- It shall have scan rate of 1000 Hz or better for sampling each of the analog channel having fundamental frequency of 50 Hz. The frequency response for these channels shall be DC on the lower side to 500 Hz or better on the upper side. Any interposing devices provided shall be suitable for this frequency response.
- The pre and post fault recording time shall be atleast 200 ms and 5s respectively.

All external and internal faults in the DR equipment such as power supply fail, printer faults, paper exhausting, processor failure, memory failure etc., are to be indicated by means of light emitting diodes on the front of the panel of restitution unit. The DR shall be provided with a Workstation and printer.

The internal clock of the system shall be synchronized through the GPS. The output shall be in IEEE / COMTRADE format. The format shall be compatible for dynamic protection Relay Test Kit Necessary interfacing and software for analysis shall also be provided.

The amplitude resolution of the analog channels shall not be less than 16 bit and event resolution for digital channels shall be 1 ms or better.

4.5.0 Control Panel For Generator

4.5.1 The control, monitoring, measurement, annunciation & synchronizing of generator shall be performed at Generator control panel (GCP). These functions shall also be performed from plant DCS system. Local/remote selector switch shall be provided in GCP for selecting the place of control. All the control and protection devices required for the safe and reliable operation of the generator shall be provided.

4.5.2 Provision shall be made for the starting, bringing up to rated voltage and speed, initiation of synchronizing and closing of Generator circuit breaker & EHV GT breaker.



- 4.5.3 Generator control panel shall be complete with the following:
- Synchronising equipment with a check synchronising relay, double voltmeters, double frequency meters, synchroscope, guard relay, voltage transformer, and lamp indications.
 - Closing and opening control switch for EHV Generator Transformer main-1 Circuit Breaker.
 - Closing and opening control switch for EHV Generator Transformer main-2 Circuit Breaker.
 - Closing and opening control switch for Field breaker.
 - Closing and opening control switch for Generator Circuit Breaker.
 - DAVR Selection & Control
 - Raise / lower push button for generator field.
 - Raise / low push buttons for generator speed.
 - Close, open and auto trip indications for EHV Generator transformer main circuit breaker and tie circuit breaker.
 - Semaphore indicators for ON/OFF status indication of all isolators and earth switches of Generator Transformer bay.
 - Breaker selector switch
 - Indicating meters
 - Energy meter
 - Auto synchroniser
 - Manual synchronising equipment
 - Mimic diagram depicting the position of GCB / EHV circuit breakers, isolators and earth switches of Generator transformer bay and tie breaker bay , Generator, UAT, ST and Excitation system etc.
 - All other necessary control, metering, indication and alarms.
 - In Auto synchronising mode, the dedicated auto synchronising relay itself issues speed and voltage correction signals, checks the Synchronism and the command to the respective breaker shall be issued by the auto-synchronised relay.
 - In Manual mode the speed / voltage are manually adjusted so that the check synchronising relay gets picked and the breaker is closed manually on conforming the pickup of the check synchronising relay.
- 4.5.4 Synchronising equipment shall consist of auto synchroniser, double voltmeter, double frequency meter, synchroscope, check synchronizing relay, guard relay, synchronizing lamp, raise/lower push buttons, Auto/manual switch etc.
- 4.5.5 When the "Remote" mode is selected, synchronizing shall be initiated from DCS through auto synchroniser. When the "Manual" mode is selected, synchronizing shall be done from the stand-alone synchronizing panel.
- 4.5.6 The following digital meters of 0.5 class shall be provided in GCP. For Measurement and display of the following parameters on the DCS, Transducers of 0.5 class shall also be provided. All transducers shall be of dual output, Programmable, multifunction type.
- Generator currents of all 3 phases
 - Generator Voltage of all 3 phases
 - Generator Frequency
 - Generator power factor
 - Generator MW, MVAR
 - Generator field current
 - Generator field voltage
 - DAVR – Auto / Manual Null Balance Meter
 - Service Hour Meter
- 4.5.7 The interposing relays required for EHV circuit breaker operation and also for interfacing with DCS shall be located in the generator control panel. The coupling relays shall be rated for 0.5 Amp breaking at 220 V DC and 6 Amp make and continuous current at 220 V DC.



- 4.5.8 The GCP shall be provided separate microprocessor based alarm annunciation system to indicate the major trip and alarm function. Minimum 20% of annunciation channels and window facia shall be provided as spare. Necessary Test /accept / reset Push-buttons shall be provided.

4.6.0 Energy Meter For Generator

- 4.6.1 Energy accounting and audit meter (Tariff meter) shall be of 0.2S class which shall be provided at Generator terminals as per CEA metering regulation. The meter shall be located in generator control panel.
- 4.6.2 Tariff meters shall meet the requirements of the respective State Electricity Regulatory Commission.
- 4.6.3 The meters shall be 3-phase, 4 wire, 0.2S accuracy class electronic tri-vector energy meters shall be provided at the Generator terminal before the tape off of GT / UAT / GCB.
- 4.6.4 Energy accounting and audit meters shall have facility to download the parameters through meter reading instruments as well as remote transmission of data over communication network.
- 4.6.5 The energy meters shall be capable of receiving periodic time synchronization signals via proper on-line system. The meter time shall be in synchronism with GPS system.
- 4.6.6 The meter shall be immune to external influences like magnetic induction, vibration, electrostatic discharge, switching transients, surge voltages, oblique suspension, and harmonics and necessary tests shall be carried out in accordance with relevant standard.
- 4.6.7 The Meters shall be provided with LCD display for local indication and shall be provided with communication port suitable for communicating on MODBUS protocol. Energy auditing meters shall be connected to Ethernet switch and shall be further integrated with energy management system.
- 4.6.8 The meter must perform four quadrant measurements. The interface meters suitable for ABT shall be electronic type, composite meters, as self-contained devices for measurement of active and reactive energy, and certain other parameters as described. The meters shall be suitable for being connected directly to VTs having a rated secondary line-to-line voltage of 110 V and to CTs having rated secondary current of 1 A. The reference frequency shall be 50 Hz.
- 4.6.9 The active energy (watt-hour) measurement shall be carried out on 3-phase 4-wire principle with accuracy as per class 0.2S of IEC-687 / IEC-62053-22. The VAR and reactive energy measurement shall also be on 3 phase 4 wire principle with accuracy as per class 0.2S of IEC 62053-22 or better.
- 4.6.10 The meter shall be compatible with time of the day (TOD) tariff. For TOD tariff, meter shall have the provision to define maximum eight (8) TOD registers for different energies.
- 4.6.11 The meter shall continuously monitor and calculate the average demand in kVA during the integration period and maximum out of these shall be stored along with date and time in the meter's memory. The integration period shall be programmable for 15/30/60 minutes on real time basis on block / sliding window principle that shall also be programmable. The meter shall also display maximum demand (MD) reset count.
- 4.6.12 The meters shall have following facilities:
- a) Communication port: RS 485, RS 232 & front optical port
 - b) Load survey capability



- c) Missing potential indication in case of failure of potential at the meter incoming terminal.
- d) Provision for telemetering using common protocol
- e) Provision for collection of data by meter reading instrument (MRI)
- f) Provision for time synchronizing facility from external clock. Provision for correcting real time by MRI
- g) Sliding integration window/block integration
- h) Real time clock
- i) Non-volatile memory for 35 days
- j) Test output device in the form of a pulse indicator accessible from the front and capable of being monitored by suitable testing equipment
- k) CT/VT error compensation

4.7.0 Energy Meter For Unit Transformer / Station Transformer

- 4.7.1 Energy accounting and audit meter shall be of 1.0S class, electronic type and shall be provided on HV side of each Unit transformer & station auxiliary transformer. Where generator control panel is included in Contractor's scope, energy meter shall be located in the generator control panel. Otherwise, the same can be located in the UAT transformer relay panel itself.
- 4.7.2 Energy accounting and audit meters shall meet CEA regulation. It shall be integrated with integrated energy management system. The energy audit meters shall be suitable for measurement, recording and display of cumulative active energy with date and time. It shall have data storage capacity for at least 35 days in a non-volatile memory. It shall have facility to download the parameters through meter reading instruments as well as remote transmission of data over communication network. It shall also have the facility to measure, record and display the following parameters. All parameters excluding instantaneous electrical parameters shall also be stored in memory.
- (a) Apparent power
 - (b) Phase wise kilowatt at peak KVA
 - (c) Phase wise KVA (reactive) at peak KVA
 - (d) Phase wise voltage at peak KVA
 - (e) Power down time
 - (f) Average power factor
 - (g) Line currents
 - (h) Phase voltages
 - (i) Date and time
 - (j) Tamper events

4.8.0 Relay Details

- 4.8.1 All the main protective relays shall be fully numerical type. The relays shall have features for continuous monitoring of all the components and power supply with watchdog and healthy indication lamp. Any failure may be indicated with external alarm. The relays shall have programmable output relays to configure trip and other alarm functions. The communication protocol shall be as per IEC 61850. The relays shall have digital inputs to accommodate any external trips if necessary.
- 4.8.2 All AC operated relays shall be suitable for operation at 50 Hz. AC voltage operated relays shall be suitable for 110 V, VT secondary and current operated relays for 1 A / 5 A CT secondary. All DC operated relays and timers shall be designed for the DC voltage specified, and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.
- 4.8.3 All protective relays, auxiliary relays and timers except the lock out relays and interlocking relays specified shall be provided with self-reset type contacts. All protective relays and timers shall be provided with externally hand reset positive action operation indicators with inscription. All protective relays which do not have built-in hand reset operation indicators shall have additional auxiliary relays with operating indicators (flag relays) for this purpose. Similarly,



separate operating indicator (auxiliary relays) shall also be provided in the trip circuits of protections such as Buchholz relays, oil and winding temperature protection, sudden pressure devices, fire protection etc. Minimum of 20% of numerical relay space contacts shall be wired up to TB.

4.8.4 The main protection relays shall be numerical type and shall have following features:

- Fully numerical with state-of-the-art technology
- Fully reliable, accurate in measurement and fast acting
- Continuous monitoring of all the internal components and power supply
- Watchdog with healthy indication and remote alarm in case of failure
- On line display of important parameters
- Fault trip recording
- Programmable output relays
- Digital I/O points
- Provision for interface with data concentrator
- Provision for remote access / modification of the relay setting
- In-built event recording
- In-built disturbance / fault recording
- Necessary front / rear port connection provision
- Possibility of down loading relay parameterizing and disturbance/fault record through front port
- Communication facility as per IEC 61850
- Numerical relays shall be provided with licensed software
- All the accessories / kit for down loading the data shall be provided with the relays
- Facility for synchronization of internal clock with GPS
- Panel flush mounting type
- During any momentary loss of DC supply / change over, the relay shall not develop any signal to DCS / SCADA

4.8.5 Differential relay shall be numerical with the following features:

- Second and fifth harmonic restraint feature
- Unrestrained transient free instantaneous units with variable settings
- Biased differential with selectable pickup & slope settings
- Triple pole with faulty phase indication
- Ratio / phase angle corrections as in-built feature
- Self-monitoring feature
- Disturbance recorder and sequential event recorder (SER)
- Over fluxing protection with inverse time characteristics matching transformer over flux withstand capability curve
- Operation indicators

4.8.6 Non-directional over current relay shall be numerical with the following features:

- Selectable IDMT characteristics
- Selectable pickup and time multiplier settings (TMS)
- Number of elements corresponding to three phases, one earth fault (E/F) and one dedicated sensitive E/F element.
- Operation indicators
- VT fuse failure monitoring feature

4.8.7 Restricted Earth Fault Relay (64) shall have the following features:

- Single pole with selectable current setting
- High sensitivity with provision of 10% current setting



- Relay shall be high impedance or low impedance type
 - In case of low impedance, the relay shall be with adjustable bias characteristic with selectable slope and cut off points
 - In case of high impedance, the relay shall be with necessary stabilizing resistor and metrosils
- 4.8.8 The Numerical relays shall be networked through Ethernet switch, Gateway/Data Concentrators and shall be further integrated with SCADA based electrical monitoring system for monitoring, measuring, fault data analysis & relay parameterization. All necessary hardware including Managed Ethernet switches, accessories and licensed software shall be supplied by the Contractor.
- 4.8.9 Ethernet switches shall be 'substation hardened' and shall comply with IEC61850-3 for communications and environment requirements. The Ethernet switches shall be of managed type with two no. of fibre optic cable ports for ring network and Fourteen/Sixteen of Copper ports to achieve the LAN configuration. These switches shall be mounted inside the switchgear Panel.

5.0.0 PANEL FEATURES

- 5.1.0 Panels shall be of simplex type design preferably with front toughened glass door. It shall consist of CRCA sheet steel with thickness not less than 3 mm for weight bearing panels and 2 mm for other panels and shall provide a degree of protection not less than IP 31. Panels shall be free standing, floor mounting type. All doors and removable covers of panels shall be gasketed all around. Anti-vibration pads shall be placed between panel and base frame. Cable entries to the panels shall be from the bottom.
- 5.2.0 Panels shall be provided with two numbers of 220 V DC feeders. Each of the above feeders shall be fed from separate section of DC board. Manually operated 3 position selector switch with positions called source I, independent, source II, shall be provided to select any one for main I supply and other as main II supply. DC supply supervision shall be provided before and after the select or selection. Provision shall also be made for Auto changeover of DC supply by Diode Decoupling arrangements with two sets of Diodes and fuses.
- 5.3.0 10% spare NO/NC contacts shall be provided in each control and relay panel.
- 5.4.0 Wiring shall be by 1100 volt grade multi-stranded PVC insulated copper wire having a cross-sectional area of not less than 1.5 sq.mm. All connections from CT leads up to instruments, relays and terminal board shall be made by copper wires of minimum 2.5 sq.mm size. The cables shall be tested for flammability test as per applicable standards and shall also withstand service temperature without deterioration.
- 5.5.0 Terminal boards shall have separate terminals for incoming and outgoing wires with not more than two wires connected to any one terminal. Terminal boards shall be mounted vertically at the side of the cubicle or in horizontal rows and properly spaced to have clean wiring arrangement, adequate access for putting ferrules, making terminations etc. It shall be possible to read the ferrule numbers when the wiring is complete. Where terminals may be live when the equipment is isolated from the main supply, these shall be clearly marked on the panel.
- 5.6.0 Extra flexible wires shall be used for wiring to devices mounted on moving parts such as hinged doors. The wire bunches from the panel inside to the doors shall be properly sleeved or taped. All internal wiring terminations shall be made with solder less crimping type heavy duty tinned copper lugs. Insulation sleeves shall be provided over the exposed parts of lugs.
- 5.7.0 Engraved core identification plastic ferrules marked to correspond with panel wiring diagrams shall be fitted at both ends of each wire.



- 5.8.0 Control terminal blocks shall be of 650 V grade, rated for 10 A and in one piece molding. It shall be complete with insulating barriers, clip-on type terminals and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. Terminal blocks for CT and VT secondary leads shall be provided with test links and isolating facilities. CT secondary leads shall be provided with short circuiting and earthing facilities.
- 5.9.0 In all the panels, at least 20% spare terminals for external connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks.
- 5.10.0 A typed circuit directory, card holder and card with clear plastic covering shall be provided on the inside of each cabinet door. The directory card shall provide space to identify each circuit in the panel board. An electronic copy of the circuit directory shall be provided to the Owner.

6.0.0 TESTS

- 6.1.0 All the equipment supplied shall be of type tested quality. Type test reports shall be submitted for review. The panel shall be subjected to the routine test in accordance with the relevant Indian Standards/ IEC. All equipment shall be completely assembled, wired, adjusted and tested at the factory as per the relevant standards of IS/IEC. Factory acceptance tests shall also be carried out (FAT).

The tests shall include the following:

- Verification of GA / BOM , paint shade and thickness
- Power frequency voltage (dry) test on the main circuit
- Measurement of insulation resistance of the main circuit, before and after HV Test
- Voltage test on control and auxiliary circuits
- Verification of wiring as per approved drawings
- Functional tests
- Testing of relays

6.2.0 Site tests

All equipment and accessories included in the scope of this contract shall be tested at site after installation during commissioning. The tests and pre-commissioning checks shall include but not limited to the following:

6.2.1 Relay Panels & metering panel

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

- a) Cubicle Wiring
- It should be made sure that the wiring is as per relevant drawings. All interconnections between panels shall similarly be checked
 - Insulation resistance of all the wires with respect to earth
 - Functional checking of all control circuit e.g. closing, tripping interlock, supervision and alarm circuit including proper functioning of component/ equipment
 - Check terminations and connections
 - Wire ducting
 - Gap sealing and cable bunching
- b) Relays
- Check internal wiring
 - Insulation resistance between all terminals and body
 - Insulation resistance between AC and DC terminals
 - Check operating characteristics by secondary injection



- Check minimum pick up voltage of DC coils
- Check operation of electrical/ mechanical targets
- Check CT connections with particular reference to their polarities for differential type relays
- Relay settings
- Test communication link

- c) Meters
 - Insulation resistance of all insulated portions
 - Check CT and VT connections with particular reference to their polarities for power type meter
 - Check calibration certificate

- d) General
 - Wiring check in conformity with schematics.
 - Insulation check.
 - Primary injection test.
 - Secondary injection test.
 - On load test.
 - DC sequential test.

7.0.0 DRAWINGS & DOCUMENTS

The following documents shall be submitted by the successful Bidder after the award of contract:

- Technical data sheet
- Dimensional general arrangement drawing
- Single line diagram
- Schematic diagrams
- Trip matrix
- Block logic diagrams
- CT / VT sizing calculation
- Relay setting calculation
- Foundation plan & loading details
- Catalogues / drawings / leaflets for all items
- Quality plan
- Test certificates
- O&M manual
- As built drawings



SECTION-3.12: ELECTRICAL MONITORING SYSTEM (EMS) AND INTEGRATED ENERGY MANAGEMENT SYSTEM (IEMS)

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of electrical monitoring system, integrated energy management system and DCS interface for electrical system.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) SCADA based Electrical Monitoring System (EMS)
- b) Integrated Energy Management System (IEMS).
- c) Workstations and Multi-function printers along with furniture
- d) Control aspects of electrical system from DCS
- e) Data storage facility or backup tape drive
- f) Commissioning spares and consumables
- g) Mandatory spares
- h) Tools & tackles
- i) Any other equipment required for the system

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant Standards, except where modified and /or supplemented by this specification.

3.0.0 TECHNICAL REQUIREMENT

3.1.0 Electrical Monitoring System (EMS)

3.1.1 Electrical Monitoring System (EMS) shall be SCADA based, and shall provide the following functions:

- Monitoring, recording and storage of analog parameters of high voltage switchgear, low voltage switchgear and control & relay panels
- Monitoring, recording and storage of operation of high voltage switchgear, low voltage switchgear and control & relay panels
- Printing stored parameters
- Logging of events
- Alarm handling
- Real time and historical trend
- Reports generation
- Fault and disturbance recording
- Relay parameterization
- Monitoring parameters from meter IEDs

3.1.2 EMS monitor following equipment:

- HV Unit switchgear
- HV Unit auxiliary switchgear
- HV Station switchgear
- HV standby switchgear
- HV Station auxiliary switchgear
- LV Main plant PCCs and MCCs
- LV Emergency PCCs and MCCs
- Generator relay panel



- GT relay panel
- UT & ST relay panel
- HT switchgear of auxiliary plants such as CHP, AHP, Sea water intake etc.
- LT switchgear of auxiliary plants such as CHP, AHP, Sea water intake, CWPH, FOPH, Water treatment plant, Electric Chlorination, etc.
- Battery chargers
- UPS
- Bus transfer panel
- DG sets
- GIS switchyard through Substation automation system
- Numerical tap changer of transformers

3.1.3 Architecture diagram of Electrical monitoring system is enclosed in Section-7 of Volume-II.

3.1.4 EMS system shall collect data from numerical protection relays and digital meters installed in various switchgear panels. The system shall have Ethernet switch for each switchgear/panel for. The data exchange between switchgear equipment and data concentrators shall be through ring architecture over IEC-61850 protocol.

3.1.5 EMS shall have provision for integrating with EMS system of future stage of power plant.

3.1.6 The system shall be divided into two levels: Station Level and Switchgear Level.

3.1.7 The Station level shall include the following:

- Redundant data concentrator Industrial grade server with Windows Server OS having redundancy communication
- Redundant Ethernet LAN to connect the data concentrator to HMI
- Redundant IEC 61850 substation communication bus to connect the numerical relays to data concentrator
- Redundant Communication bus to connect the metering devices to data concentrator
- Fiber optic ports on Ethernet LAN for communication to DCS system
- Two numbers work stations with Windows OS loaded with HMI Application for Operator Interface
- Gateways to DCS of future power plant EMS and Remote control centre
- One number A4 size multi-function laser jet colour Multi-function printer
- One number A3 size multi-function laser jet colour Multi-function printer

3.1.8 The Switchgear level shall include the following:

- Numerical type protection devices and IEC 61850 Ethernet switches.
- All the process data including analog measurements, status signals, alarms etc. are acquired by the data concentrator from protection relays through IEC 61850 Ethernet Switches
- Binary inputs acquired from the numerical relays providing status indication of each breaker of incomer, bus coupler and outgoing breaker
- Analog inputs acquired from the metering devices (multi-function meters and energy meters)
- The data exchange between switchgear level relays and Ethernet switches shall take place using Ethernet cable
- The data exchange between switchgear level Ethernet switches and data concentrator panel mounted Ethernet switches shall take place via single mode fiber-optic cable according to IEC 61850 standard

3.1.9 Data concentrator shall act as a gateway between numerical relays, HMI and DCS. The data concentrator shall be based on industrial hardware design operating on Windows operating system and to monitor and acquisition of the real-time data from numerical relays. It shall also



provide a framework for monitoring this data at HMI. Data concentrator shall store the data day wise and it shall be possible to take back up of data at any time without affecting the normal operation of the system. Data concentrator shall have required number of TCP/IP ports for connection to HMI having operators work station and engineering station PC.

- 3.1.10 The HMI shall support creation of graphic objects that represents power system devices and animation of these objects to represent status and conditions, display of analog values, input fields for analog values, dialog boxes, message boxes and any other tool necessary to develop a fully functional HMI application. The security features shall prevent unauthorized access, and limits access based on user groups and automatic application startup when the workstation is started. The HMI shall continuously monitor the status of different field devices in the system and shall update the screen once in 2 second. It shall keep a detailed alarm history of all the alarms, errors, and fail-overs. It shall also provide on-line monitoring of all pertinent control system parameters. It shall allow the user to view system conditions, alarms and control inputs. The features of HMI shall include the following:

- Single line diagrams
- Process data displays on graphic screens
- Data storage
- Trend displays
- Alarm summary and history
- Sequence of events
- Reports
- Alarm alerts
- Fault and disturbance recording
- Relay parameterization

- 3.1.11 The IEDs shall communicate with data concentrator through IEC-61850 protocol on Ethernet medium. The data exchange between switchgear equipment and data concentrators shall be through ring architecture over IEC-61850 protocol. To achieve redundancy and no single point of failure between a single board, ring topology shall be used. Data concentrator shall be a part of the ring topology for the downstream communication with IED's. Independent rings shall be connected to different data concentrator. All Ethernet connections between the switches shall be fiber-optic cabling. The Ethernet medium shall transfer data for the following:

- IEC-61850 data nodes for real-time analog and status to be displayed on the HMI.
- Event record collection from the relays
- Engineering access for settings, and additional report functions

- 3.1.12 The communication system and HMI architecture shall consist of:

- All applicable 61850 relays shall be connected directly to the Ethernet system. Through this connection these relays shall provide various status and analog information to the HMI system. This connection shall provide engineering access for event reports, settings, and other data for relays.
- A dedicated computing platform shall be configured to act as data concentrators and gateways to the DCS system. These data concentrators shall be connected to upper level HMI and DCS by a redundant network in star topology.
- GPS Clock in the power plant shall provide time signal of relevant format to synchronize all applicable devices.

- 3.1.13 Station Level Ethernet switch located at the data concentrator panel shall be provided for connection to DCS System.

- 3.1.14 The EMS system shall include the following:

- HMI system.
- Acquisition of Switchgear Status
- Busbar Coloring
- Operator Work station.
- Application software.



- 3.1.15 In the HMI, the application created shall contain all information and means needed for the supervision of the process. The application creation involves the following:
- Each switchgear overview
 - Each Switchgear detailed view
 - Relay faceplates
 - Communication overview
 - Alarm display
 - Alarm history display
 - Real time trend display
 - Historical trend display
 - Reports
 - Sequence of events
- 3.1.16 The Switchgear overview screen shall show the overall SLD of respective switchgear. From this screen navigation shall be possible to any switchgear.
- 3.1.17 The Switchgear detailed view screen shall help to see the details of each switch boards. Here it shall be possible to see the relay, measurements, Alarms. Trends, of a particular feeder. In each feeder there shall be measurement box showing all the 3 phase currents and total power.
- 3.1.18 On clicking the relay button in the detailed switch board view, it shall open a popup showing the Relay faceplate. From this window it shall be possible to see all the measurements, all the front panel LEDs status and I/O status of the relay.
- 3.1.19 From Communication Overview screen it shall be possible to see the network architecture and communication status
- 3.1.20 The system has have facilities for displaying alarms. Alarm summary page shall display all the existing alarms. Latest alarm shall display in the top. Alarm page shall display information like Alarm description, date and time of alarm, priority and alarm area etc. Unacknowledged alarms shall display in red color while acknowledged alarms shall display in black color. Date, priority and alarm area wise filtering also available. Acknowledged alarms shall go to alarm history.
- 3.1.21 Measurement reports like for MW, PF, Voltage, current etc. are configured for the analysis purpose. The Measurement Report shall support the following time related formats:
- Hourly report (time resolution: 3 minutes)
 - Daily report (time resolution: 15 minutes)
 - Daily report (time resolution: 30 minutes)
 - Daily report (time resolution: 60 minutes)
 - Weekly report (time resolution: 1 day)
 - Monthly report (time resolution: 1 day)
 - Yearly report (time resolution: 1 month)
- 3.1.22 The various functions of the system shall include the following:

Acquisition of measurement data: Various analog parameters shall be measured from HV & LV switchgear. The important measurement value shall be displayed in SLD. The important parameters monitored shall include 3 Phase Current, Line Voltage, 3-Phase Real Power, 3-Phase Reactive Power, 3-Phase Energy, Frequency & Power Factor.

Acquisition of event records: The software shall Poll all the events from the relay in every 15 minutes and it shall be stored in data concentrator drive. The event stored in data concentrator can be viewed by using the software installed in HMI. The event reports generated during an event shall be viewed. Based on the relay settings the event report can contain analog inputs (voltage and currents), control outputs, digital inputs and outputs. The Event Reports shall sample analog data when an event triggers.



Time Synchronization: Synchronization clock of main plant DCS shall be used for synchronizing data concentrators, HMI PCs and IEDs shall be connected to one Data Concentrator using serial communication cable.

Relay Parameterization: Parameterization of relays shall be done from HMI.

Historical data: 3 Phase Voltage, 3 Phase Current, Active Power and PF For all feeders shall be logged into the historical database in data concentrator. Data shall be sampled and logged to the historical database at predefined intervals.

Data exchange with protection relays: The major process data collected from the protection relays shall include Phase Current, Phase Voltage, Active Power, Power Factor, Breaker Status, Protection Status, Fault Information, and Disturbance Information.

Server main and standby servers as well as workstation servers shall be of industrial grade and state of the art. The server shall be capable of performing all functions of the entire switchyard including future requirements. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. The capacity of hard disk shall be selected such that the following requirements shall occupy less than 50% of disk space:

- Storage of all analogue data (at 15 minute interval) and digital data including alarm, event and trend data for 90 days
- Storage of all necessary software
- 1 Tera byte space for Owner's use

Main and standby servers shall be rack mounted.

Bulk data storage facility or tape drive shall also be provided, to store data for back up for longer duration.

3.2.0 Integrated energy management system (IEMS)

3.2.1 Integrated energy management system (IEMS) with ABT features, on board digital I/O, Analog I/O etc. shall be provided for monitoring auxiliary power consumption for the entire plant including switchyard. Energy management software shall carry out energy audit by integrating data from various energy meters. Energy accounting and audit meters and energy meters provided at various voltage levels in various panels shall be integrated for the same. The energy meters/ energy accounting and audit meters shall include the following:

- Meters of all 33 kV, 11 kV, 6.6 kV switchgear
- Meters of all 415 V power control centres and motor control centres
- Meters of Generator, Unit transformers and station transformers
- Meters of 400 kV GIS switchyard

3.2.2 The IEMS system shall have dedicated redundant servers, gateways, Ethernet switches, HMI workstation, display units, A4 laser colour Multi-function printer, furniture, interconnecting communication cables, fiber optic cables, proven software, etc. All the electrical parameters of various systems such as Current, voltage, power factor, kW, kVAR, kVA, frequency, harmonics etc. from the above meters shall be displayed in the HMI workstation including real time data, wave form, graphs, etc.

3.2.3 From the above data, Unit consumption and station auxiliary consumption shall be segregated and displayed (7 segments LED display) at 10 locations by means of appropriate hardware. These locations shall be firmed up during detail engineering.

3.2.4 Energy meters and audit meters shall have matching ports/protocol for IEMS integration.



3.2.5 The following reports shall be generated in the IEMS system.

- Auxiliary power consumption of each system/ subsystem/ switchboard
- Unit wise auxiliary power consumption
- Main plant auxiliary power consumption
- Station auxiliary power consumption
- Total power consumption
- Periodic power consumption report
- Power consumption trend
- Power losses in the equipment

3.2.6 Transducers shall be provided in all the buses so that algebraic summation in electrical system shall be Zero.

3.3.0 Control from DCS/Respective control system

- a) For the Switchgear, all the protection interlock shall be hardwired in the respective switchgear. Control shall be from DCS or respective control system. Switchgear shall receive close/trip command from DCS/Respective control system.
- b) For DCS commands, interposing relays shall be provided in 'Interposing relay cabinet' of DCS system or in respective switchgear.
- c) For switchgear having two incomers and bus coupler, Local / Remote selection, 'Trip selection', 'Auto/Dead bus/ Sync' selection and synchronizing selection of breaker (I/C-1, B/C, I/C-2) shall be provided in DCS
- d) In local mode, control shall be from switchgear. In remote mode, control shall be from DCS /Respective control system wherever remote controls are envisaged.
- e) For all motor feeders signals (I/O) requirement shall be as per C&I section.
- f) The following signals (I/O) shall be considered, in DCS/Respective control system for each feeder (other than motor), of HT Switchgear
 - Start Command
 - Stop Command
 - ON Feedback
 - OFF Feedback
 - Switchgear disturbance (Overload relay operated/ control supply fail)
 - Electrical Trip (Protection Relay)
 - Switchgear Available (breaker in service position, switchgear in remote & breaker spring charged)
 - Current Transducer input
- g) The following signals (I/O) shall be considered in DCS/Respective control system for each feeder (other than motor) of LT Switchgear
 - Start Command
 - Stop Command
 - ON Feedback
 - OFF Feedback
 - Switchgear disturbance (Overload relay operated/ control supply fail)
 - Electrical Trip (Protection Relay)
 - Switchgear Available (breaker in service position, switchgear in remote & breaker spring charged)
 - Current Transducer input



- h) The following signals (I/O) shall be considered as a minimum, in DCS/Respective control system for each transformer
- OTI alarm
 - WTI alarm
 - Buchholz alarm
 - Oil low alarm
 - OTI trip
 - WTI trip
 - Buchholz trip
 - Sudden pressure trip
 - OLTC surge relay alarm
 - Control supply fail
 - Power supply fail
 - OLTC struck
 - Fan failure
 - Pump failure
- i) Signals (I/O) for the following equipment /panels shall also be considered in DCS.
- DG set
 - Bus transfer panel
 - UPS
 - Battery charger
 - Numerical tap changer panel

4.0.0 PAINTING

Painting shall be carried out by approved process. After preparation of the under surface the equipment shall be painted with epoxy based paint by powder coating. The final thickness of paint film on steel shall not be less than 85 microns. Final shade shall be RAL 7035.

5.0.0 TESTS

All the equipment supplied shall be of type tested quality. Type test reports shall be submitted for review. The panel shall be subjected to the routine test in accordance with the relevant Indian Standards/ IEC. All equipment shall be completely assembled, wired, adjusted and tested at the factory as per the relevant standards of IS/IEC Factory acceptance tests shall also be carried out (FAT).

The tests shall include the following:

Type Tests

The following are the major type tests to be carried out:

- Accuracy tests
- Insulation tests
- Electromagnetic compatibility tests
- Function tests
- Environmental tests

Factory Acceptance Tests

The following are the major factory acceptance tests to be carried out:

- Hardware integration tests
- Integrated system tests
- Pre power on checks.
- Power on checks.
- Functional tests.



- Parametric tests.
- Power failure auto-restart tests.
- Interlocking tests.

Site Acceptance Tests

- Check name plate details according to the specification
- Check for physical damage
- Check earth connection and earth continuity
- Check for correct CT/PT terminals
- Functionally check all control circuits
- Check connections and wiring
- Megger all terminals to body
- Test communication links
- Carry out functional check
- Loop testing of all measurement signals and control loops
- Test protection interlocks
- Carry out cable continuity checks
- Carry out functionality of all displays and alarms
- Check operation of VDUs
- Check operation of printers
- Check functioning of all software

6.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- System architecture drawing for EMS
- System architecture drawing for integrated energy monitoring system
- Hardware specification
- Guaranteed technical parameters,
- Functional design specification
- Guaranteed availability and reliability
- I/O signal lists
- Schematic diagrams
- Logic diagram (hardware & software)
- Test specification for factory acceptance test (FAT)
- Test specification for field tests
- Product manuals
- Operator's manual
- Listing of software and loadable in CD ROM
- List of apparatus
- Test specification for site acceptance test (SAT)
- Plant Display details
- GA drawing of panels
- Catalogues / drawings / leaflets for all items
- Erection and commissioning procedures
- Operation and maintenance manual
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.13: BATTERY CHARGER

1.0.0 INTENT OF SPECIFICATION

This specification covers the requirements of Battery Chargers, MCCB box, DCDB & Discharge resistor.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) 220 V DC SMPS based modular charger for Unit-1
- b) 220 V DC SMPS based modular charger for Unit-2
- c) 220 V DC SMPS based modular charger for switchyard
- d) 24 V DC SMPS based modular charger for Unit-1 (If applicable)
- e) 24 V DC SMPS based modular charger for Unit-2 (If applicable)
- f) 220 V DC SMPS based modular charger for various auxiliary plants such as (CHP, AHP, WTP, Sea water intake etc.)
- g) 48 V DC SMPS based modular chargers for EPABX systems
- h) 220 V DC Distribution boards
- i) 48 V DC Distribution boards
- j) 24 V DC Distribution boards (If applicable)
- k) Discharge resistors for testing the Batteries
- l) MCCB box for each battery
- m) Commissioning spares and consumables
- n) Mandatory spares
- o) Tools & tackles
- p) Any other equipment required for the system

3.0.0 DESIGN REQUIREMENTS

- 3.1.0 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant Indian Standards, and IEC publications and any other standards, if any, except where modified and /or supplemented by this specification
- 3.2.0 220 V DC Power supply system shall provide normal source of power to the 220 V DC loads, such as the emergency oil pumps, Control Supply to switchgear / panels and emergency lighting. It shall also be capable of constantly supplying emergency loads for a period of 2 hour when AC supply to Charger fails.
- 3.3.0 For each Unit for main plant, two sets of batteries shall be provided each catering to 100% load. One float cum boost chargers shall be provided for each battery.
- 3.4.0 The 220 V DC Power supply system shall be ungrounded system.
- 3.5.0 Following DC systems shall be provided.
 - For each unit of main plant, 2X100% rated 220 V batteries with 100% rated, dedicated SMPS based float cum boost charger for each battery and common DCDB.
 - For GIS switchyard, 2X100% rated 220 V batteries with 100% rated, dedicated SMPS based float cum boost charger for each battery and common DCDB.



- For each of CHP/AHP/WTP/Sea water intake/ Ash Silo/ Ash water recovery PH/ FOPH etc., 1x100% rated 220 V batteries with redundant SMPS based float cum boost charger and common DCDB.
 - For C&I equipment, for each Unit, 2X 100% rated 24 V battery with 100% rated, dedicated SMPS based float cum boost charger for each battery and common DCDB (If applicable)
 - For each EPABX system, 2x100% rated 48 V battery with redundant SMPS based float cum boost charger and a common DCDB
- 3.6.0 Float mode of SMPS-FCBC charger shall be sized for the following:
- Continuous normal DC power requirement.
 - Trickle charging of battery.
 - Rated full load current of largest rated Motor
- 3.7.0 Boost mode of SMPS-FCBC charger shall be sized to boost charge the fully discharged battery to its normal capacity in a period of 8 hours in case of lead acid batteries.
- 3.8.0 In case of failure of one charger, the other charger shall be capable of float charging both the battery banks (1&2).
- 3.9.0 Voltage regulating diodes shall be provided to limit the voltage within permissible limits during boost charging.
- 3.10.0 In case of mains failure to charger or charger failure, battery shall supply the full load. After the restoration of supply, selected boost charger shall boost charge the battery and the selected float charger shall supply the DC load.
- 3.11.0 A design margin of 10% shall be considered in selecting the rating of chargers. Higher of the float charging rating and boost charging rating is considered for sizing the FCBC Charger. SMPS charger shall be modular type. For modules of up to 5, one additional module shall be provided for redundancy and for modules of above 5, two additional module shall be provided,
- 3.12.0 Single Line Diagram for DC Distribution is enclosed in Section-7 of Volume-II.**

4.0.0 TECHNICAL REQUIREMENTS

4.1.0 Charger shall be SMPS type and shall have following features:

- Pulse width modulation
- High frequency DC/AC converting
- Voltage stabilization tolerance: $\leq \pm 0.5\%$
- Current stabilization tolerance: $\leq \pm 0.5\%$
- Ripple coefficient: $\leq 0.05\%$
- Power factor: ≥ 0.92
- Efficiency: $\geq 92\%$
- Standby mode: N+1 module on-line
- MTBF: $\geq 100,000$ h
- Remote control functions
- Modular Design
- LCD Control Display Panel
- Multi-Point Monitoring
- Remote Communication
- Software Programmable (PLC Based)
- AC Ripple $< 0.5\%$
- Dynamic Response < 100 micro. sec.
- THD $< 5\%$
- Enhance earth fault monitoring
- Tunable Output
- Intelligent float boost & equalize charging



- Temperature compensated charging for VRLA
 - Calculating battery charge/ discharge capacity
 - Discharge calculation with K factor & temperature compensation
 - Monitoring of each DC feeder status
 - Total control on each charging module
 - Storing historic alarms
 - Remote communication with RS 232 & 485
 - Individual cell monitoring
 - Ground fault identification suitable for opto-coupler loads
 - Identifies faulty feeders
 - Monitors insulation level of feeders
 - Both positive & negative monitoring
- 4.2.0 The Insulation monitoring system shall on-line monitor the insulation between the DC bus and the earth, as well as the grounding resistance and capacitance of branches. The detector shall be divided into two parts: master and slave. The master shall monitor the bus, while the slave shall monitor the system output branches. Each master shall be configured with a built-in slave. It shall have following features:
- Real-time monitoring combined with branch polling.
 - RS485 serial port communication.
 - Capable of monitoring one or two sections of independent DC buses.
 - Automatic capacitance compensation function addressing the big branch capacitance, ensuring measurement precision of branch grounding resistance.
 - Alarm threshold configurable through controller.
 - Capable of monitoring equal insulation deterioration at positive bus and negative bus.
 - Capable of self-checking, convenient for maintenance.
 - The master being capable of dry contact output for dual-section bus poor insulation alarm.
- 4.3.0 The battery management shall use a two-layer monitoring mode to on-line monitor the battery parameters, including cell voltage, charge/discharge current and ambient temperature. Its function shall include:
- Calculating the battery capacity change according to the battery charge/discharge situation.
 - Carrying out current-limit boost charge (BC) automatically according to the preset conditions after the battery discharge.
 - Carrying out normal battery BC by controlling the bus voltage.
 - Carrying out timed battery BC and BC/FC voltage temperature compensation automatically.
- 4.4.0 The battery insulation monitoring relay shall monitor the insulation of the DC system. The insulation relay shall observe and when bus insulation deteriorates to a certain set level, the faulty branch shall be identified and reported to controller and alarm shall be made.
- 4.5.0 The battery management system shall transfer battery from float charge (FC) to boost charge(BC) based on the battery charge current, and from BC to FC based on the charge current and time. It shall be equipped with a temperature sensor, to make temperature compensation to the FC voltage. Based on the battery current and total load current, the system shall ensure the charging effect and prolong the battery life span by adjusting rectifier output current and current limit to control battery current and voltage, and prevent battery over charging-current.
- 4.6.0 The scheme shall employ a SMPS based dual Float cum Boost charger with centralized monitor and control unit. The system shall operate with 3 Phase AC supply of 415V, 50 Hz. Each individual charger shall be provided with AC 3 pole MCCB on the input side enables to isolate the system from the AC mains. The system shall be provided with 3 Phase Surge Protection Device on the input side. Each charging rectifier module shall be provided with individual MCBs at the input for isolation. All the charging rectifier modules of each charger shall be connected in parallel and configured as Float



cum Boost Charger. The MCCB of suitable rating shall be provided on the DC output side for isolation.

- 4.7.0 In normal operation, both the chargers are working in Float mode float charging the batteries connected to it and simultaneously feeding the rated DC load. In case of failure of either of the chargers, the other charger will Float charge the batteries and simultaneously feeding the rated DC load. During of mains failure, the batteries will take care of the complete DC load without any break. When the mains supply is restored, the discharged batteries requires to be boost charged. Under this condition, one of the charger is put into boost mode for charging the battery bank connected to it while it is disconnected from the system load. During this time, the other charger will be float charging the battery connected to it while feeding the rated DC load. After completion of boost charge of one of the battery set, the respective charger is put into Float mode and the other charger is put into boost mode for charging the other discharged battery.
- 4.8.0 The DC output voltage of the Float charger shall be maintained within $\pm 0.5\%$ of the set voltage with output ripple content less than 0.05% for the specified input voltage range. The FCBC shall be capable of boost charging the batteries in constant current mode settable from 10% to 100% of the rated current. The current shall stabilized within $\pm 0.5\%$ of the set value for the specified voltage range. The automatic changeover from Boost to Float mode and vice versa shall be controlled by monitoring .
- 4.9.0 Battery health monitoring system for monitoring the individual battery voltage and monitoring the battery AH capacity shall be part of this system.
- 4.10.0 Insulation monitoring system for monitoring the insulation of individual DC feeders shall be included in the system. The feature of individual DC feeder status monitoring shall also provide in the system, placed in the DCDB.
- 4.11.0 A separate unit of suitable rating called Super Filter consisting of Filter circuits for reducing the input harmonics to the specified level shall be placed between the AC mains supply and each Battery charger unit.
- 4.12.0 A separate DCDB consisting of the specified incoming & outgoing DC feeders shall be provided.
- 4.13.0 Digital indicating meters shall be provided on the front to read the following. Further transducers shall be provided for these measurements and shall be connected to remote DCS/EMS/SAS for remote monitoring.
- AC incoming voltage
 - AC incoming current
 - DC output voltage of float cum boost charger
 - DC output current of float cum boost charger
 - DC charge/discharge current of battery
 - DC load voltage
 - DC load current
 - DC leakage current
- 4.14.0 The following LED Status indications shall be provided as a minimum on the panel for each Charger.
- Battery status
 - R,Y,B supply ON
 - Float charger ON
 - Boost charger ON



4.15.0 The following annunciations shall be provided as a minimum on the panel for each Charger.

- Charger overload
- Charger fail/trip
- DC output MCCB failure
- Positive grounded
- Negative grounded
- AC input supply of float cum boost charger failure
- Battery fully discharged
- Battery on Boost.
- AC input supply failure
- AC input under voltage
- DC voltage low
- DC voltage high
- DC system earth fault.
- SMPS module fail

4.16.0 For remote indication/ Annunciation in DCS/EMS/SAS, the following potential free contacts shall be provided for each Charger.

- DC system under voltage /over voltage
- Battery on Boost
- AC under voltage /AC Over voltage
- Charger fail
- DC earth fault
- Battery fully discharged
- AC Overload trip
- SMPS module fail

4.17.0 Isolated 4-20 mA signals for DC voltage, Current, AC input Voltage current, frequency, Inverter output Voltage and current etc., and alarm signals for Charger Over Load ,AC input supply failure, DC voltage Low, DC voltage High, DC system earth fault, DC output MCCB failure, Discharge Resistor connected etc. shall be considered for remote connection to DCS/EMS/SAS.

4.18.0 MCCB shall be Triple pole type for incoming supply to Battery charger, Double Pole type for outgoing supply from Battery charger. It shall be quick make, quick break, and independent manual type with trip free feature. All MCCB shall have the following :

- Short circuit release
- ON/OFF Trip position indicators
- Test trip push button
- Voltage rating shall be suitable for 500 volts AC/DC.

4.19.0 The annunciation system shall have audio-visual arrangement and shall have LCD display. It shall also be provided with acknowledge, reset and test push buttons. On occurrence of fault, the corresponding LED lights up and stays in lighted condition until the fault is cleared and the reset push button is pressed.

4.20.0 Chargers shall be metal enclosed, fixed type, suitable for indoor mounting on floor. Panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. The frames shall be enclosed by cold rolled sheet steel of thickness not less than 1.6 mm. At bottom removable gland plates of atleast 3 mm thick non-magnetic material shall be provided. All incoming and outgoing cables shall be terminated on suitable terminal blocks.



4.21.0 The charger panels shall be provided with an illuminating CFL lamp, a 5 Amp socket and space heaters with thermostat. Toggle switches and fuses shall be provided separately for each of the above fittings. Space heaters "ON" indication to be provided. Two separate grounding pads shall be provided for each panel suitable for connecting of GI earthing strip.

4.22.0 The panel shall be of sheet metal, enclosed, dust and vermin proof, conforming to IP 31 degree of protection. Battery charger shall be located in Air conditioned room.

5.0.0 BATTERY MCCB BOX

For each Battery, MCCB box shall be provided for maintenance isolation and for short circuit protection. The MCCB box shall comprise MCCB sized for the Battery capacity. MCCB be shall be designed to carry the rated in both direction of current flow and also shall protect against the short circuit in both the direction. It shall be enclosed in sheet steel enclosure of at least 2 mm, having IP: 54 degree of protection. The MCCB box shall be wall mounted type located in Battery room.

MCCB shall be double pole type rated for DC. It shall be quick make, quick break, and independent manual type with trip free feature. It shall have the following:

- Short circuit release
- ON/OFF Trip position indicators
- Test trip push button
- Voltage rating shall be suitable for 220 volts DC.

6.0.0 DC Distribution board (DCDB)

6.1.0 DCDB shall be metal enclosed, indoor, floor mounted and free standing, DCDB frames, load bearing members, doors and covers and gland plates shall be fabricated using CRCA sheet steel. The thickness of sheet shall be not less than 1.6 mm for non-load bearing members and 2.0 mm for load bearing members. Gland plate thickness shall be minimum 3.0 mm.

6.2.0 DCDB shall be fixed type with compartmentalized construction, single front or double front type.

6.3.0 DCDB shall be provided with an integral base channel of at least 50 mm height. It shall be mounted on channels embedded in concrete by tack welding base channels.

6.4.0 Suitable synthetic rubber gaskets shall be provided to make DCDB completely dust-proof and vermin-proof with a degree of protection of IP 52 for all switchboards.

6.5.0 DCDB shall be divided into distinct vertical sections (panels), each comprising of the following compartments:

- Main bus bar compartment
- Switchgear/feeder compartment
- Cable alley of at least 300 mm width

6.6.0 DCDB shall be of modular design, consisting of units or modules, segregated into single or multi-tier compartments. Each unit shall be placed in individual compartment. All units grouped together shall form the complete switchboard. Completed switchboard shall be of flush-fronted design having a neat appearance and shall be readily extensible.

6.7.0 DCDB shall be designed to prevent contact with live parts both within the modules and in the cable alley. Following are the minimum segregations to be provided amongst the different parts of the switchboard:

- a) Main horizontal bus bar chamber and vertical bus bar chamber
- b) Between different modules



- c) Between modules and cable chamber
- e) Between vertical bus bars and modules

All insulating materials used as partitions guards and shrouds shall be non-hygroscopic and flame retardant.

- 6.8.0 Interlock between compartment door and modules shall be provided such that the door cannot be opened without switching off the power supply to the module. Defeat interlock shall be provided as a means of isolation, such that it is possible to open the door with device ON and the unit in 'SERVICE' position.
- 6.9.0 DCDB shall be equipped with thermostatically controlled space heaters in each panel (separate for front and rear in case of double fronted panels having separate cable alleys) so as to maintain interior temperature 5°C above the ambient. They shall have manual disconnect switch and MCB for protection.
- 6.10.0 At least 20% of feeder modules covering the range of motors/ outgoing feeders used subject to minimum of one module in each bus section shall be provided as spare. Spare modules shall be completely wired up.
- 6.11.0 20% of control terminals in each module shall be provided as spare subject to a minimum of 2 terminals.
- 6.12.0 All single front switchboards shall be provided with single leaf, hinged or bolted covers at the rear. The bolts shall be of captive type. The covers shall be provided with 'DANGER' labels.
- 6.13.0 Minimum air clearance for horizontal and vertical bus bar termination shall be 25 mm between phases and 20 mm between phase and earth. For all other components the clearance shall be 10 mm minimum.
- 6.14.0 The arrangement of the feeders shall ensure that operating handle of the switch/breaker shall be above 350 mm but below 1800 mm from finished floor level.
- 6.15.0 Each panel section shall be equipped with the following as required:
 - Illumination lamp with door switch
 - 5 Amp, 3 pin socket with miniature circuit breaker (MCB) protection
- 6.16.0 DC distribution boards shall have two bus bars.
- 6.17.0 For double front type of board, separate vertical bus bars for each front shall be used.
- 6.18.0 Bus bars shall be made of high conductivity copper/aluminium alloy. Vertical bus bar for all multi tier modules shall be of copper /aluminium. They shall be supported on insulators of material such as fiber reinforced polyester or epoxy cast resin. All bus bar joints shall be provided with high tensile steel bolts, Belleville/spring washers and nuts. All bus bars and bus taps shall have HRPVC sleeves, colour coded as follows:
 - Red, yellow & blue for R, Y & B phases respectively
 - Black for neutral
 - Grey & white for positive and negative respectively
- 6.19.0 All horizontal and vertical bus bars and joints shall be covered by insulating shrouds.
- 6.20.0 DCDB shall be rated for short circuit rating of 25 kA for 1 second. It shall have two incomers and a bus coupler (as per enclosed schematic diagram). All the components shall be DC rated.



DCDB shall comprise the following:

- MCCB as incomer
- Digital Ammeter and voltmeter at incomer
- Bus voltmeter
- Earth fault monitoring relay
- Insulation monitoring device
- MCCB in all outgoing feeders
- Mutual inductor in all outgoing feeders
- LED indication lamp in all outgoing feeders

7.0.0 DISCHARGE RESISTOR

Discharge resistor shall be provided for testing the Battery. The discharge resistor shall be adequately sized for charge – discharge cycle testing of different type & rating of batteries with necessary tapping. It shall be enclosed in sheet steel enclosure of atleast 3 mm, having IP: 31 degree of protection. Resistor shall be of punched stainless steel. Temperature rise shall be limited to 150 degree C over ambient. The Discharge resistor shall be mounted on trolley with bi-directional wheels.

8.0.0 PAINTING

Painting shall be carried out by an approved process by powder coating. After preparation of the under surface, the equipment shall be painted with epoxy based paint. The final thickness of paint film on steel shall not be less than 50 microns. Final shade shall be RAL-7035 (light grey).

9.0.0 TESTS

9.1.0 All type, routine and acceptance tests shall be conducted on the Battery Chargers, Fuse box & Discharge resistor as per applicable standard. Copies of certified reports of all type tests carried out on similar type and rating shall be furnished.

9.2.0 Test reports shall be submitted for approval before the dispatch of Equipment.

9.3.0 Following tests shall constitute functional tests for the charger panel.

- Voltage regulation
- Ripple content at different loads and noise measurement
- Insulation resistance test
- General operation
- Voltage/current stability test
- High voltage test
- Measurement of surface temperature of charger panel
- Current limiting features.
- Efficiency & PF measurement
- Temperature Rise test
- Short circuit at full load
- Short circuit at No load

9.4.0 Following tests shall constitute type tests on the charger panel.

- Degree of protection Test for Battery Charger Panel
- Vibration Test of the Electronic Card Rack/Panel
- Environmental Tests on the Electronic Cards
- RFI Test
- Surge Withstand capability Test



9.5.0 Site tests for charger

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- Complete physical examination
- Checking of proper operation of annunciation system
- Temperature rise test at full load
- Insulation resistance test
- Automatic voltage regulator operation
- Load limiter operation.
- Dynamic response test - overshoot/ undershoot in output voltage of the charger as a result of sudden change in load from 100% to 20% and 20% to 100% shall be measured with the batteries connected and disconnected. Output voltage of the charger connected with battery shall be within 94% to 106% of the voltage setting in above conditions and shall return to, and remain, within the limits specified as mentioned elsewhere, in less than 2 seconds (as applicable).

10.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Charger sizing calculation
- Technical data sheet
- General arrangement, layout drawing and section
- Charger room layout
- Schematic wiring diagram
- Drawing for MCCB box
- Drawing for discharge resistor
- Erection and commissioning procedures
- Operation and maintenance manual
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.14: BATTERY

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of Battery.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) 2 numbers lead acid Plante battery for 220 V DC system of Unit-1
- b) 2 numbers lead acid Plante battery for 220 V DC system of Unit-2
- c) 2 numbers lead acid Plante battery for 220 V DC of switchyard
- d) 2 numbers Lead acid Plante battery for 48 V DC of EPABX at each location
- e) 2 numbers lead acid Plante battery for 24 V DC of I&C system of Unit-1(If applicable)
- f) 2 numbers lead acid Plante battery for 24 V DC of I&C system of Unit-2(If applicable)
- g) 2 numbers lead acid Plante battery for main plant UPS of Unit-1.
- h) 2 numbers lead acid Plante battery for main plant UPS of Unit-2.
- i) Lead acid Plante battery for 220 V DC systems of auxiliary plants such as CHP, AHP, WTP, Sea water intake PH, Fuel oil PH, AWRPH, Ash silo etc.
- j) Lead acid Plante battery for UPS systems of auxiliary plants such as Switchyard, CHP, AHP, WTP, Sea water intake PH, H2 plant, Fuel oil PH, AWRPH, Ash silo etc.
- k) Lead acid Plante battery for UPS systems of Service building and Admin building.
- l) Lead acid Plante battery for Diesel generator set
- m) Battery impedance tester
- n) Battery earth fault locator
- o) Battery Health monitoring system
- p) Commissioning spares and consumables
- q) Mandatory spares
- r) Tools & tackles
- s) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant Indian Standards, and IEC publications and any other standards, if any, except where modified and /or supplemented by this specification.

- a) IEEE: 485 Recommended practice for sizing for large lead storage batteries for generating stations and substations.
- b) IEEE: 484 IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications
- c) IS : 14782 Code of practice for maintenance and testing of large lead- acid batteries for generating systems and substations
- d) IS: 1652 Specification for stationary cells and batteries, lead acid type with Plante positive plates).
- e) IS: 266 Specification for sulphuric acid.
- f) IS: 1146 Specification for rubber & plastic containers for lead acid storage batteries
- g) IS: 3116 Sealing compound for lead acid batteries.
- h) IS: 8320 General requirements and methods of tests for lead acid storage batteries.



- i) IS: 6071 Specification for synthetic separators for lead acid batteries.

4.0.0 DESIGN REQUIREMENTS

- 4.1.0 Each battery shall be sized to cater to 100% load plus 10% design margin. The ageing factor and electrolyte temperature correction factors shall also be considered for the site ambient temperature.
- 4.2.0 Type of battery shall be as follows.
- 220 V Unit battery for main plant : Lead acid Plante type
 - UPS battery for each Unit (main plant) : Lead acid Plante type
 - Switchyard battery for 220 V system : Lead acid Plante type
 - Switchyard battery for 48 V system : Lead acid Plante type
 - Main plant I&C battery for 24 V system : Lead acid Plante type
 - Communication battery for 48 V system : Lead acid Plante type
 - UPS battery for Switchyard : Lead acid Plante type
 - UPS battery for Auxiliary plants : Lead acid Plante type
 - 220 V battery for auxiliary plants : Lead acid Plante type
- 4.3.0 The duty cycle imposed on the 220 V battery shall be for duration of **two hours**. The loads shall include the following.
- Loads for two hours (Seal oil pumps, Scanner air fans, indicating lights, continuously energized coils, Annunciation, Relays, emergency lighting etc.)
 - Momentary loads for a duration of up to 1 minute (switchgear operation (Trip coil / Closing coil), Solenoid valves, starting current of emergency DC motor, emergency steam sop valves, inrush current of supervisory safety, system for fuel, turbine and generator controls)
 - Loads for two hour (Emergency oil pump, Jacking oil pump, etc.)
- 4.4.0 The duty cycle imposed on the UPS battery shall be for duration of **two hours**.
- 4.5.0 The duty cycle imposed on the 48 V battery for communication system shall be for duration of **ten hours**.
- 4.6.0 The duty cycle imposed on the 24 V battery shall be for duration of **two hours**.
- 4.7.0 Batteries shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency conditions when AC supplies fail. Batteries shall be suitable for a long life under continuous float operations and occasional discharges.
- 4.8.0 The following items shall be provided for the Battery.
- Insulators (if applicable)
 - Long/short connectors with insulated cover
 - Inter row connectors with insulated cover (if applicable)
 - Interbank connectors with insulated cover (if applicable)
 - Vent plug
 - Level indicator and float guide
 - Battery take-off
 - Fasteners
 - Cell number plates
- 4.9.0 End take off connections from positive, negative and tap cell terminals of the battery shall be suitable for single core cables having XLPE insulated stranded aluminium conductors.



Necessary supports for termination of these cables on the batteries shall be provided by the Contractor.

- 4.10.0 All the inter cell, inter row and interbank connectors supplied along with the battery shall be capable of continuously carrying the maximum discharge current of the respective batteries and through fault short circuit current which the battery can produce and withstand for the period declared.
- 4.11.0 Insulated mild steel racks suitably treated/coated with alkali /acid resistant compound mounted on the insulators shall be provided for the batteries.
- 4.12.0 Battery racks and other supporting/interconnecting accessories shall be as per layout arrangement to be approved by Owner during contract engineering stage. The cells shall be supported on insulator fixed on to the rack with adequate clearance.
- 4.13.0 Each battery bank shall be supplied with microprocessor base battery health monitoring system (BHMS). It shall be capable of calculating the net charge of Battery bank, deterioration of batteries in battery bank during the charge/discharge cycles and actual efficiency of the batteries. It shall continuously monitor each cell in the battery bank to identify deterioration in the cell prior to failure and Identify the net charge in the battery bank by monitoring charging and discharging currents. It shall identify the faulty cell by monitoring cell's parameters and create audio and visual alarms whenever battery fault occurs. Remote monitoring of battery health at DCS/SAS/EMS system through modem communication shall be provided.
- 4.14.0 Following accessories shall be provided for the Batteries as applicable.
- Electronic Syringe type Hydrometer with temperature measurement and with built in memory.
 - Cell testing voltmeter with built in memory.
 - Acid resistant funnel
 - Acid resistant jug.
 - Rubber apron and gloves
 - Insulated Spanners
 - Wall mounted teak wood rack/ Acid resistance rubber insulated Steel rack for above items
 - Lifting device for cell

5.0.0 TECHNICAL REQUIREMENTS

5.1.0 Lead acid Plante Battery

- 5.1.1 The cell capacity shall be specified at 10 hour discharge rate. The nominal voltage per cell shall be 2.0 V and the end voltage of cell shall be not less than 1.85 V. AH efficiency of battery shall be not less than 90%. Battery sizing shall be carried out as per IEEE: 485.
- 5.1.2 Batteries shall be Lead-Acid Plante, Type F – HDP as per IS 1652.
- 5.1.3 Battery Containers shall be made of fire retardant polypropylene / fire retardant transparent styrene acrylo nitrile (SAN) polymer. Containers shall be robust, heat resistance, leak proof, non-absorbent, acid/alkaline resistant, non-bulging type and free from flaws such as wrinkles, cracks, blisters, pin holes etc. The electrolyte shall be prepared from battery grade sulphuric acid and distilled water
- 5.1.4 Batteries shall have thick plates designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. Cells shall be fitted with electrolyte level indicator floats enclosed in transparent tub covers. Vent plug shall be provided which shall be anti-splash type.



- 5.1.5 The cells shall be supported on porcelain insulator fixed on to the rack with adequate clearance between adjacent cells.

6.0.0 TESTS

- 6.1.0 All type, routine and acceptance tests shall be conducted on the batteries as per applicable standard. Copies of certified reports of all type tests carried out on similar type and rating shall be furnished. The charges for carrying out all other routine/acceptance tests shall be deemed to be included in the Bid price.

- 6.2.0 Sampling scheme and criteria for acceptance shall be as per IS.

- 6.3.0 Acceptance test shall be conducted at Site on completion of installation and commissioning and immediately prior to putting the battery in service.

- 6.4.0 Type tests shall comprise the following:

- Verification of constructional requirements.
- Dimensional check
- Test for capacity
- Retention of charge test
- Ampere - hour and watt-hour efficiency tests.
- Life & Endurance test.
- Short circuit current and internal resistance measurement test.
- Test for loss of capacity on storage
- Test for resistance to overcharge
- Test for voltages & specific gravity during discharge.
- Test for high rate discharge at normal temperature & at low temperature.
- Internal resistance measurement test.
- Accelerated aging test followed by Seismic test.

- 6.5.0 Acceptance tests shall comprise the following:

- Visual inspection.
- Dimensional check
- Test for capacity
- Test for voltages & specific gravity during discharge.
- Insulation resistance.
- Internal resistance of cells.

- 6.6.0 Site tests shall comprise the following:

- Check name plate details according to the specification
- Check for physical damage
- Check tightness of all bolts, clamps, joints and connecting terminals
- Check for electrolyte level
- Check for correct polarity
- Check charging and discharging cycle

9.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Battery sizing calculation
- Technical data sheet
- General arrangement, layout drawing and section
- Battery room layout
- Rating factor & Battery selection table



- Erection and commissioning procedures
- Operation and maintenance manual
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.15: UNINTERRUPTED POWER SUPPLY SYSTEM

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of 230 V UPS system.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the parallel redundant UPS with voltage stabilizer for the following:

- a) UPS for each Unit-1 for main plant.
- b) UPS for each Unit-2 for main plant.
- c) UPS for switchyard.
- d) UPS for coal handling plant
- e) UPS for Ash handling plant
- f) UPS for Water treatment plant
- g) UPS for fuel oil system.
- h) UPS for cooling water pump house.
- i) UPS for seawater intake pump house.
- j) UPS for other auxiliary plants such as H2 plant, AWRPH, Ash Silo, FOPH etc.
- k) UPS for service building and Admin building.
- l) Commissioning spares and consumables
- m) Mandatory spares
- n) Tools & tackles
- o) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Indian Standards, except where modified and /or supplemented by this specification.

a) IEC : 62040	Uninterruptible Power Systems (UPS)
b) IS: 3895	Mono crystalline semiconductor rectifier cells and stacks.
c) IS: 4540	Mono crystalline semiconductor rectifier assemblies and equipment.
d) IS: 6619	Safety code for semiconductor rectifier equipment.
e) IS 6297	Transformer and inductors for electronic equipment
f) IS 13947	LV switchgear and control gear
g) IS 6553	Environmental requirements for semi-conductor devices and integrated circuits
h) IS 9000	Basic Environmental Testing Procedures for Electronic and Electrical Items

4.0.0 DESIGN REQUIREMENTS

4.1.0 UPS system shall be Digital type. It shall provide uninterrupted power supply to critical AC loads such as Control & Instrumentation system, DCS system, Respective control system, etc.

4.2.0 UPS, which shall be located in air-conditioned area, shall be designed for design ambient temperature of 30°C. Other equipment shall be designed for design ambient temperature of 50°C.



4.3.0 Each UPS shall be parallel redundant UPS system consisting of 2X100% chargers, 2X100% inverters, 2X100% Battery, SMPS based voltage stabiliser, Static bypass and Maintenance bypass, UPS DB, MCCB box for battery, interconnecting cables among UPS & voltage stabiliser etc.

4.4.0 Single Line Diagram for UPS Distribution is enclosed in Section-7 of Volume-II.

4.5.0 UPS shall be located in Air conditioned room.

4.6.0 Battery shall conform to the requirements stated in 'Battery section of this specification.

4.7.0 UPS battery shall be rated for 60 minutes back up

4.8.0 UPS shall have following features:

- Digital Technology
- True on-line double conversion
- High frequency PWM design
- Programmable power walk-in
- High efficiency
- High input power factor
- Constant voltage & frequency
- Pure sine wave output power with no break output during normal to battery operation
- Wide frequency synchronizing range
- Wide input range
- Soft start capability
- 100% nonlinear load handling capability
- LED mimic
- LCD Display
- RS 232 /RS 485 Interface complete with Communication software
- Permissible harmonics at rated continuous load +/- 2% for linear loads & 3% for non-linear loads.

4.9.0 UPS shall be suitable for connecting to a 415 V, 3 phase, 4 wire, 50 Hz system with a symmetrical fault level of 50 kA rms. Nominal voltage output shall be 230 V, 50 Hz, Single phase with +/- 1% resolution.

4.10.0 Variation in inverter output voltage and frequency shall not exceed specified limits for the load variation between zero and the rated output of the UPS and also for the following input supply variation.

- For the input power supply condition of 415 V +/- 10% and 50 Hz +3%, -5%
- For the DC input voltage over the range corresponding to battery float / boost charge operation and battery operation and battery discharge operation up to battery end cell voltage.

4.11.0 The changeover from inverter to by-pass transformer shall not be more than 5 m.second.

4.12.0 The design shall provide for high availability of equipment by ensuring high mean - time - between failures (MTBF) and low mean-time-to-repair (MTTR).

4.13.0 The UPS shall have an over load capacity of 125 % rated capacity for 10 minutes and 150 % rated capacity for 10 sec. The inverter shall have sufficient I^2t capability to clear fault in the maximum rated branch circuit. The sizing of UPS shall be based on the power factor of the loads being fed subject to a maximum of 0.8.



- 4.14.0 On failure of one UPS, the other UPS shall take over the 100% load automatically without any interruption and on failure of both UPS, voltage stabiliser shall take over the power supply distribution and shall supply the power without any interruption.

5.0.0 TECHNICAL REQUIREMENTS

- 5.1.0 The UPS system including the stabilized bypass shall be galvanically isolated from input power supply system by providing double wound Isolation transformers. A rectifier shall have a double wound transformer at its input.
- 5.2.0 Transient / surge protection circuit shall be provided in the input circuit to rectifiers to protect the UPS from surge & voltage spikes.
- 5.3.0 The UPS shall be provided with automatic sequence and power walk in circuits with adjustable time delay such that the rectifiers and inverters can start operating automatically when incoming AC power is restored allowing the UPS to be loaded automatically.
- 5.4.0 The inverters shall operate satisfactorily for variation of DC bus voltage from fully discharged condition of the battery to rapid charge voltage of the battery and inverter output load current waveform having a relative harmonic.
- 5.5.0 It shall be possible to vary the inverter output voltage steplessly within $\pm 5\%$ of the specified output voltage. This adjustment shall be possible to be made when the inverter is in operation.
- 5.6.0 UPS shall be provided with current limit circuit to avoid excessive loading beyond its permissible overload withstand capability. The UPS shall be designed to permit ready access to power switching and control modules and PCBs. The locations of components, test points and terminals shall be such that they are accessible for circuit checking adjustment, trouble shooting, and maintenance from the UPS without removal of any adjacent module or assembly.
- 5.7.0 The stabilized bypass supply shall have a continuous current rating equivalent to the rated output of the UPS unit and be capable of conducting a current ten times the rated output for the duration more than the fault clearing time of the type of fuse provided. The load transfer devices shall comprise of continuous rated elements in both inverter and stabilized bypass supply.
- 5.8.0 The inverters shall be phase locked to the stabilized bypass power supply as long as stabilized bypass supply frequency remain within $+ 3\%$ to $- 5\%$ of nominal. When bypass supply frequency variation exceeds the above limits, the inverters shall be delinked from mains. Free running frequency tolerance limit shall not exceed $\pm 1\%$. Facility shall also be provided for adjustment of synchronizing frequency from 1% to 5% in the steps of 0.5%.
- 5.9.0 All electronic power devices including thyristors, transistors, diodes etc., shall be rated under operating conditions for approximately 200% of the maximum current carried by the device. All other electrical components such as transformers, reactors, breakers, contactors, switches, bus bars etc., shall be rated for atleast 125% of the maximum required rating. No electronic device shall be subjected to PIV greater than 50% of the rated value.
- 5.10.0 All the thyristors, diodes and other electronic devices of UPS shall be protected with high speed semiconductor fuses. It co-ordination characteristics between fuse and semi-conducting power devices shall be furnished.
- 5.11.0 Radio Frequency Filters shall be provided at the input and output of UPS to reduce radio frequency interference.
- 5.12.0 All PCBs shall be provided with a transparent epoxy coating for environmental protection and tropicalisation. They shall be suitably located away from heat sources.



5.13.0 Maximum noise level from UPS system at 1 metre distance, under rated load with all normal cooling fans shall not exceed 65 dBA.

5.14.0 MCCB shall be TPN type for incoming supply to Rectifier circuit & Standby source, DP type for battery & ACDB incomer/outgoing. It shall be quick make, quick break, and independent manual type with trip free feature. All MCCB shall have the following :

- Short circuit release
- ON/OFF Trip position indicators
- Test trip push button

5.15.0 Copper cable shall be used for interconnection among UPS & voltage stabiliser.

6.0.0 MODE OF OPERATION

6.1.0 Normal Mode

- a) During the normal operation the UPS shall be used to provide power to the critical loads. Under normal conditions, the loads shall be supplied by the inverters. The Rectifier shall derive power from normal/primary AC source and supply DC Power to the inverters. Two nos. Chargers shall feed regulated DC power to their individual inverter banks and simultaneously float charge the backup batteries.
- b) The individual inverters shall operate in parallel and shall share the load equally. The inverters shall be connected to load side through electronic switches. Outputs of the inverters are paralleled after the electronic switches and connected to load bus.

6.2.0 Emergency Mode

- a) Upon failure of the normal AC source, the loads shall continue to be supplied by inverters which, without any switching shall obtain their power from storage battery. In case of failure of the main supply, battery shall supply back up DC power to UPS system for duration of sixty (60) minutes.
- b) Upon restoration of the normal AC source, the rectifier/battery chargers shall power the inverters and simultaneously recharge the battery. This shall be automatic causing no interruption to critical loads.
- c) On failure of an inverter due to any one of the following faults the entire load shall be automatically transferred to the other inverter.
 - Excess inverter output voltage
 - Very low inverter output voltage
 - Failure of inverter.
- d) On failure of one inverter, the faulty one shall be isolated from load instantaneously and the other inverter shall continue to feed the load. In case, the other inverter also fails, automatic change over to standby transformer shall be effected through electronic switches.
- e) Parallel operation (load sharing) shall start automatically when the fault condition clears. If the transfer was due to the inverter failure the retransfer (parallel operation) shall be manually initiated.
- f) The entire load shall be automatically transferred to the alternate AC source through electronic switch within a maximum of four (5) milliseconds under the following conditions :



- Battery discharged completely
 - Initiation of manual control switch.
 - Failures of both the inverters
 - Inverter output voltage is more than +/- 5 % of the rated value
 - The load current exceeds specified over load rating and time.
- g) In case of failure of both inverters, electronic transfer switch shall changeover within five (5) milliseconds to connect the alternate AC source to the load. On restoration, the retransfer shall be manually initiated.
- h) Retransfer of load shall be accomplished automatically by synchronizing the inverter to the alternate source and allowing the inverter to ramp into the load and then disconnecting the alternate source.
- i) Manual transfer facility through electronic transfer switches shall be provided in either direction.
- j) In case of maintenance requirement, it shall be possible to isolate inverters and electronic bypass switches from load and connect alternate AC source to the load through manually operated, make before break manual transfer switch.

7.0.0 EQUIPMENT DETAILS

7.1.0 Charger

7.1.1 Charger shall have following features:

- Switch mode rectifier/Phase controlled rectifier
- DC constant voltage, Constant current
- IGBT/SCR power device
- Advanced electronic protection device backed-up with MCCBs and fast acting fuses
- Soft start
- Built in Harmonic suppression
- Active power factor correction

7.1.2 These chargers shall be of static type and shall be provided with suitable full wave thyristorised rectifiers, transformers, filter circuits, DC & AC Switchgear. Chargers shall share automatically the load during parallel operation of the inverter system and shall maintain output voltage within plus or minus one percent of the nominal value from no load to full load.

7.1.3 The rectifiers / chargers shall be designed to completely charge the battery in a maximum time of 8 hours for lead acid batteries, after complete discharge. Facilities shall be provided to initiate battery rapid charge operation by Manual & Automatic means. An auto charging sequence should be provided for the boost and float charging based on current sensing. In addition to above, the charging shall be transferred from boost to float mode after preset time adjustable through 0-24 hour's timer. Rectifier shall have protection & interlocking against single phase input & reverse phase sequencing.

7.1.4 Facility shall be provided to enable testing of rectifier independently without disconnection of inverter.

7.1.5 Facility for initial charging of batteries shall also be provided. The inverters shall be disconnected during initial charging of the battery.

7.1.6 The rectifiers shall be sized based on the maximum inverter input load when inverter is delivering its rated output at 0.8 PF lagging and recharge the battery to nominal rated capacity



of the battery. The DC load imposed by the inverters shall be considered under the worst case where only one rectifier is operating but the UPS load is equally shared by all the inverters.

- 7.1.7 The DC rectifiers shall sense the battery charging current and adjust the DC bus voltage to maintain the charging current to preset level. A separate current limit circuit shall also be provided for adjustment of battery current. The rectifiers shall be protected against reverse battery connection at DC link voltage bus. Subsequent to a discharge cycle when battery is connected to rectifier, the battery current shall be monitored, controlled and limited to set value automatically irrespective of the inverter input current.
- 7.1.8 The battery may be taken out of service for maintenance, during which period it shall be possible for the inverter to continue operation by drawing power from the rectifier. Ripple content shall not exceed 1.5%. Ripple current relay shall be provided to indicate the charger capacity failure.
- 7.1.9 Battery shall be provided with a sensitive earth leakage protection.
- 7.1.10 The chargers shall be current limiting and shall be provided with surge suppression networks for both float and boost charging. All equipment and devices required to protect the chargers from short circuits e.g. fast acting semiconductor fuses, trip fuses and micro switch with alarm contacts etc., shall be provided. Rectifier shall have protection & interlocking against single phase input & reverse phase sequencing.

7.2.0 Inverter

- 7.2.1 Inverters shall have following features:

- Digital PWM IGBT design
- Advanced electronic protection device backed-up with MCCBs and fast acting fuses.
- High speed pulse balancing electronic over voltage/under voltage protection
- Electronic overcurrent trip with reset.

- 7.2.2 Inverters shall be PWM controlled IGBT (Insulated gate bipolar transistor), filters, necessary oscillators, voltage regulators, current limiting and surge suppression networks. Two nos. 100% capacity Inverters shall be provided. In addition the inverters shall have features of soft start, wave shaping, transient recovery etc. Any other equipment required for normal operation of the inverter shall be included irrespective of whether specified or not.
- 7.2.3 The inverter input voltage shall match with the battery and rectifier charger output voltages and shall be designed to operate over the entire range of variation of input DC voltage to accommodate decrease in battery voltage during discharge and to accept voltage increase under battery boost charge or equalizing charge conditions. The output from the inverter shall be 230 V AC, sine wave 1 phase.
- 7.2.4 The inverters shall always work on their internal oscillators or frequency variations with plant AC electrical system. Output voltage frequency shall be controlled simultaneously for both the inverters through common control bus. The plant AC electrical system shall provide a signal to each inverter to control the frequency and phase relationship of its output during normal operations. When this signal to an inverter deviates more than one hertz from the desired 50 Hz frequency, the inverter shall transfer automatically to its internal oscillator which shall maintain inverter frequency at 50 Hz. Within 0.5%. During operation on its internal frequency signal source, an inverter shall continuously monitor the frequency of the plant auxiliary AC electrical system.
- 7.2.5 Upon restoration of the plant auxiliary AC electrical system to 50 Hz. operations, inverter shall automatically adjust the phase relationship between its output and the plant auxiliary AC electrical system and return to the plant auxiliary AC electrical system as its output frequency



and phase relationship signal source. During operation on its internal oscillator and inverter shall inhibit transfer of the electronic transfer switch to the alternate source. The automatic adjustment of the phase relationship between the inverter output and plant auxiliary AC system shall be accomplished at a controlled rate which shall not exceed one hertz per second. The inverters shall include a separate voltage distribution and voltage monitoring system for all command and interlock logic.

- 7.2.6 Selective protection shall be provided for each individual drive card and its associated interlock logic. The two inverters shall be designed for normal continuous parallel operation. To maintain specified output at maximum ambient temperature, inverters may be provided with cooling air fans as required. Fan cooling, if envisaged, shall be achieved with 2 x 100% cooling banks. One cooling fan bank shall be in operation while the other shall remain on standby. In case of failure of running bank / one fan, the standby bank shall start automatically. The power supply for the fans shall be tapped from the inverter output.
- 7.2.7 All the fuses used in inverter power and control circuits shall be fast acting semiconductor type, operating in less than 5 m.second. Indications and alarms shall be provided to enable fault to be located and rectified at the earliest. Lamps to indicate fault / trouble / failure of each sub group shall be provided on the cubicle front and lamps for each logic card shall be provided on the card itself.

7.3.0 Electronic Transfer Switch

- 7.3.1 The electronic transfer switches shall use SCRs and other electronic devices, for automatic transfer of load from the Normal source to the Alternate source. The transition shall be "make before break" in both directions. The continuous capacity of each electronic switch shall be equal to the full load capacity of one inverter. Maximum transfer time including sensing shall not be more than ¼ cycle. The voltage failure shall be sensed at the output of the electronic switch. Failure shall cause the electronic switch to transfer. The load from the working inverter shall be transferred to the alternate source, i.e. second inverter or auxiliary power supply source by electronic switches, whenever the output voltage of the inverter deviates more than +10% from nominal. However transfer shall not be made to the alternate source on over current conditions. Transfer shall be permitted only if voltage of the alternate source is within $\pm 2\%$ of nominal. .
- 7.3.2 The electronic switch shall be provided with fuses in both 'normal' and 'alternate' power source. Provision for annunciation of failure of fuse or failure of alternate source shall be made. The switch shall be provided with surge suppression networks and shall also be rated to withstand transient voltages up to 150% of rated voltage. The short time rating of the switch shall be 150% of the rated full load current for two minutes.

7.4.0 Bypass Switch

Make before break type manually operated bypass switch of 100% UPS rated capacity shall be provided in the back up supply circuit to isolate electronic switch and inverter from its load and supply alternate power to load without interruption. Power supply to the loads is continuous during switch operations. Necessary isolators shall be provided to isolate both UPS system completely from back up supply circuit when the UPS loads are fed by back up source through bypass switch.

7.5.0 Transformer and Voltage Stabiliser

Transformers shall be provided at input and as well as output side of UPS.

The transformer shall be dry type, double wound, Class F insulated with copper conductor limiting temperature rise to class B limits, enclosed in CRCA sheet steel panel 2 mm thick. The cooling shall be by means of natural convection. Transformer connection shall also be



considered, provided the connection has minimum unbalance on the primary side. The transformer shall be adequately rated for the duty involved. The actual value may be slightly increased to take care of any losses in the voltage stabilizer.

Voltage stabilizer shall employ SMPS controlled circuitry and shall maintain the specified output voltage for 0 to 100% load, with maximum input voltage variation.

7.6.0 UPS Enclosure & Accessories

UPS shall be metal enclosed, fixed type, suitable for indoor mounting on floor. Panel shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm for load bearing members and 1.6 mm for non-load bearing members. Suitable synthetic rubber gaskets shall be provided to achieve a degree of protection of IP-31. At bottom removable gland plates of atleast 3 mm thick shall be provided. All incoming and outgoing cables shall be terminated on suitable terminal blocks.

7.7.0 Metering & Protection

Voltage, current, frequency at input and output shall be measured either through LCD display or separate meters in UPS panel front. For remote metering of essential parameters, 4-20 mA transducer outputs shall be provided. For remote indication/ annunciation, potential free contact shall be provided along with RS485 port. LED status indications and alarm indications shall be provided on the mimic on the panel. The following protections shall be provided.

- MCCB at each input supply
- DC MCCB at Battery supply
- Filter at input
- Surge suppressor across transformer secondary
- Semiconductor fuses for SCR bridges
- HRC fuses for filter capacitors
- DC over voltage protection
- Charger input current limit
- Battery current limit
- Under voltage on input side
- Negative sequence current protection on input side
- Overload on inverter
- DC ground fault protection
- HRC fuses in control circuit
- Under voltage / Over voltage protection
- Any other protection required for safe operation of the UPS.

Isolated 4-20 mA signals AC input voltage, current, AC output voltage, current, DC battery voltage, current and Alarms such as AC I/P supply failure, AC O/P (UPS output) supply failure, Inverter trouble etc., shall be considered for remote connection to DCS/EMS/SAS.

7.8.0 UPS AC Distribution Board

7.8.1 AC distribution board shall be metal enclosed, fixed type, suitable for indoor mounting on floor, bottom cable entry. The distribution board shall be single front having horizontal and vertical bus bars. All bus bars shall be PVC sleeved. Where specified, it shall be compartmentalized type.

7.8.2 The distribution board shall be fabricated using cold rolled sheet steel of thickness shall be 2.0 mm minimum for load bearing and 1.6 mm for other members and enclosure shall be IP 52. Earthing bus bar shall run in the bottom chamber through the length of the panel. Suitable synthetic rubber gaskets shall be provided to make boards completely dust and vermin proof. Two separate grounding pads shall be provided for each panel.



7.8.3 MCCBs shall be of triple pole construction for panel mounting, operating mechanism shall be trip free, quick make quick break type. MCCB should be current limiting type only. The MCCBs shall be provided with front operating handles & mechanical ON/OFF indicators. MCCBs shall be provided with overload releases setting range of 80% to 100% of rated current and adjustable short circuit magnetic releases from 5-10 times rated current. MCCBs shall have following accessories & features:

- Shunt trip release
- Auxiliary contact set of 1 NO + 1NC
- Fault signalling contact set of 1 NO + 1NC
- Insulation shields to isolate the connection between each pole.
- Finger protection plate to prevent accidental contact.
- The compartment door shall be interlocked with handle of MCCB

7.8.4 MCB shall be rated for 10 kA short circuit rating. It shall be quick make, quick break, and independent manual type with trip free feature. MCB shall have the following :

- Over current protection
- ON/OFF Trip position indicators
- Auxiliary contact block

7.8.5 Painting

The fabricated parts shall undergo a treatment of degreasing, pickling and two coats of primer before being given the epoxy finish. Two coats of final paint shall be applied. The external and internal surface of the board shall be powder coated epoxy finish of gray shade RAL 7035. The final thickness of paint film on steel shall not be less than 50 microns.

8.0.0 TESTING & INSPECTION

8.1.0 Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. The Owner shall review the type tests certificates furnished by the bidder at contract stage. Routine tests, functional tests and system tests shall be carried out as per applicable standard. Copies of certified reports of all tests carried out at the works shall be furnished.

8.2.0 Following tests shall constitute functional tests for the panel as per IS:4540 & IS:9000

- Voltage regulation
- Ripple content at different loads and noise measurement
- Insulation resistance test
- General operation
- Voltage/current stability test
- High voltage test
- Measurement of surface temperature of charger panel
- Current limiting features.
- Efficiency & PF measurement
- Temperature Rise test
- Short circuit at full load
- Short circuit at No load
- Connection checking of Rectifier assembly.

8.3.0 Following tests shall constitute type tests on the panel.

- Degree of protection Test for Panel
- Vibration Test of the Electronic Card Rack/Panel



- Environmental Tests on the Electronic Cards
- RFI Test
- Surge Withstand capability Test

8.4.0 System tests shall be performed on the completely assembled UPS system at Manufacturer's works. System tests shall include the following:

- Frequency regulation
- Voltage regulation
- Current limiting feature
- Voltage & frequency control of inverters for synchronisation
- Harmonic content tests
- Transfer of load through electronic switch due to inverter failure
- Loss on inverter output
- Under voltage
- Load overcurrent
- Manual transfer/Retransfer
- Mains failure/restoration
- Tests on alarms/indications
- Availability test

8.5.0 **Site tests shall include the following:**

- a) Check name plate details according to the specification
- b) Check for physical damage
- c) Check tightness of all bolts, clamps, joints and connecting terminals
- d) Check earth connection and earth continuity
- e) Check for polarity
- f) Functionally check all control circuits
- g) Check connections and wiring
- h) Megger all terminals to body
- i) Test relay cards
- j) Test CTs and VTs
- k) Test rectifier transformer

9.0.0 **DRAWINGS & DOCUMENTS**

The following drawings and documents shall be submitted for approval during detail engineering stage.

- UPS sizing calculation
- Technical data sheet
- Dimensional general arrangement drawing of UPS.
- Dimensional general arrangement for distribution board.
- Schematic & wiring diagram for UPS.
- Single line diagrams
- Sizing calculation for battery
- Cable schedule/ Interconnection diagram.
- Erection and commissioning procedures
- Operation and maintenance manual
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.16: MOTORS

1.0.0 INTENT OF SPECIFICATION

This section covers the technical requirements of HT motors, LT Motors and DC motors.

2.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest edition (including amendments) of the following Indian Standards (IS), IEC publications and other codes except where modified and /or supplemented by this specification.

a) IS: 325	Three phase induction motors
b) IS: 12615	Energy efficient induction motors
c) IS: 900	Code of practice for installation and maintenance of induction motors
d) IS: 996	Single-phase AC induction motor for general purpose
e) IS: 1231	Dimensions of three-phase foot-mounted induction motors
f) IS: 2223	Dimensions of flange mounted AC induction motors
g) IS: 4029	Guide for testing three-phase induction motors
h) IS: 8789	Values of performance characteristics for three-phase induction motors
i) IS: 13555	Guide for selection and application of 3-phase AC induction motors for different types of driven equipment
j) IS: 5571	Guide for selection of electrical equipment for hazardous areas
k) IS: 12065	Permissible limits of noise level for rotating electrical machines
l) IS: 12075	Mechanical vibration of rotating electrical machines
m) IS 60034-5	Degree of protection provided by Integral design of rotating electrical machines
n) IS 60034-8	Terminal marking and direction of rotation
o) IS 60079-1	Equipment protection by flame proof enclosure
p) IS 60034-1	Rotating electrical machines.
q) IS 60079	Explosive atmospheres
r) IS/IEC 60529	Degrees of protection provided by enclosures (IP code)
s) IEC 60034	Rotating electrical machines.
t) IS 3177	Code of practice for Design, Manufacture, Erection and testing of Cranes and Hoists

3.0.0 TECHNICAL REQUIREMENTS

3.1.0 Design ambient temperature

Motors shall be suitable for an ambient temperature of 50 degree C and relative humidity of 95% and shall deliver the rated output without exceeding its guaranteed temperature limits.

3.2.0 Supply voltage

Motors rated up to and including 415 V are termed as LT motors and the motors rated higher than 415 V are termed as HT motors.

Motors shall be capable of delivering the rated output under following voltage and frequency variations without exceeding its guaranteed temperature limits.



- Frequency variation : (+) 3% and (-) 5%
- Voltage variation for LT motors : ($\pm$) 10%
- Voltage variation for HT motors : ($\pm$) 6%
- Combined variation of voltage and frequency : 10% (absolute sum)

All the motors shall be so designed that maximum inrush currents, locked rotor torque and pullout torque developed at extreme voltage and frequency variations do not endanger the motor and the driven equipment.

3.3.0 System Parameters

Sl. No.	Description	11 kV and 6.6 kV System	LT System
1.	Voltage level	6.6 kV : Above 200 kW and upto 2000 kW 11 kV: Above 2000 kW	240 V : up to 0.2 kW 415 V: >0.2 kW and up to 200 kW.
2.	System earthing	Earthed through resistance, limiting earth fault current to 300 Amps	415 V system solidly grounded.
3.	Fault withstand rating of motor terminal box (Breaker operated)	50 kA for 0.2 sec for 11 kV and 31.5 kA for 0.2 sec for 6.6 kV	415 V system : 50/65 kA for 0.2 second

3.4.0 Type

AC Motors shall be squirrel cage induction type unless otherwise it is specified.

3.5.0 Duty

- All AC motors shall be squirrel cage three phase/single phase induction motors. All the motor shall be designed for bi-directional rotation.
- All the motors shall be rated for S1 duty for continuous operation. Motors of crane and hoist application shall be intermittent duty.
- DC motor shall generally be of shunt wound type rated for 220 V DC.
- Motors shall be suitable for installation in hot, humid and tropical atmosphere and polluted at places with coal ash and or fly ash.
- The motors shall be suitable for bus transfer schemes provided on the 11 kV/6.6 kV/415 V systems without any injurious effect on its life.

3.6.0 Design margin

Whenever the basis for motor rating are not specified in the corresponding mechanical specification section maximum continuous motor rating shall be atleast 10% above the maximum load derived of the driven equipment under entire operating range including voltage & frequency variation.

The motor characteristics shall match the requirements of the driven equipment so that adequate starting, accelerating; pull up, breakdown and full load torques are available for the intended service.

Service shall be considered as 1.0 only.



3.7.0 Method of Starting

- All the motors shall be suitable for direct on-line starting on full load. Where variable voltage and variable frequency (VVFD) operation is envisaged through VVFD drives, motors shall be specially designed for such application.
- LT motors rated up to 125 kW shall be controlled through MPCB/MCCB and contactor. LT motors rated more than 125 kW shall be controlled through air circuit breaker.
- HT Motors shall be controlled through vacuum circuit breaker.

3.8.0 Efficiency

All the duty motors shall be energy efficient type. For HT and LT motors, it shall be IE3 class as per IS 12615. For VFD controlled HT and LT motors, it shall be IE2 class as per IS 12615.

3.9.0 Temperature rise

- Winding Insulation shall be Class F.
- Temperature rise of air cooled motors shall not exceed 70°C over air temperature of 50°C by resistance method, while delivering its maximum rated output.
- Temperature rise of water cooled motors shall not exceed 80°C over inlet cooling water temperature by resistance method, while delivering its maximum rated output.

3.10.0 Starting voltage

- a) Motors shall be capable of starting and accelerating the load at following starting voltage, with direct on-line starting, without exceeding specified winding temperatures.
 - HT Motors (up to 1000 kW) : 85% of rated voltage
 - HT Motors (> 1000 kW up to 4000 kW) : 80% of rated voltage
 - HT Motors (> 4000 kW) : 75% of rated voltage
 - LT motors : 80% of rated voltage
- b) During fast changeover of power supply source, vector difference between the motor residual voltage and the incoming supply voltage shall be about 150% of the rated voltage and the motors shall withstand voltage stress and torque stress developed during that time, which may last for a period of one (1) second.
- c) The motor shall be capable of operating at full load at a supply voltage of 75% of the rated voltage for 5 minutes.

3.11.0 No. of Starts

Continuous duty motors shall be suitable for the following starting requirements under the specified conditions of load, torque and inertia.

- No. of consecutive hot starts shall be 2 (with initial temperature of the motor at full load operating level).
- No. of consecutive cold starts shall be 3 (with initial temperature of the motor at ambient temperature).
- For conveyor motors, no. of consecutive hot starts shall be 3 (with initial temperature of the motor at full load operating level).



3.12.0 Starting current

- Locked rotor current of HT motors for applications other than listed below shall be limited to 600% of the full load current, and is subject to IS tolerance.
- For energy efficient LT motors, locked rotor current shall be as per IS: 12615.
- Locked rotor current of the VFD controlled AC motors shall be limited to 300% of the full load current, and is subject to IS tolerance.
- Locked rotor current of the BFP motors shall be limited to 450% of the full load current of the motor, and is subject to IS tolerance.

3.13.0 Locked rotor withstand time

- The locked rotor withstand time for HT motors under hot conditions at 110% rated voltage shall be more than the starting time at minimum permissible voltage specified above by atleast three seconds or 15% of the accelerating time whichever is greater. Provision of speed switch shall be avoided to the extent possible. In case the speed switch is required, it shall be indicated by the bidder in his offer
- For the LT motors having starting time up to 20 seconds at minimum permissible voltage, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 2.5 seconds more than the starting time.
- For the motors having starting time more than 20 seconds and up to 45 seconds at minimum permissible voltage, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 5 seconds more than the starting time.
- For motors having starting time more than 45 seconds at minimum permissible voltage, the locked rotor withstand time under hot condition at highest voltage limit shall be more than starting time by at least 10% of the starting time.
- Speed switches mounted on the motor shaft shall be provided in cases where above requirements are not met.
- When a speed switch is mounted on the motor shaft, the same shall remain closed for speeds lower than 20% and open for speeds above 20% of the rated speed. The speed switch shall be capable of withstanding 120% over speed in either direction of rotation.

3.14.0 Torque Requirements

- Accelerating torque at any speed with the lowest permissible starting voltage shall be at least 10% motor full load torque.
- Pull out torque at rated voltage shall not be less than 205% of full load torque.
- Motors subjected to reverse rotation shall be designed to withstand the stresses encountered when starting with non-energized shaft rotating at 125% of rated speed in reverse direction.

3.15.0 Enclosure

- a) Motors shall have IP 55 degree of protection.
- b) For hazardous location, the enclosure of motors shall following have flame proof construction conforming to applicable standard.
 - Fuel oil area Group – IIB
 - Hydrogen generation plant area : Group – IIC)



3.16.0 Cooling

- LT motors shall be totally enclosed fan cooled (TEFC), type IC411. The cooling shall be effected by self-driven bi-directional centrifugal fan protected by fan cover.
- HT motors can be totally enclosed fan cooled (TEFC) or totally enclosed tube ventilated (TETV) or closed air circuit air cooled (CACA-IC6A1A1) type.
- Motors rated >3000 kW can be closed air circuit water cooled (CACW).
- Motors with CACA/CACW heat exchangers shall have dial type thermometer with adjustable alarm contacts to indicate the following:
 - Hot and cold air temperatures of the closed air circuit for CACA motors.
 - Hot and cold, air and water temperatures for CACW motors.
- The Alarm switch contact rating shall be minimum 0.5 A at 220 V DC and 10 A at 230 V AC.

3.17.0 Winding

- Winding shall be class F insulation with temperature limited to class B. Insulation shall be Non-hygroscopic, oil resistant, and flame resistant. Winding, fittings and hardware shall be corrosion resistant. Winding shall be tropicalized and suitably varnished, baked and treated for operating satisfactorily in humid and corrosive atmosphere.
- For the VFD operated drives, insulation shall be designed to take care of stresses due to high DV/DT. Motors shall be wound with dual coated winding wires and impregnated with VPI process. Further for such application, insulated bearings shall be provided to avoid circulating current caused by shaft induced voltages.
- Space heaters rated for 240 V AC, 50 Hz supply shall be provided for motors rated 30 kW and above to maintain windings in dry condition when motor is standstill.
- For HT motors, insulation shall be Vacuum Impregnated (VPI).
- HT motors shall withstand one minute power frequency voltage test or 1.2/50 micro sec lightning impulse Voltage wave of $4U+5$ kV (U =Line voltage in kV) test on main insulation as per IEC 60034-15. The coil inter-turn insulation shall withstand steep front impulse withstand voltage as per IEC 60034-15.
- For HT motors, 12 nos. simplex or 6 nos. duplex RTDs (two per phase), each having D.C. resistance of 100 ohms at 0°C, embedded in the stator winding at locations where highest temperatures may be expected, shall be provided. The material of the ETD's shall be platinum.

3.18.0 Bearings

- Motor shall be provided with antifriction bearings, unless sleeve bearings are required by the motor application. Bearings shall be provided with seals to prevent leakage of lubricant or entrance of foreign matters like dirt, water etc. into the bearing area.
- Sleeve bearings shall be split type, ring oiled with permanently aligned, close running shaft sleeves. Grease lubricated bearings shall be pre-lubricated and shall have provisions for in-service positive lubrication with grease nipple and relief holes. For sleeve bearings, the bearing housing shall be preferably in end shield itself.
- Vertical shaft motors shall be provided with thrust and guide bearings. Thrust bearing of tilting pad type is preferred. However, if anti-friction bearings can take vertical thrust, thrust and guide bearings are not required.



- Lubricant shall not deteriorate under all service conditions. The lubricants shall be limited to normally available types. For motors rated 30 kW and above re-lubrication facility shall be provided.
- For motor with forced lubrication, a shaft driven oil pump shall be provided along with an electrical auxiliary pump. Alternatively, two motor driven pumps may be provided, one working and one standby. All necessary auxiliaries and accessories shall be provided to complete the system. A pressure gauge and pressure switch for low oil pressure warning and to start the standby oil pump automatically shall also be provided. A motor driven jacking oil pump may be provided, for heavy shaft loads.
- Flow switches shall be provided for monitoring oil flow of forced lubrication bearings, if used. Alarm switch contact rating shall be minimum 0.5 A at 220 V DC and 10 A at 230 V AC.
- For bearing temperature measurement, duplex RTDs shall be provided for each bearing and shall be wired up to the terminal box.
- Each bearing shall be provided with dial type thermometer.
- For all VFD operated motors shall have insulated bearings to prevent flow of shaft currents.
- For motors rated above 1000 KW having shaft length more than 1.5 M shall have insulated bearings to prevent flow of shaft currents.
- All the motors rated <15 kW shall be provided with sealed ZZ bearings.
- Lub oil pressure transmitters shall be provided to DCS for remote monitoring. Lub oil pressure very low trip to HT equipment shall be 2 out of 3 logic.

3.19.0 Terminal Boxes

- Separate terminal boxes of IP 55 degree of protection shall be provided for stator leads. For single core cables, gland plate shall be non-magnetic material. Terminal box of HT motors shall be capable of being turned 360° in steps of 180°. Terminal box of LT motors shall be capable of being turned 360° in steps of 90°. The terminal boxes shall be split type with removable cover with access to connections.
- Terminals for motors shall be stud type, thoroughly insulated from the frame. The terminals shall be clearly identified by phase markings, with corresponding direction of rotation marked on the non-driving end of the motor.
- The terminal box shall be capable of withstanding maximum system fault current for 0.2 sec for all breaker operated motors and shall be provided with explosion vent.
- For contactor operated LT motors, the terminal box shall be capable of withstanding the fault current for 0.2 sec minimum and operating time of MPCB/MCCB.
- Removable gland plates of thickness not less than 2.5 mm sheet steel or 3 mm aluminium (for single core cables) shall be provided for cable boxes.
- Cable spreader box shall be provided for larger cable sizes.
- Cable boxes of HT motors shall be phase segregated type. The terminals of three phases shall be segregated by barriers of metal or fiber glass. For HT motors, cable box design shall be suitable for accommodating cable termination kits.
- Separate terminal box for space heaters shall be provided.
- A separate terminal box of IP 55 degree of protection shall be provided for temperature detectors.
- Motors rated >1000 kW shall be provided with neutral current transformers of PS class on each phase for differential protection in neutral side terminal box. The three phases shall be connected to form the star point after passing through the CTs. The CT details shall be



finalized during detail engineering. Neutral terminal box shall have IP 55 degree of protection.

- The secondary leads of CT shall be wired to separate auxiliary terminal box of IP 55 degree of protection
- All the accessory terminal boxes shall be located on the same side of the main (power) terminal box.
- For LT motors, terminal box shall be located on top, unless otherwise specified.

3.20.0 Earthing Terminals

The frame of each motor shall be provided with two separate and distinct grounding pads complete with tapped hole, GI bolts and washer. The terminal box shall have a separate grounding terminal.

3.21.0 Noise and Vibration

- Motors shall be selected with low noise levels in accordance with IS 12065.
- The peak amplitude of the vibration shall also be within the specified limits of IS: 12075.
- All HT motors shall be provided with vibration pads for mounting vibration detectors.

3.22.0 Name Plates

Motor shall have stainless steel nameplate(s) showing diagram of connections, all particulars as per IS: 325 / IS: 12615 and shall also have 'BEE' marking.

In addition to the minimum information required by IEC/IS, the following information shall be shown on motor rating plate:

- Temperature rise in °C under rated condition and method of measurement.
- Degree of protection.
- Bearing identification no. and recommended lubricant.
- Location of insulated bearings.

3.23.0 Canopy

Canopy shall be provided for all the motors located outdoor. For details, please refer Civil section.

4.0.0 DC MOTORS

DC motors shall be provided where specified/required. DC Motors shall be sized for operation with fixed resistance starting for reliability. DC motors shall be shunt wound type. Motors shall be capable of delivering the rated output at 220 V DC with (+) 10% and (-) 15% variations without exceeding its guaranteed temperature limits. 220 V DC system shall be unearthed. Starting current of the DC motors shall be limited to 200% of the full load current of the motor, and is subject to IS tolerance. DC Motors shall be similar to AC Motors with respect to other features like enclosure type, cooling and class of insulation.

5.0.0 INSTALLATION

Installation shall be carried out as per IS: 900.

6.0.0 PAINTING

Painting shall be carried out by an approved process. Pretreatment shall conform to applicable standard. The equipment shall be subject to a coat of red oxide primer paint. All inside and



outside surface shall be painted with epoxy based paint. The final thickness of paint film on steel shall not be less than 100 microns. Finish shade shall be 631 of IS: 5 (smoke grey).

7.0.0 TESTING AND INSPECTION

7.1.0 Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished for the motors rated 30 kW and above.

7.2.0 The following type tests shall be conducted on LT motors.

- Measurement of resistance of windings of stator and wound rotor.
- No load test at rated voltage to determine input current power and speed
- Full load test to determine efficiency power factor and slip.
- Temperature rise test.
- Momentary excess torque test.
- High voltage test.
- Test for vibration severity of motor.
- Test for noise levels of motor
- Test for degree of protection
- Over speed test.

7.3.0 The following additional type tests shall be conducted on HT motors.

- No load saturation and loss curves up to approximately 115% of rated voltage
- Measurement of noise at no load.
- Momentary excess torque test
- Full load test
- Temperature rise test at rated conditions.
- Lightning Impulse withstand test on the sample coil shall be as per IEC-60034, part-15
- Surge-withstand test on interturn insulation shall be as per clause no. 5.1.2 of IEC 60034, part-15
- Degree of protection test for the enclosure followed by IR, HV and no load run test.
- Terminal box-fault level withstand test for each type of terminal box.

7.4.0 The following routine tests shall be carried out for the motors as per applicable standards.

- IR of Winding before and after HV tests
- HV test on main winding space heater, RTD, BTD
- Resistance measurement
- No load run test Major Electrical
- Phase sequence and direction of rotation
- Vibration check Major Electrical
- Reduced voltage running test
- Locked rotor test at reduced voltage
- Record of RTD & BTD resistance at the end of no load test
- Test on space heater & RTD
- Visual Control of terminal box and verification of construction with respect to short tested terminal box

7.5.0 The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- Measurement of vibration.
- Measurement of insulation resistance and polarization index.
- Measurement of full load current.
- Test running of the motors, checking the temperature rise and identifying the hot spot etc.



8.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Motor sizing calculation
- Technical particulars
- General arrangement drawings
- Performance curves (Efficiency, power factor, starting current)
- Characteristic curves (Speed torque, Hot/cold with stand time, Negative sequence current)
- Terminal box details
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.17: ELECTRICAL ACTUATORS

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of motor operated electrical actuators.

2.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest edition (including amendments) of the applicable Indian Standards (IS), IEC publications and other codes except where modified and /or supplemented by this specification.

3.0.0 TECHNICAL REQUIREMENTS

- 3.1.0 Electric actuators shall be provided as specified in Mechanical and C&I section. It shall be equipped with 3 phase induction motor, rated for S2-15 minutes duty for ON/OFF valve and intermittent duty for inching duty
- 3.2.0 Motor shall be class F insulated with temperature rise limited to class B. Motor shall be of class H insulation with temperature limited to class B used for high pressure and high temperature valves.
- 3.3.0 Motor shall be surface cooled designed for enclosure protection class of IP 67. Motor shall be suitable for starting direct on-line.
- 3.4.0 For installation in potentially hazardous areas, the actuators shall have suitable explosion proof / flame proof type enclosure.
- 3.5.0 Actuators shall be suitable for operation at an ambient temperature of 50 degree C and relative humidity of 95%.
- 3.6.0 Maximum continuous motor rating shall be atleast 10% above the maximum load derived of the driven equipment under entire operating range including voltage & frequency variation.
- 3.7.0 Motors shall be capable of operating under following supply variations without exceeding its guaranteed temperature limits.
- Frequency variation : (+) 3% and (-) 5% of 50 Hz
 - Voltage variation for LT motors : (±) 10% of 415 V
 - Combined variation of voltage and frequency: 10% (absolute sum)
- 3.8.0 All actuators shall be of integral type. Duty cycle of actuators shall suit the system requirement. The actuators shall be capable of giving the required torque at the output shaft. The actuators shall be designed to take the full thrust.
- 3.9.0 Electrical Actuators of Inching type position transmitters of non contact type shall be interfaced to DCS.
- 3.10.0 Actuators shall be of totally enclosed weather proof and dust proof construction with NEMA-6/IP 65 enclosure and shall be suitable for outdoor application without the necessity for a canopy. The actuator shall be suitable for mounting directly on the valve. The actuator shall be capable of giving the required torque, rpm and thrust without the help of any spur gear arrangement. The actuator shall be suitable for mounting in any position. Actuators shall be provided with integral starters.



- 3.11.0 The actuator shall be complete with motor, reduction gears, change gears, terminal compartment, switch compartment with limit switches and torque switches, local position indicator, position transmitter for remote position indicator, thermistor, space heaters, cable glands, mechanical position indicator, hand wheel for manual operation, valve attachment etc.
- 3.12.0 Each actuator shall have a hand wheel fitted on it for emergency operation. The hand wheel shall be designed such that it is declutched automatically when the power supply to the motor is restored. The material of the hand wheel shall be either malleable iron or steel. The hand wheel shall have adequate clearance from housing for each gripping and operation. Actuators offered shall be with self-locking worm.
- 3.13.0 Two number adjustable torque switches (one for open and one for close) each with 2 NO and 2 NC potential free contacts shall be provided. It is required to have calibration for the torque switches so that the switches can be easily set to any value desired.
- 3.14.0 Two numbers of position limit switches (one for open and one for close) each with 2 NO and 2 NC potential free contacts shall be provided. Two auxiliary limit switches (one for open and one for close) with 2 NO and 2 NC potential free contacts shall also be provided. The limit switches shall be of independently adjustable type. Limit switches and actuating mechanism shall be rust proof suitable for damp atmospheres. Limit switch compartment shall be weather proof and spacious enough for easy setting. The limit switches shall be suitable for the following ratings, both 240 Volts AC, 10 A and 220 V DC, 0.5 Amps.
- 3.15.0 Each actuator shall have a space heater in the limit switch compartment suitable for 240 V AC 50 Hz single phase supply.
- 3.16.0 The wiring from the limit switches, torque switches etc. shall be brought out in a separate terminal box of adequate size, so as to easily terminate the control cables.
- 3.17.0 Actuators shall be supplied with integral starter which shall have sophisticated electronic controls with field programming feature. It shall be designed for remote control from DCS/Respective control system. Required interposing relays for receiving open/close/stop command from DCS/Respective control system shall be provided. Potential free contacts and transducers shall be provided to provide status indication at remote DCS/Respective control system..
- 3.18.0 A three position selector switch (marked as LOCAL-OFF-REMOTE) and push buttons OPEN-STOP-CLOSE (for local operation) with indication lamps for running OPEN and running CLOSE shall be provided.
- 3.19.0 The Remote command signal (OPEN-STOP-CLOSE) from DCS/Respective control system/Control panel shall be isolated from control electronics through opto-isolator.
- 3.20.0 The following individual sStatus annunciation LED's and fault annunciation LED's shall be provided locally (Integral to actuator) to annunciate the following for easy local monitoring.
- Actuator in local mode
 - Actuator in remote mode
 - Actuator running in OPEN direction
 - Actuator running in CLOSE direction
 - Actuator in inching mode.
 - Actuator in self-retaining mode
 - Limit switch OPEN trip
 - Limit switch CLOSE trip
 - Control voltage availability
- 3.21.0 The following individual fault annunciation LED's (Colour-Red) shall be provided locally. (Integral to Actuator)



- Torque switch OPEN
- Torque switch CLOSE
- Thermo switch trip
- Electronic overload relay trip
- Motor single phasing
- Common fault (Inclusive of any one or combination of above fault)

3.22.0 View port shall be provided on integral starter unit to monitor the above status annunciation and fault annunciation.

3.23.0 Electronic Overload relay shall be provided to trip actuator in case of overload. Plug in connections/design shall be provided between:-

- Integral starter unit and basic actuator
- Between external customer connections and actuator.

3.24.0 OPEN-CLOSE indication /LED shall be provided for indication of full open/close position.

3.25.0 Automatic phase correction facility and potential free contact for annunciation of power failure shall be provided.

3.26.0 The following individual potential free relay contacts shall be provided in the actuator for remote annunciation to facilitate continuous monitoring of the actuator.

- Actuator (valve) running in OPEN direction.
- Actuator (valve) running in CLOSE direction.
- Actuator in remote mode.
- Actuator in local mode.
- Actuator power switched off /single phasing.
- Torque switch trip, thermo switch trip and overload relay trip

4.0.0 TESTING AND INSPECTION

Equipment offered shall be of type tested and proven type. Routine tests shall be carried out for all the equipment as per applicable standards. Copies of certified reports of all tests carried out at the works shall be furnished.

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

- Measurement of insulation resistance.
- Measurement of full load current.
- Test running of the motors.

5.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Integral starter details
- Technical particulars of actuator
- Wiring diagram
- General arrangement drawings
- Test reports
- Manufacturing quality plan
- Field quality plan



SECTION-3.18: DIESEL GENERATOR SET

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of Diesel Generator (DG) set.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) One DG set for unit-1
- b) One DG set for unit-2
- c) One common standby DG set for two units
- d) AMF panel for each DG set
- e) DG controller unit for each DG
- f) Acoustic enclosure for DG set
- g) Exhaust stack with support structure for each DG as per CPCB norms
- h) Commissioning spares and consumables
- i) Mandatory spares
- j) Tools & tackles
- k) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest edition (including amendments) of the following Indian Standards (IS), IEC publications and other codes except where modified and/or supplemented by this specification.

- a) IS/IEC 60034 Rotating electrical machines
- b) IS 15999 Rotating electrical machines
- c) IS 13364 AC Generators driven by IC engines
- d) IS 10000 Method of tests for IC Engines
- e) IS 4503 Heat exchangers
- f) IS 803 Storage Tanks
- g) ISO 8528 Reciprocating internal combustion engine driven alternating current generating sets
- h) ISO 3046 Reciprocating internal combustion engines performance
- i) BS: 5514 Methods of tests for IC engines.
- j) BS 2613 Specification for electrical performance of rotating electrical machines
- k) Regulations laid by the office of the Pollution control board

4.0.0 TECHNICAL AND OPERATIONAL REQUIREMENTS

- 4.1.0 All Electrical Equipment selection and derating shall be based on ambient temperature of 50 deg. C and relative humidity of 95% maximum.
- 4.2.0 Diesel Generator shall be rated for “**Prime duty**”. Generator shall be rated of 415 V, 3 phase, 4 wire supply.
- 4.3.0 The DG Set shall provide power for essential loads, following the loss of auxiliary power. In the event of loss of auxiliary power, AC power shall be supplied by the DG set. Generator shall



feed Emergency Motor control centers. There shall be three (3) no. DG sets, one for each unit and one common standby.

- 4.4.0 Diesel Generator Sets capable of starting and picking up the load within 30 seconds. The DG set shall be sized to feed power supply for the following:
- Barring gear motors of TG set and BFP turbine
 - Seal oil system
 - Air pre heater lub oil pump
 - Jacking oil pumps of main turbine and BFP turbine
 - main oil tank vapour extractors
 - Turbine gear oil pump
 - Turbine auxiliary oil pump
 - Stator water cooling pump
 - Bearing chamber exhaust fan for hydrogen
 - Lubricating oil system of BFP, ID,FD,PA fans
 - Seal air fans
 - Scanner air fans
 - Elevators
 - DC Battery chargers
 - UPS
 - Emergency lighting
 - HP&LP bypass auxiliary PRDS oil supply motors
 - Instrumentation and data acquisition system
 - Mill lub oil pumps
 - Mill inching motor
 - BFP oil tank vapour extractors
 - DM make up pumps
 - Condenser vacuum breaker valve
 - BFP vacuum breaker valve
 - Stand by air conditioner for control room and control equipment room
 - Switchyard auxiliary power supply
- 4.5.0 The sizing of DG set shall be based on the actual loads thrown on DG sets after the emergency and not the algebraic sum of all connected loads.
- 4.6.0 The normal operating condition of the DG set is de-energized and ready. The emergency operating condition of the DG set occurs when power is not available from the power plant/grid. In this circumstance, the DG set shall be started on auto and shall be available to supply power to emergency and essential loads. On restoration of normal power supply, emergency loads to be normalized without any interruption of supply by reverse synchronisation of the DG set with the grid supply.
- 4.7.0 The DG set shall have auto and manual mode of starting enabled through an Auto/Manual selector switch. In auto mode the DG shall start automatically on receipt of mains failure signal. Under manual mode the unit shall be started from a push button.
- 4.8.0 All the controls required for starting shall be integrated to achieve automatic starting sequence both in auto mode and manual mode of operation when a single start signal is initiated.
- 4.9.0 The DG set shall be periodically tested to confirm its ready-to-start condition. It shall be manually started, brought up to speed and voltage, synchronized onto a 415 volt bus, and loaded. Following completion of the test, the DG set shall be unloaded and manually removed from service.
- 4.10.0 The DG set shall be capable of being started, synchronized to the system, and loaded to its full rating without dependence on AC auxiliary power.



- 4.11.0 The DG unit shall be capable of starting the largest motor while carrying the remaining emergency loads. Voltage drop in the Generator shall be limited to 15% during starting of motor using DOL starter while delivering base load.
- 4.12.0 Diesel engine shall be directly coupled to a generator, mounted on a common steel base and installed in the DG room.
- 4.13.0 Diesel engine shall be suitable for HSD oil as per IS 1460.
- 4.14.0 The diesel engine may stand idle for a considerable period, yet must be immediately available for full load. Any special lubricating arrangements necessary to meet this condition shall be provided. The lubricating oil capacity shall be sufficient for 24 hours continuous operation.
- 4.15.0 The diesel engine shall be cold and self-starting type. The starter battery shall be of sufficient capacity to meet the engine starting and control gear requirements.
- 4.16.0 Control & Operation
- a) The DG set shall be controlled from the Auto-On-Mains failure (AMF) panel located in the DG room and also shall be controlled from the DCS in the main control room.
 - b) During normal operating condition, unit emergency MCC shall be fed from the Unit switchgear and when normal supply is not available, the DG shall be started and hence power shall be made available to emergency MCC for feeding emergency loads.
 - c) The DG breaker shall be normally open and the DG I/C breaker to emergency MCC shall also be in open.
 - d) DG shall have Local /remote selection at AMF panel. In local mode, the DG can be started /stopped manually from AMF panel. In Remote mode, the DG can be (start/stop) controlled from DCS from main control room. In DCS Auto/Manual selection shall be provided. In manual mode, the DG can be started /stopped from DCS. In Auto mode, on receipt of (signal volt) from Emergency MCC, the DG shall start automatically.
 - e) If the normal power supply is restored, while DG is in operation, then DG shall be manually synchronized with normal supply and DG I/ C breaker shall be tripped after momentary paralleling.
 - f) Necessary arrangement to be provided for manual synchronization DG with normal supply from DCS and AMF panel.
 - g) It shall be possible to carry out speed (raise/lower) and voltage (raise/lower) from DG control panel and also from remote DCS. Signals required for the above interface shall be provided at DG control panel.
- 4.17.0 The starting time required from the initiating signal until the operating speed and voltage is attained and the engine and generator are ready to take load, shall not be greater than 30 seconds. Three attempt starting facility shall be provided using two impulse timers and a summation timer. The DG shall be capable of being stopped manually from remote and local. Interlock shall be provided in AMF panel to prevent shutting down operation as long as the circuit breaker at its generator output is closed.
- 4.18.0 The DG set shall have minimum vibration and noise under all types and conditions of load. Anti-vibration pads shall be provided to reduce DG set vibration and noise transmission to the surrounding structure. The set shall be statically and dynamically balanced. DG sets shall meet the requirements of environmental (protection) rules.
- 4.19.0 DG set shall be installed indoor with acoustic enclosure to meet MOEF requirements and housed in a separate building. The noise level shall be 90 to 95 dB under free field condition as per 'Pollution control board' norms.



4.20.0 Each DG set shall be complete with the all components and accessories such as follows:

- Diesel engine
- Step timing control injectors
- Turbocharger
- Electronic governor & engine protection/safety controls
- Microprocessor based control system
- Lube oil system with plate type lube oil cooler
- Radiator/heat exchanger & coolant inhibitor
- Outboard after cooler
- Combustion air system
- Engine starting system with starting motor
- Batteries with Battery Charger
- Pulse tuned exhaust system along with piping & structural support till the outlet point to atmosphere
- Fuel feed pump
- Automatic inlet valves and level controllers for fuel oil system
- Generator with brushless exciter and PMG
- AMF panel
- Flexible coupling
- Fly wheel housing
- Oil filters, fuel oil filters and air filters, Oil bath air cleaner
- Fuel tank
- Exhaust tack
- Necessary foundation bolts and base channels for the engine, alternator, fuel service tank and for all other equipment
- AVM pads
- All integral piping, valves and specialties, pipe supports, hangers, etc.
- Self-contained piping for various systems as mentioned above
- Acoustic enclosure

4.21.0 Diesel Engine

- 4.22.1 The generating unit shall be complete with all auxiliaries and the performance, torsional vibration, materials and workmanship, etc. shall be in accordance with the standard practices of diesel engine manufacturer's association.
- 4.22.2 The diesel engine shall be a full compression diesel fuel, four stroke cycle, single acting, solid injection, radiator cooled vertical in line or 'V' type cylinder arrangement. Aspiration shall be turbocharged after cooled. The engine shall be electric start developing required BHP at 1500 RPM.
- 4.22.3 Engine capacity shall meet the 110% overload capacity of the Generator. for continuous operation of generator at rated capacity. In addition 10% overloading of Generator shall be taken care.
- 4.22.4 The diesel engine shall be provided with a Class A1 electronic governing system with transient response of 15 m.sec. The governor shall have isochronous and droop governing application to take care of heavy duty motor starting.
- 4.22.5 Engine speed sensing shall be done with magnetic pick up unit and PID controllers in electronic governor.



- 4.22.6 The diesel engine shall be provided with combustion controls to minimize air pollutants. A mechanical device operating independently of the governing system shall be provided to limit over speed to a safe value and to cut-off the fuel supply directly.
- 4.22.7 The engine and Generator shall be coupled by means of specially designed flexible coupling and both the units including the radiator/heat exchanger shall be mounted on a rigid base frame to form a compact arrangement.
- 4.22.8 The engine shall be properly balanced so as to transmit only small unbalanced forces to the foundation.

4.22.0 **Electronic Governor**

The governing system shall be advanced electronic type provided with the following features:

- Accurate speed sensing by magnetic pickup
- Electronic PID controller
- A1 class governing with transient response of 15 m.sec.
- Isochronous & Droop governing
- Features for faster synchronizing & load sharing functions

The governor shall be provided with motor operated speed gear for remote adjustment of generator frequency. The Governor/Excitation/Control Systems shall permit operation of DG set without exceeding the active and reactive power limitation of the Generator.

A mechanical over-speed trip device shall be provided to automatically shut-off fuel in case the speed exceeds 110% of the rated value.

4.23.0 **Lubrication System**

The engine lubrication system shall include an engine shaft-driven positive displacement lubricating oil pump, AC power driven pre-lubricating pump, full-flow lubricating oil strainer on the pump suction side, and a full-flow replaceable lubricating oil filter on the pump discharge side. Lubrication oil shall conform to relevant IS amended up to date. Temperature and pressure gauges shall be fitted to engine lubricating system.

The lube oil cooler shall be designed to utilize the engine coolant as the cooling medium. The heat exchanger shall be mounted on the unit base.

4.24.0 **Fuel System**

A fuel system shall be furnished to regulate fuel flow to maintain constant rated engine speed regardless of load variations. The fuel system for each DG set shall include an electronic engine governor, fuel metering equipment, filter and fuel cutoff valves, and a diesel fuel oil tank.

The fuel oil tank of not less than 990 liters fuel capacity shall be of all welded steel construction complete with supports, access manhole, moisture drain valve, inlet and outlet connections, valve drain connection, level gauge, level alarm contacts (high and low), air breather, shielded level gauge and strainer. The tank shall be coated with oil resistant paint. The fuel tank shall be hydrostatically tested. Fuel tank shall be placed inside the building mounted on fabricated steel plat form.

The fuel tank shall be made of 3 mm thick MS sheet. The tank shall have fuel level indicator with brass cover for mechanical protection, filling inlet with removable fuel screen, outlet located at minimum of 25 mm above from the bottom of the drain plug, air vent and necessary piping.

Hand pump for pumping the fuel into the service tank with 5.0 m flexible tube shall be provided. The inlet of the pump shall be provided with flexible/rigid pipe with suitable filters. The fuel oil filter shall be multi-disc or fold type.



Diesel oil level indication shall be indicated at DCS.

4.25.0 Engine Cooling System

Cooling shall be by an engine mounted fan cooled radiator/heat exchanger. The cooling system shall be designed for the maximum ambient temperature of 50°C. All fans, motors, coolant additive concentrate, ducting, supports, pipe work and valves required for this purpose shall be provided.

Radiator system shall utilize an engine-driven fan.

Water/coolant shall be circulated by an engine-driven pump with a stainless steel shaft. Thermostat shall be provided in Jacket water line. Cooling water for jacket and oil cooling shall be thermostatically controlled to maintain efficient operating temperature. Suitable after-coolers shall be provided for efficient combustion and reduced internal stresses for longer life.

4.26.0 Combustion Air Intake System

Air intake system shall include air intake manifold, dry type air cleaner, vacuum indicator etc. A replaceable dry cartridge-type intake air filter shall be provided with the diesel engine.

The diesel engine may take combustion air directly from inside the DG room. Necessary filter silencer shall be provided in the air intake line to meet the noise criteria. Acoustic louvers of adequate size shall be provided to draw outside air in to the DG room.

4.27.0 Exhaust System

The exhaust system shall meet requirements of 'Pollution Control Board'. Two numbers residential silencer shall be provided. The silencing system shall be sized to ensure against loss of engine power due to excessive back-pressure.

The exhaust system shall include turbocharger, pulse tuned exhaust manifold, stainless steel exhaust flexible connections, steel exhaust pipe, exhaust stack, Insulation for exhaust piping, galvanized support steel structure, etc.

Stack height shall be as per Pollution Control Board norms.

Suitable thermal insulation together with jackets shall be provided on all exposed hot pipes and equipment to limit the surface temperature to 60 degree C.

4.28.0 Engine Starting System

A DC electric starting system shall be provided for starting the engine, complete with electric starting motor, battery charging alternator, batteries and rack, charger, charger control and automatic voltage regulator, and thermal cutout in a suitable enclosure. The Automatic start equipment shall have the following features:

- Energize the starter circuit
- Provide three intermittent cranking cycles
- De-energize the starting circuit when the engine starts
- Limit the total cranking time and lock out, requiring manual reset in the event of a failure to start

The emergency diesel generator shall be able to start and achieve rated speed within 15 seconds following the initiation of a start signal. After achieving rated speed, voltage and frequency, it shall be capable of maintaining voltage and frequency within +/- 5 & 3% respectively under steady-state load conditions.



4.29.0 Ventilation System

Ventilation system of adequate capacity shall be provided. The system shall comprise of tubular axial flow fans for air intake and air exhaust. The ventilation shall be design to ensure required air flow rate as per manufacturer recommendations, after providing necessary acoustic treatment/ silencers in air flow path. The ventilation system shall be design to prevent leakage of sound and maintain required room temperature for comfortable working in the area not to deteriorate performance of DG.

4.30.0 Battery& Charger

4.30.1 Two sets of batteries and float & boost chargers shall be provided. Normally, one shall cater to the loads of AMF panel and the other to the starting loads of the engine. Each shall be a 100% stand-by to the other, so that in the event of one not being available, the other battery shall meet the load of the unavailable battery in addition to its own normal load. Each battery shall be suitably rated. A heavy-duty selector switch shall be provided to select the two batteries to supply their respective loads or to select any one of them to supply the entire load of AMF Panel and starting load. Each battery shall have its own float and boost charger, which shall be housed in a cabinet. Battery shall be mounted on stand.

4.30.2 The battery shall be capable of six (6) normal consecutive starts without recharging. Battery shall be lead acid grid electrode of adequate capacity.

4.30.3 Battery charger shall be of silicon controlled rectifier/SMPS type. Battery charger shall be able to boost charge the battery from fully discharged condition within 8 hours. The charger shall be equipped with transformer, full wave rectifiers, automatic surge suppresser, DC ammeter, voltage regulator, circuit breaker/fuse etc. Ripple shall not be more than 1% (rms) to get smooth DC voltage shall be provided. Charger shall be provided with output ammeter and voltmeter. There shall be facility to charge the batteries either in boost or in float mode. Boost or float mode shall be selectable through a selector switch. The charger shall have the following features:

- Automatic float and boost charging
- Current and voltage limiting circuits to avoid over charging
- Short circuit protection
- Reverse polarity protection
- Auto cut-off when DG set is ON

4.31.0 Generator

4.31.1 The generator shall be directly connected to the engine flywheel with a flexible coupling. The generator shall be mounted on a common structural steel base frame with the engine. The generator shall be rated for three phase at 415 V, 1500 rpm, 0.8 pf lagging, 50 Hz and shall confirm to IS 13364(part II).

4.31.2 The generator shall be rated for continuous operation and shall comply with the requirements of the relevant parts of IEC-60034. The generator and exciter insulation shall be Class H. The temperature rise of the generator and exciter windings shall not exceed the limits for Class F limits when the machine is delivering rated output at 50 °C of ambient conditions.

4.31.3 Resistance temperature detector (RTD) shall be installed at the following locations:

- 12 nos. simplex RTDs in stator windings
- 1 No. duplex RTD in each bearing

4.31.4 Generator shall be capable of parallel operation with grid without any quadrature droop compensations. Generator shall have 10% overload capacity for one hour at every 12 hours of running.



- 4.31.5 The generator shall be capable of delivering continuously the rated power at rated power factor:
- When frequency variation is + 3% to -3% of the rated value
 - When the voltage variation is within +/- 10% of its rated value
 - When the absolute sum value of combined voltage and frequency variation does not exceed 10 %
- 4.31.6 The Generator shall be capable of withstanding 3-phase short circuit at its terminals for 3 seconds when the machine is operating at rated MVA and power factor and permissible maximum over voltage.
- 4.31.7 The generator shall be totally enclosed air cooled type with a degree of protection of not less than IP 23.
- 4.31.8 Strip type space heaters rated for 240 V AC, 50 Hz supply shall be provided for generator stator winding and the same shall be wired to separate terminal box.
- 4.31.9 The stator windings shall be brought out to six insulated terminals in two separate terminal boxes. The alternator shall, be provided with three separate terminal boxes i.e. for the live and neutral stator connections and for control connections. The star connection shall be formed in the neutral terminal box. Terminal box shall be capable of withstanding short circuit current for 1 sec. The terminal box shall be of dust and vermin proof construction and each shall have IP55 degree of protection.
- 4.31.10 DG sets rated 1000 KVA and above shall be connected through non segregated phase bus duct to the respective AMF panel. Busduct entry shall be from the top.
- 4.31.11 The excitation shall be brushless, with rotating diodes. Power to AC exciter field shall be supplied from directly coupled Permanent magnet type pilot exciter. The engine and Generator shall be directly coupled by means of self-aligning flexible flange coupling to avoid misalignment. The coupling shall be provided with a protecting guard to avoid accidental contact.
- 4.31.12 Required current transformers and voltage transformers for metering & protection and DAVR shall be accommodated in the generator terminal box suitably.
- 4.32.0 **Digital Automatic Voltage Regulator (DAVR)**

The DAVR shall be digital type and shall have negligible dead band and high speed of response. All essential indications/annunciation system required for DAVR/excitation system shall be provided. Provision shall be made for remote operation with necessary controls, indications and annunciation.

The DAVR shall be designed to regulate the output voltage of the generator within $\pm 0.5\%$ of the setting from no-load to full-load and under worst condition of supply of power. The DAVR supplied shall have following characteristics:

- The DAVR shall function correctly between frequency variation of +/- 3% on 50 Hz and shall ensure a voltage variation not more than $\pm 0.5\%$ of the set point in steady operating condition between no load to full load
- It should be able to prevent automatic rise of field voltage in case of failure of potential supply
- The excitation and voltage regulation should be designed so as to cause necessary de-excitation in case of any short circuit



- The current and voltage signal required for feedback to the DAVR shall be derived by bidder
- It shall interface with DCS for remote voltage raise/lower and speed raise/lower control

4.33.0 Acoustic enclosure

- 4.33.1 Acoustic enclosure shall be provided covering each DG set. It shall be designed to achieve specified noise level as per State Pollution Control Board norms.
- 4.33.2 The sound absorptive layer shall comprise of bonded type mineral wool/glass wool of adequate thickness and density to comply the design requirements.
- 4.33.3 The door design shall be compatible to the acoustic treatment. The door shall be provided with heavy duty hinges and handles. The sealing shall be done with neoprene/silicon rubber gasket to avoid leakage of noise.
- 4.33.4 All ventilation openings shall also be treated adequately to achieve desired sound proof.

4.34.0 Anti-Vibration Pads

The DG set shall be provided with visco damper type vibration dampening pads (suitable for loads and vibration they are required to carry) with minimum vibration transmitted to the surface the set is resting on.

Skid mounting type base-frame fabricated from suitable machined MS channel to ensure perfect alignment of the engine & Generator with rigid construction and necessary reinforced to ensure minimum vibration shall be provided. The base frame shall be provided with lifting facilities and pre-drilled foundation holes suitable for permanent installation on anti-vibration pads.

4.35.0 AMF(Auto-On-Mains-Failure) Panel

- 4.35.1 AMF panel shall receive power supply from alternator and feed to emergency MCC of Owner. It shall be provided with required air circuit breakers, CTs, PTs, protection relays, multi-function meters, indication etc. as per enclosed single line diagram.
- 4.35.2 The AMF panel for the generator set shall comprise of control, protection and metering equipment, indicating instruments etc. The panel shall be free standing; sheet steel enclosed having a degree of protection of IP 52. Sheet steel thickness shall not be less than 2 mm. Non load bearing members like doors, covers shall be of thickness not less than 1.6 mm.
- 4.35.3 The Boards shall be designed to withstand, without damage, for a fault of minimum 50 kA RMS at 415 V for one (1) second duration. The peak S/C with stand current of the bus shall be 105 kA.
- 4.35.4 Air circuit breakers shall be 4 pole, stored energy, trip free, air break, horizontal drawout type, motor operated. There shall be "SERVICE", "TEST" and "ISOLATED" positions for the breakers. The protective relays and instruments shall be mounted in separate compartment. ACB shall be rated for 50 kA short circuit current rating for 1 sec.
- 4.35.5 Necessary current transformers and voltage transformers shall also be provided for required metering and protection. The location of the CTs and VTs shall be in the AMF panel. CTs shall be cast resin type. CT shall have short time rating equal to that of switchgear. Line CT shall be mounted on AMF panel. Neutral CT shall be mounted in generator neutral bushing. VT shall be cast resin type. Line VTs shall be located in AMF panel.



- 4.35.6 Manual control of DG set such as start / stop, voltage raise / lower and speed raise / lower shall be provided on the AMF panel and remote DCS. DG set essential indications, alarms etc. shall also be available in remote DCS.
- 4.35.7 A microprocessor-based control & protection system shall be provided for diesel engine and generator set for monitoring, metering and control. The control system shall provide an operator interface to the DG set.
- 4.35.8 Provision of synchronizing DG set with normal AC system shall be provided for testing and cut in/cut out of DG set without interruption of power supply.
- 4.35.9 DG controller shall be of type PEC 3320 of Cummins make or equivalent with reverse synchronizing facility. The controller shall have communication ports to interface with DCS and EMS system.
- 4.35.10 Control features shall be provided for the following:
- Digital engine speed governing controls
 - Digital voltage regulation
 - Generator control
 - Starting control system
 - Exhaust temperature monitoring
 - Voltage raise/lower
 - Speed raise/lower
 - Auto/Manual control
 - Start/Stop control
 - Emergency stop
 - Local/remote selection
- 4.35.11 Alarm/indicating lamps shall be provided for the status and for various alarm & trip conditions. Indicating lamps shall be of clustered LED type. The following tripping and alarms shall be provided:
- Fail to start (alarm)
 - Overload (alarm)
 - Cooling water pressure low (trip)
 - Lube oil pressure inadequate (trip)
 - Over speed (trip)
 - High coolant temperature (trip)
 - Abnormal voltage (under / over voltage) (alarm)
 - Charger ON / OFF (alarm)
 - Fuel level low in day tank (alarm and trip)
 - High lube oil temperature (trip)
 - Low air pressure in receiver (alarm)
 - Stator temperature high (alarm)
 - Protective relays operated (trip)
 - Low and high battery voltage alarm
 - Weak battery alarm
 - Fail to start alarm
- Necessary pressure switches, level switches, thermostats, flow switches, auxiliary relays etc. required for the above shall be provided.
- 4.35.12 Multifunction digital type meter having current (3 phase), voltage (3 phase), frequency, power factor, kW, kVA, kVAR and energy (accuracy 0.5) metering shall be provided for the generator. Meter shall have communication port for remote connection to DCS.



4.35.13 Metering devices for the following shall also be provided.

- Engine starting battery voltage
- Engine lube oil pressure
- Engine coolant temperature
- Engine lube oil temperature
- Hour run meter
- DC volt meter for exciter field voltage
- DC ammeter with shunt for exciter field current
- Generator temperature scanner

4.35.14 Numerical multifunction relay type suitable for flush mounting shall be provided for the following functions.

- Voltage controlled over current protection
- IDMT Over current Relay
- Overload alarm
- Reverse power protection.
- Standby earth fault protection.
- Negative phase sequence protection
- Over / under voltage protection
- Under / over frequency protection.
- Differential protection (DG set rating above 1000 kVA)
- Hand reset lockout relay

4.35.15 Control Interface for remote operation and control from DCS shall be provided. Critical parameter shall be hooked-up to DCS for indication and alarm. Required transducers and potential free contacts shall be provided in DG control panel and protection panel.

4.36.0 PAINTING

Painting shall be carried out by approved process. After preparation of the under surface the equipment shall be painted with epoxy based paint. All exposed metal parts including base channel, radiator cover, air filter, oil filter dynamo, starter etc. shall be in single colour suitably finished to prohibit corrosion under climatic conditions prevailing at site. Oil resistant paint epoxy based, shall be applied as required. The final thickness of paint film on steel shall not be less than 100 microns and shall not be greater than 150 microns. Final shade shall be ONAN green for engine, generator and fuel tank.

5.0.0 TESTS

5.1.0 Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. For the various bought out item test certificates from equipment manufacturer shall be furnished for Owner's review.

5.2.0 Type tests on Generator shall constitute the following:

- Measurement of resistance
- Phase sequence test
- Regulation test
- Measurement of open circuit characteristic
- Measurement of short circuit characteristic
- Efficiency test
- Temperature rise test
- Over speed test
- Insulation resistance test
- High voltage test



- Momentary over load test
- Test for vibration severity
- Determination of deviation of voltage wave form from sinusoidal

5.3.0 Routine tests on Generator shall constitute the following:

- Measurement of resistance
- Phase sequence test
- Regulation test
- Measurement of open circuit characteristic
- Measurement of short circuit characteristic
- Insulation resistance test
- High voltage test

5.4.0 The following acceptance test shall be carried out on DG set at shop and as well as at site.

- DG set shall be checked for alignment
- Full load test for a period of atleast 6 hours at rated kVA at UPF
- 10% Over load test for one hour after the full load test
- Temperature rise test
- Voltage and speed regulation test
- Speed & governing test
- Check for fuel consumption
- Insulation resistance test
- High voltage test
- Functional test
- Measurement of vibration level
- Measurement of noise level
- Performance of DG set
- Measurement of resistance & air gap
- Phase sequence test
- Regulation test
- Measurement of open circuit and short circuit characteristics
- Efficiency test
- Temperature Rise Test
- Momentary overload test
- Over speed test
- Determination of Deviation of voltage waveform from sinusoidal.
- Any other special/statutory test as laid down by Pollution control board

5.5.0 Routine tests shall be carried out for all the equipment (generator, DAVR, exciter & battery etc.) as per applicable standards. Copies of certified reports of all tests carried out at the works shall be furnished.

5.6.0 The tests to be conducted on each DG set at site shall include but not be limited to those listed below. Any other test considered necessary by the contractor shall also be carried out :

- a) Visual Test
- b) Electrical Tests
- c) Calibration of instruments relays etc.
 - Primary and secondary injections tests of protective devices.
 - Function, interlock test of control panel
 - Insulation resistance measurement of power and control circuits.
- d) Mechanical Tests
 - Trial run of engine
 - Governor testing



- Over speed trip test
- Load pick up and load rejection tests
- Load test and temperature rise measurement of engine and alternator

e) Generator Tests

- Measurement of the insulation resistance of the stator windings to the frame and between phases, after drying out the machine.
- Measurement of the DC resistance of all windings and embedded temperature detectors
- Open circuit and short circuit tests
- Measurement of temperature rise at the rated load

6.0.0 TECHNICAL PARAMETERS

Sl. No.	Item Description	Unit	Data
	General		
1.	Equipment location		Indoor
2.	Output voltage	V, Hz	415 V, 50 Hz, 0.8 PF, 3 phase
	Diesel Engine		
9.	Applicable standard		BS 5514/ISO 3046
10.	Engine type		Vee configuration, 16 cylinders
11.	Speed	rpm	1500
12.	Over load capacity of engine	%	110% for 1 hour at every 12 hours of running
13.	Type of Cooling		Radiator
14.	Aspiration		Turbo-charged-After cooled
15.	Governor		Electronic – A1
	Generator		
1.	Applicable standard		IS/IEC 60034, IS 13364
2.	Degree of protection		IP23
3.	Class of insulation for stator, rotor & exciter		Class H
4.	Temperature rise	°C	Class F limits
5.	Speed	RPM	1500
6.	Rated voltage	Volt	415+/- 10%
7.	Rated Frequency	Hz	50 +/- 3%
8.	Rated PF		0.8 lagging
9.	Type of cooling		Air cooled
10.	Type of excitation		Brush less self-excited
11.	Type of pilot exciter		PMG
12.	No. of winding RTD & type		6 Nos. duplex or 12 nos. simplex PT100



Sl. No.	Item Description	Unit	Data
13.	No. of bearing RTD & type		1 No. duplex in each bearing, PT 100
14.	Voltage Regulation		+/-5 %
15.	Total harmonic factor		Better than 2%
16.	Wave form distortion		< 1.8% for no load & <5% on full load

7.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- DG sizing calculation
- Technical particulars of all equipment
- General arrangement drawings of all equipment
- Cable routing layout
- General arrangement and section drawing for DG building
- General arrangement and section drawing for DG set
- Calculation and Foundation details for DG set
- Single line diagrams
- Electrical control and schematic wiring diagram
- Recommended relay setting calculations
- P&ID diagram for fuel oil system & exhaust system
- Cable Schedule & Interconnection Schedule
- Earthing drawings
- Calculation, structural & foundation drawing for stack
- Fuel system layout
- Exhaust system layout
- Statutory Certification for the complete set & the acoustic treatment
- Piping drawing
- Calculation, drawings & details for ventilation
- Drawings for engine
- Drawings for Alternator
- Drawings for fuel tank
- Drawings for battery & charger
- Details of DG control system
- Erection and commissioning procedures
- Test certificates
- Operation and maintenance manual
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.19: ELEVATORS

1.0.0 INTENT OF SPECIFICATION

This section covers the technical requirements of passenger elevators.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) Two nos. 3000 kg capacity Passenger cum goods elevator for boiler-1
- b) Two nos. 3000 kg capacity Passenger cum goods elevator for boiler-2
- c) One no. 3000 kg capacity Passenger cum goods elevator for the crusher house
- d) Two nos. 884 kg capacity Passenger elevator for the power house building
- e) Two nos. 884 kg capacity Passenger elevator for the service building
- f) One no. 884 kg capacity Passenger elevator for the Admin building
- g) Two nos. 884 kg capacity Passenger elevator for ESP building-1 and 2
- h) One no. 884 kg capacity Passenger elevator for CHP JNT-8
- i) 884 kg capacity Passenger elevator for other buildings of height 15 M and above.
- j) Commissioning spares and consumables
- k) Mandatory spares
- l) Tools & tackles
- m) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest edition (including amendments) of the following Indian Standards (IS), IEC publications and other codes except where modified and /or supplemented by this specification.

- a) IS: 14665 (Part-1 to 5) : Electric Traction Elevators
- b) IS: 2365 : Specification for Steel Wire Suspension Ropes for Elevators, Elevators and Hoists
- c) IS: 325 : Specification for Three Phase Induction Motors
- d) IS: 13947 : Specification of Low Voltage Switchgear and Control Gear
- e) IS: 60947 : Low Voltage Switchgear and Control Gear
- f) IS: 732 : Code of Practice for Electrical Wiring Installation
- g) IS: 3043 : Code of Practice for Earthing
- h) Elevators Acts and Rules

4.0.0 TECHNICAL REQUIREMENTS

4.1.0 The Elevators shall be complete with all fittings and accessories including the following:

- Hoisting machine including motor
- Over speed governor
- Brakes
- Limit switches.
- Guide rails, guide bracket and wall inserts
- Machinery support structure / beams
- Steel beams of raft for machine and pulleys
- Safety grips



- Buffers and any associated steelworks,
 - Steel wire ropes
 - Enclosed vestibule with framing
 - Hoist way entrances, doors and door tracks
 - Car enclosure with door and door hangers
 - Car frame and platform construction
 - Supporting steel works for horizontal sliding doors and frames for hinged doors
 - Pit screen to counter weight
 - All steel embedment for fixing landing doors and equipment.
 - Steel ladder for access to pit
 - Car operating panel with controls, indications and protections
 - Landing call station with call registering push buttons and call registered indication
 - Load plate
 - Intercom for three way communication
 - Controller panel
 - VVFD for elevator
 - UPS with battery
 - Disconnecting switch
 - Power and control cables
 - Galvanized steel conduits, cable glands/ lugs and terminations
 - Earthing system
 - Lighting panel
 - Lighting for hoist well
 - LED Light, fan and telephone for car
 - Emergency stop switch on top of car
 - Emergency stop switch in the pit
 - Car and counterweight buffer switch
 - Auto rescue device for passenger elevators (Excluding boiler elevator and crusher house elevator)
 - Erection material
 - First charge of lubricants and consumables
 - Startup and commissioning spare parts
 - Special tools and tackles required for maintenance of equipment
- 4.2.0 Elevators shall cover all the floors in respective locations. In power house building, for each unit, all the floors of BC bay, AB bay and central control building shall be reached by elevator.
- 4.3.0 All the equipment and its components shall be designed for design ambient temperature of 50°C.
- 4.4.0 The Elevator shall be suitable for operation at 415 V+10% to -10% of the supply voltage, 50 Hz +3% to -5% of the supply frequency and combined voltage and frequency variation of 10%.
- 4.5.0 Installation shall be carried out as per IS: 14665.
- 4.6.0 Elevator installation shall be provided with the following safety features
- a) Safety gear operated by speed governor located overhead and driven by governor rope suitably connected to the car and mounted on its own pulleys
 - b) Terminal buffers.
 - c) Terminal switches shall stop the car automatically at terminal floors within the top and bottom permissible over travel
 - d) Electro-mechanical door lock
 - e) Motor operated / electromechanical brake



- f) Counter-weight guards
- g) Overload alarm through load cell
- h) Alarm bell at the top of car and in the machine room
- i) Emergency door lock release operating key
- j) "Slackening of rope" identification

4.7.0 Elevator operations

- a) Microprocessor based simplex selective- collective operation with/without automatic operation by means of one button in the car for each landing level served and by up-and-down buttons at the landings, wherein all stops registered by the momentary actuation of car made as defined under non-selective automatic operation but wherein the stops registered by the momentary actuation of the landing buttons are made in the order in which the landings are reached in each direction of travel (irrespective of the sequence in which the buttons have been actuated).
- b) With this type of operative all 'up' landing calls are answered when the car is traveling in the up direction and all 'down' landing calls are answered when the car is traveling in the down direction except in the case of the uppermost or lowermost calls which are answered as soon as they are reached in-respective of the direction of travel of the car.
- c) A by-pass button (non-stop button) shall also be provided inside the car to enable the attendant position. The operation of the cars shall be identical with that described for automatic operations except that closing of doors and starting of cars shall be initiated by the car buttons only and landing by-pass shall be effective.
- d) The control circuit shall be designed to the type of elevator specified for safety operation. It shall not be possible to start the car unless all the car and landing doors are fully closed and landing doors locked. The circuit shall have an independent fuse protection for fault and over loads and be arranged so that earth fault or an open circuit shall not create unsafe condition. The circuit shall be so arranged that for the stoppage of the car at specified landing or for actuation of a contactor by emergency switches or operation of safety gears the system shall not depend upon the completion or maintenance of an electrical circuit to cut off power supply and apply the brakes.
- e) Door open and close push button shall be provided in the car. It shall be possible to stop or reverse the door closing through the door open button in the elevator car. Door close button shall allow the door to be closed for a call. The following buttons shall also be provided in the car operating panel in addition to standard buttons.
 - Emergency Stop
 - Attendant Transfer Switch/Key
 - Alarm
- f) When the car door panel is touched by a person or object while the car door is closing, the car and Hoist way doors shall return to their open position. The doors shall remain open until expiration of a pre-determined interval and then close automatically.
- g) Elevator shall have means to cut off power from the motor, whenever an excessive descending speed is reached, and apply the normal brake prior to the application of the safety brake.
- h) Overload of the elevator shall be sensed by improvised sensing devices such as strain gauge, load cell and shall be precise and accurate. The elevator car and landing door shall not close on overload condition and shall remain open till the over load cease to exist. Audiovisual alarm for overload shall be provided inside the car.



- i) Elevator shall be provided with a self-leveling feature that shall automatically bring the car to floor landings. This self-leveling shall, within its zone, be entirely automatic and independent of the operating device and shall be self-correcting for over-travel or under-travel and rope stretch.
- j) Elevator shall have auto recorded audio annunciation system which shall annunciate for arrival of each landing, improper closing of doors and any other required for the elevator.
- k) Elevator shall be equipped with an automatic stopping device, arranged to bring the car to a stop at the terminal landings independently of the regular operating device in the car. Final limit switches shall be provided in the hoist way, operated by the car and arranged to stop the car and prevent normal operation should it travel beyond the zone of the normal stopping device.

4.8.0 PAINTING

The fabricated enclosures/panels shall undergo a treatment of degreasing, pickling and two coats of primer before being given the epoxy finish. Two coats of final paint shall be applied. The external and internal surface of the board shall be powder coated epoxy finish. The final thickness of paint film on steel shall not be less than 50 microns.

5.0.0 TESTING AND INSPECTION

- 5.1.0 Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. For the various bought out item test certificates from equipment Manufacturer shall be furnished. Routine tests shall be carried out for all the equipment as per applicable standards. Copies of certified reports of all tests carried out at the works shall be furnished.
- 5.2.0 The load test shall be conducted at site for all elevators. The operating license shall be handed over to the Owner.
- 5.3.0 All components shall be tested as per IS: 14665. Test reports shall be furnished for approval. All materials used in manufacture of various components shall be of tested quality and shall conform to relevant standards/specification.
- 5.4.0 Inspection and tests shall be performed in the field in accordance with the requirements and recommendations of respective standards and the local regulation. Testing shall include a comprehensive demonstration of all safety devices, interlocks and controls.

6.0.0 TECHNICAL PARAMETERS

Sl. No.	Item Description	884 kg elevator	3000 kg Elevator
1.	No of elevators	As specified	As specified
2.	Application	Passenger elevator	Passenger cum goods elevator
3.	Type	Floor elevator system with car.	Floor elevator system with car.
4.	Applicable standard	IS: 14665	IS: 14665
5.	Type of operation	With/without attendant	With/without attendant
6.	Minimum carrying capacity	884 kg	3000 kg



Sl. No.	Item Description	884 kg elevator	3000 kg Elevator
7.	Speed	1 metre /second	1 metre /second
8.	Position of machine room	Over the elevator well	Over the elevator well
9.	Car enclosure (Interior)	Stainless steel	Sheet steel
10.	Car flooring	Steel, Granite finish, PVC flooring except CHP JNT-8 For CHP JNT-8: Steel, Granite finish, Stainless steel flooring with knerling	Steel chequered plate
11.	Car door	Centre opening, automatic horizontal sliding type. Stainless steel construction.	Centre opening, automatic horizontal sliding type. Stainless steel construction.
12.	Levelling accuracy	± 12 mm	± 12 mm
13.	Hoist way door opening	Pressed steel frames and hollow metal doors – with weather gasketing	Pressed steel frames and hollow metal doors – with weather gasketing
14.	Drive	Variable Voltage, Variable Frequency (VVVF) Drive.	Variable Voltage, Variable Frequency (VVVF) Drive.
15.	Control system	Directional collective control. Fully automatic microprocessor based control	Directional collective control. Fully automatic microprocessor based control
16.	Safety device for door operation	Infra-red light curtain required	Infra-red light curtain required
17.	Type of construction of car operating panel	Box type with stainless steel face plate	Box type with stainless steel face plate
18.	Type of construction of car position indicator	Box type with stainless steel face plate	Box type with stainless steel face plate
19.	Type of display of car position indicator	7 segment led display	7 segment led display
20.	Type and mode of operation of over speed governor device	Centrifugal action	Centrifugal action
21.	Tripping speed of over speed governor device	As per IS 14665	As per IS 14665
22.	Type and location of safety gear	Friction type, safety gear located at bottom of car frame	Friction type, safety gear located at bottom of car frame
23.	Power supply	415 V , 3 phase, 4 wire, 50 Hz supply	415 V , 3 phase, 4 wire, 50 Hz supply
24.	Type of motor	AC, squirrel cage induction motor	AC, squirrel cage induction motor
25.	Duty of motor	Elevator duty suitable for inverter application	Elevator duty suitable for inverter application



Sl. No.	Item Description	884 kg elevator	3000 kg Elevator
26.	Type of enclosure of motor	IP 55	IP 55
27.	Class of insulation of motor	Class F, temperature rise limited to class B limits	Class F, temperature rise limited to class B limits

7.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Machine room layout
- Shaft well layout
- Schematic diagram
- Technical particulars of all equipment
- General arrangement drawings of all equipment
- Conduit/wiring layout
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.20: RACK & PINION ELEVATOR

1.0.0 INTENT OF SPECIFICATION

This section covers the technical requirements of Rack and pinion Elevator.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) One no. 400 kg capacity rack and pinion type elevator for chimney
- b) One no. 400 kg capacity rack and pinion type elevator for Ash silo
- c) Commissioning spares and consumables
- d) Mandatory spares
- e) Tools & tackles
- f) Any other equipment required for the system

3.0.0 TECHNICAL REQUIREMENTS

3.1.0 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest edition (including amendments) of the applicable Indian Standards (IS), IEC publications and other codes except where modified and /or supplemented by this specification

3.2.0 The Elevator shall be rack and pinion type complete with all fittings and accessories including the following:

- Rack and pinion
- Mast
- Motor
- Brakes
- Buffers
- Worm reduction gear
- Limit switches
- Elevator Cage
- Buffers
- Cage operating panel, controls, indications and protections
- Landing enclosure
- Ground enclosure
- Cage Panel
- Base Panel
- UPS with VRLA battery (gel filled) battery
- Power and Control cables
- Cable trolley, Cable guide, cable bracket.
- Cables
- Earthing System
- Junction boxes

3.3.0 The stack elevator including mechanical and electrical components shall be installed inside the chimney in case of multi flue chimney and outside the chimney in case of single flue chimney. Since chimney is a free standing structure, deflection of chimney top is expected during the normal operation, so the design of the elevator shall be in such a way that the elevator operation shall be safe even with the expected maximum deflection of the chimney structure.



- 3.4.0 All Electrical and Mechanical equipment shall be designed for continuous operation at rated capacity at Design Ambient Temperature of 50°C. All the Equipment shall be designed for operation indoor/outdoor with dusty and high humidity conditions.
- 3.5.0 Chimney elevator shall be attached to the chimney shell using expansion type anchor bolts drilled in to chimney shell. Elevator shall be capable of operating from the ground floor to the top platform with intermediate stops at all platforms. Landing for elevator parking shall be one (1) metre above the stack ground floor. Suitable staircase leading to the landing for entry to Cage shall also be provided.
- 3.6.0 For Ash silo, rack and pinion elevator shall be suitably located.
- 3.7.0 A three-sided enclosure with one access door shall be provided at graded level. At each platform landing above graded level, a one sided enclosure with access door shall be provided. Enclosures shall be fabricated from mild steel and expanded metal or wire mesh, 2.1 m high and epoxy primer coated. Enclosure access doors shall be electrically and mechanically interlocked so that they remain closed and locked except when the Cage is at the landing. Doors shall be bi-parting and swinging type. Base of three-sided enclosure shall be securely anchored to the grade level floor slab using expansion type anchors.
- 3.8.0 Mast shall be provided in sections approximately 1.52 m in lengths considering of tubular sections and/or structural shapes welded together to form a frame work to which the rack is bolted. Mast shall be securely anchored to the concrete chimney walls.
- 3.9.0 Cage**
- 3.9.1 Cage frame shall be fabricated from mild steel and enclosed with Aluminium sheet. Cage floor shall be of aluminum chequered plates. Cage shall be attached to a framed structure and form integral part with the drive mechanism located atop the Cage.
- 3.9.2 Framed structure shall include guide rollers and safety hooks to ensure positive engagement of the rack and pinion to prevent Cage disengagement in case of roller failure. Cage roof shall be provided with an escape hatch electrically interlocked with the hoist control system. Tubular steel handrail shall enclose the Cage roof for maintenance operations.
- 3.9.3 Cage door and landing level enclosure doors shall be electrically and mechanically interlocked to prevent the Cage from being operated unless the Cage door and landing level enclosure doors are fully closed and to prevent doors from being opened while the Cage is in motion. Cage shall be provided with the following:
- Push button for raise lower control
 - Ventilation fan with switch,
 - Fluorescent lamp fittings with switch
 - Emergency light with battery and charger.
 - Overload indication lamp.
 - Emergency alarm with push button
 - Emergency Stop Switch
 - Cage Position indicator
 - Key switch
- 3.9.4 Sufficient numbers of buffers of spring loaded/hydraulic type shall be fitted below the Cage. The buffers shall be capable of stopping the Cage without permanent damage or deformation to themselves or any other part of the equipment. The number of buffers shall be so fixed as to ensure proper sharing of impact loads by all of them.



3.10.0 Drive unit and safety Device

- 3.10.1 Drive unit located on the top of the Cage shall be complete with AC squirrel cage induction motor, reduction gear, drive pinion and an over speed governor. The motor shall be connected to a worm gear which drives the pinion.
- 3.10.2 Drive unit shall incorporate an electric disc brake and an external manual brake release. The brake on the electric motor shall be of the electromagnetic single disc self-adjusting type with the mechanical compression spring being held by the electromagnet. In the event of power failure, the brake shall be automatically applied and shall stop the Cage. A hand lever, which can be operated from the cage, is to be provided to enable the occupants to ease the brake and lower the cage to the bottom level.
- 3.10.3 An over speed governor in constant mesh with the rack by means of frame hardened steel pinion shall be incorporated to protect the Cage against over speed during the Cage downward motion. At the pre-determined speed higher than normal, the centrifugal action of the governor pawl shall actuate the incorporated brake mechanism and stop the downward motion of the Cage gradually. The brake should remain locked on following this action and has to be manually reset before normal elevator operation can be resumed.
- 3.10.4 The hoist shall be provided with a centrifugal brake to prevent accidental tripping of safety device when the cage shall be taken to the ground by gravity in case of power failure.
- 3.10.5 Each landing assembly shall include a limit switch for door interlock and push button control station installed and wired to a landing junction box.
- 3.10.6 Reverse phase relay connected to prevent operation of the Cage with improper phase rotation or failure in any phase in the power supply.
- 3.10.7 Electrical and mechanical interlocks on Cage access door and landing level enclosure doors, over travel protection, over load protection, emergency stop push button, over speed governors shall be provided.
- 3.10.8 An alarm push button shall be provided in the cage connected to a battery-operated alarm at the elevator base. Simultaneous alarm shall also sound at the plant control room in the event of any fault in the stack elevator for which one potential free contact shall be provided in each elevator for audiovisual alarm in control room for "Stack Elevator fault" indication.

3.11.0 Control System

- 3.11.1 Cage shall be controlled by a semi-automatic control system. One base control panel shall be located at grade level enclosure. Panel shall be equipped with a main 'ON-OFF' isolating switch, main contractor, relays, control transformer and fuses, tone frequency transfer, terminal blocks and all other accessories required for normal operation of the elevator.
- 3.11.2 One cage control panel shall be located on the top of the Cage. Panel shall be equipped with isolating switch, battery, charger, tone frequency receiver, contactors, MPCBs, MCBs, control transformer and fuses, electronic overload relays, and all other equipment and accessories required for normal operation of the elevator.
- 3.11.3 The Panel shall be floor /wall mounted, made of minimum 2 mm CRCA thick sheet steel cubicle. The thickness of doors/ covers shall not be less than 1.6 mm. The Panel shall have rolled edges with neoprene rubber gaskets to form IP52 degree of protection. Terminal blocks shall be provided for cable terminations. The Panel shall be provided with removable gland plates.
- 3.11.4 Electronic over load relay shall have selectable setting, self-powered, , ambient temperature compensated, sensitive to phase loss/unbalance, trip free mechanism, with trip indication, test



and stop function, current display etc.. Type-2 coordination shall be ensured between MCCB/MPCB, contactor and overload relay.

- 3.12** Motors shall be suitable for Elevator duty. Motors shall be suitable for direct on-line starting. Class of insulation shall be Class F. however temperature rise shall be restricted to limits corresponding to Class – B insulation. Degree of Protection shall be IP-55. Method of cooling shall be IC 01 41 (TEFC)

3.13 Cables

- 3.13.1** Cables shall conform to relevant IS standards amended up to date. All the fixed cables shall be armoured and shall be FRLS (Flame retardant and low smoke type).
- 3.13.2** Separate cables shall be provided for circuit of different plant and auxiliaries for different voltage levels and for circuits fused separately. Power, control and instrumentation circuits shall be taken through separate cables. Minimum size of power cables shall not be less than 2.5 sq.mm copper. Minimum size of control cables shall be not less than 1.5 sq.mm copper.
- 3.13.3** Trailing cable shall connect the Cage main control panel to the auxiliary control panel at ground level. Cable shall supply the Cage with all power requirements. Cable guides shall be installed at every 6 metres to avoid entanglement of this cable. Trailing cables shall be suitable for the duty intended and shall be elastomeric outer sheathed with copper conductor. Separate trailing cable shall be used for power and Control circuits. Trailing Cables shall be properly suspended such that no strains are imposed on the conductors.

4.0.0 PAINTING

The fabricated enclosures/panels shall undergo a treatment of degreasing, pickling and two coats of primer before being given the epoxy finish. Two coats of final paint shall be applied. The external and internal surface of the board shall be powder coated epoxy finish. The final thickness of paint film on steel shall not be less than 50 microns.

5.0.0 INSPECTION AND TESTS

Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. For the various bought out item test certificates from equipment Manufacturer shall be furnished. Routine tests shall be carried out for all the equipment as per applicable standards.

All components shall be tested as per IS: 14665. Test reports shall be furnished for approval.

6.0.0 Technical parameters:

Sl. No.	Item Description	For Chimney	For Ash Silo
1.	Type	Rack and Pinion type	Rack and Pinion type
2.	Chimney height	275 M	As required
3.	Travel Length	About 260 M	As required
4.	No.of floors served	G+25	As required
5.	Type of Operation	With attendant	With attendant
6.	Minimum carrying Capacity (Pay load)	400 kg	400 kg
7.	Speed	0.5 m/sec	0.5 m/sec
8.	Type of control	Semi-Automatic Control Tone Frequency System	Semi-Automatic Control Tone Frequency System
9.	Cage door	Manually operated , mild steel construction	Manually operated , mild steel construction



Sl. No.	Item Description	For Chimney	For Ash Silo
10.	Cage construction	MS pipe covered with aluminium sheet and with aluminium chequered plate floor	MS pipe covered with aluminium sheet and with aluminium chequered plate floor
11.	Controls and Indications in Cage Push Button Station (Inside Cage)	Up, down , next landing, stop, fan, cage light, key switch, hooter/alarm, o/l indicating lamp	Up, down , next landing, stop, fan, cage light, key switch, hooter/alarm, o/l indicating lamp
12.	Controls and Indications in Landing Push Button Station (At Every Landings)	Stop, Next landing, Up and down	Stop, Next landing, Up and down
13.	Power Supply	415 V , 3 phase, 3 wire, 50 HZ supply	415 V , 3 phase, 3 wire, 50 HZ supply
	Motor	Squirrel cage induction motor, S4 duty, Class F insulated, IP55	Squirrel cage induction motor, S4 duty, Class F insulated, IP55

7.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Block diagram
- Schematic diagram
- Technical particulars of all equipment
- General arrangement drawings of all equipment
- Conduit/wiring layout
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.21: PUBLIC ADDRESS SYSTEM

1.0.0 INTENT OF SPECIFICATION

This section covers the technical requirements of Public address system.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:
No. of stations and speakers shall be firmed up during detail engineering.

- a) Central Control exchange
- b) Master Control Station
- c) Handset stations of various types
- d) speakers of various types
- e) sound proof enclosure
- f) Power distribution panel
- g) Signal distribution panel
- h) Junction boxes
- i) Power/ control /signal /speaker cables
- j) Commissioning spares and consumables
- k) Mandatory spares
- l) Tools & tackles
- m) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) except where modified and/or supplemented by this specification. Major standards which shall be followed are listed below. Other applicable Indian standards for any component part, even if not covered in the listed standards, shall be followed.

- IS : 9302 : Characteristics and methods of measurement for Sound System Equipment
- IS: 7741 : Loud Speakers
- IS:9302 : Sound System Equipment
- IS:1882 : Outdoor installation of Paging system
- IS:10426 : Public Address Amplifiers
- IS 1881 : Code of practices for Installation of Indoor Amplifying and Sound Distribution System.

4.0.0 TECHNICAL REQUIREMENTS

- 4.1.0 Public Address System shall be an open line communication system which shall comprise Master control stations, Field Handset stations and Speakers with amplifiers controlled by a Central Control Exchange. Master control stations shall be located at various control rooms which control the communication among the field handset stations. Field handset stations shall be spread all over the plant.
- 4.2.0 Indoor PA system shall be provided in all the Local control rooms and pump houses. Out Door installations shall be provided near all major and critical equipment. For H₂ plant, Fuel unloading pump house, Tank farm area & FOPH shall be provided with explosion proof system. Weather proof enclosures shall be provided at outdoor installations.



- 4.3.0 Public address shall be extended up to Sea water intake pump house.
- 4.4.0 The system shall provide reliable and efficient communication between plant personnel located in different areas of the plant.
- 4.5.0 The system shall be extended up to external cooling water intake pump house.
- 4.6.0 The system shall be modular and expandable type.
- 4.7.0 The system shall be installed in an adverse industrial environment. Equipment in some areas shall be subject to vibration, coal dust, fly-ash, oil/water vapors as prevalent in thermal generating plant.
- 4.8.0 The design shall be such as to provide highly intelligible two-channel voice communication even in areas of high background noise (50 dB to 100 dB).
- 4.9.0 The system shall be distributed amplifier type with provision for easy future extension. Each station shall be complete with its own pre-amplifier, signal processing and power amplifier.
- 4.10.0 Equipment shall be self-protecting against transients in the input A.C supply and against failure of any component or cable in the entire communication system.
- 4.11.0 Public Address system shall be complete with all accessories in all respects such as follows:
- Master control stations
 - Central Control Exchange
 - Field Handset stations
 - Speakers with amplifiers
 - Canopy
 - Sound proof enclosures
 - Siren
 - Junction boxes and pull boxes, terminal blocks, sockets.
 - Power, Control and Signal cables
 - Conduits including fittings and accessories
 - Grounding materials and connections.
 - All fittings, supports, brackets, clamps and connectors
- 4.12.0 Voice paging shall be accomplished from any handset through all speakers in the system with automatic speaker muting provided where required to prevent acoustic coupling between adjacent handset and speaker units. When the paging circuit is used for communication, all speakers except those automatically muted shall carry all sides of the conversation.
- 4.13.0 Party line conversation shall be accomplished from any handset to any combination of handsets in the system, utilizing the transmitters and receivers in the handsets and muting all speakers to the conversation. All speakers shall be available for paging during the use of the party line circuits.
- 4.14.0 Various areas in the Power project shall be grouped under following zones for the Paging system. For each zone, one master control station and associated field hand set stations shall be provided.
- One zone for Unit-1
 - One zone for Unit-2
 - Separate zones for station and common system



4.15.0 Master control stations are proposed at following locations.

- Unit-1 Control room
- Unit-2 Control room
- Cooling water intake pump house Control room
- AHP Control room
- CHP Control room.

4.16.0 Central control exchange shall be located in main plant control room. All the master control units shall be connected in parallel with central control exchange.

4.17.0 The Central control exchange shall be interfaced with EPABX system and Walkie Talkie system.

4.18.0 Public Address system shall be suitable for operation with 240 V AC, 50 HZ supply which shall be derived from Plant UPS system. Power supply shall be extended at auxiliary plants from respective local UPS system.

4.19.0 Central Control exchange shall be microprocessor based with all the control and Switching hardware without any moving part. Central control exchange cabinet shall be single front, fabricated out of CRCA sheet steel of 2 mm thickness, dust proof and with swing out assembly of Plug-in card rack. It shall be possible to locate faults by monitoring from the cabinet. All hardware necessary for fault isolation and troubleshooting shall be supplied in the Central control exchange.

4.20.0 Master control stations shall have facility for generating and introducing the siren tone in the page channel. The tone generator shall be provided to produce a siren tone (fire alarm signal) that can be inserted into the "All Call" paging channel of the Public Address System.

4.21.0 The system shall provide two-way voice communication on each party line and use a page line for voice transmission over a plant-wide speaker system. While a conversation is taking place on a party line, other conversation may be held on other party lines or page line. Paging shall be used for everyday contact with plant maintenance staff and shall provide a means to alert plant personnel to an emergency. Each page/party handset station shall have party lines and page line.

4.22.0 The following communications are envisaged.

- Communication between handsets with in Zone.
- Communication between handset and Master control station
- Communication from Master control station
- Communication between master control stations
- Communication between handsets of different zone through master control station
- Communication between Telephone system and different zones of PA system.

4.23.0 Central Exchange shall be wide band microprocessor based system band width shall be at least 200-10 kHz (+10 dB). System shall have provision for sufficient spare zone for future expansion. Suitable hardware and programming tools for communication between any handset of the communication system with Telephone system. Master control stations shall be microprocessor based, desk type with keyboards.

4.24.0 Drivers used in hazardous area shall be rated for hazardous classification of the area.

4.25.0 A higher speaker density shall be provided in areas with high ambient noise.

4.26.0 Cone speakers shall be used in finished areas and installed in the finished ceiling with a grill.

4.27.0 False ceiling speakers shall be used in control room area.

4.28.0 Handset stations and speaker amplifiers shall be mounted at 1.4 meters from the center line to



the floor or platform.

- 4.29.0 The Master station shall be desk mountable, complete with wooden / steel desk, microphone, speaker, selector switches, call registering device, indicating switches, 'ALL CALL' switch, Emergency hooter switch, loud speaker mute switch, Buzzer, Buzzer mute switches and all other associated auxiliaries and accessories.
- 4.30.0 The Slave station shall be suitable for wall / column / structure mounting, conventional telephone type complete with sensitive microphone ear piece, coiled cord retractable cable and loud speaker. It shall have push button feedback switches on the front panel for two independent channel namely page and private channel operation along with functional switch necessary control and indication facilities. Each station shall be complete with its own pre-amplifier, signal processing and power amplifier with provision for future extension.
- 4.31.0 The Handset station shall have all solid state component mounted in an enclosure suitable for the environment in which it shall be located and assembled in plug in type module. The PA System handset stations shall include the following devices mounted on the front panel:
- Handset hang-up switch.
 - Telephone type handset with retractable cord.
 - Push button "Page-Party line."
 - Push button "All Call."
 - Party line bat handle selector switch.
 - Amplifier, handset type, mounted on the back of the panel.
 - Amplifier, speaker type, mounted on the back of the panel.
 - Amplifier self-aligning plug mounted on the back of the panel.
 - Key-operated switch for radio/PA System interface unit.
 - Headset jack

5.0.0 OPERATION REQUIREMENTS

5.1.1 Communication between handset within Zone

To originate a call, the caller shall lift the handset off the cradle at his station and press the page button. The associated loudspeaker shall get muted to prevent acoustic feedback. A call attention gong shall be heard over all other loudspeakers. The caller shall then make his announcement and release the page button. The announcement shall be heard over all loudspeakers except those muted. On hearing the announcement, the called party likewise shall lift the handset off the cradle at his station and establish two way communications over party channel. Party channel busy lamp shall be lit up at all stations as soon as the channel is in use. Loudspeaker associated with any station engaged in party channel conversation shall be free to receive any paging announcement. An additional switch shall be provided at each handset to mute the associated loudspeaker, if required, when engaged in party channel. The slave stations in each zone shall have conference facility so that any number of stations of that zone can join in the conference on private channel.

5.1.2 Communication between handset and Master control station

The person at the slave station shall press the necessary switch to call the Master station. A red lamp indicating call pending shall light up at the Master station and simultaneously buzzer shall be activated. It shall be possible to mute the buzzer by a switch but the red lamp shall continue to glow till the operator answers the call. Once the call is attended, a green lamp shall glow, which shall go off, when the switch is put in the 'OFF' position.

5.1.3 Communication Between Masters Control Stations

To initiate a call, the calling station shall operate the selector switch corresponding to the desired station. At the called station, a buzzer shall sound and a lamp corresponding to calling station shall glow. The buzzer can be muted but the lamp stays lighted till the calling party resets his switch. To attend a call, the called party shall also operate the relevant selector switch at his station. The call is now established and communication can now proceed in duplex mode over



the handsets. After the call is over, the selector switch at both stations shall be reset to terminate the call. It shall also be possible to have conference facility, if required by calling other stations through relevant switches.

5.1.4 Communication from Master Station:

Master station operator shall be able to select the desired zone by putting the switch for that zone in paging position and talk into his mouthpiece. This announcement shall be heard at all the loud speakers of that zone. A call attention gong tone shall automatically precede all paging announcement. The called party shall go to the nearby Slave station and shall press necessary button to indicate his availability at the call station. The Master station operator shall then put the selector switch in private position and both the parties shall be able to talk on the private channel

It shall be possible for the Master station operator

- To connect two Slave stations for direct communication between two selected zones.
- To hold a conference between the selected Slave stations in different zones and/or the Master station.
- To contact all the zones through the "ALL CALL" switch. Also when the Master station is unmanned by any chance, by putting the switch in the "ALL CALL" mode, each zone should be able to contact other zones without the aid of the Master station operator.
- To introduce an emergency call attention gong which shall sound different from the normal call attention gong, when it is required to draw the attention of the personnel.
- To sound emergency hooter using the necessary switch, through all the zonal station loud speakers overriding all other communication.
- To enable emergency evacuation alarm / siren tone

5.1.5 Communication Between Handsets of different Zone through Master Control Stations

To originate a call between two zones through Master control station, the person of a particular zone shall press the necessary switch to call the Master station. Master station operator shall be able to select the desired zone by putting the switch for that zone in paging position and talk into his mouthpiece. This announcement shall be heard at all the loud speakers of that zone. A call attention gong tone shall automatically precede all paging announcement. The called party shall go to the nearby Slave station and shall press necessary button to indicate his availability at the call station. Master station operator shall connect two Slave stations by putting the selector switch in private position and both the parties shall be able to talk on the private channel. It shall be possible to hold a conference between the selected Slave stations in different zones and/or the Master station.

5.2.0 PAINTING

The fabricated enclosures/panels shall undergo a treatment of degreasing, pickling and two coats of primer before being given the epoxy finish. Two coats of final paint shall be applied. The external and internal surface of the board shall be powder coated epoxy finish.

6.0.0 INSPECTION AND TESTS

- 6.1.0** Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. For the various bought out item test certificates from equipment Manufacturer shall be furnished. Routine tests shall be carried out for all the equipment as per applicable standards.



7.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Design basis report
- Block diagram of PA System
- General Arrangement of PA System
- Schematic diagram
- Technical particulars of all equipment
- General arrangement drawings of all equipment
- GA drawing of acoustic enclosures
- GA drawing of all cabinets, junction boxes
- Parameters of cables
- Wiring layout of each area/building
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.22: TELEPHONE SYSTEM

1.0.0 INTENT OF SPECIFICATION

This section covers the technical requirements of Telephone system.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) One set IP based, multimedia communication system (hot standby mode), with 100 trunk lines, 1000 extensions, modular, expandable type, having ISDN PRI trunk interface, analog trunk interface, digital extension ports, SIP/IP VOIP extension ports with CLIP facility, E&M with substation communication through OPGW, Public address system port, SNMP based system administration, networking features, video conferencing features, etc. expandable up to 10000 ports by adding cards
- b) One set distributed processor
- c) Voice mail system
- d) One set PC based operator console with communication head set including PC.
- e) 600 nos. Analog Desk top Telephones
- f) 50 nos. Analog Wall mounted Telephones
- g) 25 nos. IP telephones
- h) 50 nos. latest digital cordless phones
- i) 50 nos. Digital telephone with speaker phone and display
- j) 10 nos. Chief/ secretary Telephone set
- k) GSM/3G Fixed Cellular Terminal for Voice applications (10 nos. GSM SIMS shall be provided)
- l) Telephone SMS facility for sending SMS to 50 nos. cell phones (By accepting the text file from DCS and forward to the assigned numbers automatically)
- m) Two numbers Multi-function printers (Xerox/fax/scanner/printer)
- n) Fiber optic phone adapters
- o) Telephone tag box & Junction box
- p) Power cables
- q) Fiber optic Telephone cables
- r) CAT5/CAT6/twisted pair telephone cables
- s) Jelly filled telephone cables
- t) Distribution frames
- u) 50 nos. Wireless Walkie-Talkie system.
- v) 2X100% 48V DC batteries for each location
- w) 2X100% 48V float cum boost chargers for each location
- x) Necessary System software for programming through PC and equipped/ wired for full capacity.
- y) Testing cords and Krone punching tools.
- z) Programming console instrument.
- aa) Commissioning spares and consumables
- bb) Mandatory spares
- cc) Tools & tackles
- dd) Any other equipment required for the system



3.0.0 TECHNICAL REQUIREMENTS

- 3.1.0 The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the applicable Indian Standards, IEC standards and ITI Specifications, except where modified and /or supplemented by this specification
- 3.2.0 All electrical equipment selection and derating shall be based on ambient temperature of 50 deg. C and relative humidity of 95% maximum.
- 3.3.0 The EPABX shall be located in switchyard control building. The telephone sets shall be installed in various areas of power plant.
- 3.4.0 Equipment shall be sturdy, impact resistant, dust and damp-proof, corrosion proof, pilfer proof design. It shall conform to IP: 32 degree of protection for indoor location. Equipment shall be made tamper-proof by use of non-standard screws, which can be opened only by means of special keys.
- 3.5.0 Model and make of the EPABX, Wireless system, Telephone sets shall be got approved from Owner.
- 3.6.0 **For EPABX, 48 V DC supply shall be provided as detailed under 'Battery' and 'Battery charger' section.**
- 3.7.0 The EPABX system shall be interconnected with Public Address System.
- 3.8.0 The EPABX system shall have provision for interconnecting with EPABX of Colony.
- 3.9.0 EPABX system shall have voice communication via data networks (VoIP).
- 3.10.0 The system is required for switching of outgoing, incoming and transit calls effectively and reliably. It shall support Optical/Electrical connectivity over Optic Fibre, UHF radio links, VOIP & GSM and substation communications on dialing & express trunks. The exchange shall support CO lines also. The System design shall have,
- High speed processor to provide real time response to all the incoming and outgoing calls fluently.
 - 19"rack mounted design.
 - Dedicated DTMF circuit for each user port to provide 100 % Non-Blocking operation even while dialing.
 - Multiprocessor architecture, wherein each interface card with own dedicated microprocessor (slave processor) for local processing of events and commands and the master processor manages all the slaves.
 - Built-in PCM/TDM digital technology and switching matrix to provide unrestricted communication to all users simultaneously.
 - Platform which allows replacing old or faulty interface cards without switching off the system.
 - To support in addition to E&M (6 wire- 2W Tx, 2W Rx , E wire & M wire) ports , CO lines, ISDN BRI, ISDN PRI, T1/E1, GSM/3G and VoIP network operation simultaneously using respective interface cards, which enable the system to be used as a common switch for PLCC, POTS,ISDN,GSM/3G and the VoIP telephony network.
 - Primary Protection by means of providing IPM (Inter Protection Module) that consists of resettable fuses and GD Tubes to be mounted on MDF.
 - To offer redundancy for its all critical functional cards like switching card, Power supply card and main processor (master) Card. In the event of failure of the power card and



Switch card, the stand-by card should have to take over without interruption of their functionalities. Whereas, if the active Master card fails, the system should restart and take over automatically.

- j) DSP based Subscriber Loop Integrated Circuit (SLIC) which allows having programmable line parameters features.
- k) All the expansion slots shall be universal in nature, so that, it would be possible to insert any of the cards in any slot and it will be automatically configured by the System when inserted. Thus, design will eliminate configuration bottleneck and offer true flexible configuration.
- l) Flexible and user friendly web browser based GUI which would help to program the system from anywhere on IP network. To configure the EPABX remotely using internet, EPABX should also require having built-in server.
- m) The system shall have voice communication via data networks (VoIP).
- n) The system shall be used to interface with substation communication terminal. Hot line communication between the substations/switchyard shall be established through this system.
- o) The system shall have CUG communication through 10 nos. SIM cards.
- p) It shall support DTMF facility without compromising with suitability of matching existing switching network of the substation/Grid.
- q) It shall have the hot standby facility for CPU & PSU. It shall have universal slot architecture.
- r) The surge arrestors and fuses on all ports of subscriber and trunk lines shall be provided for Protection of electronic circuitry against external induction, short circuits, high voltage surges etc.

3.11.0 The 2 wire Telephone instrument shall have following facilities.

- a. Push button number key.
- b. DTMF and pulse Dialing.
- c. Flash key.
- d. Pause key.
- e. Redial key.
- f. LED indication for incoming ring.
- g. Long cord connecting between handset and base unit.
- h. Adjustable ring volume.
- i. LCD display

3.12.0 The Digital key Phone shall be supplied having following features:

- a. LCD Display
- b. Minimum 15 Direct station Selection Keys
- c. Auto answer
- d. Adjustable Ringer Volume level
- e. Adjustable speech level
- f. Call duration display
- g. Call cost display
- h. Directory dialing by name
- i. Dual color LED's for port status
- j. Full duplex
- k. Forced answer



- l. Hands free operation
- m. Headset Connectivity
- n. Missed calls
- o. Multiple ringer tones
- p. Ring LED indication
- q. Text message

3.13.0 System architecture shall have,

- a. PCM/TDM 100% non-blocking
- b. Digital ISDN switching platform for PLCC
- c. High density digital switching
- d. 32 bit processor architecture
- e. Distributed processing architecture wherein each card of EPABX should have its own dedicated Micro-controller, EPROM & RAM.
- f. Open, Universal slots architecture to allow flexible configuration and easy expansion in future without changing the basic platform.
- g. System should support separate dedicated DTMF circuit for each port.
- h. The latest surface mount technology
- i. Secondary protection on each port with resettable fuse in addition to the primary protection.
- j. Support substation communication and normal PBX switching operation simultaneously.
- k. SLIC based design
- l. Redundancy for critical cards
- m. Support Hot-swapping of cards

3.14.0 System should have following facilities:

- a) Built-in RS 232 port for operation of Debug and system activity monitoring simultaneously.
- b) Built-in Ethernet Port for programming the EPABX through PC and printing of reports by printer connected to PC.
- c) Built-in USB Port.
- d) Built-in Digital Extension Port & also the provision to insert card for Digital Extension subscriber.
- e) Built-in port for connecting external music source.
- f) Built-in port for connecting Public Address System (PAS)
- g) Built-in port for potential free contact (PFC) relay connection to interface external error annunciation device.
- h) Built-in Auto Attendant functionality.
- i) Built-in Voice mail System functionality.
- j) Generation & printing of System Configuration reports
- k) Generation & printing of System Activity Log reports
- l) Transferring the file using external modem
- m) Display of Software version

3.15.0 The System should support following interfaces.

3.15.1 Trunk (Network) Interfaces

- a) CO (TWT) Lines: This interface shall allow terminating 2-Wire Analog Trunks (CO lines) to function the EPABX as both PLCC EPABX and Conventional PBX at the same time.
- b) E&M Trunks: E&M card shall provide interface to substation OPGW panel to extend connectivity for both 6 Wire E&M (2W Tx speech, 2W Rx Speech, E wire & M wire) Dial-



in/Tie line as well as E&M Express lines. Using E&M interface, the offered EPABX shall also to be integrated in the network with Routers, VSAT, DACS/Multiplexers, etc.

- c) GSM/3G (Mobile)Trunks: GSM/3G card shall support GSM/3G connectivity by means of GSM/3G (SIM) line to avail benefits offered by GSM networks.
- d) ISDN BRI/PRI Trunks: This interface shall support connectivity to ISDN BRI (2B+D) and ISDN PRI (23B+D or 30B+D) lines to the system. These lines when configured as NT or TE as per application requirement, the system with this card should allow an ISDN terminal; Video phone or LAN connectivity to ISDN port in NT mode.
- e) T1/E1 Trunks: This interface shall provide connectivity based on T1/E1 standard and interface of EPABX to Radio link, STM, xDSL Modem, Multiplexers etc.
- f) VoIP Trunks: Each VoIP card shall provide 32 channels and enable users to call on channels simultaneously.
- g) GSM SIM network connectivity: 10 nos. GSM SIM cards for CUG communication.

3.15.2 Extension Interfaces:

- a) Analog Telephones (FXS):This interface shall provide FXS port to interface standard Analog (2- Wire) telephone instruments. The system shall also be programmed using any analog telephone connected to FXS port.
- b) Digital Phone Interface: This interface shall provide digital extension port to connect Digital phone through 2-Wire full duplex Digital Subscriber Network interface circuit. The each key of digital phone shall be programmable for required function/application viz. Call transfer, call pick up, to access Express trunk of E&M card, to access trunk by single touch push button by programming & storing the access number etc.
- c) IP Extension: The IP phone, PC with soft phone or Mobile phone with SIP client shall function as IP extension. Each IP extension shall be assigned unique user name and password to authenticate and established calls using system resources regardless of being located anywhere on the global IP network.
- d) ISDN Extension (NT mode):This interface shall provide ISDN BRI (2B+D) and ISDN PRI (23/30B+D) ports.

3.15.3 Auxiliary Interface:

- a) External Music Port: The external music port shall allow an external music source to connect to EPABX.
- b) Public Address System Port (PAS):The public address system port shall allow any station user to make public announcement on external speakers.
- c) Security Dialer Port: This interface shall allow sensor devices to connect to its digital input port. In case of emergency, the EPABX will dial different predefine numbers and play a prerecorded message. In case of emergency a hooter shall also be activated.
- d) Call accounting System (CAS) Interface: The offered EPABX should have to support interface for most types of call accounting System protocols available world-wide which will help in easy integration of the third party call accounting software.



3.16.0 The EPABX shall have the following substation communication features.

- a) Alternate Routing : In a typical substation network, there can be multiple paths that a call can take to reach the destination. The offered EPABX shall have the facility to select an alternate route if a particular route is busy.
- b) Compander Control Signal: To improve S/N ratio, speech signals are necessary to be compressed at source and decompressed at the destination. This process is activated by the CCS. The offered EPABX shall have to provide CCS for each E&M port.
- c) Destination restricted Dialing: This feature shall restrict all the users of the system to make a call to certain destination even though availability of trunk line to that destination.
- d) Disable out-of-Order Trunk: In the event of faulty trunk line, the EPABX shall disable the faulty trunk and takes it out of service to avoid routing of calls on such trunk lines.
- e) Field Programming: The hardware & software configuration should be changed in the field to adapt to the dynamic field requirement. Hardware capacity, port configuration and programming should be managed at the installation site. No specific tool should be required while expanding the configuration on field.
- f) Flexible extension numbering: The EPABX should offer flexible numbering plan for all the stations users (1 to 3 digits) and even overlapping numbers is also possible.
- g) Flexible Station ID: In a network, each EPABX is require to give a programmable Station Identification Number (SID), which helps to route a call to its correct destination. EPABX should allow setting of SID from 1 to 3 digits, allowing seamless integration of offered EPABX in any substation communication network.
- h) Multiple station ID: The same EPABX shall be programmed for multiple stations ID with mixed digit length which provides flexibility to connect the EPABX with multiple networks.
- i) Priority: In a network it is desired that calls from selected users have precedence over others. Such important users may be allowed to interrupt an ongoing call to request them for release of current call. The offered EPABX shall extend this feature for both priority within a system & priority over E&M lines.
- j) The EPABX shall be programmable using normal analog telephone, digital phone and remotely using web-based GUI.
- k) Web based Programming: For offered EPABX, it shall also be possible to change programming from remote location once it will be connected to the internet which will save valuable time and efforts in providing essential technical support.
- l) The EPABX shall provide facility to search detailed reports for Calls Viz. outgoing, incoming & internal and also to print the same whenever require for analysis. The EPABX shall have sufficient & separate
- m) buffer capacity for each type of call i.e. outgoing, incoming & internal in multiplication of 1000.
- n) The important events viz. module going faulty, System restarting, port getting hang etc. shall be recorded in internal log file of the system and shall also provide option to print by connecting printer on parallel or a serial printer and to transfer log file to PC/laptop.
- o) The EPABX shall have suitable relay port to announce failure of a card or related problems.
- p) The EPABX shall have system fault log to maintain the log of all faults occurring in system & on event of fault it would have to activate buzzer.
- q) The EPABX shall have transit barring feature to block unauthorized routing of calls to streamline the flow of traffic only on the designated routes.
- r) The EPABX shall have trunk restricted dialing feature to group the trunks to avoid traffic on critical routes which allow keeping the trunk reserved for specific traffic. Similarly user restricted dialing feature shall also to be supported.



- s) The EPABX shall have “allowed & denied lists” and “auto attendant functionality” features to restrict dialing of long distance & international calls made by users and to perform the task of virtual operator.
- t) The EPABX shall offer interface for most types of call accounting system protocols available world-wide to have easy integration of the third party call accounting software.
- u) The EPABX shall also support features like Call Duration Control, Caller line identification, Conference Dial in, Conference – Multiple Participants.
- v) The EPABX shall support paging, Voice mail system & Voice message application.
- w) Call routing progression Tone to the caller- A beep should be given to the caller every time the call passes through a station.
- x) Trunk disable option to avoid call on an out-of-order trunk
- y) Trunk Groups to restrict ordinary traffic on a certain trunks/routes.
- z) Maximum digit on E&M Trunks should be programmable.

3.17.0 System shall have following features.

- a) Programmable feature Access codes
- b) Allowed and denied Lists
- c) Call cost calculation
- d) Configuration report
- e) Conferencing
- f) DID
- g) DISA
- h) Distinctive rings
- i) External call forward
- j) External music input port
- k) Help report
- l) Voice mail system integration
- m) Music on hold
- n) Remote programming
- o) Station message detail recording
- p) System activity log for diagnostic purpose
- q) Trunk Access groups-Programmable
- r) Trunk landing group-Programmable
- s) Field up gradation of software using a PC
- t) Control application using a relay port
- u) Voice messages

3.18.0 The extension shall have following features.

- a) Abbreviated Dialing
- b) Alarms – Time, daily, Date & Time, Multiple
- c) Auto answer
- d) Auto call back : (a) Busy, (b) No reply
- e) Auto Redial on Normal trunk
- f) Call duration control
- g) Call forward: (a) All calls, (b) On busy, (c) On no reply
- h) Call park
- i) Call pick up: (a) Group, (b) Selective



- j) Call splitting
- k) Call Transfer
- l) Calling line identification presentation in DTMF and FSK format
- m) Calling line identification restriction
- n) Conference : (a) 3 Party, (b) Multi party, (C) Dial-in
- o) Do Not disturb
- p) Dynamic lock
- q) Follow me
- r) Forced call disconnection
- s) Call hold
- t) Hot line
- u) Last caller recall
- v) Last number redial
- w) Missed calls
- x) Over ride
- y) Paging
- z) Priority
- aa) Selective trunk access
- bb) Voice prompts for tones
- cc) Programmable speech level for each port
- dd) Programmable ring cadences

3.19.0 The following Diagnostic and Maintenance features shall be provided :

- a. Power on self-test, logic on each card to indicate hardware failure on a particular card.
- b. Port status and activity indication for E&M lines.
- c. Auto indication of an error condition
- d. System should have capability of generating of system Activity Log with
 - Any error, exception or important activity should be logged in a non-volatile memory file with date, time and details of event.
 - Activity log should be transferred to a computer for storage.
 - Facility to print system activity log on a standard printer
 - Facility of on-line printing/transferring of system activity for continuous monitoring
- e. Programming / Configuring the EPABX :
 - The System should have capability to program it using any standard analog telephone.
 - Interactive programming using Digital Key phone.
 - Window based GUI tool to program the EPABX using PC.
 - Facility for remote programming.
- f. Dialing Scheme: For a subscriber dialing scheme will be as follows:
 - Dialing '0' for access to tie lines.
 - Double digit or 3 digit station number.
 - Double digit or 3 digit number for the subscriber.

3.20.0 Cabinet:

The system shall be of rack-mounted type. Degree of protection shall be IP 54. Material and construction of shall be sheet steel.



3.21.0 Junction Boxes

Junction boxes can be Main Distribution Frame (MDF), Intermediate Distribution Frame (IDF), Distribution Board (for outdoor) or any other distribution frames for the purposes of distributing the telephone extensions. The JB's shall be of FRP for outdoor type.

3.22.0 Main Distribution Frame

The system shall be provided with MDF for termination of all incoming and outgoing trunks, telephone extension and other miscellaneous circuits. The MDF shall preferably be of rack-mounted or wall mounted type. Degree of protection for MDF/Junction boxes shall be IP 54 for indoor and IP 55 for outdoor application. Material and construction of MDF/Junction box shall be sheet steel or die cast Aluminum, It shall be complete with double compression type cable glands suitable for terminating or looping armored signal/power cables and earthing stud. It shall be suitable for wall/column/structure mounting. The MDF shall be equipped with high-speed gas discharge lightning protectors on each and every line circuit irrespective of whether internal or external.

3.23.0 Telephone Cables:

- i. Telephone cables shall comprise Fiber Optic (FO) cables, CAT5/CAT6 cables, jelly filled outdoor cables and twisted pair cables as per the requirement.
- ii. Fiber Optic (FO) cables shall be primary coated single mode fiber, filled, loose tubes, assembled around the central strength member, filled core, metallic moisture barrier, polyethylene sheathed optical fibre telecommunication cables, complying with National and International Standard Specifications. For outdoor application, it shall be armoured type.
- iii. Twisted pair cable shall be atleast 0.5 sq.mm, PVC insulated, PVC sheathed, annealed, tinned electrolytic copper conductor, Color coded and in twisted pairs, laid up, taped and sheathed. For outdoor application , it shall be armoured type.
- iv. Outdoor telephone cable shall be multi pair, at least 0.63 mm. dia., annealed, tinned, electrolyte copper conductor, Polyethylene insulated, color coded, twisted into pairs, laid up, jelly filled, PVC Sheathed, galvanized steel tape armored with overall, FRLS PVC sheath. The cable shall be suitable for laying on cable trays along with other power cables and other public address system and clock system cables. Screening shall be provided for telecom cable for the proposed installation.
- v. In all the telephone cables, 50% spare capacity shall be provided.
- vi. Complete wiring installation up to individual telephone instrument shall be carried out. Telephone wiring shall be concealed wiring with necessary socket. In service building and admin building these wiring shall be done in modular furniture.

3.24.0 Acoustic hood

The protection hood shall be made of synthetic material and lined on the inside with sound absorbing mineral fibre boards behind a perforated plate cover. The special shape of the hood and its inner lining of sound-absorbing material shall optimally reduce the noise in the area of the telephone. The hood shall be mounted with its back facing the noise source.



3.25.0 Wireless Walkie-Talkie system

- 3.25.1 The wireless system facilitates contacting/alerting a particular person who is in the premises within the range of radio transmitter.
- 3.25.2 The wireless system shall consist of specified quantity of base stations, control console and portable two-way transmitter receiver sets. The base stations along with VHF transmitter, antenna and power supply units shall be installed at centrally located place suitable for radio transmission.
- 3.25.3 Each hand held transmitter receiver shall be supplied along with batteries (long life, heavy duty), battery chargers, carry case, etc.
- 3.25.4 The system shall be capable of coupled with the EPABX system such that any wireless set can be contacted from any of the EPABX-extensions and any wireless set can be used to contact any of the EPABX-intercom number/pager through EPABX.
- 3.25.5 The system shall have minimum operating range of 15 km.
- 3.25.6 The operating frequency allotment from govt. authority and operating license shall be arranged by the bidder.
- 3.25.7 The wireless set shall be addressable type and the transmission of address signal shall be done by depressing the keys of control console with the code number of a receiver (carried by the required person). The signal shall be received by the respective receiver and it shall give an audible beep signal. There shall be a provision to silence the beep with a push button on the receiver.

4.0.0 PAINTING

The fabricated enclosures/panels shall undergo a treatment of degreasing, pickling and two coats of primer before being given the epoxy finish. Two coats of final paint shall be applied. The external and internal surface of the board shall be powder coated epoxy finish.

5.0.0 INSPECTION AND TESTS

Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. For the various bought out item test certificates from equipment Manufacturer shall be furnished. Routine tests shall be carried out for all the equipment as per applicable standards.

6.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Design basis report
- Block diagram of EPABX System
- General Arrangement of EPABX System
- Technical particulars of all equipment
- Technical particulars of wireless paging system
- General arrangement drawings of all equipment
- Parameters of cables
- Telephone wiring layout of each area/building
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.23: ILLUMINATION SYSTEM

1.0.0 INTENT OF SPECIFICATION

This specification covers requirements of Illumination system.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following for all plant buildings, non plant buildings, watch towers, boundary wall, roads, parking areas, outdoor areas, etc.

- a) Light pipe solar lighting system (100 nos.)
- b) Lighting fixtures
- c) Aviation obstruction lights for chimney & cooling tower
- d) Lighting distribution boards
- e) Lighting panels
- f) Receptacle panels
- g) Receptacles
- h) Minimum 25 nos. Lighting mast (Winch operated)
- i) Lighting poles
- j) Switchboxes
- k) Junction boxes
- l) Hand lamp units
- m) Conduits
- n) 100 nos. wall mounted fans
- o) Ceiling fans
- p) 25 nos. pedestal fans
- q) Wires
- r) Commissioning spares and consumables
- s) Mandatory spares
- t) Tools & tackles
- u) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant Indian Standards, IEC publications and other standards as listed, except where modified and / or supplemented by this specification. The design and testing shall follow the following standards.

a) IS: 1777	Industrial luminaire with metal reflectors.
b) IS: 1913	General and safety requirements for Luminaires.
c) IS: 10322-5-5	Luminaires- Flood lights
d) IS/IEC 60079 -1	Equipment Protection by Flameproof Enclosures "d"
e) IS: 2149	Luminaires for street lighting.
f) IS: 2206	Flame proof electric lighting fittings
g) IS: 4013	Dust-light electric lighting fittings.
h) IS: 8224	Electric Lighting fittings for Div. 2 areas.
i) IS: 9583	Emergency lighting units.
j) IS: 9974	High Pressure sodium vapour lamps.



k)	IS: 10322	Specification for Luminaires
l)	IS: 732	Electrical wiring installation (system voltage not exceeding 650 V).
m)	IS:5216	Guide for safety procedures and practices in electrical works.
n)	IS: 12640	Residual Circuit operated Circuit breakers.
o)	IS/IEC: 60947-1	low-voltage switchgear and control gear.
p)	IS/IEC:60898-1	Miniature circuit breakers
q)	IS/IEC 60715	Dimensions of low-voltage switchgear and control gear.
r)	IEC: 60309-1	Plugs, socket-outlets and couplers for industrial purposes
s)	IS/IEC 60529	Degrees of protection provided by enclosures (IP code)
t)	IS: 694	PVC insulated cables for working voltages up to and including 1.1 kV.
u)	IS: 9537	Conduits for electrical installation.
v)	IS: 3480	Flexible steel conduits for electrical wiring.
w)	IS: 1239	Mild steel tubes, tubular and other wrought steel fittings. (for size above 63 mm dia of rigid conduits)
x)	IS: 14768	Fittings for rigid steel conduits for electrical wiring.
y)	IS: 3837	Accessories for rigid steel conduits for electrical wiring.
z)	IS: 14772	Boxes for enclosures of electrical accessories.
aa)	CIE-173	Tubular day light guidance system

4.0.0 LIGHTING DESIGN

4.1.0 The plant lighting system shall comprise following categories :

- Tubular day light guidance system
- Normal 230 V AC Lighting System
- Normal-cum-Emergency 230 V AC Lighting System
- Emergency DC Lighting System

4.1.1 Tubular daylight guidance systems are linear devices that channel daylight into the core of a building. They consist of a light transport section with, at the outer end, some device for collecting natural light and, at the inner end, a means of distribution of light within the interior. Collectors may be either mechanical devices that actively focus and direct daylight (usually sunlight), or be passive devices that accept sunlight and skylight from part or whole sky hemisphere. The transport element is usually a tube lined with highly reflective or prismatic material or may contain lenses or other devices to redirect the light. Light is distributed in an interior by output components, commonly diffusers made of opal or prismatic material.

4.1.2 Normal AC lighting shall be provided by lighting distribution boards and lighting panel distributed throughout the plant. Supply to these lights shall be ON as long as the station AC supply is available. AC lighting fixtures shall be fed from respective area lighting panels. If fault level at lighting panel is more than 10 kA, lighting distribution boards shall be fed through 415/433 V ratio lighting transformers.

4.1.3 Emergency AC lighting shall be provided by DG set through unit emergency switchgear and lighting distribution boards. In main plant area, about 20% lighting shall be fed from AC emergency source.

4.1.4 In main plant area and other auxiliary plants, emergency DC lighting shall be provided in control rooms, in critical operating area, and for safe exit in case of black out. These lights shall be fed from DC distribution board backed by DC batteries. These lights shall be of LED type. DC lights shall remain continuously ON along with AC lighting system.

4.1.5 For Off-site buildings, where DC supply is not available, Emergency lighting units with integral batteries shall be used. Offsite area building emergency DC lighting shall be provided by self-contained emergency lighting fixtures. Each emergency fixture shall provide emergency light for



3-4 hours when the normal power source is lost. Each emergency light fixture shall be provided with Ni-cd gel battery, battery charger and two CFL lamps.

4.2.0 Tubular day light guidance system

- 4.2.1 The sunlight is captured from a transparent dome on the rooftop of a building and then the light travels through a daylight pipe (by way of multiple reflections from the daylight pipe's specular inside surface) to inside the building where sunlight is delivered to the indoor spaces through diffusers.
- 4.2.2 The transparent dome collects sunlight from above the roof level and then the daylight pipe guides the same to the interior spaces of a building. So, at the interface with open sky, the light pipe is provided with a transparent dome having the following attributes: adequate impact strength, sufficient daylight capture surface, high transmittance for the visible spectrum i.e. 400–750 nm, surface designed to scatter light uniformly; fire resistance, U-V stabilized, U-V blocking (up to 380 nm) and capable of preventing the ingress of moisture, dust, anti-bird measures, etc.
- 4.2.3 The light pipe system should have the following features: high impact strength; high transmittance for visible portion of sunlight spectrum i.e. 400–750 nm; purest color rendition (no color shift); U-V stabilized; U-V blocking (up to 380 nm); fire resistance; low attenuation of solar radiation while traversing the length of light pipe and any bends therein; minimal transmission of heat along with daylight; (preferably) low aspect ratio (length : diameter); and arrangement for control of available sunlight. For negotiating non-straight paths, light pipe bends should also be available. The daylight pipe and associated items are required to be maintenance free.
- 4.2.4 The diffuser should be designed so as to achieve the following goals: transmittance of required amount of daylight and to spread it efficiently throughout the space to be illuminated; there should be no glare; visual comfort; 99% U-V blocking (up to 380 nm); resistance to impact; fire resistance; prevent ingress of moisture and dust; U-V stabilized; control of light output, including switching off the light during daytime.
- 4.2.5 While installing the daylight pipe, correct type of roof flashing should be used so that no ingress of water, dust, etc. takes place at the junction between masonry work and daylight pipe. The dome, light pipe and diffuser should be electrostatically neutral during installation.

4.3.0 Lighting shall be provided in all the areas of power plant. Lux level proposed are given below:

S. No.	Area	Lux level
1.	Turbine Hall (operating floor)	200
2.	Turbine Hall other floors	100
3.	Boiler Platforms & ESP platforms	100
4.	Switch gear /MCC rooms, Battery room, DG Room, Elevator machine room	200
5.	Transformer yard	50
6.	Gas insulated switchgear building	200
7.	Control room	400/500
8.	Control equipment room	300
9.	Office area	300
10.	Air compressor house	150



S. No.	Area	Lux level
11.	Crusher house, Transfer tower and other indoor areas of coal handling plant	150
12.	Pump houses, WTP area, Chlorination building, AHU room	150
13.	Sea water intake pump house	150
14.	Main Road	20
15.	Secondary Roads	10
16.	Cable galleries	100
17.	Stair cases, Passages, Toilets	100
18.	Stockyard	30
19.	Conveyors	50
20.	Tank area and outdoor equipment location	20
21.	Chimney platforms	100

4.4.0 For indoor Areas, average lumen method shall be adopted to calculate luminance. Lighting level design shall include a Maintenance factor as follows to account for lamp lumen depreciation, luminaries' surface dirt and room surface dirt, etc.

- Air-conditioned clean interiors such as office rooms, Control and Electrical room : 0.8
- Clean interiors such as office rooms, laboratories : 0.75
- Industrial areas with normal interiors such as workshops. : 0.7
- Industrial areas with dusty interiors : 0.6
- Industrial areas with very dusty interiors : 0.5

4.5.0 Lighting level design shall also include the coefficient of utilization factor as calculated from table of reflectance provided by manufacturer for respective type of fixture.

4.6.0 For Outdoor flood lighting design, 'point by Point' method shall be adopted based on computer aided design package of the Contractor software. Uniformity in horizontal illuminance E_{min}/E_{avg} should be greater than 0.25.

4.7.0 Lighting for chimney

4.7.1 Chimney shall be provided with aviation obstruction lights. Aviation obstruction lights shall meet the requirements of Annexure-14 of 'International Civil Aviation Organization' (ICAO). Lights shall be of high intensity type or combination of medium intensity and low intensity. In case of later option, day time marking shall be provided on chimney as per the requirements of ICAO.

4.7.2 Number of levels of installation for obstruction lights shall be provided as per ICAO. Four lights shall be spaced at quarter points around the chimney at each elevation level. Photoelectric lighting controls shall adjust the lighting to one of three illumination levels depending on ambient light conditions (daylight, twilight, or night). All obstruction lighting fixtures shall be suitable for lamp replacement from internal platforms. Necessary swing door arrangement shall be provided for aviation obstruction lights.

4.7.3 Temporary aviation lights shall be installed above the top most point of the obstruction as construction progresses. This arrangement shall continue to exist till permanent arrangement to provide such lights are completed.



- 4.7.4 Aviation obstruction lighting shall be powered from AC emergency power supply.
- 4.7.5 Lighting shall be provided for various platforms and ground floor. Lighting fixture with LED lamps shall be provided to have maintenance free installation.

4.8.0 Aviation obstruction lights for natural draught cooling tower (NDCT)

- 4.8.1 NDCT shall be provided with aviation obstruction lights. Aviation obstruction lights shall meet the requirements of Annexure-14 of 'International Civil Aviation Organization' (ICAO). Lights shall be of medium intensity type.
- 4.8.2 Number of lights at each level shall be provided as per ICAO. Photoelectric lighting controls shall adjust the lighting to one of three illumination levels depending on ambient light conditions (daylight, twilight, or night).
- 4.8.3 Temporary aviation lights shall be installed above the top most point of the obstruction as construction progresses. This arrangement shall continue to exist till permanent arrangement to provide such lights are completed.
- 4.8.4 Aviation obstruction lighting shall be powered from AC emergency power supply.

4.9.0 LIGHTING CONTROL

- 4.9.1 Switch control shall be provided for controlling lighting fixtures located indoor.
- 4.9.2 Electric power to light fixtures located outdoors shall be switched with photoelectric controllers and timers. Provision shall be made to bypass the photoelectric controller and timer. For Road lighting, alternative lighting fixtures shall be fed from different phases.
- 4.9.3 Load on each lighting circuit and single phase receptacle circuit shall be limited to about 1500 W and the number of luminaries connected to lighting circuit shall be limited to about fifteen (15).
- 4.9.4 Electronic ballasts shall be provided for fluorescent fittings. For main plant control room, low loss copper ballast shall be provided. All the fixtures shall be provided with rapid start lamps and long life ballasts.
- 4.9.5 At least one 6/16 ampere, 230 volt AC universal socket outlet with switch shall be provided in offices, cabins, etc. In service building, atleast 4 nos. 5 Amp plug points shall be provided in each cubicle. Receptacles with decorative cover plates shall be used in office / Control rooms.
- 4.9.6 20 Amp, 230 V, Single phase convenience receptacle with switch shall be provided in plant area. The convenience outlets shall be spaced to provide access to any point in the interior industrial areas with a 25 meter extension cord.
- 4.9.7 63 Amp, 415 V, 3 phase welding receptacle with switch shall be provided in plant area. The receptacles shall be provided in all the floors of power house building at 50 m interval along A-row and B-row. Further in Boiler at alternate floors, welding receptacles shall be provided. In ESP top platform welding receptacle at 100 m interval shall be provided. In chimney at alternate floors, welding receptacles shall be provided. In outdoor locations, in the vicinity of major equipment, welding receptacles shall be provided. In pump houses, water treatment plant, compressor house, coal crushers, mill bay, coal transfer towers, ash handling plant, fuel oil pump house, H2 plant, GIS building, Switchyard, etc., minimum one welding receptacle shall be provided at each elevation at each enclosed area. In Transformer yard, 4 nos. 63 Amp welding receptacle and 4 nos. 250 Amp receptacle with MCCB unit shall be provided to extend power for oil filtration units during maintenance.



- 4.9.8 Each receptacle panel shall be provided with one earth leakage circuit breaker rated 30 mA in outgoing circuits.
- 4.9.9 In areas with hazardous atmospheres such as Hydrogen generation plant, fuel oil pump house, oil decanting pump house, lighting and convenience outlets shall be flame proof type. Receptacles located in Conveyor galleries shall be flame proof type.
- 4.9.10 Wall mounted fans shall be provided for all cubicles of admin building, service building, laboratories and other non-plant buildings.
- 4.9.11 Search lights of halogen lamps having adequate coverage shall be provided in watch towers.

5.0.0 EQUIPMENT DESCRIPTION

5.1.0 LIGHTING FIXTURES

- 5.1.1 For all service building, admin building, laboratory, conference rooms, SWAS room etc., LED lamp light fittings shall be used.
- 5.1.2 For other buildings/installations having room height of up to 5 metre, Fluorescent light fittings of following types shall be used:
- Industrial trough type/Industrial General purpose Rail type for all industrial areas
 - Corrosion proof type for battery room and chemical areas, etc.,
 - Anti-glare mirror optic type for Control rooms housing VDUs.
 - Mirror optic type for other Control rooms.
- 5.1.3 In false ceiling areas, type of light fixtures shall suit the type of false ceiling provided.
- 5.1.4 For low bay and medium bay areas, LED light fittings of well glass / medium bay type shall be used for the installations having room height of above 5 metre.
- 5.1.5 For high bay areas, light emitting plasma (LEP) light fittings shall be provided.
- 5.1.6 For outdoor areas involving road lighting and flood lighting, light emitting plasma (LEP) light fittings shall be provided.
- 5.1.7 Road lighting / Flood lighting poles shall be of galvanised steel pole. Each Street lighting pole/Flood lighting pole shall be provided with MCB protection.
- 5.1.8 Winch operated high mast lighting shall be provided in select outdoor areas such as transformer yard, switchyard, coal yard, stock yard, fuel tank farm etc.
- 5.1.9 For DC lighting LED lights shall be used.
- 5.1.10 Flame proof equipment shall be provided in H2 plant, coal tunnels, underground conveyor gallery, and Fuel Oil unloading & forwarding areas.
- 5.1.11 AC lighting fixtures and accessories shall be suitable for operation on 240 V, AC, 50 Hz supply with supply voltage variation of $\pm 10\%$, frequency variation of $\pm 5\%$ and combined voltage and frequency variation of absolute sum of 10%. DC lighting fixtures and accessories shall be suitable for operation on 220 V, DC with variation between 190 V & 240 V.
- 5.1.12 Power factor of fluorescent lamp fixtures shall be not less than 0.90. Suitable power factor improving capacitors shall be provided for this purpose. Capacitors shall be hermetically sealed in aluminium enclosures to prevent seepage of impregnate & ingress of moisture.



- 5.1.13 Luminaires shall meet atleast Electrical safety class-I as per relevant IEC.
- 5.1.14 The lighting fixtures shall be designed for minimum glare. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection.
- 5.1.15 Twin fluorescent lamp fixtures shall be wired in lead lag circuit to minimise stroboscopic effect.
- 5.1.16 High bay fixtures shall be suitable for pendant mounting and provided with safety chains.
- 5.1.17 Fluorescent Tubular Lamp shall be 36 Watt rated, cool day light type with Triband Phosphor having lumen output of 3250 lumens.
- 5.1.18 High Frequency Electronic ballast shall be suitable for 1X36 Watt FTL / 2X36 Watt FTL. Operation at high frequency shall increase lumen output. It shall conform to IS 13021 (Part I). It shall have following features:
- System loss less than 4 Watt.
 - Circuit power factor 0.95 or better
 - No humming noise.
 - Protected against mains disturbances.
 - Automatic cut off protection for a de-activated tube.
- 5.1.19 Copper Ballast shall be low loss design, copper wound, silicon lamination, manufactured using Vacuum pressure impregnation technology. Winding temperature shall not exceed 70 degC over an ambient of 50 deg C.
- 5.1.20 Recommended luminaries at various places are listed below :

Sl. No.	Area	Type of Luminaries
1	Turbine Hall operating floor	LED high bay
2	Turbine building other floors	LED Medium bay/ well glass
3	Switch gear /MCC rooms	Fluorescent industrial fixture
4	UPS, Battery charger room,	Fluorescent industrial fixture
5	Lead acid battery Room	Corrosion proof fluorescent fixture
6	Boiler area/ESP area	LED well glass
7	Cable galleries	LED well glass fixture
8	Stair cases, Passages, Toilets	Fluorescent rail type fixture/Mini lights
9	Office	Mirror optics, decorative Fluorescent fixture
10	Chemical house/ Chlorination plant	Fluorescent Corrosion proof surface-bracketed mounted
11	Control rooms with PCs/VDUs	Mirror optics non-glare type Fluorescent fixture
12	Air compressor house	LED Medium bay
13	GIS building	LED Medium bay
14	Water treatment plant/ DM plant	Fluorescent industrial fixture / LED / well glass
15	Fuel oil Pump House	Flameproof luminaries
16	DG Room	LED well glass fixture



Sl. No.	Area	Type of Luminaries
17	Emergency 220 V DC Lighting	DC LED Lamps
18	Transformer yard / Outdoor Area	LEP plasma type flood lighting fixtures on steel poles / Masts
19	Pump houses	LED Medium/LEP plasma High bay
20	Roads	LEP plasma type street light fixtures on galvanized Steel poles

5.2.0 Lighting distribution board

Lighting distribution board shall comprise, TPN MCCB as incomer and required no. of TPN MCCB feeders as outgoing feeders to feed lighting panels and receptacle panels. Construction of lighting DB shall be similar to ACDB and is detailed in LV switchgear section.

5.3.0 Lighting Panels & Receptacle Panel

- 5.3.1 The panels shall be rated for 415 V, 3 phase, 4 wire, AC with neutral bus and suitable for either wall/column mounting. Indoor panels shall have degree of protection of IP 54 and outdoor type shall have degree of protection of IP 55 and shall have a sloping canopy. Panels shall be constructed from CRCA sheet. Sheet thickness shall be 2.0 mm.
- 5.3.2 Miniature circuit breakers (MCB) shall have thermal elements for overload protection and an instantaneous magnetic trip to protect against severe faults. All MCBs provided shall be suitable for breaking capacity of 10 kA (minimum) at 240 V AC.
- 5.3.3 Contactors shall be of the air break type fitted with arc shields. Time switch shall be suitable for automatic switching ON and OFF of street lighting / flood lighting circuits. Time switch has 00 - 24 hours clock base. Time switch shall indicate actual time and shall permit accurate time setting. Time switch shall be provided with Ni-Cd gel battery.
- 5.3.4 Lighting panel shall be provided with 415 V AC, 63 Amp, TPN MCB with ELCB as incomer, required nos. of 20 A, 240 V AC, single pole MCBs for outgoing circuits, Separate neutral at terminal block for each outgoing circuit.
- 5.3.5 DC lighting panel shall be provided with 220 V DC, 63 Amp, DP MCB isolator as incomer, required nos. of 20 A, 220 V DC, double pole MCBs for outgoing circuits.
- 5.3.6 Street lighting panel shall be provided with 415 V AC, 63 Amp, TPN MCB isolator as incomer, 63 Amp Three pole AC Contactor, 00 - 24 hours timer and a photo-electric switch for automatic switching of contactor, a by-pass switch for timer/photo switch, 6 Nos. 20 A, 415 V AC, TPN MCBs for outgoing circuits, Separate neutral at terminal block for each outgoing circuit. One number light sensor in weather proof enclosure having IP: 55 degree of protection shall be installed separately with necessary interconnecting cable for each street lighting panel. Additionally 100% sensors shall be supplied for future use
- 5.3.7 Receptacle panel shall be provided with 415 V AC, 63 Amp, TPN MCB with ELCB as incomer, 6 Nos. 20 Amp, 240 V AC, single pole MCBs for outgoing circuits, Separate neutral at terminal block for each outgoing circuit.

5.4.0 Three Phase Industrial Receptacles

The receptacle shall be of 63 A, industrial heavy duty insulated type with 5 pin (with earth connection) suitable for 415 V, 3 phase, 50 Hz supply. The receptacle shall be switched and interlocked type with MCB and shall be housed in a thermoplastic enclosure of IP-55 protection



class. Socket shall be provided with safety cover. Terminal blocks of adequate rating shall be provided for incoming/loop-in-loop out connection.

5.5.0 Three Phase Flame proof Industrial Receptacles

The receptacle shall be of 63 A, industrial heavy duty insulated type with 5 pin (with earth connection) suitable for 415 V, 3 phase, 50 Hz supply. The receptacle shall be switched and interlocked type with MCB and shall be housed in a thermoplastic flame proof enclosure of IP-65 protection class. Socket shall be provided with safety cover.

5.6.0 Single Phase Industrial Receptacles

The receptacles shall be heavy duty type rated for 20 A, 240 V AC supply. The receptacle shall be switched and interlocked type with MCB and shall be housed in a thermoplastic enclosure of IP-55 protection class. Socket shall be provided with safety cover. Terminal blocks of adequate rating shall be provided for incoming/loop-in-loop out connection.

5.7.0 Single Phase Flame proof Industrial Receptacles

The receptacles shall be heavy duty type rated for 20 A, 240 V AC supply. The receptacle shall be switched and interlocked type with MCB and shall be housed in a thermoplastic flame proof enclosure of IP-65 protection class. Socket shall be provided with safety cover.

5.8.0 Flush type indoor receptacles

Flush type 3 pin, 6/16 A, 240 V AC sockets shall be provided for office rooms and control rooms. The receptacle shall be complete with 16 A modular type switch & safety shutter. It shall be housed in suitable thermoplastic enclosure.

5.9.0 Lighting mast

5.9.1 Each Lighting Mast shall be 20 to 30 M high, complete with the following accessories.

- High mast shaft in two/three section, hot dip galvanised
- Head frame, steel wire rope & double drum winch.
- Galvanised Lantern carriage arrangement
- Integral power tool installed inside base compartment for its operation.
- Foundation bolts
- Luminaires
- Aviation obstruction light with 2 nos. LED lamps.
- Control panel
- Power & control cables and cabling accessories required for the installation.
- Special tools & tackles

5.9.2 The High mast shall be of continuously tapered, polygonal cross section, at least 20 sided, presenting a good and pleasing appearance and shall be based on proven design to give an assured performance, and reliable service. The entire fabricated mast shall be hot dip galvanized, internally and externally, having a uniform average thickness of atleast 85 microns.

5.9.3 An adequate door opening shall be provided at the base of the mast and the opening shall permit clear access to equipment like winches, cables, plug and socket, etc. and also facilitate easy removal of the winch.

5.9.4 A fabricated Lantern Carriage shall be provided for fixing and holding the flood light fittings and control gearboxes. The lantern carriage shall be of steel tube construction, the tubes acting as conduits for wires, with holes fully protected by grommets.



- 5.9.5 The winch shall be completely self-sustaining type, without the need for brake shoe, springs or clutches. Each driving spindle of the winch shall be positively locked when not in use, gravity activated PAWLS. Individual drum also shall be operated for fine adjustment of lantern carriage. The minimum-working load shall be not less than 750 kg. The winch shall be self-lubricating type by means of an oil bath and the oil shall be readily available grades of reputed producers.
- 5.9.6 The suspension system shall essentially be without any intermediate joint and to consist of only non-corrodible stainless steel of AISI 316 grade. The breaking load of each rope shall not be less than 2350 kg, giving a factor of safety of over 5 for the system at full load. The thimbles shall be secured on ropes by compression splices.
- 5.9.7 A suitable, high-powered, electrically driven, internally mounted power tool with motor, with manual over ride shall be supplied for the raising and lowering of the lantern carriage for maintenance purposes. The power tool shall be of single speed, provided with a motor of the required rating. The power tool shall be supplied complete with suitable control.

5.10.0 Lighting poles

Lighting pole shall be octagonal type, galvanized steel, supplied with base plate, foundation bolts, and necessary fixing-bracket for fixing the luminaire. Street lighting pole shall have integral junction box. All poles shall be provided with heavy square nuts on the anchor bolts under the pole base plate and hex nuts on the top. GI conduits shall be embedded in muff for incoming and outgoing cables. Height of poles shall be about 10 m. Junction box shall be integral to the pole, supplied along with MCB and neutral link.

5.11.0 Wires

XLPE/PVC insulated wires shall have multi stranded copper conductor. Wires shall be of 1.5 sq.mm/2.5 sq.mm/4 sq.mm sizes. The insulation material shall be resistant to flame, oil, acid and alkali and shall be tough enough to withstand mechanical stresses during handling. Wires shall have following colors.

- Red for R phase
- Yellow for Y phase
- Blue for B phase
- Black for Neutral
- Yellow-Green for Earth wire
- Grey & white for positive and negative connections respectively.

5.12.0 Rigid Conduits and Fittings

Rigid conduits shall conform to the requirements of IS: 9537 (Part I & Part II). However conduits above 63 mm diameter shall conform to the requirements of IS: 1239. All conduits and pipes shall be of medium duty. The rigid conduits shall be hot dip galvanized inside and outside. Weight of zinc shall be as per IS: 4759. Conduits shall be thoroughly cleaned and pretreated, conforming to IS: 6005.

Conduit fittings shall be made out of tube or cast to the shape as to match with corresponding conduit sizes. All fittings shall be screwed type and hot dip galvanized inside and outside.

In corrosive areas, epoxy coated conduits shall be provided.



5.13.0 Flexible Metallic Conduits and Fittings

Flexible metallic conduits shall conform to the requirements of IS: 3480. Flexible conduits shall be made of strip steel which shall be of cold rolled mild steel. The strip shall be of uniform width and thickness throughout. The strip shall be electro galvanized to a minimum thickness of 25 microns. The surface of the strip shall be thoroughly cleaned before application of protective coating. Pretreatment, before galvanization, shall conform to IS: 6005. Flexible conduits shall be supplied with suitable end coupler nipple and check nut.

5.14.0 GI pipes shall be of medium duty as per IS: 1239

5.15.0 Hume pipes shall be of reinforced concrete conforming to class NP3 for road crossings as per IS: 458.

5.16.0 Switch Boxes

The switch boxes shall be of surface/flush mounting type with steel construction. Switch boxes shall have conduit knock out on the sides. The switches shall be of quick make and quick break type and shall be of modular type. Where required, 3 pin 240 V type receptacles shall be provided with safety shutter and modular switch in the switch box. The switch box shall be flush mounted in places such as control rooms and office rooms.

Switches furnished shall be 6 or 16 Amps, 240 Volt totally enclosed modular type with side connected screw type terminals, phenolic compound housing and operating levers, and single mounting yoke design.

Switches used for switching direct current shall be 10 amperes, 240 Volt T-rated AC/DC switches.

5.17.0 Lighting Junction Box

The junction boxes shall be of FRP weather proof type. 650 Volt grade multiday terminal blocks complete with screws, nuts, washers and marking strips shall be furnished for connection of incoming/outgoing wires in the junction boxes. The Junction box shall be suitable for mounting on wall/column/poles/masts.

5.18.0 Hand lamp units (24 V Supply Module)

Hand lamp unit shall comprise 240/24 V transformer with 3 pin 24 Volt hand lamp socket. Required MCB protection shall be provided at the incomer. The unit shall be enclosed in sheet steel enclosure. 24 V hand lamp with guard and flexible cord of at least 15 Metre length shall be supplied as specified. Module shall be portable box type suitable for providing local lighting requirements during maintenance and inspection.

5.19.0 Fans

Ceiling fans shall be of reputed make, BIS approved, 1200 mm sweep complete with copper wound, class E insulated motor, and three nos. balanced blades, suspension rod, canopy and other accessories conforming to applicable IS. Ceiling fans shall be supplied with a wall mounted controller to turn the fan on and off and to vary the fan speed from 0 to 100%. Controller shall be Electronic type free from humming noise.

Pedestal fans shall be of reputed make, BIS approved, 500 mm sweep, complete with aluminium blades, cast iron base, copper wound, class E insulated motor, support column, control switch and other accessories conforming to applicable IS.

**6.0.0 INSTALLATION**

6.1.0 The bottom of wiring devices shall be mounted the following distances above the finished floor.

Wiring Devices	Location	Distance above Floor (minimum)
Receptacles	Offices and finished areas	500 mm
Receptacles	All other locations	900 mm
Switches	All locations	1500 mm
Ceiling fan control	All locations	1500 mm
Ceiling fans	All locations	2500 to 3000 mm

6.2.0 The location of the light fittings, receptacles, switches, etc. shall be such as to avoid interference with piping / ventilation ducts / busduct or other equipment and to avoid objectionable shadows and glare.

6.3.0 In false ceiling areas the switchgear and the conduits shall be recess mounted.

6.4.0 In all Office rooms & Control rooms conduit shall be concealed type. In, admin building, canteen, dispensary, , concealed conduit wiring shall be adopted.

6.5.0 Wooden plugs in walls and ceilings for fixing of lighting fixtures and accessories are not acceptable. Nylon rawl plug shall be offered.

6.6.0 In the rooms where false ceilings are provided, the lighting fixtures shall be supported separately by false ceiling grid over false ceiling if it is of steel structural or from ceiling or from cable trough / channel and not by the false ceiling board. The arrangement shall be to the approval of Owner.

6.7.0 A four (4) way terminal junction box shall be provided near each lighting fixture, for loop-in, loop-out and off connection of lighting wires or as required.

6.8.0 Conduit shall be routed at least 150 mm from the insulated surfaces of hot water, steam pipes and other hot surfaces. Where conduit must be routed parallel to hot surfaces, special high temperature cable shall be used.

6.9.0 Conduits supports shall be provided at an interval of 750 mm for horizontal runs and 1000 mm vertical runs.

6.10.0 Conduit shall be clamped on to approved type spacer plates or brackets by saddles or U-bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding and to concrete or brick work by grouting or by nylon rawl plugs.

6.11.0 Wiring for indoor Lighting installation shall be carried with insulated wire following sizes laid in Galvanised steel conduit of

- Lighting Panel to lighting Fixtures : 2.5 sq.mm copper
- Lighting Panel to Switch box : 2.5 sq.mm copper
- Switch box to lighting Fixtures : 1.5 sq.mm copper
- Lighting Panel to Sockets : 4 sq.mm copper

6.12.0 Voltage drop in the cable shall be limited as follows,

- Lighting panel to lighting fixtures :3%
- Switchbox to lighting fixtures :1.5%



- Lighting panel to socket :3%
 - Lighting panel to switch box :1.5%
- 6.13.0 For outdoor lighting & road lighting, XLPE insulated, PVC inner sheathed, armoured, FRLS PVC outer sheathed cables shall be provided.
- 6.14.0 Wiring for lighting circuits of Normal AC system, Emergency AC System and DC system shall run in separate conduits.
- 6.15.0 Wiring for lighting fixtures and receptacle units shall be fed from different circuits and shall run in separate conduits.
- 6.16.0 Two different phase circuits shall not be laid in the same conduit.
- 6.17.0 Ceiling fans with variable speed electronic regulators shall be installed in the non-air-conditioned areas as specified.
- 6.18.0 Ceiling Fans & pedestal fans for of required size and quantity to be provided in individual rooms / areas like Workshop, Stores, Office building / areas, Service building, etc.
- 6.19.0 Receptacles and lighting circuits shall be fed from different circuits. The switch controlling these circuits shall be on the live side (phase wire) of the circuits.
- 6.20.0 Wiring shall be spliced only at junction boxes. Maximum two wires shall be connected at each terminal.
- 6.21.0 Lighting branch circuits, telephone circuits, and intercommunication circuits shall be routed in conduit. Lighting circuits shall be routed in electrical metallic tubing (EMT) for indoor areas, rigid conduit for hazardous and outdoor areas.
- 6.22.0 All conduit system shall be sized considering fill criteria specified in IS: 732.
- 6.23.0 Each lighting poles and lighting / lightning mast junction box shall be earthed by 25 x 3 mm GS flat bonded to one (1) 20 mm dia MS earth electrode of 3 meter length driven vertically in the ground.
- 6.24.0 The lights shall not be fixed at gantry. In buildings it shall be fixed with suitable fixtures and not directly on the walls.
- 6.25.0 One (1) no. of mini truck mounted with adjustable hydraulic lift for the maintenance of street lights.
- 6.26.0 For the maintenance of lighting fixtures within the high bay areas, four (4) nos. free standing adjustable aluminium ladder, adjustable from 5 m to 10 m shall be provided.
- 6.27.0 Three nos. Portable Aluminium Ladders of various sizes suitable for main control room, switchyard control room etc., shall be provided.

7.0.0 TESTS

Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. For the various bought out item test certificates from equipment Manufacturer shall be furnished. Routine tests shall be carried out for all the equipment as per applicable standards.



8.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Design basis report
- Illumination design calculation
- Tubular day light guidance system
- GA drawing and single line diagram of lighting distribution board
- GA drawing and single line diagram of lighting panel & receptacle panels
- GA drawing of poles and masts
- GA drawing of receptacles
- General arrangement drawings of lighting fixtures
- Lighting design software
- Technical data sheet
- Test reports
- Catalogues
- Illumination layout for Transformer Yard
- Illumination layout for GIS building
- Illumination layout for switchyard control building
- Illumination layout for Switchyard
- Illumination layout for Power house building
- Illumination layout for Boiler and mill bay
- Illumination layout for ESP
- Illumination layout for plant roads
- Illumination layout for Main control building
- Illumination layout for Control room
- Illumination layout for outdoor yards
- Illumination layout for coal handling plant
- Illumination layout for Ash handling plant
- Illumination layout for Water treatment plant
- Illumination layout for Chimney
- Illumination layout for Cooling tower
- Illumination layout for Sea water intake system
- Illumination layout for Fuel handling system
- Illumination layout for CWPH
- Illumination layout for Electro chlorination plant
- Illumination layout for other auxiliary plant buildings
- Illumination layout for Admin building
- Illumination layout for Service building
- Illumination layout for Watch tower
- Illumination layout for Boundary wall
- Illumination layout for other non-plant buildings
- Illumination and Small power distribution arrangement
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION - 3.24: CABLES

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of cables.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) 19/33 kV grade XLPE insulated armoured FRLS power cables
- b) 11/11 kV grade XLPE insulated armoured FRLS power cables
- c) 6.6/6.6 kV grade XLPE insulated armoured FRLS cables
- d) 1.1 kV grade XLPE insulated armoured FRLS cables
- e) 1.1 kV grade XLPE insulated armoured FRLS control cables
- f) Trailing cables
- g) Shielded cables
- h) Telephone cables
- i) Fiber optic cables

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest edition (including amendments) of the following Indian Standards (IS), IEC publications and other codes except where modified and / or supplemented by this specification.

a) IS: 3975	Mild steel wires formed wires and tapes for armouring of cables.
b) IS: 4905	Methods for random sampling.
c) IS: 5831	PVC insulation and sheath of electric cables.
d) IS: 7098 Part-I	Cross-linked polyethylene insulated PVC sheathed cables (LV)
e) IS: 7098 Part-II	Cross-linked polyethylene insulated PVC sheathed cables (HV)
f) IS: 8130	Conductors for insulated electric cables and flexible cords.
g) IS: 10418	Drums for electric cables.
h) IS: 10810	Methods of tests for cables.
i) IS: 3961	Recommended current ratings for cables

4.0.0 TECHNICAL REQUIREMENTS

4.1.0 Power cables shall be provided for the following systems:

- 33 kV earthed system having phase fault current and earth fault current of 25 kA.
- 11 kV unearthed system having phase fault current of 50 kA and earth fault current of 300 A.
- 6.6 kV unearthed system having phase fault current of 31.5 kA and earth fault current of 300 A.
- 415 V earthed system having phase fault current and earth fault current of 65/50 kA.
- 220 V DC unearthed system having fault current of not less than 25 kA.

4.2.0 Power cables shall be sized to withstand the system fault current for the fault clearing time indicated below:

- Breaker operated Motor feeders and transformer feeders: 0.16 second.
- Breaker operated outgoing feeders: 0.5 second.
- Tie between two switchgear: 0.5 second.
- Incomers: 1 second.



- 4.3.0 Power cables shall be sized to satisfy the following Criteria:
- To withstand specified system short circuit current for the specified fault clearing time.
 - To carry full load current under applicable installation conditions considering Site ambient temperature & site installation (Grouping) conditions based on Manufacturer's recommendation.
 - To limit the voltage drop under steady state/transient state conditions to permissible values.
- 4.4.0 Cables shall be armoured type only.
- 4.5.0 Power cables shall be XLPE insulated. Control cables shall be PVC / XLPE insulated.
- 4.6.0 PVC insulation shall be suitable for continuous conductor temperature of 70°C and short circuit conductor temperature of 160°C. XLPE insulation shall be suitable for continuous conductor temperature of 90 °C and short circuit conductor temperature of 250 °C.
- 4.7.0 Cables for 33 kV system shall be rated for 19/33 kV earthed grade, cables for 11 kV system shall be rated for 11/11 kV unearthed grade and Cables for 6.6 kV system shall be rated for 6.6/6.6 kV unearthed grade. Cables for 415/230 V AC and 220 V DC shall be rated for 1.1 kV grade.
- 4.8.0 To minimize the damage that can be caused by a fire, conductors installed in electrical cable tray systems shall have jackets which have non-propagating, and self-extinguishing flame retardant, low smoke (FRLS) characteristics. Outer sheath shall be of PVC black in colour. These cables shall meet the following test requirements.
- Oxygen index of minimum 29 when tested as per IS 10810 Part-58
 - Temperature index of minimum 250°C when tested as per IS 10810 Part-64
 - Acid gas emission of maximum 20% when tested as per IS 10810 Part-59 Average light transmission of 40% minimum when tested as per IS 10810 Part-63 (average smoke density is maximum 60%)
 - Flame test requirements as per IS 10810 Parts-53 and 62
 - Flame retardant test requirements as per IS 10810 Part-61
- 4.9.0 For power cables, copper conductor shall be used for current rating of up to 10 A. For higher current rating, conductor can be aluminium/copper. Minimum size of copper conductor shall be 2.5 sq.mm and aluminium conductor shall be 6 sq.mm.
- 4.10.0 Conductor of control cables shall have plain annealed copper. The minimum size of control cable shall be of 1.5 sq.mm. For CT circuit minimum size shall be 2.5 sq.mm copper. Control cables shall have 20% spare cores.
- 4.11.0 Current transformers leads shall be checked for the lead burden vis-a-vis the current transformer VA capacity and knee point voltage. Minimum 2.5 sq.mm copper cables shall be used for connection of CT to load. In case 2.5 sq.mm size impose unacceptably high burden on CTs, 4 sq.mm copper shall be used. Voltage transformer leads shall be checked for voltage drop which shall be limited to within 1% for all cases other than tariff metering. For tariff metering the voltage drop shall be limited to 0.2%. In case the voltage drop with 2.5 sq.mm copper conductor exceeds this value, higher conductor sizes shall be used.
- 4.12.0 Power cables shall carry the full load current of the circuit continuously under site conditions considering the various derating factors like thermal resistivity of soil, ambient air/ground temperature, grouping, method of laying, etc.
- 4.13.0 Design ambient air temperature and ground temperature shall be considered at 50°C and 40°C respectively for cable sizing.
- 4.14.0 For 11 kV & 6.6 kV cables, screen of each core shall be sized to withstand 300 A for 1 sec. For 33 kV cables, screen of each core shall be sized to withstand system earth fault current for 0.16 sec.



- 4.15.0 For HT motors the voltage drop in the cable, during motor starting condition, shall be limited to 10% and during full load running condition, shall be limited to 2.5% of the rated voltage. However, the voltage drop from transformer secondary to motor terminals during full load running of motors shall be limited to 5% of rated voltage
- 4.16.0 For LT motors the voltage drop in the cable, during motor starting condition, shall be limited to 15% and during full load running condition, shall be limited to 3% of the rated voltage. However, the voltage drop from transformer secondary to motor terminals during full load running of motors shall be limited to 6% of rated voltage.
- 4.17.0 Cables for the following systems shall be fire survival type.
- DC emergency lube oil pumps
 - DC seal oil pump
 - DC emergency lighting cables for main building.
 - Batteries to chargers and DC distribution boards
 - Turbine lub oil pumps
 - Jacking oil pumps
 - Emergency turbine trip by push button in control room
 - Inter trip cables between Boiler master fuel trip and turbine trip relays
 - Inter trip cables between Generator trip relays and turbine trip relays/400 kV circuit breaker/generator field breaker/UT breakers
- 4.18.0 Method of curing for HT XLPE insulation shall be **gas/steam curing**.
- 4.19.0 Conductor screen and insulation screen shall both be of extruded semi-conducting compound and shall be applied with XLPE insulation in one operation through triple extrusion.
- 4.20.0 For armoured cables, armouring shall be of aluminium for single core cables. For multicore armoured cables, armouring shall be of galvanised steel.
- 4.21.0 All the cables shall be protected against rodent and termite attack. Necessary chemicals shall be added into the PVC compound of the outer sheath. The sheath shall be resistant to water, UV radiation, fungus, etc.
- 4.22.0 Multi-core cable color coding shall be as follows:
- Red, yellow, blue, black and gray for five core cables
 - Outer sheath shall be of black in colour.
 - For more than 5 cores, core identification shall be by alpha numerical numbering system at an interval of one meter.
- 4.23.0 Three core 19/33 kV earthed grade, 11/11 kV unearthed grade, 6.6/6.6 kV unearthed grade cables shall constitute the following:
- Circular stranded and compacted aluminium conductor
 - Extruded semi conducting compound as conductor screen
 - Extruded XLPE insulation
 - Extruded semi conducting compound as insulation screen
 - Copper tape as metallic screen for each core
 - Extruded PVC inner sheath
 - Galvanised steel formed wire/strip
 - Extruded FRLS PVC outer sheath
- 4.24.0 Single core 19/33 kV earthed grade, 11/11 kV unearthed grade, 6.6/6.6 kV unearthed grade cables shall constitute the following:
- Circular stranded and compacted aluminium conductor
 - Extruded Semi conducting compound as conductor screen
 - Extruded XLPE insulation
 - Extruded Semi conducting compound as insulation screen
 - Copper tape as metallic screen
 - Hard drawn aluminium wire armour
 - Extruded FRLS PVC outer sheath



4.25.0 Multicore 1.1 kV earthed grade cables shall constitute the following:

- Circular / shaped, stranded aluminium conductor (compacted for >10 sq.mm)
- Extruded XLPE insulation
- Extruded PVC inner sheath
- Galvanised steel formed wire/strip
- Extruded FRLS PVC outer sheath

4.26.0 Single core 1.1 kV earthed grade cables shall constitute the following:

- Circular stranded and compacted aluminium conductor
- Extruded XLPE insulation
- Hard drawn aluminium wire armour
- Extruded FRLS PVC outer sheath

4.27.0 **Trailing power and control cables for mobile equipment shall constitute the following:**

Unearthed grade HT power cables, earthed grade LV power cables and control cables shall be flexible trailing with annealed tinned copper conductor, EPR insulated, EPR inner sheathed, CSP outer sheathed. For HT cables, insulation screen shall be provided. Cables shall conform to applicable IS/IEC standard requirements.

4.28.0 **Fire survival cables**

Fire survival cable shall be of copper conductor and comply with IEC-60331 (withstanding 750 degree C temperature for 3 hours). Also the halogen acid contents in outer sheath shall not be more than 2% when tested as per IEC-60754 and the smoke density in percent light absorption shall not exceed 20% when tested as per ASTM-D-2843. 1.1 kV earthed grade fire survival cables shall constitute the following:

- Circular/shaped stranded and compacted annealed copper conductor
- Elastomeric materials (XLPE, EPR, SR, or LSOH) insulated
- Glass mica tapped
- Extruded FRLS compound or LSOH material as inner sheath
- Galvanised steel formed wire/strip
- Extruded FRLS compound or LSOH material as inner sheath

4.29.0 Multicore 1.1 kV earthed grade control cables shall constitute the following as per IS:1554-1 / 7098-1:

- Multi stranded annealed copper conductor
- Extruded PVC / XLPE insulation
- Extruded PVC inner sheath
- Galvanised steel formed wire/strip
- Extruded FRLS PVC outer sheath

4.30.0 Multi pair 1.1 kV earthed grade, overall screened signal cables shall constitute the following as per BS EN 50288-7:

- Multi stranded annealed copper conductor
- Extruded PVC insulation
- Twisted pair
- Overall polyester taped, Al-mylar screened with ATC drain wire
- Extruded PVC inner sheath
- Galvanised steel formed wire/strip
- Extruded FRLS PVC outer sheath

4.31.0 Multi pair 1.1 kV earthed grade, individual and overall screened signal cables shall constitute the following as per BS EN 50288-7:

- Multi stranded annealed copper conductor
- Extruded PVC insulation
- Twisted pair



- Individual polyester taped, Al-mylar screened with ATC drain wire
- Overall polyester taped, Al-mylar screened with ATC drain wire
- Extruded PVC inner sheath
- Galvanised steel formed wire/strip
- Extruded FRLS PVC outer sheath

4.32.0 Cable drums

Cables shall be supplied in non-returnable wooden or steel drums of heavy construction. All ferrous parts shall be treated with suitable rust protective finish or coating to avoid rusting during transit and storage. All wooden parts shall be manufactured from durable quality wood duly seasoned and treated with copper nepthenates or zinc nepthenates for preserving the wood. The surface of the drum and the outer most cable layer shall be covered with waterproof layer. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/rubber caps, secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS 10418.

4.33.0 Cable identification system

- a) In addition to manufacturer's identification on cables as per IS, following marking shall also be embossed/printed on the outer sheath at an interval of one metre throughout the length of cables.
 - BIS mark
 - Manufacturer's name and or trade mark.
 - Year of manufacture
 - Cable code
 - Type of cable and voltage class.
 - Nominal cross section area of conductor and no.of cores.
 - Progressive sequential length making.
- b) Cables shall be marked as having FRLS outer sheath at every 5 meters.
- c) The embossing/printing shall be progressive, automatic, in line and marking shall be legible and indelible.
- d) Multi-core cable color coding shall be as follows:
 - Red, yellow and blue for three core cables
 - Outer sheath shall be of black in colour.
 - For more than 5 cores, core identification shall be by alpha numerical numbering system at an interval of one meter.
 - For multi pair cables, each pair shall be coloured and numbered.

5.0.0 TESTS

Cables offered shall be type tested and proven type. Routine tests shall be carried out on 100% drums. Type tests, special tests and acceptance tests shall be carried out on 1 drum selected on random basis, out of every 10 or less number of drums of each type and size of cable of each lot. Size shall mean area of cross section in sq.mm read in conjunction with the number of cores. Type shall mean type of insulation, sheath, volt grade FRLS/FS etc.

5.1.0 Type Test

- a) Tests on conductor



- i) Annealing Test (for copper)
- ii) Tensile test (for aluminium)
- iii) Wrapping test (for aluminium)
- iv) Resistance test

- b) Tests for armour wires/strips
- c) Tests for thickness of insulation and sheath
- d) Physical tests for insulation
 - i) Tensile strength and elongation at break
 - ii) Ageing in air oven
 - iii) Shrinkage test
 - iv) Hot test
 - v) Water absorption (gravimetric)
- e) Physical test for outer sheath
 - i) Tensile strength and elongation at break
 - ii) Ageing in air oven
 - iii) Shrinkage test
 - iv) Hot deformation
 - v) Heat shock test
 - vi) Loss of mass test in air oven
 - vii) Thermal heat stability test (as per IS : 5831)
 - viii) Bleeding and blooming test
- f) Anti-termite and anti-rodent test (on outer sheath).
- g) Partial discharge test
- h) Bending test
- i) Dielectric power factor test
 - i) As a function of voltage
 - ii) As a function of temperature
- j) Insulation resistance (volume resistivity) test
- k) Heating cycle test
- l) Impulse withstand test
- m) High voltage test
- n) Flammability test
- o) Cold impact test

5.2.0 Acceptance Test

- a) Annealing test (for copper)
- b) Tensile test (for aluminium)
- c) Wrapping test (for aluminium)
- d) Conductor resistance test
- e) Test for thickness of insulation and sheath
- f) Hot set test for insulation
- g) Tensile strength and elongation at break test for insulation and outer sheath
- h) Partial discharge test (for screened cables)
- i) High voltage test
- j) Insulation resistance (volume resistivity) test

5.3.0 Routine Test

- a) Conductor resistance test
- b) Partial discharge test



- c) High voltage test

5.4.0 Special Test

- a) Oxygen index test as per IS 10810 Part-58
- b) Temperature index test as per IS 10810 Part-64
- c) Acid gas generation test as per IS 10810 Part-59
- d) Smoke generation test as per IS 10810 Part-63
- e) Flammability tests as per IS 10810 Parts-53 and 62
- f) Flame retardant test as per IS 10810 Part-61

5.5.0 Site Test

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

- a) Insulation resistance test
- b) High voltage test

6.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Design basis report
- Cable sizing calculation
- General arrangement drawings
- Technical data sheet
- Test reports
- Catalogues
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.25: CABLE TRAYS, SUPPORTS & ACCESSORIES

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of Cable trays & accessories.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) Ladder type Cable trays
- b) Perforated type Cable trays
- c) Cable troughs
- d) Cable Tray bends, Tees, Cross, Coupler plates, etc.
- e) Cable tray covers
- f) Bolted (Unistrut type) cable tray support system
- g) Erection hardware
- h) Consumables
- i) Tools & tackles
- j) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Indian Standards, except where modified and /or supplemented by this specification.

- a) IEC: 61537 Cable tray systems.
- b) IS: 1079 Specification for hot rolled carbon steel sheet and strip.
- c) IS: 1730 Dimensions for steel plates, sheet strips and flats for general engineering purposes.
- d) IS: 1363 Hexagon head bolts, screws and nuts.
- e) IS: 6005 Code of practice for phosphating iron & steel.
- f) IS: 2629 Recommended practice for hot dip galvanising on iron and steel.
- g) IS: 2633 Methods for testing uniformity of coating on zinc coated articles.
- h) IS: 6745 Methods for determination of mass of zinc coating on zinc coated iron and steel articles.
- i) IS: 816 Code of practice for use of metal arc welding for general construction of mild steel.
- j) IS: 4759 Specification for hot-dip zinc coatings on structural steel and allied products

4.0.0 TECHNICAL REQUIREMENTS

4.1.0 Cable Trays

- 4.1.1 Cable trays shall be ladder type for power and electrical control cables and perforated type for signal cables, prefabricated, made out of hot / cold rolled mild steel sheets complete with matching fittings, accessories and hardware as required. Cable trays shall be with standard width of 150 mm, 300 mm, 450 mm, 600 mm, 750 mm and 900 mm and standard lengths of 2.5 metre or more. Minimum thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. For ladder trays, rung spacing shall be 250 mm maximum. The thickness of side coupler plates shall be minimum 2 mm and of tray covers shall be minimum 1.6 mm.

- 4.1.2 In corrosive areas, FRP cable trays shall be provided in general.



4.1.3 FRP cable trays also shall be provided for the following areas

- Water Treatment Plant
- Coal Handling Plant
- Sea Water intake system
- Interplant cable trays

4.1.4 Separate cable trays shall be provided for the following cables:

- HT Cables
- LT power cables
- Electrical Control cables
- Signal cables
- Fiber optic cables

Cable trays shall be designed to cater to a load of minimum 75 kg/m.

4.1.5 Cable trays shall be complete with matching fittings and accessories (like elbows, bends, reducers, tees, crosses, side coupler plates, etc.) and hardware (like bolts, nuts, washers, etc.) as required. At both the ends of cable trays, four holes shall be provided for fixing side coupler plates. All the slots and coupler holes shall be machine punched.

4.1.6 Cable trays, fittings and accessories and covers shall be hot dip galvanized. Thickness of galvanizing shall be not less than 610 grams/sq.m. Fasteners like bolts, nuts; screws washers etc. shall also be hot dip galvanized.

4.1.7 For branch cabling routes involving fewer cables, sheet steel galvanized cable trough of size 50/75/100 mm shall be provided.

4.1.8 Cable tray covers shall be provided for horizontally laid outdoor trays, on top most trays. It shall be prefabricated made out of hot/cold rolled mild steel sheets, complete with hardware as required. Special clamps shall be provided for fixing tray covers without drilling holes on trays.

4.2.0 Cable Tray Support System

4.2.1 Cable tray supports shall be of prefabricated preformed sections of sheet steel, bolted type and shall be hot dip galvanized.

4.2.2 Cable tray support system shall be similar or equivalent to "Unistrut make". Support system for cable trays shall essentially comprise of the two components i.e. main support channel and cantilever arms. The main support channel shall be of following two types:

- Single channel strut support for supporting cable trays on one side
- Double channel strut support for supporting cable trays on both sides

4.2.3 Cable supporting steel work for cable racks/cables shall comprise of various channel sections, cantilever arms, various brackets, clamps, floor plates, all hardware such as lock washers, hexagon nuts, hexagon head bolt, support hooks, stud nuts, hexagon head screw, channel nut, channel nut with springs, fixing studs, etc.

4.2.4 The system shall be designed such that it allows easy assembly at site by using bolting. All cable supporting steel work, hardware fittings and accessories shall be prefabricated factory galvanised.

4.2.5 The main support and cantilever arms shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hardware etc. of the components shall not be allowed.



- 4.2.6 All steel components, accessories, fittings and hardware shall be hot dip galvanised after completing welding, cutting, drilling and other machining operation.
- 4.2.7 The typical arrangement of flexible support system shall comprise the following:
- 4.2.8 The main support channel and cantilever arms shall be fabricated out of minimum 2.5 thick rolled steel sheets conforming to IS.
- Cantilever arms of required length to match cable tray width. The arm portion shall be suitable for assembling the complete arm assembly on to component constructed of standard channel section. The back plate shall allow sufficient clearance for fixing bolt to be tightened with tray in position.
 - The size of structural steel members or thickness of sheet steel of main support channel and cantilever arms and other accessories as indicated above or in the enclosed drawings are indicative only.
 - Main support channels may be supplied in any suitable lengths to minimize the wastage. Nevertheless, the support system shall be designed by the bidder to fully meet the requirements of type tests as specified.
- 4.2.9 Thickness of galvanizing on steel sections shall be not less than 610 gm/sq.m on all steel sections.
- 4.2.10 Horizontally running cable trays shall be clamped by bolting to cantilever arms at an interval of 1500 mm for outdoor and 2000 mm for indoor locations. Vertically running cable trays shall be bolted to main support channel by suitable bracket/clamps on both top and bottom side rails at an interval of 1500 mm. For vertical cable risers/shafts cable trays shall be supported at an interval of 1000 mm.
- 4.2.11 The cantilever arms shall be positioned on the main support channel with a minimum vertical spacing of 300 mm.

5.0.0 TESTS

Equipment offered shall be type tested and proven type. Tests shall be carried out for galvanizing thickness of trays and supports. Load test shall be carried out for trays and supports.

Load Test for Cable trays shall be carried out as follows:

A 2.5 metre straight section of each type of cable tray shall be simply supported at the two ends. A uniformly distributed load of 100 kg per meter shall be applied along the length of tray. The maximum deflection at mid span shall not exceed 7 mm.

6.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- General arrangement drawings for trays and fittings
- General arrangement drawings for support system
- Technical data sheet
- Test reports
- Installation details
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.26: CABLING ACCESSORIES

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of cabling accessories.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) Cable joints & terminations
- b) Cable glands
- c) Cable lugs
- d) Camps
- e) Tags
- f) Conduits & Pipes
- g) Junction boxes
- h) Consumables
- i) Tools & tackles
- j) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Standards except where modified and /or supplemented by this specification.

- a) VDE 0278 Joints and Terminations
- b) IS: 13573 Joints and Terminations for polymeric cables for working voltages from 6.6 kV up to and including 33 kV-Performance requirements and type tests.
- c) BS:6121 Mechanical cable glands (Part 1 -Specification for metallic glands)
- d) IS: 12943 Brass Glands for PVC Cables
- e) IS: 8309 Specification for compression type tubular terminal ends for aluminium conductors of insulated cables.

4.0.0 TECHNICAL REQUIREMENTS

4.1.0 Joints & terminations

- 4.1.1 Termination and jointing kits shall be of proven design and make which have already been extensively used and fully type tested. Kits shall be complete with all accessories and consumables required for complete termination or jointing. Copper cable lugs & jointing ferrules for straight through joints shall form part of the kit.
- 4.1.2 Termination and jointing kits shall be suitable for the following types of cables as per IS.
 - 19/33 kV earthed grade cable
 - 11/11 kV unearthed grade cable
 - 6.6/6.6 kV unearthed grade cable
 - 1.1 kV grade power cables
- 4.1.3 Termination kits shall be 'elastimold' or 'Push on type' or 'heat shrinkable type'.
- 4.1.4 Cable joints shall be avoided to the extent possible. If joints are unavoidable due to circuit length, in excess of permissible maximum drum length. Jointing kits shall be 'heat shrinkable type'.



4.1.5 Straight through joint and termination shall be capable of withstanding the fault level of 50 kA for 11/11 kV cables and 31.5 kA for 6.6/6.6 kV Cables and 25 kA for 33 kV cables.

4.1.6 Straight through joints shall be protected against mechanical damage, rodent and termite attack. It shall be suitable for directly buried cables.

4.2.0 Cable glands

Cables shall be terminated using cable glands suitable for the voltage grade of cables. Cable glands shall be heavy duty brass machine finished and tinned. Cable glands shall be supplied with neoprene seal and earth lugs suitable for the fault capacity of the armour of the installed cables. Cable glands shall be double compression, weather proof type for armoured cables. For flame proof equipment cable glands shall be of flame proof type

4.3.0 Cable lugs

4.3.1 Cable lugs shall be of aluminium for aluminium cables and tinned copper for copper cables. Thickness of tinning shall be not less than 10 microns Type of end connection shall be solder less crimping type.

4.3.2 Cable lugs for conductors of power cables shall be "heavy duty" long barrel type. The type & size of cable lugs for power cables shall be selected according to the number and sizes of strands of the cable.

4.3.3 Solder less crimping of terminals shall be done by using corrosion inhibiting compound. Cable lugs for control cable termination shall be insulated. These lugs shall be pin type/flat type/ ring type/U Type to suit the terminals provided in the panels.

4.3.4 Type of cable lugs shall be as follows:

• Power cables with aluminium conductor	: Aluminium crimping type.
• Power cables with copper conductor	: Copper crimping type.
• Control Cables	: Copper pin type /Copper screw type
• Special cables	: pin type / maxi-termi type

4.4.0 Trefoil Cable Clamps

- Clamps required for single core cables carrying alternating current shall be suitable for holding three cables together in delta formation. Clamps shall be of FRP material.
- Clamps shall be of suitable sizes to firmly hold the cables of various outer diameters including tolerance in OD.
- Clamps should have been type tested for Short Circuit Withstand Test.
- For Trefoil clamps run spacing shall be 2000 mm and axial spacing shall be double the diameter of larger adjacent trefoils cable or 150 mm whichever is less. Supports shall also be provided at each bend

4.5.0 Omega Cable clamps

- Omega clamps shall be of galvanized mild steel and shall be used to fasten the individual multi-core cables.
- Clamps shall be of simple construction, made of 2 mm thick, 25 mm wide strip of omega shape and suitable for clamping on the rungs / perforated sheet of tray with the help of two bolts.
- Clamps shall be of different sizes for different outer diameters of cables. Omega cable clamps shall be used for individual cables above 35 mm outer diameter.



- Steel clamps shall be hot dip galvanized. Weight of zinc not less than 610 grams. per sq. metre
- For cables of above 35 mm OD, cables shall be individually clamped at 5000 mm interval for Horizontal runs and shall be individually clamped at 1000 mm interval for Vertical runs. Supports shall also be provided at each bend.
- For cables of up to 35 mm OD, cables shall be collectively clamped at 5000 mm interval for Horizontal runs and shall be collectively clamped at 1000 mm interval for Vertical runs. Supports shall also be provided at each bend.
- For cables supported along structures/ceiling, clamp spacing shall be 750 mm. Supports shall also be provided at each bend.

4.6.0 Strip Cable Clamps

- Strip clamps shall be of galvanized mild steel and shall be used to fasten the group of multi-core cables up to 35 mm diameter only on a full or part of the tray width.
- Clamps shall be of simple construction, made of 3 mm thick Steel, 25 mm wide strip to cover the entire width up to 300 mm wide tray and part of the tray for more than 300 mm wide trays. Strip shall have two right angle bends at each end for fixing on to the rung/perforated sheet of tray with the help of two bolts.
- Clamps shall be of different sizes for different sizes of tray width. However, the maximum size of clamp shall be 300 mm and for cable trays of greater width, two clamps shall be used.
- Clamps shall be hot dip galvanized. Weight of zinc not less than 610 grams. per sq. metre

4.7.0 Self-locking Clamps

- Clamps shall be of FRP material. Clamps shall have self-locking feature when the cord is looped. Clamps shall be provided with manual lock release.
- Clamp cord shall not move in the backward position once it has been locked, unless the lock release is applied.
- Type test certificates to ascertain the strength of clamps shall be submitted for Owner's approval.
- Not more than four (4) cables shall be clamped together, wherever collective clamping is permitted.
- Clamp length shall be selected such that not more than 80% of lockable length is utilised for clamping.
- Nylon self-locking tie strips for collective clamping (up to 35 mm OD max. group of 4 cables) shall be 4 mm having Tensile strength 30 kg.
- Nylon self-locking tie strips for individual multicore clamping (above 35 mm OD up to 55 mm OD) shall be 4 mm having Tensile strength 20 kg.
- Nylon self-locking tie strips for individual multicore clamping (above 55 mm OD) shall be 7 mm having Tensile strength 60 kg.

4.8.0 Tags

- Cables shall be provided with cable number tags for identification.
- Cable tags shall be of aluminium.
- Cable numbers shall be engraved type
- Tags shall be of durable quality of size 60 mm x 12 mm with a tie hole at each end.
- Samples of tags shall be approved by the Owner before delivery.
- Tags shall be provided with non-corrosive wire of sufficient strength for tagging.



4.9.0 Junction Boxes

- 4.9.1 Junction box with IP 55 degree of protection shall comprise of a case with hinged door constructed from FRP material. The junction box shall be provided with canopy. The boxes shall include brackets, bolts, nuts, screws, glands, lugs, M8 earthing stud etc.
- 4.9.2 Terminal blocks shall be of 650 Volt grade, rated for 10 A and in one piece moulding. It shall be complete with insulating barriers, clip-on-type terminal numbering on wiring diagrams. Terminal block shall be suitable for terminating 2Cx2.5mm² cable on both sides and arranged to facilitate easy termination. Cable entry shall be from bottom.
- 4.9.3 The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable / conduit entry knockouts and terminals.

5.0.0 TESTS

Equipment offered shall be type tested and proven type. Test reports shall be submitted for review. For junction boxes degree of protection test shall be carried out.

6.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- General arrangement drawings
- Technical data sheet
- Test reports
- Installation details for junction boxes
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.27: FIRE STOP SYSTEM

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of Fire stop system for cable penetrations.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of Fire proof cable penetration seals for the following:

- a) All floor openings and wall openings (cable penetrations) in the electrical rooms/ cable spreader rooms
- b) All floor openings and wall openings (cable penetrations) in the main plant buildings
- c) All floor openings and wall openings (cable penetrations) in the auxiliary plant buildings
- d) Consumables
- e) Tools & tackles
- f) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

All the equipment and accessories covered under this specification shall be designed, manufactured and tested in accordance with the latest revision of the specified / applicable Standards. The fire proof cable penetration system shall confirm to the requirement of latest editions including amendments of the following standards:

- a) BS: 476 Part- 20 to 23 Fire tests on building materials and structures
- b) IS: 3809 Fire resistance test for structures
- c) IS: 12458 Method of test for fire resistance test of fire stops.
- d) ASTM E – 119 Standard test methods for fire tests of building construction and materials
- e) ASTM E – 814 Standard test methods for fire tests of Through Penetration fire stops
- f) UL:1479-1983 Fire tests of Through Penetration fire stops

4.0.0 TECHNICAL REQUIREMENTS

- 4.1.0 Fire barriers shall be provided for all fire rated wall and floor penetrations and for all direct cable entries into electrical equipment. Sleeves and openings for the passage of electrical cable or raceway shall be sealed with fire stops. Fire barriers and fire stops shall have a fire rating not less than 2 hours.
- 4.2.0 All fire stops shall be installed in accordance with the manufacturer's recommendations including installation by trained personnel when so recommended by the manufacturer. All fire stop materials, fire stop testing, and installation methods shall be approved by the Owner prior to installation.
- 4.3.0 The fire proof cable penetration sealing system shall prevent spreading of fire in cable beyond the seal system in case of fire and shall have minimum two hour fire resistance rating
- 4.4.0 The fire proof cable penetration sealing system shall comprise either of the following methods:
 - a) Panel sealing method complete with
 - Encasing Panels
 - Cavity fill material
 - Sealant



- b) Mortar sealing method shall basically include Mortar based fire seal compound. The process shall include
- Surface preparation like dusting / removal of any oil substance
 - Mixing Mortar with water
 - Damming / Shuttering
 - Filling
 - Curing with water
- 4.5.0 The fire proof cable penetration sealing system offered should have been tested and evaluated at CBRI, Roorkie for compliance for the following tests. The following tests should have been carried out one after the other on the same sample in the specified sequence without any touching up/repair/modifications. A copy of test report shall be furnished along with the Bid. (But not more than 5 Years old).
- Accelerated ageing test
 - Water absorption test
 - Vibration test
 - Fire rating test
 - Hose Stream test
 - Anti-Rodent test
 - Temperature rise test for cables in fire stops
- 4.6.0 The fire proof cable penetration sealing system shall be suitable for site condition at 50°C ambient temperature and relative humidity of 60%. Contractor shall co-ordinate, plan and use the material within stipulated self-life of material.
- 4.7.0 The fire proof cable penetration sealing system of each wall / floor crossing shall be adequately designed / sized such that 20% addition of cables is possible at any later date without disturbance / wastage of material in the penetration system.
- 4.8.0 The fire proof cable penetration sealing system shall be physically, chemically, thermally stable and shall be mechanically secured to the masonry / concrete / structural members. The system shall be mechanically robust and capable of giving satisfactory performance under vibrations encountered in power stations.
- 4.9.0 The encasing panel (support frame) shall be of single panel of uniform density. Paper laminated gypsum boards shall not be used.
- 4.10.0 Sealing putty shall not be based on chlorinated rubber.
- 4.11.0 Under normal load, short circuit & fire conditions cables may be subjected to movement and vibration. The fire proof cable penetration sealing system shall be designed to withstand & perform satisfactorily under these conditions. The fire proof cable penetration sealing system shall have life expectancy of 40 years.
- 4.12.0 The fire proof cable penetration sealing system should not affect the current carrying capacity of cables passing through it.
- 4.13.0 Asbestos shall not be used in the construction of fire penetration seal system.

5.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Design basis for fire stop system
- Installation details for fire stop system



- Layout for fire stop system
- Fire stop arrangement details for floor crossing, wall crossing, below panels.
- Test reports
- Data sheet
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.28: EARTHING & LIGHTNING PROTECTION SYSTEM

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of Earthing & Lightning protection system.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

- a) Buried earth mat for the main plant, auxiliary plants, non plant buildings and switchyard
- b) Embedded earth mat in the concrete floor of buildings, electrical rooms including GIS building.
- c) Equipment enclosure earthing for all electrical equipment
- d) Earthing of all metallic structures including cable racks
- e) Electronic earthing for all DCS/Respective control system/SAS/EMS and other electronic equipment
- f) Earthing for communication system
- g) Lightning protection for GIS building, Switchyard and transformer yard
- h) Lightning protection for main plant building, Boiler, ESP
- i) Lightning protection for Chimney
- j) Lightning protection for Cooling tower
- k) Lightning protection for Ash silo structure
- l) Lightning protection for CHP buildings and structures
- m) Lightning protection for Ash buildings and structures
- n) Lightning protection for all auxiliary plant buildings/structures and outdoor equipment/structures
- o) Lightning protection for all non-plant buildings and structures

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Standards except where modified and /or supplemented by this specification.

- a) IS: 3043 Code of Practice for Earthing
- b) IS: 2309 Protection of building and allied structures against lightning - Code of practice
- c) IS: 1079 Specification for hot rolled carbon steel sheet and strips
- d) IS: 2629 Recommended practice for hot dip galvanizing on iron & steel
- e) IS: 4759 Specification for hot-dip zinc coatings on structural steel and , allied products
- f) IS: 6745 Methods for determination of weight of zinc-coating on zinc coated articles.
- g) IEEE 80 IEEE Guide for safety in AC substation grounding
- h) IEEE 142 Grounding of industrial & commercial power system.
- i) CBIP manual on AC earthing system
- j) Indian Electricity Rules

4.0.0 TECHNICAL REQUIREMENTS

4.1.0 Earthing System

- 4.1.1 Earthing system shall be provided for complete power station including switchyard.



4.1.2 Earthing system shall comprise the following:

- Neutral earthing to establish the ground reference of the electrical system
- Safety ground connections for protecting personnel from injury and property from damage
- Equipment earthing to ensure a low impedance return path for ground current should an electrical fault occur between the live conductors and the equipment enclosure

4.1.3 Various system earthing envisaged in the power project are as follows:

S. No.	System Voltage	Neutral	Maximum earth fault current
1.	400 kV system	Solidly earthed	63 kA
2.	33 kV system	Solidly earthed	25 kA
3.	Generator	High impedance earthed	10 A
4.	11 kV system	Medium resistance earthed	300 A
5.	6.6 kV system	Medium resistance earthed	300 A
6.	415 V system	Solidly earthed	65/50 kA

The safety and equipment earthing systems should meet the following requirements:

- a) All metallic enclosures on equipment and exposed noncurrent-carrying conductive materials capable of becoming energized due to either insulation failure, inadvertent contact with an energized conductor, or building up of a static or induced voltage should be earthed.
- b) The earthing arrangement should ensure a deliberate earth fault current return path, so that the (overcurrent or earth fault) protection shall sense the fault and either trip the faulty circuit or provide an alarm to the station operator.
- c) The earthing should limit the step and touch voltage to acceptable limits during an earth fault.
- d) The earthing conductors and connections should withstand the earth fault current for the duration of the fault, without being damaged by thermal, thermo-mechanical or electromechanical stresses.
- e) The earthing conductors should be continuous; no switching device should be inserted in the earthing conductors (except where the operation of the switching device shall also automatically disconnect all power sources to the equipment earthed by that conductor). Equipment enclosures should not be used as part of the earthing conductor.
- f) The earthing conductors should be mechanically reliable or protected in order to withstand any possible mechanical stress imposed on them. The exposed connections of earthing conductors should be accessible for inspection.
- g) The earthing system should be designed to minimize corrosion to adjacent structures, equipment and enclosures.

4.1.4 The earth mat design for GIS building , switchyard and transformer yard shall be designed as per IEEE 80. The earthing system of Switchyard shall meet the following requirements:

- Ensure adequate earth fault current for operation of earth fault protection
- Limit step and touch voltages to acceptable limits during earth fault
- Earthing conductors and connections shall withstand earth fault current for the duration of the fault



- 4.1.5 The earth mat shall be designed with grid spacing such that safe voltage gradients are maintained. Earth conductors shall be installed below ground shall be spaced in a grid pattern to provide the earthing mesh grid throughout the site. Switchyard earth mat shall be interconnected with main plant earth mat by a minimum of two parallel conductors.
- 4.1.6 The mild steel earth grid shall be designed to withstand 40 years of corrosion and still retain safe touch and step potentials in accordance with IEEE 80. Corrosion rate shall be arrived at as per soil resistivity report.
- 4.1.7 The earth mat of the station shall be designed such that the total ground resistance does not exceed 0.5 ohm.
- 4.1.8 Earth mat and all earthing conductors for GIS building earthing shall be of copper. The earthing conductor material for other locations shall be corrosion resistant steel.
- 4.1.9 400 kV system earth fault current of 63 kA shall be considered for earthing design. The earthing design shall consider the following:
- Earth fault current duration for conductor sizing : 1 sec
 - Shock duration for mesh sizing : 0.5 sec
 - Depth of buried earthing conductor : minimum 600 mm
 - Human body weight for step / touch voltage calculation : 70 kg
 - Resistivity of concrete : 500 ohm m
- 4.1.10 Contractor shall carry out earth resistivity test of power project site and shall establish homogeneous soil resistivity for earthing design. Number of earth resistivity test locations shall be not less than 10. The test locations shall be subject to Owner's approval.
- 4.1.11 For Gas insulated switchyard the following aspects shall be considered:
- All metallic enclosures should normally operate at ground voltage level.
 - When grounded at the designated points, the bus enclosure design should ensure that no significant voltage differences exist between individual enclosure sections and that neither the supporting structures nor any part of the grounding systems is adversely influenced by the flow of induced currents.
 - To avoid the circulation of enclosure currents beyond regular return path within the GIS assembly, power cable sheath grounds should be tied to the grounding system via connections that are separated from the GIS enclosures. Very fast transients generated by switching or by faults in the GIS may cause these insulation elements to flashover. In such cases, the consequences of such flashovers on current distribution within the grounding system should be considered.
 - Enclosure return currents also cannot be permitted to flow through any mounted current transformers.
 - In GIS building, earth mat of copper flat shall be embedded in the concrete floor in grid / mesh form. Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover.
- 4.1.12 The grounding system shall be designed and provided as per IEEE-80-2000 and CIGRE-44 to protect operating staff against any hazardous touch voltages and electro-magnetic interferences. The following shall be ensured.
- The grounding system shall ensure safe touch & step voltages in all the enclosures
 - All GIS equipment, bus ducts, enclosures, control cabinets, supporting structure etc. shall be connected to the ground bus of GIS.
 - The enclosure of the GIS shall be grounded at several points so that there shall be grounded cage around all the live parts. A minimum of two nos. of grounding connections



should be provided for each of circuit breaker, transformer terminals, cable terminals, surge arrestors, earth switches and at each end of the bus bars.

- The grounding continuity between each enclosure shall be effectively interconnected with copper bonds of suitable size to bridge the flanges.
- Suitable measure shall be provided to mitigate transient enclosure voltage caused by high frequency currents caused by lightning strikes, operation of surge arrestor, phase/ earth fault and discharges between contacts during switching operation. Suitable barrier of non-linear resistor at SF6/ Air termination, cable bushing etc. to mitigate transient enclosure voltage shall be provided.

- 4.1.13 Earthing terminal of each lightning arrester and capacitor voltage transformer shall be directly connected to earth electrode which in turn, shall be connected to station earthing grid.
- 4.1.14 Isolation of main plant earth mat and GIS Switchyard earth mat shall be provided by test link.
- 4.1.15 All ground connections shall be made by electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it.
- 4.1.16 Resistance of the joint shall not be more than the resistance of the equivalent length of the conductor.
- 4.1.17 Earthing conductor shall be buried 2000 mm outside the Switchyard fence. All the gates and every alternate post of the fence shall be connected to earthing grid.
- 4.1.18 For the power house building involving turbine hall, boiler and ESP, earthing conductor shall be buried in ground in mesh form to enable earthing of all major steel structures, electrical equipment etc.
- 4.1.19 For auxiliary plants, earthing conductor around the building shall be buried in earth at a minimum distance of 1500 mm from the outer boundary of the building. Earth risers shall be extended to the building interior for equipment earthing.
- 4.1.20 In all the electrical rooms, earth mat (galvanized steel flat) shall be embedded in the concrete floor in grid / mesh form. Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover.
- 4.1.21 Earth pit shall be constructed as per approved drawing. Electrodes shall be embedded below permanent moisture level. Minimum spacing between electrodes shall be 6000 mm. Earth pits shall be treated with salt and charcoal.
- 4.1.22 Wherever earthing conductor crosses cable trenches, underground service ducts, pipes, tunnels, etc., it shall be laid minimum 300 mm below them and shall be circumvented in case it fouls with equipment / structure foundations. Earthing conductors crossing the road / rail tracks shall be laid at 600 mm depth.
- 4.1.23 All earth electrodes shall preferably be driven to a sufficient depth to reach permanently moist soil. Electrodes shall preferably be situated in a soil which has a fine texture and which is packed by watering and ramming as tightly as possible. The electrodes shall have a clean surface, not covered by paint, enamel, grease or other materials of poor conductivity.
- 4.1.24 Earth pits shall be located avoiding interference with road, building foundation, column, equipment foundation etc. The disconnect facility shall be provided for individual earth pits to check their earth resistance periodically. Proper symmetry and distance between earth pits shall be maintained as per applicable standards and procedures. Treated earth pits shall conform to relevant standard.



- 4.1.25 Construction of trench for earthing conductor shall include excavation, laying of conductor, back filling and compacting. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures. Back filling shall be placed in layers of 150 mm. Minimum earth coverage of 300 mm shall be provided between earth conductor and the bottom of trench / foundation / underground pipes at crossings.
- 4.1.26 HV Neutral point of the following transformers shall be directly connected to earth through two numbers treated earth pit.
- Generator transformers
 - Standby transformer
 - 33 kV winding of Auxiliary transformer
- 4.1.27 LV Neutral point of the following transformers shall be directly connected to earth through two numbers treated earth pit.
- LT Service transformers
- 4.1.28 LV Neutral Points of the following transformers shall be connected to Neutral Grounding Resistors (NGRs). NGR shall be connected to earth through two numbers treated earth pit.
- Unit transformer
 - Station Transformer
 - Unit auxiliary transformer
 - Station auxiliary transformer
 - Other auxiliary transformers
- 4.1.29 Earth pits/earth electrodes shall be interconnected to near by station earthing grid.
- 4.1.30 For equipment earthing, earthing conductor shall be sized to withstand earth fault current of the system for the duration permissible by the protection device. Thickness of galvanising shall be atleast 610 gm/sq.m for all steel conductors.
- 4.1.31 Size of the earthing conductor shall be not less than the following:

Sl. No.	Equipment	Size/ type of Earthing material
1)	Main earthing conductor / Earth mat	40 mm dia corrosion resistant steel rod
2)	Earth risers from earth mat	40 mm dia corrosion resistant steel rod or 65X8 mm size GS flat
3)	Rod earth electrode	40 mm dia corrosion resistant steel rod
4)	Earth conductor embedded in concrete in GIS building	Copper flat
5)	Earth conductor embedded in concrete	50X6 mm GS flat
6)	Treated earth pit for power circuit	Minimum 65 mm dia galvanized steel pipe electrode as per IS:3043
7)	Electronic earthing	Chemical earth pit with copper electrode
8)	EHV Equipment	
	a) Equipment earth pad to structure, Structure to earth mat	2 nos. 75X8 mm galvanized steel (GS) flat
	b) Control cubicle, Mechanism box	2 Nos. 50X6 mm GS flat



Sl. No.	Equipment	Size/ type of Earthing material
	c) Lightning arrester Insulating base to surge counter	50 mm ² copper cable
	d) Lightning arrester Surge counter to earth (without touching structure)	75X8 mm GS flat
	e) CVT neutral to earth electrode	75X8 mm GS flat
	f) Earth switch rod to isolator frame	2 nos. copper flexible
9)	Switchyard Towers	
	a) Tower peak to test link	7/3.66 mm galvanized steel shield wire
	b) Test link to main earth mat	50X6 mm GS flat
	c) Structure to earth mat	75X8 mm GS flat
10)	HT transformers (enclosure and neutral)	65X8 mm GS flat
11)	LT transformers (enclosure and neutral)	75X8 mm GS flat
12)	DG set (enclosure and neutral)	50X6 mm GS flat
13)	Generator, LAPT, NGT, NGT neutral	50X6 mm GS flat
14)	HT Switchgear, HT motors, HT busducts	50X6 mm GS flat
15)	LT Switchgear (PCC & MCC), LT busduct	75X8 mm GS flat
16)	All distribution boards	50X6 mm GS flat
17)	LT motors of 75 kW and above	50X6 mm GS flat
18)	LT motors of 30 kW to <75 kW	32X5mm GS flat
19)	LT motors of 9.3 kW to <30 kW	25X3mm GS flat
20)	LT motors of 5.5, 7.5 kW	4 SWG GS wire
21)	LT motors of <5 kW	6 SWG GS wire
22)	Charger / UPS	50X6 mm GS flat
23)	Lighting panels	25X6 mm GS flat
24)	Relay panels / SAS panel	25X6 mm copper flat
25)	Cable trays	50X6 mm GS flat
26)	CT junction box / PT junction box	50X6 mm GS flat
27)	Lighting / Control junction boxes	14 SWG GS wire
28)	Lighting poles/masts	20 mm dia, mild steel earth electrode
29)	Local push button stations	8 SWG GS wire

4.1.32 Metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system, each of 100% capacity. Steel columns, metallic stairs, hand rails etc. of the building housing electrical equipment shall be connected to the nearby earthing grid conductor by one earthing.

4.1.33 Metallic conduits shall not be used as earth continuity conductor.



- 4.1.34 Flexible earthing connectors shall be provided for moving parts.
- 4.1.35 50 mm x 6 mm galvanized steel flat shall run all along the cable tray routes and the same shall be welded / connected to each of the tray /rack. Further, this flat shall be earthed at both ends and at an interval of 30 m.
- 4.1.36 Earthing connections with equipment earthing pads shall be bolted type. Contact surfaces shall be free from scale, paint, enamel, grease, rust or dirt. Two bolts shall be provided for making earth connection. Equipment bolted connections, after being checked and tested, shall be painted with anti-corrosive paint / compound.
- 4.1.37 Connection between earthing conductors shall be welded type. For rust protection, the welds shall be treated with red lead and coated with two layers bitumen compound.
- 4.1.38 Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingress.
- 4.1.39 Metallic sheaths and armour of all multi-core power cables shall be earthed at both equipment and switchgear end. Sheath and armour of single core power cables shall be earthed at switchgear end only.
- 4.1.40 Earthing conductors along their run on cable trench, ladder, walls etc. shall be supported by suitable welding / cleating at intervals of 1000 mm. Wherever it passes through walls, floors etc., pipe sleeves shall be provided for the passage of the conductor and both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.
- 4.1.41 Railway tracks within the plant area shall be bonded across fish plates and connected to earthing grid at several locations.
- 4.1.42 Electronic panels and equipment shall be grounded utilising an insulated copper ground wire terminated at separate earth electrode.
- 4.1.43 For electronic equipment such as DCS, Respective control system, SAS, EMS etc., chemical earthing pit shall be provided. The earth pit shall be tested and proven type and shall be guaranteed for service life of 40 years. The chemical earth pit shall comprise pipe electrode, crystalline conductive mixture, bentonite etc. constructed in a pit of not less than 4000 mm depth. The pit shall be effective in all weather conditions and offer medium resistance. For electronic earthing system, earthing conductor shall be of copper.
- 4.1.44 **Earthing of chimney:** Earthing shall be carried out by routing 50x6 mm galvanised steel strip earthing conductor from chimney top up to ground. Each earthing conductor shall be earthed by using 40 mm dia 4 metre mild steel rod and shall also be interconnected with the power station earthing grid.
- 4.1.45 Earthing of cabling system
- Armour of the HT cables and LT single core cables shall be earthed only at one end of cable.
 - Armour of other cables shall be earthed at both ends of cable.
 - Screen of HT power cables shall be earthed at one end only.
 - Screen of C&I screened control cables shall be earthed at one end.
 - Screen of electronic earthing system cables shall be earthed as per the requirements.
- 4.1.46 After completion of grounding system installation, the measurement of ground resistance shall be performed by the Contractor. continuity of earth conductors and efficiency of all bonds and joints shall be checked. Before measurement, the overhead ground wires shall be disconnected from the GIS Switchyard. The method of measurement shall be as per relevant standards / codes. The ground resistance of GIS Switchyard grounding system shall be not more than 0.5



ohm. Earth resistance at earth terminations shall be measured in presence of Owner's representatives

5.0.0 LIGHTNING PROTECTION SYSTEM

- 5.1.0 Direct stroke lightning protection (DSLPP) shall be provided in the GIS Switchyard by lightning masts and shield wires including connections, earth pits etc. to make the lightning protection complete for the outdoor GIS Switchyard including reactors. The arrangement shall be based on DSLPP calculations. Contractor shall furnish necessary design calculation for approval by Owner.
- 5.2.0 The lightning protection system in the transformer yard shall cover the following equipment in the protection zone.
- Generator transformers
 - Station transformers
 - Standby transformers
 - Auxiliary transformers
- 5.2.0 All areas of the power station shall be provided with lightning protection. The lightning protection system for buildings shall consist of air termination network, down conductors, test link and earth electrodes.
- 5.3.0 Air termination network consisting of vertical or horizontal conductors or combination of both shall be provided for the building. Down conductors shall follow the most direct path possible between the air terminal network and the earth termination network. Each down conductor shall be provided with a test link for testing. An earth electrode shall be connected to each down conductor.
- 5.4.0 For Lightning protection, material & sizes shall be as follows:
- Vertical air termination : 20 mm dia galvanised steel rod
 - Horizontal air termination : 25X6 mm Galvanised steel Strip
 - Down conductor : 25X6 mm Galvanised steel Strip
 - Test link : 150x50x6 mm Galvanised steel Strip with Box
 - Earth Electrodes : Treated earth pit with rod electrode as per IS:3043
- 5.5.0 Thickness of galvanising shall be atleast 610 gm/sq.m for all galvanised steel conductors.
- 5.6.0 The lightning protection system shall not come in direct contact with other equipment/systems such as cables, conduits, electrical equipment, underground metallic ducts etc. All metallic structures within vicinity shall be bonded to the lightning protection system.
- 5.7.0 All welded/brazed joints shall be coated with anti- corrosive paint for rust protection.
- 5.8.0 Lightning conductor when used above ground level and shall be connected through test link with earth electrode/earthing system. Down conductors shall be as short and straight as practicable and shall follow a direct path to earth. Down conductor shall not be connected to other earthing conductors above ground level.
- 5.9.0 Each down conductor shall be provided with a test link at 1500 mm above ground level for testing but it shall be in accessible to interference. No connections other than the one direct to an earth electrode shall be made below a test point. All joints in the down conductors shall be of welded type.
- 5.10.0 Down conductors shall be cleated on outer side of building wall/ welded to outside building columns at 750 mm interval.



- 5.11.0 Lightning conductor on roof shall be cleated on surface of roof using insulated clamps/saddles for conductor fixing at an interval of 1000 mm for horizontal run and 750 mm for vertical run..
- 5.12.0 Conductors of the lightning protection system shall not be connected with the conductors of the safety earthing system above ground level.
- 5.13.0 Installation of lightning conductors on the roofs of buildings shall include construction of support, laying, anchoring, fastening and cleating of horizontal conductors, grouting of vertical rods wherever necessary, laying, fastening / cleating / welding of the down comers on the walls / columns of the building and connection to the test links to be provided above ground level.

5.14.0 Lightning protection system for chimney

- 5.14.1 The lightning protection system for chimney shall be installed in accordance with IS 2309. Pointed vertical air terminal rods shall be provided at the top and these shall be equally spaced at 120 degree around the circumference of the top flue cane. Air terminals shall project not less than 1000 mm above the highest part of the flue cane. Air terminals shall be mechanically and electrically connected to a continuous circumferential conductor.

- 5.15.0 For Lightning protection, material & sizes shall be as follows:

- Vertical air termination : 20 mm dia lead coated steel rod
- Horizontal air termination (top 12 metre): 25X3 mm lead coated copper strip
- Horizontal air termination (remaining portion): 50X6 mm Galvanised steel Strip
- Down conductor (top 12 metre) : 25X3 mm lead coated copper strip
- Down conductor (remaining portion) : 50X6 mm Galvanised steel Strip
- Coronal band (top) : 70 sq.mm lead coated copper conductor
- Coronal band (mid-height) : 70 sq.mm copper conductor
- Test link : 150x50x6 mm Galvanised steel flat in steel enclosure
- Earth Electrodes : Treated earth pit with rod electrode as per IS:3043

- 5.14.2 Two cable collars, , shall encircle the chimney; one at the top, interconnecting the lower ends of the air terminals and the down conductors, and one approximately mid-height of the chimney, connecting the down conductors. Not less than four down conductors along shell shall be located along the exterior wall of the shell, shall extend to the chimney base to earth electrode pit, and shall be connected to the plant grounding grid.

- 5.14.3 Air terminals, connections, conductors, clamps, fixtures, anchors, etc., exposed within 12000 mm of the top of the chimney shall have a continuous lead covering of a sheath of commercially pure lead not less than 2 mm in thickness.

- 5.14.4 During construction, temporary lightning protection should be maintained by connecting the concrete reinforcement to two permanent electrical grounding conductors. After the top lift of the chimney shell has been completed, temporary air terminals which may consist of reinforcing bars, should be installed at the top to serve as a temporary protection until the lining and cap are completed and permanent air terminals are installed.

5.16.0 Lightning Protection System for cooling tower and Ash Silo

- 5.15.1 Pointed vertical air terminal rods shall be provided at the top and these shall be spaced around the circumference of the top. Air terminals shall consist of galvanized steel conductors, each not less than 20 mm diameter galvanized steel rod, projecting not less than 1000 mm above the highest part structure. Air terminals shall be mechanically and electrically connected to a continuous circumferential conductor. Number of down conductors as per IS: 2309, shall be located along the exterior wall, shall extend to the base to earth electrode pit, and shall be connected to the power station earth grid.



5.17.0 For Lightning protection, material & sizes shall be as follows:

- Vertical air termination : 20 mm dia lead coated steel rod
- Horizontal air termination : 50X6 mm Galvanised steel Strip
- Down conductor : 50X6 mm Galvanised steel Strip
- Coronal band (at top)) : 70 sq.mm copper conductor
- Test link : 150x50x6 mm Galvanised steel flat in steel enclosure
- Earth Electrodes : Treated earth pit with rod electrode as per IS:3043

5.15.2 During construction, temporary lightning protection should be maintained by connecting the concrete reinforcement to two permanent electrical grounding conductors.

5.16.0 On completion of lightning installation, continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured in presence of Owner. Resistance of individual earth electrode shall be measured after disconnecting it from the grid. Tests shall be carried out as per IS : 3043 for earthing installation including the following:

- a) Earth continuity checks
- b) Earth resistance of the complete system, sub-system and earth pits

6.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Soil resistivity report
- Design basis report for earthing and lightning protection system
- Earthing design calculation
- Typical installation drawings for earthing and lightning protection
- Electronic earthing layout and details
- Earthing layout for Transformer Yard
- Earthing layout for Power house building, Boiler and ESP
- Earthing layout for Chimney
- Earthing layout for Cooling tower
- Earthing layout for all auxiliary plant buildings
- Earthing layout for all non-plant buildings
- Earthing layout for GIS building and Switchyard
- Lightning protection design calculation
- Lightning protection layout for Power house building, Boiler and ESP
- Lightning protection layout for transformer yard
- Lightning protection layout for all auxiliary plant buildings
- Lightning protection layout for all non-plant buildings
- Lightning protection layout for GIS building and Switchyard
- Lightning protection layout for Chimney
- Lightning protection layout for Cooling tower
- Field quality plan



SECTION-3.29: ELECTRICAL INSTALLATION

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of Electrical installation and also supply and installation of the following items:

- Rubber mats for switchgear
- Caution boards
- Sand buckets
- First aid box
- Sheet steel cover for /cable shaft/trench etc.
- Sheet steel hood for the outdoor electrical equipment/motor
- Cable route markers & Cable joint markers
- Shock hazard chart
- Erection hardware

2.0.0 CODES AND STANDARDS

Installation of cabling work shall comply with the latest edition of following Indian standards, rules, regulations and acts.

- IS: 1255 : Code of practice for installation and maintenance of power cables up to and including 33 kV rating.
- IS: 732 : Electrical wiring installation (system voltage not exceeding 650 V).
- IS 10028 : Code of Practice for selection, Installation & maintenance of transformers.
- IS 10118 : Code of practice for selection, installation & maintenance of Switchgear & Control gear.
- IS: 5216 : Guide for safety procedures and practices in electrical works.
- IS 2551 : Danger notice plates
- IS 8923 : Warning Symbol for dangerous voltages.
- Indian Electricity Act.
- Indian Electricity Rules.
- Fire insurance regulations.
- Regulations laid down by the Chief Electrical Inspector of the State.
- Regulations laid down by the Factory Inspector of the State.

3.0.0 GENERAL REQUIREMENTS

- 3.1.0 The work shall be carried out in the best workman like manner in conformity with the latest editions / amendments of relevant specifications / codes / standards / regulations.
- 3.2.0 Manufacturer's drawings, instructions and recommendations shall be correctly followed in handling, erecting, testing and commissioning of all items / equipment and care shall be exercised in handling to avoid distortion to stationary structures, marring to finish, or damaging of delicate instruments or other electrical parts.
- 3.3.0 All the equipment covered under this specification shall be installed in neat, professional manner such that the structures and equipment are level, plumb, squat, properly aligned and oriented. Clearance around electrical panels / equipment shall be as per relevant standards.
- 3.4.0 The Contractor shall effectively protect his work, equipment and materials under his custody from theft, damage or tampering. Finished work where required shall be suitably covered to



keep it clean and free from defacement or injury. Contractor shall be held responsible for any loss or damage to equipment and material issued to him until the same is taken over by the Owner according to Contract.

- 3.5.0 All safety rules and codes as applicable to work shall be followed without exception. All safety appliance and protective devices including belts, hand gloves, aprons, helmets, shields, goggles, safety shoes etc. shall be provided by the Contractor for his personnel.
- 3.6.0 The Contractor shall provide guards and prominently display caution notices if access to any equipment / area is considered unsafe and hazardous. In order to avoid hazards to personnel moving around the equipment such as switchgear etc. which is kept charged after installation, before commissioning, such equipment shall be suitably cordoned off to prevent anyone accidentally going near it.
- 3.7.0 The Contractor shall have a separate cleaning gang to clean all equipment under erection as well as the work area and the project site at regular intervals to the satisfaction of Owner. In case this is not done, the Owner shall have the right to carry out the cleaning operation and any expenditure incurred in this regard shall be to the Contractor account.
- 3.8.0 The Contractor shall ensure that instruments and gauges to be used for testing and inspection have valid calibration and the accuracy can be traced to National Standards.
- 3.9.0 It shall be the Contractor's responsibility to obtain approval from local statutory authorities including Electrical Inspector / CEA, wherever applicable, for carrying out any work or for installation carried out which comes under the purview of such authorities. All such documents and original certificates shall be handed over to Owner which then shall be property of the Owner.
- 3.10.0 The installation shall be carried out only by electrical Contractor, holding a valid license, issued by relevant authorities for carrying out installation work of the voltage classes involved, under the direct supervision of a person holding valid certificates of competency for the same voltage classes, issued or recognized by the state Government.
- 3.11.0 The installation shall have to be approved by statutory government authorities like Electrical Inspector, Factory Inspector, Insurance Officials etc. It shall be the responsibilities of Contractor to prepare and submit all necessary drawings, calculations and test certificates to electrical inspectorate and obtain approval/certification prior to installation and commissioning work and also arrange inspection by them after installation.

Necessary fees and other charges for the same shall be paid by Contractor.

- 3.12.0 Contractor shall take utmost care in holding instruments, relays and other delicate mechanisms wherever these are supplied separately. They shall be installed only after the associated panels have been erected and aligned. The packing materials employed for safe transit of these shall be removed after ensuring that panel have been completely installed and no further movement of the same are necessary. Any damage shall be immediately reported to Owner.
- 3.13.0 All the electrical equipment, panels, motors, busduct, cables etc. shall be stored under covered shed and oil filled power transformers can be stored outdoor. The OEM recommendation for electrical equipment shall be strictly adhered and proper periodical record shall be maintained, which shall be inspected by Owner.

4.0.0 CABLING CONCEPT

- 4.1.0 Cabling installations shall be carried out on trays. In all electrical rooms and control rooms, cable spreader room shall be provided. A clear working space of 800 mm shall be provided



horizontally between trays and on either side of the trays. A clear head room clearance of 1800 mm shall be provided in the cable spreader room.

- 4.2.0 In transformer yard and outdoor switchyard, cables shall be laid in cable trenches. Cable trenches shall have cable trays installed at a vertical spacing of 300 mm between the trays and supported at every 1500-2000 mm to trench wall. Cables shall be laid on trays only. Separate trays shall be provided for each of HT, LT, Control, signal cables. In the cable trench, a clear working space of atleast 600 mm shall be provided adjacent to trays. Cable trenches shall be properly sloped and connected to sump. For Cabling from equipment to trenches, GI pipe can also be used.
- 4.3.0 For short cable runs in auxiliary plant areas local to equipment shall be laid in floor slits up to near the equipment. Cable trenches are not permitted in other areas.
- 4.4.0 In the plant buildings and structures cables shall be laid overhead suitably supported on along wall/structures.
- 4.5.0 All interplant cable tray routing shall be on overhead cable trestles or combined with pipe trestles in a separate tier..
- 4.6.0 Cable routes shall be segregated unit wise, to the extent possible. Similarly, cables for the standby drives shall preferably be taken through the alternative route. Separate routes shall be considered for duplicate control supply cables, first and second channel protection cables, and cables to common station service of two or more units.
- 4.7.0 Cables shall be avoided below oil pipes and in the vicinity of steam pipes.
- 4.8.0 Cable trays shall be laid in vertical formation in boiler, mill and ESP areas to avoid accumulation of coal-dust / ash on cables and cable-trays.
- 4.9.0 Cables shall not be routed in coal conveyor gallery, a separate cable gallery shall be provided.
- 4.10.0 In cable trenches, pipe racks/ cable racks, overhead routes, cable shafts and cable spreader rooms, cables shall be laid in cable trays only. Fewer cables installed along buildings, structures, ceilings, walls, etc., which are required to be protected against mechanical damage, shall be taken in GI conduits.
- 4.11.0 GI Conduits shall be used for flameproof installations, wherever required, with sealing at both ends.
- 4.12.0 Entry of cables from trenches into buildings shall be atleast 300 mm above finished ground level.
- 4.13.0 Where direct heat radiation from equipment/pipes exists, heat isolating barriers for cabling system shall be adopted.
- 4.14.0 Wherever cables are to be laid below roads and railway tracks, the same shall be taken through ducts buried at a suitable depth.
- 4.15.0 At certain places where leakage of oil or other hazardous material may cause damage to the cables, cable trenches/slits may be sand-filled, after installation of cables.
- 4.16.0 In corrosive atmosphere, PVC conduits shall be used for routing cables. Metallic pipes / conduits shall not be used in corrosive areas.
- 4.17.0 Three phase AC single core cables, while laying in steel conduits, shall be laid in trefoil formation only.



- 4.18.0 Complete cable tray & accessory installation work shall be inspected for proper alignment, leveling (by use of plumb lines), use of proper accessories, provision of proper bending radius and high quality workmanship.
- 4.19.0 Cable trays shall be ladder type for power and electrical control cables, while perforated type cable trays shall be used for instrumentation and control cables. However, in vertical cable tray risers, all trays shall be ladder type.
- 4.20.0 Flexible conduits shall be used between fixed conduits and equipment terminal boxes, where vibration is anticipated.
- 4.21.0 Junction boxes shall be installed so that they are level, plumb & properly aligned and present a pleasing appearance. Boxes shall be adequately supported by means of proper supporting arrangement.

5.0.0 CABLE TRAY AND SUPPORT SYSTEM INSTALLATION

- 5.1.0 Cable trays shall be bolted to tray mounting supports with a minimum clearance of 300 mm between cable tray tiers / as shown in the drawings.
- 5.2.0 For horizontal runs in door and in trenches, cable trays shall be supported at an interval of 1500 mm and for outdoor installation it shall be 2000 mm. For vertical cable risers/shafts cables shall be supported at every 1000 mm interval.
- 5.3.0 Support system shall be so designed that it is able to withstand weight of the cable trays, weight of the cables (75 Kg/metre run for each cable tray), concentrated load of 75 Kg between every support span without any permanent deflection. Factors of safety of atleast 1.5 shall be considered.
- 5.4.0 Cable tray supports shall be of bolted (similar to Unistrut) type, which shall be installed at site, by bolts. Fixing of tray supports by welding is not allowed. Cable tray support structure shall be bolted to the steel structure by clamping and to concrete structures by embedding or using anchor fasteners.
- 5.5.0 All cable way sections shall have identification, designations as per cable way layout drawings and painted/stenciled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 60 mm. For long lengths of trays, the identification shall be painted at every 10 meter. Risers shall additionally be painted / stenciled with identification numbers at every floor.
- 5.6.0 Tray covers shall be provided for outdoor overhead cable trays on top most tiers. Tray covers shall be provided for top tray of horizontal tray runs located under grating floor or insulated piping, and for all trays routed in areas where oil might enter or accumulate. The cable risers or vertical raceways shall also be covered by cable tray covers up to 1.5 metres from respective floor for mechanical protection. The tray cover shall be of galvanized sheet steel, removable type.
- 5.7.0 Atleast 250 mm spacing shall be maintained between top of the trays and beams/piping etc..
- 5.8.0 **Typical cable tray installation details are shown in the drawings enclosed in Section-7 of Volume-II.**

6.0.0 CONDUITS/PIPES/DUCTS INSTALLATION

- 6.1.0 Rigid steel conduits shall be used indoors in non-hazardous areas. Unplasticised PVC conduit shall be used for duct banks and for some below grade concrete encased conduit.



- 6.2.0 Exposed conduits shall be routed parallel or perpendicular to dominant surfaces with right angle turns made of symmetrical conduit bends or fittings. Conduits shall be securely supported within 900 mm of connections to boxes and cabinet.
- 6.3.0 Embedded conduits shall have a minimum concrete cover of 50 mm. All conduits to be embedded in concrete shall be inspected to ensure continuity and accuracy of placement before concrete is poured. All embedded pipes/conduits, sleeves, long radii bends etc. shall have at least 50 mm long extension beyond the embedded part, for extension of the same or for providing end plugs. If any embedded conduit is not required, it shall be plugged/sealed. All accessories/fittings required for making the installation complete, shall include tees, elbows, check nuts brass or galvanized steel end caps, PVC/brass bell mouths for water proof sealing, pull boxes, saddles, spacers and required steel supporting work.
- 6.4.0 Flexible conduit shall be terminated using suitable end coupler and check nut at both ends.
- 6.5.0 All conduits installed outdoor shall be sloped towards pull boxes, hand holes/manholes for drainage. Low points of conduits not terminating in pull boxes, hand holes/manholes shall be provided with weep holes for drainage. Care shall be taken to see that no rough edge is left around the weep holes. Where no provision for drainage can be made, both ends of conduits shall be sealed after cable is laid through. Minimum slopes of 1 in 400 shall be provided.
- 6.6.0 Exposed conduit shall be adequately supported by racks, clamps, straps or by other approved means. Conduits supports shall be erected square and true to line and grade. For bending of conduits, bending machine shall be arranged at site by the Contractor to facilitate cold bending. The bends formed shall be smooth.
- 6.7.0 When two lengths of conduits are joined together through a coupling, running thread equal to twice the length of coupling shall be provided on any one length to facilitate easy dismantling. The Contractor shall have at site die for threading pipe or conduit. After threading of conduits anti corrosive paint shall be provided.
- 6.8.0 Occupancy of conduits shall not be greater than 40%.
- 6.9.0 Liquid tight flexible metallic conduit shall be used for connections to solenoid valves, limit switches; pressure switches etc., and for connection to motors or other vibrating equipment and across areas where expansion or movement of the conduit is required.
- 6.10.0 Minimum bending radius for conduits shall be 10 times the external diameter of the conduit.
- 6.11.0 All conduits shall be permanently identified at each end with the conduit number assigned to it as per the applicable drawings.
- 6.12.0 Pull boxes shall be installed between termination points wherever required to facilitate cable out at a maximum interval of 30 metres.
- 6.13.0 Conduits shall be firmly fastened within 900 mm of each junction box, cabinet or fitting. Conduits shall be supported at least every 2000 mm.

7.0.0 CABLE INSTALLATION

- 7.1.0 Power and control cables shall be laid on separate tiers. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables. Generally HT cables shall be laid on top most tier and cables of subsequent lower voltage grades on lower tiers of trays. Separate cable trays shall be used for the following:
- HT Power Cables
 - LT Power Cables
 - Control Cables



- Instrumentation/communication cables
 - Fire Survival cables
- 7.2.0 Single core cable in trefoil formation shall be laid with spacing equal to the diameter of the Trefoils and clamped at every two metre. All multicore cables shall be laid in touching formation. Power and control cables shall be securely fixed to trays /supports with self-locking type nylon cable strap with de-interlocking facility at every 5 meter interval for horizontal run and cables laid in vertical run of trays shall be securely fixed to trays/supports by galvanized steel clamps at every one metre interval. All power cables should be clamped individually.
- 7.3.0 HT cables and LT power cables of >16 sq.mm shall be laid in one layer only. LT power cables of up to 16 sq.mm can be laid in two layers. Control cables can be laid in 3 layers.
- 7.4.0 Bending radii for cables shall be as per manufacturer's recommendations.
- 7.5.0 Where cables cross roads/rail tracks, the cables shall be laid in hume pipes embedded in ground with a minimum cover of 1 metre or with RCC covering for lower depth.
- 7.5.0 In each cable run some extra length shall be kept at suitable point to enable one straight through joints to be made, should the cable develop fault at a later stage. Control cable termination inside equipment enclosure shall have sufficient lengths so that shifting of termination in terminal blocks can be done without requiring any splicing.
- 7.6.0 For Directly Buried cables, construction of cable trench for cables shall include excavation, preparation of sieved sand bedding, riddled soil cover, concrete protective covering, back filling and compacting, provision of route markers and joint markers. Before the cables are placed, the excavated portion shall be filled with a layer of sand and leveled. The cables laid over it shall then be covered with 150 mm sand on top of the largest diameter cable and sand shall be lightly pressed. A protective covering of concrete shall then be provided on top. The remaining portion of the excavated trench shall then be back filled with soil, rammed and leveled.
- 7.7.0 RCC cable route and RCC joint markers shall be provided wherever required. The voltage grade of the higher voltage cables in route shall be engraved on the marker. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable Joint". The marker shall project 75 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road crossings and drain crossings. Top of cable marker/joint marker shall be sloped to avoid accumulation of water/dust on marker.
- 7.8.0 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, and at every 30 meters in cable tray/trench runs. Cable tags shall also be provided inside the switchgear, motor control centers, control and relay panels etc. where a number of cables enter together through a gland plate. Cable tag shall be of rectangular shape for power cables and control cables. Cable tag shall be of 2 mm thick aluminium with number punched on it and securely attached to the cable GI wire.
- 7.9.0 Where a cable route crosses a permanent road/railway line cables shall be drawn through hume pipes or G.I. pipes. Pipes should be laid in a straight configuration. Filling criteria in any pipe shall not be more than 40%.
- 7.10.0 Conduits shall be used for routing of cables (power / control) from cable trays to equipment/ junction boxes. Pipe sleeves shall be used for routing of cables between floors, road crossing, entry/exit from outside of building etc. All conduits/pipe shall have their ends closed by caps till the cables are pulled. After the cables are pulled, the ends shall be sealed by suitable sealing compound having 2 hour fire withstand capability.



- 7.11.0 The location of cable joints, if any, shall be clearly indicated with cable marker with an additional inscriptions "Cable-Joint" and "Cable Number".

8.0.0 CABLE TERMINATION AND JOINTING

- 8.1.0 All cable entries in the equipment shall be sealed by cable glands.
- 8.2.0 Adequate length of cables shall be pulled inside the switchgear, control panels, terminal boxes etc. so as to permit neat termination of each core / conductor.
- 8.3.0 Power cable terminations shall be carried out in a manner such as to avoid strain on the terminals by providing suitable clamps near the terminals.
- 8.4.0 Control cable cores entering switchgear or control panels shall be neatly bunched and strapped with PVC perforated tapes / nylon ties and suitably supported to keep them in position at the terminal block. All spare cores shall be connected to spare terminals, wherever possible. If spare terminals are not available, spare cores shall be neatly dressed and suitably taped at both ends.
- 8.5.0 Screened control cables of small cross sectional area, shall be terminated by means of Maxi-Termi termination system.
- 8.6.0 Termination and jointing of HT cables shall be done with approved type termination/ jointing kits. Cable joints are permitted, only when the route length exceeds one full drum length.
- 8.6.0 Screened control cables of small cross sectional area, e.g. 0.5 mm², shall be terminated by means of maxi-termi termination system. Contractor shall ensure the availability of all tools, tackles and accessories such as maxi-termi guns, clips, wire etc. required for the termination of small cross section screened control cables by this method. Compressed air supply for maxi-termi guns shall also be the responsibility of Contractor.
- 8.7.0 Individual cores of control cables shall have ferrules for identification. Ferrule numbers shall be provided as per control schemes and other related documents. The spare cores shall be ferruled as spare.
- 8.8.0 Fiber optic termination and splicing equipment shall be used for cutting, finishing and joining fiber optic cables. An optical fiber tool shall be used to slice into the cable's outer coating and unpack the fibers without damaging them. Fiber optic cleaners, cleaning chemicals or solvents and cleaner dispensers shall be used for preparation of the cut and polished joint or splice. Fiber optic cables shall be terminated by using connectors to couple the cable to network devices. Fiber optic connectors shall be specifically designed to limit light loss and provide a secure connection to a device. The fiber optic termination connectors shall have a bayonet mount and a cylindrical ferrule to hold the fiber in place.

9.0.0 OVERHEAD LINE STRINGING WORK

- 9.1.0 Stringing work shall mean the activities of fixing of insulator and insulator hardware, jointing, tensioning, clamping with armour rod, providing dampers, repairing of conductors (if any), fixing the conductor at tension hardware etc.
- 9.2.0 The stringing work shall be carried out with the help of tensioner and puller machine. Manual stringing shall not be allowed. Stringing work shall be carried out as per approved sag tension chart.
- 9.3.0 Sufficient numbers of aluminum snatch blocks shall be used for paying out the conductors. Necessary precautions shall be taken to avoid conductor rubbing on the ground by providing



adequate ground roller, rollers on supports etc. Additional rollers shall also be provided to cross thorny hedges, footing and other obstructions to avoid scratching of conductor.

- 9.4.0 The conductor and earth wire shall be made to sag correctly as per stringing charts, before they are finally transferred to the hardware for conductors and to clamps for earth wire. No joint shall be made at less than 30 m from the tower end and no joint shall be permitted in road and other important crossings spans. There shall not be more than one joint in a span of each conductor.
- 9.5.0 Dynamometers shall be used in tensioning the conductors. All conductors shall be stressed to their maximum working load at the time of stringing, as per approved stringing charts. The minimum clearance between the lowest point of conductor and ground shall not be less than required.
- 9.6.0 The stringing sheaves, when suspended on the transmission structure for sagging, shall be so adjusted that the conductor shall be on the sheaves at the same height as the suspension clamp to which it is to be secured.
- 9.7.0 Proper guys shall be provided to counter balance the paving out tension of conductor / earth wire at the tension locations, to avoid damage to towers and / or accident.

10.0.0 SAFETY REQUIREMENTS

- 10.1.0 Provisions of Indian Electricity Rules in respect of various safety requirements (especially as provided at Rule 29, 35, 36, 42, 43, 44, 64, 74 to 80, 87 & 92) shall be complied with.
- 10.2.0 The minimum safety working clearances shall be maintained for the bare conductors or live parts of any apparatus in outdoor substations as per IE rule 64 a) ii).
- 10.3.0 All practical steps shall be taken to prevent operating the earth moving, lifting and housing machinery in dangerous proximity to a live overhead power line.
- 10.4.0 Barricades or barriers shall be installed to prevent accidental contact with energized lines or equipment. Where appropriate, signs indicating the hazard shall be pasted near the barricade or barrier.
- 10.5.0 Rubber gloves and insulated shoes shall invariably be worn in all cases while operating gang operating switches controlling high tension lines and equipment where accidental contact of operating personnel with live parts are likely. While working near live lines and equipment and working on live low-tension lines and equipment, gloves shall be worn.
- 10.6.0 Safety belts shall invariably be used in all cases while working on overhead systems like lines, bus bars, substation equipment etc.
- 10.7.0 Tested rubber mats shall be kept in front of operating panels / switches etc. They shall be checked for condition periodically and replaced as necessary.
- 10.8.0 First aid box shall be maintained. These shall be checked periodically and refilled or items replaced as necessary.
- 10.9.0 Chart for providing relief and treatment of person electrocuted shall be displayed prominently at suitable places in the substation. These shall be checked for condition periodically and replaced as and when necessary.
- 10.10.0 Firefighting equipment such as fire buckets filled with sand and fire extinguishers for both electrical and oil fires shall be maintained and kept at easily accessible place in substation



- 10.11.0 The Contractor shall supply and install all danger plates as per IS 2551. The danger plates shall be written in Hindi, local language and English and shall be provided as required for all electrical equipment.
- 10.12.0 All safety appliances and protective devices including belts, hand gloves, aprons, helmets, shields, goggles, safety shoes etc. shall be provided by the Contractor for his personnel.
- 10.13.0 The following minimum safety working clearances shall be maintained for the bare conductors or live parts of any apparatus in outdoor substations excluding overhead lines of installations of voltage exceeding 650 volts.

Highest System Voltage (kV)	Safety Working Clearance (Metres)
12	2.6
36	2.8
72.5	3.1
145	3.8
245	4.6
420	6.4

- 10.14.0 The above safety working clearances are based on an insulation height of 2.44 m, which is the height of lowest point on the insulator (where it meets the earthed metal) from the ground.

11.0.0 TESTING AND COMMISSIONING

- 11.1.0 The Contractor shall take full responsibility of testing at erection, pre-commissioning and commissioning stages of all the equipment / system being installed by him. The Contractor shall submit to the Owner a checklist for testing and commissioning and the activities shall be carried out in accordance with the checklist. The Contractor shall carry out the commissioning tests and checks after erection at site as per applicable standards and also as recommended by manufacturers.
- 11.2.0 On completion of erection work, the Contractor shall request the Owner for inspection and test. The Owner shall arrange for joint inspection of the installation for completeness and correctness of the work. Any defect pointed out during such inspection shall be promptly rectified by the Contractor. The installation shall be then tested and commissioned in the presence of the Owner and put on trial run for stipulated contract period.
- 11.3.0 The Contractor shall arrange for inspection of his installation work by Electrical Inspector and shall obtain necessary approval certificate for his installation work and charging. Any modification work required by Electrical Inspector must be undertaken by the Contractor at his own cost. All rectification, repair or adjustment work found necessary during inspection, testing, commissioning and trial run shall be carried out by the Contractor without any extra cost.
- 11.4.0 Following successful inspection and testing, all the equipment shall be commissioned and put on trial run in a manner mutually agreed upon based on the commissioning schedule.
- 11.5.0 The Contractor shall have to bring all testing equipment and instruments in sufficient numbers to carry out the job simultaneously in more than one area. Tests shall be conducted by qualified and experienced personnel. Valid calibration certificates for the testing equipment shall be produced.
- 11.6.0 All documents / records regarding test data and all other measured values shall be submitted to Owner for approval and subsequent record and reference. The results of all tests shall conform



to the specification requirements as well as any specific performance data guaranteed during finalization of Contract.

- 11.7.0 All checks and tests as per manufacturer's drawings / manuals, relevant codes of installation and commissioning checklists for various electrical equipment such as transformers, breakers, motors, switchgear, relays, meters etc. shall be carried out.
- 11.8.0 The Contractor shall perform operating tests on all switchgear and panels to verify operation of switchgear / panels and correctness of the interconnections between various items of the equipment. This shall be done by applying normal AC or DC voltage to the circuits and operating the equipment for functional checking of all control circuits, e.g. closing, tripping, control interlock, supervision circuits, alarm circuits etc. All connections in the switchgear shall be tested from point to point for possible earth or phase faults.
- 11.9.0 Contractor shall submit specified copies of site testing procedures, test formats along with details of site test instruments proposed to be deployed at site along with respective valid calibration certificates, six weeks prior to commencement of site testing, for approval by Owner. Only procedures and test formats approved by Owner shall be used for site testing. After completion of commissioning of all equipment and prior to handing over, six sets of such signed test data in the agreed / approved formats shall be furnished prior to issue of provisional acceptance of the equipment / installation.
- 11.10.0 The testing of all electrical equipment as well as the system as a whole shall be carried out at site to ensure that the equipment and its components are in satisfactory condition and shall successfully perform its functional operation. The inspection of the equipment shall be carried out to ensure that all materials, workmanship and installation conform to the accepted design, engineering and construction standards as well as accepted codes of practice.
- 11.11.0 All tests shall be carried out by the Contractor using his own instruments, testing equipment as well as qualified testing personnel.
- 11.12.0 The results of all tests shall conform to the specification requirements as well as any specific performance data guaranteed during finalization of the Contract.
- 11.13.0 At site, all equipment shall be energized only after certification by the personnel performing the test that the equipment is ready for energizing and with concurrence of the Owner.
- 11.14.0 The various commissioning checks / tests to be carried out shall be in accordance with applicable standards and equipment supplier's recommendation.
- 11.15.0 Site tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

- a. Cables
 - Check for physical damage.
 - Check for insulation resistance before and after termination/ jointing.
 - HT cables shall be pressure tested before commissioning.
 - Check of continuity of all cores of the cables.
 - Check for correctness of all connections as per relevant wiring diagrams.
 - Check for correct polarity and phasing of cable connections.
 - Check for proper earth connections for cable glands, cable boxes, cable armour, screens etc.
 - Check for provision of correct cable tags, core ferrules, and tightness of connections.
- b. Cable trays/ supports and accessories



- Check for proper galvanizing/ painting and identification number of the cable trays/ supports and accessories.
- Check for continuity of cable trays over the entire route.
- Check that all sharp corners, burrs, and waste materials have been removed from the trays supports.
- Check for earth continuity and earth connection of cable trays.

12.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Block diagram for cabling
- Typical details of cabling installation
- Details of cable trays and accessories
- Layout of IPB Busduct , Segregated phase Busduct layout and 415 V NSPB Busduct
- DG Room layout
- Transformer Yard Layout
- Electrical room equipment layout for Power house building
- Electrical equipment layout for ESP building
- Electrical room equipment layout for various auxiliary buildings
- Electrical room equipment layout for non-plant buildings
- Cable Trench layout for Transformer Yard
- Cable routing layout for power house building
- Cable routing layout for Boiler floors
- Cable routing layout for ESP
- Interplant Cable routing layout
- Cable routing layout for Main control building
- Cable routing layout for switchyard and switchyard control building
- Cable routing layout for DG building
- Cable routing layout for all electrical rooms & control rooms
- Cable Routing layout for all plant buildings
- Cable Routing layout for all non-plant buildings
- Cable Schedule for power cables, control cables and signal cables for all Switchgear, equipment and control panels
- Interconnection Schedule for all Switchgear, equipment and control panels
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan



SECTION-3.30: VARIABLE FREQUENCY DRIVE SYSTEMS (VFDS)

1.0.0 INTENT OF SPECIFICATION

This section covers the technical requirements of VFDS for various high voltage motors such as sea water outfall pumps and other LV motors.

2.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS/ICE standards including amendments, if any, except where modified and/or supplemented by this specification.

3.0.0 TECHNICAL REQUIREMENTS OF HIGH VOLTAGE VFDS

- 3.1.0 The VFD shall produce a variable voltage and variable frequency output to provide continuous operation over the application speed range. The VFD shall be capable of operating with the output short circuited at full current or with the output open circuited at rated voltage. VFD shall be capable of operating squirrel cage induction motor.
- 3.2.0 The drive system shall provide controlled speed over the range specified in '**Mechanical**' section. Speed accuracy within this range, expressed as a percent of top speed, shall be within 0.1% of base speed without encoder or pulse tachometer feedback.
- 3.3.0 A "heavy duty" rating shall be available with 100% continuous current with a short time duty rating of 150% overload for one minute, once every 10 minutes (suitable for constant torque loads). The VFD shall be capable of 100% breakaway torque without tachometer feedback. Breakaway torque with tachometer feedback shall be 150%.
- 3.4.0 The VFD shall utilize sensorless direct vector control or full vector control, with pulse tachometer feedback, for optimum performance.
- 3.5.0 The VFD shall provide near sinusoidal voltage and current waveforms to the motor at all speeds and loads. Output current THD shall be less than 5%.
- 3.6.0 Standard induction motors shall not require de-rating or upgraded turn-to-turn insulation and shall not require additional service factor. The motor insulation system shall not be compromised thermally or due to dv/dt stress. Dv/dt at the motor terminals (line-to-line) shall be limited to 10 volts per microsecond. If dv/dt at the motor terminals (line-to-line) exceeds 10 volts per microsecond.
- 3.7.0 The motor insulation system shall not be compromised due to excessive peak voltage of the output waveform. The VFD shall provide stable operation of the motor without compromising the motor insulation system, regardless of motor cable distance. If an output filter is required to mitigate reflected waves, or to meet any special requirements of the application, it must be integral to the VFD controller.
- 3.8.0 If output filters are used in the VFD, a selective harmonic elimination (SHE) switching technique must be available to eliminate a potential harmonic resonance in the operating speed range. VFD induced torque pulsations to the output shaft of the mechanical system shall be less than 1% to minimize the possibility of exciting a resonance.
- 3.9.0 For VFDs controlled HT motors, it shall be IE2 class as per IS 12615. VFD system efficiency shall be a minimum of 96% at 100% speed & 100% load. System efficiency shall include VFD, input transformer or line reactor, harmonic filter (if applicable) power factor correction unit (if



applicable), and output filter (if applicable). Control power supplies, control circuits, cooling fans or pumps, shall be included in all loss calculations.

- 3.10.0 The VFD shall be capable of riding through a loss of power of 5 cycles.
- 3.11.0 Maximum audible noise from the VFD or associated VFD system shall not exceed 85 dB (A).
- 3.12.0 The VFD shall be capable of maintaining a minimum true power factor (Displacement PF. X Distortion PF.) of .98 from 30-100% power. If the VFD vendor cannot meet the true power factor requirement, then a power factor correction unit shall be provided.
- 3.13.0 The VFD system shall be designed for a minimum availability of 99.9%. The VFD system shall be designed for a Mean Time Between Failures (MTBF) of 100,000 hours. The VFD system shall be designed for a minimum life expectancy of 25 years.
- 3.14.0 Fiber optic interface boards shall be used to provide gating and diagnostic feedback signals for power semiconductor devices. The diagnostic feedback system shall allow constant control of the device as well as constant monitoring of device health and temperature feedback.
- 3.15.0 The VFD shall be capable of automatically restarting in the event of a momentary loss of power, or a clearing of a drive trip. An automatic restart delay parameter shall be available in the drive with an adjustment range of 0 -10 seconds.
- 3.16.0 The VFD system shall be capable of operating with voltage sag of 30% on the input power line. (The motor shall not be allowed to reach a pull out condition.)
- 3.17.0 A continuous copper ground bus shall be provided along the entire length of the controller line-up.
- 3.18.0 A bypass starter shall be provided. A double power bus configuration shall be utilized in the bus compartment (one is the main power bus, the other is the variable frequency bus). In order to ensure maximum safety and to allow fully isolated service access to the VFD while on bypass, an output vacuum contactor, isolating switch, mechanical and electrical interlocking shall be included with the bypass starter
- 3.19.0 The VFD shall have the following minimum protection features:

At Input Source Side:

- 1. Under voltage (adjustable)
- 2. Over voltage (adjustable)
- 3. Instantaneous over current (adjustable)
- 4. Ground fault (adjustable)
- 5. Overload (adjustable)

On System Level:

- 6. Gate driver power supply under voltage
- 7. Control power over / under voltage and signals
- 8. Over temperature protection

At Output Motor Load Side:

- 9. Short circuit protection (instantaneous over current)
- 10. Overload (delayed over current)
- 11. Over voltage (adjustable)
- 12. Motor over speed (adjustable)

Motor Protection:

- a) Electronic motor overload protection.



- b) RTD relay for sensing actual motor temperature and drive shutdown.
- c) A motor stall protective function
- d) A multi-functional motor protection relay (MPR)
- e) Motor space heater control.

3.20.0 The VFD shall have a user-friendly operator interface terminal with the following minimum features:

- Large LCD display screens (minimum 16 line – 40 characters) that are easy to read and provide 'at a glance' indication of drive operating status
- User configurable bar type LCD metering for motor speed, load, torque, and voltage
- Elapsed time indication
- Extensive diagnostic functions that provide separate fault and warning queues in non-volatile memory that retain information under all conditions
- On-line help that provides enhanced fault text messages
- Trend buffers for at least 8 variables that allow one-shot or multi-shot trending
- Multi-level password access to ensure that only qualified personnel have access to critical parameters but still allow easy access to other levels of personnel
- Extended use of plain language messages to eliminate need to look up error codes or decipher the meaning of error messages
- Start-up wizard, including auto tuning, that is interactive and user-friendly

3.21.0 VFD shall be provided with digital communication capability to allow direct control and status communication with a PLC, SCADA or other control system. Communication modules for Remote I/O, DeviceNet, and ControlNet will be suitable for DIN rail mounting or communication board mounting

3.22.0 The VFD system shall be air-cooled, provided with a mixed flow cooling fan, mounted integral to the VFD enclosure. The VFD shall include air-flow pressure switches and temperature detectors to monitor proper operation of the air cooling system. If a fan fails, the system must generate alarm indication of the fan failure. Vane type air-flow switches are not acceptable. If required, provision shall be made for ducting VFD exhaust air outside the control room.

3.23.0 VFD enclosures for air-cooled VFDs shall be IP:31. Door vents shall consist of louver panel. Safety screens shall be located behind each louver panel. Cabinets and doors shall be fabricated using minimum 2.5 mm thick steel for sturdy construction. All doors shall be gasketed to provide environmental protection and secure fits. The converter cabinet door and cabling cabinet door shall be interlocked with up-stream isolators or breakers with a key lock. Interlocking shall be fully coordinated to prevent access to all medium voltage compartments.

3.24.0 The VFD shall be provided with Indoor, dry type rectifier duty transformer for input impedance devices. It shall have the following features:

- One (1) normally closed auto reset thermal switch per coil, wired in series to a terminal strip.
- Class H insulation, limiting temperature rise to F limits.
- HV and LV bus to ends.
- Delta primary with +/- 5% taps.
- Wye secondary winding (6 pulse or PWM rectifier).
- Three (3) secondary windings: One (1) Delta, two (2) extended Delta at Delta – 20 degrees and Delta +20 degrees (18 pulse).
- 5 to 8 percent impedance
- Fully insulated from phase to ground and neutral to ground.
- Fully insulated between secondary windings (18 pulse).
- Lifting eyes on core and coil assembly - complete unit.
- Removable jacking and lifting provisions on enclosure base assembly - complete unit.
- Tap changing via solid bus jumpers.
- Diagrammatic nameplate.
- Two (2) enclosure ground pads - 2 hole stainless steel.



- Base suitable for jacking, pulling and rolling.
- Ventilated indoor enclosure with cable entry/exit.
- The transformer shall be designed for continuous operation at its base kVA rating (natural cooling) without exceeding the temperature rise. The short time rating shall be adequately designed to deliver the power demanded by the drive without loss of insulation life.
- Forced cooled transformers are not allowed.

3.25.0 VFDS shall have the following functions and features:

- PWM control strategy
- Modular design of power cell
- Power cells connecting in series topology and wave stacking method;
- AVER (automatic voltage regulator) function of output voltage
- Torque boost function
- Rotating speed (fly) start function,
- Transient power loss function,
- Auto-start function
- Synchronizing switch function
- Power cell by-pass function
- Protection of overload and over-current
- Protection of open-phase
- Protection of over-voltage
- Overheat protection
- Current limited function
- Interlock protection of control power supply
- Two sets of control power hot standby for redundancy
- Power cell communicate with controller through optic fiber,
- System running in closed-loop,
- Multiple communication methods with host computer

4.0.0 TECHNICAL REQUIREMENTS OF LOW VOLTAGE VFDS

- 4.1.0 VFDS shall be rated for 415 V supply voltage. If isolation transformer is required at input, the same shall be provided.
- 4.2.0 VFDS shall be sized for the specific application with a design margin of atleast 10% over the motor rating. The drive shall be rated to operate at a design ambient of 50°C. It shall be ensured that harmonics are filtered and not reflected at source.
- 4.3.0 Variable speed drives shall be provided for better speed response, range ability, control stability and for ease of control, and smooth, efficient and optimum speed operation of the machine drives.
- 4.4.0 The drive shall be housed in sheet steel enclosure of IP-42 degree of protection. The unit shall be complete with ACB/MCCB at incomer, contactor, semiconductor fuses, meters, indication lamps, annunciations, protections, redundant cooling fans etc.
- 4.5.0 VFDS shall be at-least 12 Pulse type with active front end rectifiers with total harmonic current distortion limited to less than 4%.
- 4.6.0 For VFDs controlled LT motors, it shall be IE2 class as per IS 12615.
- 4.7.0 VFDS system shall have the following features:-
 - High input line-side power factor throughout the speed range.



- Low harmonics on the input line-side, with the total and individual harmonic contents not exceeding the limits established in IEEE-519.
- Low load side harmonics with near sinusoidal current in the drive circuit.
- Suitable for regenerative operation as may be required for the drive application.
- Input and output side choke
- Soft start and soft stop, with capability for bi-directional operation of the drive as may be required.
- Reduced shoot through faults.
- High starting torque as may be required for the drive application.
- Suitable for various drives operating with driven equipment having constant torque, constant power, or load torque varying with square or cube of speed.
- Faster response and have a wide speed range.
- Greater tolerance to load side drive machine parameter variations.
- Wide range of low frequency and super synchronous speed frequency range of operation as may be required.
- Low torque pulsations throughout the lowest & highest frequency range.
- Stability throughout the lowest and highest load range.
- Reduced voltage spikes inflicted on the motor / VFDS equipment that can occur during commutation.
- VFDS shall be capable of flying restart.
- VFDS shall have dynamic braking unit and resistor feature.
- By pass arrangement.

4.8.0 VFDS will comprise frequency converter having following features:

- Voltage or Current Source DC link Pulse Width Modulated (PWM) Converter configuration suitable for operation at automatically produced fixed ratio of Voltage / Frequency (V / F) throughout the complete speed range of the motor; and for operation in constant torque and constant power mode as appropriate. The converter will comprise line commutated power converter connected to AC mains either directly or by a suitably rated converter transformer.
- For the Voltage Source Inverter Configuration, the DC link voltage output by the power supply converter will be smoothened by an L-C circuit and the constant voltage output that will be fed to a forced commutated three phase inverter output system. The system will be complete with shunt capacitors selected to cater to the reactive power requirements of the motor.
- For the Current Source Inverter Configuration, the DC link voltage output by the power supply converter will be by a smoothing choke in series with the converter and the constant current output of the choke will be fed to a suitably commutated three phase inverter output system. The smoothing reactor will be sized to avoid conditions of discontinuous current operation of the converter at its lowest frequency of operation and will be uniformly insulated and protected against voltage surges that could occur during load throw-off.
- Provided with suitable input transformer if required to transform the input system network voltage to the optimal voltage of the converter and to reduce the short circuit capacity and to reduce 'line notching' that can occur during commutation. The Input transformer will have appropriate phase shifting multiple windings to eliminate the 5th & 7th harmonics and their multiples.
- Suitable regulating equipment that will be so designed as to enable the drive motor system to respond to load change with good dynamic accuracy, excellent speed holding accuracy and fine speed setting resolution. From the instrumentation control system, isolated 4-20 mA dc controller output signal will be made available as a set point for the speed controller in the regulation system. The system will include as part of the speed controller any transducer/ converter that may be required to interface with the above signal. Facility for signal measurement at important points in the regulating system will also be provided.



- Independently adjustable voltage boost for VFDS start up and operation at the lower end of the frequency.
 - Separately adjustable ramp up and ramp down time facilities.
 - Complete features for drive soft start and soft or extended stop as required with features required for bi-directional operation of the drive as may be required for the particular application.
 - Close loop control to keep output voltage unaffected by system voltage and load changes. Regulation of output voltage will not be more than plus 2% to minus 2% under steady state (zero to full load) and 8% under transient conditions.
 - Maximum drift in set frequency will be plus 1% to minus 1%.
 - All facilities as required for onsite adjustments of current limits, trip time, maximum frequency, minimum frequency, start compensation, voltage boost, slip compensation, accuracy rate, deceleration rate and others as required.
 - Comprehensive protection and fault display circuit including under / voltage (supply, over current, short circuit / earth fault due to inverter and / or motor fault , internal / external fault provisions for tripping unit. covering as a minimum Over current protection, fast acting short circuit & transient suppression circuits, Overload protection, Phase sequence monitoring and protection, Single phase protection, Mains & Internally generated Transient Over Voltage Protection, Under Voltage and mains supply failure protection, Control supply failure, IGBT fuse failure, Gate suppression for output circuit faults, Thermistor protection relay for protection of windings of motors greater than or equal to 75 kW, necessary di/dt & dv/dt protection, Device / Cubicle overheating protection, Ventilation failure, and any other protection as required for the type of scheme provided.
 - Where closed loop dynamic and fast speed response is required for drives, necessary multi loop control system will be provided complete with tachometers provided in the drive shaft.
- 4.9.0 The control system will consist of a multi loop system having two internal loops. One loop is for speed control and the other is for the control of current. Each loop will have its own controller, along with an acceleration ramp function, which sets the desired value of the speed in accordance with a linear ramp function and thus prevents sudden variation in the controller input.
- 4.10.0 The primary controlled variable will be speed which will be measured by means of a tachometer, which will be provided on the drive shaft and compared with the reference speed input. The error in speed will actuate a speed controller to establish the reference current input. This reference value will be subtracted from the actual current value and the error signal actuates the current controller, the output of this should be connected to the gate control unit, which controls the firing of the IGBT.
- 4.11.0 The inner current loop is made more active than the speed control loop. The speed and current controllers will be capable of accepting the form and type of feedback signal provided by the error detector and must provide at its output a signal of the proper type to operate the IGBT.
- 4.12.0 All necessary indication and monitoring equipment that will as a minimum include speed indicator for motors with a provision for repeat indication signal for use with DCS instrumentation system, speed reference, speed feedback, current reference, current feedback, regulated power supply voltages; voltmeter, ammeter, frequency, power factor meter, kW meter at mains input supply side, pulse output meter; voltmeter, ammeter, frequency, kW meter torque meter kW meter and speed indicator on the load side.
- 4.13.0 Audio visual Alarm annunciation (with visual and audio alarm acknowledge facilities) as required that will as a minimum include drive in monitoring mode, drive in regenerating mode, control electronic power supply, over temperature, motor over current, rectifier over current, motor overload, any other motor / converter faults.



- 4.14.0 Necessary Input and output Filters will be provided at appropriate locations to suppress harmonics at the input and the output of the VFDS converter system and to improve the input power factor.
- 4.15.0 The VFDS panel will be located indoors inside electrical rooms. The VFDS panel will have self-ventilating & cooling fans fed with power drawn from within the VFDS panel complete with fan motor starters including switch & HRC fuses, contactors & overload relays as per details given for MCC in the previous sections of this report.
- 4.16.0 VFDS unit will be controlled from following 3 different locations
- VFDS panel
 - Local Operator Panel or Local Control Station
 - DCS
- 4.17.0 Following minimum control facilities will be provided on each of the VFDS Panel and the Local Operator Panel:-
- Incoming switch and HRC fuses.
 - Start / Stop PBs to switch ON / OFF of the drive.
 - All necessary contactors and switch with HRC fuses or current limiting circuit breakers for the drive control and protection along with overload protection.
 - Raise / Lower PBs for speed variation of the drive.
 - Auto / Manual Selector Switch for selection of the mode of operation.
- 4.18.0 In Auto mode, frequency will be controlled from the instrument control PLC / DCS system by a 4 to 20 mA signal. For ON / OFF control of the motor in the Auto mode, 4-20 mA interlock signal from instrumentation PLC system will be wired to the VFDS panel.
- 4.19.0 In the Manual mode, the Selector Switch will be provided to select the motor control either from VFDS Panel or from the field.
- Drive Ready Indication and
 - Speed Indicator
 - DCS interface covering :-
 - Wiring of 4-20 mA signal input from DCS/PLC for speed variation.
 - Wiring of DCS / OFF input signal / contact for motor Start / Stop.
 - Wiring of 4-20 mA signal output to DCS/PLC for speed indication.
 - Wiring of contacts to remote for Drive Ready Indication

5.0.0 PAINTING

Painting shall be carried out by approved process. After preparation of the under surface the equipment shall be painted with epoxy based paint by powder coating. The final thickness of paint film on steel shall not be less than 85 microns. Final shade shall be RAL-7035.

6.0.0 TESTS

All the equipment supplied shall be of type tested quality. Type test reports shall be submitted for each voltage class and current rating.



7.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Technical data sheet
- General arrangement and section drawing
- Single line diagram & Schematic wiring diagrams
- Metering and protection drawing
- Foundation Plan & loading details
- VFDS sizing calculation
- Test reports
- Manufacturing quality plan



SECTION-3.31: ESP ELECTRICAL EQUIPMENT

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of various Electrical equipment of Electro static precipitator (ESP).

2.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant Indian Standards, and IEC publications and any other standards, if any, except where modified and /or supplemented by this specification.

3.0.0 TECHNICAL REQUIREMENTS

3.1.0 Technical requirements of ESP Electrical equipment like motors, cables, power control centre, motor control centre, control panels, motors, actuators, power and control cables, cable trays, tray supports and accessories, cabling materials, earthing and lightning protection, illumination system, etc., which are not covered in the following clauses, shall be as per previous sections.

3.2.0 HV rectifier transformers for electrostatic precipitator

3.2.1 For each section of the ESP field, Silicone oil filled, free standing transformer rectifier set shall be provided. The sets shall be suitable for outdoor installation and shall be mounted on top of precipitator.

3.2.2 It shall be complete with HV disconnecter, ground switch, Single Phase high voltage transformer, A full wave rectifier bridge, HF choke for surge protection, Current limiting reactor to limit the short circuit current, Resistor Column for measuring & feedback etc.

3.2.3 Transformer and rectifier shall be sized with 10% design margin.

3.2.4 The temperature rise of top oil (by thermometer method) shall not exceed 50°C over an ambient temperature of 50°C and Temperature rise of winding (by resistance method) shall not exceed 55°C over an ambient temperature of 50°C. Hot spot temperature based on maximum yearly weighted average temperature shall not exceed 98°C.

3.2.5 The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that at 110 per cent continuous over-voltage condition it does not exceed 1.9 Tesla.

3.2.6 The transformers shall withstand, without injurious heating 125% over fluxing for a period of one (1) minute and 140% over fluxing for a period of five (5) seconds. (Over fluxing caused by combined voltage and frequency fluctuations).

3.2.7 The noise level of transformer, when energized at normal voltage and frequency shall not exceed, when measured under standard conditions, the values specified in NEMA standard publication TR-1.

3.2.8 Transformer rectifier equipment shall be fitted with the following as a minimum:

- HV –ve terminal



- HV +ve terminal
- HV resistor terminal
- Shunt terminals
- LV input terminals
- LV input measurement terminal
- Inspection covers
- Oil gauge
- Drain plug
- Oil conservator
- De-hydrating breather
- Thermometer pocket
- Jacking lugs
- Oil temperature indicator
- Rollers
- Filter valve
- Buchholz relay
- Pressure relief vent
- Marshaling box
- Sampling valve
- Combined rating & diagram plate
- Lifting lugs
- Earthing terminal

- 3.2.9 Transformer shall have electrostatic shielding between primary and secondary windings and shall have suitable shielding of the high voltage coil to accomplish proper voltage division in the transformer when unit is subjected to surge conditions encountered in electrostatic fly ash precipitator application.
- 3.2.10 Each output leg of each transformer-rectifier set shall serve one bus section and both bus sections served by each transformer-rectifier set shall be in the same field.
- 3.2.11 Transformer rectifier assemblies shall be mounted in a heavy gauge welded steel tank designed for full vacuum. Unit shall be adequately sealed to prevent contamination of insulation and cooling medium.
- 3.2.12 At roof level the transformers shall be suitably covered or shall be suitably mounted inside a pent house.
- 3.2.13 High voltage bus runs shall be adequately supported and protected by ducts. An opening with gasketed cover shall be provided at the transformer rectifier high voltage terminals for grounding these terminals during inspection and maintenance. Facility for clearly seeing the grounding switch contacts at the high voltage terminals before removing the cover shall be provided.
- 3.2.14 Oil & Winding temperature indication shall be provided at local and remote.
- 3.2.15 Transformer shall also conform to the requirements specified in Section-3.4, wherever applicable.

3.3.0 ESP Controller

- 3.3.1 Controller unit feeding regulated input to the transformer rectifier equipment shall be solid state thyristor type microprocessor based complete with the following:
- A pair of thyristors in anti-parallel connection



- Automatic voltage control system.
- Protection equipment
- Over load Protection
- Under voltage protection
- Metering devices
- Fault annunciation system

3.3.2 The transformer rectifier sets and their automatic controls shall be designed for high reliability and suitability under transient sparking conditions and occasional short circuit load. They shall be provided with protection against surge, excess temperature rise and under voltage. Arrangement of the rectifier units shall be such as to take any one unit off the system without affecting the operation of the precipitator.

3.3.3 Separate control panels for T/R controls, rapping mechanism, hopper heaters and insulator heating and pressurization system (if applicable) shall be provided for each stream of the precipitator. Each control panel shall be fully wired, free standing and ready for installation and shall consist of necessary relays, contactors, master controllers, timers, switches, indicating lamps etc. Master controllers and timers shall be designed to control the sequence and frequency of operation of rapping mechanism of the collecting and discharge electrodes of the different fields of the precipitators. Signal lamps shall indicate overload tripping of the rapping motors.

3.3.4 The control cubicles shall incorporate all protections required for the safe operation of the equipment/works under the scope of this specification. Provision shall be made for a disconnect switch or circuit breaker for deenergising the cubicle. Control cubicles shall be provided with instruments to indicate A.C. input current and voltage and D.C output current and voltage.

3.4.0 ESP Insulators

3.4.1 High voltage insulator shall be located outside the gas stream, suitably housed in the insulator compartments to facilitate maintenance when the precipitators are on load. Each insulator compartment shall be provided with insulator heaters or hot air ventilation system to avoid moisture condensation on insulators. In case of hot air system, it shall include fans, air filters, heaters etc. The insulator compartment shall be provided with thermal insulation. The compartment shall be designed such as to prevent ingress of flue gas into compartments.

3.4.2 Insulators for supporting emitting frame and roof bushing shall be of porcelain suitable for long life, in ESP internal environment (highly polluted with flue gas temperature of 200 °C and going upto 300 °C for 5 minutes). Rated voltage for the insulators shall be such that AC rms one minute dry power frequency withstand voltage shall be 1.5 times the DC maximum operating voltage as per relevant IS.

3.5.0 ESP earthing shielding

A complete earthing system of loop type with double path to the ground for all equipment shall be furnished. Each casing shall be provided with two earthing pads located diagonally opposite corners of each casing. The pad surface shall be tinned, drilled and tapped to accept terminal connectors.

Manual safety grounds and switches shall be furnished so that individual pieces of equipment may be earthed while being serviced. All access doors, gas distribution baffles or perforated plates located in the inlet or outlet nozzles of the precipitator shall have ground straps connected to the precipitator casing.



3.6.0 Safety Interlocks

- 3.6.1 HV connections shall be provided with isolator and earthing switches operable from outside the HV enclosure. Provision shall be there to connect portable earthing to HV grid prior to personnel attending. All access points shall be closed and keys thus inserted in the exchange base before HV supply can be restored.
- 3.6.2 A full proof manual key sequence type interlock system for the safety of operating personnel from contacting energised high voltage equipment shall be provided. Key interlocks shall be provided such that for a particular ESP casing any TR set cannot be energised until all insulator housing compartments, disconnect switch boxes, casing inspection doors are locked and emitting and collecting electrode rapping motors are prevented from energisation. It shall also prevent opening of any inspection door unless all TR sets of that stream are de-energised and all HV disconnect switches are opened to earthed position.
- 3.6.3 Rapping motors operation shall be prevented under this condition unless interlock is specifically defeated for testing.
- 3.6.4 Key interlock system shall be simple, robust, weather proof construction suitable for outdoor mounting.

3.7.0 ESP Control system

- 3.7.1 The control system shall be designed for automatic and manual local/ remote operation. ESPs serving one boiler shall be provided with a complete control system consisting of microprocessor based Electrostatic Precipitator Management System (EPMS), TR set controllers, rapper controllers, communication controllers, hopper heater controls, insulator heaters and pressurization system controls and all other controls required for safe, efficient and reliable operation.
- 3.7.2 The EPMS shall be connected to the Transformer Rectifier Set Controllers (TRC) and Rapper Controllers (RPC) through duplicate data highway. However, any other standard, proven system of communication through balanced current loop is also acceptable. EPMS shall accept the feedback analog signals like Boiler Load Index and Output from opacity monitors process these signals and issue control parameters to the TR Controllers and Rapper Controllers. It shall also control, monitor and display the status of each stream i.e. status of TR Controllers, Rapper Controllers, hopper heaters, hopper levels, insulator heaters/ pressurization air blowers etc.
- 3.7.3 The EPMS shall include, but not be limited to, the following features :
 - a) A PC based master controller with non-volatile memory and report storage capabilities for a period of 6 months.
 - b) TR set controllers and Rapper Controllers.
 - c) High resolution 24" colour CRT.
 - d) Communication ports and protocol for data transfer between EPMS Master control unit and the TRC/ RPC/ other controllers.
 - e) Keyboard for operator interface.
 - f) Color inkjet printer for alarms and reports
 - g) Facility for Auto operation of ESP with Energy Management



- h) Necessary Input/ Output points for interfacing with DCS.
- i) Self surveillance and self-diagnostic features.

3.7.4 The EPMS display unit shall display at least the following :

- a) A summary of the status of all the controllers.
- b) A summary of the readings of all the TR sets.
- c) A summary about each TRC i.e., settings, limits, voltage and current readings, alarms and the controller status.
- d) A summary of each RPC i.e. controller status, rapping frequency, alarms and indication of the rapper being operated.
- e) Status reading Energy Management System such as charge ratio of each field etc.
- f) Necessary alarms as decided during detail engineering stage.
- g) Status of hopper level, hopper heaters and insulator heater/blower
- h) ESP TR set power supply status and alarm
- i) Potential free contact for ESP trouble shooting etc. as required shall be provided.

3.7.5 The control system shall be preferably shall be of plant DCS family.

3.7.6 mA output from the opacity monitors available in the individual paths of ESP shall be used as feedback for adjusting the ESP currents.

3.7.7 Complete ESP Control and Monitoring shall be done from Central control room thru suitable OPC connectivity between EPMS and respective Unit DCS.

3.7.8 Energy consumed by individual paths of ESP shall be indicated in the monitor.

3.7.9 Additional One no OWS and EWS shall be provided for each ESP control room with 132 column dot matrix printer and One no A4 Laser printer along with modular furniture.

3.7.10 ESP hopper level shall be indicated.

3.7.11 Transformer Rectifier Set Controllers

Each Transformer rectifier set shall be provided with a separate microprocessor based controller (TRC) for regulation and control of the electric power input to electrostatic precipitator fields. It shall be designed for minimum charge ratio of 1:99. It shall automatically optimise the charge ratio and maintain the spark rate at a suitable level for variations of gas temperature, dust composition, gas flow etc. It shall regulate the rectifier in such a way, that the current through the electrostatic precipitator is corrected as the conditions for sparking are changed. It shall be able to monitor filter functioning and shall give an alarm when values are lower or higher than preset values. It shall automatically regulate the charge ratio of each field/ TR set based on V-I characteristics of the respective electrical fields. It shall have alternative arrangement of optimising the charge ratio based on Opacity Monitor signal also. The controller shall have proven noise immunity and shall be suitable for ESP application. It shall be capable of maintaining the optimum voltage and current in ESP under all regimes of boiler operation.

The system shall have the following minimum features:

- a) Display unit for all the operating values like field DC voltages and currents, Spark rate, Semi pulse current limit, Voltage low limit, Charge ratio, All other adjustable parameters

and limits

- b) Keys for operator interface and potentiometers local control and adjustments.
- c) Serial communication with protocol for communicating to EPMS.
- d) Local/ Remote selection.
- e) Spark counter.
- f) Alarms for TR set oil level low, TR set temperature high, AC current high, Low DC voltage, High DC voltage, Back corona, Management command failure, TR set buchholz / PRV trip, TR set buchholz alarm.

3.7.12 Rapper Controller (RPC)

Each stream of ESP shall be provided with a separate, microprocessor based Rapper Controller (RPC). However, any other proven standard design of rapper controller integral to TR set controller is also acceptable. It shall have proven noise immunity and shall be suitable for ESP application. It shall control the sequence and frequency of operation of the rapping mechanisms of collecting and discharge electrodes of the different fields of the precipitator. The unit shall control and survey the operation of rappers in the ESP. It shall start and stop the rappers as programmed and shall give an alarm if a rapper fails. It shall be possible to start or stop manually each rapper, without interfering with the other rappers from the controller. The operation status of each rapper shall be indicated with LEDs on the rapper controller panel.

It shall be possible to change the three timings (viz. start time, repetition time and run time), intensity (if applicable) and frequency of rapping independently for each rapper, without need for opening the panel or any alternation in programme. The range of rapping frequency available shall be upto 24 hrs. Additionally, the rapper controller shall have at least 50 no. pre-programme sequences of rapping stored in its memory so that the operator can select any of them according to his judgment or the controller itself can choose them based on feedback from boiler load.

In case one separate rapper controller is provided for each stream, one standby working rapper controller shall be provided so that in case of failure of any one of the working rapper controllers, the standby controller shall immediately and automatically take over the control functions of this rapping without affecting the operation of ESP.

The system shall have the following minimum features :

- a) Display of all adjustable parameters, rapping modes, time settings and intensity of rapper/group and rapper status, rapper alarm and controller alarms.
- b) Key board for operator interface.
- c) Local/ remote selection: In local mode all commands and adjustments shall be from RPC. In remote mode all commands and adjustments shall be from EPMS.
- d) Communication port with protocol for communicating with EPMS.
- e) Remote on/ off capability from EPMS.
- f) The controller address (field programmable), logic programmes and other adjustable parameters shall be stored in non-volatile memory and shall not be affected by power loss.



4.0.0 TESTS

Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. For the various bought out item test certificates from equipment manufacturer shall be furnished. Routine tests shall be carried out for all the equipment as per applicable standards.

5.0.0 DOCUMENTATION

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Technical data sheet
- General arrangement and section drawing
- Single line diagram & Schematic wiring diagrams
- Sizing calculation
- Equipment layout
- Test reports
- Manufacturing quality plan

**SECTION-3.32: ELECTRICAL LAB EQUIPMENT****1.0.0 INTENT OF SPECIFICATION**

This section covers the requirements of electrical lab equipment. The scope of work shall include supply, installation, testing and commissioning of the below mentioned equipment:

2.0.0 TECHNICAL REQUIREMENTS

2.1.0 The test instrument / kits shall be of latest version with necessary calibration certificate.

2.2.0 List of equipment shall include the following. Make and technical parameters of equipment shall be subject to Owner's approval. Brochures of offered equipment shall be submitted for approval during detail engineering.

Sl. No.	Name of the Test Equipment	Quantity	Make	Model
1)	Numerical relay test set for generator protection	1	OMICRON	CMC 256 Plus
2)	Portable 5 kV digital automatic insulation tester	2	METREL & MEGGER	Metrel MI2077 Megger MIT520
3)	Portable HV decade resistance box	1	SYSTEMS	DRB701
4)	Portable HV AC test set	1	MEGGER	681100
5)	Automatic capacitance and tan-delta test set with oil resistivity test cell	1	MEGGER / DOBLE	Delta 2000 / M4100
6)	Portable transformer oil break down test set	1	MEGGER	OTS100 AF/2
7)	Portable karl-fischer test set	1	MEGGER	KF875
8)	3-phase portable transformer turns ratio and vector group meter	1	MEGGER	TTR550503
9)	Portable digital DC resistance meter	1	MEGGER	Transformer Ohm meter
10)	Portable high current digital micro ohm meter	1	MEGGER	DLRO600
11)	Portable primary & secondary current injection test kit with control & loading units	1	MEGGER (Py. Injection) ISA (Sy. Injection)	INGVAR – BH-72490 TD1000 plus
12)	Portable three phase universal protective relay test set	1	ISA	DRTS-66
13)	Precision digital multimeter - various	10	FLUKE / KYORITSU / AGILENT	189S / KEW1062 / U1252A
14)	Portable digital frequency meter	1	ISA	CSP/21-FH
15)	Digital sound level meter	1	EXTECH	407750
16)	Digital tachometer	1	EXTECH	RPM10
17)	Portable cable fault locator	1	TINSLEY	5762N



Sl. No.	Name of the Test Equipment	Quantity	Make	Model
18)	Portable hand held SF6 gas leakage detector	1		
19)	Portable hand held hydrogen gas leakage detector	1		
20)	Portable vacuum tester	1		
21)	Portable light intensity meter	1	KYORITSU	5202
22)	Portable circuit breaker motion analyzer & timer	1	ISA	CBA 2000
23)	Portable Generator on-line partial discharge real time monitoring system	2	OMICRON / DOBLE	
24)	Interfacial tension meter for transformer oil	1		
25)	Portable hand held thermal imaging camera	1	FLUKE	TIR4-FT
26)	Portable high voltage / live line detector	2	MEGGER	DETEX
27)	Tong tester – various	10	KYORITSU	KEW 2009R / 2004 /2608A.
28)	Portable phase sequence / continuity indicator	3	MEGGER / KYORITSU	8031F
29)	Relay tool kit	2	MEGGER	K500
30)	HV discharge rod and portable earthing equipment	2		
31)	Hot sticks (live / dead line tester)	2	MTEKPRO / MOTWANE	BEIMCO /HV50
32)	Analog multimeter	3	MEGGER	8mark7
33)	AC clamp adaptor	2	KYORITSU	8112
34)	Bench type digital multimeter	2	FLUKE	8808A
35)	Milliamp process clamp meter	2	FLUKE	771
36)	Earth resistance tester	1	MEGGER	DET5/4
37)	1 phase & 3 phase Variac – various ratings	6	Reputed make	
38)	Rheostats & phantom loads – various ratings	10	TOSNIVAL / AGRANIC	
39)	Sweep frequency response analyzer for transformers	1	DOBLE	M5300
40)	Natural frequency test set for generators and transformers	1		
41)	Elcid test set	1		
42)	Scope meter	3	EZ-Digital-USA / FLUKE	DS-1250 / 199C
43)	Function generator	1	AGILENT	81150 A
44)	Multi-function calibrator	2	FLUKE / Practical Instruments	726 / 820



Sl. No.	Name of the Test Equipment	Quantity	Make	Model
			Electronics(USA)	
45)	Power quality analyzer	2	KYORITSU / MEGGER	KEW6310 / PA9plus
46)	CT-PT analyzers	3	ISA	T3000
47)	Hand held Infra-red temperature and humidity indicator	2	KYORITSU / FLUKE /FLUKE	5500 (IRT) / 576 (IRT)/ 971 (RH)
48)	Motor test set	3	EMC Elektronik	EMC-38
49)	Surge comparison tester	1	JABBALS	5015KHP

2.3.0 Test / Lab instruments shall be suitable for working on the following aux power supply with $\pm 10\%$ voltage variation, $\pm 5\%$ frequency variation and 10% combined voltage & frequency variation.

- 3 phase 415 V (4 Wire)
- 1 phase 240 V
- 220 V DC, 2 wire

2.4.0 Power supply shall be made available at power socket for each equipment by the Contractor.

2.5.0 Electrical Laboratory shall be provided in the service building and a separate room for lab in charge shall be provided. The following items shall also be provided in the laboratory.

- a) Required test benches
- b) Cupboard - 5 Nos
- c) Required Tables & Chairs
- d) Personal computer with furniture
- e) A3 size Black & white laser printer with furniture



SECTION –3.33: CONSTRUCTION POWER

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of construction power supply system.

2.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the applicable Indian Standards of latest edition including amendments, except where modified and /or supplemented by this specification.

3.0.0 TECHNICAL REQUIREMENTS

- 3.1.0 TANGEDCO will provide power supply for construction power at one location, near plant boundary, on chargeable basis at commercial tariff rate. HT tariff VI commercial as per TNERC norms will be levied as per the usage. Further caution deposit and statutory levies as per TNERC / TANGEDCO will be applicable.
- 3.2.0 The power at 33 kV level shall be terminated at pole. The contractor shall receive the same and establish 33 kV Construction Power Substation and distribute 33 kV supply to various distribution substations in the plant and further step down to 415 V supply to provide construction power for various locations.
- 3.3.0 The Owner may not be able to guarantee on the reliability of the power supply and it is the responsibility of the contractor to make alternative arrangement during not availability of power supply. The Owner shall not be responsible for the delay in the project execution due to non-availability of power supply.
- 3.4.0 After commissioning the permanent power supply, the same shall not be used for construction power supply requirements
- 3.5.0 The scope of work shall include supply, installation, testing and commissioning of the following items.
- a) 33 kV overhead line ring main
 - b) Required 33/0.433 kV distribution transformers distributed at various locations
 - c) 415 V power distribution boards
 - d) 33 kV double pole structure complete with switch, fuse, lightning arrester, insulators and hardware, clamps & connectors, ACSR conductors, spacers, shield wires, etc.
 - e) Metering kiosk
 - f) Capacitor banks
 - g) 33 kV Cables and terminations
 - h) LT power cables and control cables.
 - i) Illumination system including lighting panels, poles, masts, lighting fixtures & accessories.
 - j) Below ground earth mat, equipment earthing & lightning protection.
 - k) Cable glands and lugs for all the cables.
 - l) Miscellaneous items like danger boards, caution boards, rubber mats, fire buckets, etc.
 - m) Any other equipment/item as required



- 3.6.0 The Substation equipment shall be suitable for outdoor application having saline atmosphere and shall have tropical and fungicidal treatment. Electrical equipment selection and derating shall be based on ambient temperature of 50 deg. C and relative humidity of 95% maximum.
- 3.7.0 33 kV system shall be designed considering the following design parameters.
- | | | |
|-------------------------------------|---|--------------------|
| ▪ Nominal system voltage | : | 33 kV (rms), 50 Hz |
| ▪ Highest system voltage | : | 36 kV (rms), 50 Hz |
| ▪ Basic impulse level | : | 170 kV peak |
| ▪ Power frequency withstand voltage | : | 70 kV |
| ▪ Short time current and duration | : | 25 kA for 3 sec. |
| ▪ Dynamic rating | : | 63 kAp |
| ▪ Creepage distance | : | 31 mm /kV |
- 3.8.0 For the overhead 33 kV connection, ACSR conductor shall be provided. Insulator shall be made of hard porcelain. For tension locations where the line is sectionalized, disc type of insulators shall be used, while on tangent locations pin type insulators are used. The insulators shall be glazed and finished in brown colour.
- 3.9.0 33 kV load break switches shall be provided conforming to relevant IS. The Switch shall have triple pole construction suitable for assembling with light weight insulators made of high alumina body and for vertical mounting
- 3.10.0 Lightning arrester shall be 30 kV class, heavy rating, gapless, metal (zinc) oxide surge arrestors complete along with clamps, complete fitting and accessories for installation on outdoor type 33 kV transmission lines & transformers.
- 3.11.0 A separate metering kiosk shall be provided to locate tariff meters of TANGEDCO.
- 3.12.0 Transformers shall be suitable for outdoor installation in a hot, saline, humid and tropical climate. The transformers shall be capable of operating continuously at its rated output without exceeding the specified temperature limits.
- 3.13.0 415 V switchgear shall be indoor, single front, metal-clad, floor mounted, fully draw-out with ACB breaker as incomer fed from distribution transformer and MCCB breaker as outgoing feeders.
- 3.14.0 At all road crossings overhead lines shall be avoided and cables shall be provided.
- 3.15.0 33 kV cables shall be earthed grade armoured type conforming to IS: 7098 Part-II.
- 3.16.0 LV Power cables shall be of 1.1 kV grade, XLPE insulated, armoured type conforming to IS: 7098 Part-I.
- 3.17.0 Control cables shall be of 1.1 kV grade, XLPE/PVC insulated, armoured type with copper conductor conforming to IS: 1554 Part-I.
- 3.18.0 Earthing system of substation shall conform to IS: 3043. Neutral of each LT transformer shall be solidly grounded through 2 nos. treated earth pits.
- 3.19.0 Lightning protection shall be provided by shield wires including connections, earth pits etc. as per IS: 2309.
- 3.20.0 Capacitor bank shall be provided improve power factor.
- 3.21.0 Contractor shall submit drawings (layout and single line diagram) for construction power supply arrangement for approval.
- 3.22.0 It shall be the Contractor's responsibility to obtain approval from local statutory authorities including Electrical Inspector for the power supply arrangement.



Tamil Nadu Generation and Distribution Corporation Ltd.

2 X 660 MW Udangudi Supercritical Thermal Power Project – Stage-1

TENDER ENQUIRY DOCUMENT FOR EPC CONTRACT

[BID SPECIFICATION NO. SE/C/UP/EE/E/OT NO. 01/2015-16]

VOLUME - II SECTION - 4 DETAILED TECHNICAL SPECIFICATION – CONTROL & INSTRUMENTATION

FICHTNER Consulting Engineers (India) Private Limited
Chennai, India



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VOLUME - II
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INTRODUCTION

This section sets out the scope of supply, services and design/technical requirements of instrumentation and control equipment. Instrumentation and control systems specified here are only basic and minimum, detailed design shall be carried out by the bidder for safe, reliable, efficient, automatic operation of the Udangudi Supercritical Thermal Power Project. Any items not included hereunder but specified elsewhere in this specification shall also be included. The type and make of I & C equipment shall be proven in similar power projects and shall be approved by the Owner. Measurement and control equipment offered shall be complete in all respects and any equipment / accessories not explicitly indicated in this specification, but considered essential for proper functioning of equipment and process shall be included in the Bidder's scope of supply and work. If the Bidder proposes or supplies any additional plant/equipment, all corresponding instrumentation and control equipment shall be included in his scope, along with all necessary special tools and product specific configuring and diagnostic devices.



VOLUME - II
SUB-SECTION - 4.2
SCOPE OF SUPPLY AND SERVICES

1.0.0 SCOPE OF SUPPLY

- 1.1.0 The following I&C systems shall be supplied, installed, commissioned and tested for successful and satisfactory operation of the proposed thermal power project. The proposed system shall be in successful trouble free operation for at least 3 years as on bid date opening in plant capacity of 500MW or more having pulverized coal facility
- 1.1.1 SG integral controls shall be provided with the state of Art microprocessor based control & protection system. SG integral controls shall include Burner Management System, Boiler Protection System, Soot blower system, Secondary Air Damper Controls & Gravimetric feeder controls. The System shall be completely redundant for CPUs, I/Os, Communication & Power supply. For the protection system, it shall be configured in Triple modular redundancy philosophy. All hardware, software, diagnostic features and field sensors/instruments/erection hardware and other accessories required to complete the system. It is preferred that SG Control system shall be seamlessly integrated with plant DCS utilizing same family of hardware's. Alternatively SG Integral proprietary control system is provided, the same shall be linked to plant DCS through redundant OPC based Ethernet serial links. In which case Two (2) no 24" LED type /keyboard operator stations and One (1) no. 24" LED type/keyboard Engineering work station with dedicated printers for SG integral controls of each unit shall be provided at Central control room connected to the proprietary control system
- 1.1.2 TG integral controls shall be provided with the state of Art microprocessor based control & protection system. TG integral shall include (Automatic turbine run up system, Electro hydraulic governing system, Turbine protection system, Turbine stress Evaluator, Turbo supervisory instrumentation and Automatic turbine testing system). The System shall be completely redundant for CPUs, I/Os, Communication & Power supply. For the protection system, it shall be configured in Triple modular redundancy philosophy. All hardware, software, diagnostic features and field sensors/instruments/erection hardware and other accessories required to complete the system. It is preferred that TG Control system shall be seamlessly integrated with plant DCS utilizing same family of hardware's. Alternatively TG Integral proprietary control system is provided, the same shall be linked to plant DCS through redundant OPC based Ethernet serial links. In which case Two (2) no 24" LED type /keyboard operator stations and One (1) no. 24" LED type/keyboard Engineering work station with dedicated printers for TG integral controls of each unit shall be provided at Central control room connected to the proprietary control system.
- 1.1.3 It is proposed to have a common Central control room for both the 660 MW units with the DCS envisaged for 660 MW units. And BOP shall be from similar family of electronic modules of Unit DCS so as to minimize the spares management and easing the maintenance activities. The BOP systems including the Coal handling plant are controlled and monitored from the local control room with the DCS Remote I/O unit & the dedicated controller for each of the respective BOP systems.
- 1.1.4 Control of the BOP will be through the DCS with remote IO units & the dedicated controller and the bidder shall refer to the Table in sub-Section 4.5 – Plant Control Philosophy.
- 1.1.5 Back up Panel
- In addition to the OWS (operator work station) and LVS (large video screen), minimum amount of conventional hardwired pushbutton stations and indicators shall be provided in the back up panel with mosaic and vertical type (not L type) for the safe shutdown of the



unit. No full back up discrete hardwired based control or hardwired manual operation is envisaged in the 660 MW unit control room for main plant. Back up panel system shall be designed for handling the situation in Section 4.5, Clause 1.4.0 (k)

1.1.6 The microprocessor based plant DCS system comprising the following and as depicted in the Plant Control system configuration drawing.

- a) Redundant Process controllers for Units and Common
- b) Input / Output units with redundant communication links with process controllers for Units and Common
- c) Six (6) 24" LED type / Keyboard / Mouse based Operator stations for each Unit
- d) Two (2) 24" LED type / Keyboard / Mouse based Operator stations for Common
- e) Two (2) 24" LED type / Keyboard / Mouse based Operator station for Unit supervisor
- f) One (1) 24" LED type / Keyboard / Mouse based Operator station for Station Supervisor
- g) One no. of redundant Historical Data Storage & Retrieval system shall be provided with 24" LED type, Qwerty Keyboard and mouse and shall be of Raid 5 configuration for each Unit
- h) One no. of redundant Historical Data Storage & Retrieval system shall be provided with 24" LED type, Qwerty Keyboard and mouse and shall be of Raid 5 configuration for Common
- i) Printers (1 lot) as per the plant control system configuration drawing No. 00-1115112-I-350 Rev 0
- j) Redundant DCS Data bus system. Independent redundant Bus system for each unit and common connected to each other through redundant network bridges
- k) Two (2) 24" LED type / Keyboard / Mouse based Engineering station with printer for each unit.
- l) Three (3) 24" LED type / Keyboard / Mouse based Engineering station with printer for the Common and BOP Systems. Engineering station shall be capable of engineering all the BOP systems connected through Remote I/O units and the dedicated controller. In case, if engineering is not possible from this Engineering station, 1 No. independent Engineering station shall be supplied in addition to the Operator station of the respective BOP systems in the local control room.
- m) Six (6) nos large screen display (84") complete with control station and other hardware at control room for Unit.
- n) Two (2) no large screen display (84") complete with control station and other hardware at control room for Common.
- o) Hardware for remote diagnostic support
- p) One (1) no. Performance Analysis Diagnostics & Optimization Redundant Server with three (3) number of user station of 24" LED type / Keyboard / Mouse.
- q) One (1) 24" LED type / Keyboard / Mouse based Management information station Redundant server with application software for station wide.



- r) One (1) 24" LED type / Keyboard / Mouse based Operator station for common supervisor.
- s) Plant wide office LAN comprising of 450 users at various location of plant and installation of 300 PCs with 21" LED display units, keyboard/ mouse etc., in the network.
- t) Management Information System comprising of 50 PC's with 24" LED display units, keyboard/ mouse, necessary software for viewing process related information and mimics, real time parameter trends, history values etc.,
- u) One (1) HART Management station with 24" LED type / Keyboard / Mouse and Laptop PC with application software for the whole plant.
- v) DCS cabinets with all the hardware and interface equipments
- w) SOE system
- x) Marshalling & Interposing relay cabinets (Bidder to note that, all the field cables should be terminated at marshaling cabinet only and it should not be directly terminated at the I/O module).
- y) All system and application software with licenses
- z) Specified communication links / interfaces with other control/monitoring systems
- aa) Control panel to house emergency back up console.
- bb) Control Room desk and furniture.
- cc) Simulator with accessories one set with furniture.
- dd) 1 no. of Operating Station at CE's room, 1 no. of Operating Stations at Factory manager, and 1 no. of Operating Stations at Electrical System incharge room shall be provided, operation/ command shall not be executed from these three consoles to start/stop the equipments. Software and hardware security lock shall be provided not to use these controls for any operations. 1 No. A3 sized Scanner copier cum printer in CE's Chamber/Office and 1 LJP A4 Color with each Operating station shall be provided.

In-plant coal handling system shall be controlled and monitored from the CHP local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link, all hardware, software, other interfaces, cables and field sensors/instruments/erection hardware/furniture envisaged to control and monitor it.

In plant coal handling local control room shall be provided with Two (2) no. 24" LED type Operator station and CHP Mimic panel for control and monitoring the CHP locally in addition to remote monitoring from the central control room in the main plant DCS.

One (1) no. A3 color printer in addition to one (1) no. A4 laser B/W printer shall be provided in the local control room for the operator station.

Operator station in the CHP local control room shall be provided with the access to monitor the main plant operations.

CHP mimic panel with hard wired push button for back panel operation. Two No. large screen display (84") complete with control station and other hardware at CHP control room for controlling & monitoring coal handling system.



Operator station shall be provided at local control room for control and monitoring of each Wagon tippler system & stacker reclaimer locally in addition to remote operation from CHP local control room.

Microprocessor based system for Belt Weigher system, metal detector system, coal sampling unit & compressed air system.

Local control panels for the Dust suppression system, dust extraction system, bunker ventilation system, In line magnetic separator, travelling tripper, scoop coupling system, sump pump, etc.

Safety switches -- Addressable type Pull cord switch, Addressable type Belt sway switch, Zero speed switch, limit switches etc., Master cum Display unit & control panels for the safety switches (pull cord & Belt sway switches).

Anemometer for the stacker reclaimer system.

Radar type instrument for coal bunker level measurement. Three (3) nos. of Radar level transmitters shall be provided for each bunker

Necessary interface with ECHS from Udangudi port both Hardwired and also soft link.

The control of Inplant coal handling system is in EPC's scope and ECHS is in client's scope.

Further the cabling scope of the bidder shall be

- (a) For hardwire signals, the terminal point for the bidder is at the ICCHS plant DCS end. Necessary provisions (IOs and required hardware) shall be provided at the ICCHS DCS end for the interconnections of ECHS equipments.
- (b) Provision shall be made available at ICCHS end for extending the redundant time synchronizing signals to the ECHS DCS. Interface cable between master clock panel and ICCHS shall be in the bidder's scope

- 1.1.7 Ash handling system shall be controlled and monitored from the AHP local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link, all hardware, software, other interfaces, cables and field sensors/instruments/erection hardware envisaged to control and monitor it.

Ash handling local control room shall be provided with Two (2) no. 24" LED type Operator station and AHP Mimic panel for control and monitoring the AHP locally in addition to the remote monitoring from the central control room in the main plant DCS.

AHP mimic panel with hard wired push buttons for back panel operation. Hardwired annunciation panel shall be provided for controlling process. One No. large screen display (84") complete with control station and other hardware at AHP control room for controlling & monitoring ash handling system.

Operator station in the AHP local control room shall be provided with the access to monitor the main plant operations

- 1.1.8 Proprietary microprocessor based system or Unit DCS based control system for Electro static precipitator (ESP) complete with system cabinets, marshalling cabinets, Two (2) no. 24" LED type / Keyboard / Mouse based operator station for each unit, One (1) no. 24" LED type / Keyboard / Mouse based engineering cum operator station for each unit, redundant OPC communication link with plant DCS system all hardware including OPC servers, software, cables, other interfaces, analyzers and field sensors/ instruments/erection hardware and furniture



- 1.1.9 Desalination/WTP shall be controlled and monitored from the Desalination/WTP local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link, all hardware, software, other interfaces, cables and field sensors/instruments/erection hardware/furniture envisaged to control and monitor it.

Desalination/WTP local control room shall be provided with Two (2) no. 24" LED type Operator station and Mimic panel for control and monitoring the Desalination/WTP locally in addition to remote monitoring from the central control room in the main plant DCS. One No. large screen display (84") complete with control station and other hardware at control room for controlling & monitoring Desalination/WTP system.

For DM/RO plant One (1) no. A3 color printer in addition to 1 no. A4 BLW printer shall be provided in the local control room for the operator station.

Operator station in the Desalination / WTP local control room shall be provided with the access to monitor the main plant operations

Desalination/WT plant mimic panel with hard wired push buttons for back panel operation.

Hardwired annunciation panel shall be provided for controlling the process

- 1.1.10 Sea water Intake system shall be controlled and monitored from the Sea water Intake system local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link, all hardware, software, other interfaces, cables and field sensors / instruments / erection hardware envisaged to control and monitor it.

Sea water Intake system local control room shall be provided with One (2) no. 24" LED type Operator station for control and monitoring the Sea water Intake system locally in addition to remote monitoring from the central control room in the main plant DCS.

Suitable interlocks shall be provided with Desalination plant with CW in-take system for flow control.

Operator station in the Sea water Intake system local control room shall be provided with the access to monitor the main plant operations

Sea water intake system mimic panel with hard wired push buttons for back panel operation. Hardwired annunciation panel shall be provided for controlling the process

- 1.1.11 Instrument and service air compressors and driers shall be controlled and monitored from the Central control room & local control room, through the DCS Remote I/Os, Redundant processor, power supply, communication module, redundant communication link all hardware, software and other interfaces envisaged to control and monitor it. Remote operation is envisaged from the Central control room.

Instrument and service air compressors local control room shall be provided with One (1) no. 24" LED type Operator station for control and monitoring the compressors locally in addition to the remote Control & monitoring from the central control room in the main plant DCS.

Controls and protection of the Instrument air compressor shall be realized in the dedicated control system. System shall be complete with cabinets, alarm annunciation windows, all hardware, cables, dew point meter and field sensors/ instruments/erection hardware

- 1.1.12 AC and ventilation system shall be controlled and monitored from the AC and ventilation system local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link, all hardware, software,



other interfaces, cables and field sensors/instruments/erection hardware envisaged to control and monitor it.

AC and ventilation system local control room shall be provided with One (1) no. 24" LED type Operator station for control and monitoring the AC and ventilation system locally in addition to the remote monitoring from the central control room in the main plant DCS.

Operator station in the AC and ventilation system local control room shall be provided with the access to monitor the main plant operations

Microprocessor based system for Chiller unit. Accessories such as serial link cable between microprocessor to the plant DCS. Local control Panel shall be provided for Air Washer System and Unitary Air Filtration system.

Fire signal shall be wired to MCC/DCS and interlocked for all fan motor & Air washer unit / UAF& CCR inert gas system. Such that the equipment will trip on fire alarm signal from the Plant Fire Alarm system

- 1.1.13 Fuel oil system unloading, forwarding/ pressuring, and heat tracing shall be controlled and monitored from the Central control room & local control room through the DCS remote I/Os, Redundant Processor, Power supply, communication module, redundant communication link, all hardware, software, other interfaces, cables and field sensors/instruments/erection hardware envisaged to control and monitor it.

Fuel oil system local control room shall be provided with One (1) no. 24" LED type Operator station locally for control & monitoring.

Operator station in the FO Pump house local control room shall be provided with the access to monitor the main plant operations.

Local relay based control system for unloading system with status monitoring including tank level monitoring hardwired to remote I/Os.

- 1.1.14 Cooling water system which includes Condenser cooling water system & Auxiliary cooling water system shall be controlled and monitored from the Central control room & local control room through the DCS remote I/O, Redundant Processor, power supply, communication module, redundant communication link all hardware, software, other interfaces, cables and field sensors/instruments / erection hardware/furniture etc

CW system local control room shall be provided with Two (2) no. 24" LED type Operator station locally for control & monitoring.

Operator station in the CW pump house local control room shall be provided with the access to monitor the main plant operations

Cooling water system mimic panel with hard wired push buttons for back panel operation. Hardwired annunciation panel shall be provided for controlling the process

- 1.1.15 Condenser on-line tube cleaning system shall be controlled and monitored from the Unit DCS in the Central control room. System shall be complete with remote I/Os (if reqd) , Redundant Processor, power supply, communication module, redundant communication link all hardware, software, other interfaces, alarm annunciation windows, push buttons and indications, cables and field sensors/instruments / erection hardware envisaged to control and monitor it.

- 1.1.16 Mill reject system shall be controlled and monitored from the Mill reject system local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link all hardware, software, other interfaces, cables and field sensors/instruments/erection hardware envisaged to control and monitor it.



Mill reject system local control room shall be provided with Two (2) no. 24" LED type Operator station for control and monitoring the Mill reject system locally in addition to remote monitoring from the central control room in the main plant DCS.

Operator station in the Mill reject system local control room shall be provided with the access to monitor the main plant operations

- 1.1.17 Fire protection system (fire water booster system) shall be controlled and monitored from the Fire protection system local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link all hardware, software, other interfaces, cables and field sensors / instruments / erection hardware envisaged to control and monitor it

Fire water pump house shall be provided with Two (2) no. 24" LED type Operator station for control and monitoring the FPS locally in addition to remote monitoring from the central control room in the main plant DCS.

- 1.1.18 Hydrogen generation system shall be controlled and monitored from the Hydrogen generation system local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link all hardware, software, other interfaces, cables and field sensors/instruments/erection hardware envisaged to control and monitor it

Hydrogen generation system local control room shall be provided with Two (2) no. 24" LED type Operator station and Mimic panel for control and monitoring the Hydrogen generation system locally in addition to remote monitoring from the central control room in the main plant DCS. Local annunciation panel with minimum amount of conventional hardwired pushbutton stations and indicators shall be provided for the safe shutdown of the plant.

Operator station in the Hydrogen generation system local control room shall be provided with the access to monitor the main plant operations

Hydrogen plant mimic panel with hard wired push buttons for back panel operation. Hardwired annunciation panel shall be provided for controlling the process.

- 1.1.19 Micro-processor based analog addressable main fire alarm panel, local fire control panel, repeater panels for fire alarm and detection system compete with analog addressable fire alarm detectors, alarm annunciation windows, Operator cum programming station and printer, all hardware, software, cables, other interface and field sensors/instruments erection hardware (1 lot).

All interface cabling between fire alarm system and DCS for HVAC equipment/dampers interlocks shall be complete with double compression glands, lugs, ferrules, markers etc.

- 1.1.20 Electro chlorination system shall be controlled and monitored from the Electro chlorination system local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link all hardware, software, other interfaces, cables and field sensors / instruments / erection hardware envisaged to control and monitor it.

Electro chlorination system local control room shall be provided with Two (2) no. 24" LED type Operator station for control and monitoring the Electro chlorination system locally in addition to remote monitoring from the central control room in the main plant DCS. Local annunciation panel with minimum amount of conventional hardwired pushbutton stations and indicators shall be provided for the safe shutdown of the plant.

Operator station in the Electro chlorination system local control room shall be provided with the access to monitor the main plant operations



- 1.1.21 Condensate polishing unit shall be controlled and monitored from the Unit DCS in the Central control room & local control room. System shall be complete with, complete with remote I/Os (if required), Redundant Processor, power supply, communication module, redundant communication link all hardware, software, other interfaces, cables and field sensors / instruments / erection hardware envisaged to control and monitor it.
- Condensate polishing unit local control room for each unit shall be provided with one (1) no. 24" LED type Operator station for control and monitoring the Condensate polishing unit locally in addition to remote control & monitoring from the central control room in the main plant DCS. The Remote I/O Unit and control room of CPU shall be in the Dry room of SWAS panel
- Operator station in the Condensate polishing unit local control room shall be provided with the access to monitor the main plant operations
- Condensate polishing plant mimic panel with hard wired push buttons for back panel operation. Hardwired annunciation panel shall be provided for controlling the process.
- 1.1.22 Effluent & Sewage treatment plant shall be controlled and monitored from the ETP local control room through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link, all hardware, software, other interfaces, cables and field sensors / instruments / erection hardware envisaged to control and monitor it.
- ETP local control room shall be provided with one (1) no. 24" LED type Operator station locally for control & monitoring. Remote monitoring is envisaged from the Central control room
- Operation of all the sump pumps will be controlled from the DCS. Sump pump shall be connected functionally with the RIO located at different areas of the plant.
- 1.1.23 Redundant bidirectional Interface through suitable protocol with required hardware and software shall be envisaged for the following:
1. Switchyard SCADA and DCS.
 2. EMS and DCS.
- 1.1.24 Unit DCS Operator station shall also be extended to each of the following locations provided with the access to monitor the main plant operations
1. ESP control room
 2. Turbine 0 m floor
 3. HT switchgear room
 4. "A" Elevation boiler
 5. Switchyard control room
 6. Express laboratory (SWAS/chemical room)
- 1.1.25 All the BOP Operator station in the local control room shall be provided with one (1) no. A4 laser BLW printer
- 1.1.26 The BOP systems listed below are common for all units:
- Desalination / water treatment plant
 - Waste water treatment plant
 - Fire protection system
 - Electro chlorination system
 - Sea water intake system
 - Sea water outfall system



- Fuel oil unloading and storage system
 - Fuel oil forwarding / pressurizing and heating system
 - Hydrogen generation plant
 - Coal handling plant
 - Ash handling plant
 - AC & ventilation system
 - Compressed air system
 - CW system
- 1.1.27 One (1) GPS common for the plant for Time synchronization with DCS/PLC systems (if available) etc. with 25 Nos. slave clocks inside the unit and 25 Nos. slave clocks outside the unit. Slave clocks provided for outdoor services shall be IP65 and slave clock provided in the indoor services shall be IP32
- 1.1.28 Remote Modem Connectivity.
- Remote modem connectivity shall be provided by the bidder for the following functional requirements.
- (a) Interfacing plant DCS with DCS customer centre for the remote access as per Vol II, Section 4.2, Cl: 1.1.6,
- (b) Also operator screens at Owner's corporate office are to be provided by the bidder as per Vol II, Section 4.6, Cl: 1.20.0
- 1.1.29 User Interface bidirectional Connectivity with other system like ERP & PADO.
- 1.1.30 Steam & water analysis system complete with sample conditioning and analyzer panels, sensors and other accessories.
- 1.1.31 Flue gas measurement system of in situ type complete with all the analyzers, calibration unit and other accessories.
- 1.1.32 Stack Emission monitoring system of extraction type/ in situ type complete with all the analyzers, controller, dedicated PC at CCR with all the soft wares, calibration unit and other accessories. Interfaces to plant DCS shall be provided.
- 1.1.33 Ambient Air Quality Measurement AAQMS (4 lots) complete with all the analyzers, controller, dedicated PC at CCR with all the soft wares, calibration unit and other accessories. Interfaces to plant DCS shall be provided. Facility to provide necessary updation to Pollution control board
- 1.1.34 Unit Vibration monitoring & analysis system for all the HT drives and driven equipments for BTG auxiliaries such as Boiler Feed Pumps and Motors, TD BFP, Condensate Extraction Pumps and Motors, CW pumps and Motors, Auxiliary Cooling Water Pumps and Motors, DM Cooling water pumps and Motors, ID Fans, FD Fans, PA Fans, Coal Mill motors & Seal Air Fans and motors. VMAS shall be provided with a PC, analysis software and all other accessories, including interfaces to TSI of TG and TD BFPs. Necessary interfaces shall be provided to plant DCS for maintenance management system.
- 1.1.35 Vibration monitoring system for all the HT drives and driven equipments for BOP auxiliaries such as CHP, AHP, Compressed air system, Desalination pumps etc shall be provided and interfaced with the plant VMAS. Necessary interfaces shall be provided to plant DCS for maintenance management system.
- 1.1.36 Emergency backup console with all hardware and accessories for the safe shutdown of the critical auxiliaries and operation of emergency drives. Emergency back up operation shall be independent of DCS. The Unit control panel shall housed Conventional Push-button



- (ILPB) stations, Console inserts (for SG, TG & Generator like FSSS, HPBP, SADC, APRDS, ATRS, ATT, DEHC, LPBP etc), Trip Push Buttons, EWLI, Ammeters, chartless recorders (refer cl no.G of Section 4.23), CCTV for Drum Water & Furnace Flame, & min. 15 nos. digital display units for Boiler, Turbine & Generator parameters.
- 1.1.37 Bidder shall provide two work stations and A4 laser printers (B/W) along with necessary software & internet connection at Owner's corporate office for remote monitoring. However to protect against unauthorized access to network, sufficient security arrangement in the form of firewall or any other suitable hardware / software keys etc., shall be deployed. For automatic refresh features for viewing Web based Plant information extending option for additional 25 viewers shall be provided.
- 1.1.38 Four number (4) nos. of 40" LED TVs connected to DCS so as to visualize Annunciation windows/alarm messages in enlarged versions and for viewing process mimics. These LED TVs shall be installed and hanging from the false ceiling of the Central control room
- 1.1.39 All UPS room shall be air conditioned
- 1.1.40 All local control room desk, panels & modular furniture
- 1.1.41 Field instruments/sensing devices
- 1.1.42 Flow elements/Control valves/ other pipe mounted instrumentation equipments
- 1.1.43 Instrumentation, control cables and special cables
- 1.1.44 Plant security & surveillance system including closed circuit Television with camera for locations as recommended by the Bidder, digital video recorder, surveillance TV at CCR & security room, patrol guard systems, perimeter monitoring systems, cables and other hardware/software/ accessories
- 1.1.45 Power supply system for Instrumentation and Control system and grounding (1 lot)
- 1.1.46 Erection hardware for I&C systems
- 1.1.47 Instrument lab equipment with all the furniture.
- 1.1.48 Providing Engineering Drawings, documents, licensed copy of Softwares and development tools, data, instructions, operation and maintenance manual etc for Owners review/approval/record.
- 1.1.49 Arranging for Owners Inspection and testing of manufactured as well as bought out items at the respective works.
- 1.1.50 Complete control panels & instruments in Central & Local control room.
- 1.1.51 Receipt, storage, preservation and conservation of instruments, equipments and erection hardware at the site.
- 1.1.52 Pre-assembly (if any), erection, testing and commissioning of all the equipments and instruments in totality (including erection hardware, accessories/devices etc.).
- 1.1.53 All tools and tackles, special testing equipment and consumables required for erection and commissioning activities.
- 1.1.54 Spares required for I & C equipment which consists of recommended spares, commissioning spares and mandatory spares as detailed in this specification.



1.1.55 Consumables

2.0.0 SCOPE OF WORK & SERVICES

- 2.1.0 The scope of work & services shall include design, engineering, documentation, procurement, manufacture, assembly, inspection, supply, packing, transportation to site, storage, erection, calibration, testing and commissioning of the complete Instrumentation & control (I&C) system required for the thermal project.
- 2.2.0 Receipt of material at site, site storage and handling, complete erection of instruments, complete cabling, site supervision pre-commissioning, testing, start-up, run tests, load test, performance and acceptance testing of the complete system.
- 2.3.0 Bidder shall be fully responsible for design, materials selection, sizing and selection of the proper instruments for their system.
- 2.4.0 All equipments supplied shall be of proven quality both with respect to design and materials. No prototype instrument or instrument of an experimental nature shall be offered or supplied. Bidder shall be responsible for the replacement of all defective parts/equipment during the guarantee period.
- 2.5.0 The Owner reserves the right of selecting the manufacturer / model of control & instrumentation items in the interest of standardization wherever necessary and the Bidder shall agree to supply equipment of particular make if so desired by the client without any cost implication.
- 2.6.0 Bidder shall clearly define the operational philosophy suggested by him, which should be in line with requirements specified in the main package/equipment specification.
- 2.7.0 Support of spare parts for I & C equipments for period of 15 years.
- 2.8.0 Any I&C equipment required during any stages for the efficient / safe / reliable operation of the plant either during detail engineering / commissioning shall be supplied, installed and commissioned by the successful Bidder without any additional cost.
- 2.9.0 Packing and Transportation of Instruments, equipments, accessories and erection hardware's, tools from the Manufacturer's works to the site, including transit insurance. Receipt, storage, preservation and conservation of instruments, equipments and erection hardware at the site. Fabrication of Site-Constructed Items. Pre-assembly (if any), erection, testing and commissioning of all the equipments and instruments in totality (including erection hardware, accessories/devices etc. Performing availability tests and Performance and Guarantee tests on the completion of Commissioning. Fulfilling post – commission liabilities.
- 2.10.0 In the event of conflict between requirements of any two clauses or specification documents, the more stringent requirements shall apply unless confirmed otherwise by the owner in writing before the award of this contract based on a written request from the bidder for such clarification
- 2.11.0 Submission of drawings and documents as indicated below.

Drawings/Document Distribution Schedule

The successful bidder will be required to furnish all the necessary Design basis reports (DBR), drawings, data sheets etc. of the Plant/Equipment with appropriate "Status" stamp in adequate number of copies as indicated below:-



S.No.	"Status" of the Drawing, Data etc.	Number of Copies
1.	"Preliminary"	Six (6) prints
2.	"Reference"	Six (6) prints
3.	"For Approval"	Eight (8) prints
4.	"Final & Certified" duly signed	Ten (10) prints & one (1) Reproducible tracing
5.	Test Certificates	Six (6) copies
6.	Operation & Maintenance Manual	Ten (10) copies
7.	Test Procedures	Six (6) copies
8.	"For Erection Purposes"	One (1) Reproducible & ten (10) prints
9.	Erection Procedure/Manual	Six (6) copies
10.	Performance & Acceptance Test Procedure	Twelve (12) copies
11.	All Other Documents	Six (6) copies
12.	Two additional sets of DVDs of all final control programs as implemented.	
13.	Soft copies of all the drawings, Documents, catalogues etc. with navigation facility	Six (6) Nos.

System Documentation

Master document/drawing list along with dates within 3 months shall be submitted by bidder after award of contract for each package for approval of owner. The Bidder shall provide drawings, system overview & description, hardware/software details, Technical literature, functional & hardware schemes, bill of material, parts list, Inter connection diagrams, data sheets, erection/installation/commissioning procedures, Instruction/operating manuals, etc. for each of the C&I system/sub-systems/equipment, supplied under this package. The documentation shall include complete details of the C&I systems/sub-systems/equipment to enable review & approval by owner during detailed engineering stage and to provide information to plant personnel for Operation & Maintenance (including quick diagnostics & trouble shooting) of these C&I systems/sub- Systems/equipments at site. Following minimum documents shall be submitted by bidder during detailed engineering for review and approval:



DATA / DETAILS TO BE FURNISHED		
S.no	Description	Category
1	C&I System Design Basis Report incorporating Control philosophy / operation philosophy / Design philosophy / Redundancy philosophy.	A
2	Codes and application standard followed for the project.	A
3	Process & Instrumentation Diagrams (PID) indicating local gauges, transmitters, analysers for (alarm, control etc.)	A
4	Engineering documents For DCS/PLC based control systems: a. Bill of Quantity for DCS based system b. I/O Assignment for DCS. Each DCS based control system including nest loading. c. Instrument Schedule with set points d. I/O List e. Drive List/ Solenoid Valve List f. Annunciation List g. SOE list. h. Process mimics/graphics indicating Analog and digital parameters i. List of logs with point assignment j. Time Synchronisation System k. Historical Storage and Retrieval (HSR) system details. l. Rack schedule m. Flow element schedule n. Control valve schedule	A
5	Detailed technical catalog about the Analog / Digital input and output modules, drive control modules, main control processor, operator consoles, printers etc, shall be furnished for scrutiny.	A
6	Modulating Control and Sequential Control Schemes with Write ups	A
7	Logic diagrams (SAMA format) for Main Plant, Utility & Aux. Plants along with system description / functional write-up.	A
8	System Architecture/System Configuration Drawing for DCS/DCS based Offsite Package including MMI, interface with Third party systems, Master clock and Local Control Desks/Annunciator panel	A
9	Back up panel/Unit control panel, Annunciator window layout and inscription.	A
10	LVS data sheets, GA drawings along with catalogs	A
11	Field Instruments data sheets along with catalogs	
12	System Configuration Diagram with DCS interfacing details for special monitoring & analysis systems like vibration analysis, PADO, Management information system, Security & Surveillance system, Flame Analysis (by others), Tube Leak Detection (by others) etc.	A
13	Vendor Data sheets for C&I system equipment including DCS/ PLC based control system.	A
14	Sub-vendor's drawings and documents for all main & BOP packages	A
15	Central Control room layout / SWAS room layout /CEMS room layout/ Local Control Room & all control panel layout including Unit control panel.	A
16	G.A.(General Arrangement) and Internal arrangement drawings of all control panels/ cabinets / local panels with all dimensional details, wiring diagrams and terminal details.	A



DATA / DETAILS TO BE FURNISHED		
S.no	Description	Category
17	Sampling schemes including SWAS schemes.	A
18	Interconnection cable schedule.	A
19	UPS/24 V DC system Single Line Diagram, UPS/24 V DC Load List, UPS Datasheets, G.A drawings of UPS/24 V DC system, Panel Specification, Operation Philosophy, Wiring Diagrams, Battery Sizing Calculations, Battery Data Sheets, Battery Stack GA Drawings and 24VDC system	A
20	Heat load and power consumption data for DCS/PLC. UPS and +24VDC	A
21	JB Schedule, LIE/LIR for Transmitter Groupings (P, DP, F, L and transmitters)	A
22	Control Valves Data Sheets for Control valves & its Accessories, BOQ, QAP, Internal TC, Technical catalogs, O&M Manuals Solenoid Valves Data Sheets for Solenoid valves, Control Valve noise calculation (both hydro-static & hydro-dynamic)	A
23	Installation sketches (Individual Instrument Hook Up Drawing and Installation isometric drawings.)	A
24	Hardware & software design manual (covering exhaustive details of complete DCS/PLC based control system)	A
25	QAP(Quality assurance plan) for all major equipment.	A
26	Mandatory Spares and Recommended Spares List.	A
27	Detailed technical literature of each type of instrumentation equipment offered shall be furnished.	A
28	Detailed manufacturer's cable specification/data sheets with GA drawing for offered cable shall be furnished.	A
29	Factory Acceptance Test (FAT) procedure/Site Acceptance Test (SAT) Procedure / Availability test procedure / PG test procedure for C&I equipment including DCS/ PLC control systems.	A
30	Duly signed schedule of performance guarantees, List of softwares included.	A
31	All test certificates including degree of protection certificates for all packages and Explosion proof certificates for oil services.	A
32	Confirmation certificate for the latest version of software and hardware offered.	A
33	Thermowell Sizing calculation.	A
34.	Vendor data sheets/GA drawings/Catalogue for each C&I system as specified in NIT.	A
35.	All other documents not specifically mentioned here but required for completion of engineering work and proper coordination shall be unit wise. All other documents specifically called for in various sections of specification.	A/I as finalized by Owner
36.	Data sheet/specifications of components/modules etc. in respect of each and every electronic card/module as employed on the microprocessor based control system and equipment including conventional instruments, peripherals etc.	A



DATA / DETAILS TO BE FURNISHED		
S.no	Description	Category
37.	All type tests for the C&I systems/sub-systems/equipment as stipulated in QA section shall be included.	I
38	DCS / PLC / Local control system / Vibration monitoring & analysis system functional specification covering both the hardware and software details along with the data sheets and technical catalogues.	A
39	DCS / PLC IO allocation details, System loading details, controller grouping details	A
40	Details of the C&I System in offsite plants.	A
41	Interconnection Diagram of DCS showing all hardware details.	A
42	Start-up and shutdown logics with procedures and write-ups	A
43	Data sheets, Specifications and catalogues of field instruments, analyzers, lab instruments, and associated accessories	A
44	Flow element sizing calculations and dimensional drawings.	A
45	Plant graphics, alarms, various displays, logs and reports with menu and format.	A
46	Detail wiring diagrams of all panel desk, control consoles, system cabinets etc.	I
47	Instrument loop schematics.	I
48	Instrument installation & Hook-up diagrams showing all erection hardware and tapping point details.	A
49	Instrumentation Layouts such as, Control room layouts,	A
50	Drawings such as JB/ Rack/ Tray /Instrument location drawing etc.	A
51	C&I power distribution scheme including UPS supply etc.	A
52	Electronic Earthing schemes	A
53	Cable Spreader room details /false flooring details of CCR.	A
54	Spare parts list, Laboratory Instrument list, test & calibration report, special tools & tackle list	A
55	Operation and maintenance manuals for all the I&C equipments and systems.	I
	Above “A” stands for “Approval” and “I” stands for “Information	



- 2.12.0 Arranging inspection at the manufacturer's premises.
- 2.13.0 Training for I&C major and specialized I&C equipment supplied at the manufacturer works and at site. The engineers shall be given special training in shop, laboratory and drawing office of the BIDDER, where the Instrumentation and Control Equipment will be designed, and manufactured and in any other project where similar type of equipment designed, manufactured and supplied by him is under installation, test, operation or maintenance, to enable the engineers to become fully familiar with the equipment offered
- Training of plant O&M personnel on all I&C systems to effectively operate the units & BOP systems.
- 2.14.0 Participation of Bidder representatives and other equipment suppliers with owners at various stages of the project.
- 2.15.0 WAN with necessary hardware and software. Bidder shall provide two nos. work stations with A4 laser printer (B/W) each along with necessary software & internet connection **at Owner's Corporate office** for remote monitoring.
- However to protect against unauthorized access to network, sufficient security arrangement in the form of firewall or any other suitable hardware / software keys etc., shall be deployed. For automatic refresh features for viewing **Web based Plant information extending option for additional 50 viewers shall be provided.**
- 2.16.0 Unit simulator package
- 2.17.0 Enterprise resource planning
- 2.18.0 Earthing System
- 2.19.0 Packing and Transportation of Instruments, equipments, accessories and erection hardware's, tools from the Manufacturer's works to the site, including transit insurance. Receipt, storage, preservation and conservation of instruments, equipments and erection hardware at the site. Fabrication of Site-Constructed Items. Pre-assembly (if any), erection, testing and commissioning of all the equipments and instruments in totality (including erection hardware, accessories/devices etc.). Performing availability tests and Performance and Guarantee tests on the completion of Commissioning. Fulfilling post – commission liabilities.

3.0.0 O&M MANUAL

Operation & Maintenance Instruction Manual

The bidder shall furnish operation & maintenance instruction manual for all the instruments/equipment supplied by them.

These shall be sent along with the instruments/equipment. Instruction regarding installation, testing, calibration, repair, maintenance and commissioning of the instruments/equipment six months in advance before the commissioning date of the unit.

In addition the bidder shall furnish instruction manual on operation & maintenance of their overall system. This shall be furnished to the Owner Six (6) months before the commissioning date of the unit as per the enclosed distribution schedule.

4.0.0 ABBREVIATIONS

- PRDS: Aux. Pressure Reducing and Desuperheating Station



- ATT: Automatic Turbine Tester
- ATRS : Automatic Turbine Run-up System
- ACW: Auxiliary Cooling Water
- APH: Air Pre Heater
- AAQMS : Ambient Air Quality Monitoring System
- AHP: Ash Handling Plant
- BUP: Back Up Panel
- BOP: Balance of plant
- BFP : Boiler Feed Pump
- BMS : Burner Management System
- CAAQMS : Continuous Ambient Air Quality Monitoring System
- CCR: Central Control Room
- CER: Central Equipment Room
- CW: Circulating Water
- CCTV: Close Circuit Television
- CPU: Condensate Polishing Unit
- CEMS: Continuous Emission Monitoring System
- CMIMS: Computerized Maintenance and Inventory Management System
- COLTCS: Condenser On-Line Tube Cleaning System
- CRH: Cold Reheat
- CHP : Coal Handling Plant
- DMP: Dot Matrix Printer
- DCS: Distributed Digital Control and Management Information System
- DAS: Data Acquisition System
- DEHC: Digital Electro Hydraulic Control
- DMPS : DM Plant System
- EOP : Emergency Oil Pump
- EDMS : Electrical Distribution & Management System
- EHGC : Electro Hydraulic Governing Control
- ESP : Electrostatic Precipitator
- ERP : Enterprise Resource Planning
- EWS : Engineering Work Station
- ES : Ethernet Switch
- FSSS: Furnace Safeguard Supervisory System
- HRH: Hot Reheat
- HFO: Heavy Fuel Oil
- HPBP: High Pressure Bypass
- HMS : Hart Management System



- IJP: Ink Jet Printer
- IPR : Interposing Relay
- JOP : Jacking Oil Pump
- LVS: Large Video Screen
- LJP : Laserjet Printer
- LIE : Local Instruments Enclosure
- LIR : Local Instruments Rack
- LCP : Local Control Panel
- LDO: Light Diesel Oil
- LPBP: Low Pressure Bypass
- LCR: Local Control Room
- MIS : Management Information System
- MGP: Mosaic Grid Panel
- OCAMMMS: Online Computer Aided Microprocessor Based Machinery Maintenance Management System
- OWS: Operator Work Station
- OEWS: Operating & Engineering Work Station
- O&M : Operation & Maintenance
- PLC: Programmable logic Controller
- POS: Plant Optimization System
- SCADA: Supervisory Control and Data Acquisition
- SG: Steam Generator
- STG: Steam Turbine Generator
- SWAS: Steam and Water Analysis System
- SPM: Suspended Particulate Matter
- SPM : Suspended Particulate Monitor
- SADC : Secondary Air Damper Control
- SBC : Soot Blower Control
- SOE : Sequence of Event
- RO : Reverse Osmosis
- TDBFP : Turbine Driven Boiler Feed Pump
- TNEB: Tamil Nadu Electricity Board
- TANGEDCO : Tamil Nadu Generation and Distribution Corporation Ltd.
- TSC : Turbine Stress Evaluation Control System
- TBC: Turbine Bypass Control
- TMR : Triple Modular Redundancy
- TSI: Turbo supervisory Instrumentation
- UPS : Uninterrupted Power Supply



- UCP : Unit Control Panel
- UCD : Unit Control Desk
- VAS : Visual Alarm Annunciation System
- VMS : Vibration Monitoring System
- MB : Mixed Bed
- DG : Degasifier



VOLUME – II
SUB-SECTION 4.3
DESIGN REQUIREMENT

1.0.0 DESIGN REQUIREMENT

- 1.1.0 The Instrumentation and control systems shall be provided for safe, reliable and efficient operation of the thermal power project. In general a consistent control and instrumentation philosophy is to be applied throughout the power project. Adequate redundancy are to be ensured, so that no single point failure of the I&C systems/ equipments in the power project does not result in the overall reduction of the plant output. In general all I&C systems/ equipments should be of modern and compact design, incorporating proven technology and modern industrial practice.
- 1.1.1 The minimum target reliability of each piece of equipment like each electronic module/card, Power supply, Peripheral etc. considering its failure rate/mean time between failures (MTBF), meantime to repair (MTTR), such that the availability of the complete C&I system is assured for 99.7%.
- 1.1.2 The design of the control systems and related equipments shall adhere to the principle of 'Fail Safe' operation wherever safety of personnel / plant equipment is involved. 'Fail Safe' operation signifies that the loss of signal, loss of excitation or failure of any component shall not cause a hazardous condition. However, it shall also be ensured that the C&I system design with respect to control and protection functions is 'Fault Tolerant' to single faults such that the occurrence of false trips and degradation of functions are avoided / minimised. The types of failure which shall be taken into account for ensuring operability of the plant shall include but not limited to;
- a) Failure of sensor or transmitter,
 - b) Failure of main and/or redundant controller, other electronic modules,
 - c) Loss of motive power to final control element,
 - d) Loss of control power.
 - e) Loss of instrument air
- 1.1.3 Standardization concepts shall be applied wherever possible to rationalize operation, maintenance and reduce spare parts. The choice of hardware shall also take into account for sound maintainability principles and techniques. The same shall include but shall not be limited to the following:
- a) Standardization of parts.
 - b) Minimum use of special tools.
 - c) Grouping of functions.
 - d) Interchangeability.
 - e) Malfunction identification facility/self surveillance facility.
 - f) Easy modular replacement.
 - g) Fool proof design providing proper identification and other features to preclude
 - h) Improper mounting and installation.
 - i) Appropriate derating of electronic components and parts.
- 1.1.4 The design, manufacture, assembly, testing as well as performance of the equipment shall conform to the latest edition of relevant IEC/ISA and other international codes/specifications. The I & C equipment and systems shall be designed, manufactured & installed to meet the specification requirements, and perform accurately and safely under the operating and environmental conditions existing in the power project. The Instrumentation and control equipment shall be designed suitably that are subjected to saline atmosphere.



- 1.1.5 All control and instrumentation functions shall be shown on the piping and instrumentation diagrams. The symbols to be used shall be in accordance with ISA / ISO standard. The identification system (tag numbers) shall be in accordance with the KKS identification system, and shall be subject to approval by the Owner. All measurements and alarms shall be listed. Complete schematic control diagrams shall be provided for all instrumentation. Functional application and also specific control (modulating/interlock) application (by short text) for each measurement along with signal destination shall be indicated in Process and Instrumentation Diagram (P&ID). All reference engineering documents shall also be indicated in the P&ID.
- 1.1.6 Automatic single push button start facility from the plant DCS to be provided for the main plant equipments such as BMS, BPS, STG, and other DCS controlled systems. For balance of plant systems such as water treatment plant, Instrument and service air compressor, seawater system etc the controls are to be designed such that fully automatic operation should be possible from the plant DCS and minimum local intervention.
- 1.1.7 The system will have 1:1 redundancy with respect to the processor modules, power supply modules, communication modules and network interface.
- The system will be designed in such a manner that in the event of failure of the primary controller, the entire configuration of the failed controller will be instantaneously and automatically transferred to the back-up controller without operator's intervention. Mode changeover in either direction will be bumpless.
- Dual redundant power supplies to be provided for all the I&C panels. Loss of single power supply shall be alarmed in DCS for corrective action by the operator
- 1.1.8 Measurement system (MS), Closed Loop Control System (CLCS) and Open Loop Control System (OLCS) will all be configured with redundancy at processor modules, communication modules, data bus and power supply modules.
- 1.1.9 Redundant Input and output modules shall be provided for all the drive level interface (both OLCS/CLCS). For the inputs, dual or triple measurement as described in clause 2.1.0 of Section 4.8 and Clause 2.1.0 of Section 4.9 shall be provided and the individual measurements (dual or triple) shall be wired to separate input modules. No redundancy at I/O card level is required which are executing purely Data acquisition/Monitoring functions. I/O's redundancy shall be truly redundant and not engineered I/O redundancy. For measurement system, redundancy at sensor level and I/O module level is not envisaged. Logics for the redundant drives shall not be in the same processor.
- 1.1.10 The Measurement system shall have the following features:
- Linearization for temperature measurement i.e. mv Vs Deg. C
 - Square root extraction for flow measurement, where the measurement is in differential pressure.
 - Integration for totalizing the flow measurement, whenever applicable.
 - Compensation for variation in pressure or temperature or density for flow/ level measurement. E.g.: Feed water flow.
 - Limit value monitor for generation of contacts for alarm/interlock purpose. Eg.: Boiler Tube metal, Bearing, winding temperature measurements
 - Each of the analog transmitters shall be Smart type with the following:
 - 4-20mA DC signal with 24V DC interrogation.
 - HART protocol based digital communication
 - All these Transmitters shall be hooked up to a PC based Centralised Calibration system (HART System), which shall have Diagnostic and Configuration software. This system shall be located in Computer room.
 - All contact inputs shall be interrogated with 24 / 48 V DC



- 1.1.11 Where redundant sensors are provided redundancy at I/O card level is not required. Redundant sensors will be provided for all control applications.
- 1.1.12 The communication sub system will be a real time reliable communication network between control processors, operator stations, printers and engineering station.
- 1.1.13 The plant bus and communication bus shall have dual redundancy
- 1.1.14 Triple Sensors for unit/equipment and protection trip are applicable for main plant equipments and equipments which will affect plant availability.
- 1.1.15 Dual redundant sensors shall be provided as a minimum in 1 out of 2 logic for all other closed loop and open loop controls used for protection.
- 1.1.16 Sequence of event recording system shall be integral to DCS
- 1.1.17 A consistent control and instrumentation philosophy shall be applied throughout the plant and be implemented in terms of a range of equipment exhibiting a minimum diversity of type and manufacture. Range of the instrument shall be so selected that max. operating value lies in 65-75% of the full scale range.
- 1.1.18 Control & Instrumentation shall be provided such that no single failure can cause a unit trip, loss of load/overall power output or even a forced outage of the power station. Modular redundant control systems shall be provided for all plant safety critical control and protection systems.
- 1.1.19 For hazardous area, the I & C systems to be designed as per the relevant area classification and applicable standards.
- 1.1.20 In the interest of a neat and clear, space-saving layout of the installation, easy maintenance, simple starting-up, operational checks and fault-recognition, a system made up of standard sub-assemblies with plug-in modules design shall be provided. The Systems shall have a decentralized design to a large extent. In the case of power supply failure no reprogramming shall be necessary and no controller parameter shall be lost.
- 1.1.21 To ensure smooth and optimal maintenance including efficient spare parts management of various I&C instruments/equipments like vibration monitoring analysis systems, all 4-20mA electronic transmitters/ transducers, control hardware, control valves, actuators and other instruments/ local devices etc. being furnished by the Bidder for SG, TG, BOP including its auxiliaries and systems like fuel system, circulating water system, chemical dosing system, Hydrogen Generation Plant (if applicable), Desal/WTP, cooling water system, electro chlorination system, effluent treatment plant, compressed air system, fire protection system, mill reject system, HVAC, potable water system, emergency DG facility etc. and other plant auxiliaries for similar applications, the Bidder shall ensure that they are of the same make, series and family of hardware. Bidder shall furnish a composite list of bought-out items along with proposed sub-vendors for each of the same.
- 1.1.22 The operator stations in the local and remote control rooms shall be housed in the enclosed control desk with interior lighting, louvers with brass mesh, space heater and telephones. The control desk shall be constructed of 2mm thick CRCA with IP 32 protection class for air conditioned environment and IP-44 for other indoor applications.



2.0.0 LAYOUT REQUIREMENT

2.1.0 Main Plant Control Room

The Main plant central control room (CCR) shall contain all equipment pertaining to Human Machine Interface (HMI) to facilitate remote control and monitoring functions. The central control room / Electronics equipment Room will be provided with false ceiling. The Main plant CCR shall be designed for required illumination level, ergonomical design aspects, minimum acoustics levels and overall as ethic feel of a CCR. All the control rooms in main plant shall be maintained in air-conditioned environment at $22^{\circ}\text{C} \pm 1^{\circ}\text{C}$ and relative humidity of $50 \pm 5\%$. The cable vault shall be of minimum 3.5m height. Provision of 8 Nos. temperature elements in the control room for monitoring the room temperature. All the cable entries shall be at the bottom of electronic cubicles. Typical design of the central control room for both the units as per the annexure (Dwg : Control room view). However the exact design or better design shall be decided during the detail engineering.

Operator work station consoles/desk shall be of modular control desk of curved nature.. OWS consoles shall be provided with the facility for locating the CPU, document etc with all required utilities.

Unit In charge desk/consoles shall be of modular control desk of curved nature. OWS consoles shall be provided with the facility for locating the CPU, document etc with all required utilities.

Station In charge desk/consoles shall be of modular control desk of curved nature. OWS consoles shall be provided with the facility for locating the CPU, document etc with all required utilities.

Engineer work station and all other consoles/desk shall be ergonomically designed industrial grade type with swivel chairs for use at the various Programming stations and all other plant locations. All the equipment like Programmers stations, PC's, various peripherals & similar devices shall be complete with desks and they shall be of industrial grade stands and other mounting accessories and the same shall be completely erected & commissioned by the bidder.

2.2.0 CCR

The CCR shall house the LVS, operator stations, printers, emergency back up console, hard wired panels, Main fire alarm panel and all other panels necessary for the complete operation and monitoring of the plant. The main entry to the central control room shall have double entrance in series so as to avoid noise/dust entry. The main control room shall be common for both units. Additionally, unit supervisor table with necessary operator stations, printers, furnitures shall be provided for each unit at main control room.

2.2.1 Electronics equipment Room

The EER to be located adjacent to the CCR shall house all DCS cabinets, Plant Communication Equipment Cabinet, Master clock system, SG integral panels, Steam turbine generator panels, interposing relay cabinet, network cabinets, various electrical system panels. Cable connections to the cabinets shall be suitably sealed to prevent the ingress of dust or vermin or the propagation of possible fires etc.

2.2.1.1 Station In-charge room shall contain the operator station and the printer. Room for Station in charge attending in shifts shall be provided in main control room and this room shall contain the operator stations, printers, ERP station etc.,

2.2.1.2 PADO room, EDMS room and I&C server/Networking rooms

**2.2.1.3 Computer Room**

The computer room shall contain all the servers, engineering stations, printers, racks for documentation etc.

2.2.1.4 Deleted**2.2.1.5 Conference room with pantry for units. In the discussion room, video conferencing facility comprising of PC, monitor, high quality camera with dedicated internet connection shall be available so as to talk to other thermal power station, load dispatch centre, TANGEDCO headquarters etc.****2.2.1.6 Pantry room and locker room for 50 people****2.2.1.7 C&I Engineers room shall be provided with five (5) nos of closed shelf/almirah and four (4) no. of open shelf/almirah****2.2.2 Local control room**

Local control rooms and control panels shall be provided for the normal operation of auxiliary plants, at locations where local operations shall be performed. Air conditioning shall be provided for Local control room (CHP control room, AHP control room, ESP control room, Water treatment plant, Air Compressor room, AC plant, Fire Water pump house, Fuel oil pump house, H₂ plant, ETP control room etc., Turbine 'O' m room, Boiler 'A' elevation room. wherever required for the panels) and remote I/O rooms (if applicable).

Operator work station/Engg. Work stations consoles/desk shall be of modular control desk of curved nature. OWS/EWS consoles shall be provided with the facility for locating the CPU, document etc with all required utilities.

2.2.3 SWAS room

SWAS Room shall be partitioned into wet and dry rooms. Air conditioning shall be provided for the dry room which shall house all the analyzers and transmitters. Location of SWAS room shall be at TG building ground floor only.

2.2.4 C&I Laboratory

Instrument lab room (Air conditioned) in the service building. Dimensions of the C&I laboratory room shall be of minimum 14 x 7 m (L x B)

3.0.0 MAINTENANCE REQUIREMENT**3.1.0 To ensure easy maintenance Make of all I&C equipments like control valve, actuator, all electronic transmitters, control hardware, local devices, other instruments etc shall be uniform to the extent possible.****3.2.0 Selection of a particular Make and model of instruments shall be such to permit maximum interchangeability, easy maintenance and repair and to maintain minimum inventory.****3.3.0 Maintenance platforms and access ladders for all the instrumentation equipment installed at inaccessible heights. Sufficient maintenance space shall also be provided against each instrumentation equipment area with safety barricades in the platforms and handrails in the ladders.****3.4.0 Easy access shall be provided for all components in the equipment and system offered to reduce the maintenance period.**



- 3.5.0 Adequate number of test equipment like test sockets, test cables, digital voltmeters, 3-pen recorders, signal generators, card extenders, etc., shall be provided by the Bidder to facilitate ease in maintenance.
- 3.6.0 Necessary maintenance equipment tools and special erection tools which are not specifically mentioned in the specification but are normally required for ease in maintenance and to have minimum down time, shall be included in the Bidder's scope.
- 3.7.0 Standardization concept shall be used in selecting the components for the systems.
- 3.8.0 Provision shall be made for isolating sub-systems/modules, which are identified to be faulty, thus enabling on-line replacement without taking equipment off-line.
- 3.9.0 All the documentation shall be in English Language.

4.0.0 AVAILABILITY REQUIREMENT

- 4.1.0 Adequate redundancy shall be built in at various levels to increase the system availability and reliability.
- 4.2.0 To ensure high reliability of the trip circuit and to avoid spurious tripping of the plant, multiple input logic system, (e.g., 2 out of 3 logic) shall be provided for important and vital trip functions.
- 4.3.0 The equipment / instrument shall employ state of art technology to guard against obsolescence, Bidder to ensure the supply of spare part for period of 15 years.
- 4.4.0 Control valves/dampers shall be driven to the fail safe position or hold position in case of control system failure, as required. This arrangement is necessary to avoid system upsets and subsequent loss of operation.
- 4.5.0 The total system availability for plant DCS shall be above 99.7%. The Bidder shall submit detailed calculations, which with the help of a schematic of various sub-systems connected in series or parallel as the case may be and the MTBF and MTTR values for the various equipments shall show that availability of 99.7% is possible.
- 4.6.0 The I&C system shall be designed with extensive self-diagnostics and trouble shooting features. Adequate facility shall be provided for quick repair/maintenance and on-line replacement of faulty modules. This shall not result in spurious trip. Where a major equipment/unit trips likely to be inhibited when the card is pulled out, Bidder shall identify it during detailed engineering stage.

5.0.0 GENERAL TECHNICAL REQUIREMENTS

- 5.1.0 As a minimum the following pressure measurement points are to be provided by the Bidder,

Pressure gauges at the suction, discharge of the pumps, compressors and fans, common header of pumps and fans, inlets and outlet of heat exchangers, de-super heaters, pressurized vessels, and other main equipment outlet and inlet.

Pressure gauges at the discharge of compressors and at the air receiver tank.

Pressure switches at suction, permissive and trip of pumps and fans/blowers, discharge pressure low for auto-start of standby pumps and pre-trip alarm conditions.

Pressure switches at the discharge of the compressor and in the lube oil circuit. Differential pressure switches across the inlet air filters.



Differential pressure indicators across filters (Gas, water, oil service, air), strainers (Gas, water, oil service, air), cooling water line of the condensers, seal oil and hydrogen gas of generator.

Differential pressure switches across filters (Gas, water, oil service, air), strainers (Gas, water, oil service, air) & cooling water line of the condensers for high and high high alarm.

Differential pressure switches across bag filters.

Pressure transmitters at the suction and discharge of main process / pumps / compressors, for all controlled parameters, inlet and outlet of cooling water line of the condenser, flue gas line at inlet / outlet of various pressure parts, pressure conditions of major vessels like separator, de-aerator etc.

Pressure transmitter at the Compressor outlet, lube oil pressure, instrument air header and at the inter stages of the compressor

Pressure transmitters at HP/LP water pumps discharge, Water/Oil pumps. Vacuum transmitters at the vacuum pump discharge.

On both left and right sides of furnace, separate lines shall be laid and provided with furnace pressure transmitters. Independent impulse lines shall be installed to the transmitter in case of dual/trip redundant with double isolation.

Differential pressure transmitter across RO-Skid, Oil/Water strainers

Differential pressure transmitters for all level measurements, differential pressure measurements, flow measurements of condensate, steam, feed-water, air, seal oil and hydrogen gas of generator, across APH for flue gas, PA & SA paths, across membrane sections of RO plant etc.

DP Type flow transmitter shall be used at MB outlet.

DP Type level transmitter shall be used at PSF backwash tank and DG water storage tank.

Redundant pressure transmitters shall be provided when it is used for compensation algorithms.

5.2.0 As a minimum the following temperature measurement points to be provided by the Bidder,

Temperature gauges at main process pump discharge, where there is a change of temperature in the process, inlet / outlet of heat exchangers, de-super heaters etc.

Temperature switches to be provided wherever temperature abnormality to be alarmed if RTD and T/C is not provided, wherever equipment / system to be tripped on high temperature if RTD and T/C is not provided.

RTD for measuring the motor winding/bearing & bearing temperatures of compressors. Also installed at the interstages of the compressors and cooling water inlet and outlets

Temperature switches shall be of liquid filled or vapor actuated system. The bulb shall be of stainless steel with SS armored capillary tube of adequate length for installation.

Temperature gauges at the Cooling water inlet and outlet and interstages of the Compressor

Temperature gauge at the silo fluidizing blower common discharge header.



RTD is used for measuring the motor winding /bearing & bearing temperatures of ash slurry pumps, HP pumps.

Temperature gauge at the inlet of RO skid.

RTD is used for measuring the motor winding /bearing & bearing temperatures of RO HP pumps.

Temperature transmitter at the inlet of RO HPP/ Inlet of cartridge filter.

Temperature transmitters shall be provided for all control applications.

Resistance temperature detector shall be provided for monitoring points where temperature changes occur, bearing/ winding temperature.

Thermocouple for monitoring points shall be provided where temperature changes occur.

Metal temperature measurement shall be provided for super-heater, re-heater and Boiler drum.

Thermo-wells for performance test point, RTD, thermocouple, temperature switch, temperature indicators.

Redundant temperature transmitters shall be provided when it is used for compensation algorithms.

For SH/RH temperatures, the temperature sensors wires having SS shrouding are laid up to the Junction box and the terminal head shall be placed nearer to the JB.

For measurement of boiler metal temperature, flue gas temperature, air pre-heater grid temperature etc., the bidder shall provide permanent/removable duplex type mineral insulated thermo-couples terminated in junction boxes at boiler platforms. Compensating cable connecting metal temperature sensor shall be SS shrouded till the JB with Teflon coating

For measurement of turbine metal temperature turbine casing temperatures, stator winding temperature, Generator seal oil system, Turbine bearing temperature, Turbine oil temperature, Turbine bearing drain oil temperature, BFP turbine measurement parameters, MDBFP measurement parameters etc., the bidder shall provide permanent/ removable duplex type mineral insulated thermocouple/ RTD terminated in junction boxes at respective turbine side floors.

5.3.0 Flow nozzles will be used for main steam flow, feed-water flow and other critical measurements where weld-in construction is required. Orifice plates will be used for other liquid flow measurements where flanged construction is acceptable.

As for the water flow/steam flow measurements, necessary flow elements/transmitters are chosen in the process line and supplied such that their algebraic summation shall be mass balanced for calculating the system efficiency.

Venturi arrangement for PA flow for each pulverizer. Triple impulse lines + one spare impulse line to be provided in HP&LP of venturi arrangement provided for the PA flow of each pulverizer.

Coriolis mass flow meter to be used for Fuel oil and Ultrasonic flow meters for CW.

Flow glass to be provided for coolant from equipment, coolant from the coolers.

Flow switches shall be installed at the cooling water outlet flow.



Flow switches at the ejector outlet line.

Rotameter at the Pressure Sand Filter inlet, cartridge filter inlet Side Stream Filter inlet, service inlet of mixed bed and outlet of MCF – RO cleaning

Ultrasonic type flow meter shall be used for parshall flume flow, common outlet of SSF, RO module permeate line.

Electro magnetic flow meter shall be used at the inlet of PSF outlet and RO high pressure pump inlet.

Flow glasses are installed at water/oil line to the compressors & at slurry lines of bottom ash handling

Flow switches at cooling water return line/oil line to the compressors.

Flow transmitter cum switch to be provided for lube oil flow to the bearings of all HT drives, APH bearings etc

Vortex flow meter at the discharge of the compressors

Desal product to RO/DM plant (WT Plant) shall be provided with the flow transmitters.

RO plant outlet, RO plant inlet and CST inlet shall be provided with flow meters

Variable area flow indicators to be provided at the common outlet header of the identical equipment, CW blow-down etc.

Flow switches to be provided at the common outlet header of the identical equipment.

5.4.0 Guided wave radar type level transmitters shall be used for condenser hotwell level, LP heaters, Deaerators, CBD and low pressure applications.

Radar type level transmitters shall be used for condensate storage tank

Non contact redundant ultrasonic type level transmitters for CW forebay, RW reservoir etc

Differential pressure transmitters will be used for general service level measurement of all separators, feed-water heaters, de-aerators and other pressurised and vented tanks.

Transparent gauge glasses will be used for low-pressure applications. Level gauges shall be provided for all surface mounted overhead tanks, hotwell, de-aerator and any other storage tanks.

Level switches shall be provided for lube oil reservoir of HT drives, for all tanks/sumps for low and high alarm, for all tanks /sumps for low low signal used for tripping the pump, for all tanks/sumps for adequate signal used for starting the pumps.

Level switch shall be used in the water cooling tower and expansion tank level.

Level transmitters shall be provided for hotwell, de-aerator feed tanks, blowdown tank, turbine main oil tank, condensate storage tank, DM storage tank, clarified water storage tank, sumps, Stator water tanks, expansion tanks etc.

Ultrasonic type level transmitters are used for clarified water storage tank, chemical storage and dosing tanks, DM water storage tank, sludge pit, RO Reject water storage tank and neutralization pit.



Radar Level transmitters are installed at the bulk acid storage, acid dosing tank.

Non contact type Ultrasonic level transmitters shall be used for CW sump level, CW fore bay, Raw water reservoir, water sump/tank etc

Level indicator at the ash conditioner water /drain sumps, ash water tanks

Level switch at the ash conditioner water /drain sumps

Level switch at the sump, tank of the dust suppression system.

Ultrasonic type level transmitters for ash slurry sump, ash water tank application.

Radar Level transmitters are installed at the fly ash silo

Continuous level measurement for unit coal bunker and other bunkers of Coal handling system shall be provided with two (2) numbers of radar type level transmitters for each bunkers with IP 65 protection for each bunker level measurement. Bunker level shall be monitored in Travelling tippler floor and CHP control room/ DCS. Radar type level transmitters shall be FMCWR type with drop in antenna and being operated at 24-26GHz.

RF Level switch are installed at the hoppers, fly ash silo

Open channel flow measurement at upstream of RO/Water treatment plant (before stilling chamber)

5.5.0 The following analyzers to be provided as a minimum in the pre-treatment/ RO–water treatment and other services.

Turbidity and free residual chlorine at the clarifier outlet

ORP, pH, SDI at RO plant inlet

Conductivity at RO membrane outlet

Chlorine analyser at pressure sand filter and degasser outlet.

Cation conductivity, specific conductivity, pH at SAC/SBA outlet

Conductivity, Silica, pH at Mixed bed outlet.

Dew point meter shall be installed at the outlet of air dryer to measure the quality of air.

pH at Cooling tower blow down to sea

Chloride and other requirements as per the statutory norms at Cooling tower blow down to sea

Vibration switch shall be provided to monitor vibration of Axial Flow Fan-Gear box assembly of wet cooling tower.

Airstat (Flow switch) is used to measure the air flow in the supply duct.

Humidistat used to measure the return air humidity.

Zero speed switches shall be provided for protection of the rotary vane feeder

Pull cord switches shall be provided for the conveyor protection



Zero speed switches shall be provided for protection of the conveyor

The belt sway switches to identify the misalignment of conveyor

Speed measurements for all HT drives having hydraulic coupling

Speed measurements for all HT drives having hydraulic coupling and VFD equipments.



VOLUME – II
SUB-SECTION 4.4
CODES AND STANDARDS

1.0.0 CODES AND STANDARDS**1.1.0 Temperature Measurement**

- a) Instrument and apparatus for temperature measurement – ASME PTC 19.3
- b) Temperature Measurement Thermocouples – IEC 60584 – 3 / ANSI – MC 96.1 – 1982.
- c) Thermometer-element-Platinum resistance – IEC 751 / DIN 43760.

1.2.0 Pressure Measurement

- a) Instrument and apparatus for pressure measurement – ASME PTC 19.2.
- b) Instrument Accuracies - IS 3624 / ASME

1.3.0 Flow Measurement

- a) Instruments and apparatus for flow measurement (Flow nozzle assembly)- ASME PTC 19.5 (1972) Interim supplement, Part-II, BS 1042.
- b) Instruments and apparatus for flow measurement (Orifice plate)- ISO 5167 Part – 1 / BS 1042.

1.4.0 Electronic Measuring Instruments and Control Hardware

- a) Automatic null balancing electrical measuring instruments – ANSI C 39.4.
- b) Safety requirements for electrical and electronic measuring and controlling instrumentation – ANSI C 39.5 / 1974.
- c) Compatibility of analog signals for electronic industrial process instruments ISA-S 50.1: ANSI MC 12.1.
- d) Dynamic response testing of process control instrumentation – ISA –S26.
- e) Surge withstand capability (SWC) tests – ANSI C37.90.1-1989 / IEC-255-4.
- f) Electro-Magnetic Compatibility Tests – IEC 801
- g) Tests for electronic equipments – IEC 68
- h) RF compatibility standard-IEC 61000
- i) Safety Integrity level – IEC 61508
- j) Electronic Cards, Subassemblies and Components

- a) Unpackaged

i)	Vibration	:	IEC-68.2.6
ii)	Shock	:	IEC-68.2.27
iii)	Drop & Topple	:	IEC-68.2.31

- b) Packaged

Vibration, Drop & Static Compression - NSTA

- c) Electromagnetic Compatibility

i)	Electrical Fast Transient	:	IEC-801.4
ii)	Surge Withstand	:	IEC-255.4
iii)	Radiated Electromagnetic Field	:	IEC-801.3
iv)	Electrostatic Discharge	:	IEC-801.2
v)	Electromagnetic Emission	:	VDE 0871, Class B

**1.5.0 Enclosures**

- a) Classification of hazardous area – IEC 79
- b) Degree of protection for enclosures – IEC 60529.
- c) Electrical Instruments in Hazardous Area – ISA RP 12.11
- d) Purged and pressurized enclosure for electrical equipment in hazardous location – NFPA Article 496 Volume-4, 1978.
- e) Environmental conditions for process measurement and control systems – ISA S71.04
- f) Classification of hazardous area - NFPA Art. 500, Vol.70-1984.
- g) Electrical Instruments in hazardous dust locations - ISA-RP 12.11
- h) Intrinsically safe apparatus - NFPA Art.493 Vol.4.1978
- i) Purged and pressurized enclosure for electrical equipment in hazardous location - NFPA Art. 496 1982.

1.6.0 Sampling System

- a) ASME PTC 19.11 Steams and Water Sampling, Conditioning, and Analysis in the Power Cycle.
- b) Stainless steel material of tubing and valves for sampling system - ASTM A269-82 Gr TP316.
- c) Submerged helical coil heat exchangers for sample coolers ASTM D 11-98.
- d) Water and Steam in power cycle - ASME PTC 19.11(2008).
- e) Standard methods of sampling system - ASTM D 1066-69.

1.7.0 Interlocks, Protections, Symbols

- a) Turbine water damage prevention – ASME-TDP-1-1980.
- b) Boiler safety interlocks – Applicable NFPA 85 sections.
- c) Instrumentation Symbols and Identification– ISA – S5.1.
- d) Binary logic diagrams for process operations – ISA – S5.2.
- e) Graphic symbols for distributed control/shared display instrumentation – ISA – S5.3
- f) Relays and relay system associated with electric power apparatus - IEEE std.3.13.
- g) Surge withstand capability tests - ANSI C.37.90a - 1974 and IEEE Std. 472 - 1974.
- h) General requirements & tests for switching devices for control and auxiliary circuits including contactor relays - IS-6875 (Part-I) 1973.

1.8.0 Annunciations

- a) Specifications and guides for the use of general-purpose annunciations – ISA RP 18.1.

1.9.0 Control Valves

- a) Control Valve Sizing – ISA-75.01.
- b) Control Valve capacity test – ISA-75.02.
- c) Face to face dimensions of Control Valves – ANSI B16.10.
- d) Control valve seat leakage classification – ANSI / FCI 70.2
- e) Valves flanged threaded and welding end - ASME B 16.34

1.10.0 Cables

- a) Thermocouple extension wires / cables – ANSI MC96.1.
- b) Colour coding of Instrument cables – BS-5308, Part-2.
- c) Specification for PVC insulated cables – IS 5831 / 8130/ 1554/ 10810 / equivalent IEC standards.
- d) Guide for design and installation of cable system in power generating station (insulation, jacket materials) IEEE Standard 422 / NEMA VE-1, and NEC.
- e) FRLS tests - IEC 332 / IEC 754 / IEEE 383 / SS-4241475 / ASTM D2863/ 43



- f) Requirements of vertical tray flame test – IEEE 383.
- g) NFPA 70.
- h) IS 13882 : Optical Fibre Cable
- i) Oxygen index test as per ASTM D 6863
- j) Temperature index test as per ASTM D 6863
- k) Smoke generator test as per ASTM D 6843
- l) Drum for electrical cables .
- m) Acid gas generation test as per IEC754-1
- n) Swedish Test as per SEN 4241475

1.11.0 Instrument testing

Safety Requirement For Electrical and Electronic Measuring And Controlling Instruments as per ANSI C 39.5 – 1974

1.12.0 Process connection and tubing

Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service as per ASTM A 269

- a) Codes for pressure piping power piping ANSI B31.1
- b) Seamless carbon steel pipe ASTM A-106.
- c) Forged and Rolled Alloy steel pipe flanges, forged fittings, valves and parts - ASTM A-182.
- d) Material for socket welded fittings - ASTM A-105.
- e) Seamless ferrite alloy steel pipe - ASTM A-335.
- f) Pipe fittings of wrought carbon steel and alloy steel - ASTM A-234.
- g) Composition bronze or metal castings - ASTM B-62.
- h) Seamless copper tube, bright annealed ASTM B-168.
- i) Seamless copper tube - ASTM B-75.
- j) Dimensions of fittings - ANSI B-16.11
- k) Valves flanged and butt welding ends - ANSI B16.34.
- l) Nomenclature for Instrument tube fittings ISA-RP-42.1 - 1982.
- m) Seamless carbon steel pipe - ASTM - A106.
- n) Material for socket weld fittings - ASTM - A105.
- o) Dimensions of fittings - ANSI B16.11
- p) Code for pressure piping, welding, hydrostatic testing - ANSI B31.1.

1.13.0 Annunciations

Specifications and guides for the use of general-purpose annunciators - ISA RP 18.1.

1.14.0 DCS and other Control system

a. Interlocks, protections, symbols

- Instrumentation Symbols and Identification– ISA – S5.1.
- Binary logic diagrams for process operations – ISA – S5.2.
- Graphic symbols for distributed control/shared display instrumentation – ISA – S5.3
- Instrumentation Loop Diagram - ISA-S 5.4
- Graphic Symbols for Process Displays - ISA-S 5.5
- Functionally Safety – Safety Instrumented system of process section – IEC 61151
- Fossil fuel power plant steam turbine bypass system – ANSI/ISA – 77.13.01
- Human system interface design review guide lines – NUREG - 700

b. Communication system

- Logical link control - IEEE 802.2
- Local Area Network: CSMA/CD Access Method and physical layer - IEEE 802.3
- Local Area Network: Token Passing Bus Access Method - IEEE 802.4



- Information Processing System – Open System interconnection,
 - Basic Reference Model and connectionless Mode transmission - ISO 7498
 - Internal organization of network layers - ISO 8648
 - For power system monitoring, control and associated communications. - IEC 60870 - 5-101
- c. Hardware Testing of Digital Process computers - ISA RP-55.1- 1983**
- d. Standard Digital Interface For Programmable Instrumentation - IEEE - 488.2 - 1990**
- e. Electromagnetic compatibility Tests –**
- Voltage and current surge – IEC 1000-4-5, EN 61000-4-5,
 - Fast transient bursts – IEC 1000-4-4, EN 61000-4-4,
 - Damped oscillatory wave – IEC 1000-4-12, EN 61000-4-12,
 - Ring wave – IEC 1000-4-12, EN 61000-4-12.
- f. Electrostatic discharge Tests – IEC 1000-4-2, EN 61000-4-2**
- g. Magnetic and Electromagnetic fields –**
- Power frequency magnetic fields – IEC 1000-4-8, EN 61000-4-8,
 - Pulse magnetic fields – IEC 1000-4-9, EN 61000-4-9,
 - Damped oscillatory magnetic field – IEC 1000-4-10, EN 61000-4-10,
 - Ring wave – IEC 1000-4-12, EN 61000-4-12.
 - Radiated radio-frequency electromagnetic field – IEC 1000-4-3, EN 61000-4-3,
 - Immunity to conducted disturbances, induced by radio- frequency fields – IEC 1000-4-6, EN 61000-4-6,
- h. Emission test RF radiated fields – CISPR 11/EN 55011.**
- 1.15.0 Instrument switches & contacts – BS 6134**
- 1.16.0 Cable trays & conduits - IEEE 422 / NEMA VE-1 / NFPA-70**
- 1.17.0 Surge protection system**
- Surge Withstand capability Test as per ANSI C 37.90.1 (1989), R1994
- 1.18.0 Sample coolers for SWAS - ASTM D 11**
- 1.19.0 Others**
- Printed Circuit Boards – IEC 326 C
 - General requirements and tests for printed for wiring boards – IS 7405 (Part 1)
 - Edge socket connections – IEC 130 – 11
 - Dimensions of attachment plugs & receptacles ANSI C73/1973
 - Direct acting Electrical indicating Instruments IS 1248/1968
- 1.20.0 NFPA 72 – National fire alarm code (Latest edition)**
- In addition to the codes and standards specifically mentioned in the relevant technical specifications for the equipment / plant / system, all equipment parts, systems and works covered under this specification shall comply with all currently applicable statutory regulations and safety codes of the Republic of India, as well as of the locality



where they will be installed, including the following:

- Indian electricity act
- Indian electricity rules
- Indian Explosives Act
- Indian Factories Act and State Factories Act
- Indian Boiler Regulations (IBR)
- Regulations of the Central Pollution Control Board, India
- Regulations of the Ministry of Environment & Forest (MoEF), Government of India
- Pollution Control Regulations of Department of Environment, Government of India
- State Pollution Control Board.
- Rules for Electrical installation by Tariff Advisory Committee (TAC).
- Building and other construction workers (Regulation of Employment and Conditions of services) Act, 1996
- Building and other construction workers (Regulation of Employment and Conditions of services) Central Rules, 1998
- Explosive Rules, 1983
- Petroleum Act, 1984
- Petroleum Rules, 1976
- Gas Cylinder Rules, 1981
- Static and Mobile Pressure Vessels (Unified) Rules, 1981
- Workmen's Compensation Act, 1923
- Workmen's Compensation Rules, 1924
- Any other statutory codes / standards / regulations, as may be applicable.

Unless covered otherwise in the specifications, the latest editions (as applicable as on date of bid opening), of the codes and standards given below shall also apply:

- Bureau of Indian Standards (BIS)
- Japanese Industrial Standards (JIS)
- American National Standards Institute (ANSI)
- American Society of Testing and Materials (ASTM)
- American Society of Mechanical Engineers (ASME)
- American Petroleum Institute (API)



VOLUME II
SUB-SECTION 4.5
PLANT CONTROL PHILOSOPHY

1.0.0 PLANT CONTROL PHILOSOPHY

1.1.0 The overall operation and supervision of the SG integral & its auxiliaries, steam turbine generators & its auxiliaries, balance of plant and associated electrical system shall be coordinated from the Central Control Room DCS.

1.2.0 The unit start-up and shutdown process shall be fully automated with the provision for manual initiation and intervention also. The extent of remote control and level of automation shall be such that minimum operator shall be capable of supervising and controlling the day to day running of the units from the CCR with little assistance from local operators.

1.3.0 Control and monitoring system for Steam Generator (SG) integral shall be provided through a Micro-processor based control system preferably from the same family of hardware from DCS. The control and protection system for SG integral shall have PTR (proven track record). If the SG integral control systems are proprietary controls and different from DCS, then SG integral control systems shall be interfaced to the plant DCS systems for bi-directional communication through redundant OPC based Ethernet links with TCP-I/P protocol suitable for monitoring/operation of the SG through DCS operator stations in central control room (CCR). In addition to the interface dedicated operator stations for CCR operation/monitoring (separate from DCS operator stations) of SG and auxiliaries shall be provided. SG integral, control and monitoring system shall be implemented in a redundant fail safe & fault tolerant configuration. Power supply modules, communication & network interface cards, controllers, I/O modules for controls and interlocks shall be redundant. Protection, controls system for SG to be implemented in two out of three voting logic. Apart from serial communication link signals interfaced with plant DCS, signals such as critical alarms, trip feedbacks, SOE, interlocks & controls, commands shall be hardwired. Safe shut down emergency stop push button shall be provided.

1.4.0 Control and monitoring system for Turbine Generator (TG) integral shall be provided through a Micro-processor based control system preferably from the same family of hardware from DCS. The control and protection system for TG integral shall have PTR (proven track record). If the TG integral control systems are proprietary controls and different from DCS, then TG integral control systems shall be interfaced to the plant DCS systems for bi-directional communication through redundant OPC based Ethernet links with TCP-I/P protocol suitable for monitoring/operation of the TG through DCS operator stations in central control room (CCR). In addition to the interface dedicated operator stations for CCR operation/monitoring (separate from DCS operator stations) of TG and auxiliaries shall be provided. TG integral, control and monitoring system shall be implemented in a redundant fail safe & fault tolerant configuration. Power supply modules, communication & network interface cards, controllers, I/O modules for controls and interlocks shall be redundant. Protection, controls system for TG to be implemented in two out of three voting logic. Apart from serial communication link signals interfaced with plant DCS, signals such as critical alarms, trip feedbacks, SOE, interlocks & controls, commands shall be hardwired. Safe shut down emergency stop push button shall be provided.

a) The following primary systems, in general, are to be controlled and monitored through the unit DCS:

i) Closed loops control system (CLCS)

1. Coordinated master control
2. Separator level controls



3. Furnace draft controls
4. SADC controls
5. Air flow controls
6. Mills air temperature controls
7. Feed water controls
8. Fuel flow controls, LDO/HFO Flow/pressure/temperature control
9. Soot blowing steam pressure control
10. Atomising steam pressure control
11. BFP speed control
12. BFP minimum recirculation
13. SH,RH steam temperature control
14. Auxiliary steam pressure & temperature controls
15. PA header pressure control
16. HP and LP bypass controls
17. De-aerator level, flow/steam pressure controls
18. CEP minimum circulation & Hot well level controls
19. LP,HP heater level controls
20. Any other controls for BTG auxiliaries
21. CBD level
22. Stator water expansion tank level

ii) Dosing system & CPU performance (chemical parameters to be maintained in super critical boiler).

iii) Group/subgroup and Drive level binary controls

Sequential control, interlock & protection for ID, FD & PA fans, Mills, De-aerator and regenerative cycles, Boiler feed pumps, boiler vents & drains, soot blower controls and other plant auxiliaries/Valve s/Dampers.

iv) Main plant electrical control system shall be controlled and monitored from plant unit DCS. Following main plant electrical system shall be controlled and monitored including necessary indications, annunciation and measurement in Unit DCS:

1. 400 kV Generator transformer breakers controls.
2. 22 kV System – Generator, Generator circuit breaker, Power transformers etc.
3. 33 kV, 11 kV and 6.6 kV with switchgear – Incomers, tie feeders, bus couplers and all outgoing feeders
4. 415 V unit switchgear (PCC & MCC) – Incomer and bus coupler.
5. Unit HT and LT transformers
6. Generator circuit breaker
7. DC system
8. UPS system
9. DG set

v) The following systems shall also be controlled and monitored from unit DCS

1. DM cooling water system
2. Condensate polishing unit
3. Condenser online tube cleaning system
4. Main Cooling Water System & Auxiliary Cooling Water System.

b) The following system shall be controlled and monitored from common DCS including all necessary indications, annunciation and measurement in common DCS.

- 11 kV and 6.6 kV switchgear – Incomers, tie feeders, bus couplers and all outgoing feeders
- 415 V switchgears (PCC and MCC) – Incomer and bus coupler.



- HT and LT transformers
- DG set

Sequence event recording/status of breaker and fault reporting of 33 kV, 22 kV, 11 kV, 6.6 kV, 415 V distribution system, diesel generator, 220V DC system, 230V UPS etc shall be included in plant DCS.

- c) The following systems shall also be controlled and monitored from the DCS through DCS Remote I/O units with the dedicated redundant controllers.

Controls of the offsite system are realized in the plant DDCMIS through RIO unit. Whereas the operation of the offsite system are from the LCR. However the monitoring and supervisory control is envisaged from CCR.

1. Fuel oil system
2. BOP utility systems like Desalination / water treatment plant, electro chlorination system, Waste water treatment plant, Sea water intake system, Sea water outfall system, Fire protection system, Hydrogen generation plant, coal handling system, Ash handling system, Mill reject system, Air conditioning & ventilation system, Compressed air system including the electrical system.

- d) Control and monitoring system for various balance of plant systems/equipments shall be specified in the below table:-

Sl. No.	System / Package	Control System	Control from		Interface with DCS	Remarks
			Local Panel / LCR	CCR		
1.	Coal Handling System	Controlled from plant DCS through Remote I/O	Yes	No		Common for two units
2.	Ash Handling System	Controlled from plant DCS through Remote I/O	Yes	No		Common for two units
3.	Desalination / WTP	Controlled from plant DCS through Remote I/O	Yes	No		Common for two units
4.	Sea Water Intake & Outfall System	Controlled from plant DCS through Remote I/O	Yes	No		Common for two units
5.	Electro static precipitator	Proprietary microprocess or based on Unit DCS based	Yes	No	Bi-directional fibre optic cable based OPC link with DCS for monitoring	Unitized system
6.	Compressed Air System	Proprietary microprocess or based on control system/DCS Controls	Yes	Yes	Compressors Start/Stop operation from DCS shall be provided through hardwired signals	Common for two units



Sl. No.	System / Package	Control System	Control from		Interface with DCS	Remarks
			Local Panel / LCR	CCR		
7.	Fire Detection & Alarm system	Microprocess or based analogue addressable type MFAP	-	-		Hardwired to DCS for monitoring
8.	Fire protection system (for fire water booster system)	Controlled from plant DCS through Remote I/O	Yes	No		Common for two units
9.	Condenser on-line tube cleaning system (if applicable)	Controlled from plant DCS	Yes	Yes		Unitized system
10.	Effluent and Sewage treatment plant	Controlled from plant DCS through Remote I/O.	Yes	No		Common for two units
11.	Air Conditioning (A/C) and Ventilation i) For air conditioning related to TG building and including ventilation. ii) For other off site Air conditioning requirements	i) Controlled from PLC with soft link connectivity to plant DCS. CCR. ii) Relay based Local Control panel/manufacture's skid mounted systems shall be provided.	Yes	No		Common for two units
12.	Mill Reject System	Controlled from plant DCS through Remote I/O	Yes	No		Common for two units
13.	Hydrogen Generation plant	Controlled from PLC with soft link connectivity to plant DCS	Yes	No		Common for two units
14.	Electro Chlorination System	Controlled from PLC with soft link connectivity to plant DCS	Yes	No		Common for two units
15.	DG Set	Local AMF (Auto main failure) panel.	Yes	No	Hardwired to DCS for control and monitoring	Common for two units



Sl. No.	System / Package	Control System	Control from		Interface with DCS	Remarks
			Local Panel / LCR	CCR		
16.	Fuel oil unloading, forwarding /pressurizing and heating system	Controlled from plant DCS through Remote I/O	Yes	Yes		Common for two units
17.	CW system	Controlled from DCS through Remote I/O	Yes	Yes		Unitized system
18.	Service and potable water system Note - 1	Controlled from DCS through Remote I/O	Yes	No		-
19.	Stack emission monitoring system	Stand alone system	-	-	Hardwired to DCS for monitoring	Common for two units
20.	Ambient air quality monitoring system/Meteorological monitoring system	Data acquisition system with PC	-	-	Hardwired/Serial interface to DCS	Common for two units
21.	Station common electrical system	Controlled from plant DCS	No	Yes		Hardwired and Soft link interface to DCS
22.	Switchyard	Standalone control system	Yes	No	Redundant link with DCS	Common for two units
23.	Condensate polishing unit	Controlled from plant DCS	Yes	Yes		Unitized system

Note – 1: Service and potable water system shall be controlled from the common operator stations of Desalination /WTP plant in the local control room.

e) Steam and Water Analysis System (SWAS)

Analyzer output signals for steam and water analysis parameters will be directly monitored in plant DCS.

f) Stack emission monitoring system (SEMS) & Flue gas measurement system

All Flue gas measurement system and Stack emission monitoring system parameters shall be directly monitored in plant DCS.

g) Electrical Numerical relays

Numerical relays / power meters of the generators, switchgear / MCC's shall be interfaced to Electrical Monitoring System (EMS). The EMS shall be interfaced with DCS through suitable protocol.

h) Electrical System

Control and monitoring of complete unit and station electrical system including 33 kV /11 kV /6.6 kV /415 V switch gears with check synchronizing, 400 KV GT breaker, GCB, UPS, OLTC of transformers shall be provided in the plant DCS. As a minimum remote position, service position, breaker health, permissive for interlock set, breaker status, relay healthy, trip coil healthy, lock out relay status, control supply healthy, switchgear disturbance shall be considered as input to the DCS system.

Control of generator excitation and governor system shall be possible from plant DCS including mode and manual selection, set point control for various parameters and auto-synchronizing of generator.

Soft selector switch for selection of operation of equipment either from the plant DCS or hard wired panel shall be provided in the DCS system.

Sequence of Event logging shall be provided in plant DCS with a time resolution of 1 ms with first up feature for all manual operations and relay operations as detailed below:

- Status of each breaker of all equipment being controlled, isolators and earth switches.
- Close and open commands
- Selector switch positions
- Each protective relay, trip relay, alarm relay operation. Event logging for each phase shall be provided wherever applicable (eg. 3-poles of line circuit breaker, distance relay output contacts, generator protections, fuse fail alarm, etc.)

Trending of parameters during disturbance shall be with a resolution of 0.5/1.0 sec., and at 15 minutes during normal operation. The change from normal mode to disturbance mode shall be through threshold/gradient settings provided in the system for analog quantities and external binary signals obtained from selected protective relays. Capturing of momentary values of all these parameters shall also be possible triggered either by a protective relay or by a manual keyboard command.

i) Switchyard system

The entire switchyard shall be controlled & monitored from switchyard SCADA system. This SCADA shall be interfaced with Plant DCS system through suitable protocol.

j) Interface, monitoring & design requirements

SG & STG control system (if not integral to DCS) shall interface through OPC based Ethernet TCP/IP protocol.

The Bidder shall provide MOD BUS/OPC/IEC Protocol as decided during detailed engineering to interface with other control systems (If SG and TG Integral is not part of DCS) like Turbine Governing system, Turbine Protection System and Burner Management System or FSSS”, DG set control system, ESP, TSI, ERP, MIS Server, Vibration monitoring & Analysis system, OCAMMS, AAQMS, Numerical protection Relays, EDMS, A/C System, Ventilation System, Fire Protection & Detection System, SWAS panel, Flame Monitoring System, Boiler Tube leak System, UPS, 24 V DC system, battery health monitoring system, Switchyard & Electrical system etc.

The Bidder shall include in his scope the relevant software & hardware for communication with the equipment/systems. Minimum of 30 nos. of gateways of bidirectional nature (20 Nos. redundant + 10 Nos. non redundant) shall be provided by the bidder for interfacing in DCS with other control systems. Above quantities is minimum & guaranteed but the exact requirements shall be finalised during detailed engineering.



Applications for redundancy & bidirectional shall be decided during Detailed Engineering. In addition HW signal interfacing shall also be provided for any signal required for interlock, control & protection.

The interfacing between two systems shall be effectively immune to the types of electrostatic and electromagnetic interference that can be expected in the power plants. To end this, If the control system is located in different building then the communication link cable for the OPC gateway shall be through fibre optic cable with necessary EI-Optical converter and de-converter units at both the ends and this special cable are in the scope of the bidder.

DCS system shall have suitable interface arrangement so that pre-selected plant parameters and process mimics can be viewed at selected nodes on the plant's local areas network (LAN) or wide area network (WAN) or from remote locations via dial up or internet connection.

The SG control system, STG control system, plant DCS will have feature for diagnosing faults up-to card/level and each channel in I/O card. The MMI between the operator and plant will be through TFT/KBD and mouse (or) large video screen, KBD & mouse.

In order to achieve the basic purpose of extensive monitoring of the Steam Generator & its auxiliaries, water-steam cycle, regenerative system, steam turbine & auxiliaries, unit & station electrical, complex control loops, interlock and protective logic system with sequence control and annunciation system shall be provided. The design of control system will take into account:

- Failure of sensors or transmitters
- Failure of controllers during automatic operation
- Loss of motive power to final element
- Loss of control power
- Minimum accidental mal-operation, and
- Any others as needed

k) **Station Blackout**

Availability of all equipments, drives, emergency power supplies, controls, logics required for the protection/safe operation/shutdown of the boiler/turbine and auxiliaries during emergency blackout shall be ensured by bidder. All the related drives, controls shall operate automatically on the occurrence of blackout. All such drives, controls required during emergency and black out shall be provided with continuous power supply source (each type of power supply depending upon requirements, sizing shall be done considering this requirements) to ensure availability and shall be designed for fail safe mode. All the required controls shall be available as the system to be powered from plant UPS. The UPS sizing shall consider this requirement.

2.0.0 DRIVE CONTROL PHILOSOPHY

2.1.0 Bi-Directional Drives (Inching or Open/Close)

All bi-directional drives are provided with non integral starters. All these drives shall be operable from Remote i.e. from Central Control Room (CCR) / local control panel. Local operation of the drives shall be possible through open / close push buttons in the MCC.

Necessary electrical protections shall be realized in the MCC, whereas process interlocks and protections shall be realized in DCS. Drive control philosophy shall be subject to approval by Owner during detailed engineering.



Following signal exchange shall take place between DCS & integral starter of actuator.

1. Valve open, close & stop commands.
2. Integral starter disturbance (Loss of power/control supply, Thermal O/L, Local/off/Remote S/S in Local or Off mode etc.)
3. Valve Status feed back by means of end position limit switch, torque switch contacts (open/close).
4. Position feed back (4-20 mA, two-wire electronic type) for inching drives.

The analog/digital commands shall be from redundant output cards.

Following signal exchange shall take place between DCS & valve actuator, DCS & MCC for the non- integral bidirectional drives

Between DCS & MCC

1. Valve open, close & stop commands.
2. MCC disturbed
3. Remote Selected
4. EPB operated.

Between DCS & Valve actuator

1. Valve Status feed back by means of end position limit switch, torque switch contacts (open/close).
2. Position feed back (4-20 ma, two-wire electronic type) for inching drives

For each contact/signal, independent wires shall be used for the cabling, ie. One terminal of each contacts/signals shall not be shorted to create a common terminal.

2.2.0 Unidirectional LT Drives

Unidirectional LT drives shall be operable only from Remote i.e. from CCR / local control room or panel. In addition, Local push button shall be provided for emergency stopping of drive.

Remote start / stop commands, generated in DCS / local control room or panel shall be wired to MCC through interposing relays housed in respective MCC.

Emergency stop of the drive shall be envisaged for selected applications from the local push button provided near the drive. The stop push button (Stay put type) shall be provided with a press to lock and turn to release type, keyless mechanism with a protection cover. Under locked position the drive operation is inhibited from remote. The local emergency stop pushbutton shall be wired directly to MCC.

Necessary electrical protections for the drive shall be realized at MCC, whereas process interlocks and protections are realized in DCS / local control room or panel.

Life saving equipments like lube oil pump shall have emergency ON push button at CCR and local which is directly connected to MCC to tackle any DCS controller failure

Following signal exchange shall be envisaged between MCC & DCS/ local control panel:

- Drive start & stop commands
- Drive On & Off feedbacks
- MCC disturbed (Thermal Overload relay operated, MCC control power supply fail, local PB operated)



The analog/digital commands shall be from redundant output cards.

Current measurement shall be provided in DCS / Local Control Panel for monitoring for all drives rated 30KW and above & for critical drive rated less than 30KW. The Current Transducers shall be 4 -20mA, isolated output type, provided in MCC. Auxiliary power supply to these transducers shall be from the control supply of the respective switchgears. The local start push button shall be connected to the DCS so that the drive can be started on checking the process permissive through DCS another contact of local push button (Stop) shall be connected to DCS for alarming LPB latched condition in DCS.

For each contact/signal, independent wires shall be used for the cabling, ie. One terminal of each contacts/signals shall not be shorted to create a common terminal. Two stop commands from independent two DO cards placed in different racks shall be paralleled upto UCR terminals for redundancy

2.3.0 Solenoid Operated Drives

Solenoid operated drives shall be operated from remote CCR / Local Control Panel. Local operation of these drives is not envisaged. All solenoid valves are powered at 24V unless otherwise specified.

Trip solenoid valves of BMS and Turbine protection system shall be of 220 V DC. The solenoid valves shall have two coil (latch and release coil) for nozzle valves, trip valves etc. And air lock relays are preferred

Remote open / close commands shall be generated from DCS / Local Control Panel and shall be issued to the solenoid through interposing relays in DCS / Local Control Panel. The contact rating of IPR in DCS/Local control panel shall match the impedance and current rating of solenoid coil in the field used for different services.

Necessary process interlocks shall be realized in DCS / Local Control Panel.

The following signal exchange shall be envisaged between solenoid operated drive and DCS / LCP.

Valve open / close command

Valve Status feedback from the drive by means of limit switches (wherever available) for process/logic.

For each contact/signal, independent wires shall be used for the cabling, ie. One terminal of each contacts/signals shall not be shorted to create a common terminal. Depending on application two open/close commands from independent two DO cards placed in different racks shall be paralleled upto UCR terminals for redundancy

2.4.0 Unidirectional HT Drives

The switchgear has two modes of operation i.e. "Service and Test".

'Service' mode is the normal mode of operation. In service mode, the drive is operable from the plant DCS/ local control room or panel.

The 'TEST' position is envisaged to test the switch gear from local during maintenance / commissioning

Remote start / stop commands, generated in DCS / local control panel shall be wired to switchgear through interposing relays housed in respective switchgear.



Local push button shall be provided for only emergency stopping of drive. The stop push button (Stay put type) shall be provided with a press to lock and turn to release type, keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop pushbutton shall be wired directly to switchgear.

Necessary electrical protection for drive shall be realized at switchgear, whereas process interlocks and protections are realized in DCS / local control room or panel.

Following signal exchange shall be envisaged between Switchgear and DCS / local control panel:

Drive start & stop commands

Drive status feedbacks by means of ON & OFF contacts (in service/test position of switchgear)

Master trip relay operated (Electrical trip).

SWGR disturbed (control power supply failure, trip coil unhealthy, local push button operated)

SWGR available (Breaker in service position, breaker spring charged, SWGR in remote)
SWGR Breaker in test position

The analog/digital commands shall be from redundant output cards.

Another contact of local push button (Stop) shall be connected to DCS for alarming LPB latched condition in DCS. Motor current – Current transducers 4 -20 Ma type shall be mounted in the SWGR for monitoring the current in DCS / local control panel. Auxiliary power supply to these transducers shall be from the control supply of the respective switchgears. For HT drives and driven equipment bearing temperature and motor winding temperature measurement shall be provided.

For each contact/signal, independent wires shall be used for the cabling, ie. One terminal of each contacts/signals shall not be shorted to create a common terminal. Two stop commands from independent two DO cards placed in different racks shall be paralleled upto UCR terminals for redundancy. In case of LOPs of fans/pumps, all oil pumps of turbine and auto start drives, the start command shall also be from 2 different DO cards for redundancy.

2.5.0 Analog Drive

Analog drive is hooked up & interfaced to DCS / Local Control Panel. A drive control function residing in Processing Units is used to position the pneumatically operated control valves. Interlock and protection Open / Close Commands originating from field or generated internally in control logics are interfaced with the drive control function residing in processors.

Control Valve actuator design shall take care of fail safe condition i.e. bringing valve to full open / full close or stay put mode, on signal air failure or air supply failure respectively.

Auto / Manual operator control and display for various control loop shall be provided.

MMI Control displays have the following functionality:

- Auto / Manual selection with control device “Raise / Lower Buttons”.
- Set point indication with “Raise / Lower Buttons”.
- Indication for deviation between set point and measured value.
- Measured value indication.



- Final control element position feedback indication.

For each contact/signal, independent wires shall be used for the cabling, ie. One terminal of each contacts/signals shall not be shorted to create a common terminal. Two output commands from independent two AO cards placed in different racks shall be paralleled upto UCR terminals for redundancy.



VOLUME - II
SUB-SECTION 4.6
SPECIFICATION FOR DCS

1.0.0 SYSTEM REQUIREMENTS

- 1.1.0 The following specification shall serve as a guideline to indicate the special requirements for the DCS. The plant control system configuration shall be as per Drawing No. 00-1115112-I-351.
- 1.2.0 The DCS must be capable of fulfilling all requirements of the plant in an optimal way. The offered system shall have been in satisfactory operation for at least three years in plant having capacity of 500MW or more and confirm guarantee against obsolescence for 15 years. The DCS offered shall be of the latest design. The operating system shall be based on windows platform (Windows XP or better) with latest service packs.
- 1.3.0 For designing the system all the specification requirements shall be considered, where applicable. All components and systems offered by the Bidder shall be of established reliability. The maximum reliability shall be achieved by the Bidder considering the meantime between failures (MTBF) and meantime to repair (MTTR) such that system will be available for 99.7% or better.
- 1.4.0 The operation of the plant DCS shall be based on simplicity and rapid access for monitoring and taking control actions.
- 1.5.0 Plant DCS to provide plant co-ordination for start-up, synchronization, normal load range, shut down and emergency operation of the plant in a coordinated sequence.
- 1.6.0 DCS will provide automatic supervisory control and pre-planned protective actions (run back, over-ride control, control mode transfer etc.) during upset conditions if the operator or normal modulating controls cannot be expected to provide a timely or adequate response.
- 1.7.0 The operation mode of the system must be conceived in such a manner that access to the process variables, motors and actuators shall be possible very quickly with only a few key strokes. In critical situations the switch from one display which supports operator control actions to another such display must be possible directly without the need to select additional intermediate displays. Systems are preferred which, in addition to the capability of taking control actions from dedicated displays; also provide the facility of taking such actions via graphic displays.
- 1.8.0 The operator station, LVS and other peripherals will perform control and monitoring functions including data archiving & alarm monitoring, dynamic graphic display for plant operation, Group display and trend group display, Real time and history trending of each loop, Alarm display and storing alarms for history, Multi window graphic display, Logging functions, Printing of system alarms, process alarms, graphics with dynamic reading and logging, operation of printing function will be continuous, scheduled and as well as on demand.
- 1.9.0 The following control system redundancy shall be considered,
- a) SG and TG integral
- The control, protection, and monitoring system shall be implemented in a redundant fail safe & fault tolerant configuration. Power supply modules, communication & network interface cards, controllers, I/O modules for controls and interlocks shall be redundant.



b) Plant DCS

Power supply modules, communication & network interface cards, controllers and serial interface to other control systems shall be redundant. Redundant Input and output modules shall be provided for all the drive level interface (both OLCS/CLCS). For the inputs, dual or triple measurement as described in Clause no. 2.1.0 of Section 4.8 and Clause no. 2.1.0 of Section 4.9 shall be provided. And the individual measurements (dual or triple) shall be wired to separate input modules. No redundancy at I/O card level is required which are executing purely Data acquisition/Monitoring functions. I/O's redundancy shall be truly redundant and not engineered I/O's. Logics for the redundant drives shall not be in the same processor.

- 1.10.0 A functional group control hierarchy will be devised for all major plant equipment and their auxiliaries to allow operator to select a lower level of certain system or equipment during trial runs, testing etc.

DCS system will comply with following general failure criteria:-

- a) No single fault can cause the complete failure of the control system.
 - b) No single fault can cause the Turbine/Boiler/Generator protection system control to malfunction or become inoperative.
 - c) The grouping of control functions into system blocks will be arranged such that failure of any one block will only partly degrade the control of the overall system. Such degradation will always be manageable by operator intervention. Functional grouping of controllers shall be subject to approval by Owner.
 - d) The control system will be structured to reflect the redundancy provisions of the plant so that no single fault within the control system can cause the failure of the duty equipment or make the standby equipment unavailable.
 - e) As a result of a control system fault, a plant item or control function will always respond to its controls at the actuator level. That item or control function will be required to be isolated from automatic control system.
- 1.11.0 To meet the above failure criteria, the DCS system will incorporate diagnostic/self-checking facilities so that internal faults can be detected within the system itself prior to any resulting disturbance to the process. In addition, the protection and safety systems will incorporate channel redundancy or diversity of measurement as well as self-checking and adequate test facilities. For some important systems, "On line" test will be employed with no effect to the proper functioning of the protection system.
- 1.12.0 In order to achieve high plant safety and availability, the control systems shall be functionally distributed, highly modular and in a hierarchical configuration. This guarantees that any faults arising in the control system will always be confined to a limited section of the plant. The hierarchical configuration shall enhance the transparency of the plant for the operating personnel, in particular when faults arise.
- 1.13.0 Essentially, the configuration as defined shall have the result that in the event of a fault in the control system, manual operations will be required only at one or very few locations at the same time.
- 1.14.0 Controllers will be 100% hot standby.
- 1.15.0 Protection signals shall always intervene at the bottommost control level, and thus always have priority over automatic and manual interventions. Parallel wiring of protection, control signals is preferred over transmission of protection signals by way of a data bus.



Concept for I/O assignment shall be as follows:

- a) No two identical / similar equipment shall be grouped in the same I/O module and in the same rack.
- b) Any one card shall have I/O related to only one equipment and auxiliary. If, any equipment and auxiliary requires more than one card, I/Os for related auxiliaries (e.g. LOP-A, LOP-B) shall be in a different card.
- c) I/O assignment shall be identical for similar/redundant equipment. For example if BFP A run is assigned to channel 3 of a card, BFP-B run shall also be assigned channel 3 of another card.

- 1.16.0 In case of control power interruption for a short time (seconds) the Systems must maintain the plant in operation and after power restoration no false commands shall be issued.
- 1.17.0 To avoid damage to the plant equipment in the event of a major failure in the Systems, a safe shut-down of the plant must be guaranteed.
- 1.18.0 OPC servers provided shall be dual hot redundant and be of OPC UA or higher version. The OPC shall support data access, Alarm & event, Historical data access and the Bidder shall match the OPC protocol with the other systems for time stamped transfers.
- 1.19.0 The system will be provided with extensive diagnostic features so that a system failure can be diagnosed down to the module level giving location and nature of fault. Ease of maintenance and trouble shooting will be a primary consideration in equipment selection. The interposing relays provided shall be with minimum 2NO+ 2NC contacts.
- 1.20.0 DCS system shall have suitable interface arrangement so that pre-selected plant parameters and process mimics can be viewed at selected nodes on the plant's local areas network (LAN) or wide area network (WAN) or from remote locations via dial up or internet connection. Bidder shall provide two PC and A4 laser printer (B/W) along with necessary software & internet connection at Owner's corporate office for remote monitoring.
- 1.21.0 On unit tripping, alerting the maintenance Engineers/ Management/Corporate office via Email facility should also be provided in unit DCS. Unit trip and major equipment trip SMS in communication system. On unit tripping about hundred Engineers shall be informed through SMS automatically from DCS through communication system. In case of tripping of major fans/pumps/HT drive the concerned Engineer configured in such a way to get the SMS information

However to protect against unauthorized access to network, sufficient security arrangement in the form of firewall or any other suitable hardware / software keys etc., shall be deployed.
- 1.22.0 Network Monitoring device/software shall be provided as a in built feature of DCS for both the main plant and BOP.
- 1.23.0 The power supply for all the DCS panels of unit, common and BOP shall be fed from redundant feeders of plant UPS system.
- 1.24.0 UPS for the DCS of unit, common and BOP shall be redundant with redundant feeders for powering to the DCS panels located at different locations.



2.0.0 SYSTEM COMPONENTS

2.1.0 Controller Sub-System

- 2.1.1 The automatic control functions of the system shall be executed by microprocessor based controllers. The multi loop controller shall have 1:1 hot redundancy in each processor, power supply, and communication controller shall be redundant. To ensure that the above security aspects are met, the primary controller shall be backed-up by another controller that takes over automatically when the primary controller fails. The control output shall be fed back to both the controllers to allow bump-less transfer to be accomplished.
- 2.1.2 The time taken for stand-by controller to take over in the event of failure of primary controller shall not exceed one scan cycle of the controller. The transfer shall be bump-less and procedure less.
- 2.1.3 The controllers shall be capable of performing regulatory control, sequencing and interlocking.
- 2.1.4 The controller shall be capable of performing the following output processing functions.
- a) Output open check
 - b) Output high/low alarm
 - c) Output high/low limiter
 - d) Output velocity limiter
- 2.1.5 The basic control functions shall include proportional, integral and derivative algorithms.
- 2.1.6 Advance control functions shall be inclusive of feed forward, Cascade control, high-low limit control, dead-time, lead lag, high-low signal selection, real-time computational capability etc. apart from other algorithms used in the plant DCS like feedback controls, Mean value and auto selection logic, bypass valve control, start-up/shut down curves.
- 2.1.7 The controller sub-system shall be capable of performing the following input signal processing functions like square root extraction, linearization for thermocouples, pulse train input function, line segment function, digital filtering, totalizer functions etc. as a minimum.
- 2.1.8 Controller shall be able to operate in either manual, auto, cascade mode. Mode change over in either direction shall be procedure less and bumpless.
- 2.1.9 Functional grouping of controllers shall be based on the Unit and Common DCS controller grouping drawing 00-1115112-I-351, Sheet 2 - 4. Conceptual drawing shall be referred for the grouping criteria and the number of controllers envisaged based on the density of I/Os for the plant capacity. Minimum number of redundant controllers for each unit DCS (excluding TMR system for BPS & TPS and the common DCS) shall be thirty five (35) numbers.(35 pair of controllers)

Station electrical in common DCS shall be assigned with minimum of three (3) pair of controllers. And the BOP systems shall be assigned with the required number of redundant controllers in the Remote I/O units in accordance with the I/Os requirement.

However the number of controllers and the grouping shall be as per the requirement evolving during detail engineering which shall be reviewed and approved by the Owner. No mixing of functional groups is allowed. If SG integral or TG integral controls are part of the plant DCS then separate controllers for each SG integral and TG integral to be envisaged.



The Controller allocation criteria shall be as per the following guidelines as minimum

- a. The Boiler management system shall be assigned with separate controllers
- b. The control logic of the mill shall be assigned in different controllers. Any one controller shall control maximum 2 mills.
- c. The control logic of A or B side air and flue system of shall be assigned in a different controller.
- d. The control logic of each BFPT pumps, forced draft fan, induced draft fan, primary air fan, condensate pump, circulating water pump, etc. shall be assigned in a different controller.
- e. The same side of the equipment shall be assigned in the same controller as possible such as A-side induced draft fan and A side forced draft fan which can be configured in a controller. Similarly B-side induced draft fan and B-side forced draft fan can be configured in another controller. A-side forced draft fan and B-side induced draft fan does not allow to be assigned in a controller
- f. Important auxiliary device shall be assigned in a different controller
- g. Left and right air-flue gas paths do not share the controller
- h. Left and right water paths do not share the controller.
- i. Those auxiliaries who are common to both paths will be resident in the controller other than those used for left/right paths so that both paths will not be lost due to the failure of a processor.
- j. The Air and Water paths do not share controllers
- k. Unit and station electrical shall be assigned in a separate controller.
- l. Redundant components and equipment within given systems shall be distributed among processors and I/O cards to the extent possible
- m. Critical inputs shall be supplied with redundant sensors/transmitters with each input connected to different input cards. Where redundant inputs exist, the DCS shall be configured to automatically reject erroneous data. Where required, one-of-two, two-of-two, two-of-three, or median select schemes shall be utilized to ensure the integrity of critical inputs.
- n. Wherever there is a process redundancy (Left/Right or Running/Standby) or transmitter/switched redundancy available, such inputs shall be routed through independent input cards.
- o. No two control loops/interlock loop shall share the inputs (either binary or analog) vide input cards if process signals are independently available. Protective inputs for two drives shall not be allotted to the same input card.
- p. In case inputs / outputs are required from one logic to another, they can be soft wired, provided if they are on same processor. For those inputs/outputs resident on other processors, the same shall be hardwired.
- q. Critical inputs and outputs in CLCS shall be connected to redundant AI/AO cards

2.1.10 The grouping of control loops in controllers shall be done based on the input / output (I/O) handling capacity of the individual controllers such that the system availability in the event of



loss of one controller is more than 50% (i.e., whenever there is more than one similar equipment ex.: Feed water pump, necessarily the two shall be implemented in different controllers).

- 2.1.11 The controller shall be capable of carrying out following alarm check functions:
- a) Input open/output open check
 - b) High high, high, low and low low alarms
 - c) Velocity and deviation alarms
 - d) Alarm hysteresis
 - e) Alarm bypass
 - f) Alarm output off.
- 2.1.12 The system shall be capable of sending the following messages to the operator interface sub-system:
- a) Self-diagnostic alarms
 - b) Process alarms
 - c) Loop status changes
- 2.1.13 The controller shall have facility for slow and fast ramping of set point and output. Also all controllers shall have anti-reset wind up as a standard.
- 2.1.14 Two separate DO cards are to be used to de energies the solenoid coil by relatching for high reliability on safety of system.
- 2.1.15 The remote I/O panel shall be provided with redundant processor, redundant power supply unit and redundant communication modules etc., on as required basis for the measurement of boiler metal temperature, flue gas temperature, air pre-heater grid temperature etc. The remote I/O panel shall be provided with I/O cards, redundant power supply unit and redundant communication modules etc. These parameters are brought to DCS via DCS I/O bus or via redundant soft link (either TCP/IP on OPC or MODBUS with RS485) to have real time data. This remote I/O panel shall be powered from redundant UPS or 24V DC source of respective unit of respective unit. The unit enclosure shall be of weather proof, dust tight and water proof. Bidder shall provide necessary air conditioning unit, if required for the system. This panel shall also accommodate 4-20 mA and RTD signals for monitoring parameter and not for control. The quantities of remote I/O panels shall be decided during detailed Engineering. For connecting remote I/O units with plant DCS and connecting BOP system to the plant DCS, Single mode fibre optical cable with converter, de-converter, termination etc shall be provided.
- 2.1.16 Remote I/O panel shall be provided with redundant processor, redundant power supply unit and redundant communication modules etc., on as required basis for the measurement of turbine metal temperature, turbine casing temperatures, stator winding temperature, Generator seal oil system, Turbine bearing temperature, Turbine oil temperature, Turbine bearing drain oil temperature, BFP turbine measurement parameters, MDBFP measurement parameters etc. The remote I/O panel shall be provided with I/O cards, redundant power supply unit and redundant communication modules etc. These parameters are brought to DCS via DCS I/O bus or via redundant soft link (either TCP/IP on OPC or MODBUS with RS485) to have real time data. This remote I/O panel shall be powered from redundant UPS or 24V DC source of respective unit. The unit enclosure shall be of weather proof dust tight and water proof. Bidder shall provide necessary air conditioning unit, if required for the system. This panel shall also accommodate 4-20 mA and RTD signals for monitoring parameter and not for control. The quantities of remote I/O panels shall be decided during detailed Engineering. For connecting remote I/O units with plant DCS and connecting BOP system to the plant DCS, Single mode fibre optical cable with converter, de-converter, termination etc shall be provided.

**2.2.0 Data Acquisition Sub-System**

- 2.2.1 Data acquisition subsystem shall have dual redundant processors, power supplies and communication including cables. I/O redundancy is not envisaged. All other accessories as required to make the system complete shall be provided.
- 2.2.2 Data acquisition sub system shall cater to both analog and discrete inputs from open loops. The inputs shall include 4 20Ma DC, thermocouples, resistance temperature detectors (RTD), voltage signals, resistance signals and discrete contacts, as a minimum.
- 2.2.3 The data acquisition system shall be capable of performing the following alarm check functions as a minimum:
- a) Input open check
 - b) Velocity alarm check
 - c) Deviation alarm check
 - d) High/low/high high/low low limit alarm check
 - e) Alarm bypass
- 2.2.4 The sub-system shall be capable of processing linear and non-linear analog inputs, linearization for thermocouples and RTD inputs, square root extraction, totalizing of inputs and burn out protection for thermocouple inputs.
- 2.2.5 All open loops analog inputs used in DAS shall be scanned at a maximum of 250 ms interval.
- 2.2.6 It shall be possible to display all variables of the data acquisition sub system on the operator consoles by addressing from the keyboard.

a) Man Machine Interface

- i) Operator's interface sub-system shall have industrial type high resolution color LED flat panel of screen size 24". Resolution shall be minimum 1920 X 1200 resolution pixels. Each operator interface sub-system shall consist of electronics, Qwerty keyboard with special function keys, mouse or trackball, LED with antireflection features, offered with the latest configuration such that the system will not slow down while processing multiple tasks. The most current release of fully tested hardware shall be supplied. The features and the configuration for all the stations in the power project shall be reviewed and approved by the Owner.
 - ii) Large video screen (LVS) shall ensure operation even if the operator stations fail. LVS shall consists of DLP REAR projection 84" displays suitable for 24/7 application with anti reflection feature and resolution of not less than SXGA, image processors, controllers with the plat form compatible with the DCS.
 - iii) Commands through mouse operation on individual LVS by the operator to unit control systems shall be possible. Similarly for all other LVS of BOPs and CHP, commands to respective control system through mouse action on LVS by the respective operators shall be possible.
 - iv) 21 Nos. of Digital display units are required to display Total MW and this will get the total MW data on modbus TCP/IP. The digit size of the display unit will be 300 mm for 6 Nos. and 200 mm for 15 Nos. The location shall be decided during detailed Engineering.
- 2.2.7 The operator, as a minimum, shall have access to all the displays, acknowledge alarm as and when they are annunciated on the operators' console, special function keys for single stroke operation to have direct access to any parameter assigned, Auto/manual/cascade/computer



mode changeover of each controller with bump less transfer from one mode to another, facilities for slow and fast ramping of set point and output of each close loop parameter.

- 2.2.8 Access to changing control parameters, alarm limits and security level shall be through limited passwords or key lock system.
- 2.2.9 The sub-system shall be provided with highly reliable and field proven Hard Disks for storing of complete system software and operational data with minimum 30% spare capacity. Suitable battery back-up shall be provided for protection of volatile memory (for 72 hours).
- 2.2.10 The system shall be also equipped with the external DVD/CD drive as a back-up device. The external DVD/CD drive shall have read/write capability and shall be provided with all required hardware interface including error detection and correction facilities.

Features shall include the following

- i. Supported Formats: DVD+R, DVD+RW, DVD-R, DVD-RW, DVD-ROM, DVD-video, CD-R/RW, CD-ROM/XA, CD-ROM, Audio CD, VCD, CD-I(FMV), Photo CD, CD-EXTRA, CD-TEXT
 - ii. Write Speed: 8x DVD+R, 4x DVD+RW, 24x CD-R, 16x CD-RW
 - iii. Read Speed: 24x CD-ROM, 8x DVD-ROM
 - iv. Compliant with USB 2.0 High-Speed (480Mbps)
 - v. Bootable on OWSs/Laptops
 - vi. Memory buffer size: 2MB minimum.
 - vii. Powered by an additional USB power cable for best speed. (Requires one more USB port available)
 - viii. Can be powerless (only connected by the USB data cable).
 - ix. Plug & Play and hot pluggable.
 - x. Portable Design. .
- 2.2.11 In case the proprietary design/architecture of the manufacturer calls for separate Application/History processor for intensive computation, operation and bulk memory storage, the same shall be provided separately as application/history processor station with redundancy.
- 2.2.12 All the operator keyboards shall be interchangeable. All operator stations shall be identical and fully interchangeable. It shall be possible to carry out control/monitoring of total plant from any of the station and any station can be assigned for control/monitoring of any particular part of the plant. Any change made for any parameter for an input from any display shall be automatically updated on all displays configured for that input. Bidder to ensure that, any single failure in MMI hardware/software including controller, coupler, interfacing devices, cables etc. shall not lead to non availability of more than one operator station. The Operator station shall also include diagnostic functions that automatically detect process faults.
- 2.2.13 The Operator station must provide enough information under abnormal or hazardous conditions caused by failures in plant equipment or in the instrumentation and control system to allow the operator to identify the equipment causing the trouble, take measures to correct it, and move the process back to its normal operating state.



- 2.2.14 To determine whether it is the instrumentation and control equipment that is causing the problem, the Operator station should provide the following diagnostic features and make the results of diagnostic tests available to the operator:
- a) Ongoing tests and reasonable checks on the sensors and analyzers that measure the process variables of interest.
 - b) Ongoing self-tests on the components and modules within the distributed control system itself: controllers, communication elements, computing devices, and the human interface equipment itself.
 - c) Simulation of process variables shall be possible.
- 2.2.15 The engineering station configuration will be as same of that of the operator interface system except for the keyboard which shall be QWERTY type. The engineering station shall have provision for performing the following engineering functions.
- a) Database configuration including configuration of all displays and loops for various sub-systems.
 - b) Automatic downloading of the configurations in each sub-system.
 - c) Configuration of various control functions or control blocks to implement various control strategies and downloading the same into the respective control stations.
 - d) Configuration/reconfiguration of alarm settings, their values, addition/deletion of alarm from groups, controller tuning like changing P,I,D values, dead time values etc.
 - e) Defining the key lock functions or engineer keyboard functions.
 - f) On-line compilation of all types of dynamic graphic displays.
 - g) Setting of real time clock.
 - h) Plant/group alarms inhibit function.
 - i) Start/stop of each sub-system, including printers.
 - j) Enabling/disabling of different instruments/ peripheral connected to the system.
 - k) Scan-on /off-scan of different tags connected to the system.
 - l) Preparation and compilation of logs/reports/ historical trend points.
 - m) Calling of detailed self diagnostic displays for maintenance aid.
 - n) Loading, editing, compiling and executing of all programs written using high level languages supported by the system.
 - o) Performance calculation and load calculation using standard high level languages and using the real time data available on the DCS highway. It shall be possible to view the plant performance in any of the operator and MIS stations also.
- 2.2.16 Online configuration changes shall automatically update all modules, tags and subsystems affected by the change. Online configuration changes shall follow a prompt- validation sequence requiring a final acknowledgement step before the change is transmitted.



- 2.2.17 It shall be possible to save all database and configuration data on both removable and non-removable media for back up purposes without taking the system off line. It shall be possible to down load the data bases and configuration data to all modules from a single location.
- 2.2.18 Each analog input/output and analog control block shall be assigned an engineering unit. Engineering unit shall be a minimum of 6 free format alphanumeric characters. Engineering unit shall be automatically displayed along with the variable. System shall accommodate user configurable engineering units.
- 2.2.19 Printers shall be network printers and shall be freely assignable. All the printers shall be of heavy duty industrial grade. Printers shall be provided for printing of various events, shutdown reports etc. and making hard copies of various displays/ graphics, log reports, sequence of event recording etc. as given below:
- a) One Nos. Color laser A4 size printers for DCS alarm/etc
 - b) One No. dedicated 132 column dot matrix printer for SOE
 - c) One No. colour Laser printer A3 size for DCS graphics.
 - d) One No. color Laser A4 size printer for Shift-in-charge.
 - e) Two (2) nos of 132 column high speed line printers for post and pre trip logs, data base etc.
 - f) One no. Engineering station with one no. color laser A3 size heavy duty printer for unit DCS. Another Engineering station with one no. A3 size scanner, copier cum heavy duty i printer shall be provided for unit DCS
 - g) One no. Engineering station with one no. color laser A3 size heavy duty printer for common DCS. Another Engineering station with one no. A3 size scanner, copier cum heavy duty printer shall be provided for common DCS
 - h) One no. monochrome laser A3 size heavy duty grade B/W printer for station in charge

2.2.20 Displays and Logs

Displays and logs related to the turbine-generator system are indicated as below:

- (1) Real Time Parameter/Status Display (default screen).
- (2) Real Time Trend/Historical Trend graph display, print out (on demand).
- (3) Alarm summary display/print out (on demand).
- (4) Alarm limit display / print out (on demand).
- (5) Turbine Start-up log/print out (event actuated).
- (6) Shift Log/Daily Log/print out (on demand).
- (7) Generator trip log/print out (event actuated).
- (8) Turbine trip log/print out (event actuated).
- (9) Operator Control Screens.
- (10) Group Display screen (at least 8 loops).



- (11) Individual display screen (single parameter).
- (12) Flow chart/logic screens.
- (13) Operator's guidance message screen. Logs : (provisional)
- (14) Hourly Log : 250 plant data and 30 computed data.
- (15) Shift Review Log : 120 plant data and 20 computed data.
- (16) Daily Log : 120 plant data and 30 computed data.
- (17) Monthly Log : 120 plant data and 30 computed data.
- (18) Yearly Log : 120 plant data and 30 computed data.
- (19) Alarm Log : 1000 plant data and 15 computed data.
- (20) S.O.E. Log : 1024 Inputs.
- (21) Boiler Start-up Log (event based/manual) : 30 Analog, 60 Digital and 10 computed data (1 minute interval for 3 hours/ boiler start-up).
- (22) Turbine Start-up Log (event based /manual) : 30 Analog, 60 Digital and 10 computed data (10 seconds interval for 1 hour / Turbine Startup).
- (23) Synchronization /Loading Log (event based /manual) : 40 Analog, 80 Digital and 15 computed data (10 seconds interval for 1 hour/ synchronization).
- (24) Generator Trip Log (event based) : 40 Analog, 80 Digital and 15 computed data (15 second interval for 15 Minutes/GCB trip or GLR operated).
- (25) Turbine Trip Log (event based) : 40 Analog, 80 Digital and 15 computed data (15 seconds interval, for 30 Minutes/Turbine trip).
- (26) Boiler Trip Log(event based) : 60 Analog, 80 Digital and 15 computed data (15 second interval for 15 Minutes /Boiler trip).
- (27) HP Bypass Log (event based) : 20 Analog, 15 Digital and 20 computed data (15 seconds interval, for 30 Minutes/Bypass open).
- (28) Pre-Trip & Post Trip Log: 1 second interval for 3 minutes.
- (29) Maintenance logs : For the equipment with motor rating 30 KW and above.

Apart from the above logs, not less than ten other logs are anticipated. Such logs shall comprise of computed data typically like running hours of drive, fuel consumption, water consumption, auxiliary power consumption, maximum metal temperature (about 40 points), calculated values like efficiency & heat rate etc. Logs shall be configurable and reconfigurable at site.

2.3.0 Mass Storage Sub-System

- 2.3.1 Mass storage system shall be offered with necessary hard disks in RAID-5 or better configuration, controllers and back up devices. The mass storage system offered shall be capable of storing process events, alarm events, graphics, logs, reports in addition to the functional requirements of the system. It shall be possible to store the trend for at-least 1000



process variables with one sample every 1 minute for a minimum of 15 days and 500 variables with ten second for a minimum of 7 days. In order to extend the limiting period the delta value technique for change in parameter value is to be adopted. Historical recording shall be possible for storing hourly, shift, weekly, monthly averages for at-least 1000 process variables. It shall also be possible to record the alarm events.

- 2.3.2 All events (such as changes in set-points, computer/auto/ manual mode changes, alarm inhibits, changing over from one key lock position to another etc.) alarms and messages shall all be stored as historical messages and presented to the operator as and when required. Important parameters trends etc related to plant efficiency and performance equipment history etc, shall be duly secured in the storage medium viz, optical disk drive unit for long time archival. Bidder to elaborate in his proposal, the memory capacity offered and the back-up in number of days stored considering the worst case loading. At least minimum one month storage is to be considered in the hard disk without back up. Sufficient back up storage medium Magnetic Optical disks shall be supplied for a storage period of 5 years of data.

Historical Data Storage & Retrieval system shall be redundant (2x100%) and shall comprise one no. Engineering Station with one no. 132 Col Dot matrix printers for each unit and common DCS. Operator station based non-redundant distributed history data bases shall not be accepted.

This master storage system shall be capable of taking back up of third party systems like VMS,EMS etc.

2.4.0 Plant Data Bus/Communication System

- 2.4.1 The communication sub-system shall be a digital communication bus, that provides a high-speed data transfer rapidly and reliably between the various sub-systems. The transmission rate shall be minimum 1 GBPS or better as per IEEE 802.3 / 802.4/ 802.5. Communication sub-system shall be dual redundant, consisting of two separate communication buses and two separate communication interfaces for each node. Both data highway subsystems shall be active at all times. Healthiness of each bus shall be automatically tested periodically at regular intervals without affecting system operation.
- 2.4.2 In case of main bus failure or any communication device failure, the transfer to the dual redundant back up device shall be automatic without interrupting the system operation and without any operator's intervention. Information about the failed bus/device shall be displayed on the operator / engineer station.
- 2.4.3 Failure of a particular node shall not be treated as failure of communication bus. Transceiver failure at a particular node shall not be displayed as data highway failure. Bus and node devices shall be suitably isolated against the surges and noise.
- 2.4.4 It shall be possible to switch over the communication from main bus to the dual redundant bus manually without disturbing the system operation.
- 2.4.5 It shall be possible to connect or disconnect any device from the system without disturbing the operation.
- 2.4.6 The mechanism used by the communication system for error checks and control shall be transparent. Error checking on all data transfer shall be done by cyclic redundancy check and / or any other advanced codes.
- 2.4.7 The data highway offered shall have 30% spare nodes without highway extender for future expansion. It shall be ensured that the bus loading does not exceed 60%.



2.5.0 Sequence of Events Recording (SER)

- 2.5.1 The Sequence of Event Recorder shall be integral to the DCS.
- 2.5.2 It shall be possible to perform the engineering function of the Sequence of Event Recorder from the engineering station offered for the DCS.
- 2.5.3 The Sequence of Event Recorder signals shall be time stamped with one milli second resolution at the I/O card level.
- 2.5.4 SER system shall be capable of presenting/acquiring 1024 events with a resolution of one milli second.
- 2.5.5 The SOE system shall be synchronized with station GPS

2.6.0 DCS Power Supply Modules

- 2.6.1 The system power supplies shall be suitable for 230 V AC 50 Hz, 1Ø UPS power.
- 2.6.2 HMI devices, all operator stations and engineering stations shall be operated with 230VAC.
- 2.6.3 The power supplies shall have a fuse rated suitably, according to the nominal current requirement.
- 2.6.4 The power supplies shall have built-in diagnostic circuitry, which checks for out-of-range voltages and over temperature conditions. Each power supply unit shall have pair of LEDs to indicate normal operation and alarm condition.
- 2.6.5 The power supplies shall be provided with necessary cooling fans.
- 2.6.6 The power supplies shall be provided with galvanic isolation.
- 2.6.7 The power supply units shall be provided with miniature circuit breaker (MCB) of sufficient rating.
- 2.6.8 All power supply to cabinets shall be redundant & have auto change over facility or diode auctioneering. Power supply failure monitoring shall be provided in DCS for controller and I/O cards.
- 2.6.9 Power supply for operator stations and system peripherals shall be from UPS.
- 2.6.10 Redundant power supply modules shall be provided for operator stations. These shall be fed from two independent power supply feeders.

2.7.0 Main Controller Characteristics

Each controller envisaged for this project shall have following features as minimum:-

- i) Processing word length of 32/64 bit (Preferably 64 bits)
- ii) 16 Mbytes RAM
- iii) Redundant power supplies
- iv) Power fail/auto start feature
- v) Watch Dog timer
- vi) Memory protection
- vii) Direct Memory Access feature
- viii) Self monitoring & diagnostic feature
- ix) Easy modification of control functions
- x) RISC/CISC based



- xi) Real time data controller, Computer/PC based soft controller are not acceptable.

2.8.0 DCS Input / Output Modules

- 2.8.1 Input / Output (I/O) modules shall be modular plug-in-type suitable for mounting in racks. The multi-channel I/O cards for all AI cards shall have a maximum of 16 channels, AO card shall have maximum of 8 channel, DI/DO card shall have maximum of 32 channel. The analog input card shall capable of powering the transmitters with 24V DC and shall be capable of accepting the following signals. All process input / output card will have suitable isolation Galvanic / Optical for each channel at input / output respectively. Interrogation voltage for digital cards shall not be grouped and provided for each individual channels. A/D conversion of the measuring signals shall be such that the required data accuracy be guaranteed (minimum resolution 12 bits). Signal outputs shall be provided with protection against short-circuits. The principle of A/D converters shall be that of integration. 50 Hz noise shall be suppressed in a suitable way.
- 2.8.2 Analog Inputs : 4-20 Ma DC signals,
RTD 3 wire & 4 wire and T/C signals
- 2.8.3 Analog Outputs : 4-20 Ma DC,
1-5 V DC
- 2.8.4 Digital input modules (DIM) shall be provided with internal voltage source to convert contact state of potential free contacts, either change-over or ON-OFF into logic level signals. Possibility of surface film or contaminant on the contact shall be considered while selecting this source. Input interrogation voltage shall be 24V DC. Each module shall be provided with circuitry to detect card/channel failure and same shall be indicated. Couple of channel failure shall not result in total card failure. Each module shall be designed with self-checking features for detecting faulty operation. In case of individual card failure, on line replacement of the faulty module shall be possible.
- 2.8.5 Digital output modules shall be provided for controlling ON/OFF status of final control devices like motor starters, the outputs shall be 24 V DC direct driving or through interposing relays. All solenoid valve shall be rated for 24 VDC, 230V AC and 220 VDC. Interposing relays shall be accordingly provided for 230 VAC, 24VDC and 220 VDC rated solenoid valve for energizing these valves from the DOMs. Digital output modules (DOM) shall convert the internal level of the system into external binary signal levels required by the process. Digital output modules (DOM) shall be able to source / sink sufficient current while energizing field outputs. The outputs shall be able to drive breaker coils, contactors etc., directly.
- 2.8.6 All modules shall be provided with circuitry to detect card/channel failure and same shall be indicated. Couple of channel failure shall not result in total card failure. Each module shall be designed with self-checking features for detecting faulty operation. The input / output modules shall have SMART transmitter interfacing capability, detection of breakage in wire, out of range detection, contact bounce filtering, thermo-couple open circuit check features, RTD open circuit and closed circuit capabilities. Incase of individual card failure, on line replacement of the faulty module shall be possible. Output status simulation facility shall be possible, when the system is "ON-LINE".
- 2.8.7 All inputs / outputs (AI / AO / DO) shall have integral isolators and current limiting circuitry so that faults, short circuits, open circuits and overloads in one signal do not effect any other signal. Input / Output modules shall incorporate signal conditioning / filtering circuits to reduce the effects of electrical surges, noises and contact bounces.
- 2.8.8 Input / Output modules shall be designed to withstand vibration / EMI / RFI / Surges effects as per relevant standards.



- 2.8.9 Status indication of each input shall be available on the operator & engineering workstations.
- 2.8.10 It shall be possible to remove and insert the modules while the system is 'ON' (Hot swap of I/O modules)
- 2.8.11 Diagnostic LEDs shall be provided on the front plate of each module to indicate faults.
- 2.8.12 Identification labels (color-coded) to indicate one type of I/O card, signal level etc. shall be provided on the front plate for each I/O module.

2.9.0 Panels, Desks, Racks and Cubicles

- 2.9.1 In general in the following sections, panels shall mean marshalling panels, system cabinets, relay panels & power supply panels unless otherwise stated.
- 2.9.2 Unless otherwise specified, panels and cubicles shall be of floor mounted and free standing construction including those used for alarm and protection relays and the like. The electronic cubicles shall house rack mounted consisting of I/O, processor and power supply modules.

3.0.0 PANEL EARTHING

- 3.1.0 Two separate earth circuits shall be provided for earthing, one as electronic earth (or instrument grounding) through separate group of pits for earthing of instruments & electronics and second safety earthing for earthing of system cabinets. These two earth circuits shall be electrically isolated from each other.
- 3.2.0 Each cabinet shall be provided with a copper bus-bar 25 mm wide, 6 mm thick and of suitable length with tapped holes to suite M6 bolts of brass. The copper bus shall be mounted suitably inside the cabinet and shall be electrically isolated from cabinet steel structures through insulated spacers.
- 3.3.0 All circuit grounds of electronic instruments, shields & drain wires of signal cables shall be connected to this ground bus.
- 3.4.0 All doors and removable covers shall be gasketed all around with neoprene gaskets. Ventilating louvers, if provided, shall have screens and filters. The screens shall be made of either brass or SS wire mesh.
- 3.5.0 Design, material selection and workmanship shall be such as to result in neat appearance inside and outside with no welds rivets or bolt heads apparent from outside, with all exterior surfaces true and smooth.
- 3.6.0 Cable entries to the cabinets shall be from the bottom, unless otherwise specified.
- 3.7.0 Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent equipment. Equipment mounted inside the cabinets shall be so located that terminals of adjacent devices are readily accessible without the use of special tools. Terminal markings shall be clearly visible.
- 3.8.0 Wherever required cabinets shall be matched with other cabinets in the control room with respect to dimensions, color and appearance.
- 3.9.0 Cabinets shall have double leaf door with lift off hinges at the front and at the back if the door width is greater than 800 mm. Doors shall have handles with built-in locking facility. All door locks shall be provided with same lock and key combination unless otherwise



- specified. Keys shall be removable only with the doors locked and 2 keys per cabinet shall be provided.
- 3.10.0 DCS & PLC systems shall have their independent redundant Electronic Earth pits for system grounding. These earth pits shall be separate from the Electrical earth pits and located away from the HT equipments. Panel AC safety ground / Protection earth shall be connected to the Station Electrical earth Pit.
- 3.11.0 System cabinet AC and DC ground shall be electrically isolated from each other and also electrically isolated from the Instrumentation signal ground. All the above ground shall be individually connected to the single point on the ground pit. Dedicated redundant earth pit shall be provided which shall be away from the HV equipment. This earth pit shall not be shared with other electrical equipment ground and shall also be insulated from other electrical system ground to ensure single point grounding of the system. Grounding resistance shall be better than 1.0 ohm. IEEE guideline shall be followed while designing the grounding system.
- 3.12.0 All panels and cabinets shall be provided with a continuous tinned copper ground bus bar of minimum 25 mm x 6 mm cross section, extending along the entire length of the panel / desk / cabinet assembly. This signal ground bus shall be bolted to the panel structure on the insulated post. All shield wires shall be connected to this bus for onward connection to the earth pit. System DC power ground shall also be connected to the earth pit in similar way.
- 3.13.0 The panel /desk /enclosure ground shall have two (2) bolt drilling with GI bolts and nuts at each end to connect to GI / copper flat ground riser or by for protection ground. Each circuit requiring grounding shall be individually and directly connected to the panel ground bus.
- 3.14.0 Signal cable shields shall be grounded at the panel end only and shall never be left open. The ground in between panels of a shipping section shall be firmly looped.
- 3.15.0 Manufacturer recommendation and scheme shall be followed for all system panel grounding.
- 3.16.0 Electrical transmitters and switching devices, operating at a voltage less than 50V shall be grounded through the steel structure.
- 3.17.0 **Painting**
- The Bidder shall submit a detailed paint procedure for all the panels and other equipment in his scope for the Owners for approval. The procedure shall include surface preparation, paint process and physical characteristics, application and type of paint to be used. All surfaces shall be properly cleaned and prepared to receive prime and finish coatings of epoxy paint. The finish shall be designed to minimize reflections from extraneous lighting sources.
- 3.18.0 **Internal wiring**
- 3.18.1 The wires shall be neatly looped and supported in non-flammable plastic wiring raceways. The wiring is to be of general-purpose classification for non-hazardous areas as per the applicable standards. Slotted wire-ways should be used and sized, such that no more than 50% of the cross sectional area of the wire –way is filled. All AC wiring in a cabinet should be routed in steel wire –way to reduce noise in instrument signal wiring. If this is not feasible, it should be physically separated from the DC signal wiring as much as possible. Parallel runs of AC and DC wiring closer than 300 mm should be avoided. Power supply to each instrument / equipment shall be through double pole miniature circuit breaker (MCB) of adequate rating. All these MCBs shall be housed in a separate switch box mounted inside the cabinet. All wiring shall be carried out with 600 V grade, single core, stranded copper



- conductor wires with PVC insulation. The minimum number of strands per conductor shall be seven.
- 3.18.2 Terminal blocks of size suitable for 2.5-mm² cable shall be provided for all external wiring. Adequate space/ partitions shall be provided to prevent touching electronic hardware when working at terminal blocks.
- 3.18.3 Wire terminations shall be made with solderless crimping type of tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations.
- 3.18.4 Tag no. engraved identification markers made of PVC, plastic or suitable material shall be fitted at both ends of each wire. The marker shall not fall off when the wire is disconnected from terminal blocks. Single lettered ferrules are not acceptable. 'Cross ferruling' method shall be used for identification i.e. ferrule shall identify the terminal nos to which both ends of the wire is connected.
- 3.18.5 Terminal blocks shall be shrouded 600V grade clip-on type, complete with identification strips. A minimum clearance of 100 mm shall be provided between blocks of terminals. Not more than two wires shall be connected to a single terminal.
- 3.18.6 Each row or column of terminal blocks shall be identified with a unique identification and the terminals in a block shall be sequentially numbered.
- 3.18.7 Necessary cable glands shall be provided for glanding all incoming and outgoing cables. All cable glands shall be of nickel-plated brass and double compression type. At least 20% glands of each size shall be supplied as spare.
- 3.18.8 All the signals connected to a module shall be grouped and wired to a single terminal block in the marshalling/IO and system cabinets. The field cables shall not be directly wired to the I/O modules. Marshalling cabinets shall be provided such that DCS system wiring shall be done independent of field cable grouping. The terminal blocks shall be suitably tagged for easy identification.
- 3.18.9 The following colour code shall be used for cabinet wiring.
- | | | | |
|-----------------|----------|---|-------|
| 230 V AC wiring | Phase | - | Black |
| | Neutral | - | Red |
| D.C. wiring | Positive | - | Blue |
| | Negative | - | Grey |
- Interlock wiring powered by external sources – Yellow
- Earthing – Green or Green with yellow stripes
- 3.19.0 **Interior lighting and receptacles**
- 3.19.1 Each cabinet shall be provided with a LED lighting fixture rated for 230V, 1 phase, 50 Hz supply for the interior illumination of the cabinet during maintenance. The fitting shall be complete with MCB and the respective cabinet door switch shall control the switching of the fitting.
- 3.19.2 Each cabinet shall be provided with a 230 V AC, 1 phase, 50 Hz, 5 Amps, 3 pin receptacle switch mounted inside, at a convenient location.
- 3.20.0 **Name Plates**
- 3.20.1 All components mounted inside the cabinet shall be provided with individual nameplates with the tag no. and service engraved. The nameplates shall be mounted directly below the



respective component. Also the cabinet shall be provided at the top with a nameplate engraved with cabinet designation. Nameplates shall be made of anodized aluminum engraved with white letters on black background.

- 3.20.2 Enclosure Protection class for the DCS panels shall be minimum IP-32 as per IEC 60529.

4.0.0 SOFTWARE PACKAGES

- 4.1.0 Standard software modules shall be available for performing the required control and monitoring tasks. Implementation of the control functions shall be easily possible using readily understandable configuration procedures.

- 4.2.0 The offered system shall include the display of a number of mechanical flow diagrams or electrical single line diagrams by means of dynamically updated displays.

- 4.3.0 The software shall be user friendly and flexible so as to enable the user to modify the content to their requirements. Multiple windowing in a single LED monitor or in a LVS shall be provided.

- 4.4.0 The software shall give the following displays as a minimum.

a) Plant overview displays

These displays shall summarize the key information needed to provide the operator with an overall picture of current plant conditions. The display shall also identify key problem areas.

A summary of the names of various areas in the plant shall serve as a menu to the next level of displays.

b) Area level displays

The displays at this level shall provide information concerning a portion of the plant equipment like Boiler, turbine generator etc. After obtaining a summary of the plant status from the plant level displays the operator shall be able to move down the next lower level to look at the situation in a selected plant area.

c) Absolute value displays

These displays shall show the absolute value of the process variable in bar graph form. The displays shall also show the set point, high and low alarm limits, set points, control outputs, man, auto, cas mode indications. When any of these limits is exceeded the bar graph shall change color. Open loop displays shall mimic the indicator stations and push button stations; indicator displays shall include bar graphs for selected process variable with alarm set points. Push button station displays shall allow the operator to perform logic operations such as opening and closing of valves or starting and stopping of motors and shall include feedback indications like open and close position indications for the valves and running/stopped indications for the motors.

d) Parameter Displays

These displays shall display the tag number and the current value of the process variable in engineering units. If the process variable is in alarm condition the corresponding tag number shall change colour and start flashing. In all these level displays the top line of the display shall display the date, time and alarm status. These displays in addition to graphic displays shall be used to perform control operations.



e) Loop level displays

The displays at this level deal with individual control loops, control sequences and data points. These displays shall be used by the operator for control and analysis purposes

f) Tuning displays

These displays shall help the operating personnel and instrument engineers to tune the control loops. These displays shall include trend plotting capability, necessary functions to allow the operator to control the loop, a list of the tuning parameters (e.g. proportional band, reset rate and derivative rate) associated with the loop.

g) Trend display, historic trend display for various timings.

It must be possible to group the trended variables by related process functions as well as by similarities of time scale of interest. The trend graph must clearly label the tag no, service, engineering units, time increments, and absolute time of day of the trended variables. The operator must be able to obtain a precise reading (in engineering units) of both the current value as well as past values of the trended variable. The same graph displaying the trend should also show auxiliary information that would help the operator evaluate the status of the trended variable. This information includes the nominal value of the variable, the set point of the associated control loop, the allowed range of the variable and the allowed rate of change. Up to 10 trends in trend windows may be displayed on a operating screen, ZOOM and PAN function must be available to facilitate operator analysis of process condition over varied time span.

The system should be able to trend PV, SV, MV of all closed loops and PV and any system calculated values of all open loops connected to the system with a scan rate of 10 seconds.

The historical trend should be able to trend PV, SV, MV, loop status, calculated variables etc. of all the signals connected to the system with a sampling time of 1 min for a period of atleast 24 hours

h) Graphic displays.

Static fields – to provide a background for the dynamic position of the display. They include labels, symbols and other elements that do not change.

Data fields (in engineering units) – Process information that is updated automatically.

Dynamic display elements – These change size, color or shape as a function of changing process conditions (e.g. line drawings, process equipment symbols, bar graphs, or pie charts). They can include both user-defined elements as well as standard library symbols. Process mimics shall be in 3D in nature and dynamic on operation console for unit and common DCS

For improved operator efficiency, windowing (picture in picture) capabilities for graphic display will be preferred. The capabilities shall be powerful enough to allow the operator to control / monitor additional information such as trends, loop face plate, operator guide messages etc., by calling up these information as windows within the same graphic page without the need for switching between graphic pages and other information displays. It shall be possible to have more than one trend or more than one loop faceplate display at configurable locations on the graphic page to provide better informative displays for improved efficiency of operation. Bidder shall furnish a write-up about these capabilities in the offered system with supporting documents.



The number of graphic pages per process unit shall be 40 as a minimum.

i) Self diagnostics displays

Card level failure, bus failure or any other failure at any part of the integrated system should be displayed on the VDU as system alarm. An overview of the entire process information network (PIN) showing the various nodes on the network should form the self-diagnostic overview displays. Any malfunction at any sub-system shall be indicated by change of color. By a single keystroke, the operator should be able to go to the sub-system level diagnostic display, which shall show all the cards interconnected by different internal buses. Again, malfunction of a particular card/bus shall be shown by a change of color. In addition, diagnostics feature shall be available at the local level also, by means of LED indicators, at the different cards of the sub-systems. It shall be possible to print detailed diagnostic displays on the printer.

j) Alarm display.

It shall have an ability to handle process alarms as well as system alarms on the operators' stations for operators' attention. First-out alarming function, which enables the operator to know which alarm in a sequence, occurred first. Priority alarming functions, which rank the current alarms by their importance to process operation. Alarms shall be prioritized based on the color codes and categorized accordingly.

Alarms with brief comments shall appear immediately on top section of the operator stations' screen with different kinds of sound depending on priority alarm without any inconvenience to the operator while viewing other important displays of the plant. The process alarm and system alarm shall be displayed separately on the operators' consoles.

All alarms shall be displayed as they occur with change in colour of display in the following sequence, activating an audio signal:

Continuous flashing	:	unacknowledged alarm
Steady display	:	acknowledged alarm

Alarm monitoring and reporting shall be based on priority levels

In addition to alarms appearing on different displays, the system shall also be able to display alarm summary and alarm history, listing the date and time occurrence, tag no, point description, type of alarm (absolute value or deviation), serial number of alarm in the sequence of occurrence etc.

Alarms shall disappear from display only when they are acknowledged and cleared. Any abnormal condition in any sub-system or any other function devices shall be displayed as system alarm message on the Operator's/Engineer's console, irrespective of display selected.

The following alarm classification applies to alarms with DCS:-

k) Stability alarm

Stability alarm indicating a disturbance or deviation in normal process operation. These alarms are generally software configured within DCS.

l) Bad Input alarm

When an input signal to the DCS falls outside the range of prescribed limits, the system shall generate an alarm to indicate a faulty instrument signal. It shall be possible to suppress these alarms selectively on a per loop basis.



m) System alarm

These alarms shall be generated by the system diagnostic features to indicate faults within the DCS. Also alarms to be included in this category are system status, power supply failure, fan failure and abnormal system environments. These alarms shall be printed separately from operational alarms.

n) Alarm Discrimination

The DCS shall permit operators to completely discriminate between all alarm categories. This discrimination can be both via colour or priority.

o) Alarm Summary Display

It shall be possible to display summary of alarms in chronological order and shall disappear from display only when they are acknowledged and condition of alarm status returns to normal. The alarm display shall list the following for each alarm as a minimum:

The date and time of occurrence
Point identification (i.e. tag no.)
Point description

p) Type of alarm

The system shall be able to display on alarm summary a minimum of the latest 100 alarms. When all the alarms cannot be displayed on one screen area, operator shall be able to monitor the hidden alarms by scrolling the display. From the alarm summary display, operator can call any pre-defined display stored in DAS.

- a) Plant start-up, shutdown messages.
- b) X-Y plot
- c) Logs, pre & post trip logs, trend logs, hourly/shift/daily logs.
- d) Control group display.
- e) Operator guide messages display as per the results from "What if analysis". Refer Sec 4.15, CI 2.0.0
- f) Equipment operating history

Facility to accumulate running hours for all the cycles of start and stop from initial commissioning and last overhaul of the equipment.

Important parameters related to plant efficiency and performance, equipment history etc. shall be duly secured in the storage medium viz. Optical disk drive unit for long time archival. The number of signals shall be decided during detailed engineering.

Others – to be listed by the Bidder.

Software packages such as Life evaluation software, Asset management system, Equipment capability curves to be included.

5.0.0 CLOSED LOOP CONTROLS

- 5.1.0 All control loops shall be stable for all operating conditions and in all load ranges, and shall have optimum performance in compliance with the latest standards.
- 5.2.0 They shall be matched in such a way that optimal control is accomplished in compliance with the requirements.



- 5.3.0 As far as possible, the design shall be so decentralized that in the main control loop, one failure will not lead to an outage of more than one control loop.
- 5.4.0 Interlocking/protection shall be independent of the control loop or alarm annunciations, i.e. separate measuring points or independent analog transmitters shall be provided. Apart from these wherever signal multiplications are required, it shall be suitably taken care by the Bidder.
- 5.5.0 In the case of failures, e.g. interruption of power supplies, in the event of switch tripping, etc., the control circuit shall automatically be transferred to a safe condition. In the event of failure of auxiliary power, the actuators shall remain in their position or if this is not possible they shall take over a position which is safe for the process. Similarly, power supply failures shall not result in any undesired or dangerous control actions.
- 5.6.0 The control system shall have advanced control algorithms like adaptive control, self tuning control etc. Availability of advance control techniques/Algorithms ensuring process optimization. Availability of Predictive control techniques. System shall have the feasibility of auto changing of PID constants in micro-processor for different loads. Hunting of control valve at different loads is to be avoided.
- 5.7.0 Bias adjustment with indication where a single controller is controlling more than one final control element (control valve, control damper, speed drive etc.) to maintain the same process variable. Auto and manual control facility shall be transferable in both directions without bump of the value of the process variable to control the parameter during manual operation. Both master Auto Manual station and Auto / Manual station for individual control element shall be provided in OWS.
- 5.8.0 Characterization of final control element to suit the various applications with respect to load or otherwise as dictated by the process. Function generator to provide necessary characterization or variation of set points with respect to load, speed or any other requirement. Blocking/Interlocking function as dictated by Process/equipment. Monitoring of loop failures or any hardware failure in the loops.

Fail safe operation of final control elements in case of failure of motive power or Signal.

6.0.0 OPEN LOOP CONTROLS

Sequential start-up and interlock protection system shall be provided for all major critical auxiliaries of the plant. The system structure will provide for control from the highest level of unit operation down to the individual drive level.

- 6.1.0 The design of the Open-loop Control shall be implemented in the DCS.
- 6.2.0 The interposing relays shall be housed in the Motor Control Centers (MCC) of the switchgear.
- 6.3.0 All main system drives shall be provided with individual remote stop / start capability. Additional local start / stop push-buttons shall be provided in cases where local operation of the plant is necessary. In all such cases the local controls shall act only if selected by a group or individual selector in the central control room/MCC. Group selector shall be provided where a large number of local start / stop push buttons are required.
- 6.4.0 Local push buttons shall be connected to their associated command logic in order to ensure that the same starting conditions are achieved before an item of plant can be started from either the local or the remote position.
- 6.5.0 In cases where it is necessary for safety reasons to provide a local emergency off push buttons, the push button shall interact directly with the MCC/switchgear. The push button



shall be provided with suitable mechanical interlocking device in order to avoid restarting. It shall be protected against malfunction by a cover or similar protection. Another contact of stop push button shall be wired to DCS for annunciation. Start push button shall be wired to DCS so as to run the equipments on checking necessary process interlocks & protections.

- 6.6.0 After a voltage failure in the electronic equipment and upon restoration of this voltage the system shall not cause unintended orders to the breakers concerned.
- 6.7.0 In the event of On/Off commands arising simultaneously or commands repeating alternately, provision shall be made to lock out these commands.
- 6.8.0 Subgroup controls are to be provided for start-up, operation and shutdown of associated functional units and drive groups, i.e. it shall be possible to start or stop main aggregates with all associated equipment by pressing one push-button. These controls may be designed either in the form of combinational controls or in the form of sequential controls. In the case of combinational controls the issue of commands depends solely on the interlinking of certain process criteria ; in the case of sequential controls the command sequence takes place in steps and is monitored for time, taking into account incoming process criteria in a predetermined sequence and in at fixed scanning time.
- 6.9.0 The steps of the individual programs and missing criteria shall be displayed on the VDU. Subgroup controls must be capable of being switched On and Off and must have defined manual commands for 'operation' and 'stop' . Any faults in the control system which could cause blockage of the control sequence must be confined to one control sequence. For this reason an autonomous design is required for each subgroup control.
- 6.10.0 All functions performed by automatic systems must be capable of being implemented as individually remote-controlled operations via command modules.
- 6.11.0 Any faults in the control system or in the plant must lead to an automatic changeover from a faulty unit to an appropriate stand-by unit.

7.0.0 INTERLOCK, PROTECTION

- 7.1.0 To protect individual units or parts of the plant, interlocks are to be formed in accordance with process criteria, which can be either active or passive depending on their functions.
- 7.2.0 Active interlocks will automatically disconnect units or parts of the plant before they reach a critical operating condition. In addition, such dangerous conditions must be immediately indicated to the operating personnel by means of the alarm annunciation and shall lead to a print-out by the event recorder.
- 7.3.0 Passive interlocks are intended to prevent operational errors or wrong commands from being carried out in the event of selective faults in the automatic control.
- 7.4.0 For that reason active and passive interlocks must not be capable of being switched off operationally from the CCR.
- 7.5.0 Protection signals must be hardwired and interference free. The use of scanning devices or multiplexers shall not be allowed.

8.0.0 PERFORMANCE REQUIREMENTS

a) Loop execution time for CLCS	Maximum 250 ms (For all non critical Loops)
b) Loop execution time for CLCS	Maximum 100 ms (For all critical Loops)
c) Loop execution time for OLCS	Maximum 100 ms (For all Loops)



d) Loop execution time for protection and governing Controls	Maximum 20 ms
e) Updating rate of Analog display	Max. 500 ms (for measurement)
f) Updating rate of Analog display	Max. 500 ms for OLCS/CLCS
g) Updating rate of Digital value display	Max. 500 ms (for measurement)
h) Updating rate of Digital value	Max. 500 ms for OLCS/CLCS
i) Updating rate of pulse signal	Max. 500 ms
j) Change over to back up controller	less than 20ms (bump-less)
k) Time for display on screen	Max 1 seconds on demand
l) Keyboard command execution time	Max. 2 sec (max)
m) Controller Loading	Max. 60 % under worst loading conditions
n) Data Bus Loading	Max. 60 % under worst loading conditions
o) Overall system availability	99.7 %
p) Speed of communication Bus	1 GBps

Worst Loading Conditions

For DCS the worst loading condition shall include the following tasks:

- All process inputs scanning and processing is in progress and all the data is transmitted over the main data bus every one-second
- All closed loop controls in operation
- All open loop controls in operation
- All output devices are in operation with rated performance/speed
- Control/information request is initiated on control
- All the spare I/O's are connected to the DCS

9.0.0 PERFORMANCE REQUIREMENTS FOR CLOSED LOOP CONTROL SYSTEM

- The DCS shall permit the performance of the following dynamic load tests while maintaining safe furnace conditions, major process parameters and without endangering other equipment. All tests shall be performed with the system in automatic mode :
 - Drop 50 percent of maximum load capability from approximately full load at a rate of 10 percent per minute.
 - Drop load from full rated output to the lowest runback limit, at a rate corresponding to the fastest run back rate
 - Pick up 50 percent of the maximum load capability from approximately 50 percent load at a rate of 10 percent per minute.
- During transient conditions causing deviation of process variables, the control system furnished under the specification shall not permit deviations which exceed those permitted by the manufacturers of the controlled process equipment, for load changes as indicated above. The exact parameters to be monitored for this test are given in the following table.



Sl. No.	Load/ Rate of Load Change (% of MCR per min.)	MAXIMUM DEVIATION OF PARAMETERS FROM SET POINT				
		Throttle Pressure Deviation (Kg/cm)	Flue Gas Oxygen (Kg/cm) (%0.2)	Furnace Pressure Deviation (mm/ Wcl)	S.H. steam Temperature Deviation (°c)	R.H. Steam Temperature Deviation (°c)
A	Steady State Condition					
1	60% to 100%	±3.0	±0.5	±3.0	±4.0	±6.0
B.	Ramp Test (Change for max. duration of five minutes)					
1.	±3%	±3.0	±0.6 / - 0.4	±7.0	±10.0	±10.0
2.	±5%	±5.0	±0.8 / - 0.4	±12.0	±10.0	±14.0
3.	±10%	±7.0	±1.0 / - 0.5	±12.0	±10.0	±14.0
C.	Step Load Changes					
1.	From 100% to 80% at the rate of 10% per minute	±7.0	±1.5 / - 0.5	±20.0	±15.0	±20.0

The control loops shall perform to return the controlled variable to the set point in a stable manner without cycling in the shortest possible time and without any loop interactions for cycling of generation when generation matches unit load demand. The Bidder shall guarantee that the control system provided by him shall be responsive and stable and shall maintain the deviation of controlled variables from set point within the limits specified so that the equipment being controlled shall operate as specified over the range required. The controls shall operate automatically, with no assistance from the operator. The Bidder shall successfully demonstrate the performance of Closed Loop Control Systems before acceptance and taking over of this system by the Owner. Bidder shall furnish his best achievable deviation figure for each of the above mentioned parameters in the bid.

10.0.0 DCS PARAMETRIC TESTS

The following parametric tests shall also be conducted under worst case loading conditions

01 Processor Spare Duty Cycle (Free Time)

(a) For Control System:-

CPU loading, cycle time/controller reaction time and memory spare capacity

(b) For MMIPIS:-

CPU loading, spare duty cycle, spare memory capacity

02 Spare duty cycle for system bus

03 Various display response time

04 System accuracy

05 Monitor update time

b) For the parametric test, the following requirements shall be met

**01 Processor Spare Duty Cycle (Free Time)**

Under worst case loading of MMIPIS and system bus, each MMIPIS processor shall have 40% free time when measured over any two second period and 50% free time when measured over any one minute period.

Under worst case loading conditions of control system control system processor shall have 20% free time when measured over any one minute period. The Bidder shall furnish all necessary data to fully satisfy the Owner that the processor spare duty cycle figures quoted by the Bidder are realistic and based on configuration and computation capability of the offered system and these shall be actually achieved in the fully implemented system as commissioned at project site. The spare capacity of working and bulk memory shall meet the specification requirements.

02 System Bus Spare Duty Cycle (Free Time)

The system bus shall have min. 50% free time during the worst case loading conditions of control system, MMIPIS and the system bus, measured over any 2 seconds interval.

03 Display Response Time

The system shall acknowledge all operator requests in one of the following manners within one second of pressing of the last button: Commencement of the requested display or Acknowledgment of operator request in a suitable manner.

The display response time as defined above, under the worst case loading conditions shall not be worse than the following:

01 All control related displays	:	1 sec
02 Control command execution time	:	1 sec
03 Point details display (single point)	:	1-2 secs
04 Bar chart display (20 points, current data)	:	2-3 secs
05 Operator guide / plant start-up guide message display (full screen of alphanumeric information and a maximum of ten numbers of dynamic data items)	:	1-2 secs.
06 Plant mimic display of fair complexity with a minimum of 120 numbers of dynamic data items e.g., values, macros, line segment, etc.	:	2-3 secs
07 Group review display (current values of twenty points)	:	2-3 secs.
08 X-Y plot display (2 X-Y- plots and a single display requiring both historical as well as current data)	:	3-4 secs.
09 X-T plot display (trend of 6 analog points and a single display requiring both historical as well as current data)	:	3-4 secs.
10 Plant summary display (e.g., bad point summary, limit check removed point summary. Assume the whole data base search is required and the summary display contains ten points only).	:	3-4 secs.

The response time for screen update after the execution of the control command from the time the command is issued (for example command to start a motor to the time the screen is updated) shall be two seconds (excluding the drive actuation time).

04 System Accuracy Requirements

The overall system accuracy from signal input terminals to output presentation on monitor display and printers for the least accurate input range and maximum scan rate shall be not worse than +/- 0.2% of full scale of the process range.

05 Screen updated rates

All monitor & LVS displays shall be updated at least every two seconds.

**11.0.0 AVAILABILITY TESTS**

DCS availability tests shall be performed to establish the system availability guarantee of 99.7%. Bidder shall submit the availability test procedure for Owner's approval.

- a) Bidder shall guarantee 99.7 percent system availability for a period of 365 days. An Availability Guarantee Test shall be conducted to assure this level of availability. If the accrued down time exceeds 0.3 percent of 365 days, during availability test run, a new 365 days test run shall start at the time when the system becomes available again. Loss of availability shall be defined as the loss of the system's guaranteed accuracy and repeatability or of any system function; except, however, that the loss of a function for not more than five percent of the I/O points shall not be considered as complete loss of availability. Loss of a function for more not more than five percent of the points shall be treated as partial unavailability and the corresponding outage time shall be weighted with respect to function and the percentage of the points for which the function is unavailable. Loss of each function shall have one weighing factor and unavailability of each equipment, peripheral device or process I/O card etc. shall have another weighing factor. The guaranteed accuracy and repeatability and system parametric requirements specified elsewhere shall be maintained for the entire 365 days run without any manual recalibration or any other changes made to the system.
- b) Downtime shall start upon loss of a system function and shall end upon full restoration of the affected system function.
- c) If availability is lost due to Owner, down time shall not be charged to Bidder.
- d) Test Dates Starting date of the test shall be decided based on mutual consent of both Bidder and Owner.
- e) Test Duration and Definition
 - 1) The availability test duration shall be 365 days of accumulated test duration time. Such duration time shall be continuous from the start of test, except as defined hereinafter.
 - 2) The availability shall be expressed by a percentage which shall be calculated as $100 \times [\text{Test Duration Time} - \text{Accumulated System Outage Time}] / \text{Test Duration Time}$
 - 3) The accumulated system outage time shall be a total of time in which the system functions are not available. A weighing factor shall be used to determine the amount of outage time assessed due to partial failures. System outage time shall be calculated as : $(\text{Outage time}) \times (\text{Weighing factors})$
 - 4) System outage time shall be accumulated over the test duration and shall be the accumulated system outage time.
 - 5) A minimum of one hour's down time shall be charged for each loss of availability in determining system availability.
- f) Outage Time and Weighing Factors
 - 1) Bidder shall submit a list of weightage factors for all system elements / components of the DCS which shall be agreed upon by the Owner before award of Contract.
 - 2) Outage time shall be assessed for the length of time in which all or any part of any of the functions are either continuously available or not available to the operator.

<u>System Element</u>	<u>Weighting Factor</u>
Data acquisition and Validation	1.00
Control Function	1.00
Historical Storage Function	0.30
Operator guides (OWS)	0.50



System summaries	0.30
Alarming, displays and logs	0.90
Other displays	0.30
Logs (except SOE)	0.30
Report	0.30
Sequence of events log	0.30
OWS Graphic	0.30
Each Bulk Memory	0.50
Each utility OWS and alarm OWS	0.33
Display / KBD	
Each Control OWS	0.50
Each Keyboard	0.50
Each printer	0.30
Cartridge Tape	0.40
Data Highway	0.75
Each Programmer's OWS/KBD	0.30
Engineer's Workstation	0.30
5% I/O Points	1.00
5% Controllers	1.00

Weighting factors for other system elements shall be defined and agreed upon after contract award.

The loss of functions based on the weighting factors above shall be limited to 1.00 maximum.

g) Conditions

- 1) Downtime shall start at the time of notification exclusive of actual travel time required by Bidder's specialist (wherever required) but not in excess of 48 hours.
- 2) Bidder shall include commissioning spares for performing the above tests.
- 3) The Bidder shall include in his proposal the price and quantity of any spare parts necessary for his performance of the availability test
- 3) Failure of peripheral output devices shall be counted as outage time if failure of the device affects any or part of any function as per clause.
- 4) Any degradation of function shall accrues to outage time regardless of system configuration.
- 5) During a period of partial system outage, Owner shall be permitted to use other operable functions of the system if such use does not interfere with maintenance of the inoperable functions or hardware as determined by the Bidder. Should Bidder determine that partial use of the system by Owner shall interfere with Bidder's maintenance procedures, system outage time shall accumulate with a weighing factor of 1.0 since no functions are available to Owner. This shall include off-line servicing.
- 6) All costs associated with maintaining 99.7 percent availability for a continuous period of 365 days shall be borne by the Bidder. This includes hardware, software, spares and services.
- 7) The 99.7 per cent availability shall exclude downtime required for scheduled maintenance and service. The Bidder's proposal shall list maintenance and service requirement for all applicable equipment. If these requirements are not listed, it shall be understood that no downtime is required.

12.0.0 GENERAL I/O REQUIREMENTS AND SPARE CAPACITY

- (i) The DCS shall be provided with the capacity and capability to handle either 20% additional modules for each type of modules or 20% over and above the specified number of modules connected to the system bus without any additional hardware or software requirements. These additions shall not



result in decrease in system response time (i.e. control response time, display response time, SOE resolutions etc.).

- (ii) 20% spare relays of each type and rating, mounted and wired in relays cabinets. All contacts of relays shall be terminated in terminal blocks of relay cabinets. Additionally in each of the relay cabinets, 20% spare terminal blocks shall be 'provided so that additional relays can be mounted and wired. In case bidder's system employs marshalling cabinet for all inputs, the spare terminals, fully wired up to marshalling cabinets are also to be provided. Above criteria shall also be applicable for PLC based control system.
- (iii) Separate DI, DO, AI & AO shall be considered by bidder for HW Annunciation windows, Mimic, ILPB, PBs, Indicators, recorders, A/M stations & other HW etc mounted on back up control desk/panel & UCP
- (iv) Wired-in "usable" space for 20% modules in each of the system cabinets for mounting electronic modules shall be provided by the bidder. Empty slots between individual modules/group of modules, kept for ease in maintenance or for heat dissipation requirement as per standard practice of Bidder shall not be considered as wired-in "usable" space for I/O modules. Field Terminal assemblies, PCB/ Connectors (if any in the offered system), corresponding to the I/O modules shall be provided for above-mentioned 20% blank space.
- (v) 20% spare fully wired I/O channels shall be provided in each I/O module. In addition to this 10% or minimum one no. extra assigned complete spare cards (which ever is more) fully wired mounted in the cabinets for each type of I/O modules shall also be provided.
- (vi) Electrical I/Os required as per Energy Distribution Management System (EDMS), Energy Management System (EMS) and any other electrical system shall also be considered/included by bidder in respective package I/O list.
- (vii) The spare capacity as specified above shall be uniformly distributed throughout all controller systems. The system design shall ensure that above-mentioned additions shall not require any additional controller/processor/Peripheral drivers in the system delivered at site. Further, these additions shall not deteriorate the system response time/ duty cycle, etc. from those stipulated under this specification and shall meet other redundancy / functional requirement. Above criteria shall be applicable for DCS, PLC & any other microprocessor based control system.

13.0.0 HART MANAGEMENT SYSTEM (HMS)

Dedicated PC based HART Management System shall be provided for each unit for centralized configuration, maintenance, diagnostic and record keeping of all electronic smart transmitters. Transmitter signals shall be wired parallel to DCS control system and HART modules of HMS, which shall be connected to PC through suitable communication modules. Complete diagnostic, record keeping, calibration and configuration, event and log reports, historical database records of all transmitters shall be possible from the HMS.

The Bidder shall provide a dedicated and standalone Work station based system for each of the generating units for centralized configuration, maintenance, diagnostics & record-keeping for all smart type electronic transmitters and any other HART based instrument/system.

For this system, suitable HART interface modules, power supply modules etc. shall be provided, suitably mounted in cabinets for hooking up to a dedicated Work station & a colored A4 sized LaserJet printer to be provided by the Bidder. The quantum of signal connected to HMS hardware shall be minimum of 1500 nos. In addition to this 1500 signals



at least 20% spare wire slots shall be made available for future use. This system shall meet following requirements as a minimum:

- i. Each of the transmitters/HART based instrument shall be terminated in marshalling cabinets through cage clamp type maxitermi connections on special twin terminal blocks to be provided by the Bidder. The transmitter/HART based instrument signals from each of the transmitters shall be wired in parallel to CLCS/OLCS/control system and to HART interface modules via these special twin terminal blocks. The CLCS/OLCS/control system will necessarily use 4-20 mA analog signals and superimposed digital signal shall be used in HART interface modules. The interconnection between twin terminal blocks and HART interface modules shall also be through prefabricated cables with plug-in connectors connected at both ends at manufacturer's works.
- ii. The multiplexed signal from HART interface modules shall be hooked upto a HART OWS through associated communication modules, converters, etc. The communication module shall provide data on RS-485 link at a minimum speed of 19.2 K baud. If the Bidder's standard HART interface module has integral communication module to provide RS-485 link, the same shall also be acceptable. In all HART interface modules, provision for connecting at least 20% extra transmitters shall be kept.
- iii. A industrial grade RS-485 to RS-232 converter shall be provided for interfacing HART data of transmitters to a HART OWS station. This converter shall also provide proper isolation to ensure data integrity.
- iv. The processor, Power supply, communication port shall be redundant. The configuration of HART OWS shall be fault tolerant. HART management system shall be time synchronized with station GPS based Master clock system.
- v. Any failure/short/open-circuit and/or removal of any of the cards/devices/cables in this centralised configuration, maintenance, diagnostics and record keeping system, including failure/removal of HART interface modules, communication modules, converter, etc. shall in no way affect the 4-20mA analog signals being used in CLCS/OLCS/control system.
- vi. The HART interface modules and communication modules (if applicable) shall be suitably mounted in cabinets. Suitable parallel redundant 24V DC power supply packs/modules and redundant feeders shall be provided to feed all modules/ devices. These power supply packs/modules shall be fed from redundant feeders of plant UPS system.
- vii. All modules/cards/power supplies shall be mounted in cabinets to be located in Electronic Equipment Room. The Work stations and printer shall be located in I&C Engineer/Computer room.
- viii. All cables/links for connecting system described above shall be provided by the Bidder on as required basis within quoted price.
- ix. The bidder shall install suitable software in Work stations to achieve centralised configuration, maintenance, diagnostics and record keeping of smart type instruments. Following facilities shall be available as a minimum through software and the HMS software have to be licensed for 2500 tags.
 - a. Constant scanning to monitor faults of changes to instrument configuration.
 - b. Owner-defined and standard calibration and configuration procedures for all transmitters/smart type instruments.
 - c. Constant signal data collection facilities to maintain continuously updated records in accordance with ISO 9000 quality standards this will include



- historic database records of all configuration changes, test and calibration details and additional service notes.
- d. Automatic tracking of configuration changes made in the field, such as may be introduced by hand-held communicator. All configuration function associated with hand-held communicators shall be available in the system.
 - e. Event and log reports on screen as well as on printer.
 - f. Any addition/deletion of transmitter will be reported on printer and logged in hard disk.

The Bidder shall enclose detailed bill of material and schemes alongwith the bid indicating how the requirements of centralised configuration, maintenance, diagnostics and record keeping facility for transmitters are being achieved. The makes of modules/devices and configuration scheme shall be subject to Owner's approval during detailed engineering stage.

For easy handling of the various functions at HMS panel itself, one no laptop PC with necessary advanced configuration of HMS software and one no industrial grade RS 485 / RS 232 converter shall be provided for configuration, maintenance and diagnostic of all smart devices. All the functions mentioned above shall also be available in the laptop PC.

14.0.0 GPS MASTER/SLAVE CLOCK

- 14.1.0 The GPS master clock system shall be independent from any of the instrumentation system. The electronic modules of GPS master clock system shall be redundant and both are auto synchronized. Failure of one GPS unit shall activate the next standby GPS automatically. GPS Master Clock System shall be supplied with necessary hardware & software to receive the synchronizing signals from remote satellite and provide outputs to synchronize all systems like DCS, SG integral control system, TG integral control system, electrical relays & all plant PLC (if any) etc. The required time formats and number of time signals required for synchronizing the various consumers shall be decided based on requirement (eg. NTP, SNTP, IRIG-B).

In addition to the requirement GPS IRIGB ports connected to all process control systems, Switch yard SCADA, EMS etc spare ports of 10 Nos. shall be provided for future.

- 14.2.0 Global Positioning System to which the master clock gets synchronized shall be an absolute system to provide continuously 3 dimensional position fixing, velocity measurement and Time reference generation.

- 14.3.0 The master clock shall be configured as Real Time Clock with display of time in 24 hrs format and date.

- 14.4.0 The offered master clock system shall consist of the following minimum items:

- a) GPS Antenna
- b) GPS Receiver
- c) Signal Processing Unit
- d) Local and Remote display units (50 nos)
- e) Power supply and Battery charger
- f) Maintenance free Battery.
- g) All required cables, mounting accessories, cabinet for the processing electronics etc.

- 14.5.0 Technical features shall be as follows:

- a) GPS Antenna Type Helical
- b) Noise Less than 2.6 dB
- c) GPS Receiver Microprocessor based
- d) Tracking method Code / Carrier tracking



- e) Output data format NEMA 0183 or equivalent
 - f) Communication speed > 9600 BPS
 - g) Output rate every second
 - h) Signal Processing Unit Microprocessor based Digital type
 - i) Reference OCXO with stability of 1 PPM.
 - j) Time Accuracy 1 PPM
- 14.6.0 The fully wired panel shall accommodate GPS receiver, Signal Processing Unit, Battery Charger and Power supply Unit and Battery shall be supplied as required.
- 14.7.0 The Master clock system shall be provided based on Global Positioning system (GPS). Master clock shall have separate signal conditioner facilities to transmit clock pulses of specific formats, (such as IRIG-B, pulse, NTP/SNTP etc.) for time synchronizing other equipment in the power plant such as, Unit DCSs, Common DCS, BOP DCS, SOE & for all microprocessor based system like TSI, VMS, HMS, Flame monitoring & detector system, Boiler tube leak detection system, Plant performance & Optimisation system, ERP, MIS etc. PLC (if any) & Microprocessor based system in entire plant shall be time synchronized from Master Clock System. Master Clock System shall be common for all the system in complete plant. Spare 15 nos. port of each type of signal shall also be provided for future use.
- 14.8.0 Complete hardware, cables required for time synchronised at both end shall be provided by Bidder. Time synchronising signals shall be able to communicate to multiple protocols like IRIG-B, pulse, Mod-bus, NTP/SNTP, K bus, SPA protocol etc.
- 14.9.0 The receiving system of master clock shall consist of antenna, a low noise amplifier, a down converter combined as head unit, co-axial cable to carry the converted signal to indoor unit which consist of a demodulator and a decoder. The decoder time signal shall be employed for synchronisation of plant systems.
- 14.10.0 The Clock system shall be dual redundant microprocessor controlled and fully automatic. Clock system shall employ highly stable crystal oscillator to ensure accurate time indication. The stability shall be better than 0.5 sec. per day. Oscillator shall have redundant standby unit. Provision for manual setting of time shall be provided in the master clock. The master clock shall incorporate alarms for fault conditions, which shall be displayed locally on the unit and also in remote panel of DCS
- 14.11.0 The UPS power supply shall be provided for Master clock system with redundant feeders. The clock display would get automatically time synchronised to IST in less than two minutes after power up (or interruption). It shall also have the provision of manual setting and can operate autonomously in absence of satellite reception. Battery shall be provided with teak wooden rack.
- 14.12.0 The Master clock shall be housed in a suitable panel made of CRCA MS sheet of 2 mm thick and located at Central Control Room. The panel shall be vertical, floor mounted and provided with necessary illumination. The cable entry shall be from bottom shall be provided. All the control and monitoring devices and all switches for affecting the various controls shall be provided in front of the panel so as to provide easy accessibility and aesthetic look.
- 14.13.0 All the Slave clocks shall derive impulse from the Master clock. Each Slave clock shall be connected to Master Clock by 2 pair copper wire with annealed, tinned, stranded Copper conductor, PVC insulated, PVC sheathed, GI round wire armoured, overall FRLS PVC sheathed. It shall be ensured that loss of any slave display unit does not affect the display of any other slave unit. All slave clocks shall work in exact synchronism with Master Clock. They shall be weatherproof construction suitable for indoor or outdoor use. They shall be enclosed in a suitable heavy gauge sheet metal enclosure and fitted with protective antireflective glass face / cover.



- 14.14.0 Slave Clocks shall be digital type with updates at every second. The display shall be of six digits for hours, minutes and seconds. Display element shall be red LED and the digit size shall be 100 mm minimum for a viewing distance of 20 metre. Anti glare glass cover shall be provided. In control rooms wall / panel mounting type decorative slave clock shall be provided. The slave clock shall work on 240 V AC supply. Slave clocks shall be indoor 25 (twenty Five) nos. and outdoor 25 (twenty Five) nos. minimum distributed all over the power plant.

15.0.0 POWER SUPPLY SYSTEM AND GROUNDING

15.1.0 Power Supply and Fusing

a) Computers/monitors/O.S	:	230 V AC UPS
b) Control panels	:	230 V AC, UPS
c) Package units panels	:	230V AC UPS
d) Back-up monitoring panel	:	230V AC UPS
e) PLC based systems	:	230 V AC UPS
f) Solenoid valves	:	24 V DC & 220 VDC (Driven through interposing relays)
g) Input contact interrogation voltage / Transmitters power supply	:	24 V DC (From DCS)
h) SWAS & stack analyzers	:	230 V AC UPS
i) Panel lightings	:	230V AC
j) Level gauge/illumination	:	230V AC
k) Plant DCS	:	230AC UPS
l) Printers	:	230AC UPS
m) SG control system	:	230AC UPS
n) STG control system	:	230AC UPS.

The respective suppliers of the above system shall derive the other required voltage levels.

Uninterrupted power supply for all the I&C equipment shall be supplied as per the Electrical specification volume.

Preferably all I&C equipment shall be fed from the 230 V AC, UPS.

Dual redundant power supplies to be provided for all the I&C panels. Loss of single power supply shall be alarmed in DCS for corrective action by the operator

All power source and power conditioning equipment in the system shall be redundant. These redundant power supplies shall have diode auctioning or auto switchover facility.



Separate bulk power supply unit to be provided for Field interrogation voltage (24 V DC) /Transmitters power supply from DCS. Separate bulk power supply unit to be provided for DCS hardwares/Electronics.

If the Bidder wishes to use a different voltage level e.g. 24V DC, the Bidder shall justify this and shall design, supply and install all necessary equipment including DC/DC-converters or inverters, decoupling diodes, bus bars etc. for this system.

Regardless whether converters or inverters are used, the Bidder is responsible to make sure that switching from one bus bar to the other one under no circumstances affects the electronic equipment.

The main power supply MCBs shall be located in functional groups within separate power distribution cabinets.

Fuse ratings and time characteristics shall be such that in all cases, a fault within an individual item or module will cause the fuse associated with that item, to rupture and thus disconnect that item from the power supply, before the main fuse is affected.

Failure of a main fuse shall affect the overall operation of the plant as little as possible.

Failure of a main control fuse shall be indicated in the CCR by means of an alarm. This alarm shall state the identity of the failed main fuse.

Failure of an individual module or component fuse shall be indicated by a general alarm and a detailed diagnostics message.

The section of the Control Cabinet in which the fuse is located shall be indicated. It shall also be possible to locate visually the fuse that has failed.

The design of the electrical power supplies and fusing system must ensure that any faults in modules or other devices, which may block logic interlocks or control systems, are restricted to the system in which the fault has occurred.

All electronic devices shall be protected against RF (SAMA 33.1) / EMI (As per the IEC), transient voltage levels, which would otherwise damage the device.

Equipment in hazardous areas shall be provided with an intrinsically safe barrier or other explosion proof system, in order to ensure that the energy transmitted to the hazardous area equipment is restricted to a level insufficient to cause ignition. Such barriers however shall not interfere with the normal operation of the system.

The supply voltages for the control cabinets must be arranged as separately fused in feeds. The individual feeders can serve either a single cabinet or several cabinets combined as a logical group.

Power cable with necessary sizing shall be laid from UPS ACDB to C&I lab

All measuring circuits must be separately fused.

15.2.0 Grounding

The proposed instrument grounding scheme to be submitted by the Bidder. There has to be separate earthing for DCS/other control systems earthing and shield earthing with the required earth resistance. Separate power / panel earthing shall also be provided by the Bidder for all the Control building / local control rooms system earthing shall be <0.5 ohms and cabinet earthing shall be <1 ohms. I&C system earth shall be isolated from the plant earth. Ear thing scheme and calculations shall be submitted to the owner for review.

**VOLUME – II****SUB-SECTION 4.7****SPECIFICATION FOR PLC**

- 1.0.0 The intent of the specification is to comply the requirement of the PLC/ Micro PLC (if any) proposed or supplied by the bidder for the equipment mounted or skid mounted items. The microprocessor based Programmable Logic Controllers (PLC) (Operator stations / Engineering stations shall be provided as specified in this section) shall consist of dual power supply modules, hot standby processor modules and communication modules with redundant communication link for communicating with remote Central control room DCS. The PLC shall be 100% modular and expandable. On-line replacement of all modules shall be possible.
- 2.0.0 PLC based systems of same make and same family of hardware shall be provided for all PLCs offered in the plant.
- 3.0.0 The system shall provide for sequencing of automatic start-up / shutdown bringing standby equipment into operation on failure of main equipment and manual intervention facility for all the equipment.
- 4.0.0 All the necessary hardware, licensed software, interfacing/driver cards, hubs/switches, cables and connectors for this purpose shall be supplied and installed and commissioned by the Bidder to make it full functional upto the full satisfaction of the Owner. 10% wired I/O spare upto the terminal blocks on each card shall be considered by the Bidder. 10% wired spare slots to accommodate electronic modules to be provided. And processor / communication loading should not be more than 60%.
- 5.0.0 The supplied PLC system shall have open system architecture to integrate/communicate with any third party system. It is the Bidder's sole responsibility of interfacing the PLC and SCADA system with central control room DCS and make this soft link communication fully functional upto the full satisfaction of the Owner. Programmable terminal with a laptop and software shall be provided for the PLC's.
- 6.0.0 The supplied PLC system shall be interfaced with DCS through OPC DA (data access) protocol. Since the PLC interface to DCS is used for monitoring purpose, the OPC on the PLC side shall act as server and OPC on the DCS shall act as client. The interface shall be used for monitoring purpose and control is not foreseen through serial link. Each PLC shall be interfaced independently with DCS.
- 7.0.0 The PLC system features shall include but not be limited to the following:
- a) Scan time for digital and pulse inputs not greater than 100msec.
 - b) Scan time for all analog inputs not greater than 250 ms for non critical and 100 ms for a critical
 - c) Execution time not greater than 100msec.
 - d) Max. system loading of 60% under worst loading conditions.
 - e) Independent measurement circuit for each measurement.
 - f) Grouping of signals in each card is subject to approval at the time of detailed engineering.
 - g) Failure of one logic shall not result in failure of the other logics.
 - h) Overall accuracy of measurement signals shall be 0.5%.



VOLUME II
SUB-SECTION 4.8
SG INSTRUMENTATION AND CONTROLS

1.0.0 SG INTEGRAL CONTROLS

1.1.0 Burner Management System (BMS) & Boiler Protection System (BPS)

This includes integral boiler controls like Burner Management System (BMS) Sequence control and Master fuel trip (MFT), Milling plant sequence control, Seal air fans control and scanner cooling fans control.

Burner Management system shall be implemented in the DCS with adequate safety, diagnostic and redundancy with fault tolerant hardware and software. Related hardware shall be segregated in identifiable cabinet/s with no sharing of I/Os with any other system.

Triple modular redundant configuration (TMR) shall be provided for boiler protections. Each of the three independent channels shall have its own dedicated processors, controllers, communication controllers, I/O modules, interface etc. All safety related process inputs shall be fed to each of the 3 channels. All the primary sensors for unit/boiler protection shall be triple redundant. The computed signal for each of the trip condition in each channel will be considered for calculated SOE point

The acquisition and conditioning of binary and analog protection criteria signals for BPS shall be carried out in each of the three triple redundant channels. Each channel shall compute the 2 out of 3 voting logic and issue a trip command. The trip signals of the three channels shall be fed to a fail safe 2 out of 3 relay tripping unit for each drive. The protection criteria for tripping shall be executed by a program which shall be identical in each of the triple redundant channel. In case one of the independent channels or any of the triple redundant sensors is faulty, the same shall be alarmed and the balance two channels/sensors shall operate in one out of the two modes

The Burner Management System provided shall include functions such as monitoring, start-up, safe shutdown during normal as well as emergency conditions, control of all burners during all modes of operation in accordance with the latest revision of NFPA 85 **NFPA 85** Bulletin 8502 Implosion & Explosion prevention for multiple Burner Boiler Furnace and NFPA 8503 Pulverised Fuel system.

As a minimum, the BMS for each steam generator shall include,

- a) Purge supervision and control
- b) Flame scanners, amplifiers to provide start/stop interlocks and flame intensity with self checking functions
- c) Sequential start/stop of burners
- d) Igniter control for each burner
- e) Control and monitoring of the oil supply, coal mills, coal feeders and control equipment with all other associated auxiliaries
- f) Unit flame failure protection
- g) Secondary air damper control supervision



- h) Furnace pressure protection
- i) Redundant Master Fuel Trip (MFT) relays with coil monitoring relays
- j) Air flow protection
- k) Loss of all fuel trip
- l) Reheater protection
- m) All Air pre heaters off

In addition to software communication, 2 out of 3 MFT trip signals shall be hardwired from MFT to each drive of coal/fuel to ensure the safety of boiler. Provide necessary hardwiring of signals as required by other control systems for process interlocks & protections. Limiter Technique from the transmitter signals shall not be employed for MFT of BMS. The process switches are to be hooked **up** in independent impulse lines from the process for 2 out of 3 logic trips

DCS shall perform all functions that are required for the complete operation of the Burner Management system. This part of the system shall cover all burners / igniters startup and shutdown sequence and Burner / Ignitor control applications and interface with the field devices. BMS shall interface with all the field devices and flame scanners.

Control system shall be designed meeting the criteria of highest reliability and maintainability by incorporating fault tolerant hardware and software including redundant power supplies & power modules, redundant controller modules, redundant communication systems and redundant IO modules

The control system objectives is for improving overall operating performance, reliability dependability, operability, and maintainability.

Design Criteria

- a. BIDDER shall design I/O cards layout such that any redundant signals shall not be connected in the same card and also failure of any I/O card for redundant signal shall not affect the functionality of the loop.
- b. The BMS system shall have I/O and program validation capability for use in off-line verification of BMS program design.
- c. The BMS system application cycle time should not exceed half the Process Safety time (1 sec)
- d. Provide a facility for simulating field input for Burner flame ON and Ignitor ON condition to perform Boiler Interlock Test and Burner start/shut down sequence check.
- e. System shall interact with individual Burner control box either local or remote to startup/shut down individual burner for oil / gas and ignitor.
- f. All protection and critical signals to and from boiler control system (& turbine protection shall be transmitted by both hardwired and soft signal
- g. The Operator shall be able to initiate select fuels, light-off ignitors and burners, and monitor the burner/furnace flame safety from the DCS,
- h. The design of the BMS shall be in compliance with NFPA “Standard for Prevention of Furnace Explosion/Implosion in Multiple Burner cornered fire twin-Furnaces Boilers”.



- j. The DCS Operator Workstation displays shall provide full remote control and visual status indication of the equipment under the BMS control. The displays shall provide the following as minimum:
- Status of primary fuel firing permissives, and indication of trip valves.
 - Full indication and control for each burner & Ignitor (burner / burner & group/pair of burners) including START/STOP “soft” switches and equipment status indication of the individual burner.
 - System shall replicate the display for burner Gas / Oil characteristic curve in real time.
 - Show the flame intensity each burner. Whenever the burner fuel valve is closed, the intensity shall show zero value.

The BMS shall be designed to :

- Prevent any fuel firing unless a satisfactory purge sequence has first been completed.
- Prevent startup of individual fuel firing equipment unless permissive interlocks have first been satisfied.
- Monitor and control proper equipment sequencing during its startup and shutdown.
- Provide equipment status feed back and annunciator indication to the unit operator.
- Provide flame monitoring when fuel firing equipment is in service and effect a burner trip or master fuel trip upon warranted firing conditions.
- Continually monitor boiler conditions and actuate a master fuel trip (MFT) during adverse operating conditions which could be hazardous to equipment and personnel.
- Reliably operates and minimize the number of false trips.
- Provide a master fuel trip relay independent of processors and I/O modules
- Provide a completely independent trip path.
- Provide all logic and safety interlocks in accordance with National Fire Protection Association (NFPA).
- Include a first out feature in all controllers to identify the cause of any burner trip or boiler trip.
- Provide a complete BMS diagnostic system to immediately identify to the operator any system module failure.
- Allow burners and igniters to be started, stopped and tripped on a burner basis.
- Allow the automatic start and stop of burners based on boiler load.
- The sequence of which burner will be started or stopped will be selected by the operator from an OWS/LVS display.

Bidder standard and proven practice shall also be considered subject to Owner’s approval during detailed engineering.

1.2.0 Secondary Air Damper Control (SADC)

Secondary Air Damper Control shall distribute the combustion air to the air compartments of windbox which depends on the fuel fired, number of elevations in service and firing rate. The system shall maintain a differential pressure across the furnace and the windbox based on the boiler load. The system shall open all secondary air dampers on loss of ID fans or FD fans or MFT.

SADC system shall be provided to achieve the following functions :

- Control of fuel air flow.
- Control of auxiliary air flow at the oil elevations.
- Control of wind box/furnace differential pressure.
- Limit NOX content in the flue gas by modulating over fire dampers, if provided.

For tangentially fired boiler, SADC shall modulate fuel air dampers of each elevations based on the signal that is representative of the coal feed rate. Further, the auxiliary air dampers at



the oil elevations shall be modulated on fuel oil pressure signal whereas the auxiliary air dampers at all other elevations shall be modulated to maintain the wind box to furnace differential pressure.

In order to limit the NOX content in flue gas, SADC shall also include the control of over fire dampers (if provided). The secondary air damper controls and necessary interlocks to modulate or to open/close shall be incorporated as per the requirements of the boiler design.

For front or front and rear fired boiler also, the secondary air damper control system shall also be provided and all requirements indicated above shall be met by the Bidder. Further Bidder shall provide required secondary air flow devices for measurement of compartmental wind box air flow for each elevation.

Individual position transmitters are to be provided for each of the secondary air dampers and the same shall be connected to SADC Control System.

Control of Secondary Air Damper will apportion the total secondary air between various elevations depending upon the type of fuel is being burnt, number of elevation is in service and the firing rate in each elevation. SADC system shall be implemented in the DCS with adequate safety, diagnostic and redundancy. System shall be complete with wind box to furnace differential pressure transmitters, switches, actuators with non contact position transmitters etc.

1.3.0 Soot Blowing System

The steam generator shall be provided with a complete set of a programmable automatic sequential steam operated blowers for cleaning the furnace water walls, super-heater, re-heaters, economizer and air heater while the steam generator is in operation.

The minimum functional requirements of Soot Blower System are as follows: -

- a. Automatic sequential start of each soot blower.
- b. Selection facility for individual soot blower for automatic sequential
- c. Canceling the operation of any soot blower in the system when required.
- d. Capability to monitor all the essentials of the soot blowing system.
- e. Operation / manual over-riding of automatic operation.
- f. Capability of disable the operation of any soot blower
- g. Capability to do selective soot blowing based on the heat flux of that particular region for which necessary hardware/software should be provided.
- h. Indication of the soot blowers in operation.
- i. Monitoring all essential parameters of the soot blowing system.
- j. Indication of any malfunctioning of soot blower.
- k. Pressure and Temperature interlock with automatic retraction of the soot blower.
- l. Steam pressure control
- m. Indication of the soot blower-selected to operate
- n. Capability to prevent continued soot blower operation if the system is not functioning properly
- o. The ability to operate two soot blowers located in opposite walls simultaneously.
- p. Control circuit for the retractable blowers shall be so designed as to prevent insertion of the blowers into the combustion chamber unless the blowing medium is available.
- q. Limit switches and Torque switches are to be connected to DCS and command termination shall be done in DCS only for each of the blowers.
- r. Warm up control of the complete piping system which shall include flow control, drain temperature control etc.
- s. Steam temperature control (if required)



Soot blowing control shall be operated from DCS operator station. When set on automatic mode the sequencing system shall perform soot blowing at predetermined intervals at all specified locations including the main furnace as well as the air preheater areas. The control system shall maintain the required steam pressure and temperature conditions. SBC system shall be implemented in the DCS with adequate safety, diagnostic and redundancy. Related hardware shall be segregated in identifiable cabinet/s with no sharing of I/Os with any other

Separate and independent hardware shall be provided for soot Blower controls. All the above control system shall be implemented in the DCS.

Intelligent system deciding the required soot blower operation by considering the temperature measurements of boiler surfaces is to be provided. Extra thermal sensors if required for optimizing soot blower action shall be provided.

Thermal imaging devices (4 Nos. – 1 No. locked on each side of boiler) are to be provided for effective use of water canons. The data from this thermal imaging devices shall also be utilized for effective optimistic operation of Soot blower.

1.4.0 Mill Gravimetric Feeder Control

A Microprocessor based Gravimetric Feeder Control shall be provided for each pulverizer consisting of belt weigh scale and a tacho-generator to obtain an accurate coal feed rate. The system shall be reliable and shall have auto calibration, human machine interface, diagnostic monitoring and data logging features. In addition, the system shall provide alarms such as coal on belt, feeder discharge plug gage and accept demand feed rate signals from DCS. If the system does not measure coal flow on loss of any signal, alarm has to be given to DCS and initiating the feeder to run on volumetric mode from the gravimetric mode. Provision for changing the coal density by end user to run the volumetric mode with higher accuracy has to be given.

Bidder shall provide a minimum of two independent speed sensors, 2 nos. of load cell, pulser units and associated amplifiers, etc. for each of the coal feeders. Output from the speed sensors will be used to provide at least four number isolated 4-20 mA DC analog signals corresponding to coal flow rate in tons per hour and any other signals that may be required for the control of the coal feeder.

Each coal feeder shall receive signals from the DCS for feeder speed control. The signal to be provided for the same shall be in the form of galvanically isolated 4-20 mA DC. All required power amplifier units/interface devices to accept this 4-20 mA signal shall be included.

All associated electronics like buffer amplifiers, frequency to current converters etc. shall be provided for each RC feeder with local speed indicators. The speed sensors shall be totally enclosed, fire, dust and weather proof, suitable for the service conditions.

The control cabinet shall be provided with Reset push buttons and individual lights to signal the individual Internal trip conditions.

Each feeder shall be provided with a four position switch located at the feeder for remote off, local run (when there is no coal on conveyor) and calibration purpose.

If there is any electronic modules mounted local to the feeder body then these shall be suitable for operating in a non-air-conditioned area in a suitable enclosure to combat the effect of noise, vibration, entry of dust etc.



All necessary paddle switches and other detectors to monitor coal on belt, feeder discharge plugged, coal motion monitor etc. should be provided to ensure safe operation of the feeders.

1.5.0 Furnace Temperature Probe

Duplex k-type thermocouple with mineral insulation & SS sheath located in furnace below SH panels; minimum of 2 nos. Probe housing shall be weather proof & corrosion resistant. Accuracy shall be +/-0.5% of span. The junction shall be ungrounded with response time of 2 to 5 seconds. Starter box shall be provided with IP55 enclosure & 3 mm thick sheet. Electric motor with chain drive shall be provided for the lance. The traverse of the probes from opposite sidewalls shall cover the full cross section of the furnace. Automatically controlled cooling system shall be provided for the lance. Loss of cooling water shall be detected & provided as a contact. Accessories like limit/torque switches position transmitters, etc. shall be provided. All the field mounted accessories (limit switches etc..) shall comply to NEMA-4

The logic for furnace temperature probe shall be implemented in unit DCS.

1.6.0 Electromatic Relief valve (EMRV Controller)

Electronic/relay based type with pressure high & low switches. One no. of EMRV having Man/Auto/Off selection with lamps for auto/manual positions shall be provided for each side of the boiler (left and right side). IP65 or equivalent degree of protection for enclosure. Enclosure material will be epoxy coated die cast aluminium. Power supply will be 220 V DC & output signal will be pressure high' potential free contact for solenoid valve energisation. One no. solenoid valve (for each EMRV) of 220 V DC single coil with limit switches shall be supplied. Other features of solenoid valve shall be in line with that specified under 'Solenoid Valves' in this section. Terminals in terminal block of the controller & solenoid shall accept cable of 0.5 to 2.5 Sq. mm. Switch contact rating shall be boosted using relays. Provision to operate the EMRV from the DCS shall also be available.

1.7.0 Furnace flame monitoring system

The purpose of the system is to detect the individual flame and to enhance the boiler/furnace safety, to avoid spurious and unwarranted trips and to increase operational reliability, availability and efficiency of the Steam Generator such that the consumption of fuel oil shall be reduced to optimal minimum.

Fail Safe, easily maintainable Microprocessor based Flame Monitoring System shall be provided which shall include flame detectors of proven design for the type of fuel, environmental condition and other conditions, of established reliability at all loads of the Steam Generator. It shall be designed to work under all adverse conditions such as wide variation in fuel/air input ratio, wide variation in fuel characteristics, variation in operating temperature, maximum temperature under interruption of cooling air supply and shall be immune to Electro-Magnetic Interference (EMI). The system shall conform to NFPA recommendation and location of detectors as per NEC requirements. The Selection and location of the flame detectors/scanners shall be decided by the Boiler manufacturer..

Flame detector shall be working on the dynamic and static properties of primary combustion zone of each type of fuel and flicker frequency of flame. It shall pick up only the flame to which it is assigned and shall not respond to the adjacent and background flame or other radiation generated in the furnace. The design shall also take into account the absorption by a coal shroud, recirculated dust or other deposition on the flame detector head. The complete system shall provide the discrimination between oil and coal flame. Intensity indicators for main flame shall be provided along with galvanically isolated 4-20 Ma DC signals and hooked to DCS.



The system should be easily maintainable and include automatic self test facility at regular intervals. In case of tangentially fired boiler, the Bidder shall arrange flame detectors in such a manner that coal flame detectors are available both above and below each coal burner and separate oil flame detectors are provided for each oil burner. In case Bidder has discriminating type flame detectors capable of detecting and discriminating both oil and coal flame with the help of a single scanner, the same can also be utilized for monitoring both oil and coal flame. For any other type of firing i.e. non-tangential type, the flame detectors shall be provided for each coal and oil burner responding only to the flame of its associated burner. Bidder shall furnish the details of the flame detector locations and justification for the same.

The Bidder shall demonstrate the complete performance of flame detectors in cold start up test and load condition test. In cold start up test, capability of detectors to detect oil flame under varying oil pressure shall be checked. In load test, the detector shall be able to detect when only oil is present, only coal is present and both coal and oil are present. It shall be ensured that the detectors are able to detect the proven flame at very low load with oil guns withdrawn. The above tests shall be performed for every coal and oil elevation.

Provision of scanner air for cooling the flame detectors by 100% redundant Scanner Air Fans, both AC operated shall be provided. The dampers associated with scanner air fans shall be pneumatically operated with DC solenoid valves.

Pneumatically operated scanner emergency damper shall be erected to safe guard all the flame scanners even incase of failure of both FD fans off and both scanner air fans off.

Microprocessor based Flame Monitoring system shall be provided for the following:

- detect individual flame condition and to enhance the boiler / furnace safety
- avoid spurious and unwanted trips
- increase operational reliability, availability and efficiency of the steam generator

The Bidder shall also provide a portable flame detector testing kit with built in stabilizer, capable of simulating both oil and coal flame, and testing of flame detector head unit at field. The testing kit shall also have facility for testing all type of electronic cards as being used in the flame monitoring system.

The system shall be provided with one PC (1) with 24" monitor and A4 color laser printer to acquire the data and store from the flame scanner system through MODBUS/OPC/Other Protocol

In case of tangentially fired boiler, the bidder shall arrange flame detectors in such a manner that coal flame detectors are available both above and below each coal burner and separate oil flame detectors are provided for each oil burner. In case Bidder has discriminating type flame detectors capable of detecting and discriminating both oil and coal flame, with the help of a single scanner, the same can also be utilized for monitoring both oil and coal flame. For any other type of firing i.e. non-tangential type the flame detectors shall be provided for each coal and oil burner responding only to the flame of its associated burner. Bidder shall furnish the details of the flame detector locations and justification for the same.

FMS shall have the features not limited to following :-

- a) 100% self-checking for electronics and flagging of failures.
- b) Flame condition display including status of flicker frequency on scanner amplifier.
- c) Early warning of flame instability, flame-out condition and diagnosing of self fault.
- d) Pre-selectable "Flame Off" response time.
- e) Potential free contacts for interface with BMS.
- f) Internal temperature measurement to detect loss / inadequacy of cooling air and with shutter closure arrangement on loss of air or high temperature.
- g) Gain and flicker frequency adjustment.



- h) Detection not influenced by deposits on sighting head.
- i) Immunity from picking up of signal from adjacent burners or other sources.
- j) Approval from FM / TUV / CE / UL / SIL / CSA / ATEX / CENELAC{LW} / other approved agencies.

Provision of scanner cooling air for cooling the flame detectors by 100% redundant Scanner Air Fans of both AC operated shall be provided. The dampers associated with scanner air fans shall be pneumatically operated with DC solenoid valves.

1.8.0 Furnace and Flame Viewing System

The air cooled flame cameras shall be suitable for direct online continuous viewing in the central control room of the coal and oil flame and condition of the furnace internals including slogging of the water walls and any other deterioration in the furnace condition. The minimum nos. of such flame cameras to be included in the proposal shall be selected by the Bidder appropriate to his boiler design subject to minimum of four (4) numbers.

The flame camera system will consist of the following facilities/ components as a minimum:

- i) One nos. (1) OWS with 40" LED TV having multiple window viewing.
- ii) Facility for zooming and adjustment of iris from the monitor
- iii) Proper cooling arrangement (preferably air) and protection against cooling medium failure.
- iv) Weatherproof local control box for mounting of electronics.
- v) All necessary remote/ local programming tool.
- vi) All interconnecting cable and termination device.
- vii) Any other accessory to make the system completely operational.

The cameras and the total system shall be suitable for the furnace design as being offered by the main boiler vendor, the firing arrangement (corner, front/ wall fired), the fuel being fired considering the ash content of worst coal. The cameras should be expected to withstand the temperature expected in the furnace of the offered boiler but shall not be less than 1600 deg C.

The viewing angle of the camera shall be commensurate with the furnace size, the camera location and the positioning of the burners. The system shall conform to PAL and number of TV lines shall be adequate for a clear image of the furnace.

The offered flame camera system shall have a record of trouble free performance of minimum one (1) year in a coal-fired boiler of size 500 MW or above where the firing arrangement is similar to the offered boiler.

The system shall be capable of transmitting the image to the Unit DCS where it should be possible to display the same on the monitors of Operator workstation and the Large video screen.

System shall include four nos. of Thermal imaging devices with IR Technology to be located on each side of boiler. Thermal imaging cameras with necessary air cooling shall be preferred. This will give temperature profile of the boiler wall. Also the data from thermal imaging camera shall be used for operating water cannons & soot blowers in order to improve the efficiency. The data from this thermal imaging devices giving temperature profile of boiler walls shall also be utilized for effective optimistic operation of Soot blower.

1.9.0 Boiler Tube Leak Detection

Acoustic steam leak detection system shall be provided for detecting tube leakages at different zones of boiler. Isolated 4-20Ma DC signals shall be provided for monitoring the acoustic level in DCS. Bidder shall provide necessary acoustic signal generator, signal



receiver, air purging system, signal processor & controller, operator's station, cabinet, junction boxes, connecting cables and interface to DCS. The system shall be able to eliminate the effect of surrounding noise to obtain a high accuracy of leak detection. The system shall have trend recording of the leak history.

A Work station based system complete with all required software, comprising of signal processor, interface unit, OWS & A4 sized b/w LaserJet Printer shall be provided. The minimum specification of the OWS shall be as specified in specification else where.

The system shall perform the following functions :-

- i. Leak Alarming ahead of time.
- ii. Real time displaying the leak location
- iii. Showing the leak frequency spectrum
- iv. Following the leak growing trends
- v. Real time monitoring noise in the boiler
- vi. Recording the trend of the leak history
- vii. Watching operation condition of ash blowers
- viii. Self detection of device
- ix. Judging ash blocked condition of the conductive tubes
- x. Having mechanical blowing and electric ash cleaning ways in the conductive tubes.
- xi. Digital Filtering of sound signals, Frequency spectrum analysis, trends analysis, bar graph and mimic.
- xii. Automatic air purge system

To achieve the above functions, the whole system shall be divided into two parts:-

i) Signal collecting part

This part shall consist of the sound wave conductive tubes on the boiler and the enhanced sensors (min. 24 nos for boiler area) (Air borne and structure borne sensor). Each sensor consists of an enhanced sound wave sensor, amplifier and self test noise part, which shall be sealed in a stainless steel shell. In general the detecting range shall be in 10 – 15 m hemisphere space, controlled by a gain knob.

ii) Monitoring System

For Boiler Tube leak detection System, A Work station based system complete with all required software, comprising of signal processor, interface unit, Work station & B/W A4 sized LaserJet Printer shall be provided. The specification of Work station & printer shall be as specified in the specification else where. The monitoring system shall also consist of system cabinet where the cables from different sensors shall be terminated along with necessary hardware & software to achieve the above functions. Redundant Modbus interface shall also be provided with the DCS

1.10.0 On line carbon in ash analyzer system

The system shall utilize non-sampling or non-extraction type microwave technology for online monitoring/measurement of the unburnt carbon in fly ash with minimum 4 nos. probes measurement to have complete profile per location. The system shall measure a fly ash at a representative location (Locations shall be decided during detailed engineering). In order to maximize the reliability, the number of moving parts on the sensor shall be minimized. Fly ash samples shall be measured in the bulk fly ash (first hopper row of the precipitator or in an intermediate bunker. The measurement system shall not use any heating elements for the ash or piping. Each ash sample shall be larger than 100g. System shall be a proven one with the installations and operation record for substantiate the credibility.



Accuracy shall be ≤ 0.6 % minimum. The system shall also provide 4-20mA DC output to DCS and shall also be connected through soft link. Panel protection class shall be IP65. Panel shall be provided with industrial grade LED display. System shall work on UPS power supply. The offered system shall have a record of trouble free performance of minimum one (1) year in min 1 (one) nos. coal-fired boiler of size 500 MW or above where the firing arrangement is similar to the offered boiler

1.11.0 Coal mass flow balancing system

On line fuel measurement facility for accurate measurement of coal mass flow rate/air fuel ratio in each pulverized fuel (PF) pipe for each pulverizer. The equipment shall comprise of sensors working on microwave technology. The scope of each steam generator shall include two (2) nos. of erosion free measurement sensors for each PF pipe from each pulveriser, a control unit, visual display unit, connecting cables etc for making the system complete. For the purpose of above fuel measurement, each PF pipe shall be provided with two nos. of tapping points of suitable size with necessary plus/dust proof dummies etc as required.

Automatic Motorised Adjustable valve/orifice of erosion resistant/ceramic coated material suitable for highly abrasive pulverized coal applications shall be provided on each PF pipe at pulveriser outlets and the system shall enable onload adjustment of coal flow in PF pipelines to achieve balanced coal flow.

The system shall also provide 4-20mA DC output to DCS and shall be connected by soft link also. Panel protection class shall be IP65. Panel shall be provided with inbuilt laptop for data analysis. System shall work on UPS power supply. The offered system shall have a record of trouble free performance of minimum two (1) year in min 1 (one) nos. coal-fired boiler of size 500 MW or above where the firing arrangement is similar to the offered boiler.

1.12.0 Secondary air flow measurement (Left & Right)

In addition to the **conventional triple DP measurement techniques** involving venturi/ Airfoil for secondary air flow measurement, One number **Flow measurement** system each on Left side and Right side shall be provided **as redundant/checking measurement for secondary air flow** which could be used in the optimization package.

On line secondary air flow & velocity measurement facility in each on left side & right side shall be provided by bidder for accurate, absolute and simultaneous measurement of air velocity & flow rate. The equipments shall comprise of sensors working on tribo-electric technology. The error in the measuring system shall not be more than 2 %. The scope of each steam generator shall include two (02) nos of erosion free measurement sensors for each left & right side air line, redundant control units (including processors, communication modules, power modules etc), visual display unit, connecting cables etc for making system complete.

The system shall also provide 4-20mA DC output for SG C&I and BOP C&I part of DDCMIS and soft link also. Panel protection class shall be IP65. Panel shall be provided with inbuilt laptop for data analysis. System shall work on UPS power supply. The offered system shall have a record of trouble free performance of minimum two (1) year in min 1 (one) nos. coal-fired boiler of size 500 MW or above where the firing arrangement is similar to the offered boiler.

1.13.0 APH temperature measuring device

At APH, temperature measuring device of different lengths forming grid shall be provided to have average temperature for variable flow of flue gas, secondary air and primary air. These temperatures may be connected to nearest remote I/O panel.

**1.14.0 Mill and air heater fire detection system**

For measurement of pulveriser outlet temperature tungsten carbide block thermowells abrasion resistant thermowells shall be used. And not tungsten carbide coated TW to be used.

The terminals of temperature sensors shall not be at the top of mills itself. The temperature sensors wires are to be laid up to JB though SS tube of required diameter and the head shall be placed nearer to the JB. Compensating cable exposed to atmosphere in the conventional method melts away due to high temperature at the top of mill or due to coal burning.

This is for SH, RH temperatures and also both left and right sides of furnace, separate lines shall be laid and provided with furnace pressure transmitters having wide range than the furnace pressure transmitter

2.0.0 INSTRUMENTATION REQUIREMENTS

2.1.0 Minimum redundancy requirement (2 out of 3) of measurements and controls are given below.

2 OUT OF 3 INPUT REDUNDANCY	Main Steam Temperature after SH outlet Header (L/R) at Boiler End	Main Steam Pressure after SH outlet Header (L/R) at Boiler End
	Feed water Flow before Eco	Secondary Air Flow (L/R)
	Feed water Pressure before Eco	Feed water Temperature before Eco
	Main Steam flow (L/R)	O ₂ in Flue Gas (Before Economizer)
	Furnace Pressure	S.H Platen Outlet steam Temperature before De superheater (L/R)
	S.H Platen Outlet steam Temperature After De superheater (L/R)	CRH steam Temperature before LTRH (L/R)
	LTRH Outlet steam Temperature before De superheater (L/R)	LTRH Outlet steam Temperature After De superheater (L/R)
	R.H Steam Temperature after RH outlet Header (L/R) at Boiler End	Mill Temperature (outlet / inlet)
	Auxiliary Steam Pressure (MS, CRH)	Auxiliary Steam Temperature (MS, CRH)
	Feed Water Temperature	BFP Suction Flow
	S.H. Spray water Flow	Atom. Steam pressure
	R.H. Spray water Flow	Mill air Flow
	LDO press control	PA Header Pressure
	HFO press control	HFO temp control
	Separator Storage Tank A & B	Secondary air temperature (left and right)
	Boiler Flash tank Drain tank Level Control	Atomizing air pressure

All the Instruments/measurements connected with the PADO system shall be redundant.



2.2.0 Controls for the following equipment including their auxiliaries shall be implemented with redundancy, safety and diagnostic. Features of the system/equipment shall not be limited to the following.

2.2.1 ID Fan

Induced draft fan control shall be either axial flow type with inlet vane control or of variable voltage & variable frequency type additionally with damper control. The drive electronics shall be 2 X 100% redundant with manual/automatic fall back on diagnostic failure and monitoring features for speed and current. The speed turn down of the system shall be matched with the system requirement within the allowable limits. The response time of the system shall be fast enough to comply with the requirement of the Boiler control system.

Monitoring, alarm and safety devices shall be provided for the ID fan and lube oil system and shall not be limited to the followings:

- (a) Fan speed & current.
- (b) Tank oil level.
- (c) Lube oil pumps discharge pressure.
- (d) Lube oil flow transmitter cum switch
- (e) DP across lube oil strainer
- (f) Fan & motor winding and bearing temperature.
- (g) Fan & motor bearing vibration in X-Y direction with key phasor.
- (h) Lube oil pressure transmitter
- (i) Lube oil temperature elements at inlet & outlet of coolers
- (j) Suction and discharge pressure transmitter in the flue gas path

Required local instruments such as level, pressure & temperature gauges, flow sight glass, temperature gauges etc. shall be provided.

2.2.2 FD Fan

Forced Draft fans shall be provided with Inlet pitch control vanes complete with actuator, converter and position transmitter for control of secondary air flow. Monitoring, alarm and safety devices shall be provided for the fan and its lube oil/control oil system and shall not be limited to the followings:

- (a) Oil pumps discharge pressure.
- (b) DP across lube oil strainer.
- (c) Fan & motor winding and bearing temperature.
- (d) Lube oil tank level.
- (e) Lube oil flow transmitter cum switch
- (f) Fan & motor bearing vibration in X-Y direction with key phasor.
- (g) Lube oil pressure transmitter
- (h) Lube oil temperature elements at inlet & outlet of coolers
- (i) Suction and discharge pressure transmitter in the secondary air path

To carry out the purging the impulse lines of DP transmitter across Secondary air flow aerofoil/venturi., Instrument air/Service air lines with necessary isolation valves shall be connected with DP transmitter's both lines.

Required local instruments like level, pressure & temperature gauges, flowsight glass, temperature gauges etc. shall be provided.



2.2.3 PA Fan

Primary air fans shall be provided with Inlet pitch control vanes complete with actuator, converter and position transmitter for control of air flow through mills.

Monitoring, alarm and safety devices shall be provided for the fan lube oil /control oil system and shall not be limited to the followings:

- (a) Oil pumps discharge pressure.
- (b) DP across lube oil strainer.
- (c) Fan & motor winding and bearing temperature.
- (d) Lube oil tank level.
- (e) Lube oil flow transmitter cum switch
- (f) Fan & motor bearing vibration in X-Y direction with key phasor.
- (g) Lube oil pressure transmitter
- (h) Lube oil temperature elements at inlet & outlet of coolers
- (i) Suction and discharge pressure transmitter in the primary air path

Required local instruments like level, pressure & temperature gauges, flow sight glass, temperature gauges etc. shall be provided.

2.2.4 Air Pre-Heater

Following measurements shall be provided.

O₂ in FG path at each air pre heater outlet shall be measured as a measure of air leakage through seals. In addition, O₂ shall be measured per path by triple redundant sensors (03 nos.) after economizer. Differential pressure transmitter across air preheater.

Lube oil flow transmitter cum switch. Dual redundant rotor stoppage alarm shall be provided and necessary timer logic shall be implemented in DCS. No separate hardware timer shall be supplied.

Pressure transmitters and Temperature elements at I/L & O/L on Flue gas path and Air path.

To carry out the purging the impulse lines of DP transmitter across APH, instrument air/Service air lines with necessary isolation valves shall be connected with DP transmitter's both lines

Thermocouples for Air pre heater fire sensing and bearing oil temperature elements at cold and hot ends, pressure & temperature gauges, lube oil flow switch etc. for guide & support bearing. There shall be provision for turning the Air heaters by Air motor or DC drives in case of AC failure.

2.2.5 Coal Mill

Monitoring, alarm and safety devices shall be provided for all the coal mills and lube oil /control oil system and shall not be limited to the followings:

DP across lube oil strainer

Temperature element for lube oil temperature, pressure transmitter for lube oil pressure and flow switches for low lube oil flow.



Lube oil level

Coal mill DP Transmitter.

Mill outlet coal-air mixture temperatures (three per mill).

Mill Inlet air temperatures (Double redundant per mill)

Mill motors bearing vibration in X-Y direction with key phasor.

All bearing temperatures

Temperature element for coolant and lube oil inlet and outlet of lube oil cooler.

The mill bearing temperature elements inside the gear box shall be flexible and not rigid and bent

To carry out the purging the impulse lines of DP transmitters across ventury of each mill, the Instrument air/Service air lines with necessary isolation valves shall be connected with DP transmitter's both lines.

2.2.6 Boiler Circulating Water Pumps

Pump control and instrumentation shall not be limited to the followings:

- (a) Double Temperature elements for Motor cavity temperature adequate start permit, high alarm and monitoring.
- (b) Triple Temperature elements (2/3 configuration) for Motor cavity temperature very high trip.
- (c) Temperature elements at Pump casing and Suction manifold for monitoring of temperature differential.
- (d) Flow switch with local indication for "Coolant water flow to pump motor cooler" low alarm.
- (e) Purge filter DP high alarm.
- (f) Differential pressure transmitters for measuring differential pressure across the pump.
- (g) Adequate local gauges for Purge filter DP monitoring, pressure gauges at pump suction and discharge etc.
- (h) Limit switches for pump discharge valve stem position monitoring and safety start permit.
- (i) Pump & motor bearing vibration in X-Y direction with key phasor (if the BCW pump are HT drive).

2.3.0 Function Description of Auto loops

2.3.1 General Requirements

The open- and closed loop controls shall interact closely between themselves to guide the plant operation towards optimal functioning. In general, frequent operator's intervention shall be avoided and the control intelligence built into the system shall be adequate to perform routine functions. However, each Control Loop shall have an auto / manual selector station and setter to allow operator's intervention during abnormal plant conditions.

Coordinated master Control shall receive and react to the signal from Owner's load dispatch centre. The signal of unit status shall be answered back. The details of interface shall be decided during detailed engineering stage between Owner and Bidder. Plant demand load set point or "Target Megawatts" shall be set and adjusted in "remote" automatic mode from load dispatch centre according to grid control demand with frequency variation control signal as feed forward or in manual mode by the plant operator (during start up or emergencies) adjustment from the unit load setter at unit control room. Load setting shall be auctioned for



plant contingencies like run backs in case of a major auxiliary outage. Control system shall be designed to respond quickly for load demand and load changing rates and it shall also meet large output variations against ramp type load variation demands as permitted by the response time and thermal stress of major equipment. There shall be provision for “Block increase” and “Block decrease” as directional blocks in case either some equipment are in limiting conditions or in case reduction of load may lead to instability of the system.

Start-up pattern i.e whether the plant condition is cold, warm, hot or veryhot or the shut-down pattern i.e whether it is turbine cooling shut-down or normal shut-down shall be selectable under guidance from physical parameters like metal temperature.

Fuel flow control, air flow control, feed water flow control, EH governor control, etc. shall be properly tuned and controlled to meet constant or ramp load variation. The equipment shall be capable of coordinating the action of the controls in the boiler/turbine/generator unit so as to produce safe and stable operation automatically and maintain generator output, steam temperature, steam pressure, excess air (oxygen) at their desired set values. The control shall produce stable combustion, low values of unburned carbon in fly ash, and no black smoke under the steady load and load-variation.

Automatic control and adjustment of load shall be carried out in between load range 35% and 100% rated load in Automatic Plant Control mode.

Automatic runback operation in coordination with coal mill & burner control system and various others control systems shall be performed in the event of failure of major auxiliary equipments and others, which require sudden reduction in output.

Starting up and preferential shutting down of coal mills under varying load conditions shall be under automatic sequence control based on set priorities and shall not require any operator assistance other than notifying the operator about the actions being initiated. Complete automatic control shall be possible with automatic plant control system in coordination with millburner control system.

The necessary locking devices at the air failure and power failure shall be provided for all regulating duty pneumatic control to maintain plant load under failure conditions with notification to plant operator.

Automatic operation at any mode of the plant including the unit starting up and shutdown, the unit runback, the load rejection and so on shall be achieved by means of the automatic switching of the control mode (auto / manual auto-tracking mode at each control loop, the boiler follow mode, the turbine follow mode, the unit coordinated mode, etc.), the automatic changing of the various set points, the various function generators and so on. Transfer between one mode to another mode shall be bump less without disturbing the process.

Control stations on operator's station shall be grouped logically in functional blocks for compactness and ease of operation.

Protective interlocking circuits shall be provided for safety against erroneous manipulations.

Protective circuits against control system internal faults such as modules and operating ends shall be furnished.

The basic function of the Automatic Plant Control shall be, but not limited to the followings:

Bidder shall furnish the scheme of control loops & write up on his system for approval of Owner.



2.3.2 Fuel Flow Control

The fuel flow control shall regulate the supply of coal and oil (is load carrying gun is employed) to the furnace to maintain optimum efficiency at any load condition. During combustion of coal, some modulating influence shall be introduced to take account of responses of mills and boilers, clogging of coal, and variations in coal properties.

The feed water side of the boiler master cross-limiting circuit shall use two selectors to compare the feedwater demand (Boiler Master) to total fuel flow to the boiler. If the fuel flow increases, the ratio control shall increase the feed flow accordingly and visa-versa.

Similarly, the firing rate side of the boiler master shall use two cross-limiting selectors' circuits to compare the fuel flow demand (Boiler Master) to total feedwater flow. If the feed flow increases, the ratio control shall increase the fuel flow demand accordingly and visa-versa.

Since the ratio function is incorporated only in the firing rate side of the cross limiter, correction shall be made in the selectors to account for the ratio to keep the selectors in balance. A dead-band shall be introduced in all the cross limiters to allow limited excursions during rapid load changes. The cross limiters shall be limited, in turn by absolute limits to circumvent runaway condition of feedwater pumps.

A mill master, heavy oil control and light oil control stations shall permit manual operation of the pulverized coal flow and fuel oil flow respectively. For coal burning, the summation of total coal flow shall be compared with the fuel flow demand signal, the error signal modulates the output of the coal feeders. The feeder speed reset signal shall be derived from the differential pressure across the mill. Means of correcting control disturbance due to changes in the calorific value of the fuel shall be provided. The process of changing of operation from firing light fuel oil to firing heavy fuel oil and from heavy fuel oil to exclusive firing of coal at the time of loading up the boiler and the reverse from exclusive firing of coal to heavy fuel oil at the time of unloading the boiler preparatory to shutting down, i.e. switching of fuels, shall be carried out automatically. However, the mill system start-up/shutdown group sequence control shall be manually initiated.

The fuel mixing ratio set point station shall be used to obtain the desired proportion of the fuels used i.e. oil / coal during mixed firing operation of the boiler based on quantities and calorific values.

Comparison of the signal with total air flow and total fuel flow shall be continuously carried out to prevent an unsafe (air deficient) condition from arising at any time.

2.3.3 Air Flow Control

In order to achieve safe and efficient combustion the correct fuel air ratio shall be maintained at all times and an air rich mixture shall always be present when increasing and decreasing load. Oxygen and BTU corrections shall be included in the air side to ensure proper combustion, minimize heat losses and reduce carbon oxide presence in flue gas stream. The firing rate signal from the fuel master shall be high selected with fuel flow on the airflow demand side and low selected with air flow on the fuel demand side.

The lead-lag selector mentioned above shall maintain the proper relationship between fuel and air flow by correcting the firing rate signal on the air side only.

Excess Oxygen in the flue gas shall be measured at economizer outlet. This analysis shall be used to form part of the automatic air fuel ratio control system. The measured values shall be validated in a two-out-of-three algorithm before being applied to the loop. The measured Oxygen shall be compared with a load dependent set point in a PID controller.



The auto/ manual station shall permit the operator to manually set the desired bias and corrections.

After the lead/lag auctioning, the air demand shall be trimmed for excess air and BTU. BTU correction shall be performed by calculating the difference between input energy (total fuel in) and energy output (total steam flow). This adjustment shall have a long time constant to ignore mismatches during transients. The corrected air demand shall (i) be compared with temperature compensated airflow and the deviation shall be used to reposition the forced draught fan pitch controls to satisfy the airflow requirements, (ii) correct the fuel flow demand by adding correction factor to actual fuel flow calculation and (iii) shall incorporate a minimum airflow limit, set normally at 25% to ensure safe boiler operation at low loads. The actual total air flow being the sum of primary air and the secondary air, at two different temperatures, mass flow shall be computed by compensating for density by measuring the flowing temperature. In case of failure of a temperature measurement, the computation shall fall back upon boiler rated parameter with an alarm flag.

Directional blocking shall be applied to the air flow loop from the furnace pressure control. If furnace pressure is already too positive, there shall be a raise inhibit on air flow signifying that the load increase shall be blocked. Similarly, the reverse will occur when the furnace pressure is already too low.

Directional blocking shall be extended to UCC if air flow is too much or too less compared to the demand, FD vanes are driven to extreme. FD vane shall not be permitted to be set on auto mode in case the furnace draft control is on auto mode.

Synchronizing circuit between the two fans shall be provided for equal or unequal sharing (by biasing) with respect to vane position or motor current or air flow etc on each side.

Bidder may offer fine tuning facility of excess air based on carbon monoxide in flue gas.

2.3.4 Furnace Draft Control

Furnace pressure control shall generally adjust the regulating inlet dampers of ID fans and the fan speed to maintain constant negative pressure at the furnace chamber. Speed adjustment will come into picture when the pressure excursion will be beyond certain limit. Bidder can furnish any alternative scheme for his system offered. Average FD fan demand, through a characterizer, provide the feed forward signal for the ID Fan inlet dampers. The PID controller shall compare and maintain the furnace pressure at the desired set point. The non-linear gain of the controller shall be desensitized near the set point to avoid minor oscillation. It shall be possible for the entire operational process from starting of the draught system at the time of starting a unit to stopping of the system during shutting down of the unit to be automatically controlled in accordance with the pressure set for the interior of the furnace. A safety override feature shall act as a counter-measures against explosions and implosions for safe operation of boilers. The override shall come into operation on high pressure deviations to adjust the demand signal for the ID fans. The safety circuit shall quickly bias the inlet dampers, based on air flow, when MFT occurs. The override shall withdraw itself when the furnace pressure comes within its Norman excursions. The safety system will requisition MFT when predefined limits of pressure are exceeded. In the event of any limitation occurring in the draught plant capability, the draught plant shall continue to operate under automatic control at or close to the new operational limit, and the unit generation shall be automatically ramped down to match the group or subgroup constraint in an orderly manner.

On Both left and right sides of furnace, separate lines shall be laid and provided with furnace pressure transmitter having wide range (-300 to +300 mmwc) than the furnace pressure control transmitter to monitor the furnace pressure swing



The control system and means of measurement shall be designed to enable accurate repeatable automatic control of combustion to be carried out over the load range from 35% rated output to boiler MCR. Forward path steady state and dynamic compensators whose parameters are load dependent and which account where necessary for the number of draught fans in operation shall be incorporated in the furnace pressure modulating loop.

Directional blocking shall be extended to UCC if furnace draft is too much or too less compared to the set value, ID dampers are driven to extreme. Synchronizing circuit between the two fans shall be provided for equal or unequal sharing (by biasing) with respect to damper position or motor current etc on each side.

2.3.5 Mill Outlet Temperature & Air flow control

Mill outlet temperature and air flow control shall be maintained at set value by varying positions of hot air damper and cold air damper.

2.3.6 Superheater Steam Temperature Control

Superheater Steam Temperature Control shall be capable of dealing with sudden load changes and other disturbances with a minimum variation in steam temperature which will also mean a minimum variation in superheater tube metal temperature and thus the stress.

The system shall include those features necessary for safe operating practice and shall provide stable control during transients conditions. Such feature as anticipatory control based on state variables shall be applied to the loop in for anticipatory and immediate action when the boiler load is varied.

The superheat control loop shall also include a technique for quick restoration of temperature by 'boosting' the spray flow when load changes have occurred. The final boiler steam temperature shall be controlled by two independent methods. First, since the boiler acts as a heat exchanger, the ratio between the heat input (firing rate) and heat takeaway (feedwater flow) shall affect the final temperature. Second, spray water introduced in the superheater section also impacts the final steam temperature.

The overall temperature control scheme shall coordinates the two methods as follows:

- (a) The feed water/firing rate ratio stations shall control the long term final temperature which in turn shall control inputs to the ratio function between the boiler and firing rate masters.
- (b) The spray valves shall control the short term final temperature.

In this scenario the sprays shall always be available for transient (short term) temperature control. Under the correct feedwater/firing rate ratio, the interstage final temperatures shall be controlled to set points derived from the boiler load index. The final (boiler outlet) temperature shall be controlled to the boiler design temperature.

Boiler design temperatures shall be controlled using cascaded type control schemes. The upstream controller PID shall control the temperature leaving a superheater section (interstage or boiler outlet) by adjusting the set point of the downstream controller PID. The downstream controller shall be controlling the temperature immediately after the spray that is entering the superheater section.

The feedwater flow to the firing rate ratio shall also be controlled by a cascaded control scheme.

The downstream controller shall control the waterwall temperature (separator temperature) and shall quickly impact the firing rate (and waterwall temperature) since it is adjusting the firing rate demand from the Boiler Master to the firing rate master.



The upstream controller shall directly control the spray flow to the superheat sections through the firing rate.

If the spray flow is found greater than setpoint at a given load and with a final temperature at setpoint, the upstream controller shall reduce the setpoint for the downstream controller (waterwall temperature). The resulting reduction in firing rate in turn shall reduce the final temperature. The sprays shall adjust (reduce) to bring the final temperature back to setpoint and in doing so, shall also bring the spray flow to setpoint. This loop shall be slow acting and shall be meant to keep the sprays in play so that they can active during boiler load changes.

The spray flow setpoint shall be derived from the boiler load index and calculated to be a percentage of the current boiler load. When the spray control shall be set in manual, the feedwater to firing rate ratio shall be automatically transferred to directly control the final superheat temperature through firing rate adjustments. Since the downstream PID controller in this scheme is actually controlling the waterwall temperature, protection can be added to this loop to keep the waterwall temperature within limits.

To improve the performance of the loop the temperature measuring wells shall be designed for fast response

2.3.7 Reheat Steam temperature control

Reheat Steam temperature control shall primarily be done by burner tilt mechanism. Reheat attemperator water shall only function as an emergency measure to bring down hot reheat temperature. During normal operation there shall not be any reheat spray flow. For operating burner tilt mechanism individual I to P converter shall be provided at each corners (Totally 4 Nos. of I to P converter) instead of laying the pneumatic control line covering all the corners with single I to P converter



VOLUME II
SUB-SECTION 4.9
TG INSTRUMENTATION AND CONTROLS

1.0.0 TG INTEGRAL CONTROLS

Steam turbine control system shall comprise of two partitions one for control and other for protection. Control partition includes automatic start up & speed control, synchronization, load control, load rejection, frequency control, over speed runback and valve testing. Protection partition includes monitoring & safety interlocking of turbine critical parameters, over speed tripping and test for trip channels. All the above partitions shall be integrated into the DCS so that it can use the similar hardware & software component, same operator interface, communication network, integrated operation & reporting and common co-ordinated boiler & turbine control.

All the data and control performance shall be available to all the partitions of DCS including report generator, operator workstation, historian and plant management information system. Supervisory systems such as turbine rotor stress calculation, automatic start up program and performance calculation can also easily access the turbine control system over the communication network.

Control system shall be designed meeting the criteria of highest reliability and maintainability by incorporating fault tolerant hardware and software including redundant power supplies & power modules, redundant controller modules, redundant communication systems and redundant IO modules

Other balance controls of TG system such as ATRS, Bypass, Gland steam pressure, TG integral pumps, Turning gear, Condenser evacuation system, Generator auxiliaries etc. shall be configured in unit DCS

1.1.0 Automatic Turbine Run up System (ATRS)

An Automatic Turbine Run-up System (ATRS) shall also be implemented in the Digital Electro Hydraulic Control system (DEHC). The ATRS shall run the turbine automatically from zero speed to synchronizing speed and then load the turbine up to block load without impairing the life of the turbine.

All the electronic modules to be used in this system shall be dual redundant and the field sensors shall be two out of three configurations.

The ATRS system shall be designed to provide the following functions:

- a) Automatic start up/shut down sequence.
- b) Stress/temperature margin controlled acceleration as per the preselected mode, i.e. slow, normal, fast.
- c) Stress/temperature margin controlled loading/unloading.
- d) Automatic synchronization and loading up to 100% MCR.
- e) Unloading and shut down of the machine.

The start-up/shut-down sequences of the turbine and its auxiliary systems shall be configured in a hierarchy system of Functional Group Control (FGC), Sub-Group Control (SGC) and Sub-Loop Control (SLC) in a coordinated manner. The functional group control shall include sequence control, interlocks and protection of all valves, drives, equipment and devices that are related to turbine startup/shutdown, turbine drains, gland steam supply, vacuum/condensate, oil supply, turning gear and auto synchronizer as a minimum.



ATRS shall run the turbine automatically from zero speed to synchronizing speed and then load the machine upto block loading and continuously check the operation upto 100% MCR without impairing the life of turbine.

1.2.0 Turbine Stress Evaluator (TSE)

The Turbine Stress Evaluator (TSE) shall analyze, monitor, display and control the thermal stress levels of the turbine. It shall automatically co-ordinate with the turbine auto-run-up program and loading program in order to ensure that the permissible turbine stress levels are never exceeded. In case the allowable safe thermal stress margin is exceeded during run- up and loading, the TSE shall automatically halt the speed/load in position until the thermal stress has come down within the allowable margin. If the stress margin is exceeded during the run-up program at the critical speed, the TSE shall then reduce the speed to a safe value below the critical speed and halt on it until the stress becomes normal and the run-up program shall then re-start automatically. The safe value below the critical speed shall be well defined, as it will not be allowed to keep reducing the speed down through the whole range. TSE shall store long term data and carryout residual life analysis & fatigue analysis for all affected components.

TSE shall be provided with 1 No. Engineering station with 1 No A3 laser colour printer. The data from the TSE system shall be interfaced to DCS so as to the view the TSE results in DCS operator stations. TSE systems shall have redundant OPC interface to be connected with unit DCS. The TSE system shall be synchronized with station GPS

Bidder shall provide a proven turbine stress control system which shall work in conjunction with turbine governing system and ATRS to achieve the following functional requirements:

- i) Continuous on-line monitoring of thermal stress levels in all critical parts of the turbine such as main stop valves, control valves, HP casing, HP shaft and IP shaft etc.
- ii) Continuous on line computation of stress margins available for the above mentioned critical components of the turbine during various regimes of operation i.e. run-up, synchronization, loading, load maneuvering, normal operation, run backs, unloading, shut-down etc.
- iii) Computation of the limits of speed and load changes allowable at any particular instant before synchronization and after synchronization respectively. The system shall be designed to inhibit further operation like speed/steam temperature raising or lowering wherever upper/lower temperature margins are not available (during periods prior to synchronization) and load/steam temperature raising or lowering whenever upper/lower load/temperature margins are not available (after synchronization) within allowable limits.
- iii) Carry out a fatigue analysis for all affected components of the turbine and also to compute the percentage service life consumption of the turbine.
- v) Display the stress margins etc. on the operator station for operator guidance and storage of necessary data such as percentage service life consumption etc.
- vi) Store long term data & carry out residual life analysis.
- vii) One (1) no of operator station for TSE for unit in charge with A4 color printer shall be provided.

1.3.0 Electro Hydraulic Governing System

The turbine governor shall be provided with high-pressure hydraulic fast response control valve actuators. The governor equipment shall be complete in all respects and shall be capable to carry out the following control tasks:

- a) Speed/frequency regulation
- b) Electrical power regulation
- c) LP extraction steam pressure regulation
- d) Live steam pressure limitation



e) Condenser pressure limitation

The turbine control system shall be capable to control the LP steam extraction pressure under all conditions of steam load changes.

Logics as per CEA's requirement for Restricted Governing mode of operation shall be included. As per the CERC requirement, the operation of 660 MW Turbine on RFGMO mode to be implemented for enhancing the safety of electrical grid due to frequency disturbances. Necessary hardware and software for running the 660 MW Turbine on RFGMO mode shall be supplied in Turbine Control System based on the latest guidelines given by CERC and available at the time of implementation of project.

The EHGS shall have the features not limited to the following:

- a) Capable for run up, run down, synchronization, loading, load rejection and house load operation with good dynamic response and high degree of operational reliability and dependability.
- b) The turbine governing controls shall position the control valves and adjust load. Turbine Stress Control System (TSCS) signal shall be used for safe operation of the turbine.
- c) Hydraulic control for quick, smooth and continuous delivery of large actuation forces.
- d) Precise maintenance of the rated frequency of the power grid by means of an exact frequency-load-characteristic with sensitive response and facilities for fine adjustment of the characteristics.
- e) Free governor operation in interconnected grid.

The controls covered in this system shall basically consist of speed controller, load controller, valve-lift controller, inlet steam pressure controller and output frequency droop characteristic controller. Automatic tracking device shall provide bumpless transfer amongst different control mode. The speed controller shall ensure controlled acceleration of the turbine generator and shall prevent over speed without tripping of the unit under any operating condition or in the event of full load throw-off.

The speed controller shall limit the over speed of the turbine on loss of full load to a value less than 8% of rated speed. The governing system shall be equipped with speed /load changer to control the speed or power output of the steam turbine within the limits. The speed/load changer provided shall be capable of adjusting the speed of the turbo set to any value in the range of 94% to 106% of rated speed for manual/auto Synchronization of the generator with the bus. It shall be capable of varying the load on the machine from no load to full load.

The speed-sensing element shall respond to small speed variations so as to maintain dead band within 0.06% of nominal speed. Speed shall be adjustable within 0 to 106% and Frequency compensation / Droop adjustment shall be within 2 to 8%.

Indication of the speed/load changer position shall be provided on the operator station. The governing system shall be equipped with a load limiting device capable of being operated both locally as well as remotely from unit control room for the purpose of limiting the amount of opening of the governor controlled valves to set the load at a pre-determined limit, while the turbine is in operation. Contacts shall also be provided on the load limiter for signalling load limited operation in unit control room.

There shall be a Unit load constraint co ordinator. During any load change the co ordinator shall monitor critical turbine and boiler parameters and shall automatically reduce the unit loading rate if it is determined that excess stress is likely to occur. When the transient conditions are clear and stress is reduced, loading rate shall automatically returned to the original operator adjusted settings. Co coordinator shall also monitor the availability of plant auxiliaries such as fans, pumps, coal mills etc. and automatically adjust the maximum and



minimum limits for load changes based upon the equipment availability. Turbine shall be capable to run in parallel with the boiler in co coordinated control mode.

Servo valve shall be of highest reliability by two or three coil design and position feed back signal of servo valve shall be available to the control system. Controller shall be able to detect for any open and short circuit of servo valve coil and stuck valve condition. Position transducers to determine the actual position of the electro hydraulic transducer. Control valve position transducer & Emergency stop valve position switches to determine the position.

The electro-hydraulic governing system shall limit the over speed of the turbo set below the trip points or safe limits on loss of full load. The controls shall operate satisfactorily without causing the turbine to hunt under any conditions of steam supply and variation in load regardless of whether the turbine is operating synchronously or asynchronously.

The speed-sensing element shall respond sensitively to speed variations so as to maintain dead band within 0.06% of nominal speed. Speed shall be adjustable within 0 to 106% and Frequency compensation adjustment shall be within 2 to 8%.

The electro-hydraulic governing system (EHGS) shall have the following features:

- (i) Capable for run up, run down, synchronization, loading, load rejection and house load operation with good dynamic response and high operational reliability and dependability.
- (ii) The turbine governing controls shall position the control valves and adjust load. Turbine Stress Evaluator (TSE) signal shall be used for safe operation of the turbine.
- (iii) Hydraulic control for quick, smooth and continuous delivery of large actuation forces.
- (iv) Precise maintenance of the rated frequency of the power grid by means of an exact frequency-load-characteristic with sensitive response and facilities for fine tuning of the characteristics.
- (v) Reliable operation of isolated power grid by automatic switchover of the load reference value with the aid of the Turbine Stress Evaluator (TSE).
- (vi) Support of the pressure control system of the steam generator via adaptation of the turbine load.
- (vii) Free governor operation in interconnected grid.
- (viii) Operation of EHGS shall be performed from DCS HMI also.

The electrical part of the EHGS shall contain

- (i) The devices for acquisition of the measured data from various transducers & sensors.
- (ii) The electrical controller – consisting of the “power supplies” and “Controllers” for valve position, rotational speed, load & throttle steam pressure.

Following devices are foreseen

- (i) Measuring devices for the rotational speed of the turbo set.
- (ii) Power measuring devices for active electrical power delivered.
- (iii) Throttle pressure measuring transmitters.
- (iv) Electro-hydraulic positioner to position the control and stop valves.
- (v) Sensors to determine the position of the electro-hydraulic transducer.
- (vi) Control valve position transducer.
- (vii) Stop valve position switches.

Controls within EHGS shall include

- (i) Speed control to control the steam admission in the range for speed control upto synchronization.
- (ii) Load control to control the steam admission in the load control range after synchronization.
- (iii) Pressure control to control the turbine load with respect to the steam pressure.
- (iv) Automatic tracking Device.



- (v) Device to form the frequency dependent characteristic (droop characteristic).

Three channel measurements for the rotational speed shall be adopted. If one of the probe/channel fails, the control shall continue to operate without interruption. In addition, at least one probe shall be provided for monitoring and one shall be kept as spare. The power delivered by the generator shall be measured with three channel containing three independent measuring systems. Electro hydraulic transducer (servo valve) shall accept electrical signal from the EHGS controller and convert it into hydraulic signal to operate hydraulic actuator of control valve. Servo valve shall be of atleast two coil design and position feed back signal of servo valve shall be available to the control system.

Steam Control Valve Position Control Loop

The Control Loops for speed, load and steam pressure shall be superimposed in the steam valve position control loop. Position control loop shall be designed for the high sensitivity. Each channel of Turbine EHG control shall have its independent valve position controller. Controller shall be able to detect for any open and short circuit condition of servo valve coil and stuck valve condition. Controller can perform calibration of Servo valve and valve testing.

Speed Control Loop

The time dependent speed reference shall rise during start-up until the final speed reference value has been reached. The gradient of the signal shall be modified according to the available margins computed by the TSE in every instant to allow a rise of the turbine speed at the highest permissible rate. The speed controller shall be used for start-up and shutdown of the turbine, for synchronization of the generator with the power grid and to provide a minimum load operation and to operate the turbo-set in the complete power range. When the load or pressure controller controls the turbine gain control, the speed controller shall remain in a standby mode. In cases of load shedding with subsequent operation of the turbo-set in idling mode or supplying station load only, the speed controller shall assume control of the turbo-set. The speed controller shall temporarily control the set during rapid, large frequency fluctuations.

Load Control Loop

The load reference value shall be adjusted manually or from coordinated master control. The time dependent load reference shall have a time constant set based on loading curve. TSE signal will continuously influence the rate of integration. To protect the turbo-set against overload or to limit the power delivered by the turbo-set, the turbine controller shall limit the power output. Frequency deviation shall not cause the turbo set to exceed the preset power level. The load limit shall be allowed to vary only at a defined rate. Coordinated master controller signal shall be limited by an upper and a lower loading set value. Within the limits the coordinated master controller shall be permitted to vary the load freely. In case of faults in the coordinated master controller, the load reference value assumes control of the turbo-set. If the unit becomes isolated, the controller shall automatically switch to speed control for supplying station load.

Steam Pressure Control

The pressure controller shall control the turbine load with respect to the steam pressure deviations and shall prevent pressure drop during a quick load increase. Two operational modes – Initial pressure control and Limit pressure control shall be permitted. In “Initial Pressure Control” mode, the pressure controller reduces a pressure difference between the reference pressure value and the actual pressure value to zero. In “Limit Pressure Control” mode, the pressure controller influences the control valve to support steam generator pressure control, if a preset main steam pressure deviation is exceeded.



Three transmitters shall be employed for throttle steam pressure control.

During operation of the turbo-set one of the controllers shall be active. The other controllers, on standby duty, shall match with the active controller to allow quick transition from one type of control to the next without bumps. The speed and the load controller shall be tied to each other by means of a maximum selection circuit. The combined speed and load dependent valve lift signals shall be tied to the output signal of the pressure controller by means of a minimum selection circuit.

Load Shedding

In case of load shedding, the output signal of the load controller is immediately reduced below the output signal of the speed controller. The speed controller assumes control and returns the turbine back to the set reference speed. This shall keep the turbo-set speed from rising along the droop characteristic. In case of automatic re-closing the generator main circuit breaker, the reduction of the load controller output signal below the speed controller output signal shall be cancelled and the initially selected load level restored.

House load operation

In case of sudden opening of the main generator breaker the protection system will send command to close the control valve rapidly and reduce the load reference setting to house load.

1.4.0 Automatic Turbine Testing System (ATT)

On-load testing shall be provided for the following equipment/systems:

- a) Turbine Stop and control Valves
- b) Protection System Channels.

The test shall not cause a trip to the turbine. The test shall be conducted in an automatic sequence through all the above equipment/systems and the result of each test shall be indicated. Any test failure shall be indicated with alarm message. The test program shall either be initiated manually by the operator from the DCS operator station or automatically at pre-set intervals.

The Bidder shall provide ATT system for on load testing of turbine protective equipment automatically in a sequential manner without disturbing normal operation and keeping all protective functions operative during the test. The ATT facility shall include but not be limited to the following.

- i) Opening and closing of emergency stop and control valves, reheat stop and Interceptor valve.
- ii) Over-speed trip
- iii) Low vacuum trip
- iv) Thrust bearing trip
- v) Electrical remote trip.
- vi) Lube oil Trip
- vii) Vibration trip channel
- viii) Axial shift trip channel

1.5.0 Turbine Supervisory Instrumentation (TSI)

The Turbine Supervisory Instrumentation (TSI) system shall continuously monitor the conditions of main rotating and stationary components to provide a safe operation within the defined limits and give prior warning when there is a change in turbine mechanical behavior.



The system shall provide the status of the machine, post incident recording and initiates alarms / trips when preset operating limits are exceeded.

Turbine supervisory instruments will consist of measurements as listed below:

- a) Rotor eccentricity
- b) Shaft vibration
- c) Axial shaft position (Axial Shift)
- d) Turbine casing expansion
- e) Bearing vibration
- f) Turbine casing and rotor differential expansion
- g) Turbine Speed
- h) Vibration phase angle (Key phasor)
- i) Steam and metal temperatures for turbine operation
- j) Governing Valve Position
- k) Bearing metal and oil temperature
- l) Axial shift of the rotor (three sensors).
- m) Turbine speed (four sensors to be mounted inside the turbine and three sensors connected to EHG processors and the balance sensor shall also be connected to different processor of DCS).
- n) Bearing drain oil temperature.
- o) HP, IP, LP casing temperatures at different zones.
- p) Emergency stop & control valve position (with redundant position feed back sensors).

1.6.0 Turbine Protection System (TPS)

The protection system for turbine shall protect the turbine from overload and damage throughout the complete operating range and provide a high degree of reliability and availability. The following protection criteria shall be considered as a minimum,

- a) Over speed trip device operated
- b) Bearing metal temperatures (thrust and journal) greater than maximum
- c) Axial Shaft positions not correct
- d) Turbine shaft vibrations greater than maximum
- e) Wall temperature difference of turbine casings greater than maximum
- f) Lubricating oil pressure smaller than minimum
- g) Condenser Pressure greater than maximum
- h) HP Exhaust Temp. High
- i) Main Steam Temperature Very Low:
- j) Shaft eccentricity
- k) Generator protection operated
- l) Fire protection system operated
- m) Unit trip operated
- n) Local turbine trip operated
- o) Boiler protection tripped
- p) Emergency push buttons operated.
- q) ATRS steam turbine "Shutdown"
- r) Control fluid supply to valves – Emergency and protection off.
- s) Any other protection as recommended by Manufacturer
- t) An independent dedicated electronic over speed device with dedicated speed probes and with 2 out of 3 voting logic shall be provided, in addition to over speed trip provided in electronic governor.

Operating personnel shall be made aware of any danger by pre-alarms before the initiating of the protective mechanisms.

The Turbine Protection System shall meet all applicable safety standards/requirements including those stipulated in VDE 0116 Section 8.7. The system design shall be such that



safety function of the total system must not be jeopardized on occurrence of fault. Any single fault in either primary sensor, input/output modules, controller module etc. shall in no way jeopardize the safety of the turbine. All modules to be used in this system shall be of failsafe design. Bidder shall provide all the required primary sensors etc. required for protection system as per his standard and proven practices. All trip signal inputs required for the safety of the turbine shall be based on 2out of 3 logics. The system shall include turbine lock-out relays, redundant turbine trip solenoids and necessary hardware required for testing. The tripping devices shall be designed to operate on DC supply. The trip coils shall be monitored continuously for healthiness and failure shall be alarmed.

Triple modular redundant configuration (TMR) shall be provided for turbine protections. Each of the three independent channels shall have its own dedicated processors, controllers, communication controllers, I/O modules, interface etc. All safety related process inputs shall be fed to each of the 3 channels. All the primary sensors for unit/turbine protection shall be triple redundant. The computed signal for each of the trip condition in each channel will be considered for calculated SOE point.

The acquisition and conditioning of binary and analog protection criteria signals for TPS shall be carried out in each of the three triple redundant channels. Each channel shall compute the 2 out of 3 voting logic and issue a trip command. The protection criteria for tripping shall be executed by a program which shall be identical in each of the triple redundant channel. In case one of the independent channels or any of the triple redundant sensors is faulty, the same shall be alarmed and the balance two channels/sensors shall operated in one out of the two modes.

Suitable release interlocks (passive protection) shall protect the turbine generators from faulty operation. Processor shall be triple redundant all the trip signal input shall be shall be 2/3 logic.

All the mechanical-hydraulic and electrical protective circuits on the turbine shall be designed in such a way that faults at protective interlocks do not cause any erroneous release. The protective circuits shall be supervised by checking equipment and it must be possible at any time to inspect the functional correctness of the protection without causing a trip of the turbine. The protective signals shall initiate closing of all turbine emergency stop valves and, where appropriate, on the bleed and extraction emergency shut-off valves. It shall be possible to check the functional correctness of the emergency stop valves during operation.

1.7.0 BFP Turbine Electro hydraulic Governing System

Each BFP turbine shall be equipped with a microprocessor based electro hydraulic governing (EHG) system, and Turbo supervisory Instruments (TSI). The speed demand signal is fed from the feedwater control loop to the speed controller of the EHG systems. This signal, in turn, is fed to the valve lift controller which modulates the opening of the valve admitting steam into the turbine.

For the purpose of BFP turbine supervision, instruments for measuring eccentricity, axial shift, differential axial expansion, overall expansion, bearing vibration, speed, bearing, turbine and stop valve metal temperature shall be provided.

Controls of TDBFP auxiliaries like drain valves, EOP, JOP, TSI etc. shall also be implemented in DCS. Control of MDBFP shall be from DCS.

Following measurements shall be provided as minimum.

- i) Shaft eccentricity detection.
- ii) Absolute as well as relative shaft vibration measurement, of each bearing in both X & Y direction(both for Turbine and Generator bearing).



- iii) Differential expansion of rotor and cylinder
- iv) Overall expansion
- v) Absolute bearing vibration measurement of each bearing in both X & Y directions (both for turbine and generator bearings).
- vi) Axial shift of the rotor, (three sensors).
- vii) Turbine speed (Two set of Three working speed sensors and one spare speed sensor).
- viii) Emergency stop and Control valve position (with redundant position feedback sensors)
- ix) Main steam and hot reheat steam inlet temperature and pressure.
- x) Turbine metal temperature.
- xi) In case of vibration, shaft mounted reference detectors, Key Phasor and required supervisory instrument circuitry shall also be provided.
- (xii) Turbine casing expansion & temperatures at different zones.
- (xiii) Bearing metal and oil temperature
- (xiv) Bearing drain oil temperature.
- (xv) Any other measurements recommended by the Turbine manufacturer or required for the safe and reliable operation.
- xvi) Steam pressure, temperature, and flow to each BFP steam turbine
- xvii) Provision of motorized isolation valves at inlet of each TDBFP from CRH, PRDS & HPH.
- xviii) Lube oil temperature at inlet & outlet of lube oil cooler.
- xviii) Open & close indication of all manual isolating valves related to feed water
- xix) Lube oil flow elements and transmitters for lube oil, cooling water, or any other auxiliary system as required. Bidder may consider turbine type flow meter as cooling water and oil flow measurements. Flow nozzle for feed water flow measurement.
- xxi) Duplex RTD's/Thermocouples for bearing temperature, thrust bearing of pumps, journal bearing of main and booster pumps, suction & discharge of pumps and differential temperature, bearing drain oil and all other bearing temperature,
- xxii) Turbine rotor axial displacement.

The drive turbine speed shall be controlled by electro - hydraulic governor, stable and satisfactory speed control over full speed range from 0% to 100%. Electro hydraulic governing system shall be implemented in the DCS with adequate safety, diagnostic and redundancy. Related hardware shall be segregated in identifiable cabinet/s with no sharing of I/Os with any other.

When the governing system is in auto mode, it shall receive speed demand signal from FW control loop and in manual mode shall be fed either from Operator station. The actual speed of the turbine should be measured by three independent speed sensors and three independent speed measurement channels. These three signals shall be fed to the selection circuit which shall choose the median value. The speed controller output shall be fed to the valve lift controller. The output of the valve lift controller shall be fed to the electro-hydraulic converter which shall vary the position of the control valve. The electro-hydraulic controller shall be designed such that the transfer between different steam sources should be bumpless. The electro-hydraulic control system to be provided by the bidder shall be of proven design, whose configuration and hardware implementation should have been employed in at least Two (2) turbine driven pumps of equivalent capacity which are in operation for not less than two (2) years.

1.8.0 Steam Turbine Water Induction Prevention (TWIP) Logic

The turbine water induction prevention logic detects the presence of potential water admission sources, disposes of accumulated water, and isolates the turbine from the water source as required. The turbine water induction prevention logic shall be designed in accordance with ASME Standard TDP-1. For detection of leakage of various drain valve,



drain pipes and turbine, metal temp. thermocouple shall be provided to meet ASME TDP-1 standard.

The TWIP logic serves four major functions:

- a) Prevents water accumulations by inhibiting the use of attemperating sprays at low loads.
- b) Prevents the carry-over of water from sources such as the boiler and deaerators.
- c) Disposes of accumulations of water in low point drains by forcing drain valves open during low load operations and prior to turbine startup.
- d) High level in heaters resulting water ingress inclusion of gland seal condenser.

The TWIP logic shall be implemented in the unit protection processors. The logic shall be implemented in two trains, with each train receiving process status information through separate input cards. In addition, process status information shall be transmitted to the unit protection processors via the data highway. The DCS outputs which act to trip the steam turbine via its proprietary control system shall also be from separate cards and shall be configured in a two-out-of-two de-energize to trip scheme.

Bidder to ensure that Motorized isolating valves shall be provided at extraction lines, condensate lines & extraction drain lines as per the protection criteria of ASME Standard TDP-1 "Recommended Practices for the Prevention of Water Damage to Steam Turbines used for Electric Power Generation".

2.0.0 INSTRUMENTATION REQUIREMENTS

2.1.0 Minimum redundancy requirement (2 out of 3) of measurements and controls are given below.

2 OUT OF 3 INPUT REDUNDANCY	Hotwell level control (A & B)	Steam Pressure at Turbine inlet
	BFP Suction Temperature	LP bypass Pressure and Temperature
	Main Steam flow (L/R)	Both cold and Hot R.H Steam Temperature (L/R) Turbine End
	Main Steam Temperature (L/R) Turbine End	Deaerator flow
	HP bypass Pressure and Temperature	Total Feed water Flow
	BFP discharge Temperature	GS Steam Pressure
	CEP discharge Pressure	Deaerator Level
	CEP discharge Flow	BFP Discharge header pressure
	Discharge flow of individual I BFP's	MDBFP Protections
	TDBFP protection system	Heater levels control
	PRDS – LP control	PRDS – HP control
	Turbine protection system	

All the Instruments/measurements connected with the PADO system shall be redundant

**2.2.0 Steam Turbine shall be equipped with Instruments not limited to the following:**

- (a) Pressure transmitters for pressure measurement downstream of main stop valve, after 1st stage, before reheat stop valve, extraction pressure to water heaters, turbine exhaust pressure, bearing oil pressure and control oil pressure.
- (b) Thermo elements for measuring main steam, reheat steam, turbine casing wall and rotor, LP exhaust, extraction steam to water heaters, oil at oil cooler outlet, bearing oil and bearing metal temperature.
- (c) Guided wave radar Level transmitter with zener protection & explosion proof. Level gauge for measuring oil level in main oil tank and control oil tank.
- (d) Protective & interlock initiating devices including devices for automatic operation of standby equipment and auxiliaries viz.

Turbine AC/DC lube oil pumps, control oil pumps, jacking oil pumps and seal oil pumps shall also be furnished.

Generally Flow nozzle shall be used for feed water flow, Auxiliary steam flow etc. and for lines equal to or above 4" diameter. For lines of lower sizes suitable orifices will have to be provided.

Major equipment such as MDBFP and TDBFP including their sub systems shall be adequately monitored for "Oil pressure of various oil systems" such as lube oil/working oil/control oil, "Oil level in various tanks", "Oil temperature", "Bearing temperature", "Motor winding temperature" and other parameters such as suction & discharge pressure of the pumps, flow through pumps etc,. Initiating devices for automatic switching over to standby equipment and auxiliaries shall be furnished.

Critical strainers such as Turbine oil strainers, BFP suction strainers and CEP suction strainers shall be continuously monitored in control room with DP transmitters.

Important tank levels such as turbine lube oil tank, control oil tank, seal oil tanks, BFP lube oil tank etc. shall be monitored.

Performance test instrument for carrying out performance test shall be furnished.

External chamber co-axial guided wave radar type level transmitters shall be provided for the level measurement of Main Turbine oil tank, Control oil tank, BFP oil tanks, Condenser hotwell and LP heater under vacuum.

The type of field instruments shall be selected by the Bidder based on the process and the reliability of the instrument at similar power projects.

IBR certificates to be provided for all the instruments, flow elements, control valves and other equipments as applicable

The Control and Instrumentation system and equipment shall confirm to the guidelines issued by Central Electricity Authority (CEA) as per the latest revision / update.

In the event of conflict between the requirements of any two clauses or documents forming a part of this section, the more stringent requirements shall apply unless otherwise confirmed by the Owner in writing. The decision of the owner shall be final and binding in all such cases.

2.3.0 Generator Gas System

Control & monitoring instruments for Generator Gas System shall not be limited to the following:



- (a) Cubicle for gas system shall include instruments and regulating valves required to fill and empty the generator casing and to monitor the normal operation of the gas system. A suitable regulator shall be provided within the cubicle to maintain the casing gas pressure at the required value and to take care of any leakage within the hydrogen gas system. Instruments including analyzers to check purity for hydrogen /carbon dioxide, H₂ and CO₂ manifold pressure, moisture content meter, casing gas pressure etc. Necessary signals shall be provided in DCS for monitoring.
- (b) On line Moisture measurement in Hydrogen shall be provided.
- (c) Triple temperature sensors shall be provided for generator hot gas outlet temperature high protection.
- (d) Generator gas drying system shall be operated from central control room in addition to its local operation.
- (e) It shall be four temperature elements for cold gas temperature measurement

2.4.0 Generator Seal Oil System

Generator seal oil system shall include the required instruments not limited to the following:

- (a) Dial type temperature indicator for measuring the temperature of cooling water, seal oil.
- (b) Pressure gauges at the outlet of each pump, cooling water pressure at inlet to oil coolers, hydrogen side and airside seal oil pressure at inlet to seals.
- (c) Differential pressure indicators and differential pressure switches across the strainers.
- (d) Flow indicators to measure seal oil flow through seals and cooling water flow through oil coolers.
- (e) Adequate number of liquid detectors at the bottom of the generator tank to detect any liquid leakage.
- (f) A water detector with sight glass & drain valves shall be mounted adjacent to the gas manifolds at the end of a pipe connected to the bottom of the generator casing.
- (g) Oil level indicator shall be provided in the different tanks for visual checking of oil level and level switches shall be provided for tank level low, high alarm.
- (h) Redundant seal oil and H₂ gas differential pressure remote measurement shall be installed in individual impulse lines and connected to DCS in addition to the local differential pressure gauge. The DM water seal pots shall be provided in these Seal oil/H₂ gas DP measurements.
- (i) The process interlocks, annunciations and protection of seal oil system shall be in Unit DCS.
- (j) Duplex RTDs at inlet and outlet seal oil coolers, seal oil pressure transmitters at pump level and at the generator level shall be provided in addition to other process requirement.
- (k) The local panel shall not comprise of any process interlocks and protection.



- (l) All remote signals shall be directly connected to unit DCS through zener protection/safety barrier via local junction boxes which shall not be limited to the following
 - a. H2 manifold pressure
 - b. Generator casing gas pressure
 - c. CO2 manifold pressure
 - d. Generator casing gas purity
 - e. Gas temperature leaving the generator gas coolers
 - f. Seal oil pressure and Hydrogen seal oil differential pressure.
 - g. Pump discharge pressure transmitters.
 - h. Temperature of seal oil across cooler.
 - i. Level transmitters at Seal oil storage tank and seal oil tank.
 - j. Hydrogen to seal oil difference pressure.

2.5.0 Generator Stator Cooling System

The system shall include sensors, pressure & temperature gauges, temperature elements and control valve for generator gas temperature control. Signals shall interface with DCS.

- (a) RTD for monitoring water temperature at generator hydrogen and exciter cooler inlet and outlet.
- (b) Triple stator water Flow transmitters for measurement and protection against low flow.
- (c) Level transmitters and switches at expansion tank. The expansion tank level transmitter shall be of radar type or ultrasonic type.
- (d) Temperature elements at inlet and outlet of generator.
- (e) The primary water tanks shall be provided with radar type level transmitters to ascertain the water level and low & very low level switches shall also be provided. Level control shall be envisaged in DCS
- (f) The inlet and outlet lines of mixed bed demineralized shall have conductivity analyzers with LCD digital display and these signals are to be connected to unit DCS.
- (g) Individual stator water sample line shall be drawn from the main line header and three conductivity analyzers shall be mounted locally. Conductivity very high trip (2 out of 3) with annunciation for high shall be derived in Unit DCS using the signals from these analysers.
- (h) Stator water pressure transmitters at pump level and at generator level shall be provided.
- (i) Stator water flow very low trip (2 out of 3) shall be derived in Unit DCS using the signals from three DP transmitters. Three independent DP impulse lines shall be drawn from the orifice plate/ Flow sensor with double isolation. Local flow indicator shall also be installed for field monitoring. Additionally 100% sensors shall be supplied for future use.
- (j) DP across strainer measurement shall be provided at local and remote.
- (k) One online PH meter with local LCD display shall be provided in the stator water line.
- (l) On line conductivity measurement of stator water (Trip through two out of three logic).
- (m) On line stator water flow indicator (Trip through two out of three logic).
- (n) Set of conductivity meters in the main water circuit and after the demineraliser.
- (o) Set of flow switches (at least two nos.) to monitor low distillate condition and flow transmitters/ meters for primary water to stator winding and main bushing, make up water etc.



- (p) Sets of pressure gauges at the inlet and outlet of stator water filters, differential pressure switches for the filters, differential pressure gauge across stator winding and pressure transmitters as required.
- (q) Set of resistance temperature detectors, local indicators for primary water before and after the Generator winding, bushing and cooler.
- (r) Vapour filled temperature detectors to give signals for high temperatures.
- (s) Dual pressure switches for auto start of stator water pumps

2.6.0 Boiler Feed Pumps

Control logic & protection for motor driven and steam driven Boiler Feed Pumps shall be configured in DCS and pumps shall be operated from the central control room. Redundant sensors shall be provided for protection and control such as lube oil pressure low, speed probes for TDBFP, axial shift etc. Motor driven pump shall have hydraulic coupling actuator with 4-20 mA DC signal interface and transmitter for scoop tube position shall have instruments, not limited to the following, for safe, reliable and efficient operation:

Bearing pedestal vibration sensors in X-Y direction for pump & motor bearings, key phasor and speed.

Pump & motor bearing temperature sensors & gauges.

Zero speed sensor, speed sensor.

Pressure gauges, temperature gauges, Level switches, level gauges, flow switches, transmitters, temperature elements and switches for the sub systems such as lube oil, working oil, cooling and other systems/ equipment.

Local gauge board for each BFP with local instruments not limited to the following:

- (a) Supply oil pressure and drain oil temperature gauge at each bearing.
- (b) Gauges for differential pressure across feed water suction strainers, discharge pressure of main and booster pump, suction pressure of the booster pump, balancing leak-off pressure.
- (c) Gauges for lube oil temperature and cooling water temperature at inlet and outlet of coolers.
- (d) Gauges for seal water temperature and cooling water temperature at inlet and outlet of coolers.
- (e) Suction & discharge temperature gauges of main & booster pump.
- (f) Pressure switches for main & booster pump suction and discharge, balance leak-off, lube oil, aux. oil pump.
- (g) RTDs for measurement of motor winding, pump suction, pump discharge, bearing drain oil, seal water outlet temperature etc.
- (h) Open limit switch of feed water pump suction valve.

In addition, following instruments shall be provided for remote indication.

- (a) Pump re-circulation flow.
- (b) Balance leak off pressure.
- (c) BFP discharge pressure.
- (d) BFP suction flow (Triple redundant).



- (e) Lube oil pressure.
- (f) Lube oil tank level.
- (g) DP across water strainers.
- (h) Differential temperature across pump suction & discharge.
- (i) Oil temperature at inlet & outlet of coolers.
- (j) Steam pressure at inlet to turbine.
- (k) Steam pressure & temperature at turbine exhaust.
- (l) Top and bottom temp.
- (m) Pump bearing temperature measurements (Dual redundant)
- (n) All bearing drain oil measurements
- (o) Working oil temperature
- (p) DP across oil strainers

Feed pump re-circulation valves of suitable size and capacity and having proven background for BFP re-circulation flow service for similar operating condition with pneumatic actuators. Signal cables exposed to high temperature area shall be Teflon coated.

2.7.0 Condenser and Air Extraction Equipments

Sequence control logic & protection for the vacuum pumps shall be configured in DCS and shall be operated from central control room.

Following instruments shall be provided as minimum. Level instruments shall be mounted on stand pipes equipped with isolation and drain/vent valves: -

- (a) Magnetic type Direct Level Gauge for hotwell level indication.
- (b) Three co-axial Guided wave radar type level transmitters in 2 out of 3 configuration for hotwell level. One more guided wave radar type level transmitter for wider/entire range of Hot well.
- (c) Direct reading mercury filled manometer for local indication of condenser vacuum.
- (d) Level switches shall be provided in hotwell for safety interlock in 2 out of 3 configurations.
- (e) Three Pressure transmitters for condenser pressure.
- (f) Specific conductivity measurement at each compartment of the hotwell. Conductivity probes shall be of Insertion type with isolating valve.
- (g) Temperature gauge and element for condensate at CEP suction.
- (h) CEP minimum Recirculation control valve.
- (i) Each CEP discharge pressure transmitter.
- (j) CEP discharge header flow and pressure transmitters with 1 of 2 voting.
- (k) Direct magnetic level gauge, level switch, pressure & temperature gauge for gland steam condenser.
- (l) CEP- pump & motor winding and bearing temperature.
- (m) Vibration sensors (X-Y) for pump & motor bearings with key phasor.
- (n) Condensate Make-up & Dump water flow and totalizer for monitoring make up water consumption.
- (o) DP transmitter and gauge across CEP suction strainer.
- (p) Open & Close indication of CEP suction valves.
- (q) Ejector steam pressure control station with pressure transmitters.
- (r) Pressure switches (low, low low, high, adequate) in condensate common header.
- (s) U tube manometer with mercury filled for direct measurement of condenser vacuum shall be provided in the field with isolation valves for local indication in addition to three(3) vacuum transmitters.
- (t) Differential pressure indicator and differential pressure transmitters across debris filterer shall be provided with independent impulse lines and isolation valves.



2.8.0 Feed Water Heaters and Deaerator

Interlock, protection and controls for the system shall be configured in DCS and system shall be operated from central control room.

Following instruments shall be provided as a minimum. Level instruments shall be mounted on stand pipes equipped with isolation and drain/vent valves: -

- (a) Field instruments viz. pressure gauge, temperature gauge, direct level gauge shall be provided on Deaerator.
- (b) Temperature gauge and elements at the inlet and outlet of all heaters for steam and condensate/feed water.
- (c) Pressure & level transmitters and temperature elements shall be provided for remote monitoring and control of Deaerator parameters in DCS. Three wide Guided wave radar type level transmitters shall be provided at Deaerator for control. For level switching function, three separate level transmitters shall be provided. Magnetic type level gauge shall generally be provided for LP Water Heaters. Level gauge for HP feed water heaters and Deaerator can be of Reflex type. Two DP transmitters of wider/entire range of Deaerator shall be provided.
- (d) Three transmitters in 2 out of 3 configuration shall be provided for drain level of HP & LP heaters.
- (e) Three co axial Guided wave radar type level transmitters shall be provided at LP heaters where the shell pressure can reach vacuum.
- (f) Shell temperature measurements for HP & LP heaters.
- (g) Temperature elements of Duplex type shall be provided in all the drain lines of all HP and LP heaters.
- (h) Dual redundant Steam inlet pressure transmitters for all HP/LP heaters.
- (i) Triple CEP discharge header flow
- (j) Dual CEP discharge pressure transmitters
- (k) Dual flow transmitter in recirculation line to Hot well
- (l) Dual flow transmitter in recirculation line to CST
- (m) Triple condensate flow transmitter to Deaerator after final LPH with redundant temperature elements for compensation algorithm
- (m) For Condensate extraction pumps, DP gauges and DP transmitters across the suction strainer, pressure switches (Low, Very High, High Adequate) shall be provided for automation.

2.9.0 HP-LP Bypass System

HP-LP Bypass System shall consist of pressure reducing and de-superheating stations (PRDS) stations.

- (a) HP Bypass station (HPBP) shall comprise of electro hydraulic control valves along with integral type de-superheaters supplied with spray water from Boiler Feed Pump. Pressure and temperature measurements for control of HPBP shall be in 2/3 configuration.
- (b) LP Bypass station (LPBP) shall also comprise of electro hydraulic control valves along with non-integral de-super heaters getting spray water from Condensate Extraction Pump discharge. Pressure and temperature measurements for control of LPBP shall be in 2/3 configuration.
- (c) Closed loop controls, interlock and protection for the system shall be configured in DCS and shall be operated from central control room.
- (d) System shall be supplied with PLC controlled control oil unit, pressure gauges, temperature elements, transmitters as required for completeness of the system.
- (e) Following parameters of the oil unit shall be monitored in DCS.
 - (a) Oil level in tanks indication & alarm.
 - (b) Oil pump discharge pressure indication.
 - (c) Oil temperature indication & alarm.



(d) Group fault alarm.

2.10.0 Circulating Water (CW) & Aux. Cooling Water (ACW) System

Control and monitoring of the system is realized in DCS through Remote I/O unit with redundant controllers located in the local control room. CW pumps & ACW pumps shall normally be operated from central control room. However, for maintenance check-outs, local operator stations are foreseen.

Pump and motor bearings of CW & ACW pumps shall be provided with vibration pick ups (both in X-Y direction) and key phasor for on line monitoring and analysis.

For auto on/off of CW and ACW pumps, necessary pressure switches for alarm and control shall be provided. All the required valves shall be motorized and automated to enable auto start/stop off the pumps.

HT motors winding temperature and bearing temperature of equipment and motor shall be monitored in DCS. Motor current & energy consumption shall be monitored in DCS. Guided wave radar type/ultrasonic level measurements and switches shall be provided for forebay and suction pit level monitoring. Inlet & outlet temperature of heat exchangers shall be monitored. DP transmitters & gauges for monitoring fouling condition of heat exchangers. Tube cleaning system and automatic self-cleaning filter, where envisaged, shall be furnished with its own PLC based local control with limited hardwired interface with DCS.

2.11.0 DMCW Cooling Water for Boiler and Turbine Areas

Field instruments shall not be limited to the following:

- (a) Level instruments viz, transmitter, gauge and switches on the damper tank.
- (b) pH at outlet of heat exchangers.
- (c) Inlet & outlet temperature (both for cooling medium & coolant) of heat exchangers. DP transmitters & gauges for monitoring fouling condition of heat exchangers.
- (d) Pressure transmitters, pressure gauges, pressure switches and flow meter, standpipe etc. shall be furnished.
- (e) DMCW discharge header pressure control valve.

For auto on/off of DMCW pumps, necessary pressure switches for alarm and control shall be provided. All the required valves shall be motorized and automated to enable auto start/stop off the pumps.

2.12.0 Condensate Transfer Pumps & DM Service Water Pumps

Field instruments shall not be limited to the following:

- (a) Guided wave radar type level transmitters and level switches at condensate storage tank shall be provided for interlock & monitoring.
- (b) Strainers shall be monitored & alarmed for fouling condition by providing DP gauge and DP switch.
- (c) Flow measurements for monitoring actual consumption of makeup water.
- (d) Pressure transmitters, pressure gauges, pressure switches and flow meter, standpipes etc. as required shall be furnished

3.0.0 FUNCTION DESCRIPTION OF AUTO LOOPS

3.1.0 General Requirements

The open- and closed loop controls shall interact closely between themselves to guide the plant operation towards optimal functioning. In general, frequent operator's intervention shall



be avoided and the control intelligence built into the system shall be adequate to perform routine functions. However, each Control Loop shall have an auto / manual selector station and setter to allow operator's intervention during abnormal plant conditions.

Coordinated master Control shall receive and react to the signal from Owner's load dispatch centre. The signal of unit status shall be answered back. The details of interface shall be decided during detailed engineering stage between Owner and Bidder. Plant demand load set point or "Target Megawatts" shall be set and adjusted in "remote" automatic mode from load dispatch centre according to grid control demand with frequency variation control signal as feed forward or in manual mode by the plant operator (during start up or emergencies) adjustment from the unit load setter at unit control room. Load setting shall be auctioned for plant contingencies like run backs in case of a major auxiliary outage. Control system shall be designed to respond quickly for load demand and load changing rates and it shall also meet large output variations against ramp type load variation demands as permitted by the response time and thermal stress of major equipment. There shall be provision for "Block increase" and "Block decrease" as directional blocks in case either some equipment are in limiting conditions or in case reduction of load may lead to instability of the system.

Start-up pattern i.e whether the plant condition is cold, warm, hot or veryhot or the shut-down pattern i.e whether it is turbine cooling shut-down or normal shut-down shall be selectable under guidance from physical parameters like metal temperature.

Fuel flow control, air flow control, feed water flow control, EH governor control, etc. shall be properly tuned and controlled to meet constant or ramp load variation. The equipment shall be capable of coordinating the action of the controls in the boiler/turbine/generator unit so as to produce safe and stable operation automatically and maintain generator output, steam temperature, steam pressure, excess air (oxygen) at their desired set values. The control shall produce stable combustion, low values of unburned carbon in fly ash, and no black smoke under the steady load and load-variation.

Automatic control and adjustment of load shall be carried out in between load range 35% and 100% rated load in Automatic Plant Control mode.

Automatic runback operation in coordination with coal mill & burner control system and various others control systems shall be performed in the event of failure of major auxiliary equipments and others, which require sudden reduction in output.

Starting up and preferential shutting down of coal mills under varying load conditions shall be under automatic sequence control based on set priorities and shall not require any operator assistance other than notifying the operator about the actions being initiated. Complete automatic control shall be possible with automatic plant control system in coordination with millburner control system.

The necessary locking devices at the air failure and power failure shall be provided for all regulating duty pneumatic control to maintain plant load under failure conditions with notification to plant operator.

Automatic operation at any mode of the plant including the unit starting up and shutdown, the unit runback, the load rejection and so on shall be achieved by means of the automatic switching of the control mode (auto / manual auto-tracking mode at each control loop, the boiler follow mode, the turbine follow mode, the unit coordinated mode, etc.), the automatic changing of the various set points, the various function generators and so on. Transfer between one mode to another mode shall be bump less without disturbing the process.

Control stations on operator's station shall be grouped logically in functional blocks for compactness and ease of operation.

Protective interlocking circuits shall be provided for safety against erroneous manipulations.



Protective circuits against control system internal faults such as modules and operating ends shall be furnished.

The basic function of the Automatic Plant Control shall be, but not limited to the followings:

Bidder shall furnish the scheme of control loops & write up on his system for approval of Owner.

3.2.0 Unit Master or Coordinated Mode

Plant demand load set point or “Target Megawatts” signal shall manage the load and throttle pressure by sending parallel demand signals to the boiler master and turbine-generator master controllers. Demand signal shall be modified for frequency error and shall be limited by auction when the unit capability is reduced for any reason such as the loss of an auxiliary like one draft fan, a boiler feed pump, and so on. Load control station shall have maximum and minimum adjustable load limits set administratively as well as limit of load changing rate guided by thermal stress limits of major equipment.

During normal operation, coordinated control shall be exercised aggregating boiler and turbine inputs by target load and load change rate commands (central load dispatching commands, or manual setting), with various corrections made to enable Boiler control and Turbine control.

Directional blocking of the unit demand (increase/decrease of load) will be provided based on the extreme operating status of equipment and applicable process conditions. The run up and run down actions shall be provided for reducing the deviations when the respective final control elements are in the extreme positions and are unable to correct the error. Run up and run down actions shall override the unit demand signal till the adverse conditions are cleared.

The system shall provide automatic run-back facility based on the load demand signal on loss of critical auxiliary equipment. The limits and rate of run back shall be pre-determined according to the individual capacity of each auxiliary equipment and shall be supervised by Turbine Stress Evaluator. The control system shall have capability for implementation of the functional requirement with true characteristics of equipment. In case of full load rejection, the turbine-generator shall remain in service, supplying the station service power (house load operation). The boiler steaming capacity shall be quickly reduced to correspond to the capacity of HP and LP bypass systems plus the house load and operation is to be carried on at sliding pressure mode. The unit load demand shall also be corrected by deviation in system frequency. This correction provides a change in unit load demand equivalent to the expected change in megawatt output due to any deviation in system frequency.

The boiler master controller demand shall be used as a feed forward signal to the feedwater master controlling the feedwater flow and the firing rate master controlling the fuel and airflow to adjust to unit energy demand. Feed forward signals will be calibrated initially to produce a specific relationship between turbine steam flow and boiler firing rate on one hand and unit output on the other hand. However the relationship may change due to changes in system parameters such as cycle efficiency, heating value of coal, feed water temperature etc. When such a change occurs, it will be reflected in a steady state error in megawatt output. A controller shall be provided to automatically recalibrate the feed forward signals by reducing the steady state error to zero.

In addition to providing operator with the ability to set and observe unit load, the Unit Coordinated Control master shall allow the operator to select either constant or variable (sliding) pressure operation. The sliding pressure mode shall be adopted during start-up and reduced load operations principally to avoid erosion of throttling valves. Sliding pressure operation shall allow the turbine valves to be maintained at optimum position as the unit



shall be ramped to load. Sliding pressure operation shall be permitted with Unit Coordinated Control master in auto mode.

When Unit Coordinated Control master shall be in Boiler Follow Mode-2 or Turbine Follow Mode-2, described below, Unit Coordinated Control mode shall be selected. Two sub-modes shall be permitted as follows:

In Coordinated Boiler Follow Mode boiler master and turbine master shall be in auto mode. Boiler master shall control the boiler demand to control throttle pressure.

The turbine master shall modulate the EH governor using UCC demand as feed forward trimmed by turbine MW controller. The UCC demand shall track the MW to eliminate MW error.

In Coordinated Turbine Follow Mode boiler master and turbine master shall be in auto mode. The turbine control shall use feed forward based on UCC demand trimmed by turbine throttle pressure controller. The turbine master shall modulate the EH governor to control throttle pressure. Boiler master shall control the fuel firing rate based on feed forward from UCC demand trimmed with the boiler MW controller. The UCC demand shall track the MW to eliminate MW error.

Load Runback Variables

In case of major plant internal disturbance the unit shall carry on operation at a reduced load level and the grid frequency control system shall be taken out of service.

The load shall be reduced by the automatic run-back system which reduces or holds the unit load according to the capacity of main auxiliary systems.

The failure of any of the following plant systems or plant variable are to be included in the run-back system :

- (a) I. D. Fans.
- (b) F.D. Fans.
- (c) P.A. Fans.
- (d) Air preheaters.
- (e) Boiler circulation water pumps.
- (f) Boiler Feed Water Pumps.
- (g) H.P. Feed Heaters.
- (h) L.P. Feed Heaters.
- (i) Condensate extraction pumps.
- (j) Coal Mills.
- (k) CW Pumps.
- (l) Load Shedding.

Islanded Operation

In the case of the load rejection due to the external disturbances, the unit shall carry on operation at the minimum boiler load operating the turbine bypass system. The load shall be reduced to the minimum boiler load by the automatic runback system. Items not limited to the following shall be taken into account to make sure the safe and stable operation :

- (a) The quick opening of the HP and LP Turbine Bypass System.
- (b) Fuel fast cut back maintaining stable flames at the residual burners.
- (c) Sufficient spray water to the HP and LP bypass system shall be available.

3.3.0 Boiler Follow Mode

In the boiler follow mode, boiler throttle pressure master controller trims the megawatt load setting to maintain the throttle pressure at set value. When, for example, the throttle



pressure is below the set point, the fuel, feedwater and air are increased by ramping up the boiler master demand and visa versa. Two variants of Boiler Follow Mode are foreseen. In Boiler Follow Mode-1 the boiler master shall be on automatic mode and turbine master shall be left on manual mode. The boiler master controls the throttle pressure and the turbine governor control is adjusted by the operator. The UCC (Unit Coordinated Control) demand tracks the governing valve position in a characterized algorithm linking it to MW. In Boiler Follow Mode-2 the UCC demand shall be extended to both boiler master and turbine master, both and the UCC in automatic mode. Target load shall be set at UCC. Boiler master shall control the throttle pressure based on UCC signal with throttle pressure controller trim. Turbine master shall only receive the UCC signal without MW trim. If runback occurs in this mode, the system shall automatically transfer to turbine following mode when turbine governor is on automatic.

Turbine Follow Mode Turbine master shall be in charge of throttling the EH Governor Valves. In the turbine follow mode the UCC demand shall be trimmed by turbine throttle pressure to create turbine master demand.

Two variants of Turbine Follow Mode are foreseen.

In Turbine Follow Mode-1 the turbine master shall be on automatic mode and boiler master shall be left on manual mode. The turbine master controls the throttle pressure and the operator shall control the load manually by changing the Boiler master demand. The UCC shall track the Boiler master for smooth transfer of Boiler master to auto.

In Turbine Follow Mode-2, the UCC demand shall be extended to both boiler master and turbine master, both and the UCC in automatic mode. Target load is set by UCC. Turbine master shall control the throttle pressure based on UCC signal with turbine throttle pressure controller trim. In the turbine following mode the megawatt control shall be the responsibility of the boiler and throttle pressure shall be controlled by the turbine control system. In this mode the unit demand shall be subject to maximum and minimum limits, rate of change, interlocks and run backs etc. When turbine following mode is in automatic, all runbacks, run-ups limits and rate of change shall be automatic.

3.4.0 Manual Mode & Base Mode

Manual mode shall be the lowest level mode in the hierarchy. In this mode the Boiler Master Control including the air, fuel and feedwater loops and Turbine Master Control are switched over to manual mode and the unit will be controlled manually. Generation error and Frequency error will not affect the demand signal. As a variant, in base mode, the Boiler Master and Turbine Master Control shall be in manual mode. However, one sub-loop either air, fuel or feedwater as well as the firing rate ratio will be on automatic mode. This shall help internal tracking of the UCC.

3.5.0 Boiler Master Control

Boiler outlet temperature and pressure shall be maintained stable under all load conditions. The pressure control shall be based on regulating the feed water flow, while the superheat temperature shall be regulated by firing control, in the long term. Feed water to firing rate ratio control shall maintain constant attemperation flow.

Cross limiting between the feedwater flow and the firing rate shall ensure that the ratio between the two remain within permissible limits. While transient conditions persist at load changing, the boiler master signal shall be transiently modified in order to achieve over or under firing. Such transient signal modification shall be applied for the fuel flow control, the airflow control, the steam temperature control and other necessary control loops in order to maintain the various parameters safe and stable during any mode of the operation.



Boiler master shall develop the demand signals for feedwater flow and firing rate (fuel flow) to the boiler. The demand for firing rate (fuel flow) shall be modified by feed flow to firing rate ratio function. The boiler master control station shall be designed to allow manual control of the boiler input demand.

3.6.0 Turbine Master Control

The MW demand signal from unit master shall compare to the actual MW signal and the deviation signal shall be transmitted to EHG Load controller. This controller produces the governor control valve position demand signal.

During the unit initial start-up the manual mode (the auto-tracking mode) shall be applied followed by sliding pressure mode until the turbine valve transfer is completed during which the turbine EHG speed controller shall control the turbine speed, the initial block loading and the valve transfer.

And then the turbine load control shall be handed over to the unit master control and the turbine master shall automatically set on auto mode. Beyond the sliding pressure regime, the main steam pressure is maintained constant and the machine load shall be controlled by throttling the turbine governor value.

Under fixed pressure operation, the turbine governor control valve controls MW but when the main steam pressure controller, overseeing the control finds pressure error larger than the set limit, control mode of this valve shall be transferred to the main steam pressure control to unload the machine as necessary for pressure recovery. The main steam pressure control shall also be used when the boiler master is on manual mode.

Turbine master control signal shall be transmitted to the digital electrohydraulic (EH) governor system.

3.7.0 Deaerator and Hot Well Level Control

Deaerator level shall be maintained by regulating condensate flow control valve in the main condensate line to Deaerator. This will be three (3) element control consisting of Deaerator level, Feedwater flow including SH & RH attemperation flow and condensate flow along with extraction steam flow to Deaerator and HP heater drain flow to Deaerator. Hotwell level will be maintained by regulating the valves "DM water make up to hotwell" and "Dump to condensate tank".

3.8.0 Balance of plant controls

Other balance of controls not limited to the following shall be provided :

- (a) HP Heater level control- normal & emergency drain.
- (b) LP heaters level controls- normal & emergency drain. GSC level control.
- (d) Deaerator pegging steam pressure control.
- (e) Flash tank level control.

**VOLUME II****SUB-SECTION 4.10****PLANT AUXILIARIES AND OFFSITE PLANT CONTROL SYSTEMS****1.0.0 COMPRESSED AIR PLANT****1.1.0 Control Philosophy**

Instrument and service air compressors and driers shall be controlled and monitored from the Central control room & local control room, through the DCS Remote I/Os, Redundant processor, power supply, communication module, redundant communication link all hardware, software and other interfaces envisaged to control and monitor it. Remote operation is envisaged from the Central control room.

Instrument and service air compressors local control room shall be provided with Two (2) no. 24" LED type Operator station for control and monitoring the compressors locally in addition to the remote control & monitoring from the central control room in the main plant DCS.

Controls and protection of the Instrument air compressor shall be realized in the dedicated control system. System shall be complete with cabinets, alarm annunciation windows, all hardware, cables, dew point meter and field sensors/ instruments/erection hardware

1.2.0 Operational requirement

- a) Operation of the compressors and driers shall be performed from One (1) no. 24" LED type Operator station provided in the local control room. All pressure and temperature conditions used for tripping the compressor shall be provided with pre-trip annunciation in the operator station
- b) All initiating devices, relays and other hardware required to achieve annunciation, control and interlock system shall be provided by the bidder.
- c) Auto switching on standby compressor incase of tripping of running compressor of failing air pressure.

1.3.0 Important Safety Interlocks

The safety interlocks shall be furnished by the vendor during detail engineering and will be reviewed and approved by owner.

1.4.0 Special Instrument Requirement

On the discharge line of each compressor, Vortex flow meter will be provided for the measurement of airflow of each compressor.

Solenoid valves with manual over ride feature shall be provided at cooling water inlet shall be provided. Necessary auto drain shall be provided at each branch header and main headers.

With acknowledgement to the fact that the entire area is vibration prone, capillary type instruments like temperature and pressure gauges and switches be mounted on Local Panel to avoid vibration. Instead, Duplex copper - constantan (T) type thermocouples / RTDs shall be provided for remote monitoring.

Bidder shall provide Dew point measuring instrument at the each common header in addition to the on line Moisture analyzer at each compressor outlet.



1.5.0 Annunciation System

The Alarm Annunciation on the local control panel shall provide annunciation for the conditions furnished by vendor during detail engineering subject to approval of owner.

1.6.0 Monitoring & Control

Bidder shall consider instruments as per P&ID requirements as well as his recommended instruments for Control and monitoring.

- a) Loading / unloading indication.
- b) Remote and local Remote start & stop.
- c) Remote and local Cooling water pressure & temperature at I / L & O / L of intercooler & after cooler.
- d) Remote and local Open & Close indication of valve at inlet of cooling water line.
- e) Remote and local 1st. stage and 2nd. Stage discharge pressure and temperature.
- f) Remote and local Air pressure and temperature at each cooler outlet (1st Stage, After Cooler).
- g) Remote and local Pressure on each air header at various locations distributed throughout the plant.
- h) Cooling water flow at I / L and O/L, Lubricating oil pressure, Moisture separator temperature are preferred to be used for interlock and protection.
- i) Motor current
- j) Zero load, 50% load, 100% load control for energy savings.
- k) On line Dew point monitor at each compressor outlet and at each header shall be provided.
- l) Any other instrument recommended by the OEM.
- m) Remote and local Cooling water Header Inlet and outlet temperature at DCS.
- n) Cooling water flow low alarm to each compressor
- o) Control of moisture separator circuit shall be implemented in control system.
- p) Auto drain valves and solenoid operated valves through timers of control system are to be paralleled at the bottom of reservoir tank.
- q) Necessary flow switches for cooling water flow to each compressor inlet shall be provided

1.7.0 Lay Out of Local Control Room

- Separate battery room and UPS room shall be provided
- The control room & remote I/O panel rooms shall be Air conditioned
- The control room shall be provided with pantry room , Locker room , Toilet etc.,
- The required modular furniture's and cabins for operators.

2.0.0 ASH HANDLING PLANT & SILO LOADING/UNLOADING SYSTEM

The Ash Handling System, referred here shall imply Bottom & Coarse Ash and Fly Ash removal systems with all sub-systems and accessories. The operation of both Bottom & Coarse Ash and Fly Ash removal systems shall be carried out. Ash level indication shall also be available in the central control room DCS.



2.1.0 Control Philosophy

Ash handling system shall be controlled and monitored from a common local control room for all sub system of Ash Handling System. Each sub system such as Fly ash handling system (Vacuum system, transport air system etc.), Bottom Ash Handling System , Ash slurry System and Recovery water system are controlled from the AHP central control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link, all hardware, software, other interfaces, cables and field sensors/instruments/erection hardware envisaged to control and monitor it.

Ash handling local control room shall be provided with Two (2) no. 24" LED type Operator station and AHP Mimic panel for control and monitoring the AHP locally in addition to the remote monitoring from the central control room in the main plant DCS.

AHP mimic panel with hard wired push buttons for back panel operation. Hardwired annunciation panel shall be provided for controlling process. One No. large screen display (84") complete with control station and other hardware at AHP control room for controlling & monitoring ash handling system. The remote I/O panel of each sub-system shall have in-built 17" or higher TFT monitor and Mouse and Keyboard for emergency operation and maintenance.

The control system shall be fully automatic / Semi-automatic / Manual for Fly Ash Extraction, Bottom Ash Extraction and removal of Ash Water and Ash Slurry. The Control system shall perform sequential operation of Scraper Chain conveyors, Clinker Grinders, Air Compressors, blowers, extraction gates, pumps etc.,

Back Panel redundant operation with process mimics and hardwired annunciation system is also envisaged considering the severe dusty environment.

Necessary instruments like diaphragm Seal pancake with flushing and capillary type pressure and differential type transmitters, level indicators, Bourdon type with diaphragm seal pressure gauges, Radar proven type Level transmitters shall be provided. The junction boxes and instruments / electronics housing used shall be Non – corrosive material.

Remote and local indications of various parameters to the process requirement shall be provided. (The same can be decided during detailed engineering)

2.2.0 Operational Philosophy

The operation philosophy shall be submitted by the Bidder during detail engineering subject to the approval of owner

2.3.0 Control system

Ash handling system shall be controlled and monitored from the AHP local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link, all hardware, software, other interfaces, cables and field sensors/instruments/erection hardware envisaged to control and monitor it.

The controls includes

- 1) Bottom Ash Handling System up to ASH dyke
- 2) Fly Ash system up to silo and up to Ash Dyke
- 3) ASH slurry pump house
- 4) Recovery water pump house



2.4.0 Annunciation System

The Alarm Annunciation on the local control panel shall provide annunciation for the conditions furnished by vendor during detail engineering subject to approval of owner

2.5.0 Control & Monitoring

The ASH handling control system shall be interfaced with Plant DCS for monitoring through Optical fibre cable

Following minimum control function shall be carried out in addition to process requirement:

- a) Remote and Local Start & Stop of all Pumps, Compressors and Blowers from Operator console.
- b) Remote and Local Start & Stop of MOV's from Operator console.
- c) Control & Monitoring of analog & digital parameters from control room console.
- d) Local / Remote start & stop of Air Compressors and other accessories.
- e) Remote and Local Operation and Monitoring of pneumatic conveying system and Belt conveying system.
- f) Remote and Local Monitoring the level of ASH water tank, Seal water tank , Settling Tank , Drain Sump , Bottom Ash Silo & Fly ash silo etc, Slurry basin, ASH silos etc.,
- g) Remote and Local - Scraper chain control including its hydraulic controls
- h) Remote and Local Open & Close indication of valve at inlet of Lube oil cooling water line.
- i) Start permissive, Trip logic, Interlocks and Sequence control.
- j) Monitoring of alarms and status at Central control room.
- k) Auto start of standby pumps with auto operation of required motorized valves and required instruments and logics.
- l) Monitoring of all electrical parameters such as current , voltage etc of MCC and drives as detailed elsewhere in the specification (Electrical & Instrumentation)
- m) The critical protection system shall be based on 2 out of 3 voting logic and other critical control loops shall be 1 out of 2
- n) All the fluid tanks are to be provided with level transmitters of proven type
- O) The pumps discharge header shall be provided with pressure transmitters and Local gauges for monitoring from remote.
- P) The fire detection and alarm system shall be provided for the control room, ASH water pump house, MCC room etc., and cable gallery and other auxiliary systems.
- Q) Provision of interfacing ASH Silo weigh bridge with AHP control system shall be provided (for updating MIS system).
- R) Remote and Local operation of Silo discharge valve for loading at trucks
- S) Protection and interlocks of ASH handling Service transformers including monitoring of parameters
- T) Local / Remote operation of Breakers etc.,
- U) Monitoring incoming current & voltage including the metering.
- V) Provision of 4 nos Temperature elements in control room for monitoring the room temperature.
- W) Integration of ASH handling control system with plant MIS
- X) Provision of flow transmitter for all make up and blow down of water for accountability
- Y) Density meters of nucleonic and non-nucleonic type shall be provided.

2.6.0 Lay Out of Local Control Room

- Separate battery room and UPS room shall be provided
- The control room & remote I/O panel rooms shall be Air conditioned
- The control room shall be provided with pantry room , Locker room , Toilet etc.,
- The required modular furniture's and cabins for operators.

**3.0.0 PRE-TREATMENT PLANT & RO – DM PLANT INCLUDING OTHER PUMPS**

The RO – DM water System, referred here shall imply sea water pre-treatment system, Ultra filtration system, SWRO system, BWRO system, DM plant with all sub-systems and accessories. The operation of both RO-DM shall be carried out fully automatic (sequentially).

The RO – DM water System shall be controlled and monitored from the Desalination/WTP local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link, all hardware, software, other interfaces, cables and field sensors/instruments/erection hardware/furniture envisaged to control and monitor it.

The RO – DM water System local control room shall be provided with Two (2) no. 24" LED type Operator station and Mimic panel for control and monitoring the Desalination/WTP locally in addition to remote monitoring from the central control room in the main plant DCS. One No. large screen display (84") complete with control station and other hardware at control room for controlling & monitoring Desalination/WTP system.

For DM/RO plant One (1) no. A3 color printer in addition to 1 no. A4 BLW printer shall be provided in the local control room for the operator station.

Operator station in the Desalination / WTP local control room shall be provided with the access to monitor the main plant operations

Desalination/WT plant mimic panel with hard wired push buttons for back panel operation.

Hardwired annunciation panel shall be provided for controlling the process

The necessary instruments shall be provided as per the process requirement for complete auto operation from the pre treatment system to DM storage tank. The instruments to be provided for process parameters shall be chosen so as to study the performance of individual equipments / system.

The control system must capable of operating the RO –DM plant in partial load at auto mode.

Necessary instruments like diaphragm Seal pancake with flushing and capillary type pressure and differential type transmitters, Ultrasonic or proven type flow transmitters, Radar level transmitters / Switches, Conductivity type level switches, Magnetic type level indicators, Bourdon type with diaphragm seal pressure / differential pressure gauges, temperature elements / Gauges, Smart Control Valves of pneumatic type shall be provided. The junction boxes and instruments / electronics housing used shall be Non – corrosive material.

The bidder shall furnish required list and type of instruments during detail engineering subject to the approval of owner. Selection of instrument shall be based on the quality (guaranteed parameters) of outlet of water at each and every stage so as to access the chemical / Mechanical behavior of various process machineries.

The dosing of chemical at various stages of process shall be controlled through Stroke adjustment from Operator station. No independent controllers for chemical dosing are allowed.

Pneumatic actuators with all accessories shall be controlled using solenoid valves, which shall be energized from Control Panel / Operator station. The opening and closing of these valves is based on system requirement, which is programmed in the Control system. Feed



backs to the control system regarding the valve open / close position are set through the limit switches.

Monitoring of all electrical parameters such as current, voltage etc of Service Transformer, MCC and drives as detailed elsewhere in the specification (Electrical & Instrumentation).

The fire detection and alarm system shall be provided for the Local control room, Pre-treatment plant, RO-DM plant, MCC room etc. including cable gallery and other auxiliary systems & chemical lab.

Accountability of product output of SWRO, BWRO, DM plants etc., through flow measurements and also water feed to CST tanks of each unit shall be provided with flow measurement and these are to be hooked up to DCS. Signals required to find the functioning time of RO-DM plant are to be classified and to be connected with DCS for cost evaluation in MIS / ERP.

Flow transmitter shall be provided at the blow down header, to Service water tank, Desalinated storage tank/ reservoir, every stages of RO plants, fluid flow to individual tanks, etc.,

Pressure transmitter, pressure gauges shall be provided at discharge headers of all pumps for remote monitoring.

The critical protection system shall be based on 2 out of 3 voting logic and other critical control loops shall be 1 out of 2.

DP transmitters and DP gauges shall be provided for all strainers, all the stages of RO plants, across the other equipments where the fluid flow is to be monitored.

All the fluid tanks are to be provided with level transmitters of proven type.

The required number of analysers (Silica, pH, Chlorine , SDI, Turbidity etc.), shall be provided.

The chlorine leak detection system shall be provided in respective area and the annunciation shall also be replicated at RO-DM Water control system.

Flow control station upstream of pre treatment system consisting of a throttling type motorized butterfly valve with isolation valves and by pass valve shall be provided for regulation of inlet water to the RO system.

- Ultrasonic or Radar type level transmitters shall be provided at various tanks.
- Local Start, Stop push buttons shall be provided for all drives.
- Auto Start of high pressure pumps of RO plants shall be implemented by designing remote operated pneumatic valves
- The provision of Start and Stop of various sump pumps shall be provided in the control system.
- Flow transmitters shall be provided at the outlet of ACID unloading pumps.
- pH measurement at the outlet of neutralization pit pumps shall be provided



RO DM PLANT			
I/L TO PRE TREATMENT SYSTEM			
Type	Location	Range	Unit
Turbidity	I/L to Pre Treatment System	Contractor to Specify	Contractor to Specify
Chlorine	I/L to Pre Treatment System	Contractor to Specify	Contractor to Specify
pH	I/L to Pre Treatment System	Contractor to Specify	Contractor to Specify
Conductivity	I/L to Pre Treatment System	Contractor to Specify	Contractor to Specify
I/L TO UF MEMBRANE BLOCK			
Turbidity	I/L UF Membrane Block	Contractor to Specify	Contractor to Specify
Chlorine	I/L UF Membrane Block	Contractor to Specify	Contractor to Specify
pH	I/L UF Membrane Block	Contractor to Specify	Contractor to Specify
I/L TO SWRO SYSTEM			
Turbidity	I/L SWRO HP pumps	Contractor to Specify	Contractor to Specify
SDI	I/L SWRO HP pumps	Contractor to Specify	Contractor to Specify
Chlorine	I/L SWRO HP pumps	Contractor to Specify	Contractor to Specify
ORP	I/L SWRO HP pumps	Contractor to Specify	Contractor to Specify
pH	I/L SWRO HP pumps	Contractor to Specify	Contractor to Specify
Conductivity	O/L of each stream of RO membrane and common header	Contractor to Specify	Contractor to Specify
I/L TO BWRO SYSTEM			
Chlorine	I/L BWRO HP pumps	Contractor to Specify	Contractor to Specify
pH	I/L BWRO HP pumps	Contractor to Specify	Contractor to Specify
Conductivity	O/L BWRO each streams and common header	Contractor to Specify	Contractor to Specify
RO REJECT			
pH	RO Reject water to SEA	0-14	pH
I/L TO MIXED BED (DM PLANT) on each stream			
pH	I/L to Mixed Bed	Contractor to Specify	Contractor to Specify



Conductivity	I/L to Mixed Bed	Contractor to Specify	Contractor to Specify
Silica	I/L to Mixed Bed	Contractor to Specify	Contractor to Specify
Sodium	I/L to Mixed Bed	Contractor to Specify	Contractor to Specify
Conductivity	O/L of Mixed Bed	Contractor to Specify	Contractor to Specify
DM STORAGE TANK TO CST			
Sodium	DM water pumped to 800 MW unit	Contractor to Specify	Contractor to Specify
Cation Conductivity	DM water pumped to 800 MW unit	0-1/ 10	μS/cm
Specific Conductivity	DM water pumped to 800 MW unit	0-100	μS/cm

3.1.0 Lay Out of Local Control Room

Separate battery room and UPS room shall be provided

The control room & remote I/O shall be Air conditioned

The control room shall be provided with pantry room, Locker room, Toilet etc.,

The required modular furniture's and cabins for operators.

Chemical Lab

4.0.0 FUEL OIL UNLOADING, STORAGE, PRESSURIZING AND HEATING SYSTEM

The Fuel oil system is designed for fully automatic operation through the **DPU of plant DCS** system housed in the Fuel oil pump house air conditioned control room.

4.1.0 Control and Operation Philosophy

Fuel oil system local control room shall be provided with One(1) no. 24" LED type Operator station locally for control & monitoring. Remote operation is envisaged from the Central control room.

Operator station in the FO Pump house local control room shall be provided with the access to monitor the main plant operations

The unloading system operation, pump running status, Flow meter reading with status monitoring including tank level monitoring hardwired to remote I/Os.

The stand by pressurizing pump shall be automatically started in the event of either low pressure in respective pump discharge header or tripping of any of the running pumps.

Open and Close limit switch feed backs of valves are to be connected to control system for remote viewing and for interlocks and protection.

The sequential control of HFO and LDO pressurizing pumps shall be made available in DCS. Local start/stop facility shall be provided through DCS.



The stand by pressurizing pump shall be automatically started in the event of either low pressure in respective pump discharge header or tripping of any of the running pumps.

Open and Close limit switch feed backs of valves are to be connected to DCS for remote viewing and for interlocks and protection.

Remote and local indications of various parameters to the process requirement shall be provided. (The same can be decided during detailed engineering)

Steam flow to each HFO heater shall be independently regulated through DCS by means of automatic control valve on steam line and actuated from heater outlet oil temperature. The motorized valves on steam supply lines to HFO heaters shall have start/stop facilities.

Individual recirculation control valve shall be provided for each HFO and each HSD pressurizing pump to maintain the pump discharge. This control shall be made available in DCS DPU and not thru local pneumatic controller

The fuel oil tank heating and oil decanting pumps operation shall also be controlled from the DCS

The signals from the instruments for fuel oil tanks level, temperature, HSD / LSD flow from during decanting operation and other miscellaneous instruments shall be hooked up to the DCS

Mass Flow transmitters for both (HFO / L:DO) at each unit takeoff header and also return line for measuring unit fuel consumption

The Decanting pumps controls / Status, Oil tanks level transmitters, Tank heating, Drain oil tank level and control & miscellaneous instruments which will be provided by bidder shall be hooked up in the FOPH control panel for monitoring and control

The HFO pumps shall be controlled by VFD.

Remote & local station DP measurement, pressure low, very low switches for auto start & alarm shall be provided for both HFO/LDO system. Discharge pressure gauges for individual pump shall be provided at pump house for both HFO & LDO system. Common header pressure transmitter at FOPH for both the LDO & HFO shall be provided.

All the transmitters/switches signals employed in fuel oil handling system shall have zener protection and all the transmitters employed in this are shall be of explosives proof as per the hazardous are classification.

For safe and reliable operation control of the Fuel Oil System Following minimum instruments / control function shall be carried out in addition to process requirement

- a) Remote and Local differential pressure across each strainer in LDO, HFO line at pressurizing pump suction and at heater outlet.
- b) Remote and Local differential pressure across strainer at pressurizing pump suction in HSD line.
- c) Remote and Local pressure at discharge of each HFO pressurizing pump
- d) Remote and Local pressure at discharge of each HSD pressurizing pump
- e) Remote and Local pressure at suction and discharge header of HFO heaters



- f) Remote and Local pressure at discharge header of HSD pressuring pumps
- g) Remote and Local temperature of steam & HFO at inlet/outlet of each HFO heater
- h) Remote and Local temperature in the connected fuel oil tanks
- i) Remote and Local pump suction temperature (for HFO only).

4.2.0 Lay Out of Control Room

Separate battery room and UPS room shall be provided

The control room & remote I/O panel shall be Air conditioned

The control room shall be provided with pantry room , Locker room , Toilet etc.,

The required modular furniture's and cabins for operators.

5.0.0 CONDENSATE POLISHING UNIT

Condensate polishing unit shall be controlled and monitored from the Unit DCS in the Central control room. System shall be complete with, complete with remote I/Os, Redundant Processor, power supply, communication module, redundant communication link all hardware, software, other interfaces, cables and field sensors / instruments / erection hardware envisaged to control and monitor it.

Condensate polishing unit local control room along with remote I/O panel and monitor shall be located at SWAS dry panel room in addition to remote monitoring from the central control room in the main plant DCS. CPU local control shall be provided with one (1) no. 24" LED type & A4 laser jet printer B/W per Unit in Condensate polishing unit local control room. The power supply for control system shall be taken from station UPS.

One no additional 17" LCD TFT type inbuilt in the remote I/O panel for emergency/local operation and maintenance of CPU regenerative system. The remote operation of the CPU regenerative system shall also be from the unit DCS monitor located at SWAS dry panel room.

Operator station in the Condensate polishing unit local control room shall be provided with the access to monitor the main plant operations

Condensate polishing plant mimic panel with hard wired push buttons for back panel operation. Hardwired annunciation panel shall be provided for controlling the process.

The instruments shall be offered as per the process requirement for complete auto operation.

Various analysers namely pH, conductivity, cation conductivity, silica, dissolved oxygen, sodium etc., shall be provided in the required process lines.

Necessary instruments pressure gauges, Temperature gauges, DP instruments, Pressure transmitters, Radar Level transmitters, Differential pressure transmitters, Temperature Elements Various analysers, Magnetic type level indicators, shall be provided. The junction boxes and instruments / electronics housing used shall be Non – corrosive material.

Flow transmitters for each stream of CPU are to be provided for monitoring the performance and accountability

The bidder shall furnish required list and type of instruments during detail engineering subject to the approval of owner.



5.1.0 Control and Operation of Plant

i) General

The regeneration system shall be external. Under normal conditions, it will hold a complete charge of freshly regenerated and mixed resin, ready for use, in its storage tank. For regeneration, resin from the exhausted exchanger vessel will be transferred hydraulically to this facility. The empty exchanger vessel will then be filled up with the already regenerated resin which was stored in the regeneration facility. This exchange vessel shall come into service soon after perquisite condition is satisfied or as and when desired by the operator. In the meantime, the exhausted resin shall be cleaned, separated, regenerated, mixed and rinsed before being stored for next use.

ii) Control and operation of the condensate polishing unit

- a) The condensate polishing unit shall be controlled from either Station DCS or the condensate polishing unit Operator station.
- b) It shall be possible to select each of the CPU vessels for any of the following operations:
 - Service
 - Resin transfer from CPU vessel to regeneration plant
 - Resin transfer from regeneration plant to CPU vessel
 - Isolation from service
 - Rinse recycle
- c) The Remote I/O Unit and control room of CPU shall be in the Dry room of SWAS panel. The dry room of SWAS panel shall comprise of Express Lab also in addition to CPU controls and SWAS Instrumentation & control panels. The size and location shall be topographically selected so as to accommodate these provisions.
- d) The Remote I/O Unit and control room of Regenerative system for CPU shall be in the Control room of DM/RO Plant. The DM/RO plant shall be designed topographically and the physical size of the plant shall also be selected so as to accommodate the equipments of Regenerative system for CPUs. Individual building and control room shall not be required for this system.

iii) Condensate polisher control system

From condensate polishing control system it shall be possible to initiate any of the following operating modes:

a) Rinse recycle

The rinse recycle shall be a manually initiated in full automatic sequence. This sequence shall include the rinse down step until the unit effluent quality is acceptable for boiler feed water. The effluent quality shall be determined by conductivity monitoring of the rinse water outlet. A panel mounted cation conductivity indicator shall be interlocked to prevent advancing of the automatic sequence until the rinse down is complete.

**b) Service mode**

Service flow rate for each polishing vessel shall be monitored by panel mounted flow indicators. During periods of low condensate flow the operator may select to remove one of the vessels from service by a manually initiated automatic sequence. A differential pressure switch installed between the influent and effluent headers shall on a high signal cause an annunciator alarm.

Panel mounted cation conductivity indicators shall be provided to monitor the polishing system influent and effluent streams as well as the discharge of each service vessel.

- c) The sequence resin transfer from CPU vessel to regeneration plant and from regeneration plant to CPU vessel shall be initiated from the local control station of CPU as well as from Unit DCS.

iv) Regeneration control system

- a) Manually initiated automatic sequences shall be provided for transferring resin from a vessel to the remote common facility for physical cleaning and chemical regeneration and for returning fresh resin to that vessel. Control for chemical dosing system and alkali preparation facility shall also be provided in it.
- b) Regeneration shall include hydraulic reclassification of the resins and the transfer of the resins to the respective regeneration vessels. The separated resins shall then be backwashed, cation and anion regenerated with hydrochloric acid and sodium hydroxide solutions respectively, rinsed and then followed air scrubbing and a good backwash. The resin is then transferred back to the resin separation vessel and the resins are air mixed. The mixed resins after regeneration are given a final rinse with the discharge conductivity being monitored. If the quality is satisfactory, the mixed resin shall be transferred to the resin storage vessel otherwise regeneration sequence shall be repeated.
- c) Demineralised water shall be used throughout the regeneration process for backwashing, regenerant diluents, rinsing and resin transfer. A conical bottom hopper having a water ejector will be used for resin make-up.
- e) It shall be possible to operate the regeneration plant in auto/semi-auto /manual mode.
- f) Following operations shall be possible from the regeneration control panel:
- Complete regeneration
 - Resin transfer from CPU vessel to regeneration plant.
 - Resin transfer from regeneration plant to CPU vessel.
- g) In 'Auto' mode, once the sequence has been initiated, it shall proceed from step to step automatically.
- h) In 'Semi-auto' mode each step shall be performed only after initiation by the operator.
- i) In 'Manual' mode complete operation shall be by the operator by operation of the control switches on the panel.



- j) On Plant DCS, it shall be possible to operate the valves by means of manual operation of solenoid valves also.
- k) It shall be possible to switch mode of operation from one to the other at any moment and the operation shall proceed on the newly selected mode from that time.
- l) The system shall incorporate the necessary safety features. During automatic sequential operation, if any pre-requisite criteria is not fulfilled or missing for a pre determined time interval, the steps should not proceed further, and Alarm shall be provided. Missing criteria, sequence which is under hold up etc. shall be displayed on the Operator station
- m) A mimic diagram of the Regeneration system shall be provided on the front of the local panel. The status of various drives and valves shall be indicated by LED on the mimic diagram.
- n) Wherever standby equipments are provided, it shall be possible to select each of the drive on 'standby' duty.
- o) The detailed logic for the sequence and for each of the drive shall be subject to the Owner's approval during detail engineering
- p) Start, progress and stop of each of the sequence shall be annunciated in all the control panels.
- q) At any time only one of the sequence shall be in progress.
- v) **Interlocks**

All interlocks for safe operation of the plant shall be provided. They shall specifically include the following as minimum requirement:

 - a) Service vessels shall be taken back in service, only after they have been pressurized.
 - b) Service vessels shall be taken up for resin transfer only after they have been completely isolated from the condensate system and depressurized.
 - c) Resin shall be transferred to and from only one service vessel at a time.
 - d) Resin transfer between the service and the regeneration skids shall be permitted only when the receiving vessel is initially empty.
 - e) It shall be possible for the operator to extend the timing of a particular step by isolating the timer for the duration. The timer will restart once the operator puts back the system on 'auto' and the other steps will then follow as programmed.
 - f) The regeneration sequence shall be prevented from advancing further in the event of tripping of a running motor or other fault condition which do not permit the various desired parameter of this step to be achieved. A manual override for this shall also be provided.
 - g) The immersion heater in the hot water tank can be put on only when there is adequate water level in the tank.



6.0.0 AIR CONDITIONING SYSTEM & VENTILATION SYSTEM

AC and ventilation system shall be controlled and monitored from the AC and ventilation system local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link, all hardware, software, other interfaces, cables and field sensors/instruments/erection hardware envisaged to control and monitor it.

AC and ventilation system local control room shall be provided with One (1) no. 24" LED type Operator station with one no. A4 B/W laser printer for control and monitoring the AC and ventilation system locally in addition to remote monitoring from the central control room in the main plant DCS.

Operator station in the AC and ventilation system local control room shall be provided with the access to monitor the main plant operations

Microprocessor based system for Chiller unit. Accessories such as serial link cable between microprocessor to the plant DCS. Local control Panel shall be provided for Air Washer System and Unitary Air Filtration system.

Fire signal shall be wired to MCC/DCS and interlocked for all fan motor & Air washer unit / UAF& CCR inert gas system. Such that the equipment will trip on fire alarm signal from the Plant Fire Alarm system

Air conditioning facilities shall be provided for areas of control room, control equipment room, shift- in-charge room, Engineer's room, UPS room, analyzer room etc. in the main plant building; ESP control room; service building; Admin buildings, Operator rooms of various system, Switchyard control room and other rooms in the scope of the bidder requiring provision of air conditioning. The system shall consist of:

- a) Central chilled water type air conditioning plant for main plant building and service building (Including Instrumentation Lab, Electrical lab and Computer server room, telephone exchange room, etc.,)
- b) DX air conditioning plant for ESP control room, AHP, Switchyard Control Building & RO-DM plant (Including Chemical Lab) Fuel oil pump house and CW pump house
- c) Split/ window type for other areas as required.(Boiler A Elevation, SWAS and Chemical Express Lab, Fire water pump house, Turbine 0 Metre Control room, HT switchgear operator room, Service Water Pump House, Compressor room , etc.,

Evaporative type ventilation system shall be provided for main plant building with air washer units distributed along 'A' row and 'B' row of the building. Filtered and cooled air from the air washer unit shall be distributed to various areas through diffusers. The main plant building shall be provided with adequate number of roof exhausters. Unitary air filtration system using water repellent type nylon filters shall be provided for ESP control buildings as applicable. Mechanical type ventilation system using supply air fans, exhaust air fans and roof exhausters as applicable shall be provided for other miscellaneous areas such as cable vaults, electrical switch gear rooms, battery rooms, toilets, elevator machine rooms, AC plant room, DG set room etc..

The basic function of the system shall be to closely control and monitor inside temperature and humidity conditions inside the air-conditioned spaces, to provide remote centralized monitoring & control for various mechanical facilities including sequential start/stop of the whole HVAC System, automatically calculate record and cooling load for each hour/ day/season, to generate maintenance data & alarms, to maintain records of plant operation & energy consumption for varying loads, duty cycling to operate all the equipment including standby equipment for equal duration, automatic startup of



standby equipment in case of failure of operating unit and displaying fault alarm status of the tripped unit, activating/ deactivating water valves to startup/stop water flow through chiller/condenser circuit.

A) Water Chilling Plant Control

- i) DCS controls shall be provided to meet the requirement of all system operations and controls.
- ii) The inside room temperature and humidity is controlled by controlling the chilled water flow by means of Motor operated three way modulating valve provided at the Chilled water Return line of each AHU to allow chilled water to flow through the cooling coils or bypass the chilled water to return line. This valve is modulated (opened/closed) based on the return air temperature. The return air temperature is measured with Temperature & Relative Humidity Sensor provided in the return air path of each AHU Room. Pan Humidifier is interlocked with humidity & safety thermostat called Gyserstat.
- iii) Pan Humidifier will automatically turn "ON" in case of humidity of the return air is lower than the set point and turn "OFF" automatically when required level of Humidity is maintained. It will be functioning at the lower limit of RH. Gyserstat trips the Pan Humidifier when the water temperature reaches above the set point.
- ii) Water chilling unit control system shall be designed to have a constant chilled water outlet from evaporator at all load condition by means of controlling ON-OFF thermostat (one for each compressor) in an automatic manner.
- iii) Water chilling unit shall be equipped with superheat control of water chilling unit through thermostatic expansion valve, which gets its impulse from temperature element connected with suction line after chiller outlet.
- iv) High discharge pressure cut-out and oil pressure (OP) differential cut-out shall be of manual reset type and low pressure cut-out shall be automatic reset type. The OP cut-out shall trip the compressor in case of low oil pressure.
- v) On-off toggle switch to close the liquid refrigerant line solenoid valve shall be provided to shut the compressor by the operation of the operation of low pressure cut-out (after the refrigerant has been pumped to the condenser).
- vi) Switching of crank case heaters shall be interlocked with starting and stopping/tripping of compressor motor. Further, the safety thermostat shall switch off the crank-case heater in the event temperature rises above safe limit.
- vii) Provision shall also be made for the manual restarting of the compressor.
- viii) On-off type anti-freeze thermostats, one for each chiller shall be provided in addition to the controlling on-off thermostat for safety purpose and shall act in the event of failure of on-off thermostat to close the liquid line solenoid valve and also to trip the compressor simultaneously.
- ix) Compressor starting/running shall be interlocked with the flow switches to be provided at the outlet of each chiller and each condenser and as well as with pressure in the inlet of the condensers. In addition closure or open status of various valves through limit switches shall be used for interlock, alarm and control of air conditioning system.
- x) The standby condenser water pumps (if applicable), standby chilled water pumps, standby fresh air fan & standby AHU shall be started automatically when the working equipments are stopped/tripped. Auto/manual selector switches and working /standby selector switches for the pumps/AHU/fresh air fan shall be provided in the panel.
- xi) Closure of fire dampers shall raise an annunciation in the panel.
- xii) Condenser water pumps shall be interlocked with the low level switch in each cooling tower sump and operation of cooling tower fans. High level in the cooling tower shall be annunciated in the panel by means of a separate level switch.

**B) Air handling unit**

- i) Control of the inside room temperature and humidity shall be by controlling the chilled water flow by means of motor operated three way modulating valve and the modulating valve shall get its signal from the temperature sensor.
- ii) Humidistat located in the return air duct shall actuate the pan humidifier to obtain the desired degree of humidification.
- iii) Separate Humidistat and thermostats shall be provided and interlocked in steps with winter heater / re-heater / strip heaters for monsoon and winter re-heating or heating as the case may be.
- iv) Heater banks shall be interlocked with the running of AHU, temperature of return air, humidity of return air and safety thermostat (Geyserstat located in front of the each heater in the supply air duct)
- v) AHU shall be started either from its local panel or from the main control panel of AC system by means of Remote/Manual selector switches.
- vi) The closure of fire dampers, automatic tripping of AHU fans and fresh air fans shall be interlocked with Bidder's fire Detection System.
- vii) Each AHU shall be provided with temperature indicators and flow indicator in the chilled water piping inlet and outlet to monitor the air-conditioning load of each area.
- viii) The motorised air regulators shall be provided for individual rooms for regulating the room temperature. The temperature control of different portions of central control room shall also be possible for maintaining different temperature.

C) D-X air-conditioning system

- i) The control and interlocks described above for water chilling plant shall be application for this system also.
- ii) Further, the compressor starting/ running shall be interlocked with the flow switches in condenser water circuit and as well as with AHU motors.
- iii) The standby condenser water pumps, fresh air fan & standby AHU shall be started automatically when the working equipments are stopped/ tripped. Auto / manual selector switches and working/ standby selector switches for the pumps, fresh air fans and AHU shall be provided in the panel.

D) General requirements

- i) Separate emergency local stop push button shall be provided for each pump, compressor, fans etc. of AC system.
- ii) All the annunciation related to failure of equipments, tripping of equipments, source of failure / reason due to which the equipment is stopped/tripped, low & high limits of parameters such as level, temperature, pressure drop, pressure etc shall be provided for each pump, fan, compressor, AHU etc. in the respective panel.
- iii) Fully wired, twenty percent (20%) spare annunciation windows shall be provided in all the panels.
- iv) Air washer units shall be started / stopped by initiation from the plant DCS as well as local control panel and the starting/stopping of fans and pumps shall be automatic upon such initiation.
- v) The operation of the pumps shall be interlocked with the low level of water in the sump. High level of the sump shall be annunciated. The standby pump shall be started automatically when the working pump is tripped.
- vi) Auto/manual selector switches and working/standby selector switches for the pump shall be provided in the panel.
- vii) A selection switch enabling the running of AWU fan or pump alone shall be provided.



Separate emergency local stop push button shall be provided for each pump, fans etc.

- vii) All the annunciations related to failure of equipments, tripping of equipments, source of failure/ reason due to which the equipment is stopped/ tripped, low and high limits of parameters such as level, temperature, pressure, pressure drop etc. shall be provided for each pump, fan, AWU etc. in the respective panel.

- viii) Both supply and exhaust fans shall be operated locally.

7.0.0 ON LOAD TUBE CLEANING SYSTEM

Condenser on-line tube cleaning system shall be controlled and monitored from the Unit DCS in the Central control room. System shall be complete with remote I/Os (if reqd), Redundant Processor, power supply, communication module, redundant communication link all hardware, software, other interfaces, alarm annunciation windows, push buttons and indications, cables and field sensors/instruments / erection hardware envisaged to control and monitor it. Local operation shall also be provided.

I) Condenser On Load Tube Cleaning System (COLTCS)

- i) COLTCS shall be of sponge rubber ball type designed for continuous and trouble free operation. Provision of abrasive coated balls shall be made for cleaning in case of hard deposits inside tubes.
- ii) The system shall consist of non-clog type ball recirculation pump, ball injection nozzles, ball collecting vessel, ball monitoring system, necessary instruments, pipings and accessories etc.
- iii) Provision of manual and automatic back wash arrangement shall be made with automatic collection of balls prior to back washing.
- iv) Ball monitoring system shall include ball circulation monitor, oversize monitor and ball sorter.
- v) The ball collecting strainer shall have differential pressure transmitter with back-washing system.
- vi) Provision shall be made to prevent loss of balls under normal and abnormal operation including tripping of CW pumps.
- vii) The no. of balls in circulation shall be at least 10% of no. of condenser tubes. Bidder shall indicate no. of ball losses in 1000 hours of normal operation. The indication of no of balls collected shall be available in DCS.
- viii) Provision shall be made to avoid any dead zone inside water box. There shall not be crowding of balls at the inlet of ball collecting strainer at discharge pipe.
- ix) To ascertain the performance of OLTCS the temperature elements and temperature indicators in the inlet and outlet of condenser sea water lines and the differential pressure indicator and transmitter across sea water inlet and outlet of condenser shall be provided.

II) Debris Filters

- i) Two number debris filters shall be provided on the circulating water pipelines upstream of the condenser for online filtering of cooling water.
- ii) Each debris filter shall comprise of perforated stainless steel screen, butterfly valves, turbulence flap, debris flushing valve, drain plug valve, motor actuators for the valves, differential pressure gauge and control and instrumentation etc.
- iii) The materials of construction of various components shall be of proven type as per quality of water to be handled by the debris filters. Inside surface of the debris filters shall be coated with anti-corrosive paint to ensure long life.
- iv) The filters shall be capable of removing solids, suspended matter and fibrous material up to 5 mm size.



- v) The removed debris shall be suitably disposed off. The operation of the debris filters shall be of automatic type with facility provided for remote manual operation also.
- vi) The maximum allowable pressure drop under clean screen condition shall be limited to 0.5 mwc, and under 50% choked screen condition the pressure drop shall not exceed 1.0 mwc. The filter shall be designed for pressure of 5 kg/cm² (g) and vacuum of 0.1 kg/cm²(abs).

Following Instruments/control functions shall be provided at CW debris filter in addition to instruments provided as per process requirement

- 1) Remote & Local indication DP transmitters & gauges across debris filters and self cleaning strainer.
- 2) Auto start /stop of Cleaning devices for debris filters for high DP and Low DP

8.0.0 HP & LP DOSING SYSTEM

HP & LP dosing complete system shall be controlled from the Unit DCS monitor available at SWAS dry panel control room including stroke adjustment. Local controller for this stroke arrangement are not allowed. Remote / local operation of all pumps and stirrer etc., are to be provided.

The NaOH dosing system for pH correction in DMCW system shall also be controlled from the DCS including stroke adjustment, Remote / local operation of all pumps and stirrer etc., shall be provided.

The levels transmitters of proven type for various chemical tanks of HP/LP dosing systems.

Pressure transmitters and pressure gauges for all the dosing pumps shall be provided.

9.0.0 ELECTRO-CHLORINATION SYSTEM

9.1.0 Control Philosophy

Electro chlorination system shall be controlled and monitored from the Electro chlorination system local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link all hardware, software, other interfaces, cables and field sensors / instruments / erection hardware envisaged to control and monitor it.

Electro chlorination system local control room shall be provided with Two (2) no. 24" LED type Operator station for control and monitoring the Electro chlorination system locally in addition to remote monitoring from the central control room in the main plant DCS. Local annunciation panel with minimum amount of conventional hardwired pushbutton stations and indicators shall be provided for the safe shutdown of the plant.

Operator station in the Electro chlorination system local control room shall be provided with the access to monitor the main plant operations

Operational requirement

- a) Operation of the pumps, Transformer Rectifier, Electrolyser and other equipments shall be performed from the operator station located at the Electro Chlorination Building (air conditioned area) as well as remote monitoring in central control room of the main plant.



- b) All conditions used for tripping the Transformer Rectifier, Electrolyser and pumps etc., shall be provided with pre-trip annunciation in the operator station
- c) All initiating devices, relays and other hardware required to achieve annunciation, control and interlock system shall be provided by the bidder.

Important safety interlocks

The safety interlocks shall be furnished by the vendor during detail engineering and will be reviewed and approved by owner.

Special Instrument requirement

Sea water booster pump suction pressure low trip (2 out of 3).

Sea water Booster pump discharge header pressure transmitter (1 out of 2) for monitoring and Auto cut in stand by pump and pressure gauges

Differential Pressure Transmitter and local gauge across the suction strainer of Booster pump

Booster Pump by pass valve shall be motorised

Differential Pressure Transmitters and gauges across each electrolyser.

Flow transmitter along with flow control valve shall be provided at the inlet of each electrolyser to regulate the flow of sea water according to generation rate of hypochlorite.

Level transmitters shall be provided in the hypochlorite degassing tank for controlling level in the tank.

Hypochlorite pump discharge header pressure transmitters and gauges at each header (For monitoring and Auto cut in stand by pump)

5% HCL tank Level transmitter and Local level Indicator

Air Dilution Blower fan discharge header pressure switch at each header (For monitoring and Auto cut in stand by pump)

Flow transmitter along with flow control valve shall be provided at the outlet of each Hypochlorite pump discharge header to regulate the dosing rate of hypochlorite

All pumps and fan status (Run / Stop / Trip) and their MCC status (ON , OFF) etc shall be indicated in the OWS as specified in section V

All electrical parameters of Transformer Rectifier such as Input Voltage, current and output voltage and current shall be displayed at Operator station

The necessary protection and control for Transformer Rectifiers and Electrolysers as per the recommendation of OEM shall be provided.

Process instruments & logic control connected with heater circuit

Multiple online chlorine leak detectors in chlorine storage tank area, chlorine producing unit area, chlorine pumping room, chlorine processing zone areas inside the building.



10.0.0 SERVICE WATER AND POTABLE WATER SYSTEM

Service and potable water system and miscellaneous pumps shall be controlled from the common operator stations of Desalination /WTP plant in the local control room (shall be decided during the detailed engineering)

- a) Service water pumps and potable water pumps and their lube oil and other accessories including Butterfly valves shall be controlled and operated from the Operator station of Desalination /WTP plant.
- b) Status indication of Service water and Potable water pumps shall be provided in Operator station in Control Room. Manual operation of the above equipment shall also be possible from the local.
- b) Auto start of standby pump shall be envisaged along with the opening and closing of pump discharge valve. The valves shall be motorised valves to facilitate this auto operation.
- c) An interlock shall trip all Service water pumps at very low levels of the respective storage tanks. Level transmitters shall also be provided to generate alarm in case of low/high level in the sump.
- d) Operation philosophy as detailed above is indicative minimum and Bidder shall furnish the complete interlock scheme for Service Water and Potable water system along with drawings. However, the interlock scheme to be adopted shall be finalised in during detailed engineering phase of the project.

Following minimum control function shall be carried out from the Operator station

- a. Remote & local operation for Start & Stop of Pumps.
- b. Remote & local operation for Open & Close of MOV's.
- c. Control & Monitoring of analog & digital parameters from control room console as well as locally.
- d. Monitoring of alarms at control room.
- e. Provision of Flow transmitters at each header

At each pump discharge headers pressure transmitters may be provided

The Service water pump house LT MCC shall be interfaced with the control system for the following indications Run / Stop / Trip / Test ,Current voltage etc ., Emergency stop push buttons for all drives at local shall be provided near the pumps

Air-conditioned control room shall be provided along with pantry room and a locker room.

11.0.0 FIRE WATER PUMP HOUSE

Fire water pump house shall be provided with One(1) no. 24" LED type Operator station for control and monitoring the Fire water pump house locally in addition to remote monitoring from the central control room in the main plant DCS

All pumps and compressor (Hydrant, HVWS, FOAM , Jockey Pumps, Air compressor etc) in fire water pump house and other accessories including valves shall be controlled and operated from the Operator Station as well as from Local Control Panels. Manual operation of the above equipment shall also be possible from the local.

Auto start of pump in case of header pressure drop shall be provided.

Pressure transmitters, gauges, switches for each pump discharge header and main header shall be provided.



All the critical control shall be from 1 out of 2 logic.

The MOV shall be provided at the inlet of each header from the fire water reservoir.

Provision of DP switch shall be provided for each suction strainer

Provision of two no's ultra sonic level transmitter at each compartment of fire water reservoir. An alarm in case of low/high level in the reservoir

The Fire water pump house LT MCC shall be interfaced with the control system for the following indications Run / Stop / Trip / Test, Current voltage etc.,

The Auto start and stop of jockey pump based on the hydro pneumatic level shall also be provided.

The level transmitter shall be provided for any water tanks/reservoirs or Hydro pneumatic tanks for remote as well as local indication.

The Auto start and stop of Air compressor based on the pressure in the hydro pneumatic tank shall also be provided

Pressure transmitter shall be provided for the Hydro pneumatic tank and at each pump and compressor discharge header.

The Auto start and stop of Fire water sump pump based on level shall be provided.

Provision of pressure transmitter at various location of power plant at fire water headers shall be provided

The Foam spray system with necessary control shall be provided

ON/RUN feedback of diesel engine fire water pump shall be alarmed in Operator station

Operation philosophy as detailed above is indicative minimum and Bidder shall furnish the complete interlock scheme. However, the interlock scheme to be adopted shall be finalized in during detailed engineering phase of the project.

The standby diesel engine driven pumps shall be started on Auto for emergencies.

The jacket cooling water system for diesel engine shall be provided with a solenoid operated valve with manual over ride feature. The solenoid valve shall automatically opened when ever Diesel engine is started and the same shall be closed manually. Flow switch shall be provided for annunciating the Cooling water flow low.

The various status of Diesel engine shall be provided in the Operator station (such as diesel oil tank level, Cooling water flow low, Battery voltage, Battery Charging current etc.,)

Air-conditioned control room shall be provided along with pantry room and a locker room.

Following minimum control function shall be carried out from the Operator station

- a. Remote & local operation Start & Stop of all Pumps.
- b. Remote & local operation Open & Close of MOV's.
- c. Control & Monitoring of analog & digital parameters from control room console.
- d. Monitoring of alarms at control room.



12.0.0 COAL HANDLING PLANT

12.1.0 Control philosophy

In-plant coal handling system shall be controlled and monitored from the CHP local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link, all hardware, software, other interfaces, cables and field sensors/instruments/erection hardware/furniture envisaged to control and monitor it

In plant coal handling local control room shall be provided with Two (2) no. 24" LED type Operator station and CHP Mimic panel for control and monitoring the CHP locally in addition to remote monitoring from the central control room in the main plant DCS.

One (1) no. A3 color printer in addition to one (1) no. A4 laser B/W printer shall be provided in the local control room for the operator station.

Operator station in the CHP local control room shall be provided with the access to monitor the main plant operations

CHP mimic panel with hard wired push button for back panel operation. One No. large screen display (84") complete with control station and other hardware at CHP control room for controlling & monitoring coal handling system.

Two Nos. large screen display (84") complete with control station and other hardware at CHP control room for controlling & monitoring coal handling system. Emergency backup panel shall be provided for the fail safe operation to safeguard the equipments/process.

Operator station shall be provided at local control room for control and monitoring of each stacker reclaimer locally in addition to remote operation from CHP local control room.

For stacker and reclaimer, automatic cable reeling or releasing system with necessary sensor arrangement shall be provided.

For stacker and reclaimer, feedback/command signals shall be established wireless mechanism so as to avoid frequent damages to the flexible convention cables and fail safe commands/ feed back shall be hardwired.

Microprocessor based system for Belt Weigher system, metal detector system, coal sampling unit & compressed air system.

Microprocessor based system for Belt Weigher system shall provide mA signal output for the coal feed to be connected to DCS of CHP.

Necessary chute block switches shall be provided at transfer points for alarms in DCS of CHP.

Local control panels for the Dust suppression system, dust extraction system, bunker ventilation system, In line magnetic separator, travelling tripper, scoop coupling system , sump pump, etc.

Safety switches -- Addressable type Pull cord switch, Addressable type Belt sway switch, Zero speed switch, limit switches etc., Master cum Display unit & control panels for the safety switches (pull cord & Belt sway switches).

Anemometer for the stacker reclaimer system.



Continuous level measurement for unit coal bunker and other bunkers of Coal handling system shall be provided with three (3) numbers of radar type level transmitters for each bunkers with IP 65 protection for each bunker level measurement. Bunker level shall be monitored in Travelling tippler floor and CHP control room/ DCS. Radar type level transmitters shall be FMCWR type with drop in antenna and being operated at 24-26GHz.

Necessary interface between ICHS and ECHS from Udangudi port shall be both hardwired through I/O devices and also by redundant bi directional OPC link for interlock protection.

12.2.0 Lay Out of Local Control Room

Separate battery room and UPS room shall be provided

The control room & remote I/O shall be Air conditioned

The control room shall be provided with pantry room, Locker room etc.,

The required modular furniture's and cabins for operators.

13.0.0 SEA WATER INTAKE AND OUTFALL SYSTEM

13.1.0 Control philosophy

Sea water Intake and outfall system shall be controlled and monitored from the Sea water Intake system local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link ,all hardware, software, other interfaces, cables and field sensors / instruments / erection hardware envisaged to control and monitor it.

Sea water Intake and outfall system local control room shall be provided with Two (2) no. 24" LED type Operator station for control and monitoring the Sea water Intake and outfall system locally in addition to remote monitoring from the central control room in the main plant DCS. The exact location of these monitors shall be decided during detail engineering stage.

Suitable interlocks shall be provided with Desalination plant with CW in-take and outfall system for flow control.

The pumps & VFD controls of Cooling water outfall system to sea shall be controlled from the OWS available at Sea water intake pump house.

The communication interface sea water intake and outfall control system and station DCS shall be thru single mode OFC.

Operator station in the Sea water Intake and outfall system local control room shall be provided with the access to monitor the main plant operations

Hardwired annunciation panel shall be provided for controlling the process.

Ultrasonic or Radar type level transmitters shall be provided at various tanks and forebay.

Local Start, Stop push buttons shall be provided for all drives.

The provision of Start and Stop of various pumps shall be provided in the control system.



pH, temperature, chlorine etc. measurement shall be provided at the outfall water line as per statutory norms .

Online chlorine monitoring and control of dosing system by stroke adjustment shall be provided for the sea water intake.

Sea water intake & outfall flow measurement (non contact type) shall be provided.

Necessary instruments as per process /control requirement shall be provided.

13.2.0 Lay Out of Local Control Room

Separate battery room and UPS room shall be provided

The control room & remote I/O shall be Air conditioned

The control room shall be provided with pantry room , Locker room etc.,

The required modular furniture's and cabins for operators.

14.0.0 MILL REJECT SYSTEM

14.1.0 Control philosophy

Mill reject system shall be controlled and monitored from the Mill reject system local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link all hardware, software, other interfaces, cables and field sensors/instruments/erection hardware envisaged to control and monitor it.

Mill reject system local control room shall be provided with Two (2) no. 24" LED type Operator station for control and monitoring the Mill reject system locally in addition to remote monitoring from the central control room in the main plant DCS.

Operator station in the Mill reject system local control room shall be provided with the access to monitor the main plant operations

14.2.0 Lay Out of Local Control Room

Separate battery room and UPS room shall be provided

The control room & remote I/O shall be Air conditioned

The control room shall be provided with pantry room , Locker room etc.,

The required modular furniture's and cabins for operators.

15.0.0 COOLING WATER SYSTEM

15.1.0 Control philosophy

Cooling water system which includes Condenser cooling water system & Auxiliary cooling water system shall be controlled and monitored from the Central control room. System shall be complete with DCS remote I/O, Redundant Processor, power supply, communication module, redundant communication link all hardware, software, other interfaces, cables and field sensors/instruments / erection hardware/furniture etc

CW system local control room shall be provided with Two (2) no. 24" LED type Operator station locally for monitoring. Remote operation is envisaged from the Central control room.

Operator station in the CW pump house local control room shall be provided with the access to control & monitor the main plant operations



Hardwired annunciation panel shall be provided for controlling the process.

CW pumps and ACW pumps will be operated and controlled from DCS at central

Control room. Bidder shall provide redundant DPU and the same shall be located in the CW pump house, which will act as a DCS node. All instruments and vibration signals will be connected to the DPU. DPU shall be housed in a local panel, The vibration monitoring system for CW and ACW pumps shall be provided and as defined else where in the specification. Bidder shall arrange necessary redundant power supply for the local panel.

- a) Circulating Water (CW) pumps, Auxiliary Cooling Water (ACW) pumps and their lube oil and other accessories including Butterfly valves shall be controlled and operated from DPU (Digital Panel Unit), Local Control Panels as well as from the Central Control Room DCS. Status indication of CW and ACW pumps and Cooling tower I/L & O/L temp shall also be provided in Central Control Room and at the local control panels.
- b) Starting and Stopping of CW and ACW pumps shall be suitably interlocked with the opening and closing of pump discharge butterfly valve.
- c) The standby CW/ACW pump shall have auto/manual starting facility. The standby pump shall be started automatically in case of tripping of any running pump or if its discharge header pressure falls below a preset low value.
- d) An interlock shall trip all CW pumps from very low level of water in the sump of the CW pump house. Redundant Ultrasonic type Level transmitters shall also be provided to generate alarm in case of low/high level in each CW sump.
- e) Each CW pump (and associated motors) shall have vibration monitoring facility. Bidder shall provide the necessary vibration transducers, monitors and suitable pads etc. Bidder is to mount the necessary mounting pad for these vibration transducers. Bidder shall also furnish necessary data/documents of Vibration Monitoring System to be designed as per chapter 4.
- f) Operation philosophy as detailed above is indicative minimum and Bidder shall furnish the complete interlock scheme for CW/ACW system equipment proposed by him along with drawings. However, the interlock scheme to be adopted shall be finalised in during detailed engineering phase of the project.
- g) An interlock shall trip all ACW pumps from very low suction pressure

15.2.0 Control & Monitoring

Following minimum control function shall be carried out in addition to process requirement:

- a) Remote and Local Start & Stop of all Pumps, from Operator console.
- b) Remote and Local Start & Stop of MOV's from Operator console.
- c) Control & Monitoring of analog & digital parameters from control room console.
- d) Start permissive, Trip logic, Interlocks and Sequence control.
- e) Monitoring of alarms and status at Central control room.
- f) Auto start of standby pumps with auto operation of required motorized valves and required instruments and logics.
- g) Monitoring of all electrical parameters such as current, voltage etc of MCC and drives as detailed elsewhere in the specification (Electrical & Instrumentation)
- h) The critical protection system shall be based on 2 out of 3 voting logic and other critical control loops shall be 1 out of 2
- i) All the CW sumps are to be provided with level transmitters of proven type
- j) The pumps discharge header shall be provided with pressure transmitters and Local



- gauges for monitoring from remote.
- K) The fire detection and alarm system shall be provided for the control room,
 - L) Local / Remote operation of Breakers etc.,
 - M) Monitoring incoming current & voltage including the metering.
 - N) Provision of flow transmitter for all make up and blow down of water for accountability
 - O) Provision of Chlorine analyser
 - P) Provision of Non contact type flow meters for CW inlet header to Condenser and also ACW header.
 - q) Motors winding temperature shall be monitored from remote. For measurement of the same, RTD shall be connected to the DPU.
 - r) All motor current shall be monitored at central control room.
 - s) Open and Close limit switch feed backs of valves are to be connected to DCS for remote viewing and for interlocks and protection.

For control and monitoring, Ultrasonic type or any Latest type for CW basin level measurement, Flow, etc. shall be provided.

Level low trip cooling water basin level low 2 out of 3 ultrasonic type level transmitters shall be provided for tripping of pumps. In addition to this, one more Ultrasonic level transmitter for over all measurement for the sump shall be provided

At CW & ACW pump discharge headers flow transmitters may be provided (Non Contact ultrasonic Type preferable)

At CW & ACW pump discharge headers pressure transmitters with 1 out of 2 logic shall be provided for auto start of stand by pumps

The Operator control room and Panel room shall be air conditioned room of CWPH.

The CWPH LT MCC shall be interfaced with the DPU for the following indications Run / Stop / Trip / Test, Current voltage etc ., of the switchgear. The online chlorine, salinity conductivity and pH analyser shall be provided in the cooling water pump discharge line.

Cooling water blow down line shall be controlled from the CWPH DCS

Cooling Water make-up control based on CW sump level shall be from CWPH DCS.

Cooling water makeup flow transmitter shall be hooked up at CWPH DCS.

Cooling water blow down pumps shall be controlled from the CWPH DCS.

The MCC incomer Current, Bus voltage and transformers parameters shall be indicated in the OWS for monitoring as detailed in elsewhere in this specification.

Following Instruments shall be provided at CW line to condenser & ACW line to heater in addition to instruments provided as per process requirement

- a) Remote & Local indication for Flow, pressure, Temperature measurement at each condenser I/L & O/L
- b) Remote & Local indication DP transmitters & gauges across at each condenser
- c) Remote & Local indication Temperature elements & gauges at cooling tower inlet.
- d) Remote & Local indication DP transmitters & gauges across debris filters and self cleaning strainer.
- e) Remote & Local indication DP transmitter & gauges across each Heat exchanger
- f) Remote & Local indication Temperature elements & gauges shall be provided before and after all heat exchanger.



15.3.0 Lay Out of Local Control Room

- Separate battery room and UPS room shall be provided
- The control room & remote I/O panel rooms shall be Air conditioned
- The control room shall be provided with pantry room , Locker room , Toilet etc.,
- The required modular furniture's and cabins for operators.
- A pantry room and a locker room shall be provided in CWPB and this room shall have access from CWPB control room.

16.0.0 HYDROGEN PLANT SYSTEM

16.1.0 Control Philosophy

Hydrogen Plant shall be controlled and monitored from the H2 local control room, through the DCS remote I/Os, Redundant Processor, power supply, communication module, redundant communication link all hardware, software, other interfaces, cables and field sensors / instruments / erection hardware envisaged to control and monitor it.

H2 plant local control room shall be provided with Two (2) no. 24" LED type Operator station for control and monitoring the H2 plant system locally in addition to remote monitoring from the central control room in the main plant DCS. Local annunciation panel with minimum amount of conventional hardwired pushbutton stations and indicators shall be provided for the safe shutdown of the plant.

Operator station in the H2 plant local control room shall be provided with the access to monitor the main plant operations

Operational requirement

- a) Operation of the pumps, Transformer Rectifier, Electrolyser, Compressor and other equipments shall be performed from the operator station located at the H2 plant Building (air conditioned area) as well as remote monitoring in central control room of the main plant.
- b) All conditions used for tripping the Transformer Rectifier, Electrolyser, Compressor and pumps etc., shall be provided with pre-trip annunciation in the operator station
- c) All initiating devices, relays and other hardware required to achieve annunciation, control and interlock system shall be provided by the bidder.

Important safety interlocks

The safety interlocks shall be furnished by the vendor during detail engineering and will be reviewed and approved by owner.

Special Instrument requirement

Water Booster pump discharge header pressure transmitter (1 out of 2) for monitoring and Auto cut in stand by pump and pressure gauges

Differential Pressure Transmitter and local gauge across the suction strainer of Booster pump

Booster Pump by pass valve shall be motorised

Differential Pressure Transmitters and gauges across each electrolyser.



Flow transmitter along with flow control valve shall be provided at the inlet of each electrolyser to regulate the flow of water according to generation rate of H₂.

Pressure transmitters shall be provided in the H₂ tank.

Duplex PT100 shall be provided in each cell.

KOH pump discharge header pressure transmitters and gauges at each header (For monitoring and Auto cut in stand by pump)

28% HCL tank Level transmitter and Local level Indicator

Air Dilution Blower fan discharge header pressure switch at each header (For monitoring and Auto cut in stand by pump)

Flow transmitter along with flow control valve shall be provided at the outlet of each Hypochlorite pump discharge header to regulate the dosing rate of hypochlorite

All pumps and fan status (Run / Stop / Trip) and their MCC status (ON , OFF) etc shall be indicated in the OWS as specified in section V

All electrical parameters of Transformer Rectifier such as Input Voltage, current and output voltage and current shall be displayed at Operator station

The necessary protection and control for Transformer Rectifiers and Electrolysers as per the recommendation of OEM shall be provided.

Process instruments & logic control connected with heater circuit and Hydrogen detection System

H₂ Leak detection system in all parts of Hydrogen plant buildings shall be provided for the system

H₂ Purity analyser system shall be provided for the system

O₂ & Moisture analysers shall be provided

Hydrogen flow meter shall be provided at the outlet of H₂ manifold

Level transmitter shall be provided for DM water tank

Redundant level switches shall be provided for final product (H₂) tank

Zener protection for all the digital/anologue signals involved in the process of Hydrogen plant shall be incorporated.

16.2.0 Lay Out of Local Control Room

- Separate battery room and UPS room shall be provided
- The control room & remote I/O panel rooms shall be Air conditioned
- The control room shall be provided with pantry room , Locker room , Toilet etc.,
- The required modular furniture's and cabins for operators.

17.0.0 DMCW SYSTEM

The De-mineralized Cooling Water System shall be controlled from Plant DCS.



Following Instruments shall be provided at DMCW system for monitoring & Control

- a) Remote & Local indication Temperature elements & gauges , DP transmitter & gauges etc at each Heat Exchanger I/L & O/L
- b) Remote & Local indication DP transmitter & gauges across at each Strainer
- c) pH & conductivity Analyser at DMCW water Header
- d) 1 out of 2 Overhead Tank Level transmitter for control
- e) Remote & local operation of DM water makeup Valves.
- f) Flow transmitter at DM water makeup Inlet.
- g) Remote & Local operation for Start & Stop of Pumps from DCS console.
- h) Remote & Local operation for Open & Close of valves at discharge of pumps
- i) Motor Current and other parameters
- j) 2 out of 3 pressure transmitter at the Suction and discharge of DMCW pumps
- k) Remote & Local operation for Open / Close of all MOV at DMCW pump Inlet and Outlet and also Heat exchangers
- l) Flow transmitter at the Outlet of each DMCW pumps and at common header.
- m) Auto start of DMCW Pumps The valves used in this system shall be MOVs which shall be operable on remote for auto facilitating the auto on off of DMCWPs.
- n) Logic controls of DMCWPS shall be distributed.

18.0.0 EFFLUENT AND SEWAGE TREATMENT PLANT

Effluent and sewage treatment plant shall be controlled from remote I/O DCS from the common operator stations in the local control room (shall be decided during the detailed engineering). Effluent and sewage treatment plant local control room shall be provided with One(1) no. 24" LED type Operator station and one A4 B/W laser printer for control and monitoring of the Effluent and sewage treatment system locally in addition to remote monitoring from the central control room in the main plant DCS. In case if the effluent treatment and sewage treatment are in different location more than a kilometer then separate local control room with DCS with remote I/O with all necessary work station and printer shall be provided.

Operation of all the sump pumps will be controlled from the DCS. Sump pumps shall be connected functionally with the RIO located at different areas of the plant. Level controls shall be realized in the DCS. Standby pump shall auto start at high and auto stop at normal level based on level control. Alarm for low level will be provided in the OWS of ETP through level switch.

All waste water sumps low/high level alarm shall be provided in DCS for monitoring from the local control panel. pH measurement shall be provided as per the statutory norms if required.

18.1.0 Lay Out of Local Control Room

- Separate battery room and UPS room shall be provided
- The control room & remote I/O panel rooms shall be Air conditioned
- The control room shall be provided with pantry room, Locker room, Toilet etc.,
- The required modular furniture's and cabins for operators.



VOLUME II
SUB-SECTION 4.11
ALARM ANNUNCIATION

Some alarm annunciations are of interest to the operating personnel only if the corresponding part of the assembly or units is in the start-up, operating or shut-down condition. These linked annunciations are usually made up of signals showing conditions and process monitoring criteria. The alarms shall be inactive when the relevant unit or equipment is supposed to be out of operation. Hardwired back panel annunciation system for BOP plants is envisaged whereas for main plant in central control room, LVS based annunciation system is preferred.

1.0.0 ANNUNCIATION SYSTEM

1.1.0 General Requirements

Alarm annunciation system for presenting alarms with BTG package or with Unit DCS shall be integrated & part of Unit DCS system as mentioned below:

- a) Conventional hardwired alarm annunciation system has not been envisaged. All alarm will be displayed in Unit DCS. In addition to the Unit DCS alarm, first three (3) rows of LVS will be used for critical alarm display. First row will be kept reserved for fixed alarm and the other two rows will be used for other alarm display for which location of window may vary. Four number (4) nos. of 40" LED TVs for each unit connected to respective unit DCS so as to visualize Annunciation windows/alarm messages in enlarged versions and for viewing process mimics. These LED TVs shall be installed and hanging from the false ceiling of the Central control room
- b) Number of Unit DCS alarm and LVS alarm will be decided during detailed engineering stage.
- c) For the BOPs & Coal handling system, HW annunciation system shall be driven by Digital output channels or diode auctioning of input signals. For other relay based control systems, stand alone solid-state annunciation system shall be provided.

1.2.0 Scope of Supply

Requirement of annunciation system are specified on a system basis. Bidder shall be fully responsible for engineering and furnishing a fully operational system complete in all respects meeting the intent and requirements of this specification. All equipment and accessories required for completeness of the system shall be furnished by the bidder within the quoted price, whether these are specifically mentioned herein or not.

Annunciation system offered shall be from reputed, experienced manufacturer of specified type and range of equipment whose trouble free performance has been proven at least for two years in not less than two pulverized coal fired utility power stations of reheat type. The evidence regarding experience shall be furnished.

The annunciator components shall be designed for 50 deg.C ambient temperature and 90 percent highest average monthly humidity.

The windows shall be in multiple groups as required. The arrangement on the panels will be decided and advised when panel layouts are finalised. Each window shall be 50 mm high and 75 mm wide and shall be provided with sixteen high intensity LEDs wired in parallel, and capable of replacement from the front. The life expectancy of these LEDs shall be minimum of 100,000 hours.



Sets of push buttons, namely, Silence 'Acknowledge', 'Reset', System Test and Lamp Test shall be provided for Annunciation system on control panel/control desk/UCP/BUP. In addition, set of Annunciation PBs shall also be provided on Operator control desk in parallel to Annunciation PBs provided on Unit control panel/desk.

The system shall be so designed that during the lamp test, the existing fault annunciation is automatically disconnected from the lamp test circuit. Also any additional fault occurring during the lamp test shall automatically be isolated from the lamp test circuit & annunciated in the normal way.

In the case of group annunciation windows, the group alarm shall be annunciated every time any of the inputs associated with the group go into alarm status. Facility shall exist in the system to specifically identify the particular input in alarm state within the group.

A separate annunciation shall be provided on each panel to indicate mains supply failure for which 220V DC feeder shall be provided by bidder.

Integral Audio Visual Annunciation System with facia windows (approx. 60 nos. (min.) for each package having high intensity 16 nos. LED shall be provided in backup control desk for the BOP Packages as covered in Clause 1.0.0 of Section 4.2

The system shall be designed for bidding purposes that up to 30% of the windows will be group alarms with each group consisting of about four (4) inputs. Input sizing and provision of group alarm modules with retransmission facility shall be affected in line.

1.3.0 Annunciation Sequence

The sequence of annunciation for main control panels shall be as follows:-

Sl. No.	Condition	Visual	Audible
1	Normal	OFF	OFF
2	Alarm	Fast Flash	ON
3	Silence PB actuated	Fast Flash	OFF
4	Return to normal		
	a) before acknowledge	Slow Flash	ON(different tone)
	b) after acknowledge	Slow Flash	ON(different tone)
5	Alarm Acknowledge		
	i) before return to Steady normal	OFF ON	
	ii) after return to Slow normal	ON Flash	(different tone)
6	Return to abnormal (alarm)	Fast Flash	ON



7	Reset	OFF	OFF
8	System test	Fast Full Operational Sequence	
9	Lamp test	ON	

Note : Pitch and volume of the tone generators for the audible alarms shall be adjustable. Three sets of hooters buzzers, beacon lamps etc shall also be provided above control panel sections. Each audible device shall be driven by separate tone generator. Hooters and Buzzers provided on the panel shall be electronic with adjustable volume and pitch control. Operator interface push button stations shall be provided in appropriate sets on panels as per functional groupings desired. Push button stations shall also be provided in Operator interface.

Annunciation system shall be designed to ensure during LED / System test, existing fault annunciation is automatically excluded from test program with latching of status at card level. Once test command is removed, the system should display once again the faults annunciations.

LED box assemblies:

LED boxes shall have removable impact polystyrene windows of snap ON type. Inscriptions shall be black lettering on white background/film inserts with character height of typically 5 mm with 16 characters per line and 4 lines per window. LED illumination shall ensure clear readability.

1.4.0 Stand Alone Annunciation System

Stand alone Visual Alarm Annunciation System shall consists of requisite Buffer Terminal Cabinets, Input sharing networks, Remote annunciator logic cabinets with logic cards, power supplies in completely redundant mode, panel mounted lamp box assemblies, set of operator interface devices such as push buttons, audible devices, prefabricated FRLS interconnecting cables with connectors for signal transmission from logic cards to lamp windows as per actual length as required.

Panel type logic cabinet/cabinets to be furnished under this specification, shall receive cables from all contacts. Spring loaded type termination shall be provided for each contact input. This cabinet shall also contain the input logic cards and all other logic cards. The necessary contact interrogation and contact bounce filtering to provide a delay of 15 milli seconds shall also be provided. Modular construction shall be employed. All printed circuit boards shall be of epoxy fiber glass construction. All contacts shall be gold plated. Solid state CMOS Logic circuits/microprocessor based system shall be furnished for all windows.

The driver circuits for LEDs shall be provided with current limiting features and regulate current to LEDs and shall protect against short circuits in the LED circuit. Spurious alarms shall not be generated when system is switched ON.

The logic cards shall be provided with optical isolation feature for all input signals. Solid State Logic circuits shall be capable of meeting surge withstand capability in accordance with ANSI C37.90a or IEEE Standard 472-1974. The logic cabinet shall be constructed of 3 mm MS sheet. Cable entry shall be from the bottom. The logic cabinet shall be provided with anti-vibration mounting. 20% spare completely wired in slots with all internal and external cabling shall be furnished. The system shall require adding of additional logic cards only for these spare capacity to be implemented. To utilise this expansion capacity, prefab cables with requisite connectors to windows shall also be furnished as part of the system.



Each window or a group of windows shall be provided with Solid State CMOS Logic Cards, which shall be mounted separately in cabinets. Jumper switch shall be provided on each card so as to make it suitable for contacts that either open or close.

The flash frequencies among annunciation windows distributed in various panel sections shall be highly regulated to offer uniform flashing rate throughout the control room. The flasher module for this function shall also be uniformly distributed within the logic cabinet to approximate the finally decided window distribution in control panel sections. Generally not more than 30 points are expected to be hooked up to one flasher module.

The Buffer terminal cabinet with their auctioneering diodes shall receive field inputs on rows of terminals. The diode matrix shall be mounted on plug in type printed circuit boards and shall offer clear isolation of input status signals to annunciation system & other control system. The Diode matrix card shall be designed for a maximum of eight inputs per card.

Multipin sockets for the prefabricated plug in cables and the terminal block shall be interconnected through Diode matrix by cabinet internal wiring. Prefabricated plug in cables with connectors shall be furnished for interconnection of signals from Buffer cabinets to Visual Annunciation System cabinets, Control system. Signals used for HW Annunciation shall not be multiplied/ diode auctioneered, it shall be thru control system's digital output only.

1.5.0 Terminals and Wiring

Separate terminal blocks with twenty (20) percent spare terminals shall be provided for contact input termination and 240V AC supply. Terminals for each point shall be suitable for connecting two (2), size upto 2.5 sq.mm copper, 650 grade PVC insulated, single strand, flexible, single/multicore conductors.

Wiring inside panels shall be of copper, 650V grade PVC insulated, flexible conductor. Both ends of wiring shall have numbered ferrules for identification.

Cables

Prefabricated cables with plug-in connectors for connecting IPR/logic cabinet to annunciator windows (VAS) as well as interconnection among IPR/logic cabinets, shall be supplied and installed by the BIDDER. All the interconnecting cables shall be FRLS type. All terminations on his equipment shall however be executed by the Bidder. Bidder shall clearly specify if any special type of cables (e.g. Screened cables) are required for field connection.

Cable Specification

1. Reference : IS-1968, part-I
2. Insulation : Any polymeric/Elastomeric material conforming to IS-5831/IS-6380

1.6.0 Power Supplies

The cabinet shall be furnished with a system of duplex receptacles fed from the 240 V AC UPS power supply.

The logic and other power supplies requirements shall be derived by the BIDDER internally in the logic cabinets/IPR cabinets.

Redundant solid-state power supplies shall be furnished for the logic levels. Contact interrogation, and lamp drives. The outputs of the supplies shall be short circuit proof and diode auctioneered to ensure continuity of power within the system even with one power supply failure. The system shall also be furnished with "Earth fault" detection and monitoring equipment.



Bidder shall ensure that the interrogation voltage levels for Visual Annunciation System and DAS portion of the Distributed System are matched.

Factory Tests

Annunciation system shall be factory tested under various stages of manufacture and also on full completion with total system with its attendant subsystems fully integrated as per owner approved Quality Assurance Plan. The tests shall include but not limited to the following :

Type tests

1. Enclosure test as per IS-2147
2. Surge withstand capability (SWC) test as per ANSI C37.90a IEEE-472 1974.
3. Damp heat cycling tests as per IS-2106 Part-II-1962 or equivalent international standards.
4. Noise immunity test

Routine test

1. Burn-in power on test
2. Complete operational tests
3. Insulation resistance, high voltage, tests and continuity test of panel and cubicle wiring
4. Short circuit test for current limiting functions.
5. Under voltage/over voltage tests



VOLUME II
SUB-SECTION 4.12
FIELD INSTRUMENTS SPECIFICATION

1.0.0 TECHNICAL REQUIREMENT FOR INSTRUMENTATION

1.1.0 Field Instruments

- a) Analog outputs signals from field instrumentation to the control systems are 4-20 Ma DC signals. Instrumentation can be self-powered, or loop powered from the control systems. Self-powered analog signals shall be true “isolated from ground” signals.
- b) Field switches will be micro switch type with auto reset. Switches will have NO and NC contacts. Switch contacts shall be snap acting, 2 Nos of SPDT, hermetically sealed, potential-free with a minimum contact rating of 230 V AC 5A/ 24V DC 1A.
- c) Transmitters will be used to provide the required 4 to 20Ma signals for all controllers and receivers. Transmitters will be of the electronic, two-wire type, capable of driving an output impedance of 600 ohms minimum at 24 V dc, and will be generally powered from the control system I/O cards. All the transmitters supplied shall be SMART type with HART capability. All the transmitter shall be provided with 5 digit local indicators
- d) SMART transmitters' calibration shall be carried out through a PC based system to be located in the computer room.
- e) Pressure and differential pressure transmitters accuracy shall be within + 0.04% or better of FSR for BTG package, + 0.065% or better of FSR for BOP packages and + 0.2% for remote seal type transmitter. Repeatability shall be +0.05% of span or better. Errors caused by change in ambient temperature shall not exceed 0.01% of span per °C change. Stability 0.15% for five years.
- f) The plant instrument air supply pressure shall be:
 - 1. Maximum supply pressure 7 kg/cm²
 - 2. Minimum supply pressure 4.5 kg/cm²
- g) All instruments and analyzers shall employ EMI, RF protection in the system design.
- h) Instrument tags should be permanently attached to the device. If this is not possible, the instrument tag should be fastened to the instrument with stainless steel wire.
- i) Speed switches and the actual device should drive transducers, if possible.
- j) All instrumentation mounted inside, away from direct exposure to the elements, shall be as a minimum IP-44 construction unless it is in an environmentally controlled environment (e.g the control room). If the instrument is mounted in an environmentally controlled environment the instrument shall be as a minimum IP-32 construction.
- k) All instrumentation mounted outside shall be as a minimum IP-65 construction. IBR certification shall be provided for instruments / valve / Erection hardware wherever applicable.
- l) Vibration switch (alarm, trip) and oil level switch to be provided for the cooling towers.
- m) Transmitters and switches shall be grouped depending on the location. Individual instruments shall be mounted on stanchion or pipe mounted.



- n) For saline applications and other applications which are corrosive in nature, the wetted part material to be selected which shall meet the process applications, preferably diaphragm seal to be used. Hastelloy C wetted part material and SS316L impulse piping / root valve material to be considered for the above applications.
- o) All field instruments junction boxes & local panels located in hazardous area shall be explosion proof as per the relevant applicable standards.
- p) Reverse rotation switches to be provided for High Pressure Boiler Feed pumps, Main condenser cooling Water pumps, Condensate extraction pumps and sea water intake pumps
- q) The following metric engineering units shall be used for all instrumentation devices :
 - 1. Pressure – kg/cm²g
 - 2. Temperature - °C
 - 3. Steam flow – kg/hr / T/hr
 - 4. Liquid flow – m³/hr (Feed Water flow (in kg/hr or T/hr)
 - 5. Distance – meters (m) or millimeters (mm)
 - 6. Differential pressure – mmH₂O
- r) For speed varying pumps/fans, speed measurement in 4 – 20 mA shall be connected to DCS.
- s) Required Water analyzers for ACW pump discharge header mainly FRC (Free residual chlorine) analyzers shall be considered at CW /ACW common header return line.
- t) Wireless transmitters :
For CW sump level, Raw water reservoir level, Turbine oil tank, coal bunkers, Ash Silo, LDO/HFO tank, DM water tanks, CS tank, Acid and alkali applications, only non contact type level transmitters like Ultrasonic or Radar based shall be provided by the bidders as per the specification and as approved by owner.

Considering the type of application, wireless technology to bring signals to DDCMIS may be adopted by interfacing with OPC gateway to avoid cabling from smart level transmitters as specified above. And for other applications, if any shall be decided during Detailed Engineering. However Wireless technology as adopted by Bidder shall be reliable and field proven in power plants and same shall be approved by Owner.

1.1.1 Pressure Instrumentation

- a) Pressure transmitters are electronic, analog 2-wire transmitters with isolated 4-20Ma DC output signals.
- b) Pressure transmitters will be supplied with integral mounted two valve manifolds.
- c) All pressure transmitters shall be capable of withstanding their body rating conditions without permanent damage or loss of calibration.
- d) Differential pressure transmitters of the capacitance type, regardless of the applied service, shall be capable of withstanding a differential pressure equal to full process



pressure on either side of the measurement element without damage or loss of calibration.

- e) Differential pressure transmitters will be supplied with integral mounted three valve manifolds for air service and 5 way valve manifold for steam & water service. For pressure and differential pressure transmitters, overall Accuracy: + 0.04% or better of FSR for BTG package & + 0.065% or better of FSR for BOP packages. Accuracy shall be + 0.2% for remote seal type transmitter.
- f) Pressure gauges will be generally 150mm dial, solid front safety case type with blowout back, 1/2" NPT bottom connection, drawn stainless steel case, 316SS bourdon and socket, stainless steel movement, micrometer pointer. Pulsation dampers will be provided for pulsating pressure services. Liquid filled gauges shall be used for all pump discharges, vibrating or pulsating services. Pigtail ressu shall be used for the steam service where gauges are mounted close to the tap.
- g) Pressure switches will generally be snap acting type, DPDT action, with individual "on" and "off" points to be on a calibrated scale or dial. Pressure switches will have amphoral connection. Repeatability shall be +/- 0.5% or better. Pressure sensor shall be 316 SS with over range protection. Die cast aluminum with stored enamel black finish and epoxy coating for corrosive atmosphere.
- h) Dual type control switches such as pressure switches having two sets of contacts with independently adjustable set points shall not be used where set point adjustment and deadband are a problem (e.g. low pressure and vacuum applications). If a potential problem exists, two single purpose switches shall be used. Switch differential shall be adjustable.
- i) The indicating type switches are not acceptable. If application requires indication and switching function, then a separate blind switch and a gauge to be used.
- j) All the switches are internally connected and brought to the surface with Amphenol male/female connection. Cabling need not be terminated inside the switch. Cable ends are to be soldered in connector and to be inserted for easy maintenance.
- k) Condensate pots for pressure transmitters and siphons for gauges shall be used for steam and high temperature applications. Chemical seals to be used for highly corrosive and viscosity applications
- l) The switches shall have the following:

Contact rating	:	230V AC, 5A / 24V DC 1A.
Repeatability	:	±0.5% FSR
- m) Turn down ratio to be 100:1
- n) Response time for pressure and differential pressure transmitter shall be 100 ms.
- o) Protection for gauges fitted in the vibration lines/equipments shall be provided

1.1.2 Temperature Instrumentation

- a) For temperature up to 300°C 3-wire RTD duplex type, PT 100 type shall be used. For temperature beyond 300°C thermocouples shall be used. Thermocouples shall be manufactured in accordance with the ISA Standard MC96.1, Temperature Measurement Thermocouples. All thermocouples shall be Chromel Alumel (Type K) for $300^{\circ}\text{C} \leq T < 850^{\circ}\text{C}$. R or S type for $T > 850^{\circ}\text{C}$.



- b) The Mv signal of thermocouple shall be used as input to the DCS. Cold junction compensation shall be achieved in the DCS
- c) Thermocouples shall have duplex elements and ungrounded measuring junction.
- d) An extension nipple / union / nipple of sufficient length to extend beyond lagging and connection head shall be furnished for each thermocouple assembly. Terminal blocks shall be marked with polarity and connectors shall be resistant to heat, vibration and galling. The cap shall provide a weather tight enclosure and a chain shall be provided to prevent loss of cap. The cap shall be made of cast aluminium.
- e) RTDs of Duplex type furnished by the Supplier shall be of the three-wire type made with 100 ohm platinum resistance elements. They shall be certified to meet the requirements of the International Temperature Scale, calibrated to the IEC-751 standard ($\alpha = 0.00385 \text{ Ohms/Ohm/}^\circ\text{C}$). The RTDs shall be contained in an insulated material and a sheath or sleeve of stainless steel SS-316 and shall be so mounted that they can withstand the greatest shocks and vibrations that can be imposed upon them in the system piping without deterioration. Specific information shall be furnished concerning type and accuracy of bridge circuits to be used with the RTDs. RTDs shall be directly connected to DCS without any transmitters
- f) Unless specified otherwise, each temperature element and thermometer shall be provided with a 1" socket weld type, 316 stainless steel tapered thermowell suitable for the requirements of the given application. Temperature element process connection shall be $\frac{1}{2}$ NPTM.
- g) Temperature transmitters of SMART type are to be provided for all temperature measurements that are used in any CLCS. For thermocouple, cold junction compensation shall be implemented within the transmitter.
- h) Thermocouples will be of duplex MI type in ISA, K(chromel-Alumel), Platinum-Rhodium/Platinum with sheath OD 6 mm. RTD will be Duplex, Pt 100 ohm, 3 wire type as per DIN standard 43760 or equivalent. Thermo wells will be ASME PTC 19.3 latest revision with process connection M 33x2 for threaded connection and flanged connection for Air and Gas system & tanks.
- i) Thermowell immersion length will generally be between $\frac{1}{3}$ and $\frac{1}{2}$ the distance to the center of the pipe. Where thermo wells are installed in lines smaller than 4 inches, the piping shall be expanded to 4 inch size to accommodate the thermo well. Thermowell shall be drilled from solid bar stock.
- j) All thermo well in a high velocity line or duct shall have an ASME PTC 19.3 calculation for determination of the wells resonant frequency. Thermo wells that do not meet the acceptance criteria shall be resized or relocated as necessary.
- k) Thermocouple extension wire is to be solid, shielded, twisted pairs.
- l) If intermediate terminal blocks are required in a thermocouple measuring circuit, they need not be the same material as the thermocouple.
- m) Dial thermometers shall be bimetallic, minimum 150mm dial, every angle form, hermetically sealed with external recalibration adjustment, $\frac{1}{4}$ " OD SS stem, $\frac{1}{2}$ " NPT connection and SS case.
- n) Temperature switches shall be actuated by filled bulb-type elements equipped with standard-length armored capillary tubing. All the switches are internally connected and brought to the surface with Amphenol male/female connection.
- o) Temperature gauges shall have $\pm 1\%$ accuracy and overage protection of 125%.



p) Switches shall have the following:

Max. contact rating : 230V AC, 5A
Repeatability : $\pm 0.5\%$ FSR
Contact type : snap acting
Over all accuracy 0.1% of calibrated span

q) Protection for gauges fitted in the vibration lines/equipments shall be provided

r) For measurement of pulverizer outlet temperature, tungsten carbide block thermowell aborium resistant shall be used instead of tungsten carbide coated thermowell. And for sea water titanium sleeve thermowell or better shall be used

s) Switch differential shall be adjustable. Fan DE/NDE, motor DE/NDE temperature are to be fitted with capillary type dial thermometers with standard length.

1.1.3 Flow Instrumentation

a) Flow nozzles will be used for main steam flow, feed-water flow and other critical measurements where weld-in construction is required. Orifice plates will be used for other liquid flow measurements where flanged construction is acceptable. Accuracy of the measuring orifice plates, nozzles and annubar shall be minimum $\pm 1\%$. Ultrasonic type flow meter shall be used for cooling water flow application with an accuracy of minimum $\pm 0.4\%$ of measured flow or better and haste alloy C wetted part material to be used if insertion type is provided.

b) Flow elements will be accompanied by IBR certification.

c) Flow nozzles and orifice plates shall conform to requirements of ASME "Fluid Meters".

d) Flow nozzles shall be of the weld-in holding ring type ASME long radius, with dual wall taps and shall be of stainless steel. Flow nozzles shall be furnished complete with metered runs in accordance with ASME PTC 6.1. Metered pipe run and nozzle shall match the pipe material and size that metered section is to be installed in.

e) Orifice plates shall be 316SS, sharp square edge thin plate, and paddle type suitable for installation between raised face orifice flanges. Orifice flanges, gaskets and jacketing screws shall be furnished by the Supplier. Paddle shall be stamped with the orifice ID bore diameter on the upstream side. Orifice flanges will be of the raised face, weld-neck type with dual 2 sets of taps as required for redundancy.

f) Beta ratios shall be between 0.3 and 0.7. Flow elements (flow nozzle & orifice) sizing shall as per BS-1042/ISO-5167.

g) Differential type flow transmitters shall be supplied with three valve manifolds directly mounted to the transmitter for gas applications and five valve manifolds directly mounted to the transmitter for steam and liquid applications

h) Differential type flow transmitters shall be electronic, analog 2-wire transmitters with isolated 4-20 Ma dc output signals.

i) Square root extraction of the flow signal is performed in the DCS.

j) The flow sight glass shall be of rotary type with tempered glass, carbon steel body and bronze wetted parts.



- k) Variable area flow indicators to be provided at the common outlet header of the identical equipment, CW blow-down etc. Carbon steel body with SS 316 float and scale shall be provided. Accuracy shall be minimum $\pm 1\%$.
- l) Flow switches to be provided at the common outlet header of the identical equipment. Carbon steel body with SS 316 element and contacts shall be provided.
- m) Algebraic summation of steam flow and water flow shall be mass balanced for calculating the system efficiency by providing necessary required flow transmitters and process lines
- n) Accuracy for mass flow shall be 0.15% of measured value for liquid.
- o) Accuracy for Vortex flow meter and turbine flow meter shall be 0.5% of full scale range.

1.1.4 Level Instrumentation

- a) Differential pressure type level transmitters are electronic, analog 2-wire transmitters with isolated 4-20 Ma dc output signals. Radar and ultrasonic level transmitters will be 24V DC powered, with isolated 4-20 Ma dc output signals powered from the transmitters.
- b) Constant head chambers shall be furnished for all differential pressure-type level transmitters used with pressurized vessels. Reservoir piping connections shall be $\frac{1}{2}$ inch outlet and a $\frac{1}{2}$ inch inlet socket-welded type suitable for the pressure and temperature encountered.
- c) Transparent gauge glasses will be used for low-pressure applications. Transparent or reflex gauges will be used for high-pressure applications. All gauge glasses will be equipped with gauge valves, including a safety ball check.
- d) Level switches shall generally be cage float / Displacer type, rated for ANSI B31.1 requirements.
- e) Non contact type level measurement shall be provided for CW sumps and for CW make-up applications.
- f) Electronic level indicator of discrete type based on electric conductivity of water and steam with 50mm gap between successive electrodes in the measuring range shall be provided in addition to level transmitter. The **vessel** holding electrodes **shall be IBR certified**.

1.1.5 Control Valves

- a) Control Valves are defined as Pneumatic operated modulating valves.
- b) Control valves for regulating service will be pneumatically operated and provided with characterized plugs. In general, equal percentage characteristics will be provided for throttling service; linear characteristics for pressure reducing applications and quick opening characteristics for On/Off service.
- c) Control valves will be designed to prevent cavitation, flashing on the downstream side of valve or piping. For cavitation /flashing services, valves with anti-cavitation trims will be provided. Hardened trim material shall be provided for control valves subjected to DP > 7 Kg/cm² and for flashing applications 17 – 4 PH material is recommended.



- d) The control valves will be of straight through globe body double port balanced type or of Angle body except for large cooling water lines.
- e) Instrument air shutoff valve shall be provided on each control valve assembly.
- f) The following end connections shall be used when weld type connections are specified in the piping line specification :
 - g) Socket weld end connections : 2 inch and under control valve bodies.
 - h) Butt weld end connection : 2-1/2 inch and over control valve bodies.
- i) Valve bodies shall be Globe, single – port unless otherwise required and shall be not more than two nominal sizes smaller than the line in which they are installed.
- j) Valve body material shall be as specified in the piping line specifications.
- k) All integrally mounted instrumentation (controllers, positioners, regulators, etc.) to be designed for a maximum instrument air supply pressure of 7kg/cm²g. Minimum instrument air supply pressure is 4.5kg/cm²g. Separate air filter regulators with inlet and outlet gauges shall be provided for each control valve.
- l) SMART positioners with HART compatibility shall be provided for all the control valves.
- m) Necessary diagnostics software along with SMART positioners shall be provided.
- n) Color of the control valve shall be identified based on the fail safe position of the valve.
- o) All the control valve shall be provided with block and bypass valves. The bypass valves shall be automatic inching valve for critical applications only.
- p) It is the intent that the valves shall fail either open or closed or fail lock in the event of failure of air signal or electric signal from any valve component (controller or positioner), as well as failure of the main control air supply or voltage to the solenoid.
- q) Position transmitters of non-contact, 2-wire 4-20Ma DC type shall be provided for modulating control valves. Also in general limit switches shall be provided for control valves wherever applicable.
- r) Pilot solenoid valves for on-off service control valves are to be designed for 24 Vdc with a minimum orifice size of ¼ inch. Limit switches (open and close) to be provided for all on-off valves.
- s) Instrument tubing is to be stainless steel, in accordance with the tubing line specifications. Minimum tubing size is ¼ inch, SS-316.
- t) Control valve limit switches to be designed to operate at 24 VDC.
- u) The control valves shall generally have the max. flow handling capacity of 120% and the limit of valve travel shall generally be between 10% and 80%. The trim characteristics shall be so selected that the control valve is operated in the controlled flow range of 20 – 75 %.
- v) The following shall be specified for control valves.

Max. noise – 85 Dba from 1m. distance from the equipment.

The max. permissible outlet velocity shall be as per ISA-S75.01 based on service (liquid, steam or flashing services). The control valve sizing shall be as per ANSI / ISA: S75.01.



Leakage class will be class V as per ANSI FCI 70.2 or better.

For fuel gas applications the valve leakage class shall be minimum class VI.

1.1.6 PH Measurement

- a) Micro processor based system supporting HART Protocol with system accuracy of ± 0.02 Ph, auto span and zero calibration, manual zero and span calibration, integral indicator, automatic ultrasonic cleaner, iso-potential adjustment having flow type cells.
- b) Output shall be isolated 4-20 Ma DC linear signal. Accessories shall include preamplifier, screened junction box for electrode.
- c) The Ph shall have built-in reference chambers.
- d) Stability: $\pm 0.02\%$ pH per week
- e) Repeatability: $\pm 0.02\%$ pH
- f) Self diagnostics feature shall be available.
- g) For Ph measurement, reference calomel / silver, silver-chloride electrode shall be of rugged and sealed construction moulded in glass coupled polypropylene. Electrical connection shall be made directly on to the outer end of the element ensuring better electrical performance of the electrode.
- h) Annunciation contacts from the electronic module shall be high and low, 2 SPDT, snap action micro switch, ratings of 5A 240V AC, 0.2 A, 220V DC.

Wherever, variations in sample temperature may occur, automatic temperature compensation device shall be provided.

1.1.7 Conductivity Measurement

- a) Micro-processor based system supporting HART protocol with an accuracy of $\pm 0.25\%$, auto zero and span calibration, integral indicator having flow line (screwed) type cell. Housing for cell and analyzer shall be weather and water proof. Output shall be isolated 4-20 Ma DC linear signal.
- b) The conductivity sensors shall have built-in reference chambers.
- c) The conductivity cell shall in general be of flow through type or insertion type depending upon the area of application.
- d) Conductivity transmitter shall have local indication and provision for automatic temperature compensation up to 100 deg. C.
- e) Condenser cooling water conductivity to be remotely monitored for the blow-down purpose.
- f) Stability: $\pm 1\%$ of full scale per month non cumulative
- g) Repeatability: $\pm 0.3\%$ of span.
- h) Conductivity comparator with dual cell input and 4 – 20 mA DC isolated with HART outputs for required parameters. Self diagnostics feature shall be available

**1.1.8 Silica Measurement**

- a) Micro-processor based system with an accuracy of $\pm 1\%$ of span or 2ppb whichever is minimum, response time better than 10 min for 90% change, six numbers of sample streams having features like auto zero & span calibration with manual provision also, ambient temperature compensation and integral indicator.
- b) Self diagnostic features shall include alarm for no reagent, calibration fault and silica concentration low/high. Analyzer housing shall be weather and water proof. Output shall be isolated 4-20 Ma DC linear signal.
- c) 3 channel instrument is preferred. Auto sampling facility with necessary valves & solenoids in the sample lines shall be provided
- d) All chemical reagents for twelve months of operation of analyser shall be supplied with addition to commissioning requirement.
- e) One cycle time shall be maximum of twelve minutes.

Liquid handling unit comprising of valves, manifolds, tanks (if required), power supply unit, pressure reducer etc.

1.1.9 DO₂ (Dissolved Oxygen) Measurement

- a) The dissolved oxygen analyzer shall be of continuous flow through solid State/micro-processor based system based on electro-chemical type with an accuracy of $\pm 1\%$ of span or 1ppb whichever is minimum, response time better than 15s for 90% change, ambient temperature compensation and integral indicator.
- b) Self diagnostic features shall include alarm for transmitter fault, no reagent, calibration fault, high cell current as a minimum. Analyzer housing shall be weather and water proof. Output shall be isolated 4-20 Ma DC linear signal.
- c) Annunciation contacts from the electronic module shall be high and low, 2 SPDT, snap action micro switch, ratios of 5A 240V AC, 0.2 A, 220V DC.

The field mounted cabinets for DO₂ analyzer system shall have the following:

- a) Auto zeroing and calibration facility
- b) Manual overriding
- c) Liquid handling unit comprising of valves, manifolds, thermometers, power supply unit, pressure reducer etc.

1.1.10 Phosphate Measurement

- a) Micro-processor based system with an accuracy of $\pm 4\%$ of span or 2ppb whichever is minimum, response time better than 3 min for 90% change, six numbers of sample streams having features like auto zero & span calibration with manual provision also, ambient temperature compensation and integral indicator.
- b) Self diagnostic features shall include alarm for no reagent, calibration fault and silica concentration low/high. Analyzer housing shall be weather and water proof. Output shall be isolated 4-20 Ma DC linear signal.
- c) All chemical reagents for twelve months of operation of analyser shall be supplied with addition to commissioning requirement.



Liquid handling unit comprising of valves, manifolds, tanks (if required), power supply unit, pressure reducer etc

1.1.11 Hydrazine Measurement

- a) The hydrazine analyzer shall work on amperometric method through Micro-processor based system with an accuracy of $\pm 4\%$ of span or better, response time better than 120 sec for 90% change, ambient temperature compensation and integral indicator.
- b) Self diagnostic features shall include alarm for transmitter fault, no reagent, calibration fault as a minimum. Analyzer housing shall be weather and water proof. Output shall be isolated 4-20 Ma DC linear signal.
- c) All chemical reagents for twelve months of operation of analyser shall be supplied with addition to commissioning requirement

The field mounted cabinets for hydrazine analyzer system shall have the following:

- a) Auto zeroing and calibration facility
- b) Manual overriding
- c) Liquid handling unit comprising of valves, manifolds, thermometers, power supply unit, pressure reducer etc.

1.1.12 Sodium Measurement

- a) The sodium analyzer shall work on potentiometric method through Micro-processor based system with an accuracy of $\pm 5\%$ of span or better, response time better than 120 sec, ambient temperature compensation and integral indicator.
- b) Self diagnostic features shall include alarm for transmitter fault, no reagent, calibration fault as a minimum. Analyzer housing shall be weather and water proof. Output shall be isolated 4-20 Ma DC linear signal.
- c) All chemical reagents for twelve months of operation of analyser shall be supplied with addition to commissioning requirement

The field mounted cabinets for sodium analyzer system shall have the following:

- a) Auto zeroing and calibration facility
- b) Manual overriding
- c) Liquid handling unit comprising of valves, manifolds, thermometers, power supply unit, pressure reducer etc.

1.1.13 Chlorine Analyzer

The chlorine analyzer shall be Micro processor based and the analyser shall be continuous flow through type with accuracy of minimum $\pm 1\%$ of span with automatic temperature compensation.

Self diagnostic features shall include alarm for transmitter fault, no reagent, calibration fault as a minimum. Analyzer housing shall be weather and water proof. Output shall be isolated 4-20 Ma DC linear signal.

The field mounted cabinets for Chlorine analyzer system shall have the following:

- a) Auto zeroing and calibration facility



- b) Manual overriding
- c) Liquid handling unit comprising of valves, manifolds, thermometers, power supply unit, pressure reducer etc.

1.1.14 Turbidity Analyzer

Turbidity analyzers shall be continuous type with accuracy of $\pm 2\%$ of reading or ± 0.2 NTU whichever is better, response time of 2 sec of full scale. Operating principle shall be alternating light source and self cleaning facility shall be available.

The analyzer shall also include features such as auto temperature compensation, auto calibration, zero check and self cleaning system for electrode. The analyzer shall be provided with integral indicator. Housing for analyzer shall be waterproof with IP65 protection. Output shall be isolated 4-20 mA DC linear signal. Fault diagnosis data shall include faults in analog/digital circuits, contamination detection on optical window, failure of cleaning system, calibration fault and power supply failure.

1.1.15 H₂ Gas Analyser (Microprocessor based):

H₂ Gas analysers shall be provided with the following features

Type	: Conductivity type or multimode oscillation type
Case Purity shall	: 0 to 100% H ₂ in Air.
Purge	: 0 to 100% H ₂ in CO ₂ 0 to 100% air in CO ₂
Hydrogen Flow rate	: 100 to 700 CC/min.
Output Signal	: 4-20 m Amp.
Display	: Digital with Gas Purity in real time.
Power Supply	: (90-250) V, 50 Hz, 1 Phase
Sample gas flow control	: Required
Reference gas flow	: Required
Reference gas pressure regulator	: Required
Cell response	: 95% of change in 30 Sec.(Appox.)
Accuracy	: 2% of full scale
Repeatability	: 1% of full scale
Local Indicator	: Indicating meter of 1% accuracy
Alarm facility	: Dual (High & Low) independently adjustable.
Contact rating	: 0.5A at 220 V AC
Accessories	: As required i.e Flow meter, flow control valve , pump with complete software.
Hazardous duty Version	: FM Standards.

Calibration gas cylinders and installation accessories such as tubings and fittings for connecting calibration gas cylinders and auto calibration units.

Cylinder ownership certificates, pressure test and explosion proof certificates to be given for refilling the gases by owner for future calibration.



1.1.16 Vortex flow meter

Transmitter type shall be capacitance / piezoelectric , microprocessor based electronics. Reynolds's no. shall be at least 20000 and minimum flow velocity shall be as specified by the manufacturer. For gas/air application, the bluff body shall be in horizontal position to avoid condensate and for liquids in vertical lines the flow shall be upwards to keep the line full. A location with minimum pipe vibration shall be selected. The pipe shall be supported at both ends, as necessary. If pressure and temperature compensation are required for gas/air flow application, the pressure tapping shall be placed as close as possible to upstream of flow meter. The temperature tapping point shall be located at least 5D on the down stream of the flow meter. Straight length requirement shall be as specified by manufacturer. If meter is smaller than the line size, concentric pipe reducers shall be used. Eccentric reducers shall not be used as they disturb the flow profile.

1.1.17 Solenoid Valves

On line two (2) way solenoid valves shall be provided, where process line of less than 2 inch with low pressure & temperature application is involved.

Three (3) way solenoid valves shall be provided commonly, where the pressure is admitted or exhausted from a diaphragm valve or single acting cylinder.

Four (4) way solenoid valve shall be provided for operating double acting cylinders. If applicable.

Dual coil Solenoid valves shall be supplied for equipment trips and single coil for balance.

Body material of bronze, plug material of SS316 shall be provided with a leakage class of class IV.

All single coil solenoids shall be of continuous duty operating on 24V DC, 230 V AC and insulation class shall be H.

Double coil solenoid valve shall be provided for BMS services..For operation of the fuel oil corner nozzle valves, fuel oil trip valves etc., double coil solenoid valve (latch coil & relatch coil) shall be adopted.

Single coil usage requires always power and loss of power leads to closure of above valves resulting the unit trip or loss of generation.

On collection of water in the drains of instrument air lines, mechanical automatic drains and periodically solenoid operated drains (with electronic timer - 15m, 30m, 60m and 2 Hours & Timing adjustable) are to be provided.

For mechanical type & Electrical type, the locations to be provided in the instrument air lines of boiler area, Chimney area, turbine area etc., and same shall be decided during detailed Engineering.

For mechanical type & Electrical type, the locations to be provided in the instrument air lines of boiler area, Chimney area, turbine area etc., and same shall be decided during detailed Engineering.

Individual Moisture separator in the instrument air lines for vital final control elements or oxygen analysers shall be provided to enhance the cell life of oxygen probe or continuous operation of final control elements. The numbers and locations shall be finalized during the detailed engineering.

**1.1.18 Position Transmitters / Positioners**

Position Transmitters shall be provided for all motorized inching valves and control valves. Position transmitters shall be 24 VDC, 2 wire, system. SMART Positioners with HART communication shall be provided for all pneumatically operated control valves, power cylinders etc., for converting controller output of 4-20 Ma to 3-15 PSI (0.2 -1 kg/cm²) for interfacing with pneumatic actuators. Separate moisture separator unit for ensuring dryness of air entering Positioners/ E/P converters as well as the power cylinder is to be supplied. The I to P converters shall retain the pneumatic signal (last value) even in failure of control signal and shall have self volume boosters. The Positioners/ E/P converters shall retain the pneumatic signal (last value) even in failure of control signal and shall have self volume boosters.

1.1.19 I/P Converter

Two wire type I/P convertors with an accuracy of +0.25% accepting 4-20 mA dc signals from control system and converting to 0.2 to 1 kg/cm² air pressure to operate valve positioner of all final control elements; Housed in cast aluminum casing (with polyurethane paint); NEMA 4 or equivalent degree of protection for enclosure. Material of accessories will be SS. I/P convertors shall have fail freeze (stay put) feature also. Process connection shall be 1/4" NPT (F) and Electrical connection shall be 1/2" NPT (F). Zero/span adjustment facility shall be provided. The I to P converters shall retain the pneumatic signal (last value) even in failure of control signal and shall have self volume boosters. Necessary air lock devices and pressure switches for air pressure low alarming shall be provided.

1.1.20 Air Filter Regulators

Air filter regulator along with gauges shall be provided in each of the

- a) Air supply line to valve positioners /power cylinders
- b) Air supply line to electric to pneumatic converters
- c) Air supply line to pneumatic interlocked block valves

1.2.0 Vibration Monitoring and Analysis System (VMAS)**1.2.1 General**

The vibration monitoring and analysis system shall provide critical analysis of health of rotating machines on continuous on-line basis and shall guide the plant maintenance personnel regarding the nature of fault and the maintenance action required.

The analysis system shall acquire both the vibration and process information from the data acquisition software plus programmed rules to provide clear analysis and recommendations for effective machinery management. It shall be an extensive and accurate knowledge base to enable quick determination of the condition of a machine by providing alarm notification or advisory of the machinery malfunction.

The analysis system shall be able to specifically evaluate the available data while checking for the presence of the most frequently occurring machine mal functions such as

- a) High synchronous vibration
- b) Shaft bow
- c) Fluid induced instability (WHIRL and WHIP)
- d) Radiant pre-load force(Including mis alignment)
- e) Vector change
- f) Rotor hub
- g) Loss rotating parts
- h) Compressor surge
- i) Electric motor non-uniform air gap
- j) Gear mesh problems pump cavitations



1.2.2 Design and Functional Requirement

Unit Vibration monitoring & analysis system for each unit and Vibration monitoring system of BOP systems shall be provided.

Vibration monitoring system of BOP systems shall be interfaced with the Unit Vibration monitoring & analysis system

The vibration monitoring and analysis system shall provide condition monitoring and analysis of the bearings of all critical machines, equipments with HT drives and their driven equipment. Vibration monitoring & analysis system shall be in accordance with API 670 standard.

The vibration monitoring system shall be complete with proximity type vibration sensors, signal conditioning cards, amplifiers, special cables, vibration monitor (if required) etc. together with all necessary equipment and accessories.

Vibration sensors shall be provided for measurement in both X (horizontal) and Y (vertical) axis at 90° angle to each other for each bearing. Sensitivity of the pick-up shall be minimum 15 mv/mm/s. All outdoor mounted vibration pick-ups, amplifiers, junction boxes and other equipments shall be provided with IP-65 protection class.

For bearings of high speed machines (≥ 1500 rpm) accelerometer type sensor and or low speed machines (< 1500 rpm) velocity type sensor shall be provided. Necessary, one or two stage integrators for obtaining vibration measurement in terms of displacement shall be provided in the system.

Vibration monitoring system shall provide the vibration measurement in the form of 4-20 Ma DC signals to be directly connected by hardwired cable to plant DCS for monitoring. Limit value generation (soft) for alarm and protection applications for the auxiliaries and their drive equipment shall be carried out in DCS/PLC.

Vibration monitoring and analysis system shall be an independent microprocessor based system (PC based). The system shall be interfaced with the plant DCS through redundant communication link. The system shall interface with plant DCS for any process signals which may be required to perform condition monitoring functions through soft link.

All the turbine supervisory vibration parameters of TG & TD BFP shall also be fed to VMAS for analysis.

1.2.3 VMAS Hardware/ Software/ Interfacing Requirement

Vibration analysis system for each unit & one Common VMAS shall include all hardware and software as required for proper functioning of the system including but not limited to the following:

- a) One (1) no Server with necessary Engineering Station & 24" Video Display unit for configuring the VMS modules and for maintenance activities
- b) One (1) no user station (With PC, 24" Video Display Unit, Keyboard/ Mouse and Colour Laser Printer)
- c) Vibration analysis software with all relevant User's license.
- d) One No. lap top PC with condition monitoring/machine management software and data collection from VMAS through necessary interface system cable shall also be supplied.
- e) Server & User PCs operating licenses.
- f) Bulk data storage and retrieval facility
- g) Redundant OPC communication link with all necessary hardware and software.
- h) System cables etc.



The vibration analysis system shall be able to carry out the following tasks:

To determine the exact nature of fault in the rotating machines like misalignment, shaft crack, bearing looseness, dynamic un-balancing of rotor etc. indicating the magnitude of vibration and phase angle information and the corrective action to be undertaken by maintenance personnel. For example, in case of dynamic un-balancing of rotor, the system shall provide the guidance about the approximate mass needed to be added to the rotor with the direction information.

To provide the guidance about predictive maintenance requirement of the machines. Predictive maintenance requirement guide shall also include the "Period of safe operation of machines available at any given point of time".

Shall be capable of collecting data both asynchronously and synchronously (with a Keyphasor signal) and store the data in the original time domain format.

The analysis system shall be able to carry out the following types of analysis to meet the tasks of analysis system detailed above. The system shall not require the intervention of vibration expert to determine the nature of the fault:

On line spectrum/harmonic analysis of the vibration measurements.

The system shall have facility to generate and analyze the following:

- a) Bode Plot
- b) Time wave form
- c) Orbit Analysis
- d) Shaft centerline
- e) Cascade Plot
- f) Water fall
- g) Bar graph
- h) Current values
- i) Spectrum
- j) Alarms – amplitude and spectral
- k) Data collection during start up and coast down
- l) Operating point for pumps and fans

The analysis software should be capable of outputting direct message on video monitor of the exact nature of fault.

The system shall have facility to store bulk data for 5 years duration with facility for retrieval of the same. The system shall have facility to share all the data in the hard disk/ back up media and provide user friendly utilities to retrieve and analyze stored data.

The system shall be provided with redundant UPS power supply. The power supply provision shall be such that on failure of one power supply the other power supply shall cater to the requirement of the equipment so as never to hinder the functioning of the system in any manner due to power supply failure.

Configuration Software:

The monitoring system shall be software configurable using any standard Windows TM 95/98 and Windows TM NT host computer. The configuration software shall provide a list that establishes the Modbus register locations of all data exportable from the monitoring system. The optional display software shall provide displays including Bargraph displays, trend information, machine train diagrams with real-time values of measurements tagged on the diagram, as well as access to the system events and alarm events lists.

**Condition Monitoring/Machinery Management Software:**

The condition monitoring software shall run on the Windows NT platform. It shall be capable of collecting data both asynchronously and synchronously (with a Keyphasor signal) and store the data in the original time domain format. From the stored time domain sample, it shall be possible to reproduce a spectrum in addition to other time domain data formats at any time for review of data saved in historical trend files. To accommodate acquisition of non-protection system monitored parameters, there shall be provision for import of data from other systems, (e.g.) DCS, using either OPC, a serial link using Modbus/DDE protocol. The software shall collect and store data from the monitor racks and communication processors or process information from the digital links connected to it. The software shall allow the display of all collected data from the one or more other data acquisition computers when networked together. The software shall have the capability to take process data directly from DCS and correlate this data with vibration data. The software must integrate with thermodynamic performance management without including another software. The software shall display at least the following plots:

Plot display formats: Must have the ability to select and store transit or steady state data, from stored Alarm Event Data, or from Baseline Data. This must include current data, in which case, the computer requests a sample of the current signal(s) from the associated monitor channel:

Steady state plots:	Transient data (during start-up/shutdown conditions) plots:
Virtual probe rotation	Bode plots for 1X & 2X vectors during startups & coast-downs
Current values	Polar plots for 1X & 2X vectors during start-ups & coast-downs
Alarm event and system event listing	Cascade / Full cascade plots
Bargraph of current values	
Machine train diagrams	
Fast trend	
Trend	
Multivariable trend	
Acceptance region	
Time-base	
Orbit & time base	
Shaft centerline	
Both spectrum and full spectrum	
X versus Y (any variables) plot	
Waterfall / Full waterfall	
Plot orbits & plus Spectrums	
Quick-view	

Alarm data acquisition and storage: Condition Monitoring Software shall provide computerized machinery management with continuous, online data acquisition, archiving, and display capabilities. Static and dynamic data shall be collected, the data acquisition modes can be both automatically and manually initiated, based on alarm conditions, startups/shutdowns, and other events.

Software alarms can be implemented in the software as a proactive maintenance tool, these alarms are usually set below the protection system hardware alarm set points (used for machine shutdowns). The information provided by typical software plot format in form of an "Acceptance Region" information provides a machinery user, a valuable indicator of an impending machine malfunction.



VOLUME II
SUB-SECTION 4.13
STEAM WATER ANALYSIS SYSTEM

SWAS will consist of continuous on-line analysis of steam and water media to establish their purity and suitability for durability of pressure parts. The system shall be generally designed in Accordance to the recommendation of ASME PTC 19.11 Part-II, water & steam in power cycle. The measurement will be carried out at different cycle points of the plant to establish conductivity, Ph, dissolved oxygen, sodium, hydrazine and silica content. The SWAS will include all requisite microprocessor based analyzers. All data will be made available in plant DCS. Continuous monitoring of various parameters using indicator with an isolated analog outputs of 4-20Ma, DC for each parameter shall be provided for monitoring in plant DCS.

Primary cooling of all samples having temperature in excess of 45 deg C shall be provided through an individual sample cooler (primary cooler) of submerged helical coil type of shell and tube design with removable shell, meeting the intent of ASTM D 1192-1977, to bring down the temperature to around 45°C.

A Steam and Water Analysis System (SWAS) Room shall be provided with separate Dry panel room and Wet panel room. The dry panel alone shall be air-conditioned. SWAS shall be complete with sample conditioning and necessary analyzers and indication in dry panel. Chiller unit as required to cool the samples after primary coolers shall also be provided. Primary coolers shall be kept near the sample tap-off point. Adequate exhaust fans shall be provided in wet panel room.

The main analyzers for steam and water shall be arranged in groups in such a way that excessively long process pipes will not be necessary.

All samples shall be adequately cooled and pressure reducing devices shall be provided where necessary. The sample coolers / chillers shall be designed to provide samples to various analyzers at 25°C or at temperatures as required by the analyzers. Wherever necessary two stage cooling/chiller units shall be provided. The sizing calculations for the coolers / chillers shall be submitted for approval during engineering. The Primary coolers shall be located near the sampler tapping points. Each sample cooler shall be protected by a built-in shell relief valve.

IBR certificate is required for the necessary equipments involved in SWAS where ever applicable in SWAS. Two (2) X 100% capacity water cooled cylinders shall be provided.

Include pressure reduction of samples shall be accomplished by means of a variable rod in tube capillary capable of discharging low flow at low pressure in to sample steam as per requirement of analyzers. These pressure reducing elements shall be conveniently located for removal and cleaning.

The sampling system shall be designed to provide samples around 2 Kg/cm² or as required by the analyzers. Necessary pressure reducing valves shall be provided for this purpose. The sizing calculation and selection of these valves shall be subject to approval during engineering. Body material shall be of SS and rating shall suit the process requirement. At the outlet of the pressure reducing valves suitably sized pressure relief valves shall be provided to protect the sample lines in case of failure of pressure reducing valves. The sizing and selection of these pressure relief valves shall be subject to approval during engineering. Body and Internal material shall be of SS of suitable rating as per process requirement. Only in the case of very low pressure and temperatures, transmitters for measurements such as conductivity, Ph, dissolved oxygen, SiO₂ content etc. be installed directly in the pipe. Suitable cartridge type filter with 316 SS body shall be provided on the sample line to remove particulate of size 40 micron and above. The filter element shall be



removable for cleaning. In order to provide samples at a constant flow rate to the analyzers, a constant head chamber (reservoir) shall be envisaged. The chamber shall be of 316 SS with toppings for pressure and temperature gauges. Required gauges shall be provided for monitoring.

A protective device shall be incorporated in the sample cooler to isolate the analyzer in the event of excessive pressure & temperature. For this purpose, Thermal shut off valve and High precision relief valve shall be envisaged. High precision relief valve shall divert the sample to the drain header.

In order to monitor the sample flow rate to individual analyzers, a rotameter type flow indicator with adjustable needle valve is envisaged. The graduations and the needle valve shall be accessible from the front plate of the wet section of SWAS panel. Body material shall be of carbon steel and rating shall be as per process requirement. As a minimum pressure and temperature gauges shall be provided at the sample outlet line of the sample coolers and at the inlet and return line of the cooling water. In addition a flow switch and flow rotameter shall be provided at the inlet of the cooling water line. Pressure and temperature gauges shall be with 150 mm. dials, stainless steel body, socket and movement. Each gauge shall have a dial engraving or separate phenolic nameplate to identify the service.

In order to eliminate the influence of ammonia and hydrazine on the conductivity measurement, cation filters shall be provided. The cation filters shall have visible color indicators to show when they have to be regenerated.

For all analyzers, temperature compensation shall be provided, with the temperature sensor being an integral part of the probe.

For cation conductivity measurements, wherever specified, suitable cation exchange columns shall be provided. Two (2) nos cation exchange columns for each stream shall be provided, one (1) working and one (1) standby. Necessary switching valves for switching to the standby column shall also be provided. The switch over shall be possible from the front of the panel. Also one (1) conductivity cell for each stream shall be provided after the cation exchange column.

The sampling system shall include all probes, valves, filters, coolers, drainage facilities, flow regulators, flow meters, piping and pumps as necessary, to give the analyzer a representative and suitably conditioned sample. Interconnecting pipe work and accessories shall be of stainless steel. The arrangement shall permit testing of the entire assembly before dispatch to site and shall be arranged for convenient removal from on-line operation to facilitate routine maintenance and calibration.

Each automatic analysis sampling point shall be provided with a manual sampling point to permit a sample to be easily taken. Manual sampling shall not interrupt automatic sampling. All sampling lines shall run to common sampling racks on which all the analysis associated equipment shall be fitted.

One teak wood laminated work tables 1x 2 meters, two nos. industrial grade high adjustable wheeled swivel chairs, two vertical cabinets 1000 x 480 x 2000 mm made of sheet steel (18 gauge sheet thickness) and equipped with safety locks, one shelf 200 x 500 x 200 mm with partitions made of steel, operator work station and printer table shall also be provided by bidder. All items shall be placed in SWAS air conditioned room.

Dry Panel

A centralized analyzer room for steam / condensate / feed water sampling will be provided at a suitable location in the ground floor.



The room will house

- a) Dry section (A/C) comprising electronics / transmitters
- b) Wet section (Non A/C) housing different stream processing equipment and measuring cells.

The electronic signal from analyzer section will be hooked up with plant unit DCS through hardwired signals for monitoring. The panel shall be a totally enclosed structure to provide maximum protection against dirt. The Analyzers/ indicators in the Dry panels shall be dual channel type with proper grouping by similar samples for each of pH, conductivity etc.

The analytical panel shall be equipped with adequate internal lighting and AC outlets for ease of maintenance. The lighting shall be initiated by hand switch located conveniently inside the panel door. Thermal protection shall be provided for analyzers on high temperature sample sources.

No instrument shall be mounted less than 700 mm above the panel floor. Wiring between sensors and analyzers shall be made flexible to facilitate removal of the sensor.

The dissolved oxygen and silica analyzers shall be fitted with a replaceable basket micro-filter to reduce fouling from particulate iron. Analyzers shall be flush mounted on the front vertical face of the panel. The panels shall be sheet steel of 2mm thick. The piping material for sample tubing and blow down is SS. Drains and cooling water headers shall be Carbon Steel. Parts subject to wear, corrosion or other deteriorations or requiring adjustments, inspection or repair is readily accessible and capable of convenient removal, when required.

Wet Panel

The field conditioned sample enters the wet panel located in the SWAS room for further conditioning through bulkhead.

Before the sample is further conditioned the samples are filtered to remove particulate with suitable cartridge type filter. The filter element shall be removable for cleaning.

The sample pressure is further reduced to around 2 Kg/cm² or as required by the analyzers. Necessary pressure reducing valves shall be provided for this purpose. The sizing calculation and selection of these valves shall be subject to approval during engineering.

In order to provide samples at a constant flow rate to the analyzers, a constant head chamber (expander) shall be envisaged. The expander shall be provided with tapping points for mounting the pressure, temperature gauges and temperature switch. The sizing of the chamber shall be subject to approval during engineering.

For protection of the secondary cooler, its upstream is provided with a 3 way solenoid valve. In case temperature in expander goes beyond the pre set value the solenoid valve alters the sample path to drain by isolating the sample entering secondary cooler. Direct operated solenoid valves, with shut off class (leakage) VI, body material of bronze, and plunger material of 316 SS rated for continuous duty. IP 65 class for enclosure. Insulation class of 'F' for the solenoid. Body ratings shall suit the pressure and temperature conditions.

Additional cooler (secondary cooler) if required to bring down the sample temperature of 25 °C or to a temperature suitable for the analyzer shall be provided after root cooler. Samples shall be cooled in secondary cooler by chilled water. The secondary cooler shall also be provided with necessary pressure relief valve on shell side connected to blow down for safety purpose, drain plug at the bottom of each cooler and cooler shall be protected with a check valve on the coolant outlet line of the cooler.



Indoor located, coil in shell type sample coolers with counter flow operation shall be provided for secondary cooler.

A backpressure regulator shall be installed on the end of the sampling system to provide maximum flow to analyzer by controlling its back pressure.

In order to monitor the sample flow rate to individual analyzers, a glass tube purge rotameter with built-in regulating valve shall be provided. The graduations and the needle valve shall be accessible from the front plate of the wet section of SWAS panel. Body material and rating shall be process as per process requirement.

Temperature and pressure gauge along with accessories after each cooling and reducing station shall be flush mounted on the sample-conditioning panel or indicated locally. Gauges shall be with 150 mm dial (white dial & black numerals). Temperature gauges shall be generally of Mercury in steel type thermometer and Pressure gauges shall be with stainless steel movement bourdon tubes.

The sample drains shall be run to the plant blow down pit. A blow down connection and suitable blow down valve shall be furnished upstream of each isolating valve. Blow down valves shall be manifolded into a suitable blow down header.

SAMPLE CONDITIONING SYSTEM

A) GENERAL

- i) Sample conditioning system shall be designed and constructed to receive and condition all samples (listed in the enclosed Sample Stream Specification) as required by the respective analyzers connected to the sample streams. This will include all conditioning as specified herein and shall cover the following:
 - Sample filtering
 - Primary and final sample cooling and temperature control
 - Pressure reduction and control as required
 - Flow rate control
 - Other treatment as required by individual analyzers or specified herein.
- ii) The sample conditioning system shall provide samples at 25 °C or a preset temperature required by the analyzer within tolerance of + 1 °C, at a pressure of about 2 kg/cm² and at flow rates as required by individual analyzers/streams.
- iii) Sample line to analyzer elements shall incorporate an anti-syphon design to prevent possibility of running dry because of a broken or plugged sample line.
- iv) Sample conditioning system shall be designed and constructed to fully meet the intent and requirements of this specification.
- v) A backpressure regulator shall be installed on the end of the sampling system to provide maximum flow to analyzer by controlling its back pressure.
- vi) In order to monitor the sample flow rate to individual analyzers, a glass tube purge rotameter with built-in regulating valve shall be provided. The graduations and the needle valve shall be accessible from the front plate of the wet section of SWAS panel. Body material and rating shall be process as per process requirement.
- vii) Temperature and pressure gauge along with accessories after each cooling and reducing station shall be flush mounted on the sample-conditioning panel or indicated locally. Gauges shall be with 150 mm dial (white dial & black numerals). Temperature gauges shall be generally of Mercury in steel type thermometer and Pressure gauges shall be with stainless steel movement bourdon tubes.



- viii) The sample drains shall be run to the plant blow down pit. A blow down connection and suitable blow down valve shall be furnished upstream of each isolating valve. Blow down valves shall be manifolded into a suitable blow down header.

B) SAMPLE FILTERS

Sample particulars removal shall be accomplished by passing all sample through cartridge filters with type sintered 316 stainless steel body. Removable type filter element shall be capable of retaining particles of 40 micron and larger. These elements shall be installed down stream of solenoid operated sample shut off valves at each branch of analyser sample stream.

C) SAMPLE COOLER

All samples having a temperature in excess of 45 Deg.C shall be cooled by use of sample cooler. .

The sample cooler shall use general DMCW as cooling water. This cooling water temperature may vary from 20°C to 40 °C. A maximum cooling water temperature of 40 °C shall be considered for design of sample cooling system. Capacity of cooler shall be adequate to cool the sample within 5 °C of cooling water inlet temperature considering the combined flow of each analyzer connected to sample cooler and one manual grab sample at flow rate of 500 cc per minute assuming adequate flowing factor. Cooler capacity calculations shall be submitted by Bidder.

Provision shall be made for adjusting the temp. of each sample individually at an optimum value.

Sample cooler shall be of Indoor located, submerged Helical coil type of shell and tube design with removable shell. The sample tube shall be of seamless with no welds and other joint inside the cooling jacket. Unions shall be provided to facilitate removal of coils. All sample tubing and fittings, other components shall be constructed of type 316 stainless steel. Cooler design shall conform to requirements of ASTM D1192-64 (Equipment for sampling industrial water and steam). IBR certificate is required wherever applicable. The secondary cooler shall also be provided with necessary pressure relief valve on shell side connected to blow down for safety purpose, drain plug at the bottom of each cooler and cooler shall be protected with a check valve on the coolant outlet line of the cooler

For protection of the secondary cooler, its upstream is provided with a 3 way solenoid valve. Incase temperature in expander goes beyond the pre set value the solenoid valve alters the sample path to drain by isolating the sample entering secondary cooler. Direct operated solenoid valves, with shut off class (leakage) VI, body material of bronze, and plunger material of 316 SS rated for continuous duty. IP 65 class for enclosure. Insulation class of 'F' for the solenoid. Body ratings shall suit the pressure and temperature conditions.

Additional cooler (secondary cooler) if required to bring down the sample temperature of 25°C or to a temperature suitable for the analyzer shall be provided after root cooler. Samples shall be cooled in secondary cooler by chilled water.

In order to provide samples at a constant flow rate to the analyzers, a constant head chamber (expander) shall be envisaged. The expander shall be provided with tapping points for mounting the pressure, temperature gauges and temperature switch. The sizing of the chamber shall be subject to approval during engineering.

**D) ISOTHERMAL BATH**

Provision shall be made for supply of isothermal bath.

In isothermal bath each sample stream shall be finally cooled to the required temperature as specified by the analyzer manufacturer and as approved during engineering within a variation ± 1 Deg. C before passing sample to the respective measuring cells. This shall be accomplished in isothermal bath by counter current heat exchange of each sample against the flow of chilled water at 20 Deg. C. The chilled water for isothermal bath shall be provided by package refrigeration unit (chillers).

Sufficient heat exchanger capacity shall be provided to obtain the required temperature at sample outlet for maximum flow rate required by the analyzers and grab samples requirements considering adequate fouling factor at both ends of the coils. Capacity calculations shall be furnished. Provision shall be made for adjusting each sample temperature individually.

Temperature control shall be provided to maintain the isothermal bath temperature at the required value. The make of isothermal bath shall be sentry or Lowe only.

Temperature control system shall be provided to maintain the isothermal bath temperature at the required value as mentioned below:-

- i. A Temperature control system shall maintain the isothermal bath temperature at $20 \text{ deg C} \pm 1 \text{ deg C}$ and sufficient heat exchanger capacity shall be provided to maintain the temperature of all sample stream at $25 \text{ deg C} \pm 1 \text{ deg C}$ under all operating conditions with adequate margin for future expansion.
- ii. Isothermal bath temperature shall be maintained by a local Temperature controller modulating a three way –mixing valve, which mix the chilled water from the chiller with the recircled water from the isothermal bath.
- iii. The chilled water isothermal bath shall include the following:-
 - Automatic water makeup
 - Bath Temperature Gauge
 - Bath water level Gauge
 - Drain and overflow connection for bath
 - Chilled water Recirculation System
- iv. Temperature Switch shall be provided to annunciate high chilled water Temperature on the Dry panel and in DCS.

E) CHILLER

Two (2) 100% capacity water cooled chillers shall be provided for the SWAS package.

Each chiller unit shall be designed with sufficient refrigeration capacity to ensure each sample stream temperature to $25 \text{ deg. C} \pm 1 \text{ deg. C}$ when all streams are simultaneously at maximum flow rate and maximum temperature. The chiller capacity shall have a provision of 25% spare capacity for future samples.

Suitable temperature monitoring and control systems shall be provided for maintaining the chilled water temperature at chiller outlet at 20 deg. C or at a designed preset value and within the desired band. The compressor shall be readily accessible for service and shall include low noise hermetically sealed motors. Compressor assembly shall also include crank case heaters, suction and



discharge valves, oil sight glasses, forced feed lubrication system and an integrated motor protection system along with the necessary instruments.

The condenser shall be water cooled, cleanable shell and tube with water regulating valve. The cooling water shall be supplied from closed cooling water system.

Chiller shall be of the direct expansion type with refrigerant tubes inside a shell, completely insulated and to be constructed in accordance with the ASME code for unfired pressure vessels.

Refrigerant circuit shall be complete with a thermostatic expansion valve, liquid line solenoid valve, sight glasses, filter-dryer, refrigerant shut-off and charging valves.

The chiller water pump shall be of the centrifugal type, close coupled, bronze fitted construction, complete with motor. Pump & motor shall be designed for continuous operation.

Vibration dampeners shall be mounted between the packaged chiller and the channel base.

Cooling water and chilled water piping shall be provided with block valves.

The Bidder shall provide detailed calculation for chiller capacity and other technical particulars like foundation details/mounting etc. and the same shall be subject to Owner's approval.

The chiller system shall be provided with 100% redundant chilled water pumps with suction and discharge pressure gauges and temperature gauges; Chilled water circulation pump with 100% standby facility; Storage tank automatic water make up with manual by-pass facility, temperature indicator, level gauge and drain and overflow connection, in addition to any other instruments/equipments required for smooth, convenient operation of the system, which shall also be furnished by the Bidder.

The cooling / chilled water header shall be provided with pressure gauge, temperature gauge, flow switch and isolating valves.

Provision shall be made for heat exchanger shell drain which will be connected to drain header.

Potential free contact shall be provided for annunciating loss of cooling/chilled water.

F) SAMPLE PRESSURE CONDITIONING

The pressure reduction of samples shall be accomplished by using high pressure reducing element. All samples after high pressure reducing element shall be provided with back pressure regulating valves. The make shall be sentry or Lowe only.

Each sample line shall include a safety relief valve down stream of the control valve.

For samples with pressure less than 2 kg/cm^2 , suitable field mounted pumps shall be provided by Bidder as part of the sampling system.

**G) HIGH PRESSURE REDUCING ELEMENT**

Pressure reduction of samples above 40 kg / cm^2 shall be accomplished by means of a “variable rod-in-tube capillary” discharging low flow at low pressure into a sample stream as per requirement of all samples / analysers under all operating conditions as per ASME standards. The device shall be designed for inlet pressure of 350 kg/cm^2 . These pressure reducing element shall be conveniently located for removal and cleaning.

H) PRESSURE REGULATING VALVES

The pressure regulating valves shall be furnished for all samples to maintain constant sample flow at a pre-set sample pressure. Variation in sample flow to individual analyzer shall not exceed 5% when total sample flow is increased or decreased due to change in number of individual analyzers utilizing a particular sample. Valve shall be back pressure regulating type.

I) SAMPLE SYSTEM THERMAL SHUTOFF VALVE, TEMPERATURE SWITCHES, PRESSURE GAUGE, FLOW SWITCHES AND FLOW INDICATOR

The temperature gauge shall be 100 mm size, gas filled type thermometer with SS armoured capillary of suitable length required for installation in wet panel. It shall include contacts of adequate current rating. The contacts shall be multiplied by a relay and relay contacts to be used for alarm.

Thermal shut-off valve shall be provided for shut down of high temp. sample and to protect the analysers. The make of thermal shut off valve shall be sentry or Lowe only.

The pressure gauge shall be 100 mm dial size. Sample rate of flow indicator shall be purge type meter with 75 mm scale length, panel mounting bezel and SS float body.

Adequate rotometers for each sample and to evolve the quantity of sample flow is to be provided. Instrument wise sample flow measurement is to be indicated by using individual rotometer.

Flow switches shall be provided on the primary cooling water outlet and on the chilled water outlet. Accuracy/repeatability shall be $\pm 2 \%$. Make & model of flow switches shall be of Owners approved one. Temperature switches shall be provided on the sample lines as indicated in the drawings for SWAS. All switches shall be repeatable within $\pm 1.0\%$ of full scale range.

J) GRAB SAMPLES

Grab sample valves shall be arranged to allow grab sample flow to be directed to either a drain header or through a grab sample nozzles to samples trough. Enough flexible tubing shall be furnished to allow sample collection without splashing.



The following samples shall be provided with necessary SWAS analyzers as a minimum,

List of SWAS Measurements

SL. NO.	STREAM	MEASUREMENTS
1.	Main Steam Outlet	a) Ph b) Specific Conductivity c) Cation Conductivity d) Sodium e) Silica
2.	Separator Outlet Steam at LTSH Inlet	a) Specific Conductivity b) Cation Conductivity c) Hydrazine d) Silica
3.	Reheated Steam	a) Cation Conductivity b) Sodium c) pH (HRH)
4.	Feed Water at Economizer Inlet	a) Ph b) Specific Conductivity c) Cation Conductivity d) Hydrazine e) Silica f) Turbidity g) Dissolved Oxygen h) Chloride
5.	Hotwell	a) Specific conductivity (Insertion type)
6.	CEP Discharge	a) Ph b) Specific Conductivity c) Cation Conductivity d) Sodium e) Dissolved Oxygen
7.	Condensate Polisher Outlet	a) Ph b) Specific Conductivity c) Cation Conductivity d) Sodium e) Dissolved Oxygen f) Silica
8.	Deaerator Outlet	a) Dissolved Oxygen b) Specific conductivity and pH
9.	Makeup Water	a) Specific Conductivity b) Cation Conductivity c) Ph d) Silica
10.	Condenser Cooling Water	a) Ph b) Specific Conductivity c) Chlorine
11	DMCW Discharge common header line (SG & TG)	a) Ph b) Conductivity c) Cation conductivity
12	Drain to condenser from Boiler blow down	a Conductivity



The Bidder shall furnish all analyzers/monitors including sample conditioning components and other devices as specified in the sample stream detail table. The bidder shall furnish all required accessories for completeness of the analyzers furnished by him even though this may not be specifically stated in other clauses of this specification.

The system shall be furnished complete with sample conditioning devices and monitoring instruments (for temperature, pressure, flow & sample), analyzers, transmitters, indicators, alarm initiating devices, interlocks, isolated 4-20 mA DC for plant monitoring system and all required accessories to provide a complete and integrated sampling and analysis system as per the intent and requirements of this specification. Sample line diagrams shall be used to implement the design at system level that shall be subject to Owner approval. All necessary piping, tubing, fittings and valves etc. shall be furnished.

The system shall be designed in accordance with the recommendations in ASME PTC 19.11 Part II, Water and Steam in Power Cycle, ASTM standards - 31 water and ASTM D1066-69 standard method of sampling steam.

**VOLUME II****SUB-SECTION 4.14****ENVIRONMENT MONITORING SYSTEM (EMS)****1.0.0 GENERAL**

Continuous emission monitoring system shall comprise the monitoring of:

1. Flue gas monitoring
2. Stack Emission Monitoring
3. Ambient Air Quality Monitoring
4. Meteorological Monitoring System

2.0.0 FLUE GAS ANALYZERS

2.1.0 To monitor the quality of combustion and to control optimum combustion signals from various flue gas analyzers like Oxygen (Zirconia type), Carbon Monoxide etc. shall be deployed. For detection of air heater air leakage Oxygen Analyzers shall be used. The construction and material of the probe and shield shall be suitable for use in flue gas temperature up to 1600 °C and abrasion due to high ash coal.

2.2.0 Each analyzer to be provided with 2 sets of Calibration gases cylinders for span & zero checking. The cylinder capacity to suite 12 no calibrations.

2.3.0 In general the ranges for Instruments to be around 10 to 15% higher than the recommended alarm settings.

2.4.0 The following Analyzers to be considered per unit on Flue gas path,

Location	TYPE OF ANALYSER	QTY/Path
Air pre heater inlet	CO (Insitu)	3
Economizer outlet (or) Air pre heater inlet	O ₂ (Insitu)	3
Air pre heater outlet	O ₂ (Insitu)	2
ESP Outlet or each ID fan suction	O ₂ (Insitu)	2
Electro static precipitator outlet	PM ₁₀	1
Each ESP flue gas outlet paths	Opacity	1

Location	TYPE OF ANALYSER	QTY
High temperature locations	Heater less O ₂	3

* Location shall be furnished during detail engineering

2.5.0 The following design requirements are foreseen for Flue gas analyzers,

2.6.0 Oxygen Analyzer

O₂ analyzers shall be direct insertion 'insitu' type with an accuracy of $\pm 1.0\%$ of reading or better, repeatability of $\pm 0.5\%$ of full scale, response time of better than 10 sec for 90%, Drift shall not be more than 0.1% O₂ per week, auto and manual calibration having zirconia probe as sensing element, IP 65 or equivalent degree of protection for enclosure. Output shall be isolated 4-20 mA DC linear HART signal. Material for flue gas carrying parts shall be of SS. Protection tube shall be provided to prevent erosion of the probe. Maintenance requirement



shall not be more than once a week. Local indicating meter for read out to be provided. Alarm on abnormalities and self diagnosis features shall be provided. Probe material shall be SS 316. One number of Zero & Span gas cylinders for each oxygen analyzer. Calibration gas cylinders and accessories, reference air set, roto meters etc., shall be provided. To validate the measurement, for mid range value i.e. 6% of O₂ with 94% N₂, standard gas cylinder to be supplied for each analyzer in addition to zero & span gas cylinders. Electronic unit shall be separate not head mounted. Purge air shall be from Instrument air supply and not from individual compressor system.

Moisture separator unit for reference air shall be installed for long life of Zirconia cell. Electronic unit shall be separate from the probe and not be head mounted. Diagnosis facility shall be available and Alarm for failure of heater, sensor voltage, failure of sensor, failure of thermo couple etc., to be initiated and given with necessary alarm contacts. Provision of stainless steel diffuser assembly for the protection of Zirconia cell. Ownership certificate, pressure test certificate, explosion proof certificate for standard gas cylinders shall be given and these will be used for next filling up of standard gases

2.7.0 Carbon Monoxide Analyzer

CO analyzer shall be of infrared absorption technique 'insitu' type system with an accuracy of $\pm 2\%$ of measured value or better, repeatability of $\pm 2\%$ of full scale, response time of better than 5 sec for 90%, Drift shall not be more than 2% per month and having features like auto zero & span calibration, auto temperature compensation etc, IP 65 or equivalent degree of protection for enclosure. Output shall be isolated 4-20 mA DC linear HART signal. Material for flue gas carrying parts shall be of SS. Protection tube shall be provided to prevent erosion of the probe. Maintenance requirement shall not be more than once a week. Local indicating meter for read out to be provided. Alarm on abnormalities and self diagnosis features shall be provided. Electronic unit shall be separated not head mounted. 2 Nos. standard check cells with Dual redundant air lines. Dual redundant instrument air lines of $\frac{1}{2}$ " size with sufficient isolation valves & drains shall be laid nearer to these instruments located in chimney so as to avail the purge air facility.

2.8.0 Opacity Analyzer

Opacity analyzer shall be of Dual beam Optical Transmissometer type with an accuracy of $\pm 2\%$ of opacity or better, resolution of $\pm 1\%$ of opacity, response time of better than 10 sec, Drift shall not be more than 0.3% opacity per month and having features like auto zero & span calibration etc, IP 65 or equivalent degree of protection for enclosure. Output shall be isolated 4-20 mA DC linear HART signal. Material for flue gas carrying parts shall be of SS. Protection tube shall be provided to prevent erosion of the probe. Local indicating meter for read out to be provided. Alarm on abnormalities and self diagnosis features shall be provided. Dual redundant instrument air lines of $\frac{1}{2}$ " size with sufficient isolation valves & drains shall be laid nearer to these instruments located in chimney so as to avail the purge air facility.

3.0.0 CHIMNEY GAS ANALYZERS

3.1.0 Chimney Gas Analyzers shall be provided for monitoring the emission levels of various gases in flue gas exiting chimney. All the analyzers shall have facility of local display / indication apart from the indication on the analyzer cubicle. All analyzers should be provided with standard gas cylinders for calibration.

3.2.0 Gas analyzers shall be insitu probe type based on Infra red absorption type. Multi gas combined analyzer shall be provided.

3.3.0 Measured values and certain status signals shall be processed by an emission evaluation computer via serial interface, to be installed within the Central Control Room or DCS through hardwired interface from field. The emission data shall be calculated, converted, printed out and stored according to the governmental requirements.



3.4.0 Ownership certificate, pressure test certificate, explosion proof certificate for standard gas cylinders shall be given and these will be used for next filling up of standard gases.

3.5.0 The following Analyzers to be considered per unit on Chimney,

PATH	TYPE OF ANALYSER
Chimney	NO _x
	SO ₂
	CO ₂
	CO
	O ₂
	Particulate Emission (PM ₁₀)
	HF Vapor
	Specious Mercury
	Total Mercury

3.6.0 Gas Analyzers NO_x , SO₂, CO₂, CO, O₂

Analyzers shall be Infra red absorption technique 'with a accuracy of $\pm 2\%$ of measured value, precision of $\pm 0.5\%$ of measured value or better, resolution of 1 ppm, response time of better than 5 sec for 90% and having features like auto zero & span calibration, IP 65 or equivalent degree of protection for enclosure. Output shall be isolated 4-20 mA DC linear HART signal. Accessories like purge System for cleaning the window, heat shield mounting plate, auto window cleaning device etc., shall be provided. Material for flue gas carrying parts shall be of SS. Protection tube shall be provided to prevent erosion of the probe. Maintenance requirement shall not be more than once a week. Local indicating meter for read out to be provided. Alarm on abnormalities and self diagnosis features shall be provided.

3.7.0 Particulate Emission Analyzer

Particulate emission analyzer shall be of Light attenuation / photo transmissometry type with an accuracy of $\pm 2\%$ of measuring range or better, resolution of $\pm 0.1\%$ of opacity, response time of better than 5 sec for 90%, Drift shall not be more than 3% opacity per month and having features like auto zero & span calibration etc, IP 65 or equivalent degree of protection for enclosure. Output shall be isolated 4-20 mA DC linear HART signal. Accessories like back purge system etc., shall be provided. Material for flue gas carrying parts shall be of SS. Protection tube shall be provided to prevent erosion of the probe. Local indicating meter for read out to be provided. Alarm on abnormalities and self diagnosis features shall be provided.

3.8.0 HF Vapor

HF vapor analyzer shall be of Ion mobility spectrometry or Fourier Transform Infrared (FTIR) extractive type with an accuracy of $\pm 10\%$ of full scale or better, response time of 5 sec or better having features like auto calibration and correction, IP65 or equivalent degree of protection for enclosure. Output shall be isolated 4-20 mA DC linear HART signal.

3.9.0 Specious & Total Mercury

Specious and Total Mercury analyzer shall be Cold Vapor Atomic Fluorescence type with a linearity of $\pm 1\%$ of full scale or better, response time of better than 180 sec, Drift shall not be more than 3% or measuring value per month and having features like auto zero & span calibration, IP 65 or equivalent degree of protection for enclosure. Output shall be isolated 4-20 mA DC linear HART signal. The analyzer shall not get affected due to interference or quenching. Maintenance requirement shall not be more than once for a month. Local indicating meter for read out to be provided. Alarm on abnormalities and self diagnosis features shall be provided.



4.0.0 AMBIENT AIR QUALITY MONITORING SYSTEM

- 4.1.0 AAQMS shall be provided to check upon the ambient air quality inside and around the power plant and capable of generating required periodic reports for submission to relevant Central & State regulatory agencies by Owner.
- 4.2.0 Ambient air quality shall be monitored for concentration levels of selected gaseous pollutants at different locations within the power station boundary and adjoining areas as per the ambient air quality monitoring guidelines of Central & State regulatory agencies like, MOEF, Central & State Pollution Control Boards (PCBs) prevailing during contract execution phase.
- 4.3.0 AAQMS system including the analyzers being supplied shall meet all applicable requirements/guidelines of relevant Central & State regulatory agencies like, MOEF, Central & State Pollution Control Boards (PCBs) etc. or of US EPA in the absence of the same. It is the sole responsibility of the Vendor to obtain the necessary approval. Owner has no liability towards the same.
- 4.4.0 AAQMS system shall include the following:
- AAQMS Stations- 4 numbers
 - Centralized AAQMS Data Acquisition System
- 4.5.0 The following measurements will be provided for each station;
- SO₂
 - NO_x
 - CO
 - CO₂
 - Suspended Particulate Matter (PM₁₀)
 - Suspended Particulate Matter (PM_{2.5})- Respiratory
 - Ozone (O₃) - At One location only.
 - Mercury (Hg) measurement
- 4.6.0 Monitoring and report generation shall be carried out either in a centralized PC based Data Acquisition for AAQMS station
- 4.7.0 AAQMS for each plant location shall be a fixed type, self contained 'Station'. One (1) no 'Station' shall be located at the UP wind direction path. Balance three (3) number 'Stations' shall be located at different plant locations considering the factors like downwind direction, sensitive receptor, population etc. The exact location of the monitoring station(s) shall be decided in consultation with Owner and regulatory agencies during project implementation phase.
- 4.8.0 As per the TNPCB requirement all the Power plants should upload the environment parameters to TNPCB's web server. One no of PC with necessary software (as recommended by TNPCB) with modem & dedicated internet connection and necessary I/O cards to access the mA output from various analyzers, is to be supplied for uploading the parameters of CEMS/ Fluegas analyzers
- Minimum of 40 parameters are to be uploaded and actual no. will be discussed during detailed engineering.
- 4.9.0 Each AAQMS Station shall include the following including analyzers, accessories, calibration facility, mounting racks/ cabinets and housing shelter, Data Acquisition System etc. but not limited to the same:
- Individual Gas analyzers for the parameters specified
 - Necessary sampling systems for the AAQMS analyzers
 - Multi gas calibration system
 - Zero air generators



- e) Hydrogen Generator,
- f) Calibration gas cylinders
- g) Mounting cabinet/ rack for analyzers and accessories
- h) Housing shelter for AAQMS equipment- environmentally conditioned, walk-in type shelter complete with lighting and convenience receptacles.
- i) UPS & lighting power supply complete with distribution facility
- j) PC Based Data Acquisition System for AAQMS Station.

4.10.0 Technical Data sheet of AAQMS Equipment

a) NO_x Analyzer

Principle	:	Chemiluminescence
Range	:	0.05 to 100 ppm / 0.1 to 150 mg / M3
Minimum Detectable Limits	:	0.4 ppb
Zero Drift (24 Hr. Basis)	:	< 0.4 ppb of Full Scale Per Day
Span Drift (24 Hr. Basis)	:	± 1% of Full Scale Per Day
Response Time	:	10 to 40 Seconds for 0-100% reading.
Accuracy	:	± 0.4 ppb (For 500 ppb range)
Linearity	:	± 1% of Full Scale Reading
Operating Temperature	:	15-35 deg.C
Signal Output	:	4-20 mA DC / RS 232 or RS 485 link.
Power Supply	:	240 V AC (UPS)
Mounting	:	Rack Mounted

b) SO₂ Analyzer

Principle	:	Fluorescence in UV absorbance
Range	:	0.05 to 10 ppm / 0.2 to 25 mg / M3
Minimum Detectable Limits	:	0.5 ppb
Zero Drift (24 Hr. Basis)	:	< 1 ppb
Span Drift (24 Hr. Basis)	:	± 1% per week
Response Time	:	10 to 80 Seconds for 0-100% reading
Accuracy	:	± 1%
Linearity	:	± 1% of Full Scale Reading
Operating Temperature	:	20 - 30 deg.C
Signal Output	:	4-20 mA DC / RS 232 or RS 485 link.
Power Supply	:	240 V AC (UPS)
Mounting	:	Rack Mounted

c) CO Analyzer

Principle	:	IR type with Gas Filter Correlation
Range	:	0 – 10,000 ppm
Minimum Detectable Limits	:	0.04 ppm
Zero Drift (24 Hr. Basis)	:	< 0.1 ppm per day
Span Drift (24 Hr. Basis)	:	± 1% per week
Response Time	:	60 Seconds
Accuracy	:	± 0.1ppm
Linearity	:	± 1% of Full Scale Reading
Operating Temperature	:	20 - 30 deg.C
Signal Output	:	4-20 mA DC / RS 232 or RS 485 link.
Power Supply	:	240 V AC (UPS)
Mounting	:	Rack Mounted

d) CO₂ Analyzer

Principle	:	IR type with Gas Filter Correlation
Range	:	0 – 10,000 ppm
Minimum Detectable Limits	:	0.04 ppm
Zero Drift (24 Hr. Basis)	:	< 0.1 ppm per day
Span Drift (24 Hr. Basis)	:	± 1% per week
Response Time	:	60 Seconds
Accuracy	:	± 0.1ppm
Linearity	:	± 1% of Full Scale Reading
Operating Temperature	:	20 - 30 deg.C
Signal Output	:	4-20 mA DC / RS 232 or RS 485 link.
Power Supply	:	240 V AC (UPS)
Mounting	:	Rack Mounted

e) Suspended Particulate Matter (PM₁₀) & PM_{2.5}**Suspended particulate matter (PM₁₀ & PM_{2.5}) ONE for each type.**

The Continuous Ambient Particulate Monitor measures the mass concentration of suspended particulate matter (PM₁₀/PM_{2.5}) by use of beta attenuation. In addition, the ambient radioactive influence of natural Radon (Rn-222) gas is measured as a refinement step toward better sensitivity at lower ambient particulate concentrations.

The Continuous Ambient Particulate Monitor measures the mass concentration of suspended particulate matter (PM₁₀/PM_{2.5}) by use of beta attenuation. In addition, the ambient radioactive influence of natural Radon (Rn-222) gas is measured as a refinement step toward better sensitivity at lower ambient particulate concentrations.

f) SPM Analyser with Beta Attenuation Principle

Principle	Beta attenuation
Accuracy	+/- 2% 24 hr Mode
Sampling Inlet	1. PM₁₀Hood& 2. PM_{2.5}/TSP-Manually Interchangeable hoods
Range	0 –0.1,0.20.25,0.5,1,2,5,10 mg/m ³
Min. detectable level (24 hrs)	1 µg/m ³
Resolution	+/- 1 micro g/m ³
Cycle	1 Hour
Data Storage	200 days, 1 hr sample
Power supply	230V, 50 Hz supply UPS
Air flow rate	0-20 SLM user selectable
Temp. range	- 30 deg to +60 deg C
Mounting	19" Rack

g) SPM Analyser with TEO micro-balance Principle

Principle	Tapered element oscillating micro-balance
Range	0- 5 gram/m ³ & 0-10 gram/ m ³



Resolution	0.1 micro gram /m ³
Accuracy	± 1.5 micro-gram/m ³ (1 hr avg.)/ ± 0.5 micro-gram/m ³ (24 hr avg.)
Minimum detectable limits	10 nano gram, 0.06 micro-gram /m ³ (1 hr. avg.)
For mass measurement	
Accuracy for mass	± 0.75 %
Measurement	
Operating temperature	0-40 °C
Signal output	4-20 mA DC & RS 232 or RS 485 link
Power supply	240V AC(UPS)
Mounting	rack mounted
Data averaging	every 2 sec.

h) Multi Point Calibrator

Flow measurement Accuracy	:	± 2% of Set point or ± 1 % of full scale reading (in 20-100%) whichever is less.
Repeatability of flow control	:	± 0.2% of full scale reading.
Linearity of mass flow measurement	:	± 0.5% of full scale reading.
Calibration Gas Input ports	:	6 Nos
Response Time	:	< 60 Seconds for 0 – 99%
Temperature Range	:	0 – 40 deg.C
Power Supply	:	240 AC (UPS)

i) Ozone Analyser

Using UV Photometric technology, the Analyser shall measure the amount of ozone in the air from ppb levels up to ppm. The Analyser shall be based on Beer Lambert Law for measuring low ranges of Ozone in Ambient Air

Measuring principle	UV - Photometric
Ranges	0-100 ppb to 0-10 ppm ,user selectable, Dual ranges and auto ranging supported
Units	ppb,ppm,um/m3,mg/m3
Zero Noise	<0.3 ppb
Span Noise	<0.5% of reading above 100 ppb (RMS)
Display	Digital
Lower Detectable Limit	<0.6 ppb (RMS)
Zero Drift (24 hour)	<1.0 ppb/24 hours
Span Drift	1% of reading per 7 days
Mountings	Suitable for 19" Rack Mounting
Lag time	<10 seconds
Rise and fall time	<20 seconds to 95%
Linearity	1% full-scale
Sample Flow Rate	0.8 liters/min.
Power Requirements	220 – 240 VAC, 50 Hz 250 Watts
Outputs	Serial port 1 :RS232 (DB-9M) Serial port2: Standard RS232 or optional RS485 (DB 9F), Ethernet & 4-20 mA.
Inputs	6 inputs

4.11.0 Analyzer gas sampling system shall be complete with sampling hood arrangement with SS hood, SS 316 manifold, moisture trap, air compressor of requisite capacity (minimum 10 LPM) and heat less type air dryer.



- 4.12.0 Zero air generators shall be with inbuilt catalytic converter.
- 4.13.0 Calibration gas cylinders for NOX, SO₂, CO, CO₂, SPM- PM₁₀ & PM_{2.5} analyzers as required of appropriate capacity suitable for minimum 6 months calibration with SS316 regulator.
- 4.14.0 Hydrogen generator complete with fluid tank and all accessories- hydrogen purity of >99.99%.
- 4.15.0 AAQMS Analyzer Shelter

a) General Requirement

The Analyzer Shelter shall be a completely assembled unit suitable for installation on a concrete Pad or as a stand-alone unit. All internal piping and tubing shall terminate in bulkhead connections. Internal wiring will terminate in external junction boxes.

All equipment including tubing, conduit fittings, junction boxes, etc. shall be installed so as not to interfere with the removal of analyzers, sample handling systems and related equipment. Accessibility for maintenance shall be the prime consideration.

b) Construction Features

The Analyzer Shelter shall consist of a self-framing exterior skin assembled on a rigid primed and painted steel superstructure. All materials used in the construction shall be non- combustible.

Wall panels design to be completely weather resistant. The design shall allow for thermal expansion / contraction of the structure over the complete range of ambient temperatures applicable for the location without causing harmful buckling or opening of joints, etc. Materials of construction shall be 2mm thick SS sheet for external walls and 18 gauge galvanized steel for internal walls with ribbed interlocking. The ribbed interlocking shall provide a strong column for the sheets on the side valves, where the “U” profile created at the edges, when interlocked with the second sheet, increases the section modulus of ribbing.

The wall panels of the shelter shall be insulated and designed for the given ambient conditions by glass / rock wool of appx. 100 mm insulation thickness.

Roof panels design and construction to be completely weather resistant. The design shall allow for thermal expansion / contraction of the structure over the complete range of ambient temperatures applicable for the location without causing harmful buckling or opening of joints, etc (e) The base structure of the shelter shall be constructed using ISMC (1501125) IISMB (100) welded properly and adequately sized to ensure structural rigidity to prevent deformation during dragging, lifting, loading and unloading of the shelter.

The roof panels shall be provided with 80mm thick rock wool insulation. All insulation materials are to be fire retarding. The analyzer house shall have two doors; one as the main entrance and the other as the emergency exit. The doors are to be mounted on special hinges to ensure gas-tight construction of the shelter. Doors shall be sturdy, double-walled, insulated with rock wool and open to the outside. Each door shall have a window with transparent toughened safety glass.

The main entrance shall carry a plate indicating the plant area number and the tag- list of all the analyzers inside the shelter.

Analyzer Shelters meet the standards of the Uniform Building Code with the following design loads:

1. Roof 20 lb. / sq ft live load



2. Wind 35 lb. / sq ft at 0-30 ft above grade elevation.
3. Seismic Zone As applicable

All tubes and cable entries to the shelter shall be through Multicable Transit Blocks - to ensure gas tightness of the shelter. The floor is to be fabricated with anti-slip sheet and sealed continuously to ensure no loss of pressure.

c) Painting

Preliminary cleaning involving removing of grease, oil, paint and dirt which prevent pickling acid from coming in contact with the scale or mist. Structural painting shall include scraping, chemical cleaning, one coat of etch primer, one coat of Epoxy Zinc Chromate Red Oxide primer and two coats of Epoxy finish Paint. The surface coating shall take sufficient care of removing all the contaminants thus ensuring against premature and complete coating failure. Precautions to be taken to avoid air bubbles and uneven coat thickness.

Internal Sheet Metal: The internal walls shall be powder coated. Painting for the shelter is completed in every respect before despatch. No painting will be done at site except touch-up of scratches made during site erection.

d) Environmental Conditioning

Analyzer shelters shall be environmentally conditioned to keep the inside atmosphere of the shelter at a constant temperature of $24^{\circ}\text{C} \pm 3^{\circ}\text{C}$ to obtain repeatability and reliability of the analyzers and also a comfortable working environment for workman. For this purpose either a skid mounted type air conditioning unit or 'Split Type' air conditioner (1 Working & 1 Standby) to be provided.

e) Lighting

Illumination level in the shelters will be at a minimum of 300 lux at 750mm elevation inside the shelter. Maintenance factor shall be 0.65. External Dome type lighting shall be under the overhangs to provide sufficient illumination for maintenance work. Power switches for internal and external lighting will be provided near to the main entrance on the outside of the shelter.

f) Fire Detection & Protection

Necessary fire detection & protection measures for the analyzer shelter shall be provided as per regulatory requirement.

- g) If UPS feeders cannot be provided for the AAQMS 'Station', then UPS of suitable capacity with all accessories like battery and battery charger shall be provided. Battery shall be maintenance free type.

h) Power Distribution Board

Power distribution board for distribution of UPS & 230 V AC power for all individual consumers such as individual analyzers, auxiliary equipment inside and around the shelter, lighting receptacles shall be provided. Each of the main systems shall have an individual isolation circuit breaker mounted next to the individual power users. Telephone connection shall be provided for each AAQMS Stations. LAN Connectivity: LAN connectivity shall be provided for each AAQMS Station for data communication.

i) PC Based Data Acquisition System (DAS)

For AAQMS Station the DAS system for each AAQMS Station shall collect, store and analyze air quality data from all instruments of the Station. For these purpose all



instruments shall be interfaced with local DAS system suitably either through a serial link or by hardware. The application software shall have following features:

1. Calculation of arithmetic mean values, average values at different fixed intervals and user defined time periods like hourly / weekly / monthly / yearly etc.
2. Calculation of pollution load and wind roses (by interfacing meteorological data wherever provided).
3. Generation of reports for at different fixed intervals like daily, weekly, annual etc. and for user defined periods.
4. Generation of reports in the form of line / column charts / tables / curves / graphics etc.
5. Generation of reports for pollution load, wind rose, Station etc
6. Comparison of data of various parameters for the same monitoring station.
7. Generation of reports for real time data and based on archived data.
8. Display of real time (on-line momentary values) and archived values in tabular texts and graphic formats.
9. Facility for calibration windows for analyzer calibration.
10. Real time monitoring of status of all analyzers and sensors with diagnostics for maintenance personnel.
11. Alarm annunciation of analyzer/sensor abnormal conditions.

j) Central AAQMS Monitoring

Monitoring and report generation of AAQMS for the whole power station shall be a centralized system and can be carried out either through a centralized PC based Data Acquisition system or in MIS. For this purpose, all individual analyzer data from each AAQMS Stations shall be collected in PC based DAS / Plant MIS system by interfacing each AAQMS Stations suitably through a serial communication link.

Central AAQMS DAS system shall perform following functions:

1. To collect all the data from the individual AAQMS Stations at prescribed time or on request.
2. Ability to manage multiple remote AAQMS Stations.
3. Monitoring, analyze, report generation and archiving of data.

Central AAQMS DAS system software shall have following features:

1. Calculation of Arithmetic mean values, average values at different fixed intervals and user defined time periods like hourly / weekly / monthly / yearly etc. for each remote Station.
2. Calculation of pollution load and wind roses (by interfacing meteorological data).
3. Generation of reports for at different fixed intervals like daily, weekly, annual etc. and for user defined periods.
4. Generation of reports in the form of line / column charts / tables / curves / graphics etc.
5. Generation of reports for pollution load, wind rose, Station etc
6. Comparison of data of various parameters for the same monitoring station.
7. Inter comparison of data between different monitoring Stations.
8. Generation of reports for real time data and based on archived data.
9. Display of real time (on-line momentary values) and archived values in tabular texts and graphic formats.
10. Facility for calibration windows for analyzer calibration.
11. Real time monitoring of status of all analyzers and sensors with diagnostics for maintenance personnel.
12. Alarm annunciation of analyzer/sensor abnormal conditions.



k) Display board

Digital display board for the display of all AAQMS parameters and the sixteen (16) analog signals of Stack Emission Monitoring system at the main gate shall be provided. And the display board specification shall be as follows

1.	Size of the display	- 4' (H) X 8' (L)
2.	Visibility Range	- 80-100m
3.	No of Display lines	- 4
4.	Display of color elements	- Color (RGY)
5.	Minimum life span	- 5 years
6.	Ambient Temperature	- Maximum 50°C
7.	Humidity Range	- 0-99%
8.	Language	- English only
9.	Color gradient	- Cluster LED based
10.	Display casing	- Weather proof casing
11.	Type	- Microcontroller/Microprocessor driven
12.	LED matrix	- 2X64X128
13.	LED pitch	- 0.6"
14.	Signal input to the display board	- (i) 16-Analog signals from stack monitoring Device. (ii) Data communication through RS 232/ 485/Ethernet or suitable protocol from CAQMS station for all parameters of AAQMS.

5.0.0 METEOROLOGICAL MONITORING SYSTEM (MMS)

5.1.0 A meteorological monitoring system (MMS) shall be provided. Meteorological data shall be monitored within the plant premises at one (1) location. The exact location of the monitoring

5.2.0 Station(s) shall be decided in consultation with Owner during project implementation phase based on the Central & State PCB guidelines. The following parameters shall be monitored:

- a) Wind Direction
- b) Wind Speed
- c) Ambient Temperature
- d) Ambient Pressure
- e) Solar Radiation
- f) Relative Humidity
- g) Rainfall



- 5.3.0 MMS shall be continuous on-line type. MMS shall allow monitoring, logging of parameter values, archiving and report generation for environmental monitoring authorities and plant management personnel.
- 5.4.0 MMS shall be complete with all the necessary measuring equipment and accessories and shall be housed in a walk-in shelter, environmentally conditioned (if required for measuring equipment), complete with lighting and convenience receptacles. For this purpose MMS equipment can be housed in one AAQMS Station shelter. Alternatively, a separate shelter for housing MMS equipment shall be provided.
- 5.5.0 Output signals of all meteorological monitoring analyzers shall be connected to plant DCS / MIS for monitoring, archiving and report generation for environmental monitoring authorities. Necessary software for the purpose shall be loaded into MIS.
- 5.6.0 Technical Specification of MMS

a) Wind Speed Sensor

Principle	:	Frequency Proportional to Wind Speed
Range	:	0 - 210 Km / Hr
Accuracy	:	± 1%
Threshold	:	0.3 Meter / Sec
Operating Temperature	:	0 - 500 °C

b) Wind Direction Sensor

Type	:	Potentiometric
Range	:	0-360 °C
Accuracy	:	± 3 °C
Threshold	:	0.3 M/Sec
Operating Temperature	:	0 - 500 °C

c) Ambient Temperature Sensor

Type	:	PRT -100 Type Resistance Temperature Detector
Range	:	0 – 500°C
Accuracy	:	± 0.25 °C
Operating Temperature	:	0 - 500 °C
Accessories	:	Non Aspirated Radiation Shield

d) Relative Humidity (RH) Sensor

Type	:	Thin film Capacitive Type Sensor
Range	:	0 - 100 %
Accuracy	:	± 3% Of Full Scale Reading
Operating Temperature	:	0 - 500 °C
Accessories	:	Non Aspirated Radiation Shield

e) Solar Radiation Sensor (Solarimeter)

Type	:	Thermopile
Spectral Range	:	0.25 - 60 Micron
Measuring Range	:	0 - 1500 Watt / M2
Accuracy	:	± 3.5%
Accessories	:	Non Aspirated Radiation Shield
Operating Temperature	:	0 - 50 °C



f) Rain Gauge

Sensitivity	:	0.5 mm
Accuracy	:	$\pm 0.5 - 1 \%$
Operating Temperature	:	0 - 500 °C

**VOLUME II****SUB-SECTION 4.15****PERFORMANCE ANALYSIS, DIAGNOSIS AND OPTIMIZATION (PADO)****1.0.0 GENERAL**

PADO system shall provide critical analysis of the plant performance and guidance for optimization on continuous on-line basis. The system shall analyse dynamically the status of the process and the equipment of the power generating units and will automatically generate the operator guidance instructions for remedial actions for maintaining the process and the system / equipment in the plant to their optimum performance

In order to achieve the maximum results from the PADO, any special type/Conventional instruments in addition to the signals designed by DCS on process information shall be identified and provided as PADO's recommendation.

2.0.0 DESIGN REQUIREMENTS**Functional Requirement**

PADO system shall provide following functional requirements:

- a) Performance analysis and monitoring of systems and components
- b) System and performance diagnosis
- c) System and performance Optimisation
- d) Emission analysis and monitoring
- e) Boiler performance optimization
- f) Boiler Stress Condition Analysis
- g) Regenerative cycle performance Optimisation
- h) Interactive water and steam chemistry management system

The PADO system shall use temperature profiles given by air cooled thermal imaging devices to study the boiler tube performances.

Heat rate deviations frequency excursion time beyond limit operating cost and cost of generation calculation display of online heat balance

This package should use relevant ASME Performance Test Codes and ASME Steam Tables: Steam Generators and ASME PTC 6S for Simplified Procedures for Routine Performance Tests of Steam Turbines.

All the instruments required for performance calculation & Optimization including Thermo Couples required for measurement of metal temperature at 50% and 100% depth of thick wall equipments such as Super heater & Reheater, Boiler, Y-Piece, etc. shall be supplied by bidder.

Performance analysis and monitoring of systems and components shall involve and facilitate the following:

- a) Computation of thermal performance status of the plant and efficiency of generation.
- b) Computation of all the key system performance indicators at system level such as heat rate, plant and equipment efficiency, generator output and controllable losses.



- c) Computation of all the key system performance indicators at major component which shall include the following:
- i. Assessment of boiler operation based on efficiency, excess air and cleanliness factors of super heater, reheater and pressurize.
 - ii. Turbine performance evaluation considering efficiency, enthalpies, steam flow and gland leakage flow estimation.
 - iii. Air Pre-heater performance involving efficiency and pressure losses.
 - iv. Condenser performance based on heat duty and heat transfer co-efficient and cleanliness factors.
 - v. Performance of re-generative heaters by computing extraction flows, drain flows, terminal temperature difference and drain cooling approach.
 - vi. Analyse the impact of individual component performance on overall losses or gains in total unit generation along with computation and display of cost of individual loss/gain.
 - vii. Performing detailed analysis of each component including computation of key performance indicators such as efficiency, heat transfer co-efficient, TTD, DCA and fouling factor.
 - viii. Visualisation of individual component efficiencies and performances and display of the same.
 - ix. Visualisation of impact of incremental change of the major process parameters including but not limited to the following on boiler efficiency, turbine heat rate and unit heat rate etc. through 'What If' query facility for operator
 1. Main Steam pressure
 2. Super heater Spray flow
 3. Re heater Spray flow
 4. Economiser Inlet Temperature
 5. Excess Air
 6. Burner Tilt (if applicable)
 7. Coal Analysis
 8. Surface effective for super heater, re heater and ressurize
 - x. Performance computations to be carried out at specified intervals based on time averaged data during steady state operating conditions.
 - xi. Computations to be based on process signals, equipment status, design criteria and manual input data (where ever needed). Raw measured value for process signals shall be reconciled before usage.

3.0.0 SYSTEM AND PERFORMANCE DIAGNOSIS

3.1.0 System and performance diagnosis shall involve detection of the abnormalities and diagnosis of system and component performance degradation up to component level to pinpointing root cause of abnormalities existing in the process and guiding the operating personnel to attend to the same.

3.2.0 Diagnosis function involves the following:

- a. Equipment health diagnosis for high/ low pressure, temperature, level & vibration etc.



- b. Plant performance diagnosis for boiler, turbine, condenser, feed water and regenerative heating system.
 - c. Identifying degradation of measuring instrument for important parameters using data validation checks
- 3.3.0 Diagnosis based on expert system in the form of “Fault Trees” / Neural and Bayesian belief networks. Etc. Expert systems shall draw inferences based on knowledge base, on-line measured data and computed performance indices.
- 3.4.0 Diagnosis system shall be capable to provide following helps:
 - a) Avoiding a possible trip
 - b) Maintaining process parameters within safe limits thereby enhancing the life of the equipment.
 - c) Drawing the operator’s attention to the degradation of the equipment and instruments.
- 3.5.0 System And Performance Optimisation**

System and performance pressurized involves pressurized of set points for controllable parameters by recommending to the operator the optimum set points for pressurize the given process or activity at the measured operating condition using state of the art pressurized techniques.
- 3.6.0 Emission Analysis and Monitoring**
 - 3.6.1 Emission analysis and monitoring functions involves the following:
 - a) Monitoring, tracking and ressuriz plant emissions such as SO₂, NO_X, CO, CO₂ etc.in real time assuming sensors are available for all except CO₂ which can be calculated.
 - b) Monitor and analyse ESP & Stack conditions such as temperature, humidity, gas flow rate and opacity.
 - 3.6.2 Facilitate obtaining lowest emissions by recommending optimal damper position to ressuriz the NO_X level measured at the stack while maintaining the CO value and unburnt carbon below desired permissible limits.
 - 3.6.3 Facilitate obtaining lowest emissions while maintaining combustion efficiency.
 - 3.6.4 Facilitate to set alarms to highlight conditions that violate pre-defined conditions
- 3.7.0 Boiler Performance Optimisation System (BPOS)**
 - 3.7.1 BPOS shall enable operating personnel to improve boiler performance and optimize fuel consumption including pressurise operation of Soot Blowing system. This system shall have following features:
 - 3.7.2 Incorporates the complete thermal design model of the boiler capable of both forward and backward computation of complete boiler thermal performance.
 - 3.7.3 Boiler thermal design model calibrated to made “Site- specific” based on series of field trials of thermal performance of the boiler during start up and prior to trial operation.



3.7.4 BPOS to function continuously taking into consideration the performance of furnace, super heater, pressurize, air heater and pulveriser based on the continuous on-line measurement of the including but not limited to the following parameters:

- a) Flue gas temperature at ECO I/L
- b) Flue gas oxygen content
- c) Other fluid temperature(s) entering and exiting various heat transfer surfaces
- d) Coal Characteristics
- e) Un burnt carbon in fly ash
- f) Coal mass flow rate/air fuel ratio in each PF pipe for each coal pulverizer

The data from instruments mentioned in the clauses 1.10.0, 1.11.0 of section 4.8 and Thermal imaging devices shall be utilized in the boiler performance optimization system. Bidder shall also provide Boiler start up optimization software

3.7.5 BPOS shall be capable for continuous on-line calculation of the thermal performance of the boiler for the operating conditions indicating performance prediction zonal absorption, metal temperature and shall have the following features:

- a) Fuel switching capability
- b) "What If" query capability
- c) Selective soot blowing of furnace/Super heater based on trends of zonal absorption.
- d) Expert system diagnostics for quick identification of the Root Cause of deviations from the predicted parameters

3.7.6 Expert system diagnostics for quick identification of the 'Root Cause' of deviations from the predicted parameters. The computer modeling and arriving at factors to make it "Site Specific" shall be to the approval of the Owner. The BPOS shall be furnished complete with the appropriate computer hardware to the approval of the Owner. Boiler Tube life fraction and stress calculation feature. Include soot blowing optimization module. The Optimization Package will also identify if soot blowing is required in the SGs. If SGs are equipped with additional firing, the Optimization Package should also compute if additional firing is required. Selective soot blowing of Furnace / Super heater based on trends of zonal absorption.

3.8.0 Boiler Stress Condition Analysis (BSCA)

BSCA monitors of thermal stresses and assess life exhaustion in thick walled components like super heater and re heater outlet headers by estimating the expended life due to low cycle fatigue and creep.

BSCA shall guide the operator during start- up and shut down regarding controlling of rate of heating or cooling of metal within specified limits and also guides the margins available for the rate of steam generation (for fuel firing) during start-up.

3.9.0 Regenerative Cycle Performance Optimisation System (RCPOS)

Regenerative cycle performance pressurized system shall involve the following:

- a) Analysis of deviation of performance of the turbine cycle by examining the deviation of important parameters of the turbine cycle.



- b) Analysis of actual efficiency of individual stages of turbine.
- c) Evaluation of LPH & HPH performance by comparing current values of TTD/ DCA to the reference values.
- d) Heater level evaluation

3.10.0 Interactive Water and Steam Chemistry Management System

3.10.1 Interactive water and steam chemistry management system shall be capable of guiding the operator for appropriate chemical dosing to maintain the chemical balance, optimal blow down and carry out further investigation as advised by the system.

3.10.2 The system shall have following features:

- a. Monitoring of various steam and water parameters at certain pre-determined points in the flow cycle and warning the operator about any distinct aberration and guiding on precautionary as well as corrective actions to be taken.
- b. The system shall use “Decision Trees” and “Fault Trees” or other suitable methods for each parameter to diagnose deviations in controlled parameters in order to find the root cause and advise corrective actions.
- c. The system shall provide following benefit to the user/operator:
 - 1. Minimisation of make up water consumption
 - 2. Decrease in consumption of dosing chemicals
 - 3. Prevention of carry over of impurities into the turbine
 - 4. Decline in degradation of turbine components
 - 5. Lessening of boiler tube scale formation
 - 6. Reduction in energy consumption

3.11.0 PADO Hardware/ Software/ Interfacing Requirement

Each PADO system per unit shall include all hardware and software as required for proper functioning of the system including but not limited to the following:

- a) One (1) no Redundant Server
- b) One (1) no of user station for Performance, analysis, diagnosis and Optimization for unit in charge (shift supervisor) with 1LJP A4 B/W(With PC, Video Display Unit, Keyboard/ Mouse and Colour Laser Printer)
- c) One (1) no. of user station user station for Performance, analysis, diagnosis and Optimization at the office of Executive Engineer/Efficiency with 1 LJP A3 BW.
- d) One (1) no. of user station for water chemistry parameters connected with PADO is to be installed at SWAS /chemical lab/Chemical Division with 1 LJP A4 BW.
- e) One (1) number engineering work station for performance calculation and optimization with 1LJP Heavy duty Industrial grade A3 color printer
- f) PADO Software with all relevant user's license.
- g) Server & User PCs operating licenses.
- h) Bulk data storage and retrieval facility. The system shall have facility to store bulk data for 5 years duration with facility for retrieval of the same. The system shall have facility to share all the data in the hard disk/back up media and provide user-friendly utilities to retrieve and analyze stored data.
- i) Redundant bidirectional OPC communication link with all necessary hardware and software.
- j) System cables, interconnecting office LAN & Station LAN etc.



- k) Pressure/DP transmitters and all other required Instrumentation for evolving Online PADO shall be provided
- l) PADO package should use relevant ASME performance test codes, ASME steam tables for steam generator and ASME PTC 6S for simplified procedure for routine performance test of steam turbines.

3.12.0 Data Validation

There should be a data validation package to check for the correctness of the measurements. The package should use the following types of checks:

- a) Sensor/measurement range check
- b) Neutral Network/Statistical checks
- c) Model based checks for consistency of data

In case of violations in range, reasonability or consistency are discovered, the package should be able to create "reconciled" data for substituting the actual plant measurement.

3.13.0 Performance calculation

Performance monitoring/calculation shall be carried out for systems like Steam Turbine Generator, Steam Generator & overall plant performance. A centralized performance calculation on-line engineering/ programming and on-line diagnostic station will be provided as part of the DCS system of various modules. Performance calculation will be in accordance with international standards ASME PTC-6, ASME PTC-8.2/11/12.1/12.3/46 for turbine, boiler and the overall plant respectively.

- (a) Performance calculation executed automatically by retrieving data from the global plant data base or from the HSU and will perform plant efficiency, heat rate and other calculations as per ASME Power Test Code and other relevant standards.
- (b) The plant performance calculation package shall also embody programs and routines to generate parameters to provide expert guidance to the plant operator. Suitable prompts and guidance messages shall be generated to guide the plant operator towards optimal plant performance.
- (c) Calculations shall use high level language. Calculations shall be made using floating-point arithmetic. The equations shall be changeable on-line at the job site. Calculation results shall be quality coded according to the quality of the inputs. The results of these calculations shall be available through the database for appropriate logs and operator displays.
- (d) Required curve fitting shall be performed at polynomial exponent for accuracy. Averages used in calculations and/or logging shall be true "load weighted" averages (load weighted with the proper variable to give true averages over the given time period). The ASME Steam Tables shall be employed.
- (e) The plant performance computation are broadly subdivided into two classes of calculations:

Class (I) - Equipment protection calculations (software generated alarms)

Class (II) - Plant and equipment efficiency and Heat rate calculations.

(i) Class-I Calculations

Class-I calculations are made every scan cycle for the purpose of detecting and alarming unit malfunctions. The following lists typical Class-I calculations that shall be required:



- a. Cold reheat steam approach to saturation temperature.
- b. Superheat spray outlet approach to saturation temperature.
- c. Turbine steam metal temperature differences.
- d. Turbine metal temperature rates of change.
- e. Excess air deviation from standard.
- f. Separator water saturation temperature rate of change.
- g. Feed water heater temperature deviation from standard
- h. Metal temperature difference for SH & RH etc.

(ii) Class-II Calculations

Class-II Calculations shall be performed in the real time for displaying and subsequent logging using data, which is accumulated over a period of time. This time period shall be adjustable from 10 to 60 minutes. The operator shall be able to manually input coal analysis data and other data for Class-II Calculation.

Class-II calculations shall include the following:

- a. Boiler efficiency (Input/Output & Heat loss).
- b. Net Turbine heat rate.
- c. Gross Turbine heat rate.
- d. Net unit heat rate.
- e. Gross unit heat rate.
- f. H.P. turbine enthalpy drop/efficiency.
- g. I.P. turbine enthalpy drop/efficiency.
- h. L.P. turbine enthalpy drop/efficiency (using dry exhaust).
- i. Feed water heater terminal temperature difference.
- j. Feed water heater drain cooler approach.
- k. Condenser performance.
- l. Economizer performance.
- m. Air heater performance.
- n. Deaerator performance

3.14.0 Merit order rating system

Merit order rating system facilitates scheduling of optimal load of the individual units of a power plant with minimum total generation cost

The salient features of this module shall be as follows:

- a. Optimum load scheduling to meet the load demand with minimum generation cost
- b. Consideration of Unit constraints
- c. Cost function generated automatically from the generation cost entered by the operator at three different loads

3.15.0 Miscellaneous Calculations

Apart from Class I & Class II calculations, this sub-system shall also perform the following functions.

1. Running hour computation of different rotating machineries.
2. Cumulative time the TG runs below or above alarm level of steam temperature.
3. SH / RH tube creep life calculation.
4. Cumulative time of any bearing running above alarm level of vibration.
5. Number of Start & Stop of various drives



6. Number of hot, warm and cold starts of the turbine
7. Plant life calculation
8. Variable Alarm Limit Calculation.
9. Heat rate deviations.
10. Revenue calculation
11. Frequency excursion time beyond limit.
12. Plant availability and load factor calculation
13. Operating cost and cost of generation calculation
14. Merit order rating calculation
15. Monitor and analyse plant emissions such as SO₂, NO_x, Co and CO₂ in real time.
16. Monitor and analyze ESP and stack conditions such as temperature, humidity, gas flow rate and opacity.

In case of standalone Performance calculation & Optimization package, this stand alone system shall be connected through **redundant bidirectional OPC** connection with the DCS network.



VOLUME II
SUB-SECTION 4.16
MANAGEMENT INFORMATION SYSTEM (MIS)

1.0.0 GENERAL

1.1.0 An integrated management information system (MIS) shall be provided for the plant. System shall be able to provide information related to the following aspects to management personnel:

- a) Plant Operation Information
- b) Plant Maintenance related Information
- c) Environmental Information

2.0.0 FUNCTIONAL REQUIREMENTS

2.1.0 MIS shall provide following plant information:

- a) Environmental and hazard management
- b) Equipment maintenance history(Computerised maintenance system including asset management and inventory management functions)
- c) Fault cause analysis
- d) On job information report
- e) Plant Operation history
- f) Plant performance details
- g) Any other plant operation data/ details
- h) Plant process parameters from historian
- i) Online processor mimics, process parameters and process trends of both the 660 MW units.

3.0.0 DESIGN REQUIREMENTS

3.1.0 MIS system shall be based on Client- Server and relational data base environment. The system shall operate on a commonly used hardware platform and network operating system.

3.2.0 System shall be suitable for simultaneous use by multiple users. Presently, the system supplied shall be used by 50 nos users (Each with Work stations, 24" LED display unit, keyboard/ mouse) and 5 nos. of laptops of latest model. 10 nos. Digital LaserJet printer cum copier A3 sized shall be provided by bidder in service building on LAN network at various locations. In addition to 10 Nos. A3 sized printer, 25 Nos. B/W laser jet A4 size shall also be provided. This 25 Nos. of printers need not be on network based and same shall be connected to individual user as decided during detailed engineering. MIS users of 50 nos shall be distributed and provided in Administrator building, Service building and other buildings. However, the system shall be expandable in future to accommodate additional 20 no users through additional client workstations and user licenses. Exact user points in each building and the location inside the building will be decided during detailed engineering



- stage. Refer MIS configuration drawing (Dwg No. 30-1115112-I-355) for the requirements and the interfaces with PADO, Plant Wide LAN and ERP servers
- 3.3.0 The system shall be password protected. It shall be possible to organize system users into groups and each group shall have a separate security profile. It shall be possible to provide additional personal security settings for individuals within a group.
- 3.4.0 3 Nos. of LED TVs having size of 54" or better (one at top floor, one at 0 m floor of service building & one at Administration Building) shall be provided. And the connectivity from MIS server shall be provided. Management information/production information using mimics/slides technique shall be displayed
- 3.5.0 4 Nos. of LED TVs having size of 54" or better for Conference room, Mini conference room, CE Room, Training room shall be provided and the connectivity from MIS server shall be provided. PC shall be provided at each location for viewing the process mimics, process trends, parameters etc. as required by the viewer.
- 3.6.0 MIS processing shall be carried out in an independent server interfaced with different plant control systems like plant DCS which includes Plant utility systems like CHP control system, Switchyard SCADA system, Raw Water & Pre-treatment system, DM plant control system, Effluent treatment plant, Hydrogen generation plant, Sea Water Intake system, Ash handling (Bottom ash system), Ash handling (Fly Ash system) & unit specific DG Set control, Fire protection system, Plant analysis, diagnostics & optimization system (PADO), Computerized Maintenance Inventory management system (CMIMS) for polling of plant operational and performance data and maintenance details. Plant environmental data shall be obtained from DCS. The MIS system server shall be connected with ERP server through L3 layer switch. And all the MIS clients shall be connected with the Plant wide LAN through the L3 layer switch. All LED TVs shall be connected with the MIS server through the Station LAN or the Plant wide LAN through the L3 layer switch.
- 3.7.0 MIS user workstations will be located in different plant buildings and the same shall be connected to the MIS server through STATION LAN network.
- 3.8.0 Where ever required same user work stations (PCs) and printers will be used for MIS & CMMS (maintenance management system).
- 3.9.0 The system shall have facility to store bulk data for 5 years duration with facility for retrieval of the same. The system shall have facility to share all the data in the hard disk/back up media and provide user friendly utilities to retrieve and analyze stored data.
- 3.10.0 The system shall be provided with redundant UPS power supply. The power supply provision shall be such that on failure of one power supply the other power supply shall cater to the requirement of the equipment so as never to hinder the functioning of the system in any manner due to power supply failure.
- 3.12.0 MIS software with multiple user's license, Bulk Data storage and retrieval facility, Redundant OPC communication link with all necessary hardware and software, Server and User Work stations with operating licenses, Industrial Grade Hardware like System cables, interconnecting cables to station LAN switch etc. All hardware like routers, bridges, switches etc shall be managed type industrial grade only.
- 3.13.0 All software user licenses shall be valid for entire life of power plant. User should not have to pay any recurring licenses fee during the usage period of the system.
- 3.14.0 It shall be possible to upgrade the installed system with the latest available version of the software model during the plant life.
- 3.15.0 MIS station of one (1) number shall be located in the simulator room to view the real time data of both the 660 MW units.



4.0.0 PLANT WIDE OFFICE LAN

4.1.0 General

A plant wide Local Area Network (LAN) encompassing the different plant buildings shall be provided. The LAN shall interconnect the buildings together and shall facilitate the smooth transfer of data from one building to the other.

4.2.0 Design and functional requirement

4.2.1 The plant wide LAN shall be provided so that all the Plant and Non Plant buildings are connected through the network through the Redundant LAN server located at Service building.

4.2.0 The LAN includes the interconnection of LAN users in the Administrator building, Service building and all other buildings inside the plant premises which shall be not less than 16 buildings. The system shall operate on a commonly used hardware platform and network operating system.

4.3.0 The Plant wide LAN shall connect but not limited to the following buildings:

- i. Station building – Central Control Room
- ii. Service building
- iii. Coal Handling Plant
- iv. Ash Handling Plant
- v. Water Treatment Plant
- vi. Workshop
- vii. Stores
- viii. Switchyard Control Building
- ix. Raw Water Intake Pump House
- x. Any other building under the scope of the specification
- xi. Admin Building
- xii. FOPH, ESP, Zero M Elev. Turbine building, Boiler - A Elevation, CWPH.
- xiii. Any other Non plant area / building where Plant wide LAN need to be provided

4.4.0 System shall be suitable for simultaneous use by multiple users of 300 numbers which is commonly used for MIS and Office LAN. Out of 300 numbers, 150 nos. of users shall be provided with PC including 21" LED monitor and all required accessories. Also the bidder shall extend the network cable, L3 switches and required accessories for connecting additional 150 nos of users. All the LAN users of 300 Nos shall be distributed among the eighteen (18) buildings. The network devices, cabling etc. in order to cater the data flow from/to the MIS, ERP, Station LAN servers shall be established for the quantities mentioned in the following buildings and however the actual locations shall be decided during detailed engineering.

Sl.No.	Description of Building	Users	ERP	LAN	MIS	Wireless
1	Admin Building	150	*	*	*	*
2	Service Building	200	*	*	*	*
3	Central Control Room & Maintenance engineers room	5	*	*	*	-
4	Switch Yard Control Room	10	*	*	*	-
5	Desalination & DM Plant and Maintenance Office	6	*	*	*	-
6	Coal Handling and maintenance Office	10	*	*	*	-



Sl.No.	Description of Building	Users	ERP	LAN	MIS	Wireless
7	Ash Handling and Maintenance Office	8	*	*	*	-
8	Central Stores	12	*	*	*	-
9	Cooling Water & Pump House and Maintenance office	6	*	*	*	-
10	Fire Station Building and Maintenance Office	3	*	*	*	-
11	Time Office / Security Office	6	*	*	*	*
12	Sea Water Intake House	3	*	*	*	*
13	ESP Control Room	5	*	*	*	-
14	Boiler Maintenance Office	5	*	*	*	-
15	Work Shop	4	*	*	*	-
16	Regeneration Building(CPU)	3	*	*	*	-
17	Ash Water Recovery Pump House	2	*	*	*	-
18	Ash Silo Building	2	*	*	*	
19	Spare	10	*	*	*	-

Total nodes 450

- 4.5.0 Exact user points in each building and within plant premises will be decided during detailed engineering stage
- 4.6.0 Refer ERP Network Infrastructure diagram (Dwg No. 30-1112140-I-354) for the requirements and the interface of Plant wide office LAN with the ERP servers and MIS servers
- 4.7.0 Redundant Server, Personal computers (PC) of 100 numbers, Operating licenses for 200 nos users, Industrial Grade Hardware like Ethernet L3 Switches, interconnecting cables to L3 switches, System cables, etc. All hardware like routers, bridges, switches etc shall be managed type industrial grade only.
- 4.8.0 Industrial grade switches (L3 layer switch) of thirty (30) nos. shall be provided. Of which fifteen (15) nos. shall have forty two (42) nos. of Ethernet ports and other fifteen (15) nos. shall have twelve (12) nos. of Ethernet ports. All these quantities indicated shall be minimum and actual quantities shall be finalized during detail engineering
- 4.9.0 Industrial grade Switches (L3 Layer switch) provided shall be minimum 4x fibre (1000 Base-SX) , 1 Gbps uplink ports, 42/12 nos Ethernet ports, configurable via browser interface and have a 50% spare capacity for future addition of LAN points. Additional features shall include the following
- Support switch management functions, protocols and features including CLI, RMON, SNMP, VoIP, VLAN, QoS, STP/RSTP network resiliency protocols.
 - Possess integrated security features including Access Control Lists (ACL), protection from DoS attacks and broadcast/multicast storms, port blocking, MAC-ID filtering, support DHCP for static IP addressing, allow secure authentication during access.



- Powered from redundant, hot swappable AC and/or DC power supplies and shall be fan cooled with adequate monitoring and diagnostics of fault conditions using SNMP traps or other switch management alerts.
- 4.10.0 Each building shall be provided with a 12.U high wall-mountable communications cabinet complete with glass door, 6 way power distribution unit, 6 shelves and force ventilation. All units are to be supplied with cage nuts and bolts to house LAN switches.
- 4.11.0 The LAN shall be designed in a manner such that failure of an individual switch shall not hamper the failure of the entire system
- 4.12.0 Inter building wiring shall be a minimum of Category 5E STP cable manufactured, tested and verified to ISO11801 EIA/TIA standard. Internal building wiring shall be of the structured cabling type and shall incorporate patch panels on every floor or as required.
- 4.13.0 The various buildings shall be interconnected through the use of minimum 4 core single mode fibre optic cable
- 4.14.0 A minimum of two RJ-45 ports shall be provided for each specified location Category 5E shuttered modules shall be used in pre-assembled faceplates to save installation time. Modules shall include a slide label system.
- 4.15.0 All software user licenses shall be valid for entire life of power plant. User should not have to pay any recurring licenses fee during the usage period of the system.
- 4.16.0 It shall be possible to upgrade the installed system with the latest available version of the software model during the plant life.
- 4.17.0 The system shall have facility to store bulk data for 5 years duration with facility for retrieval of the same. The system shall have facility to share all the data in the hard disk/back up media and provide user-friendly utilities to retrieve and analyze stored data.
- 4.18.0 The system shall be provided with UPS power supply. The power supply provision shall be such that on failure of normal power supply the UPS power supply shall cater to the requirement of the equipment so as never to hinder the functioning of the system in any manner due to power supply failure.

5.0.0 LAN HARDWARE/ SOFTWARE REQUIREMENT

LAN shall include all hardware and software as required for proper functioning of the system including but not limited to the following:

- a. One (1) no. redundant server (with PC, 21" LED display unit, keyboard/ mouse and colour laser printer)
- b. 100 nos. user stations (each with PC, 21" LED display unit, keyboard/ mouse of latest model)
- c. Extension of Network cable, switches and accessories for all sixteen buildings.
- d. Software with multiple user license for 200 nos.
- e. L3 Layer switches of minimum 30 nos
- f. Windows 2008 R2, Server software (64 bit). User PCs and Operating licenses.
- g. Auto CAD software for 2D drafting
- h. CAD works for 3D modeling
- i. CAESAR pipe stress analysis software
- j. STAADPRO for civil drawings
- k. ETAP for power studies
- l. System cables, interconnecting cables to L3 switch etc.



6.0.0 PLANT WIDE LAN SYSTEM IMPLEMENTATION

System shall be delivered fully implemented and shall be user tested at site. It is the bidder's responsibility to demonstrate the proper functioning of the system to user personnel.

It is preferred that bidder's implementation team will involve ultimate users personnel during system implementation.



VOLUME II
SUB-SECTION – 4.17
DCS ONLINE SIMULATOR

1.0.0 GENERAL

1.1.0 The simulator to be provided shall be based on the design of the Udangudi supercritical Thermal Power project 660 MW and shall provide design features given in subsequent clauses. The Simulator Design shall include equipment, Instrumentation and controls that will enable and operator to function in all modes of the specified coal fired power plant operation including normal, abnormal or emergency operating conditions except as specifically noted otherwise. The response of the simulator resulting from operator action, automatic plant controls and inherent operating characteristics shall be realistic to the extent that an experienced operator shall not observe a difference, within the limits of the performance criteria, between the HMI indications of the simulator and the reference plant. The simulator shall calculate plant system parameters corresponding to particular operating conditions, display these parameters on the appropriate displays, and provide proper alarm and/or protective system action.

- 1.2.0
- a) The simulator offered shall be capable of simulating continuously, automatically, reliably, and in real time all operations of the real plant as specified. A simulator of high fidelity and integrated behavior is called for to provide the realistic simulation of the plant system and equipment and control and instrumentation
 - b) The modeling shall be such that each plant system accurately simulates all functions as detailed in the Drawings/Documents by the BTG and BOP suppliers

The combination of all systems shall provide a realistic overall plant simulation. Any details or information of systems and equipment described in this specification is meant only as an initial bidding guide. Generally, modeling for each system and component shall be done for each operable mode, (automatic, manual etc.) where the system/equipment is capable of being operated in more than one mode.

- c) The simulator design shall provide for adequate flexibility to allow expansion or modification of the hardware and software to reflect advances in design and technology and to upgrade the simulator systems, equipment and responses to actual plant operating conditions as they become known.
- d) The simulator models of the plant dynamics shall represent the responses of 660 MW of the Udangudi TPS in a realistic manner to the operator-trainee on the HMI. The design shall include, where required, special phases of operation of certain plant functions operable from outside the unit control room during normal and abnormal simulated plant operations. These functions shall be operable from the instructor's stations, the instructor acting as a remote auxiliary operator.
- e) The information that will be required for the development of mathematical models and data base along with the schedule there of, shall be clearly brought out in the bid proposals in details.
- f) After plant startup, actual plant operating data shall be used by the Contractor in retuning of the models and data base.
- g) Simulator fine tuning shall cover all modifications required to correct the modeling inaccuracies; changes to accommodate any change in design data and drawings from data freeze date to fine tuning data freeze date due to design modifications, changes made during installations and commissioning and any other reason as well as data based on actual operation of the plant.



- 1.3.0 The computational cycle time for each system module shall be such that simulated plant transients shall have the same time dependence as when observed in the reference plant. Transient responses shall reflect plant like trends.
- 1.4.0 The simulator shall be capable of performing in the following manner:
- a) The coal fired plant simulation shall provide the transient responses such as caused by, but not limited to, changes in various pressures, flows, temperature, density, heating value, moisture content, feeder position and coal air mixture proportion changes, coal quality variations, change in positions of all valves, dampers and vanes in all plant systems etc. Ambient temperature variation should be an instructor operation particularly for the cooling water temperature variations for its variation to be felt into the system efficiency.
 - b) The simulator shall be capable of simulating continuously in real time and selectively in fast time a hot or cold startup to full load condition, load modulation (both manual and automatic) and a shutdown to hot or cold condition.
 - c) In the absence of operating power plant performance data, the simulation shall be based on predicted plant design data. The simulator shall use parameters corresponding to the particular operating conditions display these parameters, and provide the proper alarm are approached or exceeded.
 - d) In case the basic plant / equipment data is not available for a few plant areas, then artificial intelligence based modeling shall be required to be provided.
 - e) The simulator shall permit the operator-trainee to complete any part of the pre-start-up procedures conducted at the LVS/OWS. These pre-start up preparations shall include verification of trip and alarm settings and operational checkout of critical systems or equipment.
 - f) The effect of any malfunction or a combination of malfunction shall be reflected in all plant parameters just as it would be in the real plant. At the time of occurrence of malfunctions, no parameter shall show unrealistic value.
 - g) All protections, interlocks, logics and controls of the real plant shall be incorporated in the simulation model.
 - h) Remote functions shall also be incorporated in the model.
 - i) The systems and descriptions given below should not be taken as the total simulation requirements but are meant only as a guide for bid purpose to define the minimum scope of simulation that is required. The model requirements mentioned in this specification are only indicative and not exhaustive. The Bidder shall describe in the proposal the details of proposed math modelling and give explanations to satisfy model requirements for the reference plant. The Bidder has to model the actual plant for which the data shall be furnished during detailed engineering.
 - j) The system shall have the design parameter, equipment details, operating manuals, instrumentation PID diagrams/SAMA drawings, CLCS logic diagrams of OLCS as soft from inside the simulator server during the training section, requirement technical document about the plant shall be met by the system.
- 1.5.0 Wherever a quantity of certain functions is specified, e.g. Malfunction, initial conditions etc. it is intended to mean the number of such functions to be implemented. The system shall be capable of adding more quantities at any stage & configuration should in no way be restricting such expansion. Limitation, if any, in the offered system, shall be brought out clearly in the bid.



- 1.6.0 The scope of simulation shall be limited to the controls of systems operated from the Central Control Room generally for the equipment and systems located in main plant as well as a few equipment and systems those are not in main plant but controlled from main plant like CW system, Compressor etc. In addition, the water system facilities related to Unit-1 as well as Unit2 shall also be simulated which are being operated from the Water system control room.
- 1.7.0 The Data related to various plant and equipment which are to be simulated during detailed engineering stage like P&IDs, Heat Balance Diagrams, Main equipment data sheets and drawings, material specification, characteristic curves etc. for the process modeling shall be considered by the bidder. However brief description of the main plant equipment is also given in the subsequent sections for giving the Bidder some idea about the plant and equipment. Further, subsequent clauses have also been added to inform Bidder the level of simulation expected for various systems but without prejudice to the fidelity, accuracy and tolerance figures specified elsewhere in the bidding documents.

Similarly for the C&I model and HMIPIS implementation, Bidder shall furnish plant I/O list, logic and loop diagrams, HMI displays, log / HSR assignments, calculation etc. during detailed engineering as well brief functionalities of the DCS system including control system and HMIPIS functionalities to be emulated. The functionalities of the C&I system has been given elsewhere in the specification to give the Bidder an idea about the level of simulation expected for various C&I systems also.

2.0.0 FUEL AND AIR FEEDING SYSTEMS

- 2.1.0 A realistic simulation of the fuel and air feeding systems shall be provided. The simulation shall encompass the following systems, as required in the specified plant, level control, feeder and pulverizer on-off control, feeder speed control, burner control mechanism, PA fans control, seal air fans control, scanner air fan control, fuel oil control etc.

Fan starting current, bearing vibrations and temperatures and associated alarms shall also be simulated.

- 2.2.0 The fuel oil system simulation shall lend itself to fuel oil pressure, primary and secondary air flow rate and pressure. The length of the flame as affected by primary air shall also be simulated. Math models shall include air feeding systems with humidity effects, damper position, (pressure drop effects due to friction) operating point on the fan performance curve, acceleration, expansion, the air heater with proper partitioning of primary air, secondary air, gas and metal regions. Fan horsepower shall be determined from flow and pressure and shall be related to motor current. Fuel inlet flow and temperature shall vary with the air heater and flow control adjustments. Coal system simulation shall include feeder speed, feeder and coal inertia effects, variable coal quality, variable coal-air mixture, coal-air mixture temperature at different stages, and pulverizer dynamics. Fluid transport delay shall affect the excess air/oxygen indication.
- 2.3.0 Realistic pressure, flow and temperature simulation shall be provided to derive appropriate parameters readings for the air and fuel circuit.
- 2.4.0 The plant interlock and protection system shall automatically initiate protective action, such as shutting down the plant, closing isolating valves/dampers, or starting standby auxiliary systems, whenever the plant conditions monitored by the system reach prescribed limits.
- 2.5.0 The burner ignition system shall be simulated as a function of control switch logic preprogrammed ignition time delays and complete burner logic systems and furnace dynamics.

**3.0.0 STEAM GENERATOR**

- 3.1.0 The steam generator shall be simulated by modelling heat transfer throughout the gas flow path, thermodynamic properties in the water wall tubes, separator, heater, reheater and economizer.
- 3.2.0 The steam generator dynamic model shall consist primarily of conservation equations, approach to property handling, semi-empirical heat transfer for different regimes, fluid flow correlations for single phase and two phase and appropriate equations of state applied to each region.
- 3.3.0 Furnace region, the fuel and air feed streams, oil spray, water vapor entry through various mechanisms, non-ideal combustion as a function of oxygen concentration, combustion chemistry and kinetics, wind box to furnace differential pressure and furnace draft, radiation and convection heat transfer to the furnace tubes and then to the working fluid shall be simulated. The heat transfer coefficients shall vary with flow. Appropriate heat losses, slagging and scaling effects on heat transfer and draft losses shall be simulated & correlated with metal temperature etc.
- 3.4.0 Heat transfer coefficients shall be reflected in the simulation of excess air and tilt of the burners.
- 3.5.0 Other steam generator regions to be simulated are as follows:
- Platen heater and adjacent furnace roof tubing.
 - Reheater, adjacent furnace room tubing and water cooled enclosure tubing.
 - Final heater, adjacent furnace roof tubing and water cooled enclosure tubing.
 - Second pass steam cooled enclosure, low temperature heater terminal tubing.
 - Low temperature heater and steam cooled enclosure tubing.
 - Economizer and steam cooled enclosure tubing.
 - Separator and start-up circuitry.
 - Shifting of triple point on load transition
 - Worst coal feed in one mill/two mills
 - Generator LLD high
 - Stator water flow signal faulty
- 3.6.0 In the Boiler, the gas temperature transport time and draft loss shall be simulated together with heat transfer to the working fluid via metal tubing. Convection heat transfer coefficients shall exhibit the appropriate flow dependence on both sides of the tubing. Radiant heat transfer, effective emissivity, slagging effects and geometric factors consistent with empirical boiler operating data shall be simulated. Provision shall be made for degrading the heat transfer surfaces due to soot accumulation.
- 3.7.0 The soot accumulation factor shall be capable of being reduced by activation of the soot blower, restoring heat transfer effectiveness. Working fluid simulation in each region of the boiler shall include transport time, temperature and pressure drop, consistent with flow rates and water/steam properties for the entire range of operating conditions to be encountered. Response characteristics of the steam generator instrumentation shall be simulated; these include natural needle movements, thermocouple time constants response times and similar effects.
- 3.8.0 EXCESS AIR ANALYSIS AND FLUE GAS DISCHARGE**
- Flue gas leaving the steam generator enters a plenum at the economizer gas outlet. These multiple ducts shall be simulated to reflect the effects of the air heater, damper, electrostatic fly ash precipitator and discharge through the stack. The simulation shall include plenum mixing and transport delay, ducting transport delay, gas pressure drop vs flow characteristics of the ducting and associated components (including dependence



- upon damper position), ID fan head-capacity characteristics, and fan motor current (including transient starting current) and steady state current consistent with the operating point on the fan operational characteristics curve and associated controls of the flue gas analyser, excess air indication shall vary realistically in accordance with the concentration of O₂, CO, CO₂ etc. in the sample flue gas, subject to analyser limitations.
- 3.9.0 Flame scanners acoustic pyrometers, and burner management system (BMS) and other special instrumentation should also be included in the simulation.
- 4.0.0 STEAM SUPPLY AND TURBINE**
- 4.1.0 The steam supply system includes heated steam lines, reheat steam lines to and from the turbine and condenser, the turbine extraction stages, HP-LP bypass lines, seal steam supply and heating auxiliary steam system including deaerator. The entire steam supply system shall be modelled by computing pressure, flows and temperatures from mass, momentum and energy balance equations. Relief valves in the main steam lines shall be simulated based on steam pressure and shall have staggered relief points.
- 4.2.0 Steam from the final heater will accumulate in the piping inventory and pass on through the turbines and reheater to the condenser and be used to warm up the piping and the turbines, provide heating, supply the steam coil air heaters, go to steam seals and be bypassed around the turbine to the condenser. The piping metal temperature and steam metal differential temperature shall be simulated.
- 4.3.0 The turbine bypass systems shall be simulated for hot and cold startup and response to load changes and throw off. The steam dump valve shall be modelled.
- 4.4.0 The auxiliary steam supply system shall be modelled. The steam coil air heater and steam atomizer pressure will vary from auxiliary steam header up to low loads and at higher loads from the extraction lines. Auxiliary steam header is provided with pressure and temperature control.
- 4.5.0 Turbine simulation shall properly represent turbine startup, operation and coast down. High, low and intermediate pressure turbine must be modelled by techniques that give an accurate agreement with the turbine Contractor's thermal design data.
- 4.6.0 Extraction points for feed water heaters must be modelled. Mass storage in the heaters is to be modelled.
- 4.7.0 The model for the turbine and auxiliaries shall also include the following but not be limited to:
1. Turbine Kinematics, including torque resulting from steam flow, inertia, generator load and mechanical and electrical losses.
 2. Turbine mechanics including the applicable vibrations and eccentricities. The turbine clearance and vibration model should provide for turbine rotor "bowing" effects with time and temperature dependence including results of "roll-out" on turning gear.
 3. Turbine thermodynamics, including temperatures, expansions, and differential expansions of turbine shaft and casing hardware shall be provided and related to TSI measurement. Valve metal temperatures where necessary shall be simulated.
 4. Auxiliary systems such as the hydraulic oil system and the turning gear system, lube oil system gland sealing system, etc. shall be simulated. The gland seal system simulation must allow representation of malfunctions causing deficient gland sealing with resulting air-in leakage.

5. Simulation of the turbine Electro-hydraulic control backed up by mechanical hydraulic controls including those functions necessary for start up, steady-state, and shutdown operation of the turbine. The simulation of governing system shall include L.P. bypass system and throttle valves also. The electro-hydraulic controls, mechanical hydraulic controls shall interface where necessary with other plant systems. The turbine wall stress analyser and automatic run-up system including automatic synchronizing and block loading up to 10% shall be simulated.
6. All the turbine steam admission valves shall be simulated reflecting both controller demands and protective logic demands.
7. Automatic testing of turbine protection system, stop valves and non-return valves and other testing (excluding maintenance) normally done by the operator from the unit control room shall also be simulated.
8. The variation in the time and in the operational procedures required as a function of the inlet steam parameters.

4.8.0 Condenser

- 4.8.1 Simulation of condenser shall accommodate all modes of normal, start-up and shut down operation. Condenser hotwell simulation shall include the proper mass and enthalpy balances. Condenser vacuum shall be simulated as a function of work done by vacuum pumps, air leakage into the condenser and the vacuum breaking valves. Load throw off conditions shall be simulated realistically.
- 4.8.2 Condenser water mass conservation shall include inputs from low pressure turbine, drains from HP and LP heaters, unit flash tank, makeup water flow and condensate pump bypass flow. The hotwell level control system shall be simulated.
- 4.8.3 On-load tube cleaning system also in required to be simulated in way similar to soot blowing.

4.9.0 Condensate and Feedwater System

- 4.9.1 The condensate extraction pumps shall be simulated by the appropriate change in the condensate flow as a function of head capacity data and flow resistance and control valve position. Boiler feed pump recirculation to the deaerator shall be modelled. Pump motor responses to starting operating and shutdown of pumps shall be simulated. The boiler feed pumps and associated shaft-driven booster pumps shall be modelled as turbine driven Control Valve controlled as well as motor-driven with variable speed hydraulic coupling. For TDBFP, the turbine shall also be simulated in a similar way to main turbine as applicable for MDBFP. The speed shall vary as a function of feedwater flow reflected by the differential pressure across the main feed regulating station. Pump inertia and speed changer characteristics shall be included in the simulation. The shaft-driven lube oil pump shall be included in the simulation. The dynamics of the turbine of boiler feed pumps shall also be simulated.
- 4.9.2 Control valve operations and its characteristics shall be properly simulated. The Contractor shall furnish the proposed method of simulating the control valves during the engineering stage. Any simplification and linearization in simulated valve characteristics will be subject to review of TANGEDCO prior to approval.
- 4.9.3 The mathematical models for condensate and feedwater flow, deaerator, the low pressure and high pressure heaters shall be provided. Zone-wise heat exchange model shall be provided. The heater drain valves actions shall be simulated. For each HP heater, the effect of heater level on the drain cooler and heater shell pressure shall be simulated. Effect of outage of one or more heaters over the efficiency of the plant shall be simulated.



- 4.9.4 Each heater shall be simulated as a mixing of steam either from the turbine extractions with condensate from low pressure heaters. The desecrator model shall include desecrator overflow and dump from the condensate line.
- 4.9.5 The flow to the condenser of the uncondensed steam plus absorbed gases, the desecrator level, temperature and pressure shall be simulated including their controls. The pressure drop in the feed water and condensate chain of piping filter and heaters shall be simulated as a function of flow, flow resistance and stop valve apertures.
- 4.9.6 The feed water temperatures and pressures, steam generation rate, heat input, boiler water blow down conditions shall be simulated. Temperature of the feed water to economizer will affect the energy of the heat at temperatures and reheat emergency at temperatures and hence heat and reheat steam temperature regulation.

5.0.0 WATER CHEMISTRY

- 5.1.0 By use of impurity masses, conductivity indications shall be dynamically simulated at the condenser hotwell, economizer inlet, condensate pumps discharge, boiler water and main steam. The external water supplies to each simulated impurity system shall be simulated as having fixed impurity content. The impurity concentration by distillation and chemical feed shall be simulated for the boiler water and steam conductivity indication and silica indication. The change in impurity indication concentration caused by boiler blow down shall be simulated and shall reflect on the boiler water and steam conductivity indication and silica indication.

6.0.0 PLANT COOLING WATER

- 6.1.0 Simulation shall be provided for the main as well as equipment/auxiliary cooling water system which rejects heat to the cooling water cooler from such equipment as the main condensers, generator hydrogen coolers, stator water cooling, turbine oil coolers, oil coolers, fan bearings, pumps bearings and direct water cooling of miscellaneous plant equipment. Heat transfer to these coolers may be modified by the instructor to reflect fouling of the water side. Ambient temperature variation shall be an instructor operation for the cooling water temperature variation for its variation to be felt into system efficiency.

7.0.0 ELECTRICAL SYSTEM

- 7.1.0 The electrical system math model shall simulate the main generator, static exciter and voltage regulator, in-plant and effect of external load flow on generator performance and load transients.
- 7.2.0 Generator hydrogen cooling system and stator water cooling system shall be simulated and shall accommodate all controls indications, and alarms in the unit control room. Hydrogen purity can be assumed to be predetermined, but may be deteriorated by the instructor causing trainee to take corrective measures from control room. The generator seal oil system shall be simulated for all controls and indications in the unit control room. Manual and automatic voltage regulation shall be simulated.
- 7.3.0 The electrical system model shall simulate in-plant emergency use during malfunctions and shall therefore, reflect conditions imposed by the listed malfunctions.
- 7.4.0 Simulation shall be provided for the station buses including the ability for the instructor to add and reject loads arbitrarily, the ability to separate the unit from the rest of the system, and the loss of unit supply. Individual simulation shall be provided for each of the major pump motor loads and other major station loads.



- 7.5.0 Simulation shall be provided for frequency synchronization computation, control and display. Synchronization function also needs to be simulated in the software with real time response.
- 7.6.0 For cases of loss of unit power, auxiliary emergency backup power and to switching the station buses shall be simulated. Load distribution simulation is required for at least the following components:
- 7.7.0 Generator, main buses with connecting breakers, unit buses (11 kV and 3.3 kV), station buses (11 kV and 3.3 kV). Bus breaker manual and automatic operation shall conform to those for the operational plant. At the instructor's option, the plant shall follow a programmed electrical load demand cycle.
- 7.8.0 The main generator must provide suitable dynamic response for the complete range of operations to be simulated. The model must accommodate start-up, load change, and trip conditions, including synchronous operation, and when disconnected, non-synchronous operation.
- 7.9.0 Effect of changes in the grid to which the generator is connected must be simulated to including free governing mode of operation (FGMO) to the extent that effect of reasonable changes in grid voltage ($\pm 10\%$) and grid frequency (47.5 to 52.5) must be represented with good fidelity. Both megawatt and mega Var loading must be simulated. The simulator must include functional simulation of the exciter and voltage regulator. Grid frequency can be predetermined, but shall be subject to change by the instructor to represent malfunction conditions.
- 7.10.0 For large components, the simulation of load switching shall include the effects of fluctuations in power, voltage and frequency display.

8.0.0 STEAM AND COMPRESSED WATER FUNCTIONS

- 8.1.0 Generation of the steam table functions, compressed water table functions and other function curves used at all points in the steam plant simulation shall be based on techniques that provide sufficient accuracy over the entire simulator operating range so that apparent degradation of simulator performance will not result. Generated functions shall be sufficiently free of break points, slope changes, and other discontinuities so that no spurious responses will result in simulator transients. In particular, no resulting break points or slope changes shall be apparent in trend & related displays.

9.0.0 PLANT CONTROL AND INSTRUMENTATION SYSTEM

This system shall be an emulation of plant control system (DCS) covering the scope of simulation. Brief functionalities of DCS system has been provided in section 4.6, from which Bidder shall get an idea about the functionalities of DCS system, both control system which is to be emulated and HMIPIS which shall be totally replicated by emulation.

10.0.0 INSTRUCTOR FUNCTIONS

10.1.0 General

The instructor shall be able to interfere with the model in various ways outlined below. For doing this, different modes like menu mode, mimic mode, expert mode etc. shall be provided.

10.2.0 Malfunctions

- 10.2.1 The simulator shall be capable of simulating the malfunctions given in the "List of Malfunctions" attached as Annexure A to this section with provision to accommodate a



- total of at least 500 malfunctions. The remaining malfunctions and their method of initiation shall be determined by the Simulator Manufacturer in consultation with Employer.
- 10.2.2 All of the malfunctions shall simulate conditions as they would occur in the plant. Also the system must simulate conditions that might be introduced by operator errors during a malfunction. Plant response to the malfunction shall be carried out a reasonable and stable operating condition as determined by Employer, by analysis of the training value of each malfunction. Models of malfunctions must include responses for no corrective action, improper action, and operator recovery cases.
- 10.2.3 An adjustable time delay shall be included in the malfunction software to permit the instructor to insert separate initiation times for selected malfunctions. Any number of malfunctions shall be capable of being initiated simultaneously or within a delay time selected by the instructor. This time delay shall be variable up to 2 hours.
- 10.2.4 The discernible transient response of certain malfunctions shall be simulated and accurately displayed on HMI. For example, if the inserted malfunction should cause a gradual increase in a pressure, then the concurrent changes in other parameters must be simulated through the level of advance alarm setting and up to the trip setting. If the operator does not take suitable corrective action upon noting the conditions or upon receiving the advance alarm the trip setting will be reached, and appropriate trip events, including unit trip shall be initiated. All malfunctions shall be simulated to persist until corrected by the operator or terminated by the instructor. It will be possible to select a degree of degradation in the system (0-100 percent with increments of 1%) for applicable malfunctions.
- 10.2.5 Some pre-selected malfunctions are non-recoverable, that is, those malfunctions where the operator trainee is not expected to bring the plant back to normal operation, for example, a furnace explosion. With each malfunction the contractor shall provide a description of the expected “hand off” response. This description shall include a list of affected displays, showing change in process parameters, and alarm activated. In addition, the contractor shall specify the appropriate operator responses to recoverable malfunctions.
- 10.2.6 The instructor shall be able to accomplish the following malfunction operations.
- 1) Time delay malfunctions by setting a problem time for malfunction activation.
 - 2) Initiate up to 20 malfunctions at the same time.
 - 3) Make a variable malfunction become progressively larger without clearing the malfunction.
 - 4) Determine which malfunctions are active.
 - 5) Select which component of redundant components is to fail when identified in the malfunction list.
 - 6) Select in which manner (high, low or fail) an instrument is to behave when identified in Malfunctions list.
 - 7) If a malfunction summary tableau is utilized, a brief malfunction description shall be displayed for each selected malfunction.
 - 8) Clearing the malfunction.
 - 9) Initiation of malfunctions with variable severity shall be varied by numerical quantity rather than percentage, e.g. loss of pump capacity or pump loads shall be given in absolute value rather than a percentage of rated flow.
 - 10) Others as finalized during detailed engineering.
- 10.3.0 Initialization**
- 10.3.1 The instructor shall have the capability of initializing the simulator to any one of the fifty (50) initial operation conditions. Selection of initialization conditions shall be done by the instructor. Actuation shall cause the necessary plant parameters to change to correspond



with the desired initialization conditions. No changes in programming/ software and making new settings shall be necessary to accomplish these changes. Initialization shall automatically remove all conditions and malfunctions present in the previous simulator operation. The instructor shall be able to initialize to any of 50 initialization conditions, 20 pre-selected conditions and 30 snapshot conditions. The pre-selected conditions shall meet the requirements of clause 10.3.2 below and shall be chosen by the Employer during detailed engineering. After any initialization condition is selected the system shall perform a switch check function to ensure that all parameters are at the expected value and only then it will run either automatically or after instructor's intervention. Facility to override switch check shall be provided as an instructor function.

10.3.2 The simulator shall be capable of having initialization conditions added or deleted at anytime in the future. However, the pre-selected initial conditions shall be password protected. A partial list of some typical initialization points is as follows:

- 1) Cold start-All equipment is stopped and all process temperatures are at 21⁰C. All piping, heaters, hot wells, deaerator storage tank and condensate tank an auxiliary boiler filled or at normal levels. The boiler is drained. Fuel oil is available. Electrical start-up system shall be de-energised.
- 2) Same as (1) above, except with the electrical startup system energized.
- 3) Partial cold start-Auxiliary boiler on, supplying steam seals, vacuum is established, the boiler is fired and all necessary auxiliaries are operating. Process conditions will be the same as for a cold start except those affected by this level of operation.
- 4) Bypass- The unit is operating with the turbine bypass valve almost fully open and essentially no steam to the turbine. All process conditions are reflected by this level of operation
- 5) Hot start- same as mode 1, except that all process temperatures are at their value for 75 percent load. Air compressors service water pumps, and turbine oil pumps are running as required.
- 6) Hot restart after unit trip – The boiler is operating at effectively normal pressure and temperature and the turbine bypass valve is open.
- 7) Cold turbine – Generator Rolling – The unit is just on turning gear and ready for acceleration. Process conditions will be appropriate for this level of operation.
- 8) Hot Turbine – Generator Rolling – The unit is effectively in same condition as in 7 above except turbine metal and associated equipment is at a higher temperature.
- 9) Half load – Unit is at normal conditions for 50% load.
- 10) Full Load – Unit is at normal conditions for 100% load.
- 11) Cold start – Ignition preparation state.
- 12) Cold start – Condenser vacuum up preparation state.
- 13) Cold start – Turbine start up preparation state
- 14) Cold start – Synchronizing preparation state.
- 15-49) (spares) for future expansions and/or special snapshot conditions.
- 50) Replay – initiate a replay to any prior simulator dynamic conditions recorded for up to 2 hours (just prior to freeze initialization). Replay of a prior dynamics state should be similar in operation to initializing the simulator in all respects.

10.4.0 Back Track And Replay/Record

10.4.1 Backtrack

The simulator shall have back-track backward and back track forward capability. The simulator backtrack capability shall meet the following minimum requirements:-

- a) The backtrack program shall continuously record the initialization data pool in one minute interval on the disk in a wrap round manner for a period of 60 minutes. Thus at any time, 60 minute data set shall be available covering preceding 60 minutes.
- b) The desired backtrack record shall be directly obtainable by the instructor either



selecting the problem time of the record or by having the program automatically step backwards in time either manually or automatically as selected.

- c) The instructor may initialize the simulator at a specific backtrack time. However, if the backtrack time is not specified, then it will default to one minute.

10.4.2 **Replay/Record**

- a) The record program shall initially store the current status of all parameters at the same rate at which the simulation module of highest interaction rate is running.
- b) The replay/record system shall be able to record eight hours of simulator operation.
- c) The instructor shall have the ability to replay any recorded tape to review the exercise and while this tape is being played all the parameters are available in the HMI.

10.5.0 **Remote Functions**

10.5.1 Functions (such as operation of manual valves etc.) that is not envisaged to be controlled from the control room (CR) and functions (such as tank levels, temperatures, differential pressures, etc.) which will be varied to change the operational conditions and procedures are required for simulation fidelity and diversity of operation and shall be designated as remote functions. The instructor's control of these functions should require minimum operations to change a particular function. Certain continuous type functions (such as manual valve positions, throttle valve positions, tank levels, temperatures, differential pressures, etc.) shall be simulated so as to provide the instructor with variable quantities through a specified range. This will, for instance, allow the instructor to vary the rate of increase/decrease of parameter (oil, water etc.) in a tank by throttling the flow of a parameter through a pipe, utilize automatic pump/value control logic by varying input parameters, etc.

10.5.2 Even through the method of simulation may take need multiple settings to control one functions, it will be counted as one remote function only.

10.6.0 **Time Scaling**

10.6.1 The simulator shall be capable of operating in three modes namely, fast time, real time and slow time.

10.6.2 Fast time (also called Real-Time Compression) shall provide the capability to accelerate the dynamic simulation in order to observe slow transients or shorten certain time consuming activities, such as obtaining adequate turbine heat up, boiler heat up, raising of condenser vacuum etc. which are characterized by long time- constant. The fast time interaction rate shall be supplied by the Manufacturer for final review and acceptance by Employer. Real time compression shall be provided at ten (10) times real time simulation.

10.6.3 Real time simulation shall be the normal simulation mode of operation and shall apply to all systems. All system dynamic models shall have sufficient iteration rate to ensure specified tolerance / fidelity and the real plant response.

10.6.4 Slow time (also called Real Time simulator expansion) that gives an apparent increase in the time interval shall be provided to slow down dynamic simulation in order to observe fast transients and trip situation, loss of component, accidents etc. that is characterized by short time-constant.

10.7.0 **Cry Wolf Alarm**

The instructor shall have the capability to initiate cry wolf alarms. These alarms will appear to the trainee as real events although no effects on dynamic simulation models will occur. These alarms will be clearly distinguished from malfunctions and will not be included as any part of the number of spare malfunctions required by this specification.

**10.8.0 Instructor Intervention**

The instructor shall have the capability of overriding any parameter without affecting the corresponding mathematical model computer process variable value. This override shall continue until reset by the instructor or by an exercise program. Override capability shall be provided on all inputs/output alarms and not on just a few, because in real life any instrument or alarm can fail leading to a false alarm.

10.9.0 Trainee Performance Program

10.9.1 Trainee performance shall be continuously monitored during a training drill. All operators' action shall be retained in memory with the name of the device manipulated, and the time of the actions. At the termination of the drill, the trainee performance program shall generate a summary of relevant data, including trainee's (or trainees') and instructor's names, date, nature of the training drill, name of variable, critical parameters, high and low deviations from reference values, total amount of units generated during exercise, etc.

10.9.2 The termination of the drill may be accomplished by the instructor at any time or it may be terminated by a preprogrammed time interval selectable by the instructor.

10.10.0 Trainee Exercise Program

10.10.1 A computerized exercise program shall be provided that will automatically step the trainee through a series of simulator drills and exercises plus a number of operational problems. This program shall be developed so as to eliminate / minimize manual control manipulations by the instructor. There shall be minimum of 20 exercises in trainee exercise program. These exercises shall be submitted to the Employer for approval.

10.11.0 Simulator Exercise Guide

10.11.1 The Contractor shall provide a suggested guide that will contain a series of simulator drills and exercises (minimum 50) arranged in logical sequence and according to difficulty of the task to be learned, subject to acceptance by Employer. The guide shall also contain a number of operational problems that the trainee will be required to solve at the simulator. The guide shall assist the instructor by outlining training objectives and specifying the practice sessions required to accomplish performance goals.

10.11.2 Other Required Functions

10.11.2.1 The instructor shall be able to monitor the following functions:-

- 1) Manipulate external parameters, which are not modeled, but which affect the simulated plant. These include external load, frequency and /voltage, power factor, and inlet temperature of cooling water etc.
- 2) Monitor the actual value of up to 200 specified intermediate calculated variables in the plant models with proper physical units for example, enthalpy, entropy, mass, volume etc.

10.12.0 Freeze / Run

It will be possible to freeze the dynamic simulations by the instructor. All the parameters & functionalities shall hold the current value / states till the intervention of the instructor. This can be stored to be used for a future initializing point. It will be possible to continue the programs at that point itself and run the system.



10.13.0 Snapshot

A selectable snapshot capability shall be provided to allow the instructor to store the particular conditions that exist at any instant during a training session, for future recall, as an additional initialization condition. This feature shall supplement the backtrack feature by allowing the instructor to recreate a particular training condition either within or beyond the periods covered by the backtrack mode. The snapshot feature shall have no effect on other initialization conditions discussed previously.

It shall be possible to store the full set of parameters at any instant during simulation by taking a snapshot without freeze. These snapshots also can be used as initialization points in future.

11.0.0 SIMULATOR SYSTEM AND HMIPIS HARDWARE FUNCTIONS

11.1.0 The simulator system shall consist of simulation computers, simulator programmer station, instructor's station and total HMI system (consisting of servers, workstation programmer station, LED monitor, Simulator & HMI network components & communication devices, interconnecting cables etc.) The numbers of stations /programmer stations, refer DCS Simulator Architecture Drawing (Dwg No. 30-1115112-I-352) attached as part of this Specification. However it may be noted that any additional equipment / software have to be provided by the contractor to meet the functional requirement of the specification, within quoted lump sum price.

The Simulator communication network path for connecting instructor station, trainee station, simulated EWS, DCS station and servers shall be redundant

11.1.0 Major hardware component

Brief purpose of each major hardware component is indicated below

11.2.1 Simulation Computer /Servers – 2 Nos

These servers along with their associate devices shall be the hardware to run the main simulation software, which include the basic OS, simulation environment, application programs & associated routines for process models & control system models. This station shall also be capable of a running multiple simulator software for simultaneous access to the simulator from both HMIPIS locations. These servers should also be able to double as additional simulation programmer station tools as mentioned at 11.2.2 below. Quantity of simulation computer /servers shall be provided as per the system requirement on Owner's review and it shall not be limited to two. Simulation computer/Server shall have the capability of the Virtual controllers to execute the process and control system models.

11.2.2 Simulator Programming Station – 1 No.

This station is intended for development, modification & documentation of simulator software. All necessary tools like GUI based modelling tools, Data base management tool, necessary compilers/ interpreters for high level language used for any application development etc. shall be provided. Further, all the functionalities and relevant features of DCS programming station including documentation facility shall be provided.

11.2.3 Instructor Stations – 2 Nos

This station shall be used for instructor's integration with the model for training purpose. This station shall be able to perform all instructors' functions mentioned in below . It shall also be possible to develop some combination of instructor's activity (e.g. certain



combination of malfunctions & remote operation etc.) and tools necessary for the same may be provided.

One No. 84" "LVS" with PC shall also be supplied and connected with DCS simulator network and this LVS shall also be utilized as MIS display unit. MIS network node shall be made available in the simulator room for 84" LVS connectivity.

11.2.4 DCS EWS – 2 nos.

These stations shall be used for holding the total HMI data base for all operator functions as well as for other HMI applications like Historical storage, logs, calculations, displays, command processing etc. in a manner similar to the reference plant. It should also be possible for this server to be switched to the real plant as well as some other station as the case may be.

The conceptual DCS simulator architecture drawing for Udangudi is as per drawing no 30-1115112-I-352. (However, the final implementation shall be as per finalised configuration diagram of the actual supplier). It may be pertinent to note that the HMI system of the Udangudi C&I system suppliers work on the basis of a server-less system. However, the Contractor is free to configure / emulate the system in a configuration using servers meeting the entire specification functional and parametric requirement as well as the communication to the real plant as specified elsewhere in the specification.

11.2.5 OWS – 8 Nos.

These are meant for trainee operator's interaction with the simulator, whose detailed functions are elaborated in the specification section

11.2.6 Network Connection

The function of the network connection is for interconnection between simulator system HMI, remote terminals, real life plant DCS system etc. The design of this system shall be sufficient to take care of all functionalities and parametric requirement including speed, bandwidth, response time etc.

12.0.0 SIMULATOR SYSTEM AND HMIPIS HARDWARE SPECIFICATION

12.1.0 The SIMULATOR and HMIPIS as specified shall be based on latest state of the art Workstations and Servers and technology suitable for industrial application & power plant environment.

12.2.0 The actual size of the Main and Bulk Memory shall be sufficient to meet the functional and parametric requirements as specified with 25% additional working memory and 50% additional bulk memory over and above the memory capacity required for system implementation. The exact system configuration and sizing shall be as approved by Employer. The Contractor to note that wherever memory (RAM or hard disk) capacity has been specified, it indicates actual "usable" Memory.

12.3.0 The Servers / Workstation employed for Simulator and HMIPIS implementation shall be based on industry standard hardware and software which will ensure easy connectivity with other systems and portability of Employer developed and third party software.

12.4.0 Communication channel between the MMIPIS and simulator system (as well between other devices / sets as detailed out in various modes of operation) including controllers, memory etc. shall be sufficient to handle all the communication system throughput including video information to meet the parametric requirement of simulator as well as HMIPIS system under worst case data flow.



12.5.0 Power Fail Auto Restart (PFAR) facility with automatic time update shall be provided.

12.6.0 All the peripherals shall conform to the following minimum requirement but the exact make & model shall be as approved by Employer during detailed engineering. The LAN to be provided under MMIPIS shall support TCP/IP protocol (Ethernet connectivity) with OPC RDI for interface with other systems wherever applicable and shall have data communication speed of min. 100 MBPS. All network components of LAN and Servers/ Workstations shall be compatible to the LAN, without degrading its performance.

12.7.0 Minimum specification for Servers/Workstations

Sr No.	Features	Simulator Servers and Workstations for Information functions	Operator workstations/ Other workstations
1.	Processor	64 bit/32 bit with minimum spectp95- 25; specint95-19	64 bit/32 bit with minimum spectp95- 20; specint95-15
2.	Memory	1 GB RAM up gradable to 4 GB	512 RAM up gradable to 1 GB
3.	Hard Disk	3 x 40 GB Ultra wide SCSI, Hot swappable	40 GB ultra wide SCSI
4.	Monitor (colour)	Min 24" LED Flat Monitor with resolution of 1280 x 1024 non-interfaced refresh rate min. 75 Hz.	Min 24" LED Flat Monitor with resolution of 1280x 1024 non-interfaced refresh rate min. 75 Hz.
5.	RAID	SCSI-channels, hardware RAID level 5 implemented.	
6.	Redundant hot swappable power-supply	2 nos.	-
7.	Removable bulk storage drive (MOD / DVD / DAT)	6 GB (minimum)	
	Removable Bulk Storage Media for above (with each server/ work-station)	10 nos	
8.	FDD	3.5" 1.44 MB	3.5" 1.44 MB
9.	CD ROM	40 x or higher	40 x or higher
10.	Intelligent UPS (on line) with remote monitoring for each work-station/ server	1 no. with 30 mins. Battery backup on machine load	
11.	Keyboard	ASCII	ASCII



Sr No.	Features	Simulator Servers and Workstations for Information functions	Operator workstations/ Other workstations
12.	Pointing Device	Mouse/Touch Screen	Mouse/Touch Screen
13	Accessories	Industrial grade furniture as approved during detailed engineering	Industrial grade furniture as approved during detailed engineering
14.	Additional general purpose software (for using over network by servers/workstation s/PCs)	Comprehensive disk maintenance utility for disk clean sweep/ crash guard/antivirus, etc. (like "Norton System Works 2000")	

It may be noted that separate servers have been envisaged for running the process models and the C&I models. However, each server shall be sized in a manner so as to be capable of running both the models on one server meeting all functional and parametric requirements.

13.0.0 SIMULATOR COMPUTER SOFTWARE

13.1.0 General Software Requirements

The Simulator Manufacturer shall use graphical packages for development of the models so that future modifications are very easily possible. For any specific customised application commonly used standard high level languages shall be used. This applies to programs which simulate power plant processes and equipments. The Manufacturer shall not employ direct machine / assembly level programs for development of application software. Programming techniques shall ensure that the applications are structured and modular and easily understood, maintained and/or modified by programmers having average knowledge of the languages used, without the need of very special training.

All Network intrusion protection / security software (like firewall / anti-virus etc.) shall be provided with free update for five years after warranty.

The Simulator Computer Software shall include the following:

- a. Operating system software, including Utility and debug software as well as Diagnostic and test software

The Simulator Manufacturer shall utilize the computer vendor supplied operating system software. This operating system shall have the following characteristics as minimum.

1. Real time multiprogramming operating system supporting multiple concurrently executing programs.
2. Multiple software priority levels
3. Dynamic memory allocation and deal location
4. Program overlay support
5. Memory resident sub routine library support
6. Interprocess and shared memory support
7. Control & servicing of standard peripherals devices.
8. system procedure for task activation, schedule
9. file management services support
10. Global memory support
11. Re-entrant executive services



12. On line watchdog routine
13. Automatic power fail and restart capability
14. Re-entrant program generation
15. Mass storage editing programs
16. Real time I/O and interrupt handling capability

- b. Plant simulation software (Process model, C&I model and HMI to meet total functional requirements)
- c. Instructor station software (To carry out various instructor's functions including invoking of malfunctions, remote functions etc., trainee exercises and other activities)

13.2.0 HMIPIIS Software

13.2.1 System Software Requirements

- 01 The Contractor shall provide all software required by the system for meeting the intent and functional/parametric requirements of the specification.
- 02 Industry standard operating system like UNIX/WINDOWS (latest version)/OPEN-VMS etc. to ensure openness and connectivity with other system in industry standard protocols (TCP-IP etc.) shall be provided for HMIPIIS. The system shall have user oriented programming language & graphic user interface.
- 03 All system related software including Real Time Operating System, File management software, screen editor, database management software, On line diagnostics/debug software, peripheral drivers software shall be provided. Latest versions of standard PC-based software for database handling, word-processing, spread sheet, etc. and latest WINDOWS based packages etc. and any other standard language offered shall be furnished as a minimum. Systems having program development environments like Programmer's stations, Station LAN Server shall have high level programming support like Microsoft visual studio, Oracle RDBMS etc.
- 04 All application software for control system functioning like input scanning, acquisition, conditioning, processing & control along with communication among various Control System functional blocks, HMIPIIS and system bus, HMIPIIS software for operator interface of monitors, displays, trends, curves, bar charts etc., performance calculations (with Steam properties routines utilities), Historical storage and retrieval utility, sequence of events recording, system functions shall be provided.
- 05 The Contractor shall provide software locks and passwords to Employer's engineers at site for all operating & application software in order to prevent unauthorised access and only Employer's authorised engineers be able to do modifications at site.
- 06 Two sets of backup software on non-writeable media shall be provided.

13.2.2 Software License

- 01 The Contractor shall provide software license for all software being used in HMIPIIS. The software licenses shall be provided for the project (e.g. organization or site license) and shall not be hardware/machine-specific. That is, if any hardware/machine is upgraded or changed, the same license shall hold good and it shall not be necessary for Employer to seek a new license/renew license due to upgradation/change of hardware/machine in HMIPIIS at site / PMI. All licenses shall be valid for the continuous service life of the plant.
- 02 In case the s/w license is dependent on no of points, then quantity to be considered is 30% above the finally implemented points.

**13.2.3 Software Upgrades**

- 01 As a customer support, the Contractor shall periodically inform the designated officer of the Employer about the software upgrades/new releases that would be taking place after the system is commissioned so that if required, same can be procured & implemented at site. It shall be possible to download the same in the system without requiring a shutdown.

14.0.0 WARRANTY

- 01 The Contractor shall provide an unlimited warranty on all equipment and software for one year after the start of the warranty period, i.e. after satisfactory completion of initial operations. This warranty shall include repair, replacement or correction of identified software or hardware discrepancies at no cost to Employer.
- 02 No repairs/replacement shall normally be carried out by the Employer when the plant is under the vision of Bidder's visory engineers. If in the event of any emergency, in the judgment of the Employer, delay would cause serious loss or damage, repairs may be made by the Employer or a third party chosen by the Employer without advance notice to the Bidder and the cost of such work shall be paid by the Bidder.
- 03 The Bidder shall provide warranty spares and an exhaustive list of warranty spares including components for system hardware and instrumentation and peripherals based on (and keeping adequate margin over) normally experienced failure rate shall be submitted by the Bidder for Employer's review regarding adequacy of the same. The Bidder must furnish the list before inviting Employer's personnel for Factory Acceptance Test (FAT). The warranty spares as per the list mentioned above will be dispatched by the Bidder along with the main equipment consignment. The Bidder shall also provide expandable items for the warranty period. This shall include printer ribbon, ink/ toner cartridge, print head etc. Excluding floppy disk, M.O. Disk, tape cartridge and paper. Unused spare/consumable shall be contractor's property and taken back.
- 04 In case of any hardware failure which hampers normal operation, the Bidder during the warranty period must provide on-site technical expertise to repair/rectify the problem within a week and if any component is not available at site, the Bidder must arrange to supply these components at site within additional 48 hours. If a software problem is identified, this problem shall be corrected within two weeks.
- 05 After six months of Simulator operation the Bidder shall provide the list of parts and expendables utilized for the period. The same information will be provided at the conclusion of the warranty.
- 06 In order to discharge the warranty responsibility, the bidder shall include in his proposal lumpsum price for the provisions of a team of service personnel at Site who will be fully qualified to perform the required duties throughout the warranty period of one year. The Bidder shall deploy at least one engineer, two visors and four technicians in the team. The Employer shall approve the exact nos. & composition of team members. In case, the team is unable to rectify hardware or software problems, the Bidder shall depute and/or station additional specialist to rectify the problem to ensure 99.7% availability of system. The availability of system shall be calculated as per Sub-section-IV, Part-A, Section-VI of specifications.

15.0.0 ANNUAL MAINTENANCE CONTRACT (AMC)

- 01 The Bidder shall provide maintenance services of complete Simulator System under a comprehensive Annual Maintenance Contract (AMC) for period of Three years after



Warranty period. Employer shall have the option to not renew the AMC after end each year for first two years after giving a notice of one month.

- 02 On the other hand, the comprehensive AMC may be extended beyond the three year period mentioned above, with mutually agreed terms and conditions.
- 03 The AMC shall cover total maintenance of all hardware & software coming under the scope of Simulator and shall include free repair/replacement of all cards/modules/peripherals/cables/components etc., correction of software problems and supply of expendable items. The Bidder shall ensure 99.7% availability of the system with the AMC. For that purpose, contractor may maintain adequate no. of staff at site as per his own assessment if considered necessary to ensure availability.
- 04 Further, Bidder may note that during the AMC he will be allowed to use Employer's mandatory spares and has to replenish the same within three months time or before completion of AMC period whichever is earlier. However, if in the opinion of the Bidder, more spares than those included in the mandatory spare list are required to meet the availability requirement, then Bidder shall stock the same.
- 05 The Bidder shall prepare detailed list of faults corrected and parts, expendables utilised during AMC period and shall furnish the same to Employer, properly documented at the end of AMC period. Further, during AMC period the details as required by Employer/ Project Manager shall be made available by Bidder's personnel.



ANNEXURE A LIST OF MALFUNCTIONS

Sl. No.	Malfunction	Cause
1.	Coal pulverizer (A-K) choking or loading up	Coal moisture content increases from the design valve of 12% to an instruction variable amount 12-25%
2.	Coal FDR (A-K) trip	Motor overload
3.	Pulverizer (A-K) trip	Motor overload
4.	Pulverizer reduced capacity (A-K)	Rise of mill temp. due to hot air
5.	Pulverizer reduced capacity (A-K)	Change in coal quality causing the grindability index to decrease a Variable amount (0-100%)
6.	Coal FDR (A-K) fails to deliver coal	An accumulation of wet coal striking to the sides of the coal feeder disdark . Causing a reduction of pipe diameter at 5% MIN.
7.	Water wall tube leak (5 different zones)	Erosion caused by soot blowing has worn the tube metal thin enough to cause a tube leak at an instr. Variable rate of zero to 100%
8.	(A) or (B) ID fan trip	Phase to phase fault causes circuit breaker to open.
9.	(A) or (B) FD fan trip	Oil pressure switch fails closed.
10.	(A) or (B) PA fan trip	PA Fan outboard bearing temp. indication from (A) side fan or (B) side fan fails high.
11.	(A) or (B) ID fan outboard brg. Temp. high	Wiped bearing.
12.	(A) or (B) FD fan outboard bearing temp. high	Wiped bearing
13.	(A) or (B) PA fan outboard bearing vibration high	Instructor variable 0-100 microns above normal levels
14.	(A) or (B) ID fan outboard bearing vibration high	Instructor variable 0-100 microns above normal levels
15.	Flame scanner shows flame continually (for each Oil / Coal elevation)	Instructor induced malfunction
16.	Fuel flow runback to less than demand	Spurious electrical malfunction in auto combustion control causing fuel flow to drop by 20% and then revert to manual.
17.	RH tube leak	Tube failure
18.	Secondary SH tube leak	External erosion causes an instructor variable peak from 0 to 100%
19.	Electromatic safety vlv. Fails open	Steam pres. Transmitter fails high
20.	Primary air out of air heater damper fails closed	The linkage connecting the damper to the actuator fails allowing the (A) side dampers to go closed.
21.	Pulverizer (A-K) tempering air damper froze	Binding in linkage.
22.	Plugged air heater (Both for primary and secondary)	Build up of fly ASH on air heater elements
23.	Aux. Air damper adjacent to coal elev. Faulty modulating	Control malfunction giving 20% less out put than required



Sl. No.	Malfunction	Cause
24.	BMS DC supply failure	BMS cabinet fuse blown
25.	A or B FD fan discharge Damper fails closed	Broken linkage allowing the damper to close
26.	Aux. Air damper not modulating	AB Aux. Air damper stuck
27.	Left side furnace pres. Transmitter false reading	Pluggage of left side furnace pres. With ash
28.	Burner tilts fail high	Controller malfunction
29.	HO header pres. Low	Slow response from the header pres. Regulator as the first set of oil gun valves are opened.
30.	HO trip vlv. Fails closed	Broken air line to the valve actuator
31.	HO temp. low	Temperature controller fails high and causes the steam flow regulating valve to the 2 HO heater to close.
32.	HO supply header pres. Low	HO discharge strainers begin plugging up at 2% per minute until they have completely plugged.
33.	Aux. PRDS valves fail closed	Auto controller malfunction
34.	(A) or (B) air heater main drive motor trip (Both on sec)	Motor overload causes the circ. Breaker to open
35.	Firing rate limited	Poor coal quality
36.	Air flow runback to less than demand	Instructor variable 30 to 100%
37.	ID fans (A or B) inlet vanes froze	Air failure to the E/P converters
38.	High SH tube metal temp.	Partial pluggage of the final SH section causes elevated tube metal temp. on the clean side
39.	Boiler water /steam silica concentration high	Silica analyzer fails high
40.	Throttle pres. Transmitter failure	Electrical malfunction causes transmitter output to fail low
41.	Loss of seal air to pulveriser (A-K)	Seal air damper fails closed
42.	Air flow less than 30%	Air flow controller minimum set point offset to 28% air flow
43.	Air flow more than 40% during startup	Minimum air flow setpoint offset 10% high
44.	All pulverizers trip	Spurious elec. Signal from BMS hot primary air L0 L0 pres switch lasting one second.
45.	Boiler purge timer failure	Timer fails to reset and gives the purge complete indication as soon as all the purge permissive have been met.
46.	Flame scanner failure	Instructor induced malfunction
47.	Igniter pair 1 and 3 elevation (AB, CD, EF, GH or JK) fail off	IFM failure due to soot deposits.
48.	Elevation AB oil gun 1 scavenging valve sticks open	Operating solenoid stuck
49.	No start permissible pulverizer (A-K)	Pulv. Disc. Gate limit switch failure
50.	Pulv. (A-K) primary air flow temp. comp. Thermo-couple fails	Broken wire on thermocouple



Sl. No.	Malfunction	Cause
51.	Pulverizer hot air gate fails closed (A-K)	Spurious electrical signal causes the hot air gate to close
52.	Pulv. (A-K) motor stator temp. high	Partial blockage of motor ventilation
53.	Pulv. Air flow feedback offset 25% high (A-K)	Tapping point used for air flow measurement becomes partially plugged and gives false air flow signal
54.	Pulv. (A-K) fails to start	Shaft seizure
55.	Loss of coal feeder flow rate indication (A-K)	Both FDR flow transmitter fail low
56.	Furnace walls badly slagged	Poor pulverizer performance causes ASH to accumulate at 10 time the normal rate
57.	Abnormal ASH buildup on reheater pendant	Change in ASH characteristics of coal being burned causes ASH to accumulate on the reheater tube surfaces at 20 times the normal rate
58.	ASH buildup in the economiser	Poor coal quality causing ASH to accumulate at 10 times the normal rate
59.	Primary air pres. Control malfunction	PA fan inlet vane position freezes regardless of controller output.
60.	Furnace pres. Controller malfunction (A or B) side	Controller electrical malfunction causes the associated ID fans inlet vanes to go wide open
61.	Purge ready condition can not be met	Pulverizer hot air gate not proven closed
62.	Air heater fire (A or B) (both for primary and secondary)	Accumulation of unburned fuel particles
63.	Auxiliary air damper control power failure	Control maintenance personnel mistakenly turn off the electrical power serving the auxiliary air damper control
64.	Burner tilt position difference	Binding linkage on corner no. 1
65.	Stator cooling water tube leak	Broken hose supplying the stator winding being measured causes a leakage rate of 4 lit. per minutes
66.	Hydrogen cooler tube leak	Tube rupture caused by corrosion produces a leakage rate of 1 litre per minute
67.	Loss of H2 seal oil pressure	Seal oil filter beings plugging up at 2% per minute
68.	Generator hydrogen leak	Leaking pipe flange, instructor variable 0 to 100%
69.	Generator gas temperature high	H2 coolers heat exchange surfaces become fouled and impede heat transfer by 30%
70.	Low stator cooling water flow	Stator cooling water filter begins plugging at 2% per minute
71.	Loss of outside power to buses 1A & 1B	Reserve station supply breakers fail to close on unit trip
72.	Generator trip	Phase to phase electrical fault
73.	Generator auto voltage regulator failure	Pulse amplifier fails
74.	Electrical transmission network being fed by the generator drops down to 49.5 Hz	Overloaded transmission system
75.	System voltage drops low	High demand for reactive power causing main bus voltage to drop 5%
76.	Loss of Generator excitation	Load on rectifier transformer



Sl. No.	Malfunction	Cause
77.	Unequal generator phase loading	Imbalance on the main 400 kV bus
78.	Loss of 220 V DC bus to FSSS	Electrical fault on the bus opens the feeder breaker
79.	Loss of 415 VAS bus	Electrical fault of the bus opens the feeder breaker
80.	Loss of normal feed BKR to the AC/ emer. Bus section	Elect. Fault causing incoming BKR to trip
81.	Magawatt transducer fails	Blown fuse in the transmitter
82.	Low stator water resistance	Deionizer capacity exhausted and high conductivity water leaking into the system from the makeup line.
83.	Loss of one hydrogen cooler	Air locking in H2 cooler
84.	Generator bearing 1 babbit temp. high	Restriction of oil flow to bearing
85.	High stator cooling water temp.	Clarified cooling water passing through the stator water cooler in inadvertently throttle to a point where heat removal capacity is reduced by 50%
86.	Seal oil leakage into the generator	Seal oil drain port on turbine end becomes restricted
87.	Auto synchronizer rails	Running frequency input is lost
88.	Generator seal oil temperature high	Cooling water flow to the seal oil cooler is lost
89.	Generator transformer oil temperature high	Loss of cooling system
90.	(A or B) unit Transformer failure	Differential relay operates on electrical fault
91.	Loss of emergency supply power	Diesel generator fails to start on loss of normal essential service feed
92.	Generator auto voltage regulator oscillating	Control malfunction
93.	DC seal oil pump fails to start	Loss of power supply to the pump
94.	Stator cooling water pump (A-B) trips	Motor overloaded
95.	220V DC bus fuse blown	Main bus fault
96.	Loss of condenser circ. Water pump (1-3)	Phase to phase fault causes the circuit bkr. To open
97.	Ext. STM shutoff vlv. to 6 H.P. FW HTR fails closed	Spurious electrical signal
98.	LP heater 3 tube leak	Tube failure causes a leakage rate of 100 T/HR
99.	FW heater tube leak	Tube failure causes a leakage rate of 100% instrument air
100.	(A-C) BFP high brg. Vibration	Mech. Seal failure causing vibration. To increase at a rate sufficient to trip the pump on high vibration after 10 min.
101.	Loss of BFP suction (A-C)	Pluggage of suction filter
102.	Condenser tube leak	Cross sectional break in the left side tubes causing disturbance in condenser vacuum. Variable rate of leakage into the Hotwell of 0 to 100%.
103.	Condenser air leakage	Mechanical failure of the condenser structure causing an instructor variable leakage rate of 0-100%
104.	A or B condensate pump trip	Electrical fault



Sl. No.	Malfunction	Cause
105.	Ext. steam vlv. to LP FW heater fails closed	Spurious electrical malfunction
106.	FW heater tube leak	Tube failure causes a leakage rate of 100% instrument air
107.	(A-C) BFP high brg. Vibration	Mech. Seal failure causing vibration. To increase at a rate sufficient to trip the pump on high vibration after 10 min.
108.	Loss of BFP suction (A-C)	Pluggage of suction filter
109.	Condensate recirculation Valve fails open	Spurious electrical malfunction causes SV to de-energize
110.	A or B condensate pump trip	Electrical fault
111.	Ext. steam vlv. to LP FW heater fails closed	Spurious electrical malfunction.
112.	(A-C) BFP HYD coupling oil temperature high	Hyd. Coupling oil cooler becomes plugged up at 10% a min.
113.	Condenser circ. Water differential pressure high	Large pieces of debris restrict circ. Water flow by 0-25% operator variable
114.	HP FW HTR ext. stm. Block vlv. fail to go closed on demand	Mechanical binding
115.	Loss of station air pressure	Break in station air header
116.	Loss of instrument air pressure	Leakage flange
117.	Loss of aux. Steam	Aux. Steam header cross tie valve to aux. Boiler steam supply header vlv. Fails/ closed.
118.	Stuck water wall soot blower (A-B)	Fully retracted limit switch fails to make up after soot blower has done blowing
119.	AH cold end temperature low (A or B)	Condensate backs up into the steam coil air preheaters (A or B)
120.	Loss of gland steam vapor extractors	Thermal overload opens the circuit breaker
121.	Loss of turbine lube oil vapor extractor	Motor overload circuit breaker opens
122.	Scanner air fan (A or B) trips	Motor overloaded
123.	UPS supply failure	Electrical malfunction
124.	Loss of soot blowing steam	Soot blowing steam regulating valve fails closed
125.	Retractable soot blower failure	Broken steam valve actuating steam
126.	Air heater air motor fails to auto start (A or B)	Electrical malfunction
127.	Hydrazine feed pump fails (A-B)	Pump mechanical failure causes hydrazine injection to cease
128.	A or B turbine aux. Oil pump trips	Motor overload
129.	Low sec. Oil pres. To the intercept control vlv.	Leaking secondary oil piping after follow up piston
130.	Gland steam condenser tube leak	Ruptured tubes causing leakage at a rate of 100T/HR
131.	Loss of turbine gland sealing steam	Steam seal supply valve losses its control signal and fails closed.
132.	Gland steam pressure high	Gland leak off control valve losses its negative voltage input and goes closed
133.	Emergency stop valves fails closed	Spurious electrical malfunction of the test solenoid



Sl. No.	Malfunction	Cause
134.	Intercept stop valves fails closed	Spurious electrical malfunction of the test solenoid
135.	Turbine control valve malfunction	Governing system malfunction causes the control valves to fail to an instructor variable position 0 to 100%
136.	Loss of exhaust hood sprays	Spurious electrical malfunction causes the hood spray valve to close
137.	Turbine main pump failure	Broken impeller
138.	Low turbine lube oil reservoir level	Corroded cooling water tube causing a leak of oil into the cooling water at a rate which causes the turbine oil reservoir level to drop at 25 mm per min.
139.	High turbine bearing vibration	When this malfunction is inserted, the vibration on all turbine bearing will increase an instructor variable amount (0-100) microns over the normal level
140.	ATRS subgroup sequence control turbine system failure	Control coordinator card failure
141.	ATRS sub loop control turbine drains failure	Electrical fault
142.	Loss of turbine TSI power	Turbovisory cabinet power supply fuse blown
143.	Broken last stage turbine blade	Metal fatigue causing a small piece of metal to break off from one of the blades
144.	Main turbine EHG control fails high	Spurious electrical malfunction
145.	Turbine axial shift high	Thrust bearing pad failure
146.	Main turbine lube oil cooler cooling capacity reduced	Biological fouling of heat transfer surfaces
147.	Barring gear valve stuck closed	Mechanical binding
148.	High turbine back pressure	Fouled condenser instructor variable 0-100%
149.	Turbine thrust BRG trip device faulty	Return oil line plugged
150.	Emergency stop valve before seat drain valve will not open	Mechanical binding
151.	Loss of control power to turbine EHC system	Ground fault in main cont. circuit
152.	Turbine HP bypass spray valve fails closed	Remote operator inadvertently closes
153.	LP bypass desup. Valves fail closed	Loss of control oil pressure
154.	Water in the turbine inlet steam	Emergency stop valve before and after seal drain line plugged, allowing condensate to form in the main steam line.
155.	Wall stress analyzer failure	Electrical malfunction
156.	Turbine LP bypass fails	Electro hydraulic converter follow up piston sticks.
157.	Turbine HP bypasses vlv. (1-2) fails to open on demand	Steam temp. thermocouple down steam of the HP bypass valve failed high
158.	Turbine lube oil temp. control failure	Temperature transmitter being used for control, develops and offset 10 C lower than actual.
159.	Turbine low lube oil pressure trip device faulty	Pressure switch failure
160.	ATRS control power failure	Ground fault on field wiring



Sl. No.	Malfunction		Cause
161.	ATRS sub group oil system failure		Control coordinator card failure
162.	Low VAC trip device fails to function		Piston valve in the low vacuum trip device sticks in the upper position.
163	PA fan IGV Position Feed Back faulty		Loss of position feed back
164	ID fan IGV Position Feed Back faulty		Loss of position feed back
165	FD fan IGV Position Feed Back faulty		Loss of position feed back
166	Malfunctioning of Air Pre Heater rotor		Mechanical fault
167	Post purge trip		
168	AB elevation one corner HO MIV closed		Spurious close
169	Low O ₂ level in Flue gas path		
170	Generator cold gas temperature high		
171	Stoppage alarm		
172 to 500	Various failures / errors related to C&I systems starting from field instruments, actuators, instrument air supply, cables, control system modules like I/O modules, controllers, DC and UPS power supplies, impulse pipes/ tubes, fittings, analysers, HMI system components, data base and other software, System bus and other communication devices etc.		To be Elaborated During Detailed Engineering Stage.



VOLUME II
SUB-SECTION 4.18

PLANT SECURITY AND SURVEILLANCE SYSTEM (PSS)

1.0.0 DESIGN REQUIREMENT

1.1.0 Plant security and surveillance system (PSS) shall be an integrated system comprising the following systems/facilities:

- (a) Perimeter Intruder Detection System
- (b) CCTV Monitoring of Plant area/ equipment
- (c) Security card access system
- (d) Patrol Guard Monitoring System.

1.2.0 The design of the security & surveillance shall take into account of the potential risks to the Udangudi Supercritical Thermal Power Project.

1.3.0 Perimeter Detection & CCTV monitoring shall be carried out from the security room in the service building. Camera Video monitoring viewing facility shall be provided at CCR. CCTV monitoring at CCR and both CCTV & perimeter intruder monitoring shall be provided at security room.

1.4.0 The cameras for perimeter detection system and CCTV monitoring shall be connected to suitably distributed remote units and remote units shall be then be connected in groups through fibre optic single mode for transmission of video signals.

1.5.0 All camera images shall be continuously recoded. The system shall allow record and hold cameras images for minimum period of 30days. Bidder shall provide calculation of memory selected for this purpose. Facility for transferring camera videos files to separate recorders/data storage devices and include play back facility for the video files.

1.6.0 The location of LED monitors are as follows

Two (2) nos. 40" LED monitor with mouse / track ball at security room for each of perimeter monitoring & CCTV.

Four (4) no. 40" LED monitor with mouse / track ball at CCR for CCTV monitoring. These LED TVs shall be installed and hanging from the false ceiling of the Central control room

One (1) no. 32" LED monitor with mouse / track ball at CHP control room for CCTV monitoring.

One (1) no. 32" LED monitor with mouse / track ball at AHP control room for CCTV monitoring.

One (1) no. 32" LED monitor with mouse / track ball at DM plant control room for CCTV monitoring.

One (1) no. 32" LED monitor with mouse / track ball at Station In charge room for CCTV monitoring.

One (1) no. 32" LED monitor with mouse / track ball at Chief Engineer room for CCTV monitoring.

1.7.0 **Camera Mounting:** The camera shall be mounted in a clear, unobstructed view of the scene to be observed. Necessary mounting bracket / pole and accessories to be provided for proper & rigid support to the camera. The installation shall be done in such a way easily accessible for maintenance and there is minimal risk of accidental damage.

1.8.0 **Camera Enclosure:** The protection class of these enclosures shall be IP 65 or better. The camera mounting platform shall be constructed from rigid non-conducting material. The housing shall be suitable for obstruction free viewing. For outdoor camera enclosures in



addition to the requirements detailed above, thermostatically controlled heater, blower with filter and sun shroud shall be provided.

- 1.9.0 The system shall be provided with redundant UPS power supply.

2.0.0 PERIMETER INTRUDER DETECTION SYSTEM

- 2.1.0 The perimeter detection system shall be installed along the entire length of fence/boundary of the power plant and all entry & exit gates on the boundary. The system shall be capable of providing 24 hour continuous surveillance system.

- 2.2.0 The intruder detection system shall be based on video motion detection technology and shall be able to distinguish between whether the intruder is a human being or an animal. Upon detection, suitable alarms to be raised to security guards and corresponding camera video shall be displayed.

- 2.3.0 The intruder detection system shall be independent with its own servers, PC Video storage device, cameras software, poles mounting hardware and necessary civil & masonry works.

- 2.4.0 Cameras shall be provided for a proper coverage of total perimeter length. However, individual camera coverage shall not exceed 200 meter distance along the perimeter length.

- 2.5.0 Cameras shall be provided with auto IRIS lens, low lux density (0.1 lux) suitable for functioning in darkness (night shot capability) and Infra red illuminator.

3.0.0 CCTV MONITORING SYSTEM

- 3.1.0 CCTV monitoring system shall provide an overview of the important plant equipment in order to ascertain that, there are no obvious mechanical problems. Refer Plant security surveillance system configuration diagram (DWG No. 30-1112140-I-353).

- 3.2.0 The system shall provide simultaneous monitoring from both CCR & security room.

- 3.3.0 CCTV system shall be provided for following plant equipment/areas. The quantities of camera listed below are only for a unit and a common plant. Quantities shall be provided as per the below mentioned requirement.

- 3.4.0 The CCTV system shall have digital video recording facility as well as data management facility at suitable independent location. contractor shall provide suitable digital video recording & management system (dvrms) for this purpose.

- 3.5.0 The Digital Video Recording & Management System (DVRMS) shall be designed and developed to the following standards:

- i. ISO 9001 (2000)
- ii. ISO/IEC 15504 Level 3 or higher (SPICE2.0 Software Process Improvement and Capability Determination)
- iii. SEICMM Level 3 or higher (American Software Engineering Institute - Capability Maturity Model)

The Digital Video Recording & Management System shall include:

- i. Redundant Database Servers



- ii. Camera Servers
 - iii. Security or Control Systems
 - iv. Operator Stations
 - v. Network connected cameras and/or network connected camera streamers
 - vi. Network infrastructure
- 3.6.0 DVRMS shall consists of major components and software which are specified at subsequent clauses

3.6.1 Redundant Database Servers

01 The Database Server contains a database of all network-connected cameras and their configuration.

02 The Database Server shall:

- a. Manage the system database, containing details including
 - i. System configuration
 - ii. Camera configuration and settings
 - iii. Recording configuration and settings
 - iv. Configuration of Quad Views and Sequences
 - v. Details of recordings
 - vi. Schedules
 - vii. Operator security details
 - viii. Configuration of Surveillance and Alarm Monitors
 - ix. Configuration of Video Analytics
 - b. Manage communication between the Operator Stations and the Camera Servers
 - c. Video Motion Detection
 - d. Allow alarms/events in the Security System or Control System to initiate recordings
 - e. Report any camera failures or recording failures to the integrated Control system or Security system
 - f. Provide a full audit log of all system status (camera, streamer, server availability) and operator actions.
- 03 The Database Server shall be able to be use in a redundant configuration, using two separate Database Servers (being executed on separate Work stations). The backup Database Server shall be continuously synchronized with the master Database Server to ensure that it is always up-to-date and ready for a fail-over, when required.



- 04 The DVRMS must be capable of running a pair of similarly configured computers in a hot backup configuration where at any point in time, one is the acting Primary and the other is acting as the Hot Backup. An on-line database duplication mechanism must be supported.
- 05 Simply having each Database Server scan each Camera Sever, or requiring the Camera Servers send all updates to both Database Servers is not acceptable. The database duplication must be performed on a per-transaction basis for two reasons:
- i. To ensure that the duplicated Backup database is consistent at all times with the Primary database
 - ii. To avoid unnecessary loading of Camera Servers caused by duplicate polling
- It must be possible to remove one of the redundant systems for maintenance without interrupting operation, and upon its reinstatement, re-synchronize the databases, again without interruption to system operation.
- 06 The Database Server shall be able to operate with no performance degradation using the hardware and operating system configuration: as detailed in section XXI or latest

3.6.2 Camera Servers

- 01 The Camera Server(s) must be capable of supporting a large amount of disk space for online video storage and access to high capacity archiving mechanisms for the removal of stored video to off-line media.
- 02 The Camera Server shall:
- i. Manage live video from camera streamers
 - ii. Transmit live video to Operator Stations
 - iii. Receive camera control commands from Operator Stations and then send the commands to cameras
 - iv. Store live video to hard disk
 - v. Transmit previously stored video to Operator Stations
 - vi. Archive previously stored video to off-line storage media
 - vii. Retrieve archived video from off-line storage media
 - viii. Provide Video Analytics including:
 - ix. Video Motion Detection
 - x. Export the recordings into MPEG format so that it can be viewed using standard tools including Microsoft's Video Player.

The Camera Servers shall rely on the Database Server for all camera database information. Proprietary hardware platforms are not acceptable.

The Database Server must provide the following system fault tolerance:

- i. Support RAID 0+1, 1, 3 or 5 for the Operating System



- ii. Support RAID 0+1or1 for the DVRMS database (SQL Server)
- 03 The Camera Server shall be able to operate with no performance degradation using the hardware and operating system configuration as detailed in section XXI or latest

3.6.3 Network Cabling

- 01 A Local Area Network (LAN) shall be provided for communication between the system elements. All interfaces to the LAN shall be a minimum of 100BaseTX Ethernet. The LAN may use additional technologies within the backbone for greater speed or distance. Acceptable types are:
- 02 The LAN shall use standard network cables. Acceptable cable types are:
 - i. Optical Fiber
 - ii. Category 5e or Category 6 Unshielded Twisted Pair (UTP)
- 03 The LAN shall be logically and/or physically separate from any existing LAN infrastructure .Interconnection to other LANs shall be through one of the following:
 - i. A router
 - ii. A Layer 3 capable network switch
 - iii. As an additional VLAN to the existing LAN equipment. Where required to interconnect VLANs, a router or Layer 3 capable switch shall be provided

3.6.4 Video Cabling

Where standard CCTV cameras are used, RG59/RG11/RG6 coaxial cable or optical fiber shall be used to connect the camera to a video streamer. Video streamers shall be located at locations closest to the CCTV cameras. In a new installation it is not acceptable to install a star topology video cabling system with all cabling coming back to a single location.

It is not acceptable for video cables to be run back to the Camera Server. All communications with the Camera Server shall be via the LAN.

Each network camera or video streamer shall have a single network interface to be used for video and Pan/Tilt/Zoom communications.

3.6.5 Application Software Functions

a) Live Video

- i. The live output from cameras shall be viewed through a series of displays at a 40" LED monitor provided in the security room.
- ii. These shall support:
 - 1. Single camera view
 - 2. Quad view of up to four cameras
 - 3. Sequence view of camera preset positions
 - 4. Modifying settings for a camera



5. Modify recording settings for a camera
6. Adding and deleting cameras
7. Creating schedules for recordings and video motion detection
8. Modifying Video Analytics settings and tuning for video Motion Detection
Users shall be able to select a camera from a tree control listing the cameras available to the user.

iii) The system shall also support multiple monitors in the following way:

1. Alarm monitor: When an alarm occurs in the Security or Control System Server, the live video output of the camera associated with that alarm shall be switched directly to an alarm monitor. The user shall be able to acknowledge the alarm to clear the monitor using the numeric keypad. Cameras that are directed to alarm monitors will not be removed from the queue unless explicitly cleared by the operator. It shall be possible to create a queue of alarm monitors to manage multiple alarm views simultaneously.

2. Cyclic Alarm Monitors: An alarm monitor shall be available at the end of a alarm monitor queue to cycle the camera views from unacknowledged alarms if the number of cameras to view exceeds the number of alarm monitors. Once the alarm monitor queue is filled, any new alarm will be placed in the queue relative to its priority and time of occurrence. Existing activated alarm camera views shall reshuffle to accommodate the new alarm. In the event that all the available alarm monitors are used, the oldest active alarm camera shall be added to the cycling alarm monitor. The alarm views shall cycle on this final alarm monitor until acknowledged and cleared by an operator in the event of multiple alarms added to this monitor.

3. Surveillance monitor: Operators shall be able to send any Quad View, Sequence View or Single Camera View to a surveillance monitor. User shall be able to clear the monitor using the numeric keypad.

Monitors shall be able to be configured to act as both Alarm and Surveillance monitors. In this case, the monitor behaves as a Surveillance monitor until an alarm occurs, in which case it shall show the alarm video. Once the alarm is acknowledged, the video previously shown (as a surveillance monitor) is displayed again.

In each of these cases, these additional monitors shall be either connected to an Operator Station using a multi-monitor PC card or to other PCs. Systems that do not offer this functionality are not acceptable.

b) Single Camera

From this display, the user shall be able to:

- i. View the live output from the selected camera
- ii. Pan, tilt, zoom and focus the camera using a joystick attached to the Operator Station PC
- iii. Pan, tilt, zoom and focus the camera using a pointing device attached to the work station. Standard Microsoft windows 7 (64 bit) Professional or latest version pointing devices such as a mouse or touch-screen shall be supported.



- iv. For cameras which support continuous pan, tilt, zoom (PTZ), a mouse shall be able to be used for continuous PTZ directly in the live video window. By dragging the mouse up or down, left or right in the video window, the operator shall be able to tilt the camera up or down, or pan the camera left or right. Zooming must also be provided using the mouse in a similar way.
- v. Manually record live video. Recording will continue for the configured period of time. Once recording has begun, a stop button shall be provided as well as a counter showing the recording time remaining.
- vi. Manually store the current frame of video (snapshot) as a bitmap image file. The file name shall be automatically generated by the DVRMS software and include the camera name, date and time of the recording (to millisecond precision).
- vii. Indicate whether video motion detection is currently enabled for the selected camera.

c) **Quad View**

The DVRMS shall support quad views. A quad view consists of up to four related cameras viewed simultaneously on a single display. The quad view shall be divided into four quadrants. For each quadrant the quad view shall have a camera or be blank. Within each quadrant the quad view shall be configured to cycle between any of the cameras accessible to the user on a configurable time basis.

There shall be no limit to the number of cameras that can be assigned to a single Quad View. There shall also be no limit to the number of available Quad Views.

d) **Sequence View**

The DVRMS shall support sequence views. A sequence view consists of a single camera view, which can be cycled on a time basis. Pan-tilt-zoom cameras, which support preset positions, can have these presets cycled on a time basis. In this way an operator can view a variety of presets on a series of PTZ cameras. Fixed cameras can also be included in the sequence and cycled accordingly.

There shall be no limit to the number of cameras that can be assigned to a single Sequence View. There shall also be no limit to the number of available Sequence Views.

e) **Camera settings**

- i) Operator shall be able to change important settings for an individual camera. The details are grouped into several sections:
 - a) Camera Details
 - b) Camera Connection
 - c) Camera PTZ Control
 - d) Security
 - e) Camera Deletion

The parameters listed in the sub- sections below are configurable on a per camera basis and their specific selection on a particular camera(s) will not limit the ability to freely select other options on other cameras as required. It



will be easy to change any of these parameters for each camera individually as and when required. Systems that do not allow changes to each camera's parameters on an individual basis will not be acceptable.

Only operator with the highest level of security are permitted to modify camera connection details, camera PTZ control or delete cameras.

ii) **Camera Details**

The operator shall be able to configure the following parameters for each camera:

1. Name
2. Location
3. Description
4. Camera Number (for fast numeric keypad call-up)

iii) **Camera Connection**

The operator shall be able to configure the following parameters for each camera:

1. Camera Streamer Type
2. Resolution: The following resolutions shall be supported (depending on the functionality of the camera and camera streamer)
 - a) 160x120
 - b) QCIF (PAL 192x144, NTSC 176x112)
 - c) 240x180 e) 320x240
 - d) CIF (PAL 384x288, NTSC 352x240)
 - e) 480x360
 - f) 640x480
 - g) 2CIF (PAL 768x288, NTSC 704x240)
 - h) 4CIF (PAL 768x576, NTSC 704x480)
 - i) Half-D1 (PAL 720x288, NTSC 720x240)
 - j) D1 (PAL 720x576, NTSC 720x480)
 - k) Megapixel (1280 x 1024, 1280 x 960, 1280 x 720 and 1600x1200)
3. Video Frame Rate: The supported frame rates (in frames per second) shall be as follows:
 - i. For Motion JPEG encoding: 30, 25, 20, 15, 10, 5, 3, 2 and 1. Slower frame rates of 1 frame every 2, 3, 5, or 10 seconds shall also be available.
 - ii. For MPEG-4 encoding: 30, 25, 15, 12.5, 7.5, 6.25, 3.75 and 1



4. Choice of five levels of video compression, equally distributed from minimum to maximum compression
5. Streamer IP Address
6. Streamer Camera Number (when connected to a multiple port Camera Streamer)
7. Choice of frame rate or bandwidth limited streaming
8. Unicast or multicast transmission of video
9. PAL or NTSC camera format
- iv. **Camera Control**

The operator shall be able to configure any appropriate camera to be PTZ controllable. The following camera types must be supported as a minimum:

1. Video Controls Limited (VCL) Orbiter cameras.
2. Honeywell Video Rapid Dome cameras
3. Cameras supporting the Pelco P protocol
4. American-Dynamics Speed Dome
5. Hernis Scan System's Cameras
6. Axis Streamer supported PTZ cameras and devices

The following PTZ characteristics shall be tuneable on a camera-by-camera basis from the camera definition pages:

1. Pan speed
2. Tilt Speed
3. Zoom speed
4. Focus speed
5. Iris speed
6. Increment step size

v. **Recording**

The following methods of recording live video shall be supported:

1. User activated
2. Event activated
3. Scheduled
4. Continuous background recording
5. Video motion detection
6. Snapshot

vi. **User Activated**

The operator shall be able to configure the following parameters for each camera:

1. **Pre-Record Duration:** The amount of pre-recorded video that will be associated with a user request for recorded video. This will allow the Camera Server to capture video prior to the user request, as well as after



the request. Shall be selectable from a list of values ranging between 0 seconds and 10 minutes.

2. Frame Rate: Video quality required for user activated recording. It shall be possible to have different frame rates for user and event-activated recordings. Shall be selectable from the entire range of frame rates supported for the camera. For MPEG encoding, support shall be provided to record only the Index frames, or a subset of the Index frames.

3. Record Duration: User activated recordings shall terminate after this period. Shall be selectable from a list of values ranging between 0 seconds and 10 minutes

4. Retention Period: The default period that the Camera Server shall retain user-activated recordings before being deleted. The retention period of individual recordings shall be able to be changed on a per-recording basis. Shall be selectable from a list of values ranging between one hour and forever.

vii. **Event Activated**

There shall be at least four priorities of alarms/events in the Security or Control System:

- a) Event (journal priority)
- b) Low priority alarms
- c) High priority alarms
- d) Urgent priority alarms

The following settings shall be individually configurable for each alarm and each camera:

1. **Pre-Record Duration:** The amount of pre-recorded video that will be associated with an alarm/event. This shall allow the Camera Server to capture video prior to the alarm/event, as well as after the alarm/event. Shall be selectable from a list of values ranging between 0 seconds and 10 minutes.
2. **Post-Record Duration:** Event activated recordings shall terminate after this period. Shall be selectable from a list of values ranging between 0 seconds and 5 minutes
3. **Frame Rate:** Video quality required for event activated recording. It shall be possible to have different frame rates for user, event-activated, scheduled and motion detection activated recordings. Shall be selectable from the entire range of frame rates supported for the camera/streamer. For MPEG encoding, support shall be provided to record only the Index frames, or a subset of the Index frames.
4. **Retention period:** The default period the Camera Server will retain event-activated recordings before being deleted. The retention period of individual recordings shall be able to be changed as necessary. Shall be selectable from a list of values ranging between one hour and forever.



The pre-record and post-record durations in the paragraph above define the maximum allowable limits for each camera. They shall be configured on a camera-by-camera basis. However each alarm or event causing video to be recorded shall also be capable of individual configuration with pre and post alarm periods being selected from a range defined by the maximum settings for the camera.

DVRMS systems requiring a single pre and post record event period to be defined for all alarms and events on an individual camera are not acceptable. DVRMS systems requiring a single pre and post event period to be defined for all alarms and events on all cameras are also not acceptable.

In the case of multiple alarms/events relating to the same camera, a video clip shall be created for each alarm/event.

For cameras that support Pan/Tilt/Zoom Presets, a specified preset location shall be selected automatically when the alarm/event occurs prior to the event activated recording commencing. For example, when an alarm is detected on a security door, the alarm shall trigger a PTZ camera to move to a preset position, which is pointing at the door prior to the DVRMS commencing recording.

viii. **Scheduled**

The system shall support the ability to schedule recordings for each individual camera for times in the future. For each scheduled recording the user shall be able to configure the following (with descriptions as per User Activated and Event Activated recordings):

1. Start time
2. Stop time
3. Frame rate for the recording
4. Retention period before the recording will be deleted
5. Recurrence (if this is to be a recurring schedule)
6. Description (at least 255 characters)

There shall be no limit on the number of schedules that can be entered for the system. There shall be no limit to the number of schedules per camera.

ix. **Continuous background recording**

The system shall support the ability to provide continuous background recording from any camera(s) managed by the system. Background recordings will be stored as a discrete series of clips and will continue to operate in the event that communication between the Camera Server and the Database Server is lost. Once communication is restored, all relevant information will be updated to the Database Server.

For each camera the user shall be able to configure the following (with descriptions as per User Activated and Event Activated recordings):

1. Enable / disable background recording



2. Duration of the recorded clip
3. Frame rate for the recording
4. Enable / disable archiving of the clip and the period after which to archive
5. Retention period before the recording will be deleted
6. Enable or disable audio recording (if available)

Systems that require the configuration of multiple time periods to manage background recordings will not be accepted.

Continuous background recordings will not be dependant on network communications between the Camera Server and the Database server. Once configured, these recordings will continue to operate in the event that this communication is lost.

x. Video Analytics

The DVRMS system must be able to activate recordings automatically based on events generated by the real-time analysis of video from any camera on the system that has Video Analytics enabled. The real time analysis comprises several algorithms such as

Video Motion Detection

The DVRMS system must be able to support video motion detection algorithms, which can be executed by the video streamer or the Camera Server. The enabling of Video Motion Detection shall be either:

1. on a continuous basis
2. Scheduled for particular times, dates, days, months etc

The Camera Server-based algorithm must be able to provide the following functionality:

1. Detect and track objects
2. Learn the scene
3. Adapt to a changing outdoor environment
4. Ignore environmental changes including rain, hail, wind, swaying trees and gradual light changes

The operator shall be able to configure the following parameters for each camera:

1. Detection Type: Continuous or scheduled
2. Actions to Perform When Motion is Detected: When motion is detected, the following actions shall be performed automatically: Generate an alarm in the Security System, Building Control System or Industrial Control System of configurable priority (journal, low, medium, high)



3. Start a recording, with the following configurable settings

- a. Pre-Record Duration: The amount of pre-recorded video, allowing the Camera Server to capture video prior to the detection of motion, as well as after the detection of motion. Shall be selectable from a list of values ranging between 0 seconds and 5 minutes.
 - b. Post Record Duration: Motion detection activated recordings will terminate after this period. Shall be selectable from a list of values ranging between 0 seconds and 10 minutes or until motion has stopped.
 - c. Frame Rate. Video quality required for motion detection activated recordings. Shall be selectable from the entire range of frame rates supported for the camera/streamer. For MPEG encoding, support shall be provided to record only the Index frames, or a subset of the Index frames.
 - d. Retention period. The default period that motion detection activated recordings will be retained by the Camera Server before being deleted. The retention period of individual recordings shall be able to be changed as necessary. Shall be selectable from a list of values ranging between one hour and forever.
 - e. Send video to an operator station or alarm monitor: Automatically switch an operator station or alarm monitor to view the camera which has motion detected
4. Motion Finished Time: The amount of time where no motion (inactivity) is detected before the previous motion is classified as completed. This shall be used for allowing recordings to continue until motion has finished.

The DVRMS must provide a means of automatic and manual tuning of the Video Motion Detection for each camera. Incorporated within this tuning are the following:

1. Selection of the frame rate used for detection
2. Optimization for directions of movement In any direction
3. Across the camera view
4. Towards and away from the camera
5. Sensitivity level to fine tune the motion detection algorithm
6. Specification of a minimum object size to allow noise filtering in the system to reduce false detections and alarms.

The DVRMS must also provide the ability to only detect motion in particular regions of the camera view. The ability to graphically select these regions using the mouse must be provided, with an unlimited number of regions permitted per camera. The regions of interest will be multi-vertexed shapes with a minimum of 6 vertices to allow the region to be properly matched to the scene being detected. It shall be possible to add and remove vertices from the defined region of interest as needed. Solutions providing only rectangular regions of interest will not be accepted.



Each region must be able to be individually tuned and have separate tuning parameters. This method of tuning must also provide a live tuning window whereby these settings and regions can be altered and tested prior to being used. This live tuning window shall show the live video as well as the regions of interest. During the time that motion is detected within a region, the border of the region shall change to a different color. In this way, tuning can be performed to achieve the desired performance. Text shall also be provided in the window to alert the user that motion has been detected.

3.6.6 Cameras:

- i. The cameras shall be rugged high speed PTZ dome cameras with inbuilt PTZ driver unit & RS 485 receiver unit, 1/4 inch image format fully performance color CCD dome cameras. These cameras should provide high resolution and high sensitivity suitable for operation in a power plant, both in natural and artificial sighted areas.
- ii. The cameras should have features as mentioned below:
 - a. Suitable for night-time surveillance.
 - b. Manual or Automatic colour/infra red switching.
 - c. Automatic picture enhancement to give a balanced picture where there is too little/too much light.
 - d. Remote camera setup, with on screen menu display.
 - e. Back light composition
 - g. Automatic white balance, with mode selection options
 - h. Contour correction and contrast compression control.
 - i. Synchronisation selection for Gen lock, external V- lock, mains lock and internal free-running.
- iii. Detailed technical specifications are as under:
 - a. Imager Supply Interline transfer CCD, 1/4" image format.
 - b. Horizontal resolution 470TVL in PAL B mode.
 - c. Sensitivity (at f1.6-3.7) - 1 lux
 - d. Light Range
 - e. Signal-to-noise : >48dB.
 - f. Dome Size 4.8"
 - g. Pattern: 4 pattern, 240 s memory
 - h. Optical Zoom 25 X
 - i. Digital Zoom Unlimited
 - l. Power : 230V A C (From Contractor' s UPS)



- j. Operating Temperature 0 to 60 Deg C
- k. Relative Humidity 8 to 95 % non condensing
- m. The lens size for various locations based on coverage area and the same shall be decided during detail engineering.
- n. The cameras in the fuel oil pump house area and H₂ area shall be explosive proof

iv. **Camera Housing**

- (a) All the cameras and accessories are to be housed in all Weather Proof environmental housing made of aluminum. The housing with heater and blower installed should provide protection for camera/lens assemblies in the ambient temperature range of - 0 deg. C to 60 deg.
- (b) The housing should also have thermostatically controlled heater kit, continuous duty blower kit, purge air arrangement, Window wipers available within the housing.
- (c) The minimum protection standard for cameras shall be I P 65.
- (d) The cameras installed in dust prone area shall have suitable mechanism for periodical lens cleaning.
- (e) The cameras shall have accessibility for periodical maintenance.

3.6.7 **Operational Requirements:**

- i. The CCTV system should comply to the following operational requirement.
- ii. From the master control panel (keyboard) it shall be possible to select any camera and display the picture on any of the monitors.
- iii. Commands from the video server is sent via a onsite receiver/drive unit to the camera which in turn controls the pan/tilt zoom etc., functions.
- iv. Operator shall be able to control all the cameras, pan / tilt and zoom functions automatically.
- v. The video recorder shall record the activities of all the places where alarm have been alerted. The recording time shall be as per the hard capacity as mentioned in the camera server specifications.

3.6.8 **Cables:**

- i. Cables should be of FRLS PVC sheathed cables for use in CCTV and should conform to latest edition of Indian/International standards.
- ii. Cables should be suitable for installation as follows:
 - a. Above ground in open-air location (tray/ducts) in tropical, humid and corrosive atmosphere prevalent in thermal power plant.
 - b. Direct buried in underground trenches conduits with uncontrolled back fill and possibility of flooding by water and chemicals.



- c. Laid underground in RCC lined cable trenches with possibility of flooding by water.
 - d. Site condition for cables laid above/underground shall be specified in the BOM. If not specifically mentioned therein, the design ambient air temperature of 75 deg. C ground temperature of 40 deg. C, thermal resistivity of soil at 150 deg. C cm/watt and altitude and exceeding 1000, above main sea level shall be considered.
 - e. Cables of reputed make with approval of Owner / consultant shall be tested at works as well as site after installation as per applicable standards.
 - f. All the required cables shall be supplied on as required basis. Further, 500 meters of each type of cables shall be provided as spare.
 - g. Fiber optic cables are to be provided whenever the cable run length/ signal loop length is more than 500 meters.
- iii. For estimation of cable quantities, erection had wares etc., the Contractor shall refer to General Layout Plant and Equipment Location Plans drawings which are enclosed with this specifications. All the cables are to be provided by the Contractor on as required basis within his quoted lump sump price.

3.6.1.9. Quantities

- i. Cameras along with inbuilt motorized zoom lens and PAN & TILT mechanism.
- ii. The following items shall be provided for the entire plant and actual locations shall be derived during detail engineering stage.

SNO	ITEM	QUANTITY
1	Redundant Database Video Management Server	One (1) no. for the station to be located in first unit central control room.
2	Camera Server	One no. for main plant control room and seven nos. for common areas *
3	Monitors	One no. for each of the units and seven nos. For common areas .
4	Inter Connecting Cables	On as required basis without any cost implication to Owner.

* Common areas shall include Office of Chief Engineer/Head of the Project, Office of O&M in charge, Central Fire Station, Water system Control Room, Ash handling system control room, Main Gate of the Plant, any other location to be decided during detailed engineering


CCTV ANNEXURES

Sr.No.	Locations	Nos. for both the units.	Camera type	Protection class
1 a.	TG hall Building	10	Dome Type high resolution CCD Cameras	IP65
1 b.		10	High resolution CCD Cameras	IP65
2	Boiler area	16	High resolution CCD Cameras	IP65
3	PRDS & Dearator	4	High resolution CCD Cameras	IP65
4	ESP/Field area	8	High resolution CCD Cameras	IP65
5	CER	4	High resolution CCD Cameras	IP65
6	Control room	2	High resolution CCD Cameras	IP65
7	Cable Gallery (at different areas)	16	High resolution CCD Cameras	IP65
8	Switch Gear room & battery room	6	High resolution CCD Cameras	IP65
9	Transformer Bay	10	High resolution CCD Cameras	IP65
	Common Plant Areas	-	-	-
10	Ash slurry pit	2	Dome Type high resolution CCD Cameras (Out Door)	IP65
11	Ash water pump house	2	Dome Type high resolution CCD Cameras	IP65
12	Chimney	1	High resolution CCD Cameras (Out Door)	IP65
13	CW pump house & Forebay	3	Dome Type high resolution CCD Cameras (Out Door)	IP65
14	FOPH	2	Dome Type high resolution CCD Cameras (Flame Proof /Out Door)	IP65
15	Main entry gate	4	High resolution CCD Cameras (Out Door)	IP65
16	Cooling tower	2 1 for each CT	High resolution CCD Cameras(Out Door)	IP65
17	PT plant	2	High resolution CCD Cameras (Out Door)	IP65
18	RO-DM plant	3	High resolution CCD Cameras	IP65
19	Switch yard	5	High resolution CCD Cameras (Out Door)	IP65



Sr.No.	Locations	Nos. for both the units.	Camera type	Protection class
20	Coal Handling Plant	10	High resolution CCD Cameras	IP65
21	Effluent Treatment Plant	2	High resolution CCD Cameras	IP65
22	Stores	6	High resolution CCD Cameras	IP65
23	Ash silo area	1	High resolution CCD Cameras	IP65
24	Vehicle parking	4	High resolution CCD Cameras	IP65
25	Fire water pump house	1	High resolution CCD Cameras	IP65
26	Raw water pump house	2	High resolution CCD Cameras	IP65
27	Sea water intake	2	High resolution CCD Cameras	IP65
28	Service building	4	High resolution CCD Cameras	IP65
29	Other areas to be decided during Detailed Engg. Stage	12	High resolution CCD Cameras	IP65

4.0.0 SECURITY CARD ACCESS SYSTEM

4.1.0 General

Purpose of the facility is to control access to all vital areas within the important plant buildings by electronic card reader system. Access system cards shall be suitable for individual configuration of access privileges via access control software for controlling access to different locations. Biometric detection system is preferred. However, Bidder can offer other suitable systems also. Access controlled area entry/exit doors shall be fitted with Electro-magnetic locks. Access card reader shall be proximity card reader type.

The card access system shall have a dedicated server to record all entries and exits through the card access locations. However the actual location shall be derived during detailed engineering

- Central Control Room
- Local Control Rooms (including all BOPs)
- Water Treatment Plant
- Workshop
- Stores
- Switchgear Rooms
- Main Entrance and Exit of Plant
- Administration building entrance and exits.
- Service building entrance and exits.
- Laboratories



Identity Card Issuing Facility

Purpose of the facility is to issue identity card and visitor pass for control access to all vital areas within the important plant buildings by electronic card reader system. System shall have a digital camera of latest configuration and a dedicated PC with a laser color printer.

5.0.0 Patrol Guard System

Purpose of the system is to ensure that security guards on patrol duty are carrying out their duties diligently by recording the visiting time data for different locations. The system shall comprise of a selected number of proximity card readers located in various strategic locations of the Udangudi Supercritical Thermal Power Project including the perimeter. The patrol guard recorder will record the date and time when the recorder is swiped on the magnetic strips.

**VOLUME II****SUB-SECTION – 4.19****CONTROL & INSTRUMENTATION LAB INSTRUMENTS****1.0.0 GENERAL**

This section provides the technical information for the design, furnishing, construction and setup of an instrument shop, complete with instruments, furniture, tools and test equipment required to maintain the instruments and control devices of the plant within the room of dimension 14m X 7 m.

Bidder shall be responsible to provide the required calibration test instruments and test procedures covering all the ranges and various Process parameters assigned by the Bidder in 660 MW plant for smooth & safe operation

Testing instrument/devices offered shall be proven type and shall incorporate latest design. All instruments supplied under this package shall be in brand-new and unused condition. All instruments shall be supplied from reputed manufacturer as indicated later.

Testing instruments/devices shall be furnished with all necessary accessories and original instruction/operating and maintenance manuals

The shop shall be provided with a complete set of test and calibration equipment/test kits for electronic and pneumatic instruments and controls, falling under the purview of this specification.

All instruments offered, shall conform to the relevant International Standards

The various instruments/devices, small tools, accessories, etc. shall be furnished (in applicable cases) with suitable and durable crates, kits or carry boxes of convenient size; complete with necessary packing etc. for safe storage when not in use.

Bidder shall be responsible for proper functioning of supplied items and shall make any necessary additions / modifications, as required for proper maintenance and testing of the installed instruments and controls. Bidder shall also be responsible for erection and commissioning of the test equipment

It is obligatory to Bidder to furnish a complete list of spare parts for these testing/calibrating, instruments/devices. Bidder shall render guarantee for easy availability of all the spare parts required, especially for the components, which are prone to failure.

Bidder shall repair or replace the defective instruments/ devices at no extra cost within the guaranteed period of each instrument/device

Bidder shall have to provide traceability certificate for each instrument with validity while handing over the test instruments.

Bidder shall submit with the proposal a full list of testing/laboratory instruments / tools offered along with detailed specification of the items. Catalogues, drawings and manuals as required shall be submitted with the proposal to provide necessary information pertaining to the items offered. Information for the items offered shall include (as applicable) but not limited to the following:

- a) Working principle
- b) Power supply and other utility details
- c) Dimensional details
- d) Mounting details including necessary accessories



- e) Recommendations (if any) for installation, storage etc.
- f) Accuracy (wherever applicable)
- g) Make and Model
- h) Conformance to or deviation from the specification, if any.

Bidder to note that the testing and laboratory instruments specified in this section shall be in addition to the equipments required for installation, maintenance, trouble shooting and calibration of instrumentation and control equipments of the plant furnished under this volume of the specification. Also, any special simulator/test stands which may be recommended and supplied by Bidder's for use in calibrating electronic components of the instrumentation and control systems shall be considered separately in addition to the laboratory instruments specified in this section. Bidder's shall handover to Owner all equipment specified in this section immediately after receiving the equipment at the job site. Use of this equipment by Bidder's shall not be permitted without Owner's consent.

Owner has the rights to choose/select/decide the model & make.

Bidder shall include a complete set of furniture for the instrument laboratory from reputed manufacturer designed for similar applications. The set of furniture shall include but shall not be limited to chairs, tables for calibration of instruments, test benches etc, all necessary cabinets for storage of manuals / booklets / records / charts, storage racks for special tools etc. The design, color, layout and model of the furniture shall be approved by Owner.

Calibration instruments shall be of high standards, high accurate, more resolution and also shall have PC based calibration Management software to provide a fully integrated system between field and C & I laboratory.

2.0.0 CODES AND STANDARDS

The design, material, construction features, manufacture, inspection and testing of laboratory instruments shall comply with all currently applicable statutes regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable standards

3.0.0 LIST OF INSTRUMENTS

Sl. No	ITEM DESCRIPTION	QTY
1	Pressure & Vacuum Pumps	1
2	Low Pressure & High Pressure Calibrator (Table mounted)	2
3	Low Pressure & High Pressure Calibrator (Portable)	2
4	Test Pressure Gauges	2 Sets
5	Vacuum Calibrator (Table mounted)	1
6	Vacuum Calibrator (Portable)	1
7	Fortin Barometer (Mercury)	1
8	U-Tube Manometer	2
9	Test Manometer (inclined)	2
10	Test Thermometer (Various Ranges)	2 (Sets)
11	Temperature Calibrator (for TCs, RTDs – table mounted)	2
12	Temperature Calibrators (for TCs, RTDs – Portable)	3
13	Temperature Bath	1
14	Test RTD	2
15	Vibration Shock pulse Analyser	1
16	Digital Oscilloscope	1



Sl. No	ITEM DESCRIPTION	QTY
17	Portable infrared radiation thermometers	2
18	Functional generator	1
19	Frequency counter	1
20	Insulation tester	3
21	Digital multi-meter (Portable)	6
22	Digital multi-meter (Table mounting type)	2
23	Multi function instrument calibrator	2
24	RCL bridge	1
25	mV Calibrator (Table Mounted)	1
26	mV Calibrator (Portable)	3
27	mA Calibrator (Table mounted)	1
28	mA Calibrator (Portable)	3
29	Portable Flue Gas Analyser	1
30	Portable pH indicator	1
31	Portable Conductivity Indicator	1
32	Soldering Iron	3
33	Solder Sucker	3
34	Soldering Station	1
35	De-soldering Station	1
36	Dead Weight Tester	1
37	Vacuum Tester	1
38	Decade Resistance Box (Analog – 2; Digital – 2)	2
39	Tachometer(contact / Non contact)	1 each
40	Stop Watch	2
41	Torximitor	2
42	Rheostat	1
43	Wet & Dry Bulb Hygrometer	2
44	Aneroid Barometer	1
45	AC power-meter	1
46	Logic Analyser	1
47	Air Set	1
48	Thermo Couple test furnace	1
49	Logic probe	1
50	Sound Level Monitor	1
51	Auto Transformer	2
52	Portable Ultrasonic Flow-meter	1
53	DC Power Pack	3
54	Grinding Wheel	1
55	Electronic Test Bench	2
56	D.C Regulated Power Supply	3
57	Continuity Tester	6
58	Tong Tester	2
59	Stabilized Power Supply	4
60	Portable Vacuum Cleaner	6



Sl. No	ITEM DESCRIPTION	QTY
61	Stroboscope	1
62	Digital Cable Identification System	1
63	Phase sequence meter	1
64	Vibration Pick-up tester	1
65	Instrument Rack	2
66	Portable wheat stones Bridge	1
67	Test Thermocouple – K Type	2
68	Test Thermocouple – T Type	2
69	Pilot Tube	2
70	LCR Meter	1
71	Fluidised Bath	1
72	Vibration cum Balancing Analyser	1
73	Portable Digital Vibration Meter	2
74	Portable Analogue Vibration Meter	2
75	Tool Box	6
76	Work bench	1
77	Portable Ferrule Marker / label Printer	1
78	Tube bender / Cutter	2 Sets
79	Laboratory PC	1
80	Hart Communicator	6
81	Overhead Interactive White Projection Board	1
82	Projector With White Marker Board	1
83	Video Conferencing System	1
84	Digital camera 18 megapixel or latest	2
85	Digital Video camera	1
87	Digital Manometer	2
88	Magnetic screw driver Tinsley/ Beamex/Scandura/ Taparia/RS components/Hitachi/Black& Decker	1

4.0.0 PRESSURE AND VACUUM AIR PUMP - (1 NO)

4.1.0 Make- Heaven Automation / Yokogawa/ Druck Or Better

Portable type Combined pressure and vacuum pump shall be supplied. This air pump is to produce pressure upto 2 bar for intermittent service, 1 bar for continuous service and to pull a vacuum as high as 700 mm of mercury. The actual free air delivery shall be 0.03 Cu.m per minute at 1 bar.

This pump shall be complete with one set of test pressure gauges (0 - 2.5, 0 – 10, 0 – 40 KSC, 0 – (-) 760mm Mercury), lubricator, hose nipples and other fittings & accessories.

Vernier arrangement shall be available for fine adjustment. The ranges of pumps are -0.8 to 2 KSC and -0.95 to 40 KSC in order to provide positive as well as to pull vacuum to the above required levels.

**5.0.0 LOW PRESSURE AND HIGH PRESSURE CALIBRATOR (TABLE MOUNTED) (2 NO)****5.1.0 Make - budenburg, U.K. / Yokogawa/ Druck or better**

It shall be microprocessor based and operated by rechargeable battery and by 240 AC, single phase, 50 Hz. Accuracy shall be $\pm 0.05\%$. Overpressure protection & indication shall be provided.

Tentative pressure range shall be (-)1.06 bar to 1000 bar (subject to finalisation during detailed engineering)

It shall be capable of testing pressure gauges and vacuum gauges up to 400 KSC and 760 mm of mercury vacuum with an accuracy of $\pm 0.2\%$. This unit shall be complete with test gauges of ranges (0 – 10, 0 – 40, 0 – 100, 0 – 250, 0 – 400 KSC and 760 to 0 mm Hg). The dial size of test gauges shall be more than 325mm. One slide wrench, screw driver, two gauge pointer removers, gauge adaptors set packed in a separate box, one lever handle union, gauge cock 1/2" NPT(F) and 1/4" NPT(F) connectors for pressure gauges to be tested and other accessories as required. The pressure developed by the test pump shall be continuously adjustable. Filling fluid, funnel to be supplied along with the unit. Comparator shall have the features of LCD digital display for pressure. Facility for fine adjustment shall be available.

One No. Lap top PC connected to the calibrator shall prepare the test reports and store history of test reports

The comparator shall be of latest state of the art design and shall have in built battery and battery charger.

6.0.0 FIELD PRESSURE COMPARATOR – (2 NOS.)

Features : Single volume pump with integral pressure regulator for fine pressure adjustment.

Accuracy : $\pm 0.5\%$ of gauge span.

To be supplied with four test gauges. Gauge shall be compensated for temperature;

It shall be microprocessor based and operated by rechargeable battery and by 240 AC, single phase, 50 Hz. Overpressure protection & indication shall be provided. Tentative pressure range shall be (-)1.06 bar to 400 bar (subject to finalisation during detailed engineering). All required accessories to be provided

7.0.0 LABORATORY TEST PRESSURE GAUGES - (2 SETS)**7.1.0 Make - Budenburg, U.K. / HEISE, U.S.A / a shcroft Inc. U.S.A or better**

Two Sets of test pressure gauges (accuracy 0.1% or less including hysteresis) as listed below shall be supplied:

<u>ITEM NO.</u>	<u>RANGE</u>
01.	- 1 to 0 Kg/Sq.cm
02.	0 - 1.0 Kg/Sq.cm
03.	0 - 1.6 Kg/Sq.cm
04.	0 - 2.5 Kg/Sq.cm



05.	0 - 6 Kg./Sq.cm
06.	0 - 10 Kg/Sq.cm
07.	0 - 40 Kg/Sq.cm
08.	0 - 100 Kg/Sq.cm
09.	0 - 160 Kg/Sq.cm
10.	0 - 250 Kg/Sq.cm
11.	0 - 400 Kg/Sq.cm

All test pressure gauges shall have 150 mm anti-parallax white dial with black figures and graduation lines of fineness and legibility used for high precision instruments. The dial shall be mirror polished stainless steel under the tip of the pointer. Cases shall be fine wrinkle phenol or die cast aluminium, light but strong and rigid. Mounting shall be direct or flush.

The material of the sensing element shall be solid drawn phosphor bronze up to 10 Kg/Sq.cm and above 10 Kg/Sq.cm. stainless steel tube.

The pointer shall be light weight, stainless steel balanced design with tip turned 90 degree for easy reading to smallest sub- division. Connection size of all gauges shall be 1/2" NPT (M).

For all test gauges point-by-point test certificate of the readings shall be provided.

8.0.0 VACUUM CALIBRATOR (TABLE MOUNTED)

Micro processor based and operated by rechargeable battery and 240V AC single phase, 50 Hz " LCD Indication", accuracy of $\pm 0.5\%$ of gauge span and user selectable ranges shall be available. Vacuum upto 760 mm Hg shall be calibrated with this instrument.

9.0.0 VACUUM CALIBRATOR PORTABLE (1 NO.)

It shall calibrate and test vacuum instrument ranges 760 mm Hg vacuum and comprise of precision test gauge with swivel fitting shut off valve, pistol grip handle, etc.

It shall have the following features and specification:

a)	Light weight for field use	
b)	Needle valve for positive shut-off piston grip, handle for quick, easy pump action.	
c)	Carrying Case	: High impact plastic with a die cut foam insert snap open enclosures and handle fitted slots for the tester and two spare gauges.
d)	Accuracy	: $\pm 0.5\%$ of gauge span
e)	Range	: 0 to 760 mm Hg
f)	Test Connection	: 1/2" NPT 60 cm long nose

**10.0.0 BAROMETER – (1 NO.)****10.1.0 Make- Meriam Instruments, U.S.A. or Better.**

Precision barometer shall be electronic type (digital display) with a range of 660 to 790 mm Hg with 0.1 mm Hg accuracy complete with battery, battery charger and carrying case. The display shall be barometric pressure, humidity and temperature.

11.0.0 LABORATORY TYPE MANOMETER - (2 NOS.)**11.1.0 Make- Meriam instruments, U.S.A. /Ashcroft inc. U.S.A or better**

Enclosed type free-standing U-tube manometers of the following ranges shall be supplied:

<u>ITEM NO.</u>	<u>RANGE</u>
01.	0-2500 mm of WC (1250-0-1250)
02.	0-1000 mm of WC (500-0-500)

These U type manometers shall be used for measuring low pressures, differential pressures or vacuum. Scales shall be calibrated in centimeters and sub-divided into tenths. These shall be suitable for maximum static pressure of 7 bar. Cases shall be of aluminium on three sides with clear acrylic front cover. Scales shall have provision for zero adjustment.

All wetted parts and fittings shall be SS-304. Manometer will be mounted on three leg stands having level adjustment arrangement and attached spirit level. The scale graduations shall be engraved on milky white acrylic in black. Metering tube shall be clear acrylic plastic having uniform reamed bore and thick walls, gland-packed in end blocks. End connections shall be 1/2" NPT (F), with check valves. The scale shall be provided with vernire arrangement. Liquid drain plug shall be provided. Colored liquid & storing bottle, fill-up funnel and nylon tubes shall be included.

Hand pump or any other provision shall be made available for pressing the WC to the required value.

12.0.0 INCLINED TUBE MANOMETER - (2 NOS.)**12.1.0 Make - Meriam instruments, U.S.A. / Ashcroft inc. U.S.A or better**

Portable inclined tube manometers of free standing type of ranges 0-50 mm, 0-100 mm and 0-200 mm WCL shall be supplied for each Unit.

These shall be used for measurement of draft, air velocity and air pressure around atmospheric pressure. Indicating tube and oil chambers shall be drilled and reamed in a solid block of clear acrylic plastic material. These manometers shall have levelling screws at the bottom and spirit level bubbles for accurate levelling. Each manometer shall be complete with connecting tubes, mounting box, and brass range scale, tube chamber, connecting tube, 1/2" NPT process adapters, manometer liquid and drain plug. Three valve manifolds shall be supplied along with each manometer.

13.0.0 TEST THERMOMETER (2 SET)

Bidder shall supply suppressed range Mercury in glass thermometers for temperature baths / calibrator consists of the following gauges:



0 – 52 deg. C	:	1 No.
48 – 102 deg. C	:	1 No.
97 – 152 deg. C	:	1 No.
147 – 202 deg. C	:	1 No.
197 – 252 deg. C	:	1 No.
247 – 302 deg. C	:	1 No.
297 – 360 deg. C	:	1 No.
350 – 402 deg. C	:	1 No.
395 – 605 deg. C	:	1 No.

14.0.0 TEMPERATURE CALIBRATOR (TABLE MOUNTED)– (2 NOS.)**14.1.0 Make- Heaven Automation / Druk / Emersion or Better**

Micro processor based type comprising of integral electric heater, thermometer, temperature indicating controller and cooling fan with stability within ± 0.2 Deg C. Instrument shall have range of 0-1100 Deg C (Range shall be as per detailed engineering). The equipment shall be complete with all standard and required accessories and carrying case. Instrument shall have provision for accommodating different bulb size thermometers/ temperature elements (Thermocouples/RTD). All accessories to be provided.

15.0.0 TEMPERATURE CALIBRATOR (PORTABLE)– (3 NOS.)**15.1.0 Make-heaven Automation / Druk / Emersion or better**

Micro processor based type comprising of integral electric heater, thermometer, temperature indicating controller and cooling fan with stability within ± 0.2 Deg C. Instrument shall have range of 0-600 Deg C (Range shall be as per detailed engineering). The equipment shall be complete with all standard and required accessories and carrying case. Instrument shall have provision for accommodating different bulb size thermometers / temperature elements (Thermocouples / RTD). All accessories to be provided.

16.0.0 TEMPERATURE BATH (1 NO.)

The temperature bath shall be microprocessor based and shall have fully controlled temperature range of 100 to 600 deg. C(Range shall be as per detailed engineering). Temperature stability shall be ± 0.2 deg.C or better over whole range. All accessories to be provided.

17.0.0 TEST RTD PT - 100 – (2 NOS.)

Very high accuracy and used as a Standard in C&I Laboratory. Accuracy Class 1/2 DIN 43760. The resolution be 0.001°C and range shall be 0 to 300°C

18.0.0 VIBRATION SHOCK PULSE ANALYSER (1 NO)

Vibration analyzer with necessary probes, electronic units, data logging & analyzing software for the following specifications shall be supplied to analyze the various bearings of all rotating equipments supplied by the Bidder .



- a) Pulse measuring range : -19 to 99 dB SV
- b) Resolution : 1 dB SV
- c) Accuracy : 1 dB SV
- d) Vibration measuring range : 0.5 to 50mm / s r.m.s
- e) Resolution : 0.1 mm / s
- f) Velocity accuracy : ± 0.2 mm / s
- g) Frequency range : 0 - 5000 Hz
- h) Vibration analysis : FFT with frequency resolution of 0.5 Hz (0-200 Hz), 1.5 Hz (0 – 500 Hz) and 2.5 Hz (0-50,000Hz) or better.
- i) Speed measuring range : 0 to 10,000 rpm with visible laser.
- j) Speed accuracy : ± 1 revolution or 0.1% of reading
- k) Display : LCD 4 X 16 characters or better.
- l) Memory : 500 measuring points
- m) Temperature Measurement : 0 – 300 °C non – contact Infrared
- n) Resolution : 1 °C
- o) Keypad : Sealed membrane
- p) Phase measurement : Yes. 0 – 360° range having 1degree resolution

Analyzer shall also be capable of providing following features:

- a) Earphone mode for shock pulses
- b) Vibration severity measurement, ISO 10816

19.0.0 DUAL BEAM PORTABLE DIGITAL STORAGE OSCILLOSCOPE (1 NO.)

- 01 Bandwidth (3 db) : 60
- 02 Deflection factor : 2 mV/div. to 5 V/div.
- 03 No. of Steps (Vert.) : 10 (min) (1-2-5)
- 04 Accuracy : $\pm 2\%$
- 05 Input impendence :
 - (Signal) : 1 M Ohm, 20 pf
- 06. Maximum voltage : 400V DC/ AC. p to p
- 07. CMRR : 10:1 at 50 MHz (minimum)



08.	Sample rate	: 10 x 106/Sec.
09.	Record memory	: 4K points
10.	Save memory	: 4K points
11.	Display mode	: x1, x10, storage compress
12.	Time base	: 0.05 s/div. to 0.5 s/div.
13.	No. of steps (hr.)	: 20 (min) (1-2-5)
14.	Input impedance (trigger)	: 20 K Ohm
15.	Time base linearity	: $\pm 5\%$
16.	Z modulation frequency	: Up to 5 MHz
17.	Controls available	: Intensity, focus
18.	Operating voltage	: 100-250V AC, 50 Hz
19.	Ambient temperature	: 0-50 Deg.C
20.	Accessories	: Probes carry case etc., as required
21.	Screen	: 8.4 inch TFT colour LCD
22.	Print	: Built in printer
23.	Interface	: RS-232C interface

20.0.0 PORTABLE INFRARED THERMOMETER – (2 NOS.)

20.1.0 Make- Minolta / Land / Mikron Or Better

(i) Instrument shall be supplied with Display	: 4 1/2 digit LCD display Range: 400 - 2200 Deg C, Accuracy: ± 0.5 Deg C
Emissivity	: Adjustable from 0.01 to 1.00 in 0.01 steps
Interface	: RS232C interface for Printer & Data logging
(ii) FOR SECOND METER	
Display	: 3 1/2 digit LCD display Range : - 50 - 500 Deg C, Accuracy : ± 0.5 Deg C
Emissivity	: Adjustable from 0.01 to 1.00 in 0.01 steps
Interface	: RS232C interface for Printer & Data logging

Instrument shall have internal chargeable battery. Battery charging circuit suitable for 240V AC, 50 Hz shall be integral with the instrument.

High impact plastic fitted carrying case to be provided.

Three operational Modes of continuous measure, peak measure and monitor are to be available. Response time 0.5 seconds or better. Wavelengths of operation and algorithm should minimize the effects of atmospheric water vapour and carbon di-oxide and the effects of sunlight on the temp. Reading.

21.0.0 FUNCTIONAL GENERATOR – (1 NO.)

Functional generator of the following specification shall be supplied.

The instrument shall be capable of accessing dual inputs with LCD panel.

The output frequency shall be continuously adjustable and frequency reading shall be displayed on a digital indicator. The voltage of the output of the generator shall be continuously controlled and shall be monitored on a built-in digital voltmeter. The signal Generator shall have high frequency stability and low harmonic distortion. Harmonic distortion shall be less than 0.5 percent. Signal Generator shall be suitable for 240V single phase, 50 Hz, supply and shall be complete with carrying case, probes and other accessories as required.

a) Waveforms	:	Sine, square, triangle, pulse and ramp with variable symmetry.
b). Symmetry	:	10% to 90%, 1% step, +/- 2% accuracy
c) Frequency	:	Range : 0.002 Hz to 20 MHz
Accuracy	:	(a) Continuous mode - +/-0.1%;
(b) Trigger, gate, burst modes - +/- 0.1% (for freq. less than or equal to 200 Hz) & +/- 5.0% (For freq. more than 200 Hz)	:	
d) Resolution	:	Continuous mode - 4 digits.
e) Amplitude range	:	20 mv to 20 Vp-p (open ckt).
	:	10 mv to 10 Vp-p (50 ohm load).

22.0.0 FREQUENCY METER – (1NO.)

22.1.0 Electronic type

23.0.0 INSULATION TESTER OF DIFFERENT RANGE - (3 NOS)

Insulation tester shall be portable and battery operated type with LCD display. Test voltage shall be 250 V / 500 V / 2500 V D.C. Range of insulation measurement shall be from 0.5 Meg Ohms to 50,000M ohms. Insulation resistance shall be indicated on a meter.

Auto zero adjustment and auto circuit discharge facility shall be provided.

Following accessories shall be included:

- i) Necessary carriers with rubber and steel centers
- ii) Measuring roller
- iii) Extension Rod
- iv) Carrying case

The indication shall be magnetically damped. Push button shall be provided to hold the pointer for exact reading.

24.0.0 PORTABLE DIGITAL MULTIMETER - (10 NOS.)

- a) 4½ digit LCD display
- b) 6 functions DC Volts; AC Volts; DC mA, AC mA, frequency and Ohms - Total 25 ranges (min.)
- c) Battery/Mains operation with low battery voltage indicator (9 V single battery)



- d) Battery life 150 hours (min.)
- e) Automatic Polarity, auto zero, auto ranging
- f) Response time less than 5 seconds
- g) True r.m.s. display for A.C. ranges
- h) Overload protection up to 1000 V D.C. or A.C. p to p
- i) Ranges : D.C. Voltage - 0- 200 mV / 1000 V
A.C. Voltage - 0- 200 mV / 750 V
D.C. Current - 0- 20 mA / 2A A.C. Current - 0- 200 mA / 2A
Resistance - 0- 200 Ohm/ 20 M Ohm Frequency - 10 Hz to 100 kHz
- j) Ambient Temperature - 0-50 Deg.C

25.0.0 DESKTOP DIGITAL MULTIMETER - (2 NOS.)

25.1.0 Make: Fluke / Philips / Emersion / Druck / Yokogawa Or Better

Bidder shall supply desk top type Digital Multimeter for measuring DC and AC voltages, currents and resistances. Desk top type Digital Multimeter shall have the following features:

Display	:	5 – ½ digit LED display
Measurements	:	DCV, ACV, Resistance (2W, 4W), DCA, ACA
Maximum Measurements in standard ranges	:	DC V200mV / 1000V AC V 200mV / 700V
		Resistance 200 ohm / 200 Mohm
clamp is used)		DC A2mA / 2A up to 100A (Current
clamp is used)		AC A2mA / 2A up to 100A (Current
Data Memory	:	To store upto 2000 measured data and
atleast 10 set up information		
Operating Temperature	:	5 – 40 deg C
Power Requirements	:	240V AC, 50 Hz
Communication Interface	:	RS-232C
Special functions	:	Auto range mode, Auto sample mode
Accessories	:	Power supply cord, Measurement lead,
Remote connector,		
Resolution for all measurements		
DC Voltage	:	200 mV - 10 Micro V 100 V - 100 mV
AC Voltage	:	200 mV - 10 Micro V 700 V - 100 mV
DC Current	:	2 mA - 100 nA 2 A- 100 Micro A
AC Current	:	2 mA - 100 nA
	:	2 A - 100 Micro A
Resistance	:	200 Ω - 10 MΩ 200 MΩ - 100 KΩ
Diode Measurement	:	2000 mv with driving current of 1 mA
Capacitance measurement	:	20 nF to
2000 Micro F for AC&DC		

DB measurement with possible range to be available.

**26.0.0 MULTIFUNCTION CALIBRATOR – MICROPROCESSOR BASED - (3 NOS.)****26.1.0 Make- Heaven Automation / Yokogawa/ Druck Or Better**

Portable Multifunction Calibrator shall be supplied for testing and calibration of process instruments. The calibrator shall have facility for measurement and simulation of the following instruments and parameters:-

- a) Pressure and DP transmitters
- b) Electro-pneumatic converters.
- c) Thermocouples and RTD
- d) Electronic receivers and controllers
- e) DC voltage & current generation
- f) Frequency

The calibrator shall have large multiple digital indicator 4 to 5 digits. According to function and menu guided set up mode. The calibrator shall have storing facility of field calibration data together with set up information as per requirement.

The calibrator shall be microprocessor based with latest state of the art design and shall have membrane type key pad with tactile sound, in built battery & battery charger, carrying case, test probes etc.. Preferred feature - IP-65 enclosure class.

The calibrator shall also be compatible with HART and standard protocols to communicate with SMART transmitters.

One No. Lap top PC connected to the calibrator shall prepare the test reports and store history of test reports

27.0.0 A.C. UNIVERSAL BRIDGE- (1 NO.)**27.1.0 Make - Hewlett-Packard Or Better**

A.C. Bridge of the following specification shall be supplied together with probes, leads, clips, connectors, power supply cord, accessories etc.

R.L.C. Bridge shall have a measuring frequency of 1 KHz/10 KHz. The bridge shall be suitable for 240V, 50 Hz supply.

Ranges

Resistance : 10 Ohms to 10 M Ohms in seven full scale ranges with least count 10 m Ohms in 10 Ohms range.

Capacitance : 1000 PF to 1000 micro F in seven full scale ranges with least count of 1 PF in 1000 PF range.

Inductance : 1000 micro H to 1000 H in seven full scale ranges with least count of 1 micro H in 1000 micro H range.

It shall also be possible to measure "D" dissipation factor for capacitors and "Q" quality factor for inductances.

28.0.0 MV CALIBRATOR (TABLE MOUNTED)- 1 NO

This instrument shall be microprocessor based and provide an accurate and reliable measurement of millivolt/ thermocouple signals and shall generate millivolt signals for calibration of receiver type instrumentation. Accuracy shall be +/-0.02% of selected span or better. The instrument should be powered by (i) 240 V, 1 phase, 50 Hz and (i) by self



contained rechargeable battery. The selectable input & output range shall be 0-10 mv/ 0-100 mv/ 0- 1000 mvDC. CMRR (DC to 50 Hz) shall be 120 db and ambient temp. error shall be $\pm$ 0.005% per 1 C.

29.0.0 MV CALIBRATOR (PORTABLE)- 3 NOS

This instrument shall be microprocessor based and provide an accurate and reliable measurement of millivolt/ thermocouple signals and shall generate millivolt signals for calibration of receiver type instrumentation. Accuracy shall be $\pm$ 0.02% of selected span or better. The instrument should be powered by (i) 240 V, 1 phase, 50 Hz and (i) by self contained rechargeable battery. The selectable input & output range shall be 0-10 mv/ 0-100 mv/ 0- 1000 mvDC. CMRR (DC to 50 Hz) shall be 120 db and ambient temp. error shall be $\pm$ 0.005% per 1 C.

30.0.0 MA CALIBRATOR (TABLE MOUNTED)- 1 NO

This instrument shall be microprocessor based and provide an accurate and reliable measurement of milliamp signals and shall generate milliamp signals for use in calibrating receiver type instrumentation. Accuracy shall be $\pm$ 0.05% of selected span or better. CMRR (DC to 50 Hz) of 0.1 micro Amp/ volt and ambient temp. errors of 0.0005% per 0C. The instrument should be powered by (i) 240 V, 1 phase, 50 Hz. The selectable input & output range shall be 0-10mA / 0 - 100 mA / 4-20 mA DC with built in auto overload protection.

31.0.0 MA CALIBRATOR (PORTABLE)- 6 NOS

This instrument shall be microprocessor based and provide an accurate and reliable measurement of milliamp signals and shall generate milliamp signals for use in calibrating receiver type instrumentation. Accuracy shall be $\pm$ 0.05% of selected span or better. CMRR (DC to 50 Hz) of 0.1 micro Amp/ volt and ambient temp. errors of 0.0005% per 0C. The instrument should be powered by (i) 240 V, 1 phase, 50 Hz & (ii) by self contained rechargeable battery. The selectable input & output range shall be 0-10 mA / 0 - 100 mA / 4- 20 mA DC with built in auto overload protection.

32.0.0 PORTABLE GAS ANALYZER – (1 NO. FLUE GAS ANALYSER)

Bidder shall supply one (1) no. Portable gas analyzer for determining the individual quantities of Flue Gas Ranges and accuracy shall be finalised during detail engineering All hardware and chemicals required for operation of these analyzers shall be furnished.

33.0.0 PORTABLE PH INDICATOR- 1 NO

Range: 0 -14 pH in steps of 1 pH, Accuracy: $\pm$ 0.01 pH. Power supply shall be (i) 240 VAC, 1 phase, 50 Hz and (ii) rechargeable battery. All accessories to be provided.

34.0.0 PORTABLE CONDUCTIVITY INDICATOR – 1 NO

Shall be finalised during detail engineering

35.0.0 SOLDERING IRON (3 SETS)

Soldering iron shall be provided along with temperature controlling equipment for precise adjustment of temperature. Different sizes of soldering tips shall be provided with the iron.

36.0.0 SOLDER SUCKER (3 SETS)

Solder sucker shall be provided for removal of molten solder from terminal connections.

**37.0.0 SOLDERING STATION – 1 NO**

Precision type with built in temperature controller. All required accessories shall be provided.

38.0.0 DE-SOLDERING STATION – 1 NO

Precision type with built in temperature controller. All required accessories shall be provided.

39.0.0 DEAD WEIGHT TESTER - (1 NO)**39.1.0 Make - Budenburg, u.k. / Hotek Technologies, u.s.a Or Better**

Dual range dead weight tester shall be furnished to cover 1- 6 Kg./Sq.cm. and 6 - 600 Kg/Sq.cm range. It shall be compact, stable, light in weight and self contained with anodized metallic base, steel weights, twin area screw pump with ball thrust and axially located hand wheel. Accuracy shall be 0.02% for high range and 0.025% for low range of the actual reading. Dead weight piston and cylinder shall have over pressure stops preventing the piston from coming out. These pistons shall be hardened stainless steel. Oil filter shall be furnished at fill-up point to prevent contamination. The tester shall have 1/2" NPT (F) connection. Adapters of different sizes to receive 1/4" NPT, 1/8" NPT & 3/4" NPT pressure gauge shall be supplied.

The following accessories shall be included:

- a) Angle connector for flush mounted gauges
- b) Spirit level
- c) Bag of seals
- d) Wrenches
- e) Spanners
- f) Pointer remover
- g) Pointer punch
- h) Can of fluid
- i) Replaceable spares like piston ring, bushings, 'O' – ring, seals etc.

40.0.0 VACUUM TESTER – 1 NO

Air operated dead weight type vacuum tester along with electrically operated vacuum pump and all required accessories shall be furnished. It shall have a measuring range of 15-1000 mm bar and an accuracy of $\pm 0.03\%$ or better

41.0.0 DECADE RESISTANCE BOX - (2 NOS.)**Analog – 2 ; Digital - 2**

Decade resistance box shall be supplied as per specification stated below :

A dial type resistance box shall be supplied. Range of resistance box shall typically be 0.10 to 100000 ohms. There shall be six dials, each dial providing one decade of resistance value. The resistance coils should be coated with paraffin to remove moisture. The ends of the coils should be soldered to the terminal blocks with silver solder. The direct-reading accuracy of the resistance box shall be better than $\pm 0.05\%$ at the smallest range. All resistors shall be temperature compensated.

Resistance box shall be supplied with probes, leads, clips, connectors etc.

High voltage test of 2KV between terminal and instrument case shall be pass through.

42.0.0 HAND TACHOMETER - (2 NOS.) –**42.1.0 Applicable for Both Contact (1 No) And Non-Contact (1 No) Type**

Bidder shall supply Hand tachometer with latest state of the art design.

Electronic type is preferred.

Measuring ranges shall be in 4 or 5 selectable scales such that the tachometers shall be able to indicate speeds from 30 to 50,000 rev./min. The tachometer shall be rugged in construction and shall be complete with all accessories and carrying case. A built-in safety clutch shall be incorporated to protect the tachometer against overload if the speed is higher than the selected range.

Range : 0-9999 rpm
Accuracy : ± 1 RPM
Resolution : 1 RPM
Frequency std. : Crystal
LCD Display : 4 1/2 digits
Pickup : Tacho-generator pickup
For contact type : Refelctometer
For Non-Contact Type : Reflecting Tape to be installed on rotating machinery
Test Range select : Automatic
Flash tube (for non contact): Xeon lamp – white color

Fine and Coarse adjustment knobs, low / high range selector switch shall be provided for non – contact type.

43.0.0 STOP WATCH – (2 NOS)

Stop Watch shall be electronic type with LCD type display and complete with battery operated, quality controlled and carrying case. The stopwatch shall have start, stop and reset button.

The case shall be non-rusting, dust and damp- proof. Accuracy:

± 0.5 seconds per day in time display mode.
 $\pm 1/100$ th of a second for firing of one hr. in stop clock mode
 $\pm 1/200$ th of a second for firing of 30 Minutes in Stop clock mode
 ± 0.00025 seconds firing of 1 Minute in Stop clock mode

44.0.0 TORXIMITOR – 2 NOS

Shall be finalized during detailed engineering. and will be subject to Purchaser approval.

45.0.0 RHEOSTATS (1 SET)

Bidder shall supply Rheostats of the following ratings from reputed manufacturer.

1A : 2 Nos. (100 ohm, 1 Kohm)
5A : 3 Nos. (1 Kohm, 5 Kohm, 100 ohm)
10A : 2 Nos. (2 Kohm, 10 Kohm)
18A : 1 No. (10 Kohm)

**46.0.0 WET & DRY BULB HYGROMETER – 2 NOS**

Measuring range shall be 20% - 100% with digital indication. Accuracy shall be $\pm 0.2\%$.

47.0.0 ANEROID BAROMETER – 1 NO

The Bidder shall furnish precision aneroid barometers, accurate to $\pm 0.3\%$ of full scale or better. Dial size shall be 150 mm. Graduation shall be 0.5 mm and range shall be as per detailed engineering.

48.0.0 AC POWER-METER – 1 NO

Range shall be 20-600 vrms, 0.2-20A rms, 0.2-20 KW and accuracy shall be $\pm 1\%$ of rdg $\pm 0.5\%$ of range.

Display shall be 3 1/2 digit LCD. All accessories to be provided.

49.0.0 LOGIC ANALYSER – 1 NO

Two numbers microprocessor based latest proven type of portable logic analyzers, which are highly flexible, (so that they can be connected to many different circuit points easily and also to provide a clear visual display for the user), shall be furnished. Specification shall be as per detail engineering. All required accessories to be provided.

50.0.0 AIR SET – 1 NO

Input - 6 - 7 kg/cm² as per Instrument Air system. Output - As required by Instrument/drive Filter - 5 micron.

51.0.0 THERMO COUPLE TEST FURNACE – 1 NO

This furnace shall be microprocessor based and used for precise comparison of upto 6 test thermocouples with a checking thermocouple upto a maximum temperature of 1200 deg.C. It shall be suitable to make temperature checks with least uncertainty of about ± 1 deg. C over the full range

52.0.0 LOGIC PROBE – 1 NO

It should test all digital circuits based on CMOS, TTL, DTL etc. other specification shall be as per detailed engineering

53.0.0 HAND HELD SOUND LEVER METER - (2 NO)

Bidder shall supply one (1) no. portable sound level meter. Sound analysis amplitude range shall be 45 – 140 dB. The instrument shall be electronic type with LCD display and shall be provided with battery and battery charger. Bidder shall supply all other standard features and accessories.

54.0.0 AUTO TRANSFORMER VARIAC – (2 NOS.)**54.1.0 Single Phase (1 No.), Three Phase (1 No.)**

Variac providing current up to 15A is envisaged. Voltage scale around the voltage varying knob shall have white lettering and graduation as black back ground.

3 Phase Auto transformer

Rated current - 8A

Input - 415V AC 3 Phase

Output - 0-470 V AC

Single Phase Auto

Transformer Rated Current - 20 A

**55.0.0 PORTABLE ULTRASONIC FLOW-METER 1 NO**

Shall be finalized during detailed engineering and will be subject to Purchaser approval.

56.0.0 DC POWER PACK – 3 NO

Two numbers of highly stabilized, solid state. power supply packs with over voltage/current limiting output protections shall be provided for output range of 0-60 VDC regulation shall be 0.01% or better.

57.0.0 GRINDING WHEEL – 1 NO

Shall be finalized during detailed engineering. and will be subject to Purchaser approval.

58.0.0 ELECTRONIC AND PNEUMATIC TEST BENCH - (2 NOS.)

Self contained test bench for testing and repair of electronic/ electrical / pneumatic instruments and gadgets shall be furnished. It shall be modular in design, enabling easy change of arrangement This shall include necessary isolating switch, power supply switch, holding brackets, power supply sockets, signal sockets, meters, plugs, variac, air gun etc. laid aesthetically in a bench-top unit.

The Electronic test bench shall be fitted with microprocessor based electronic calibrator and shall include necessary power packs with the following sockets mounted on the test bench:

Minimum Number of Sockets

± 24V DC (5A)	2
± 48V DC (5A)	2
± 12V DC (5A)	2
± 5V DC (5A)	2
220 V AC, 50 Hz (Stab) (5A)	2
260 V, 1phase, 50 Hz, 3 KVA stabilized – 10 A	4
0 - 60V DC (1A) :	2

Voltage level is tentative and shall be matched to supply requirements of Bidder's range of products.

The variable A.C. supply shall have a range of 0-260V and the sub- panel shall contain ammeter and voltmeter. The output shall be protected with circuit breaker. The stable 220V AC supply shall maintain stability within $\pm 0.5\%$. The stabilizer shall be servo-controlled. A voltmeter shall be provided in the sub-panel to indicate input and output voltages.

D.C. supplies shall be externally settable, floating type, reverse polarity protected. A metering sub-panel shall be provided for monitoring voltage, current with necessary plug sockets.

The test bench shall be fitted with microprocessor based pneumatic calibrator and other accessories with necessary air regulating arrangements. Fine & coarse arrangements shall be provided. Arrangements shall be made to calibrate low and high range instruments. The above test bench made of anodized aluminium, modular in design, enabling easy change of arrangement/layout The test bench shall be complete with valves , overload protection feature etc

Standard utility outlet sockets (4 nos.) shall be provided. A compressed air blowing arrangements shall be included having a gauge, regulator and flexible hose.

**59.0.0 D.C. REGULATED POWER SUPPLY - (3 NOS.)**

Bidder shall supply D.C. Regulated Power supply designed with latest state of the art electronic and IC technology. D.C. Regulated Power supply shall have the following features:

01. Voltage Range (Continuously adjustable)	: 0 to $\pm$ 60V DC, 1 Amps. (Floating)
02. Voltage/Current Range meters	: 0-60V/0-1.2A
03. Display	: LCD
04. Meter Accuracy	: $\pm$ 2% FSD
05. Power Supply Connection	: 240 V AC, 50 Hz.
06. Output	: 2 Nos. common control.
07. Output Impedance	: 50 m Ohm or less.
08. Load Regulation	: 0.1% variation in voltage
0.2% variation in current	
09. Drift in 8 Hours	: 0.1% variation in voltage
	0.2% variation in current
10. Ripple and Noise	: Less than 1 mV
11. Setting Resolution	: 20 mV / 20 mA
12. Temperature co-efficient	: 0.05% per Deg.C
13 Accessories	: Test cords and clips as required. Power supply shall be short circuit proof and crowbar protected.

Fine and coarse adjustment and overload protection facilities shall be available.

60.0.0 CONTINUITY TESTER - (6 NOS)

Continuity tester shall be electronic and battery operated. A hooter shall be provided which will sound when continuity detected. Tester shall be supplied with battery charger, lead wires and probes. The tester shall be kept in a carrying case.

61.0.0 TONG TESTER – (2 NOS.)

Electronic type Tong tester of the following specification shall be supplied.

Tong tester shall be suitable for measuring the current ranges of 0-5/10-15/30 amps AC and DC. It shall have swivelling joint between tongs and meter to facilitate easy reading.

Auto ranging and 3½" LCD display facility shall be available.

**62.0.0 STABILIZED POWER SUPPLY – (4 NOS.) – 2.5KVA (1 NO) AND 5KVA (1 NO.)**

Bidder shall supply stabilized power supply designed with latest electronics and IC technology. It shall have the following minimum features:

01. Voltage Range	: 0-230V AC, continuously adjustable.
02. Power Supply Connection	: 240V AC, 50 Hz
03. Indication	: Meters indicating voltage and current shall be integral with power supply
04. Load Regulation	: 0.25% variation in voltage

63.0.0 PORTABLE VACUUM CLEANER – (6 NOS)

Portable industrial type Vacuum cleaner with blowing (including Hot)and sucking facility shall be supplied for cleaning the control panels, C&I laboratory instruments etc.

64.0.0 STROBOSCOPE – (1 NO)

Portable stroboscope suitable for 240V AC, 50 Hz supply from reputed Make shall be supplied. Measuring range shall be from 0 to 10000 rpm minimum in suitable ranges.

Instrument shall have 4½" digit LCD display with accuracy $\pm 0.05\%$ or better with microprocessor chip for better accuracy over wide capacity.

Calibration: Crystal time base and microprocessor circuit shall not require any external Calibration.

Test range select

Low range - 100-1000 rpm,
High range - 1000-10000 rpm
Sampling time: 1 sec or better

Flash tube : Xenon lamp

Flash colour : White 6500 K

Fine and coarse adjustment knobs to be provided Low/high range select switch to be provided

65.0.0 DIGITAL CABLE IDENTIFICATION SYSTEM (1 NO.)

Features :Quick identification of shorting lines and open lines. It shall handle up to 96 pairs at one time.

66.0.0 PHASE SEQUENCE METER - (1 NO)

Electronic type

67.0.0 VIBRATION PICK-UP TESTER– (1NO.)

Instrument shall be suitable for testing of both non contact and seismic probes supplied by the machine monitoring instrument supplier. Shaker table to simulate the required vibration levels so as to check and validate the vibration pickups is to be supplied.

68.0.0 INSTRUMENT RACK – (2 NOS)

Heavy duty steel rack for storing bulk quantity of transmitters, switches, RTD, thermocouples etc during any capital maintenance of machine.

69.0.0 PORTABLE WHEATSTONES BRIDGE – (1 NO.)

Range	: 0.001 Ohm to 11.11 MOhm
Series Arm	: Four decades in steps of thousands, Hundreds, tens & units of ohm which can be used as a series resistance box also.
Ratio arm	: The ratio arms of the bridge are capable of selecting multiplying factors of 0.001, 0.01, 0.1, 1, 10, 100 & 1000 for conductive resistance measurement
Accuracy	: + 0.05%

70.0.0 TEST THERMOCOUPLE – K -TYPE – (2 NOS.)

Very high accuracy and Used as a Standard in C& I Laboratory.

71.0.0 TEST THERMOCOUPLE – T -TYPE – (2 NOS.)

Very high accuracy and Used as a Standard in C& I Laboratory.

72.0.0 PITOT TUBE – (2 NOS.)

Pitot tubes required to verify the primary and secondary air flow measurements available in the unit shall be supplied

73.0.0 LCR METER (DIGITAL TYPE)

Meter with 4½ digit LCD display compatible to measure the various components L, C and R available in the various power / electronic systems available in the unit supplied by the Bidder .

74.0.0 FLUIDISED BATH 1NO. (0 – 600 OC TEMPERATURE RANGE)

1no. of fluidized bath having the following specifications shall be supplied:

Media to be used vessel	: Alum dum cylindrical solid drum SS
Temp. range	: 50 – 600 oC
No. of heater	: 3 X 1 Kw
Voltage input for heater	: 230 V AC 1phase
Heat up time in minutes	: ambient to maximum in 120 min.
Cooling time in minutes	: maximum to ambient in 300 min
Air pressure	: 3psi
Provision of temp measure	: Thermo couple to be provided
Accuracy for thermo couple	: 0.25%
Pneumatic protection	: Pressure switch to be provided to switch if the heater supply in case of failure of air.
Heater control	: Thyristor based controller with built in PID algorithm having the facility to modify the set points, alarms, level, controller constants, etc. through key pad. 4½" digital display shall be provided.

**75.0.0 VIBRATION ANALYZER BALANCER INSTRUMENT - (1 NO.)**

The microprocessor based portable self-contained dual input instrument shall have the following specification and features:

Indication	:	Digital/Analog frequency and amplitude meter
Frequency	:	60 to 6, 00,000 CPM
Diagnostic	:	Hard copy tabular print-out
Printer	:	In-built; Amplitude and frequency plotting capability (3 speeds)

The instrument shall have two range manual tunable filter, two range internal oscillator, high density stroboscopic light. The instrument shall be capable of the following measurements:

- a) Displacement in 0 to 3000 micron in 9 ranges.
- b) Velocity in 0-3000 mm / sec. in 9 ranges.
- c) Acceleration in 0-100 g in 9 ranges.
- d) Spike energy 0-100 g's in 9 ranges.

The instrument shall have LCD backlit display, membrane type key pad, built in battery and battery charger. Enclosure class shall be IP-65.

Temperature Range	:	0 to + 50 Deg.C
Power Supply	:	230V, 50 Hz, 1 Ph, AC

This instrument shall be of latest & proven design and will be powered by a self contained rechargeable battery pack and shall be designed to operate also from a 240V AC, 50 Hz, 1 phase power supply with the battery pack removed.

This shall have frequency range of 50 to 500000 cpm and vibration range in terms of displacement/velocity/acceleration shall be 0-3000 microns/0-3000 mm/sec/0-1000gs respectively. All required accessories shall be provided. Outputs shall be in terms of built in XY plotter, diagnostic & message printout, analog amplitude & frequency meter.

One No. Lap top PC connected to the calibrator shall prepare the test reports and store history of test reports, Frequency spectrums analyzing reports etc.,

76.0.0 PORTABLE DIGITAL VIBRATION METER - (2 NOS.)

The microprocessor based portable self-contained instrument shall have the following specification and features:

Indication	:	LCD 4 1/2 digit
Frequency	:	60 to 6, 00,000 CPM
Measurements Required	:	
a) Displacement	:	in 0 to 3000 micron in 9 ranges.
b) Velocity	:	in 0-3000 mm / sec. in 9 ranges.
c) Acceleration	:	in 0-100 g in 9 ranges.

The instrument shall have LCD backlit display, membrane type key pad, built in battery and battery charger. Enclosure class shall be IP-65.

Temperature Range	:	0 to + 50 Deg.C
Power	:	Battery operated

**77.0.0 PORTABLE ANALOGUE VIBRATION METER - (1 NO.)**

The microprocessor based portable self-contained instrument shall have the following specification and features:

Indication : Analogue Meter
Range : Selection by Manually
Frequency : 60 to 6, 00,000 CPM
Measurements Required :

- a) Displacement in 0 to 3000 micron in 9 ranges.
- b) Velocity in 0-3000 mm / sec. in 9 ranges.
- c) Acceleration in 0-100 g in 9 ranges.

The instrument shall have built in battery and battery charger. Enclosure class shall be IP-65.

Temperature Range : 0 to + 50 Deg.C
Power : Battery operated

78.0.0 TOOL KIT BOX– (6NOS.)

Each box shall comprise of sets of Allen keys of different sizes both in inch and millimeter, slide wrenches of different sizes, D spanner of different sizes, electric tester, Ring spanner of different sizes, Insulated screw drivers Hammer Ball pin, File kit, burnisher, pen light, pliers of different sizes and different applications, punch centre, punch pair, stainless rule, scissors, Tape measure, wire crimper, Wire stripper / cutter Ratchet screw drivers, star screw drivers, spanners, cutters, pliers, allen keys (all type), Nose plier, Rough & smooth files, slide & pipe wrench etc. as a minimum.

79.0.0 WORK BENCH – (1 NOS.)

Heavy duty wooden construction with drawers, racks, vice, drill machine.

80.0.0 PORTABLE FERRULE MAKER / LABEL PRINTER

1 No. portable ferrule maker printing machine inter faceable to PC shall be supplied to print in 2 to 6 mm PVC tube for identifying the core and signal names.

1 No. Portable label printer for printing various sizes of labels.

81.0.0 TUBE BENDER / CUTTER

2 Nos. each size ($\frac{1}{2}$ ", $\frac{1}{4}$ " and $\frac{3}{8}$ ") tube bender preferably Swagelok make for bending the tube.

2 Nos. hydraulic type impulse tube cutter (catering various sizes).

82.0.0 LABORATORY PC : ONE NO.

The laboratory PC shall be with latest configuration. In addition, suitable connectors and associated software(s) for downloading of logged data from various maintenance & calibration instruments shall also be provided

83.0.0 HART COMMUNICATOR

It shall be possible to perform routine configuration, calibration, display process variable, diagnostics etc. from a hand held portable communicator, which can be connected at any location in the transmitter loop. It shall be possible to perform all the above functions on-line.



The loop function shall remain unaffected while communication is going on between transmitter and the field communicator.

HART protocol of latest version shall be used and shall be suitable for HART maintenance system with corner stone software or equivalent with the following features as minimum:

- a) It shall allow multi masters (two for example, primary and secondary) for configuration, calibration, diagnosis and maintenance. The primary could be control system or host computer and the secondary could be the hand held communicator or a maintenance computer.
- b) It shall be capable of implementing universal commands. It must be possible to communicate all the commands of HART maintenance system to field transmitters and smart transmitters shall be selected accordingly.

There should be no interruption on the output while communicating with the transmitter.

Field communicator shall meet the following requirements:

- a) Hand Held communicator shall be universal type and shall be compatible with all make and models of HART transmitters, Smart positioners, instruments with all engineering capability like calibration, diagnostics, configuration, inhibition of HART signal, etc.
- b) It shall be possible to connect the communicator at any of the following locations for purpose of digital communication;
 - i) Marshalling cabinet serving the transmitter, in safe area.
 - ii) Junction box serving the transmitter, in hazardous area.
 - iii) Directly at the transmitter, in hazardous area.Plug-in type connections shall be provided with field communicator. Necessary interconnection accessories shall be provided by the contractor.
- c) Offered communicator shall be dust-proof, certified intrinsically safe and suitable for outdoor location. Carrying case shall be provided with each communicator.
- d) When specified in data sheets, the software shall also be capable of configuring other makes of transmitters.
- e) They shall be battery powered with replaceable and rechargeable batteries, suitable for recharging with 240 V, 50 Hz .
- f) Battery charger : Battery charger shall be provided with all necessary accessories and shall operate at 240V $\pm 10\%$, 50Hz ± 3 Hz, unless otherwise specified.

84.0.0 OVERHEAD INTERACTIVE WHITE PROJECTION BOARD

Two Nos. of overhead projection board (Interactive White Board) with complete accessories, software i.e one for conference room at service building & one for training room shall be provided by bidder. These boards shall act as I/O device from/to the desktop computer or laptop computer.

These Interactive white boards shall be provided with following minimum features

- a. Two (2) nos. of USB port required for interfacing with PC/Laptop.
- b. Screen size 79" or better.
- c. Hand writing recognition with multi touch function
- d. Scroll down facility with wireless facility enabled.
- d. Remote conferencing enabled
- e. Should support OS: Windows, Mac and Linux
- d. Accessories as Stylus Pen, VGA cable.

85.0.0 PROJECTOR WITH WHITE MARKER BOARD

One no. projector with white marker board size of 80" shall be provided by bidder for conference room at Administrative building. The projector will be have following minimum features with DLP/LCD based technology. Minimum 3000 lumens, with wireless adapter, USB port, with in-built speaker. Network capability.

86.0.0 VIDEO CONFERENCING SYSTEM

In the discussion room/conference room, video conferencing system facility with dedicated internet connection shall be provided as per detailed below, so as to talk to other thermal power station, load dispatch centre, TANGEDCO Head quarters etc. Supplier shall be infocomm, USA Certified member

Sr. no.	Description	Quantities
01	Video Conferencing System	1 set
02	Full HD 55 inches Professional Display Unit with built in speakers.	1 set
03	Wall Mounting Bracket suitable for above display unit.	1 set
04	Minimum 2 KVA industrial grade UPS with 60 minutes Ni Cd battery backup	1 set

ESSENTIAL FEATURES:

- Provides TV-like video quality and upto 720p (incoming).
- codec and camera must be separate so that codec will go into cabinet and camera can go below the display unit.
- H.264 video support upto 4Mbps and ISDN upto 512 Kbps (4xBRI)
- 6-site multiparty conferencing via embedded MCU
- Advanced data sharing capabilities
- Data pod must be supplied with inputs for VGA, Audio and USB for making presentations.
- Live Recording of video conferencing session in point to point, Multi point or in idle mode and the recording must be within the codec itself without relying upon external device. Minimum 60 hours of recording must be possible. After recording, it must be possible to retrieve the recording to computer system by connecting PC to the USB port of the codec.
- Native 16:9 wide screen display support
- CD-quality audio using 20KHz ultra-band audio
- Web based management for easier control and administration.
- Telnet API for AMX/Creston
- Supports encrypted conferences using the H.235 encryption standard.
- USB Connectivity in system for ndirect playback of PPT,excel,files during the session.
- Live streaming of point to point or multipoint call or video on idle mode on internet, which can be retrieved by anybody by just dialing the IP no. Of the Video Conferencing System

Video Specifications:

Transmission Speed

H.323: 64 Kbps - 4Mbps

ISDN 64 Kbps - 512 Kbps (4xBRI) – Optional

Video Standards

H.261, H.263, H.263+/++

H.264 – up to 2 Mbps outgoing

Live Video Resolution

QCIF (176 x 144 pixels)

QVGA (320 x 288 pixels)

CIF (352 x 240 pixels)

SIF (352 x 240 pixels)



VGA (640 x 480 pixels)
4CIF (704 x 576)
4SIF (704 x 480)
720p (1280 x 720 pixels) incoming only

Video Frame Rate

up to 10 fps: 64 Kbps
up to 20 fps: 96 to 192 Kbps
up to 30 fps: 256 Kbps and higher

Video Inputs

1 Composite and S-Video

Video Outputs

1 each: S-Video, Composite, Digital
Video Interface (DVI), VGA

Video Features

Video device discovery
Automatic NTSC/PAL detection
support for any number of video devices & PIP facility.

HD Simulcast

Chair or participant in any
Interactive Multicast session
Integrated Broadcast Viewer
Use bandwidth-efficient IP multicast

Audio Specifications

Audio Features
Full duplex echo cancellation
Automatic noise suppression (ANS)
Automatic gain Control (AGC)
Audio device discovery
Audio Tuning Wizard
Support for Unlimited number of audio devices
Headset and Speaker profiles
Voice Activity Detection (VAD)

Audio Standards

20 Khz: AAC-LD
14Khz: G.722, G.722.1
3.4 Khz: G.711, G.723.1, G.728, G.729
AMR(3G)

Data Specification

Data Sharing Methods
Laptop plug in (via Tabletop pod)
USB Storage Key
Documents: PPT , PPS
Video Clips (AVI, MPEG, WMV, etc.)



Audio Clips (WAV, MP3)
Graphic Files (BMP, GIF, TIF, etc.)
Dual Streaming Capability
Sharing of file, or the VGA input
H.239 support
Sending and receiving capability
1 live video source + 1 data source
Resolutions supported:
XGA, SVGA, VGA, CIF, QVGA, QCIF, 4CIF

Networking Specifications

Standard Supported

ITU-T: H.323 v4.2
H.281 Annex Q (FECC)
ISDN: H.320, H.221, H.242, H.230

H.323 QoS Features

Diffserv
IP precedence
Firewall port sync
NAT IP address mask
Port pinholing
Adaptive Bandwidth Adjustment
Packet Loss recovery(FEC)
Packet ordering
Packet duplication control
Jitter correction
Lip sync correction
Overhead prediction
Max packet size adjustment

Peripheral specifications

Pan-Tilt-Zoom Camera picture – unit

1/4-color CCD
Presets – 6 positions or more
Focal length – 3.1 mm to 31mm
Pan-Tilt range - +/-100deg pan, +/-25% Tilt
Zoom range – 10x (optical) or more, 40x(digital)
Horizontal resolution
460 TVL (PAL), 470 TVL (NTSC)
Focus - Auto/Mannual
Brightness & Far end camera control.

Monitors Configurations

single DVI, VGA or TV
Dual: DVI + VGA
Dual: VGA+ TV
Dual: DVI + TV

Features Specifications

Dialing Modes Manual

Speed Dial
personal address book
Online directory
Multicast Chair
Broadcast Viewer
Telnet API for AMX/crestron



Security	Encryption using H.235 (AES) secure connect DES, 3DES and AES support AES is NIST validated Frontier - Firewall traversal - Network Address translation Supports restricted access to users via admin
Control	International Remote Control Embedded Web based Management
Environmental	0 -40deg C temperature 15 – 80% humidity Universal Power Supply Operating Voltage: 120V or 230V Operating frequency: 50 Hz or 60 Hz

TECHNICAL SPECIFICATIONS FOR 55" PROFESSIONAL DISPLAY.**Display:**

Screen size	55 inches
Resolution	1920x1080 (16:9)
Brightness	700 cd/m2
Contrast ratio	3000:1
Pixel pitch	0.53025(H) * 0.53025(V)
Colors support	8bit – 16.7M

Signal Input:

Video Signal	Analog D-SUB, DVI-D, Display port, CVBS, HDMI1, HDMI2

Features:**Special Features**

Lamp error detection, Brightness sensor, Anti Retention, Temperature Sensor, RS232C/RJ45 MDC, Built in speaker(10W + 10W), Plug and Play (DDC2B), PIP/PBP, Video Wall(10x10), Pivot Display, Button Lock, Digital Daisy Chain, Smart Scheduling, Smart F/W update

87.0.0 Digital camera – 2 nos.

Digital Camera 18.2 mega pixel with 30x zoom (shall be of the latest configuration) with rechargeable battery and charger, HDMI cables

88.0.0 Digital Video camera – 1 nos.

In built 320 GB memory (min) and built in projector with 12x optical zoom x 20x extended zoom with standard accessories, With rechargeable battery and charger, HDMI cables. (Shall be of latest configuration)

89.0.0 Digital Manometer - 2 Nos.

Make Meriam/Tinsley/Fitzer/Yokogawa/Cole Parmer/ Beamex

The range shall be .2 to 2 kg/cm2 and accuracy shall be 0.25% or better.

Technical specification

Ranging from -10,000 to +10,000 mmwc



It is used to high and low differential pressure instrument. It has large dual LCD with back light with USB & Computer interface with Rs 485 male connector.

Battery operated digital manometer mainly use for air and gas (vacuum) services.

90.0.0 Magnetic screw driver Tinsley/ Beamex/Scandura/Taparia/RS components/ Hitachi/ Black& Decker - 1 No.

CALIBRATION STANDARDS

The calibration standards shall be traceable to the National Bureau of Standards of the United States of America, comparable Indian Standards, or to applicable standards existing in the country where the equipment is manufactured and tested. The Bidder shall elaborate in the proposal the standards followed for the equipment manufacturing and testing.

Three (3) nos. teak wooden work tables with thick laminated top of size 1x2 meters, Eight (8) nos. high adjustable wheeled swivel chairs, Four (4) nos. vertical cabinets 1000 x 480 x 2000 mm made of sheet steel and equipped with safety locks, Four (4) nos. open shelf 1000x200x2000 with partitions made of steel shall be provided in addition to Electronic & Pneumatic Lab test bench.

Computer Aided Calibration system offered, shall meet the demands of high precision transfer / secondary standards for automatic testing & calibration of temperature, pressure & electrical parameters in quick time and for issuance of simple, error free, reliable, fully traceable calibration certificates conforming to ISO standards / Protocol.

Computer Aided Calibration system shall have also the following facilities: -

1. Automatic Testing and Calibration:

- i) Pressure instruments like pneumatic/hydraulic pressure/ differential pressure vacuum gauges/indicators / transmitters/ switches/controllers, electro-pneumatic instruments P/I, I/P converters.
- ii) Pressure/differential/temperature/flow transmitters current/pH converters.
- iii) Analog instruments, such as indicators for pressure, current, voltage etc.
- iv) Digital panel indicators with additional port for DC current measurement.

2. Automatic testing and calibration of all types of temperature measuring instruments including temperature indicators/ recorders/controllers, thermo switches, RTD and Thermocouples of all international standards (range from -20 Deg.C to 1200 Deg.C).

3. An automatic temperature calibration system for simultaneous calibration of multiple temperature sensors.

4. Automatic calibration and system documentation through Personal Computer offered with compatible calibration software.

Measuring/testing instruments, along with allied accessories shall be suitable for continuous operation (both indoor and outdoor installations as applicable).

Microprocessor based lab instruments shall be offered wherever applicable. All the microprocessor based maintenance and calibration units should also have provision for data logging facility for keeping calibration/maintenance record with proper communication facility to down load these data on the lab WORK STATION.

The Bidder shall supply testing instruments/ devices, specified hereinafter, for meeting the requirement of the power plant. The Bidder shall be responsible for proper functioning of supplied items, to check and make any necessary additions/tools as required for proper



maintenance and testing of the installed instruments and controls. The Bidder shall also be responsible for erection and commissioning the test equipment where applicable.

It is obligatory to the Bidder to provide mandatory spare parts for these testing/calibrating, instruments/devices as approved by Owner. The Bidder shall render guarantee for easy availability of all the spare parts required,

All the calibration instruments shall have a common WORK STATION along with A3/A4 sized B/W Digital Laser jet printer cum Copier for calibration and report generation. Specification for WORK STATION and Printer shall be same as specified elsewhere in the specification.

All the calibration instruments shall be provided with RS232C port for Lab WORK STATION interface with their own interfacing cables & software.

All the portable type lab instruments shall be provided with own rechargeable battery & charger.



VOLUME II
SUB-SECTION 4.20
INSTRUMENTATION & CONTROL CABLES

1.0.0 GENERAL

All Instrumentation Cables shall be of 600V grades and Control cables shall be of 1100V FRLS, PVC insulated, armoured 7-stranded copper conductor cable to be provided as per the latest IS/IEC standards.

Signal cable	:	600V, 0.5 Sq.mm for single pair, screened 600V, 0.5 Sq mm for multipair, individual pair and overall shielded.
Control Cable	:	1100V Screened with overall screen 1100V 1.0 Sq mm for 2 Cores 1100V 1.0 Sq mm for multi core
Power cable	:	2.5 Sq.mm for 2/3 Cores

Wiring within desks and panels shall be supported on trays and shall be segregated according to voltage level. Wire carrying AC and DC voltage shall also be segregated.

All desks, panels, cubicles and racks shall be factory-wired. Where desks or panels shall be supplied in more than one section, electrical connections between the sections shall be via terminal strips provided for this purpose.

Spare cores shall be terminated at terminal strips and shall be ferruled in such a way as to indicate that they are spare cores.

After commissioning 20% of the conductors of multi core cables shall be available as spare.

All instrument cables shall be laid on cable trays. Cable trays shall be sized to have 20% spare space as a minimum.

Junction boxes for alarm, signal, T/C, interlocks etc shall be separate. All the shield wires shall be terminated in the JB as per Cable Schedule. Separate JB shall be used for inputs and outputs. JB shall be earthed through GI flat. Separate JB shall be provided for intrinsic safe circuits. Fiber optic cables shall be routed in GI conduits.

All panel wiring shall have sufficient spares for future expandability.

Individual pair shielded & overall shield twisted pair copper cables shall be used for analog signals & overall shielded cables shall be used for digital signals. All these cables shall be armoured. The insulation of outer sheath shall be FRLS quality. The wire size shall be 0.5 sq.mm. Ferruling indicating terminal numbers on termination side shall be followed. Colour coding shall be as per Purchaser's standard.

2.0.0 INSTRUMENTATION CABLES

Instrumentation cables shall be 600VAC grade, stranded high conductivity annealed, tinned copper, twisted pair (with min. 20 twists for meter) extruded PVC insulated with overall and / or individual screening, extruded PVC inner sheathed, galvanized steel wire armoured, only extruded outer sheathed with FRLS PVC compound. The conductor size shall be 0.5 sq.mm. Pair cables can be used for RTDs. Instrumentation cables carrying digital signals shall have



overall screening along with drain wire and analogue signal carrying cables shall have each pair screening and overall screening along with each pair drain wire and overall drain wire. Colour coding for the identification of pairs shall be as per BS-5308 Part-2.

3.0.0 CONTROL CABLES

Control cables shall be 1100V AC grade, multicore, minimum 1.0 sq.mm cross section, stranded copper conductor having 7 strands, PVC insulated, inner PVC sheathed of type ST-1, galvanized steel wire armoured and outer sheath made of FRLS PVC compound of type ST-1. In situations where accuracy of measurement or voltage drop in control circuit, warrant, higher cross sections as required shall be used. Colour coding for the identification of pairs shall be as per BS-5308 Part-2.

4.0.0 FIBRE OPTIC CABLES

Mono mode type fibre optic cable with following parameters shall be provided.

- Cable Type: Mono-mode with minimum 4 fibres
- Wavelength band optimized : 850nm / 1300nm / 1550nm
- Mode field diameter : $9\text{-}10\mu\text{m} \pm 10\%$ of nominal value
- Cladding diameter : $125\mu\text{m} \pm 3$
- Non-concentricity core/cladding : not more than $2\mu\text{m}$
- Non-circularity of cladding : not more than $3\mu\text{m}$
- Cut-off wavelength : 1200nm
- Attenuation : less than 0.3-0.4 dB/km at 1300nm
less than 0.15-0.25 dB/km at 1550nm

Multi mode type fibre optic cable with following parameters shall be provided.

- Cable Type: Multi-mode with minimum 4 fibres
- Core / cladding diameter: 62.5 / 125 μm
- Jacketing Material: Halogen Free, Flame Retardant, Low Toxicity
- Attenuation @ 850 nm: Length (m) x 0.0035 db/m+2db maximum
- Outside Diameter: 8.10 mm (0.324 in)
- Minimum Bend Radius: 12.5 cm (5 in)
- Minimum Bend Radius (Long term): 7.5 cm (3 in)
- Cable Assembly: Tensile Load for attenuation increase <0.5 db: 300 N (66 lb) maximum
- Tensile Load at Installation: 1776 N (400 lb) max.
- Connector Tensile Load MIC : 133 N (30lb)
- Minimum Crush Resistance: 46 N /cm (250 lb /in)
- Maximum Cable Weight : 46 kg/1 km (31 lb/1000ft)
- Maximum Cable length: 2 km (6560 ft)

HDPE insulation shall be suitable for continuous conductor temperature of 85°C. The insulation material shall be resistant to oil, acid and alkali and shall be tough enough to withstand mechanical stresses during handling.

The cables shall have HDPE primary insulation suitable for FRLS. Inner and outer jacket shall be made of extruded flame retardant HDPE.

The cables shall be armoured. Armour shall be of galvanised steel wire / flat as per IS 3975.

The cables shall be protected against termite and rodent attack. Necessary chemicals shall be added into the compound of the outer sheath.



The material used in the construction of fibre optic cables shall be compatible with the properties of the cables and shall be in accordance with the relevant IS and IEC standards as stated above.

5.0.0 Design requirements

All cables shall be suitable for laying on racks, in ducts, trenches with chances of flooding by water and shall also be suitable for directly buried installation. All the cables shall be FRLS type designed to withstand mechanical, electrical and thermal stresses developed under steady state and transient operating conditions.

The cables shall be capable of operating satisfactorily under the power supply and frequency variations, high ambient, high humid tropical climatic conditions as specified in project information.

The cables are proposed to be laid in multi-tier overhead cable racks, in concrete cable trenches. Derating factors for grouping and ambient temperature shall be furnished by successful bidder along with filled up datasheets during contract engineering stage.

PVC insulation shall be suitable for continuous conductor temperature of 85°C and short circuit conductor temperature of 160 °C. The insulation material shall be resistant to oil, acid and alkali and shall be tough enough to withstand mechanical stresses during handling.

All the cables shall be protected against termite and rodent attack. Necessary chemicals shall be added into the PVC compound of the outer sheath.

All cables shall have PVC primary insulation as per IS 5831 Type C / IEC 502 suitable for FRLS. Inner and outer jacket shall be made of extruded flame retardant 90°C PVC to IS 5831 Type ST2 / IEC 502. Oxygen Index of PVC shall be over 29% and temperature index shall be over 250°C.

The cable cores shall be laid up with fillers between the cores wherever necessary. All the cables shall have distinct extruded PVC inner sheath.

The cables shall be armoured. Armour over inner jacket shall be of galvanised steel wire / flat as per IS 3975.

All the cores of single pair or multipair shall be twisted and twists shall not be less than 20 per metre.

The outer sheath for analog and digital cables the colour shall be light blue and black respectively.

Running length of cable shall be printed atleast every 5m interval. For multipair cables, pair identification shall be provided with numbers at interval of not more than 250mm or as per vendor's standard.

6.0.0 Construction

The insulation shall be applied directly over the conductor by extrusion method. in such a way that it fits closely on the conductor and it shall be possible to remove it easily without damage to the conductor. Two cores shall be twisted to form a pair and four such pairs shall be twisted together to form a unit.

Every pair shall be twisted with a lay of 40 to 50 mm and to be wrapped with polyester tape. Individual pair screening with edges frees poly aluminium tape with continuous drain wire of minimum overlap of 30%.



Required number of pairs to be laid up to form the cable and overall shielded with edge free Poly- aluminium tape with continuous drain wire of minimum overlap of 30%.

The cable shall be then sheathed with FRLS PVC by extrusion method. The shielding and sheathing shall be so done that it fits firmly on to the cable and are easily removable without damage to the cores.

7.0.0 Packing and Marking

Packing

The tolerance on the dispatched cable length on each drum verified and accepted by Inspector shall be limited to $\pm 5\%$ of standard drum length. However the overall tolerance of the total dispatched quantity of each size shall be $\pm 2\%$. Short lengths of individual length not less than 200m shall be acceptable only in the final drum lengths to meet the overall tolerance limits stipulated above. Cable consumed for testing and inspection will be to bidder's account.

Cable Reeling Drums

The Cable drums shall be non returnable wooden or steel drums of sturdy construction

The wood used for the construction of the drums shall be of durable quality, properly seasoned and treated with Copper Nephthenates or Zinc Nephthenates for preserving the wood (Refer IS 401). Wood preservatives anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS 10418. All ferrous parts shall be treated with suitable rust preventive coating to avoid rusting during transit and storage.

The surface of the drum and the outermost cable shall be covered with waterproof layer. Both the ends of the cable shall be properly secured with heat shrinkable PVC / Rubber caps, secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection.

Each drum shall carry the manufacturer's name, purchaser's name, address and contract no., item no. and type, size and length of the cable and net and gross weight stenciled on both sides of the drum. A tag containing the same information shall be attached to the leading end of the cable.

An arrow accompanied by suitable wording shall be stenciled on the ends of the drums of indicate which way it should be rolled. The number of each drum shall be either branded at the end of the drum or stamped on the metal disc attached to one end of the drum.

Marking

Marking on outer sheath:

In addition to manufacturer's identification on cables as per IS, the following shall be embossed on the outer sheath at every 1m throughout the length of the cable:

(i)	Manufacturer's Name & Trade Name	:
(ii)	Year of Manufacture	:
(iii)	User's Name	:
(iv)	Voltage grade	:
(v)	Type of outer sheath	:
(vi)	Type of inner sheath	:

The label which is securely attached to the reel or drum or coil shall have the following information:



Purchaser's name and address :
Purchase Order No. and item no. :
Manufacturer's /Supplier Name :
Length in meters :
Gross Weight :
Item code number and cable drum number :
Direction of rotation of drum for unwinding by means of an arrow



VOLUME II
SUB-SECTION 4.21
C&I ERECTION

1.0.0 TECHNICAL REQUIREMENT**1.1.0 Panels**

Panels and control desk shall be freestanding type and fabricated preferably from 2.5 mm thick cold rolled steel sheet. Angle iron framework shall use a minimum section of 50 × 50 × 6 mm angle. The finish shall include sand blasting, grinding, chemical cleaning, and surface finishing by suitable filter and two coats of high-grade lacquer with wet sanding between coats. Two coats of paint in panel color shall be given for non-glossy high stain finish. Panel face final color in general shall be RAL 7035. A final coat of paint shall be given at site.

Panels and control desk shall have removable hinged doors, generally at the back for easy maintenance and accessibility of the instruments. Doors shall be double leaved type with handle and shall be provided with lock and key. Adequate illumination shall be provided inside the panel. All light fittings shall be suitable for 230V, 50Hz A.C.

The local panel construction shall be suitable for the site condition and shall meet IEC requirements in accordance with electrical area classification. Pressurization or purging shall be as per NFPA 496 or equivalent.

No process fluid except air shall be piped to the control panel.

Mounting heights

1. Annunciators (top row)
2. Miniature and subminiature instruments (next 3 rows)
3. Electric push buttons (last row)

Control room panels shall have IP protection of IP 32 if mounted in an air- conditioning room and IP-45 if mounted inside a room and IP-55 if mounted outside.

1.2.0 Cable Trays

All I&C cables / tubes shall run on perforated cable trays. These cable trays shall be made out of galvanized MS and shall be of sheet steel of 2.5 mm thick. The width shall be so selected that 60% of tray space is available for future use of the complete installation.

Suitable cable clamps shall be supplied for binding the cables / tubes at every 500 mm. Cable tray shall be provided with Hot dip galvanized finish. Cable tray shall be provided with the perforation as per manufacture standards. Suitable cable tray cover shall be provided for all trays.

Cable tray shall be continuous and solid grounded. Cable tray shall not have sharp edges, Burrs or projection which is injurious to insulation or outer sheath of the cable.

The supporting arrangement of cable tray system shall be able to withstand the weight of the cable and cable tray system. The supporting interval shall not be more than the recommended span for the above loading for the type cable tray selected. The tray shall not overhang by more than one meter from the support at the dead end.



1.3.0 Process Impulse Lines /Tubes & Fittings

Impulse lines for instruments shall be 1/2" OD tubing of SS316 material according to ASTM A-269. All fittings to be used for tubing shall also be SS316, double compression type of standard make. Impulse pipes for high pressure applications shall be used with material and rating as same as that of the process line. Size and thickness of piping/tubing shall be suitable for the design pressure and temperature conditions as per ANSI16.11. Compression tube fittings are used in low pressure process systems. Socket weld tube fittings shall be used in high pressure process systems

For impulse pipes/tubes and fittings, IBR certificate shall be provided as applicable. The bidder shall provide thermal insulation (preferably mineral wool) for sampling pipes for the purpose of personnel protection so that temperature outside the insulation is 60 deg. C. Tubing shall be complete with union connections and end fittings at supply and receiving ends. Nipple shall be provided for root valves size more than 1/2" and the nipple size shall be same as the root valve size. Reducer / adapter shall be provided to suit instrument connection, where nipple, root valve size is more than 1/2". Bulk head fitting socket welded type to be provided at instrument rack/enclosure.

Impulse pipes, fittings and air supply and signal piping/tubing shall be supplied for all the instruments under the scope of this specification. Instrument piping shall be designed for maximum design pressure and temperature of the process. Pressure measurement connection shall be 1/2" or 12mm pipe depending on the temperature and pressure conditions of the fluid. Instrument on Vacuum system at CEP inlet should have vent lines connected to high point in the condenser. Instrument air tubing shall be SS.

Minimum bending radius of instrument sensing line is 3 times the tube diameter. Independent impulse lines shall be installed between the flow elements and the transmitter in case of dual/triple redundant

Instrument sensing lines are sloped in their horizontal runs, a minimum of 1/2" per foot. In general, liquid and steam lines slope from their process tap connection down to the instrument. In general, gas and non-condensing vapor lines slope from their process tap connection up to the instrument.

Instrument sensing lines shall be routed as directly as practicable from the process root valve to the instrument. The length of instrument tubing from the root valve to the instrument shall be limited to maximum of 12 meters for compressible fluids and 15 meters for non-compressible fluids. Wherever it is not possible to access the main root valve a additional root valve shall be provided near to the instrument.

Instrument sensing lines shall be grouped together as much as possible to benefit from the use of common support members and to present a finished installation that is routed in a neat and orderly manner.

The maximum process temperature for all transmitters shall be limited to 80°C. To dissipate the excess heat, a minimum of 1 meter of tubing for each 30°C of excess heat shall be installed to isolate the process media from the instrument. An additional isolation valve shall be used at the instrument for isolation on those instruments without valve manifolds

Funnel with drain header shall be provided in the racks for blowing/draining out the process fluid in the impulse tubings. The size of the drain header shall be 1". When instruments are mounted local to the tapping point and are not mounted in the rack, or panel or enclosure, the drains shall be connected to the nearest floor level or plant drain.



The erection hardware shall meet the following specifications:-

Item	Specification
a) Impulse Piping	
i) High pressure and high temperature services (Medium: Steam & Water and furnace region)	Seamless Alloy Steel Piping to ASTM A335 GR.P22 (schedule 160 for high pressure & high temperature)
ii) Low pressure and low temperature services Gr.B (Medium: Steam & Water)	Seamless carbon steel piping to ASTM A106
iv) Steam and Water Analysis system	Seamless stainless steel piping to ASTM A312 Gr. TP-321
v) Seamless copper tubing	ASTM B-75
b) Fittings	
i) Material for socket weld fittings	ASTM A105 ASTM A182 Gr. F22 6000/3000 lbs
ii) Dimensions of fittings	ANSI B16.11
iii) Fittings for steam and water analysis	ASTM A182 Gr. F-321

1.4.0 Instrument Valves and Manifolds

Bidder shall supply instrument valves (miniature type) and valve manifolds as per the Instrument Installation / Mounting diagrams.

Body material and rating shall be SS316 whichever is better and shall be forged type. Valve trim material shall be SS316.

Double root valve shall be provided under the conditions of pressure ≥ 40 bar.

a) Valves	
i) 3-way valves	SS body/Forged CS body stellited internals and SW ends as per requirement for 2500 lb/600 lb ASA ratings.
ii) 3-valve/5- valve manifolds	FAS body/FCS body 316SS stellited internals with NPT(F) SCRD ends for 2500 lb/1500 lb/600 lb ASA ratings.
iii) 2-valve manifolds	FCS body, 316SS stellited internals, NPT (F) SCRD ends.



b) Isolation and drain valves	Globe valves with FAS body/FCS body, 316SS stellited internals, SW ends for 2500 lb/1500 lb/600 lb ASA ratings.
c) Condensation vessels	FAS/FCS body with NPT (F) SCRD connection and vent plugs for 2500/600 lb ASA ratings.
d) Dust separating chambers	ERW carbon steel pipe to IS-1239 Heavy Class
e) Racks and Associated Equipment	ANSI C83.9-1972
f) Code for pressure piping, welding and Hydrostatic testing	ANSI B-31.1
g) Flexible conduits with fittings	Lead coated, paper insulated, heat resistant flexible metallic conduits with necessary fittings

1.5.0 Instrument Support / Structural Steel

Bidder shall supply instrument stands (stanchions) and other structural steel material required for supporting the Junction boxes, cable trays, impulse lines and instruments.

All field mounted instrument tubing shall be supported with steel angles/channels of a minimum 1/8" thickness fabricated to present a neat appearance. Sharp corners in the support material to be avoided

1.6.0 Transmitter Enclosures

- a) Transmitter Enclosures shall be free standing, enclosed type offering protection against dust, moisture and vermin. Enclosures shall be suitable for outdoor installations, in Udangudi Supercritical Thermal Power Project.
- b) The enclosures shall comprise of rigid welded structural frames enclosed with cold rolled sheet steel of thickness not less than 3 mm.
- c) Instrument piping inside the enclosure shall conform to the specification and in line with typical installation drawings enclosed with the specification.
- d) Blow down header shall be provided inside the enclosure as called for.
- e) Bulkhead connection shall be provided to receive and terminate the impulse pipes from root valves.
- f) Instrument tubing, fittings and isolation, drain valves shall be to ANSI code for pressure piping. Piping/tubing shall be subjects to hydrostatic tests at 1.5 times maximum system pressure.
- g) Support angles shall be provided for valve manifolds, wiring trays etc. Enclosures shall be complete with necessary bulk head fittings, junction boxes, drain header and other accessories as needed on the basis of approved hook up drawings.
- h) Sufficient spacing among adjacent transmitters shall be maintained to offer easy accessibility and operational convenience. The enclosure shall be designed with sizes to suit the grouping and to completely include all the hardware for hooking up the transmitters to the process on the basis of approved installation diagrams. A maximum of five (5) transmitters are envisaged to be grouped in one enclosure.



- i) Hydrostatic tests for piping/tubing and functional checks for correct wiring shall be carried out.
- j) The doors shall be the three-point locking type constructed of not less than 10 gauge steel. Doors shall have concealed quick removal type pinned hinges and locking handles. Doors locks shall accept the same key. Module assemblies shall be fabricated by bolting together two or more modules to form one continuous rigid structure. End covers shall then be added to complete the end closure. Gaskets shall be used between all mating sections to achieve NEMA type-12 dust proof enclosure rating for the modules and a NEMA type-4 water proof and dust tight rating on the terminal boxes. All enclosures shall have access doors on front and backsides.
- k) The quality of the erection hardware/equipment used for complete instrumentation and control equipment shall meet all the requirements indicated in the other clauses.

1.7.0 Mountings for Vibration Transducers

Vibration transducer mounting design and location shall be acceptable to the Owner and to the vibration transducer manufacturer and shall be installed in accordance with API 670. The Bidder shall provide drawings to the vibration monitoring system supplier to indicate the arrangement and dimensions of bearing housings, shaft supports, reinforcing struts, ribs, and adjacent structures. These drawings shall be in sufficient detail to allow the vibration monitoring system supplier to select and locate the vibration transducers.

1.8.0 Junction Boxes

Bidder shall supply junction boxes wherever required. These shall be of Industrial grade Fibre glass Reinforced Polyester (FRP) to weather proof, with cable entering on bottom and side entry shall be provided.

These boxes shall have terminals suitable for min 2.5 mm² cable termination (klip on) mounted on rails. 30% spare terminals shall be supplied in each junction box.

Junction box shall be provided with double compression glands.

Telephone socket shall be provided in junction boxes. Each junction box shall have a minimum of 20% or 2 nos., whichever is more, spare entry duly provided with plugs (weather proof/explosion proof, as applicable). Protection class shall be IP-65 minimum for JB and enclosures.

In general junction boxes shall be designed in accordance with NEC, Article 370, paragraphs 18, 19 and 20 or equivalent standards. Junction boxes for use in outdoor or damp locations shall be galvanized malleable iron or steel coated inside and outside. The enclosure shall conform to NEMA-4 with hinged door lockable type. Conduit and cable shall enter the lower portion of the box in such a manner that all terminals strips are above conduit entry points.

2.0.0 ERECTION SERVICES

2.1.0 Instrument Air Supply System

Dry instrument air shall be distributed to various equipments of I&C system like control valves, Analyzer purging, pneumatic On-Off dampers. The Bidder shall supply total Instrument air requirement Calculations, and design of Air compressor system along with the bid. On collection of water in the drains of instrument air lines, mechanical automatic drains and periodically solenoid operated drains (with electronic timer - 15m, 30m, 60m and 2 Hours & Timing adjustable) are to be provided.



For mechanical type & Electrical type, the locations to be provided in the instrument air lines of boiler area, Chimney area, turbine area etc., shall be decided during detailed Engineering

2.2.0 Installation of Instruments

All electronic instruments shall be generally installed on supports as per installation standards. No instrument shall be installed in such a way that it depends for support on the impulse pipes, hand rails, floor grills, process pipes or structure in the passage.

Field mounted instruments shall be mounted on brackets, subpanels, or placed on a suitable pedestal. They shall be easily accessible from grade, ladder or platform. All local indicators shall be readable from grade or operating level and if used for manual control, shall be visible from the related valve.

Wherever possible, local mounted instruments shall be mounted at approximately 1.35 meters above the platform or floor in an accessible position. Instruments shall be mounted as close to the sensing points as possible (<15 mtrs).

2.3.0 Instrument Tubing Installation

All primary piping / tubing shall be installed in the best workman-like manner and shall follow installation standard in each case. Where there is no installation standard, the decision of the Engineer-in-Charge shall be followed.

Horizontal and vertical lines shall be installed using spirit levels and plumb and shall be supported to permanent structure at every 1.5 meters.

All threaded joints shall be jointed using Teflon tapes and no other tube-jointing compound shall be used except on higher temperature services where graphited sealing compounds shall be used. Brand of Teflon tape, insulation tape, graphite compound is to be approved by the engineer in charge.

Tubing shall be bent with correct size tubing bender wherever possible to avoid the use of fittings. Tubing cutter shall always be used to cut tubing. The use of short length of tubing in long runs shall be avoided. Wherever required coils shall be provided.

All tubing shall be run in such a manner as to give the maximum protection against mechanical damage. Tubing runs shall be grouped together where possible. Tubing shall be arranged so that couplings can be tightened without disturbing lines.

Tubes installed but not connected, shall have the ends closed in an approved fashion to prevent the entry of foreign material. For a period of up to one-week, adhesive tape may be used for longer periods, caps or plugs shall be used.

All reasonable precautions shall be taken to prevent foreign material entering pipelines before and during erection. All lines shall be blown through with filtered air before connection to instruments.

No tube shall be left with mechanical strain on it.

On tubing to pipe connections and in making up screwed pipe joints, Teflon tape shall be applied to make thread in a manner to insure tape is not over the end of the male fittings.

2.4.0 Piping Supports

Piping and tubing shall be adequately supported and fixed at distances not exceeding those in the following table:



Single Tubing / Pipe Maximum distance between Supports 3/8" OD and less Continuous to 3/4" Nom. size 2 Meters (6 ft.) 3/4" to 1" Nom. size 3 Meters (9 ft.). All field mounted instrument tubing shall be supported with steel angles/channels of a minimum 1/8" thickness fabricated to present a neat appearance. Sharp corners in the support material to be avoided.

2.5.0 Process Connection and Installation

Installation of pressure instruments at locations subject to excessive vibration shall be avoided. An additional block valve and vent valve shall be required adjacent to the transmitter. Means shall be provided for venting pressure from the line and gauge, so that gauges may be removed safely. Primary injection testing shall be incorporated together in a manifold.

Approved ball valves shall be used where temperature conditions permit. The valves shall be rated for not less than the line pressure on the main pipeline. If the pressure piping is of such length that the isolating valve is inaccessible from the instrument location, a suitable valve shall also be fitted at the instrument itself.

All pressure instruments shall be installed vertically. Those for steam must be tapped directly from above, for pressure transmitters and switches, there shall also be a condensing leg. The same applies to gas and vacuum measurements, but adequate provision should be made to ensure no condensation can take place along the line, i.e. The slope shall be adequate to drain any condensate back to the main lines (sloping upwards from the sensing point). Tapping points for liquids shall be made at an angle of 45° from the bottom of the main pipe and these are to be sloped downwards from the sensing point.

SIZE OF TAPPING POINT STUB, NO. AND SIZE OF ROOT VALVES FOR DIFFERENT TYPE OF MEASUREMENTS

Sl. No	Qty. of Root	Root Valve Size	Root Valve Service Conditions
A. Pressure & Differential Pressure Measurement			
(i)	2	25	>=62 bar OR 425 degree C
(ii)	1	15	< 62 bar AND 425 degree C
B. Level Measurement			
B1-Level Gauge and Switch			
(i)	2	25	>=62 bar OR 425 degree C
(ii)	1	15	< 62 bar AND 425 degree C
B2-Level Transmitter (Displacement Type)			
2		25	>=62 bar OR 425 degree C
1		15	< 62 bar AND 425 degree C
B3-Standpipe For Level Measuring Instrument			
2		25	>=62 bar OR 425 degree C
1		15	< 62 bar AND 425 degree C
C-Flow Measurement			
2		25	>=62 bar OR 425 degree C
1		15	< 62 bar AND 425 degree C
D. Sampling System Measurement (Steam & Water Service)			
2		25	>=62 bar OR 425 degree C
1		15	< 62 bar AND 425 degree C

Transmitters, temperature switches, pressure switches and the like shall be supported independent of the pressure connection; the type of support shall depend upon the make of instrument and location. When installing pressure instruments, care must be taken to avoid the possibility of imposing stresses from the pressure piping, conduit etc. which may cause malfunction.



When the pressure impulse line is liquid filled, the measuring unit shall be compensated for static head. The head correction shall be stated on the all process connections, pressure impulse lines and instrument arrangements shall be fully detailed and to the approval of the Engineer-in-charge.

2.6.0 Laying and Termination of cables

Multicore / multipair cables shall always be installed on trays or ducts and properly clamped. At every vertical drop to/from junction boxes they shall be clamped at frequent intervals as per instruction of Engineer in charge. They shall be connected inside the junction boxes strictly according to the numbering systems mentioned in the junction box schedule.

The accessories like double compression cable glands, cable lugs, cable tags (SS), cable ties and accessories required for the cable termination shall be included in scope of supply. Insulated lugs and ferrules with proper identification shall be used for all I&C cables.

At bends, minimum radius shall be maintained as per manufacturer's standard. Multicore/Multipair cables to be laid from instrument location to control room as per required standard. Identification tags shall be provided on either end of individual cores, Multicore/paircables including unused cores as per wiring diagram/cable/junction boxes schedules. PVC ferrules shall be used, for identification of cores. SS tag plates shall be used for identification of cable/junction boxes.

All cables shall be cut, after the exact site measurements are taken, between ends and the cable drums shall be so selected before cutting the lengths, as to avoid any wastage. Meggering should be done for each drum and length. While terminating the leads at the field instruments, a 300mm length loop shall be provided to facilitate easy removal of instruments.

In the field, the cables shall be laid in the overhead ducts / trays as per layout drawings. While laying cables in ducts/trenches or burying them, care shall be taken to ensure that two signal cables like alarm, analyzer cables, special cables compensating cables, etc. are separated from other power supply cables. Separation of low signal cables and power supply cables in trays/ducts shall be done as shown in the tray/duct drawing. Jointing of cables are not permitted.

At each road crossing and other places where cables enter pipe sleeves, adequate bed of sand shall be given so that the cables do not slack and get damaged by pipe ends after pack filling. All cables shall be laid in accordance with the layout drawings and cable schedule and tubing schedule. Multicore/Multipair cables shall be bent in a large radius as per manufacturer's standards.

Cables shall be rigidly supported on structural steel and masonry individually or in groups as required using individual cast or malleable iron galvanized clips, multiple cable supports or cable trays. If drilling of steel must be resorted to, approval must be secured and steel must be drilled where the weakening of the structure will be minimum. Cable shall be supported at every 500mm. In case no such supports are available, the bidder shall provide suitable supports for the cable wherever required.

No cable shall be terminated or left with mechanical strain on it in any conduit or trenching. Where cables are run through conduit the entry and exit shall be smooth and free from burrs. The use of conduits shall be kept to a minimum, as far as possible. Cables must be pulled into ducts/conduit in a way that ensures there is no damage to the cable.

All multicables laid in ducts shall be properly dressed and tied with nylon wire of 3 mm diameter. All cables finally entering JB's/cabinets shall run through flexible PVC conduits for approximately 500mm.



VOLUME II
SUB-SECTION 4.22
C&I TESTING AND COMMISSIONING

1.0.0 ERECTION, FIELD TESTING AND COMMISSIONING

- 1.1.0 The Bidder shall select and adopt methods and procedures for equipment erection to suit the nature of equipment and erection, involved according to the best modern industrial practice and his own experience.
- 1.2.0 The Bidder shall arrange for the transportation and handling of cabinets and desks from stores to work site suitably without any damage. If any damage is observed before handling, this shall be brought to the notice of the OWNER
- 1.3.0 Before installation of cabinets and desks, the necessary openings and inserts required to be made on the floor by the Bidder shall be checked and then after proper alignment, the cabinets and desks shall be installed on the floor by the Bidder. All necessary civil work to be carried out for this shall be in Bidder's scope of supply. The cabinets and desks shall be cleaned by blowing air to remove dust or foreign particles.
- 1.4.0 Nameplates shall be installed for all the I&C equipments bearing the service description, instrument number and calibrated range.
- 1.5.0 The data base covering the instrument No. type, application, process parameters, range, set point, calibrated/feasible range & span, maximum admissible value, recommended periodicity of calibration, other information for all the instruments, final control elements etc., for the unit, BOP, etc., shall be given in soft form.
- 1.6.0 All cables shall be tested for insulation level. Cable ends shall be properly cleaned. The entry to and exit from pipes shall be smooth and free from burr where cables are run through pipes. Cable shall be pulled into the pipes in such a way that there shall be no damage to the cables. Flexible conduits shall be provided wherever necessary. Cable in hot areas shall have proper heat protection. A minimum distance of 300 mm shall be kept between instrument / signal cables and power cables. Each tray shall be filled with a maximum of two layers for instrument and control cables and one layer for power cables providing 20% spare space in the number of layers specified. Instrument Cable Trays, shall be erected vertically as far as possible to avoid dust accumulation. All the cables laid shall be tied individually to the Tray. Thermocouple cables shall be run completely independent of all other cables with minimum separation as per relevant standard and with cross over at right angles. The cabling accessories shall include terminal blocks, splicing materials, crimping tools, cable support grips, insulating tapes, GI flexible conduits, conduit fittings, GI perforated covered trays, supports, accessories, and cadmium plated trays & cable glands.
- 1.7.0 The Bidder shall get prior approval as per approved quality assurance plan of the Owner Representative before any installation work starts. If any work is carried out by the Bidder before prior approval from Owner Representative and modification is sought by Owner Representative later, then the work shall be redone by Bidder without any cost / material implications to the Owner Representative. Impulse / sample piping, air supply and pneumatic tubing, cable trays and equipment shall be supported rigid enough to prevent vibration and anchored sufficiently to prevent strains on equipment installed. Supporting clamps shall be provided at least at every one meter distance for better rigidity. Impulse / sampling piping shall be provided with adequate slope, (preferably 1:10). Hanger and supports shall be so installed as not to interfere with free expansion and contraction of the piping and tubing between anchors. Suitable vibration dampeners, etc., shall be provided wherever necessary. In addition, care shall be taken that the arrangement of impulse / sampling piping, air supply and pneumatic tubing from detrimental sagging, mechanical injury, abuse due to unusual



service conditions from sources other than those due to pressure, temperature and vibrations. All impulse lines of joints shall be welded type unless otherwise specified.

- 1.8.0 The Bidder shall set up his own instrument laboratory. The calibration equipment shall cover complete range and shall have the desired accuracy of less than 0.1% or better. The Bidder shall follow the standard procedures for calibration of various instruments and as set by the manufacturer of instruments and as instructed by the Owner including any requirements of field calibration. First, the calibrations shall be carried out independently by the Bidder and later in the presence of Owner who shall certify the same. Proper documentation in this regard shall be maintained and handed over to the Owner
- 1.9.0 All the instruments shall be calibrated for the entire range of the instrument for which it is designed. Calibration shall include test for repeatability. After first commissioning, the instruments shall be tested for calibration again to check whether the instrument maintains its zero and maximum of the range. All instruments and control equipment shall be calibrated to read correctly to the satisfaction of Owner. All switches shall be tested for the actuation of both normally open and normally closed contacts at the desired set points and also for the fixed / differential settings. All the float / displacer operated level switches shall be tested for the movement of the float and linkages to make to break the switch contacts by filling up with water before installation. For such tests, necessary testing set up required shall be arranged by the Bidder. Air leak tests shall be performed on all flue gas impulse / sample lines, air supply and pneumatic lines. Necessary equipment such as portable compressor, connecting pipes, materials, cables and test gauges shall be provided by the Bidder. All the welding shall be carried out as per the relevant codes with electrodes approved by the Engineer-in-Charge. Only qualified welders approved by the Engineer-in-charge shall carry out the welding. IBR grade of welder will be required wherever IBR grade welding is involved. After IBR welding, radiography as per the required standard to be done by qualified welder. All threaded joints shall be jointed using teflon tapes and no other pipe jointing compound shall be used except on higher temperature services where graphited sealing compounds shall be used. Brand of Teflon tape, insulation tape, graphite compound is to be approved by the engineer in charge. Tubing shall be bent with correct size tubing bender whenever possible to avoid the use of fittings. Tubing cutter shall always be used to cut tubing. The use of short length of tubing in long runs shall be avoided. All tubing shall be run in such a manner as to give the maximum protection against mechanical damage. Tubing runs shall be grouped together where possible. Tubing shall be arranged so that couplings can be tightened without disturbing lines. Pipes or tubes installed but not connected, shall have the ends closed in an approved fashion to prevent the entry of foreign material such as caps or plugs. All cables finally entering JB's / cabinets shall run through flexible PVC conduits for approximately 500mm. Field mounted instruments shall be mounted on brackets, subpanels, or placed on a suitable pedestal. They shall be easily accessible from grade, ladder or platform. All local indicators shall be readable from grade or operating level, and if used for manual control, shall be visible from the related valve. Wherever possible, local mounted instruments shall be mounted at approximately 1.35 meters (4' 6") above the platform or floor in an accessible position. When an instrument is located at a distance of 2.5 meters or more from its pressure connection, an additional block valve and a vent valve shall be provided adjacent to the instrument. Vent valves shall be arranged, if necessary, with drain lines to ensure that operation of these valves does not create a hazard. If the pressure piping is of such length that the isolating valve is inaccessible from the instrument location, a suitable valve shall also be fitted at the instrument itself. All pressure instruments shall be installed vertically. Those for steam must be tapped directly from above, for pressure transmitters and switches, there shall also be a condensing leg. The same applies to gas and vacuum measurements, but adequate provision should be made to ensure no condensation can take place along the line, i.e. the slope shall be adequate to drain any condensate back to the main lines (sloping upwards from the sensing point). Tapping points for liquids shall be made at an angle of 45° from the bottom of the main pipe and these are to be sloped downwards from the sensing point. An exception is made in the case of the tapping point for fuel oil or corrosive fluid in which the pressure instrument shall not have direct contact with the process fluid. Glycerine or other suitable liquid shall be used as a medium to separate the fuel oil from the pressure instrument. When the pressure impulse line



is liquid filled, the measuring unit shall be compensated for static head. The head correction shall be stated on the unit.

- 1.10.0 Pipes shall be bent using pipe benders and any hot bending will be totally rejected. Pipe shall be cut, using pipe-cutting devices. Hot cutting will not be allowed.
- 1.11.0 Hydro test shall be performed for all other impulse lines / sampling lines / sensors. Necessary equipment such as hydro test pumps and temporary piping to the required point, fill pump etc., materials such as temporary gaskets, miscellaneous fasteners, etc. tools and tackles including test pressure gauges, etc. are to be provided by the Bidder. For all electrical actuators of the valves, functioning, setting and performance of limit switches / torque switches of various positions shall be checked before and after installation of the actuators. The position transmitters for inching applications shall also be calibrated. Pneumatic actuators shall be calibrated at site. PG test points shall be provided on the process line at various location by the Bidder.
- 1.12.0 Chipping of foundations, alignment, as required for instrumentation installations.
- 1.13.0 Fabrication and erection of stanchions/supports for all local instruments, junction boxes, etc. Fabrication and erection of suitable supports for surface mounted instruments.
- 1.14.0 Fabrication and erection of structural steel plates, angles, pipes, required for supporting ducts, trays, local instruments, etc., complete with bolts and nuts. (GI bolts and nuts shall be used wherever applicable or directed).
- 1.15.0 Painting of all stanchion/structures meant for instrumentation work (ducts, trays, pipe/ angle, supports, etc. as per specification). Colour and codes shall be strictly followed as per guidelines/ specifications as per direction of the Engineer-in-charge.
- 1.16.0 Earthing of the Instrumentation panels on the separate earthing pits (by others).
- 1.17.0 Double compression cable glands, cable lug, ferrules, cable identification tags, trefoil clamps for single core cables, cable dressing materials etc.
- 1.18.0 Cable sealing compound to prevent water entry wherever cables enters from outdoor to indoor areas.
- 1.19.0 Supporting structures for cable trays, cable racks, etc. using mild steel sections like channels, angles, flats, chequered plates etc. shall be in bidder's scope
- 1.20.0 Excavation & refilling of soil for buried cable trench / earthing with necessary materials.
- 1.21.0 GI Cable tray with all accessories and its MS supports.
- 1.22.0 Minor civil works like drilling, chipping and punching holes and openings in concrete floors, slabs, brick walls, fabrication of supporting structures, drainage of water from cable trenches and cleaning of all debris due to instrumentation installation.
- 1.23.0 Primary impulse tubing, laying of all types of cables, glanding and wiring and all kinds of pipe/tube fittings.
- 1.24.0 Fabrication and installation of primary tubing for pressure and differential pressure instruments complete with manifolds as per standards.
- 1.25.0 Erection & supply of the PVC instrument ducts(if required for the internal wiring of GCP cables), and perforated cable trays generally as per drawing including bends, tees, supports and opening wherever required, including provision of covers wherever required. No jumping of cables will be allowed.



- 1.26.0 Laying of multi-core / pair cables for all applications on perforated trays with proper tagging, dressing clamping, glanding and terminations (including proper termination of shields) at both the ends.
- 1.27.0 Laying of multi/single pair cables in trenches wherever required.
- 1.28.0 Interconnection wiring/tubing of various field mounted instruments, viz., transmitters, transducers, positioners etc.
- 1.29.0 Identification of each cable by proper tags at every 10 meters on the main tray as per cable schedule.
- 1.30.0 Fabrication of nipples from pipes and threading of the same wherever required.
- 1.31.0 Tapping/threading of coupling wherever required for special instruments.
- 1.32.0 Welding electrodes required for the complete of the job shall be in bidder's scope..
- 1.33.0 Completion/updating of Owner's drawings/documents as per the work done at site. This should be done before applying for completion certificate.
- 1.34.0 Pre-commissioning service and commissioning assistance during start-up of plant, wherever required.
- 1.35.0 Provision of copper wire, GI wires to panel earth bus, laying and grounding of the same to the system earth pits.
- 1.36.0 Fabrication and erection of canopy (single) for instruments, wherever required.
- 1.37.0 Minor modifications/repairs required to be done on the existing instruments namely, replacement of damaged signal tubes, tapping of damaged threads on couplings, tees and other fittings.
- 1.38.0 Identification of each cable by proper tag plate/ferrules at instrument ends, inside junction boxes and inside control room outside JB's by tagging the cables with SS tags as per the cable schedule.
- 1.39.0 Drilling holes on all Panels etc. for cables/ glands/ grommets, if required, after obtaining approval from the owner. Unused holes to be plugged after completion of job.
- 1.40.0 Grounding of shield for all shielded cables to respective instrument earth bus provided in the thermocouple head/junction boxes.
- 1.41.0 Sealing of switches with standard lead seals after final setting in the presence of Engineer-in-charge.
- 1.42.0 Painting of welded joints etc. as per the engineer in charge's instruction.
- 1.43.0 Excavating roads, laying cable road crossing sleeves and refilling and finishing wherever required.



2.0.0 LOOP TESTING

- 2.1.0 The action of the controller is set as prescribed. Controller settings for various modes of operation (Proportional band, reset and rate action) are at nominal value. For current signals, 4 – 20 mA shall be injected and checked the loop for 0%, 25%, 50%, 75% and 100% of full-scale inputs. For temperature loops with thermocouples, a known milli volt signal shall be injected and the output display shall be checked for input signals of 0%, 25%, 50%, 75% and 100%. For temperature loops with RTDs, a known resistance shall be injected in the control cable through decade resistance box and Output display shall be checked for 0%, 25%, 50%, 75% and 100%. For field mounted switches for alarms / interlocks, the action shall be simulated by disconnecting the wires / shorting the terminals and the function of the associated system shall be checked. Any equipment required by the Bidder for testing, calibration and commissioning shall be brought by the Bidder at site. The list of such equipment shall be furnished along with the offer
- 2.2.0 Prior to taking the instruments in service, all impulse lines, sampling lines and air supply lines shall be blown as required with the establishment of adequate line pressure and temperature conditions to keep the lines thoroughly clean. On-line i.e., without removing control valves from the pipe, calibration of the positioners and stroking of control valves / control dampers shall be carried out as required during control system tuning. Pre-commissioning checks, individuals loop checks, power initialisation, verification of system functioning, trouble shooting final solutions to application and / or instrument problems, etc., is Bidder's responsibility. All the required software and hardware changes shall be incorporated as required for successful commissioning to Owner satisfaction. Any other tests as may be directed by the Owner Representative. After delivery of the equipment, the Bidder shall locate all the equipment including electronic cards in its final position, check all the power wiring, grounding and interconnection cables, all in accordance with manufacturer's recommendations. The Bidder shall perform initialisation of system power, field loading of system configuration / software and data base, demonstration of system functionality to verify conformance with manufacturer's instructions and specifications, tuning of control loops, implementation of any configuration changes including hardware, software and additional tapping's / instruments, cabinets as required and providing general trouble shooting and final solutions to application and / or instrument problems.
- 2.3.0 The Bidder shall take care to complete all pre-commissioning activities and simulation tests after erection to suit the over all start up of respective plant equipment. The controllers shall be tuned as per the process requirement. The list of set points, alarms / Interlocks, settings for the controllers shall be furnished in the standard format and handed over to the Owner.. Control loops shall be put in auto mode as per the operational requirement of different phases. Processor, Bus Worst loading conditions calculation and other control system performance requirements shall be proved at the time of commissioning. Before taking over of the plant by the OWNER , all the system and auto control loops shall run satisfactorily for at least one month at varying loads without disturbing any adjustment. During this period, supervision and maintenance of the system shall be the scope and responsibility of the Bidder. The performance test shall be carried out for the system offered and certificates to these effects shall be approved by the OWNER .

3.0.0 INSPECTION, TESTING, GUARANTEE & SPECIAL TOOLS / TACKLES

- 3.1.0 After manufacturing all the I&C equipments / instruments shall be factory tested and calibrated. All the required test certificates, calibration certificates for the I & C equipments / instruments to be submitted to the Owner for approval before the dispatch of the same is allowed from the factory. As a minimum hydro-test, accuracy & repeatability test, over-range test, leak test, HV test, insulation test, functional tests, temperature rise test shall be conducted as applicable for the instruments and the control system. The electronic equipments shall be subjected to burn in test and tests as per IEC 68. The details of the test to be carried out for the I & C equipment shall be submitted for the Owner consent/approval



before proceeding with the test. Bidder shall submit a detailed quality assurance program for individual I & C equipments / instruments for Owners for approval.

3.2.0 Tests for DCS / SG control / STG control / PLC system will include the following:

3.2.1 Factory Acceptance Test (FAT):

To be carried out at BIDDER's / Sub-Vendor's works and witnessed by Owner/Engineer, successful completion of which will be the basis for 'Authorization for Shipment to Site'. FAT shall be a complete integrated test of the system and carried out at BIDDER's / Sub-Vendor's works on completion of manufacturing of the system. The test shall be performed with the completely assembled system and performing all the functions, it is expected to perform while in actual service. The BIDDER shall submit a detailed "Factory Acceptance Test Procedure" in line with the above specified guidelines for Owner approval. The FAT shall be conducted as an integrated test of plant I&C system integrating the control system supplied by Other Vendors.

FAT shall be preceded by a 'Pre- FAT Inspection/ Test' to be carried out by Bidder/Vendor. Pre-FAT inspection / test shall be carried out as per approved FAT procedure detailed above and shall submit 'Pre- FAT Inspection/ Test' report for Owners review and approval. Owner shall witness the actual FAT on the basis of successful completion of 'Pre- FAT Inspection/ Test'.

3.2.2 Site Test (SAT):

Involves tests for site commissioning, calibration of monitoring and control equipment, Integrated loop test wiring, Trial Operation of the system functioning. Site guarantee tests for system performance & availability to be conducted in the presence of Owner. The reliability run shall be conducted for one month period. During the reliability run if the I&C system fails to meet the specific requirements, then the Bidder shall take immediate remedial actions and the procedure shall be restarted again for the reliability run. After the completion of the reliability run with full satisfaction of the Owner, the system shall be deemed for take over and this shall mark the commencement of warranty period.

Special tools and equipment for the maintenance, inspection and repair of the individual main equipment and auxiliary equipment shall be supplied by the Bidders in sufficient quantity to equip the shift personnel, maintenance personnel and workshop craftsman.

The special tools and equipment for maintenance and repair shall be delivered by the bidder in lockable steel boxes and they shall be marked in an approved manner for identification purposes and a corresponding tool chart shall be supplied with the steel boxes

The I&C systems offered by the Bidder shall be provided with guarantee period which will start from the date of handing over to the owner and Bidder to indicate the same in his offer.

Latest version of hardware and software available at the time of system designing shall be provided. In case of future up-gradation of software, Bidder shall remain committed to upgrade the supplied system with the new version within the warranty period. Beyond the warranty period and during the remaining life of the plant, any up gradation in hardware and software shall be brought to the notice of Buyer. Bidder shall ensure that supplied controls & instruments should be supported by the supplier such that spare parts are guaranteed to be available for purchase for a period of 15 (Fifteen) years. Similarly the service shall also be guaranteed for a period of 15 (Fifteen) years.



VOLUME II
SUB-SECTION - 4.23
C&I DATA SHEET

SPECIFICATION FOR INSTRUMENTS EQUIPMENT TO BE SUPPLIED ARE AS FOLLOWS:

A MAN MACHINE INTERFACE AND PERIPHERALS

1. OPERATOR'S & ENGINEERING WORK STATION

The operator's & Engineering station shall be Workstation based with suitable networking capability to interface with the real-time data bus as well as the MIS bus. The following general specification shall apply, but the latest version available with better configurations to suit the applications shall be furnished. Bidder shall be responsible to get the approval from the owner for the selection of systems and peripherals during detail engineering stage.

The most current release of fully tested hardware shall be supplied. The features and the configuration for all the stations in the power project shall be reviewed and approved by the Owner.

S.N.	FEATURES	QUALIFYING MINIMUM REQUIREMENTS
1.	Processor	Intel Dual Core Xeon 5160 / latest / equivalent
2.	Chipset & mother board	Intel original board, (suitable for above processor) / latest / equivalent
3.	RAM	2 X 16 GB DDR @ 800MHz & expandable up to 64 GB / higher
4.	HDD	500 GB SCSI 10000 RPM / higher
5.	Optical drive	16 X DVD – R / RW / Blue Ray disc
6.	Monitor	24" LED Type with minimum 1920 X 1200 resolution, MRP II, Energy Star Complaint, Asset Controlled (same make of workstation manufacturer preferable)
7.	Graphics	High end 3 D
8.	Type	DDC MIS / PLC wok station, industrial application
9.	Mouse	OEM optical mouse
10.	Audio	Integrated based on Intel chipset / equivalent
11.	Ethernet	Integrated 10 / 100 / 1000 with RJ45 port with ASF, WOL & PXE or latest
12.	Bays, Slots and Chassis design	Minimum 6 bays, 3 PCI (with option to expand to 5) +1 AGP slot. Chassis should be toll free design. (Tool less cover removal, Hard disk, CD, system board and PCI card removal)
14.	Ports	Minimum 1 parallel, 1 serial, 6USB (Ver 2.0), VGA, Audio.
15.	Operating system and DVDs	Latest windows 7 or latest with restore / recovery DVD and OS DVD to be supplied with every PC.
16.	Thermal Design	Minimum 3 fans. ATX chassis with tool less opening features.
17.	Power supply	Minimum 230 V AC Pre installed OEM's management agent with the following features:
18.	Manageability	Asset tag, DIMM Serial Presence detect, Serial number, Model and Manufacturer for system, monitor and HDD, ROM and system board revision levels
19.	Security	Removable media boot control, Serial, parallel and USB interface control, power-on password, setup password, and Memory change alert (through BIOS, in windows environment & on management



S.N.	FEATURES	QUALIFYING MINIMUM REQUIREMENTS
		console). Internal smart cover lock & sensor for securing internal components. Kensington slot on chassis for physically securing the chassis. For OEM: ISO 9001:2000, 14001 For Desktop: OS certification (WLP 2.0 from Microsoft website), DMI 2.0 certification (from DMTF website) , EMI / FCC compliance, energy star compliance & UL compliance For Monitor: EMI / FCC compliance, Energy star compliance, MPR II Compliance
20.	Compliances	MS Windows 7/64 bit or higher (Latest)
21.	OS Certification	3 years comprehensive on – site, backed by manufacturer support, with OEM certified spare parts.
22.	Onsite Warranty	MS (Professional) office latest (English) license with media & documentation / multi user shall be separate one.
23.	Software required	Anti Virus & fire wall Norton / McAfee / Trend Micro corporate Edition for PC's Laptop supplied through this P.O
		MATLAB, AUTO CAD, ORACLE, Photo shop (all latest with their individual license and products)
24.	Software updates	Shall be given for not less than 3 years, at no extra cost from the owner
25.	Preferable Make	HP/DELL /IBM-Lenova (Work Stations)

2. LAPTOP COMPUTER FOR MOBILE COMPUTING

S.NO.	FEATURES	QUALIFYING MINIMUM REQUIREMENTS
1.	Processor	Intel Core I-7 processor or latest at the their ordering
2.	Installed memory	4 GB or (latest configuration)
3.	Display	15.0 LED based latest
4.	Operating System	Microsoft Windows 764 bit latest at the through of supply
5.	Processor manufacturer	Intel
6.	Processor type	Pentium mobile
7.	Display size	15.6"
10.	Display Tech	LED based
11.	Display Max. Resolution	1280X1024 or better
12.	Hard Drive Capacity	SATA II – 500 GB or solid state drive or latest
13.	Storage Controller type	EIDE
14.	Installed RAM	4 GB upgraded up to 16 GB or higher
15.	RAM technology	DDR SDRAM
16.	Max Supported RAM	16 GB or Higher
17.	Installed Cache memory	1024 KB



S.NO.	FEATURES	QUALIFYING MINIMUM REQUIREMENTS
18.	CD / DVD type	DVD + RW (Combo) or Blue ray
19.	Optical drive Read system	16 X (DVD – R/RW)
20.	USB Ports	3, 1 S Video
21.	Installed Video Memory	128 MB sharable with RAM
22.	Audio output type	Integrated sound card with internal speakers
23.	Modem type	56 Kbps
24.	Analog Modulation protocol	ITU V.90, ITU V.92
25.	Networking type	Integrated 10 / 100 Eth, wireless access point
26.	Data link protocol	IEEE 1394 / 802.11b wireless, Ethernet, fast Ethernet.
27.	Battery Technology	Lithium Ion
28.	Carry bag	Leather, shoulder carry type
29.	Warranty	Three yr on site
30.	Preferable Make	HP/DELL /IBM/SONY

3. DATABASE AND WEB BASED SERVER (FOR ALL APPLICATIONS)

I) DATABASE SERVER CONFIGURATION:

S.NO.	FEATURES	QUALIFYING MINIMUM REQUIREMENTS
1.	Processor	Latest & scalable from 2p/4c to 16p/32c or higher
2.	No. of processor with 9MB of L3 cache	2-16
3.	Min/Memory	2x320 SCSI Hard drive
4.	No. of Hard partitions	4
5.	Power supply	4 nos. Hot swap, redundant

II Web Server Configuration:

1	Processor	Intel Itanium 2 based or latest
2	Chipset & Mother board	latest Intel mother Board
3	RAM	Minimum 16 GB Latest model
4	HDD	5*320 GB hot swappable ultra SCSI 360 HDD + 1 standby, 10K RPM or latest

II Configurations Common For Both Server Types(Database & Server):

6.	Optical drive	16X DVD –R / RW
7.	Monitor	24” LED Type
8.	Graphics controller	Latest



S.NO.	FEATURES	QUALIFYING MINIMUM REQUIREMENTS
9.	Mouse	Optical mouse
10.	Form Factor	5 U with option for rack mountable kit
11.	Ethernet	1GB 10 / 100 / 1000 with Ethernet controller
12.	Slots and Bays	2 Full size PCI – Express X 4 / 8, 2 full size 64 bit / 100 Mhz, 1 full size 64 bit 133 Mhz, 1 full size 64 bit 66 Mhz , total 6 PCI slots , 6 Hot swap HDD bays
13.	Operating system	(For data base server) Windows Latest server software or Linux Enterprise edition.(For web server) Windows Latest server, Linux Enterprise edition.
14.	Security	Mechanical side panel key lock (locks hot-swap disks on hot-swap models) / optional U-bolt support via knock out / power on password / boot sequence control / operation without keyboard and mouse
15.	RAID support	RAID 5 Support
16.	Compliances	For OEM: ISO 9001:2000, 14001
17.	Redundant Power supply	Hot swap redundant
18.	Warranty	3 yrs comprehensive on site, backed by manufacturers support, with OEM certified spare parts.
19.	Preferable Make	HP/DELL /IBM

For all PC's, general MS Windows latest, MS Office, MS Visual studio, Adobe Acrobat, Antivirus (Professional) software shall be included in all the PC's including the application software to suit the project specific requirement.

4. MONITOR

01. Type	:	LED Monitor
02. Sync.	:	Multisync.
03. Screen diagonal	:	24" flat
04. Display	:	Super Video Graphic Array
05. Resolution	:	1600 x 1200
06. Degree of protection	:	IP-30
07. Brightness	:	300cd/m ²
08. Contrast	:	800: 1
09. External Controls	:	Brightness, contrast, Horizontal / Vertical amplification & shift
10. Power supply	:	240 V, 50 Hz, 1 phase
11. Ambient temperature	:	0-50 °C
12. Humidity	:	95% non-condensing.
13. Version	:	To suit industrial application.

**5. KEY BOARD**

01. Type	:	Flat, spill proof membrane type or positive depression type.
02. Different keys	:	a) Soft and user defined function keys for software/ programming including text correction, scan rate alteration, zooming/ flashing color selection etc. b) Panel select keys for alarm summary, control loop display, overview, trend, graphic, operator guide message etc. c) Standard Alphanumeric keys d) Alarm acknowledge keys e) Cursor keys f) Mode loop mode / loop status switching keys g) Multiple loop setting change keys h) Print-out command keys i) Other keys as required to operate the system j) Multiple loop output change keys k) Soft and user defined function keys for process mimics
03. Key lock	:	Lockable type push button mounted on keyboard
04. Life Expectancy	:	50 million cycles per key
05. Version	:	To suit industrial application

6. PERSONAL COMPUTERS (MIS AND OTHER SYSTEM) PLANT WIDE NETWORK

01. CPU	:	Latest intel i7 processor
02. Type	:	Tower
03. Main Memory	:	4 GB DDR @ 800 MHz expandable to 8GB / higher
04. Drives	:	DVR – RW
05. Hard Disk	:	500 GB SATA or solid drive 256 GB or higher
06. Monitor	:	24" LED type for MIS Stations 21" LED type for LAN
07. Communication port	:	2 serial plus one parallel, 4 USB
08. Expansion slot	:	5
09. Connectivity	:	Ethernet LAN
10. Operating system	:	Latest windows software (64 bit)
11. Softwares	:	Latest version of MS office, (profession) Client's Software and other softwares as required
12. Features	:	101 keys keyboard and mouse
13. Accessories	:	Furniture's, Mouse pad
14. Preferable Make	:	HP/DELL /IBM-Lenova

7. LASER PRINTER

01. Type	:	Electro-photographic laser, tabletop / latest
02. Printer Memory	:	256 MB (min.)
03. Speed	:	Monochrome 24 ppm - A4 Color 20 ppm - A4
04. Resolution	:	1200 x 1200 DPI in color
05. No. of color (Basic)	:	4 (four) minimum
06. Duty cycle	:	Monochrome 75000 pages / month
07. Power supply	:	240 V, 50 Hz, 1 phase
08. Ambient temperature	:	0-50° C
09. Humidity	:	95% non-condensing.



10. Size of paper	: Letter, A4 (25 Reams of paper), Legal, Ledger, A3 (20 Reams of paper)
11. Print media	: Plain paper, transparencies, thick stock, glossy stock, envelopes
12. Accessories	: i) Adapters ii) Connector Cable iii) Multiplexer switch (4 point)

8. DOT MATRIX PRINTER**(LATEST MODEL)**

01. No. of Needles	: 24 Pin
02. Printing speed	: 300 characters per second (approx.)
03. Character dimension	: 9 x 8
04. Buffer	: 80 KB (Min)
05. Local memory	: RAM with battery backup
06. Interface	: Serial / parallel / USB for High speed
07. Power supply	: 240 V, 50 Hz, 1 phase
08. Ambient temperature	: 0-50 °C
09. Humidity	: 95% non-condensing.
10. Size of paper	: Fanfold, A4, A3
11. Character sets	: ASCII, IBM (Sets 1 & 2), Italics, user defined
12. Transfer distance	: 200 Mtrs. (minimum)
13. Print features	: Graphic printout, emphasized, double width, underlined, subscript, superscript, double strike, backspace, margin etc.
14. Reliability	: MTBF more than 8000 Hrs.
15. Noise level	: Less than 60 dBA
16. Ribbon life	: 2 million characters
17. Diagnostics	: Self diagnostic. LED error code display, Audio alarm – paper exhausted
18. No. of copies	: Minimum Original plus 3 (three)
19. Accessories	: i) Ribbon ii) Printer stand iii) Table top receiving tray iv) Interface cable v) Paper tear box. vi) 20 Reams of 132 column computer sheets and 10 Reams of 80 column computer sheets

9. DIGITAL NETWORK PRINTER WITH COPIER

01. Type	: Laser, tabletop / latest
02. Printer Memory	: 256 MB (min.)
03. Speed	: Monochrome 20 ppm - A4 10 ppm – A3
04. Resolution	: 600 x 600 DPI
05. No. of color (Basic)	: Monochrome
06. Duty cycle	: Monochrome more than 75000 pages / month
07. Power supply	: 240 V, 50 Hz, 1 phase
08. Ambient temperature	: 0-50 °C
09. Humidity	: 95% non-condensing.
10. Size of paper	: Paper weight of 45 to 165 g/M ²
11. Networking Capability	: USB / Ethernet
12. Coping	: Max Original Size – A3, Continuous Coping (1-999)
12. Accessories	: i) Adapters ii) Connector Cable iii) Duplex Unit.



- iv) Optional Paper feeder- 2 Nos
(Make – Koyecera 2035 or equivalent in cannon or HP)

10. 84” MONITOR LVS/DLP/LED/LATEST CONFIGURATION

01. Type	:	DLP colour monitor.
02. Screen diagonal	:	84” flat
04. Display	:	Super Video Graphic Array
05. Resolution	:	SXGA
06. Degree of protection	:	IP-30
07. Brightness	:	300cd/m ²
08. Contrast	:	800: 1
09. External Controls	:	Brightness, contrast, Horizontal / Vertical amplification & shift
10. Power supply	:	240 V, 50 Hz, 1 phase
11. Ambient temperature	:	0-50 °C
12. Humidity	:	95% non-condensing.
13. Version	:	To suit industrial application.
14. Fixture	:	Wall mounted type
15. Degree of viewing in horizontal & vertical	:	shall be finalised during detail engineering
16. Remote unit for switching between video signal & HMI signal, selecting the video signal channel (live camera no./location typically) shall be provided		
17. Video signal interface Interfacing with video signals, to receive & project pictures from CCTV, purchaser's Live camera, VCP Signal types: PAL, NTSC or SECAM in S-VHS/VHS		
18. Lamp Redundancy	:	Redundancy lamp configuration with auto switching in case of failure of one lamp

Functions of LVS

- a) Display of important data, graphics coming from the PC, Workstation, Video, SCADA, images from CCTV, IP camera etc in real time.
- b) To provide real time clear luminous view to share information to operators and visitors.
- c) Design of LVS shall be in such a manner, that it can be installed in linear or curvature setup.
- d) The overall resolution of the graphics wall shall be min. 8400 x 1050 pixels or better.
- e) The whole screen of the Large Screen Graphics Wall should behave as a single logical screen and the control of the same should be from a dedicated Graphical Control Unit (Controller) having a Keyboard & mouse. However as option should be possible to control the Graphics Wall from a Work stations on LAN having Windows NT/2000 OS.
- f) The complete system shall be interfaced on 10/100/1000 MBPS redundant LAN. Also LVS shall be integrated with the RGB, Video signals available in the Control Room by providing extra input cards. Complete cards shall be provided by bidder.



- g) The Large Screen System should have the functionality to pre configure and save various display layouts to be accessed at any given point of time with a simple mouse click.
- h) The system should be possible to show the mirror images of Eight (6) operator workstations running on WINDOWS NT / 2000/XP and connected using the industrial grade managed type Ethernet switch with the Display Controller.
- i) The system should be able to show the applications running on UNIX complying to X-Windows protocol.
- j) The system should be configured such that any of the operators sitting on the same Ethernet should be able to work on the Large Screen sitting at his own position with his local keyboard & mouse (in case of Windows 2000 / NT workstations).
- k) The offered system should be able to work in 24/7 days environment and is of industrial nature. LVS system shall be provided with UPS redundant power supply.

The Rear Projection Module shall have the following specifications:

- 1. The Graphics wall in CCR should be made up of rear projection modules
- 2. The rear projection modules must be based on Single Chip DLP Rear Projection technology 3 separate colour (Red, Green & Blue) LED lit, without any colour wheel.
- 3. The light source should be LEDs of 3 different primary colours; Red, Green & Blue and not a single lamp using the LED as a light source.
- 4. Should have the scalability and upgradeability to be made up of multiple rear projection modules stacked up in rows and columns to achieve a display wall for better viewing ability in linear or curved configuration.
- 5. The each Rear Projection Module shall be with a native resolution of 1400 X 1050 pixels or higher and should offer 16.7 million colors. It should be rear serviceable to avoid the operator distraction.
- 6. The Visual Display Unit / Rear Projection Modules should have in-built redundancy in LEDs, LED driver (power supply) and ensures redundancy at the light source level without any mechanical movement.
- 7. In case an LED shorts or LED driver (power supply) fails, system should ensure the image without any primary colour loss.
- 8. The MTBF of LED > 500,000 hrs.
- a) In case of LED failure or wear out, the LED's shall be field replaceable with MTTR < 15 min without engine removal.
- b) The brightness uniformity should not be less than 97% ANSI 9.
- c) The dynamic contrast shall be 1,200,000:1 or higher.
- d) The Aspect Ratio of each of projection module should be 4:3.
- e) The projector brightness should be 750 ANSI Lumens. The luminance on each rear projection module is 450 cd/m² with DNP FXS screens having 1/5 gain angle of 46° horizontal and 45° vertical.
- f) The screen should have low inter screen gap to give seamless viewing experience. It should be <0.2 mm using the stitched screen technology.
- g) During the useful lifetime of the illumination unit, there shall be real-time automatic color and brightness alignment of different projectors to a common target, resulting in a uniform display wall. The auto calibration system shall measure the hue of the color and adjust by the use of an internal spectrometer to measure the complete spectrum of each primary color, in order to derive the chromaticities with the highest accuracy.
- h) The real-time automatic color (brightness of color as well as hue) and brightness alignment shall be done in the background, without any downtime or temporary loss of content and need of external calibration devices.



- i) The Projector should support 2x Duallink DVI in and 2x Dual link DVI out to have a flicker free image on the Large Screen Graphics Wall and support content redundancy.
- j) The pixel clock shall be > 320 MHz on both the inputs.
- k) Each cube shall have its own IP address to have the access from a standard web page from any Work stations over the Ethernet and shall communicate to a viewer via ethernet and it's IP address in star architecture to prevent communication loss. It shall have it's own webpage with status, health and configuration.
- l) Power consumption for each Visual Display Unit / Rear Projection Modules should be 170 watts in the economy mode.
- m) As the LED lifetime drops by 50% if the LED junction temperature increases with 10°C, liquid cooling shall be applied directly at the junction of the LEDs in order to guarantee the advertised lifetime.
- n) To avoid visible color break up each LED shall be pulsed at 24x speed, meaning 24 pulses per frame

The Display Controller of LVS shall have the following specifications:

- 1. In an industrial 19" rack mounted casing based on processor/controller configuration same as specified for OWS or latest processor at the time of supply.
- 2. The min. memory of 4GB expandable up to 8 GB.
- 3. The unit should be equipped with a 48X or better CD/DVD ROM.
- 4. The hard Disk should be of 500 GB, 7200 rpm.
- 5. Should have dual 10/100/1000 Mbps Ethernet port for redundant LAN connection and redundant hot swappable power supply.
- 6. Supplied with a Keyboard and mouse with min. 20 m cable extension.
- 7. Based on Windows 2000 OS XP Prof/NTOS.
- 8. The system should have future expansion possibilities.
- 10. As no full hardwired backup has been envisaged, the plant LVS should ensure control/operation of the plant in case of total failure of all operator stations. Hence Complete DCS software shall also be loaded on display controller.
- 11. There should be possibility of connecting the various type of analog and digital sources using single multistandard input card in freely scalable and moveable windows on the graphics wall. It should support :
 - SDTV analog PAL, NTSC, SECAM (Composite, S-Video, Component)
 - HDTV 720p, 1080i, 1080p (Component)
 - RGB analog up to 1920x1200 (up to 165 MHz pixel clock)
 - DVI up to 1920x1200 (up to 165 MHz pixel clock)
- 12. Should have full range scaling capability from finger print size to full wall size.
- 13. The controller shall provide integrated hardware accelerated streaming video decoding using streaming video decoder cards. The Display controller shall be capable of supporting integrated streaming video input cards to achieve a seamless integration between potential future IP networks and the display wall. The streaming video card shall provide IP interfacing and hardware decoding of the streaming video input locally on the card, and shall not require any additional processing power from the CPU of the main base unit for this task. The integrated hardware decoding shall be independent from a large set of current encoder suppliers. The manufacturer shall publish his encoder interoperability list.
- 14. The decoder card shall have a dual 10/100 Base-T failover Ethernet interface.
- 15. The decoder card shall support IGMP multicasting.
- 16. The decoder card shall support MPEG-2, MPEG-4, MJPEG & H.264 compression protocols.
- 17. The decoder card shall allow implementing other compression protocols via a firmware upgrade.
- 18. The decoder card shall decode up to four (4) channels simultaneously.



Display controller shall have suitable cards for interfacing with Video signals, to receive & project pictures from CCTV, Employer's live camera, VCP/VCD player/DVD player, SCADA, Input signals like DVI – D, DVI-I, Video input (PAL, NTSC, SECAM), HD signals & DCS. The system shall also accept IP stream from CCTV camera with suitable IP input cards. The Remote unit for switching between video signal & MMI signal, selecting the video signal channel (live camera no./location typically) shall be provided.

LVS shall be designed for continuous viewing (24 hours in a day) under normal room ambient lighting without any need to darken the room. Suitable darkening of the projection screen for light absorption shall be provided for this purpose.

The LVS and its accessories shall be designed in such a way that the brightness in the centre of the screen and the edges of the screen is uniform and there is no perceivable difference in the quality of the picture on the centre and on the edges of the screen. If any extra hardware has to be provided for achieving the above feature, same shall be provided by the bidder at no extra cost.

LVS Software should have the following specifications:

- a. The software should be able pre configure various display layouts and access them at any time with a simple mouse click or based on the timer.
- b. The software should enable the users to see the desktop of the graphics display wall remotely on the any work station connected with the Display Controller over the Ethernet and change the size and position of the various windows being shown.
- c. The software should enable various operators to access the display wall from the local keyboard and mouse of their workstation connected with the Display Controller on the Ethernet.
- d. The software should copy the screen content of the workstations connected on the Ethernet with the Display Controller to be shown on the Display wall in scalable and moveable windows in real time environment.
- e. The LVS software shall allow switching the video streams.
- f. The LVS software shall allow display of video/data windows inside other graphic windows and it should be possible to configure the video/data windows to always remain on top while the operator works on the windows below.
- g. The LVS software should support open APIs to enable system integrators to integrate it with their Software.
- h. The LVS Diagnostic software shall perform health monitoring that allows timely detection of faults.
 - i) Wall health
 - ii) Cube health
 - iii) Cube IP-address
 - iv) LED hours worked
 - v) Native Brightness target & actual brightness
 - vi) Native Color (white, red, green, blue) & actual color
 - vii) Selected inputs and presence of sources on either input
- i. LVS Diagnostic Software shall allow commands on wall level or cube level or a selection of cubes :
 - i) Switching the entire display wall on or off.
 - ii) Setting all projection modules to a common brightness target, which can be either static (fixed) or dynamic to always achieve maximum (or minimum) common brightness between projection modules.
 - iii) Switching to either Eco or Normal operation mode.
 - iv) Changing the active input (of the two present DVI inputs).



- v) Finetune color of each cube
- j. The integrated view shall provide a database that
 - i) records all events
 - ii) can record full status at given time intervals
 - iii) can be exported to excel/html
 - iv) Show internal patterns

LVS Annunciation

Following indicates the guidelines for implementing LVS annunciation functionalities.

- 1) The LVS annunciation will emulate salient features of the conventional hardware annunciations while presenting more flexibility.
- 2) The annunciation points will be presented on topmost area of LVS screens. This “annunciation area” will be reserved for soft-annunciations only and no process graphics/system window/application windows will occupy this area.
- 3) The annunciation area will be divided in multiple “LVS alarm bands”. There will be 3 nos. of LVS alarm bands in each LVS screens. The height of this band will be typically 42 pixels (the size of LVS screen has been considered as 1400x1050 pixels). Light horizontal lines will be provided to separate the bands on screen.
- 4) In alarm window alarm text will be displayed when point is in alarm. There will be one alarm for each alarm window. The font type and size of message text shall be such that it is legible to operator. However typically this can be selected as “Arial 10 Bold”.
- 5) Annunciation points shall be distributed on various LVS screens based on process area. That is, each annunciation point will be assigned LVS no. and alarm band no. on which it will be displayed. First three (3) rows of LVS will be used for critical alarm display. First row will be kept reserved for fixed alarm and the other two rows will be used for other alarm display for which location of window may vary.

Number of LVS alarm will be decided during detailed engineering stage.

- 6) Each band will show up to 12 “alarm windows”. The alarm popping up sequence is from left to right. No fixed space will be reserved for any alarm on any of the band. Alarms as and when occur shall be displayed on the bands one after other (from left to right) on each LVS screen and will persist until returned to normal and reset by operator. In case ‘alarm band’ described above is full (12 nos.) and new alarm(s) is/are reported, new alarm(s) will be presented sequentially on corresponding band by automatically scrolling older alarm(s) and left side of band, one by one until all latest alarms have been displayed. Suitable scroll bar facility on both sides of each band shall be provided, which will appear only when there are more alarms than the designated display capacity (12 nos.) of LVS band. The scroll button(s) will flash (slow or fast) as per the state of alarm(s) in their band.
- 7) For each LVS annunciations, a menu based options to acknowledge, reset, configuration etc. is to be provided. Through configuration utility operator can view and edit alarm list, tag nos. etc. of all points in all LVS. The configuration utility shall be password protected for any modifications. However, with one acknowledge/reset action, all alarm point(s) of all band(s) of that LVS will be acknowledged/rest.



- 8) The hooter sounds will be different for each of the unit of power plant, when there is common control room for multiple units.
- 9) Shift/Unit in-charge can call alarm area of any LVS of that unit on his OWS.

Other Features

- a) LVS shall be designed for continuous viewing (24 hours in a day) under normal room ambient lighting without any need to darken the room. Suitable darkening of the projection screen for light absorption shall be provided for this purpose.
 - b) Adjustment of the projections shall be performed. Suitable mounts on installation and all other components shall be adjusted in the factory and shall not require further adjustment at site. Maintenance work on the LVS shall be confined to easy replacement of the lamps and cleaning of the fans, which shall be performed in few minutes by the purchaser's staff without any special training. Suitable means (operating hours displays etc.) shall be provided to indicate the need of replacement of lamp. Power switch shall be provided for isolation during replacement of the lamps.
 - c) The LVS and its accessories shall be designed in such a way that the brightness in the centre of the screen and the edges of the screen is uniform and there is no perceivable difference in the quality of the picture on the centre and on the edges of the screen. If any extra hardware has to be provided for achieving the above feature, same shall be provided by the Contractor's at no extra cost.
 - d) The screen should be flicker free and there shall not be any screen burn in due to display of same information for a long time.
 - e) Auto brightness adjustment between each screen.
10. The hardware/software of the control unit shall be such that the command execution time of any control command from the LVS shall be same or better than the execution time from the OWS. If during any stage of the contract, the command response times as stated in specifications are not achieved, the Contractor's shall upgrade the hardware/software of the control unit in order to achieve the same at no extra cost to the purchaser.
 11. In the event of failure of LVS interfacing with SG & TG package, any of the other LVS shall be capable of being used in place of the failed LVS. The Contractor's shall provide a suitable network/switching facility for this purpose.

The exact arrangement of LVS shall be decided during detailed engineering. Suitable facility shall be provided to the operator for transferring the screens, without any need of changing of hardware/wiring or software.

12. Master control unit shall be capable of projecting displays over a part of screen to multiple screens. Any communication of windows shall be possible. Facility for overlays shall be provided.

B. DCS HARDWARE

1. HIGH LEVEL ANALOG INPUT MODULES

01. Number of inputs/module	:	16
02. Types of input (Linear)	:	4-20 mA and 1-5 V
03. Accuracy	:	0.1% or better
04. A/D Converter	:	Integrating, 15 bit + Sign or better



- 05. Temperature effect : 0.01% / Deg.C or better
- 06. CMRR : 60 db (at 50 Hz) or better
- 07. NMRR : 20 db (at 50 Hz) or better
- 08. Stability : 0.03% / year or etter
- 09. Diagnostics :
 - i) Limit check
 - ii) A/D converter fault
 - iii) Channel fault
 - iv) Wire break
 - v) Short circuit
 - vi) Auto gain correction

2. LOW LEVEL ANALOG INPUT MODULES

- 01. Number of inputs/module : 16
- 02. Types of input : Thermocouples (K, R, S, T etc.,)
[Grounded & Ungrounded] RTD (Pt -100
Ohm & Pt – 1000ohm)
[Two wire, three wire] Configurable
- 03. Cold junction compensation : On module / local RTD
- 04. Accuracy : 0.1% or better (Linearized)
- 05. A/D converter : Integrating, 15 bit + sign or better
- 06. Temperature effect : 0.01% / Deg.C or better
- 07. CMRR : 60 db (at 50 Hz) or better
- 09. NMRR : 20 db (at 50 Hz) or better
- 09. Stability : 0.03% year or better
- 10. Diagnostics :
 - i) A/D converter fault
 - ii) Channel fault
 - iii) Wire break
 - iv) Short circuit
 - v) Auto gain correction

3. BINARY INPUT MODULE (SLOW SCAN)

- 01. Number of inputs/module : 32
- 02. Types of input : 24/48V DC
N.O/N.C/ch.over contacts
- 03. Input current : 5-10 mA
- 04. Maximum switching
Frequency : 100 Hz
- 05. Diagnostics :
 - i) Input simulation
 - ii) Wire break detection
 - iii) Short circuit

4. BINARY INPUT MODULE (FAST SCAN SOE)

Same as item 3 but resolution 1 m sec.

5. SMART TRANSMITTER INTERFACE MODULES

- 01. Number of inputs/module : 16
- 02. Types of input : From Smart Transmitters.
- 03. Protocol : HART or any proven compatible protocol.
- 04. Communication : Bidirectional
- 05. Accuracy : 0.1% or better
- 06. Function :
 - I) Signal processing
 - ii) EU conversion
 - iii) Alarm, Diagnostic etc.
 - iv) Configuration TX. database
 - v) Rearranging & TX. Calibration
- 07. Diagnostics :
 - i) Limit check



- ii) Channel fault
- iii) Wire break
- iv) Short circuit

6. PULSE INPUT MODULE

Generally same as Binary input modules but with 8 inputs/module (maximum) and leading / trailing edge detection. Minimum pulse width 1 m sec.

7. ANALOG OUTPUT MODULES

- 01. Number of points/module : 8
- 02. Types of output (Linear) : 4-20 mA
- 03. Accuracy : 0.4% or better
- 04. Load : 750 Ohms (min.) [Current]
1 K Ohm [Voltage]
- 05. Diagnostic :
 - i) Channel fault
 - ii) Retention of memory on DEMUX failure
 - iii) A / D converter fault.
- 06. Others : Any special type required to operate specific control vale, the Contractor to specify and submit the catalogue / technical specification for such AO module

8. BINARY OUTPUT MODULES

- 01. No. of points/module : 32
- 02. Type of output : Relay with 1 change-over contact
- 03. Contact rating : 60 VA
- 04. Contact voltage rating : 60 Volts
- 05. Switching frequency : 2 Hz
- 06. Contact life : 1 million operations

9. CENTRAL PROCESSING UNIT (CPU)

- 01. Type : Microprocessor based
- 02. Word length : 32 / 64 bits (Preferably 64 bits)
- 03. Register add cycle time : 1 microsecond (typical)
- 04. Instruction cycle time : 75 microseconds (maximum)
- 05. I/O address capability : 256 points (minimum)
- 06. Memory : NV RAM - 640 KB (minimum)
- 07. Whether redundant : Yes
- 08. Whether fall back
Transparent : Yes
- 09. Control Function :
 - a) Logical functions like AND, OR, EX-OR, Timer, counter etc.
 - b) Load/Data transfer etc.
 - c) Outputting, driving, interfacing, scanning, data validation etc.
 - d) Diagnostic/monitoring
 - e) Data/signal Exchange
 - f) Sequencing, step-checking etc.
- 10. Power supply : 24 V D.C.
- 11. Mounting : Sub-rack
- 12. Configuration : From hand-held station through front plug
- 13. Diagnostics : Invalid command checking,
(Automatic periodic illegal address detection,
routine check and memory parity check, watch



14. Indication : dog timer) time-out checking, processor status display LED, processor fault.
: Processor status and fault display

C. MACHINERY MONITORING SYSTEM

i) Vibration Monitor

01. Sensitivity : 100 mV/mil or better
02. Frequency Response : User programmable
03. Accuracy : $\pm 0.5\%$ of full scale
04. Transducer Supply Voltage : -24 V DC (Typical)
05. Alarm Adjustment : Digitally adjustable over full scale for alert and danger set-points.

ii) Thrust Position Monitor

01. Sensitivity : 100 mV/mil or better
02. Accuracy : $\pm 0.5\%$ of full scale
03. Transducer Supply Voltage : -24 V DC (Typical)
04. Alarm Adjustment : Digitally adjustable over full scale for alarm set points
05. Repeatability : $\pm 0.5\%$ or better

iii) Case Expansion Monitor

01. Sensitivity : 100 mV/mil or better
02. Accuracy : $\pm 0.5\%$ of full scale
03. Transducer Supply Voltage : -24 V DC (Typical)
04. Alarm Adjustment : Digitally adjustable over full scale for alert and damager set-points.

iv) Tachometer/ RPM Monitor

01. Sensitivity : 100 mV/mil or better
02. Accuracy : ± 1 RPM for speed output. and within ± 20 RPM/min for rotor acceleration output.
03. Transducer Supply Voltage : -24 V DC (Typical)
04. Alarm set points : Over speed and under speed Set points
05. Alarm Adjustment : Digitally adjustable over full scale for over speed / under speed set points.
06. RPM Range : 1 to 99,999 rpm
07. Accuracy and Resolution : ± 1 rpm

v) Eccentricity / Key Phasor Monitor

01. Input signal : Two proximity probes, one for eccentricity and one for key-Phasor
02. Frequency response : 0 to 10 Hz
03. Accuracy : $\pm 0.5\%$ of full scale

vi) Temperature Monitor

01. Input : 3 wire RTDs (Pt 100) as per DIN43760 K/T type thermocouple Sensor selection programmable



02. No. of channels	:	12 / 16 / 24
03. Range	:	0 – 200 / 600 Degrees Centigrade or as per application
04. Accuracy	:	+/- 1 °C
05. Display	:	LCD display, 3 ½ digits
06. Input Scan rate	:	12 Channel / sec or fast. (Any channel Skip provision shall be made)
07. Display Dwell Time	:	1 to 25 sec adjustable
08. Display Mode	:	Auto / Manual selection of channels Alarm and Trip set points independent for the selected channel.
09. Alarm display	:	To be provided for Alarm (Flashing) & Trip (steady) for each Channel
010. Sensor status Display	:	For open/short condition.(On Digital display)
011. Fail Safe Condition	:	During sensor open / short condition the Alarm / trip output of the respective channel should not energize the common relays.
012. Keys	:	4 No. Reset, Mode, Next, Previous(Min)
013. Common Output relays	:	4 No. (configurable for any channel or group of channels for alarm or trip) for 12 / 16 channels 6nos. for 24 channels.
014. Contact configuration	:	2 'NO' contacts per relay
015. Contact Rating	:	5A at 220V AC resistive (24V DC, 1A)
016. Set point programming	:	through front panel keys (membrane Type)
017. Set point / relay memory	:	non volatile (w / o battery backup)
018. Power supply	:	230V AC +/- 10%, 50Hz
019. Mounting	:	Flush panel in a powder coated cabinet
020. Termination	:	Plug & socket with best connection (for power supply and Input)
021. Environment	:	up to 600 °C bad environment with high humidity
022. Communication connectivity	:	soft link with DDC MIS through HART or standard protocol
023. Configuration & diagnostics from DDC MIS	:	through HART Protocol or standard protocol

vii) VIBRATION PICK-UPS

01. Type	:	Proximity type
02. Mounting	:	The Proximity Probe shall be mounted outside the machine case using protective housing with adjustable sleeves (stingers) that will be extended to the shaft surface.
03. Frequency response	:	0 - 10 KHz
04. Linear Range	:	Begins at 10 mils from probe face.
05. Linearity	:	Within ±1 mil of a straight line.
06. Temperature sensitivity	:	3% of span for 60° C change or better
07. Relative Humidity	:	95% non condensing
08. Module Housing	:	Fibre glass
09. Enclosure class	:	IP-65
10. Power supply	:	24V DC from monitoring units
11. Accessories	:	i) Non conductive mounting plates for housing ii) Extension cables (S.S armored) iii) Suitable junction boxes etc.

**D. CONTROL BOARD****I. Control Desk / Console / Panel Construction**

01. Applicable for	:	Indoor Panel, Desk & console.
02. Material of construction	:	Cold rolled steel sheet (Metal and plastic - Heat resistant, shrinkage free for mosaic tiles).
03. Thickness of Sheet	:	a) 3.2 mm for faces supporting instruments / terminals. b) 2 mm for other sides and top.
04. Construction	:	Welded throughout as per (metallic parts) approved National Standards.
05. i) Corners	:	7 mm inner radius
ii) Dimensional Tolerances	:	a) In height & length - 3 mm b) In height between adjacent sections - 2 mm. c) Total for a group - 6 mm
06. Doors	:	Double, recessed, turned back edges
i) Thickness of Sheet	:	2 mm
ii) Hinges	:	Stainless steel
iii) Door latches	:	Three point type
iv) Door gaskets	:	Neoprene rubber on fixed frame to result dust proof / weatherproof enclosure.
v) Opening of the doors	:	Outward
vi) Louvers	:	With removable wire mesh to ensure dust and vermin proof.
07. Color of interior	:	Glossy white
08. Colour external	:	IS 5 No. 628 (Typical) [To be decided later]
09. Protection of painting	:	Plastic peel coating
10. Gland plates	:	Removable 4 mm thick (bottom)
11. Cable entry	:	Bottom
12. Hardware	:	a) Vibration dampeners b) Predrilled base channel ISMC - 100 or equivalent for all sides. c) Stainless steel buff- finished 2 mm thick kick plate for all sides. d) Stainless steel scratch strips along desk edges fixed with pan-head recessed screws. e) Rubber strips to ensure air tightness between kick plate and finished floor. f) Power supply points 5/15 A plug point with indication lamp 5 Nos.
13. Enclosure Protection Class	:	IP-42 or as per environment condition.
14. Earthing	:	4 per standards

**E. FIELD INSTRUMENTS****I. PRESSURE**

This section provides general hardware guidelines for field instruments and equipment to be supplied under this specification.

Field transmitters shall be smart type with **HART** protocol. Temperature & Pressure switches shall be of Dual Snap type for vibration prone areas.

A. Pressure Transmitter

01.	Working Principle	:	Smart
02.	Type	:	2 - Wire
03.	Output Signal	:	Simultaneous transmission of digital and 4-20 mA DC signal isolated linear standard protocol (HART).
04.	Signal Processing	:	Silicon solid state electronic circuitry
05.	Measuring Element	:	Capsule / Diaphragm
06.	Measuring element	:	AISI-316 (Stainless Steel) Diaphragm material
07.	Static Pressure	:	150 % of maximum span continuously, without affecting the calibration.
08.	Turn-down ratio	:	100 : 1 minimum.
09.	Span and Zero	:	Locally adjustable with interacting facility or remotely accessible with HART based communicator for elevation and suppression by 100% of span
10.	Enclosure Class	:	IP-65 (Explosion proof for NEC Class-1, Division 1 area)
11.	Output Indicator (Digital display)	:	LCD type in % and engineering unit and LCD failure shall not affect the transmitter operation.
12.	Nameplate	:	Tag number, service engraved in stainless steel tag plate
13.	Body	:	Forged Carbon Steel (SS for DM Water).
14.	Operating Voltage	:	18 - 36 Volts D.C.
15.	Load	:	750 Ohms (min.) at 24 Volts D.C.
16.	Ambient Temperature	:	0 - 85 °C
17.	Performance:		
	i) Accuracy	:	+ 0.04% or better of FSR for BTG package, + 0.065% or better of FSR for BOP packages and + 0.2% for remote seal type transmitter.
	ii) Repeatability	:	± 0.05% of calibrated Span or better
	iii) Warranty & stability	:	min. of 5 yrs or better
18.	Sealing/Isolation	:	10 meters SS armoured capillary with suitable fill fluid and flange remote seal diaphragm of SS 316 or suitable material as per application, for corrosive, viscous and dirty fluid application. Flange size and pressure rating as per application.
19.	Accessories	:	a) Universal mounting bracket suitable for 2" pipe and wall mounting. b) High tensile carbon steel U- bolts. c) Installation accessories as per relevant installation drawing. d) Syphons for steam and hot water services. e) 1/2" NPT 2-valve stainless steel manifold, constructed from SS316 bar stock.



- f) Companion flange with nuts, bolts and gaskets.
- g) Hand held configuration kit for diagnostics and calibration of Smart Transmitter locally or in remote.
- h) 3/4" ET cable gland
- i) Flushing facility at process end diaphragm.
- j) Reverse polarity protection required.
- k) Three way SS manifold for (gauge) vacuum

B. Differential Pressure Transmitter

- 01. Working Principle : Smart
- 02. Type : 2-Wire
- 03. Output signal : Simultaneous transmission of digital and 4-20 mA DC signal isolated linear standard protocol -HART.
- 04. Signal Processing Unit : Silicon solid-state electronic circuitry
- 05. Measuring element : Capsule/Diaphragm
- 06. Measuring element Material : AISI-316 (Stainless Steel)
- 07. Static Pressure/ Overload Pressure : Maximum line (or static) pressure on either side without permanent deformation or loss of accuracy
- 08. Turn-down ratio : 100: 1 minimum
- 09. Span and Zero : Locally adjustable, non-interacting
- 10. Enclosure class : IP-65 (Explosion proof for NEC Class-1, Division 1 area)
- 11. Zero suppression / Elevation : At least 100% of Span
- 12. Output Indicator (Digital display) : LCD type in % and Engineering units
- 13. Nameplate : Tag number and Service engraved in stainless steel tag plate
- 14. Body : Forged Carbon Steel (SS for DM Water)
- 15. Ambient temperature : 0 - 85 °C
- 16. Operating Voltage : 18 - 36 Volts DC
- 17. Load : 750 Ohms at 24 Volts DC
- 18. Performance:-
 - i) Accuracy : ± 0.025 % of calibrated span or better
 - ii) Repeatability : ± 0.05 % of calibrated span or better
- 19. Sealing/Isolation : 6 meters SS armoured capillary with suitable fill fluid and flange remote seal diaphragm of SS 316 or suitable material as per application, for corrosive, viscous and dirty fluid application. Flange size and pressure rating as per application.
- 20. Accessories :
 - a) Universal mounting bracket suitable for 2" pipe and wall mounting.
 - b) High tensile carbon steel U-bolts.
 - c) Installation accessories as per relevant installation drawing.
 - d) Syphons for steam and hot water services.
 - l) 1/2" NPT 5-valve stainless steel manifold, constructed from SS316 bar stock.
 - e) Companion flange with nuts, bolts and gaskets.
 - f) Hand held configurator kit for diagnosis and calibration of Smart Transmitter.
 - g) 3/4" ET cable gland



- h) Flushing facility at process end diaphragm.
- i) Reverse polarity protection required.

C. Pressure Switch

- 01. Type : Seal diaphragm, piston actuated.
- 02. Sensing element material : AISI SS-316 diaphragm / piston. All other wetted part SS316.
- 03. Case Material : Epoxy coated steel plate or die-cast aluminum alloy with neoprene gasket and clear glass where applicable.
- 04. Setter Scale : Black graduation on white liner scale. Graduation 0-100% with red pointer for set points.
- 05. Over range : 150 % of maximum pressure
- 06. Process Connection : 1/2" NPT (M) bottom connected
- 07. Switch configuration : Two SPDT
Lead wires (3+3 Nos.) are to be brought externally to the male connector wherein the female pug connector will be inserted to connect the control room cables for easy removal & re - calibration
- 08. Switch Rating : 240V, 5A AC/220V, 0.5A DC
- 09. Switch Type : Dual Snap acting, shock & vibration proof
- 10. Adjustability : a) Set-point adjustable over span range.
b) Differential adjustable by 10 percent of span (minimum).
- 11. Sealing Ring : Viton, Buna-N
- 12. Terminal Block : Suitable for full ring lugs for cable connection.
- 13. Cable connection : 3/4" ET compression gland.
- 14. Enclosure Class : IP-65 (Explosion proof for NEC Class-1, Division 1 area).
- 15. Performance : a) Accuracy $\pm 1.0\%$
b) Accuracy of Setting Indication of $\pm 1.5\%$
- 16. Ambient temperature : 0 – 50 Deg.C
- 17. Nameplate : Tag number, service engraved in stainless steel tag plate
- 18. Accessories : a) Remote diaphragm seal with SS-316 armored capillary for typical application. MOC of seal material shall be as per process fluid requirement.
b) Snubbers for pulsating fluid application.
c) Retention ring and screws for surface mounting.
d) 1/2" NPT 2 Valve SS-316 manifold constructed from bar stock
e) 3/4" ET cable gland

D. Differential Pressure Switch

- 01. Type : Bellows / Diaphragm / Piston actuated
- 02. Sensing element material : AISI SS-316. For all other wetted part SS 316
- 03. Case Material : Epoxy coated steel plate or die-cast aluminum alloy with neoprene gasket and clear glass where applicable.
- 04. Setter Scale : Black graduation on white scale with 0-100% graduation and provided with red pointer for set point adjustment
- 05. Over range : Static pressure on any one side, the other side being open to atmosphere.
- 06. Process Connection : 1/2" NPT (M) bottom connected / back connected.



07. Switch configuration : Two SPDT
Lead wires (3+3 Nos.) are to be brought externally to the male connector wherein the female pug connector will be inserted to connect the control room cables for easy removal & re - calibration
08. Switch rating : 240V, 5A AC/220V, 0.5A DC.
09. Switch type : Dual Snap acting type contacts, shock and vibration proof.
10. Adjustability : a) Set point adjustable over span range.
b) Differential adjustable by 10 % of span (minimum).
11. Terminal Blocks : Suitable for full ring lugs for cable connection.
12. Cable Connection : 3/4" ET compression gland.
13. Performance : a) Accuracy of repeatability: $\pm 1.0\%$ of span.
b) Accuracy of set point Indication: $\pm 1.5\%$
14. Operating Ambient Temperature : 0 - 50 ° C (Maximum Continuous)
15. Enclosure : IP – 65 (Explosion proof for NEC Class-1, Division 1 area).
16. Accessories : a) Snubbers for pulsating fluid application.
b) Retention ring and screws for surface mounting.
c) 1/2" NPT 5 Valve SS-316 manifold constructed from bar stock
d) 3 / 4" Cable gland
17. Nameplate : Tag number, service engraved in stainless steel tag plate
18. Preferred Features : Free floating bellows attached to high-pressure bellows for temperature compensation.
19. Remote Seal type for special application : a) Silicone oil / fluorolube filled remote diaphragm seal for dirty / viscous / corrosive fluid.
b) SS armored capillary at least 3 meters each.
c) Adapter flanges with nuts, bolts and gaskets for instrument and process side

E. Pressure Gauge and Differential Pressure Gauge

01. Type : Bourdon/Bellows/Diaphragm
02. MOC Sensing & Socket : AISI-316 SS
03. Movement Material : AISI-304 SS
04. Case Material : Stainless steel casing bayonet type. Enclosure IP-65.
05. Dial Size : Generally 150 mm (100 mm for SWAS gauges)
06. Scale : Black lettering on white background in 270 Deg. arcs.
07. Window : shatterproof toughened glass
08. Range Selection : Normal process pressure – 50 ~ 70 % of range (approximately).
09. Over-range Protection : 125% of maximum range by internal stop. External stop at zero
10. Adjustment : Micrometer screw for zero adjustment. Internal micrometer screw for range adjustment.
11. Element Connection : Argon welding
12. Process Connection : 1/2" NPT (M) Bottom connection for local mounting, back connection for panel mounting.
13. Performance : Accuracy of $\pm 1.0\%$ of span or better for Pressure gauge



- Accuracy of ± 1.6 % of span or better for Differential Pressure gauge
- | | | | |
|-----|-------------------------------|---|--|
| 14. | Operating ambient Temperature | : | 0 - 50 °C |
| 15. | Safety Feature | : | Blow out disc. /diaphragm at the back |
| 16. | Accessories | : | a) Snubbers and Glycerin filled for pulsating fluid applications and at pump discharge.
b) Stainless steel 316 Diaphragm with Teflon coated seals for corrosive, viscous and solid-bearing or slurry type process fluids.
c) 3-Way stainless steel Gauge cock for pressure gauges. Process connection 1/2" NPT.
d) 5-valve SS316 manifold constructed from barstock for differential pressure gauge. Process connection 1/2" NPT.
e) Union, nut & tail piece and other Installation accessories as required. |
| 17. | Applicable standard | : | IS-3624 / 1996 |
| 18. | Electrical Contact rating | : | 240V, 5A AC/ 220V, 0.5A DC (for gauges with alarm contact). Number of Contacts:2 SPDT |
| 19. | Nameplate | : | Tag number, service engraved in stainless steel tag plate |

II. LEVEL

A. Radar Level Transmitters

01.	a) Type	:	1. Guided wave Radar type transmitter of TDR type 2-10 GHz for liquids 2. Radar type transmitter of FMCWR type 24-26 GHz, drop in antenna for coal level
	b) Probe	:	Coaxial
	c) Probe material	:	SS 316 / SS 316L
02.	calibration range	:	as per application
03.	Process medium	:	as per application
04.	Process temperature	:	as per application
05.	Static Pressure	:	Capable of working in vacuum also
06.	Power supply	:	range to be specified by the bid (Loop power available = 24V DC)
07.	Reverse polarity protection	:	required
08.	Output	:	4 to 20mA, 2wire & HART
09.	Accuracy	:	$\pm 0.03\%$ of measure distance or ± 3 mm
010.	Stability	:	Contractor specify
011.	Communication	:	Communication / configuration shall be possible either through integral key pad and display or through hand communicator. If integral key pad is not available, one number hand held communicator common for all the transmitters shall be supplied
012.	Load limitation	:	max 600 ohm at 24V
013.	Span & zero	:	adjustable
014.	Flange mounting	:	yes
015.	Environmental protection	:	IP 66 or better
016.	Process connection	:	traditional flange with 1/4" – 18 NPT on flange with process adapters (Flange & drain vent- 316SST)
017.	Electronic housing	:	Aluminium alloy
018.	Electrical connection	:	Preferably 1/2" – 14 NPT with gland.

**B. Capacitance Type Level Transmitter**

The total system shall consist of capacitance probe, pre-amplifier and transmitter

01.	Type	:	Capacitance type
02.	Probe	:	a) Rod or suspended electrode. b) Rope type probes may be used only where required probe length is greater than 3 meters
03.	Probe Mounting :	:	Stainless steel 1-1/2 ANSI RF Flange / 3/4" NPT (M)
04.	Material of construction	:	316 SS
05.	Insulation	:	PTFE Part/Full as per service.
06.	Transmitter	:	The transmitter shall receive output of the preamplifier and convert it into 4-20 mA DC output signals.
07.	Accuracy	:	±0.1%
08.	Load	:	750 Ohms or more
09.	Enclosure	:	Powder/Epoxy coated Die cast aluminium. with neoprene gasket conforming to IP-65. (Explosion proof for NEC Class-1, Division 1 area).
10.	Ambient temperature	:	0-60 °C.
11.	Mounting	:	Wall / Surface
12.	Supply voltage	:	(90-250) V AC, 50 Hz / (18-36) V DC
13.	Response time	:	100 msec or better
14.	Cable connection	:	3/4" ET Compression gland
15.	Accessories	:	Counter flange, Cable gland, prefab cable if any
16.	Preferable features	:	Alarm output contacts with adjustable set point facility

C. Ultrasonic Level Transmitter

01.	Type of Transmitter	:	Non contact Microprocessor based 2 wire type, HART protocol Compatible
02.	Output Signal	:	Galvanically isolated 4 – 20 mA DC along with superimposed digital signal (HART protocol)
03.	Sensor Accuracy	:	± 0.25% of calibrated span
04.	Sensor Repeatability	:	3 mm or better
05.	Power Supply	:	18 - 36V DC
06.	Temperature Compensation	:	To be provided within transducer
07.	Configuration	:	Sensor and electronic unit are separate. Electronic unit shall be possible to mount on the accessible location near the transducer. All cables, weather proof fittings for connection between transducer and electronic unit.
08.	Housing	:	IP 55 with durable corrosion resistant Epoxy coating
09.	Calibration	:	Through HART communicator
10.	Zero and Span adjustment	:	Continuous, Tamper proof, Remote as well as manual adjustability. Provision to calibrate the instrument without any level in the tank or sump etc.
11.	Sensor Material	:	Corrosion resistant to suit the individual application
12.	False signal tolerance	:	Facility to be provided. Shall have adjustable damping circuitry.
13.	Range	:	To be decided during detail Engg, with a facility to take care of frequency attenuation due to different obstructions (Surface, vapor)



- 14. Display : Minimum 4 character display with integral key pad, access protected features.
- 15. Diagnostics : Loss of echo alarm
- 16. Load impedance : 500 Ω minimum or as per vendor specification.
- 17. Electrical connection : Plug and socket
- 18. Accessories : Canopy for protection sunlight and rain
Mounting hardware's and accessories shall be SS 316

D. Level Switch

- 01. Type : External cage float operated. Magnetically coupled.
- 02. Float Material : AISI-316 stainless steel
- 03. Other wetted parts : AISI-316 stainless steel
- 04. External Cage : Carbon steel / Stainless steel as per process requirements, welded type / flanged construction. Cage pressure rating shall equal or exceed the rating of the main vessel.
- 05. External cage mounting : Side – Side with drain valve.
- 06. External cage connection : 25 NB socket weld to vessel or RF flanged.
- 07. Switch housing : Epoxy coated die-cast aluminum alloy with neoprene gasket conforming to IP-65. (Explosion proof for NEC Class-1, Division 1 area).
- 08. Type of switch Configuration : 2 SPDT (two nos.) Snap acting magnetically operated hermetically sealed.
- 09. Contact rating : 5A, 240V/AC, 0.5A, 220V DC
- 10. Accessories : a) Counter flange, nuts & bolts, suitable gasket etc.
b) Steel globe type drain valve.
c) $\frac{3}{4}$ " ET cable gland
d) Stainless steel alpha-numeric engraved for service and tag.
- 11. Preferred feature : Switch operating point marked on cage
- 12. Temperature rating : As per application

E. Conductivity Type Level Switch

- 01. Type : Conductivity discrimination.
- 03. Mounting : Flanged – on standpipe.
- 04. Probe MOC : Stainless steel with high purity ceramic.
- 05. Probe rating : > Maximum design pressure of vessel.
- 06. Input : four independent channels with selectable switching threshold for water conductivity.
- 07. Relay Output : Four isolated output relays for HI, LO, HI-HI, LO-LO.
- 08. Contact type & rating : 2SPDT @ 0.5A 220V DC / 5 A 240V AC
- 09. Local Display : Colored LEDs for HI, LO, HI-HI, LO-LO. Power & fault.
- 10. Power supply : Dual (90-250) V AC, 50 Hz, 1Ph.
- 11. Enclosure : IP-65, corrosion resistant & wall mounting type (Explosion proof for NEC Class-1, Division-1 area).
- 12. Accessories : Teflon (PTFE) cable having Teflon wrapped individual cores and necessary sheathing shall be used to connect the probe with electronics
- 13. Test pressure : Two times rated pressure
- 14. Cable connection : $\frac{3}{4}$ " ET Compression gland

**F. Capacitance Type Level Switch**

01	Type	:	Capacitance type
02	Probe	:	a) Rod or suspended electrode b) Rope type probes may be used only where required probe length is greater than 3 meters.
03.	Probe Mounting	:	Stainless steel 1 1/2" ANSI RF Flange / 3/4 "NPT (M)
04.	Material of construction	:	316 SS
05.	Insulation	:	PTFE Part/Full as per service.
06.	Enclosure	:	Powder/Epoxy coated Die cast Aluminium with neoprene gasket conforming to IP-65. (Explosion proof for NEC Class-1, Division 1 area).
07.	Ambient temperature	:	0-60 °C.
08.	Mounting	:	On Tap
09.	Supply voltage	:	(90-250) V AC, 50 Hz / 18-36 V DC
10.	Relay output	:	2 SPDT @ 0.5 A 220V DC / 5A 240V AC
11.	Response time	:	100 msec or better
12.	Cable connection	:	3/4" ET Compression gland
13.	Accessories	:	Counter flange, Cable gland, prefab cable and stainless steel name plate engraved with alpha-numeric.

G. Level Switch (Ultrasonic Type)

Ultrasonic type level switch, IP-65 protection; Switch with 2 nos. of SPDT contacts (1 NO and 1 NC) rated for 0.2 A, 220 V DC; Accuracy $\pm 0.25\%$; Resolution 1mm; Repeatability $\pm 0.1\%$; Linearity $\pm 1\%$; Response time 150ms; Beam angle $< 12^\circ$; Auto false echo-suppression; Accessories like integral cable between sensor and transmitter unit with connectors on both side, gasket and cable gland, digital panel meter, name plate & metal tag; the material of accessories will be SS.

H. Level Switch (Radar Type)

Radar type level switch, top mounted, IP-65 protection; Switch with 2 nos. of SPDT contacts (1 NO and 1 NC) rated for 0.2 A, 220 V DC, Accuracy $\pm 1\%$; Resolution 0.04"; Repeatability $\pm 0.04\%$; Linearity $\pm 0.01\%$; Beam angle $< 20^\circ$; Accessories like integral cable between sensor and transmitter unit with connectors on both side, gasket and cable gland, name plate & metal tag; the material of accessories will be SS.

I. Conductivity Type Electronic Level Indicator

01	Type	:	Conductivity discrimination.
02	No. of Probes	:	14, 16 or 32 as per application.
03	Probe Mounting	:	Screw type / Flanged – on standpipe.
04	Probe MOC	:	Stainless steel with high purity ceramic.
05	Probe rating	:	> Maximum design pressure of vessel.
06	Input	:	Independent channel with selectable switching threshold for water conductivity.
07	Relay Output	:	Four isolated output relays for Hi, Lo, Hi-Hi, Lo-Lo.
08	Contact type & rating	:	2 SPDT @ 0.5 A 220V DC / 5A 240V AC
09	Current output	:	Isolated 4-20 mA DC & HART
10	Local Display	:	Red, Green and flashing yellow LED's for steam, water and fault indication respectively.
11	Remote Display	:	Red, Green & flashing yellow LEDs for steam, Water & Fault indication respectively.
12	Power supply	:	Dual (90-250) V AC, 50 Hz, 1Ph.



13	Enclosure	:	i) IP-65, corrosion resistant & wall mounting type for local electronics.
		:	ii) IP-42 for remote indicator
14	Accessories	:	i) PTFE cable from probe to electronics
		:	ii) Mounting accessories.
		:	iii) Standpipe
		:	iv) Washer & gaskets
15	Test pressure	:	Two times design pressure
16.	Alarm levels	:	Probe number shall be selectable for HI, LO, HIHI, LOLO

J. Level Gauge (Float & Tape)

01.	Type	:	Float and Tape
02.	Float & Tape MOC	:	AISI 316
03.	Pulley material	:	Aluminium
04.	Guide wire	:	SS 316 Stainless steel
05.	Accuracy	:	+/- 2 mm
06.	Indication	:	On circular or vertical dial
07.	Rating	:	Twice the design pressure

K. Silo pilot

01.	Application	:	Solid material in Material bins, silos, etc.
02.	Power supply	:	(90-250) V AC, + 10%, 50 Hz selectable.
03.	Mounting	:	Top with ANSI RF Flange
04.	Protection class	:	IP-65.
05.	Ambient	:	65 °C (Max.) dust laden atmosphere
06.	Housing	:	Cast aluminum with sun Cover
07.	Measuring rope	:	Corrosion resistant steel
08.	Counting step	:	1 pulse/1-10cm depending on application
09.	Output from sensor	:	Change over contact
10.	Motor	:	1 phase

Electronics

01.	Type	:	Microprocessor based
02.	A/M Switch	:	Yes, in auto mode level measurement in regular interval as set in the instrument.
03.	Output	:	a) 4-20 mA DC (stored D/A) & if applicable HART protocol b) 2 nos. SPDT contacts
04.	No. of set points	:	2 nos.
05.	Min. counting pulse	:	20 mins.
06.	Mounting	:	Wall or 19" rack
07.	Enclosure	:	IP 65

III. FLOW INSTRUMENTS**1. Mass Flow Meter****A Sensor**

01.	Measuring Principle	:	Coriolis Mass flow.
02.	Primary Element	:	Flow Tube of 316SS or better (Suitable for the process fluid)
03.	Heating Arrangement	:	Integral with Flow Element.
04.	Temperature Control For Heating	:	To be provided.
05.	Process Connection	:	ANSI RF Flanged and rating as per process requirement.
06.	Drain	:	Self-draining facility



07. Accessories : Counter flanges, Mounting nuts, bolts, gaskets etc.

B Transmitter

01. Measured quantities : Mass Flow rate, Total Mass Flow, Density, Temperature as minimum.
02. Input Signal Processing : Digital Processing.
03. Display : Digital Display (LCD).
04. Output : 2 Nos. isolated output of 4-20mA DC selectable from four measured quantities.
05. Load : < 750 ohms.
06. Power supply : (90-250) V AC, 50 Hz.
07. Turn Down : 100:1
08. Accuracy : $\pm 0.2\%$ of measured value
09. Ambient Temperature : 85°
10. Repeatability : $\pm 0.05\%$
11. Housing : IP 65 (Explosion proof for NEC Class-1, Division 1 area)
12. Hazardous duty Version : FM Standards.
13. Nameplate : Tag number, service engraved in stainless steel tag plate
14. Accessories : a) As required for field mounting
b) Handheld configurator
c) Mounting U-bolts, nuts, bolts, prefab cable etc.
d) $\frac{3}{4}$ " ET cable gland

2. Turbine Flow Meter**A. Sensor**

01. Type : Turbine (in line full-bore, based on magnetic pick of pulses)
02. Output Signal : Pulse
03. Material of Construction : a) Body : AISI 316
b) Rotor: AISI 431 or 410
c) Bearings: Tungsten Carbide / Stellite Sleeve
04. Flow rate range : As required.
05. Linearity : $\pm 0.25\%$ or better.
06. Repeatability : $\pm 0.02\%$ or better.
07. Ambient temperature : 50°C
08. Mounting : On-Line mounting with ANSI RF flanges of stainless steel.
09. Enclosure : IP 65

B. Transmitter

01. Electronics : Solid State
02. Power Supply : (90-250) V AC, 50 Hz.
03. Input : Input from Sensor
04. Display : 4 1/2 digit LCD
05. Output : Isolated 4-20mA DC & HART
06. Measuring Accuracy : $\pm 0.5\%$ of full scale range
07. Totalized Value : Required
08. Housing : IP-65 (Explosion proof for NEC Class-1, Division 1 area)
09. Nameplate : Tag number, service engraved in stainless steel tag plate
10. Accessories : a) clamping strip, bracket, prefab cable etc.
b) Calibration or configurator kit.
c) $\frac{3}{4}$ " ET cable gland



3. Vortex Flow Meter

A. Sensor

01. Type	:	Vortex
02. Output Signal	:	Pulse
03. Material of Construction	:	AISI 316
04. Sensor Seal	:	PTFE / higher based on temperature
05. Flow range	:	As required.
06. Linearity	:	±0.25% or better.
07. Repeatability	:	± 0.1 of actual flow rate or better.
08. Ambient temperature	:	85 °C
09. Mounting	:	On-Line mounting with flanges of stainless steel.
10. Enclosure	:	IP 65
11. Accessories	:	Nuts, bolts, gaskets etc.

B. Transmitter

01. Electronics	:	Solid State
02. Power Supply	:	(90-250) V AC, 50 Hz.
03. Input	:	Input from Sensor
04. Display	:	4 ½ digit LCD
05. Output	:	Isolated 4-20mA DC & HART
06. Measuring Accuracy	:	± 0.025% of span
07. Totalized Value	:	Required
08. Housing	:	IP-65 (Explosion proof for NEC Class-1, Division 1 area)
09. Nameplate	:	Tag number, service engraved in stainless steel tag plate
10. Accessories	:	a) Clamping strip, bracket, prefab cable etc. b) Special tool kit for calibration / configuration. c) ¾" ET cable gland

4. Electro-Magnetic Flow Meter

A. Sensor

01. Measuring Principle	:	Faraday's law of Electro-magnetic induction.
02. Primary Element	:	Flow Tube of 316SS or better
03. Service	:	Conductive Liquids and Slurries
04. Sensor type	:	Insertion style / Wafer style
05. Process Connection	:	ANSI RF Flanged and rating as per process requirement.
06. Accessories	:	Counter flanges, Mounting nuts, bolts, gaskets etc.

B. Transmitter

01. Measured quantity	:	Volumetric Flow rate
02. Input Signal Processing	:	Digital Processing.
03. Display	:	Digital Display (LCD).
04. Output	:	Isolated output of 4-20mA DC & HART
05. Load	:	< 750 ohms.
06. Power supply	:	(90-250) V AC, 50 Hz.
07. Turn Down	:	100:1
08. Ambient Temperature	:	74 °C
09. Accuracy	:	± 0.25% of measured value
10. Repeatability	:	± 0.1% of Reading.
11. Housing	:	IP 65 (Explosion proof for NEC Class-1, Division 1 area)
12. Hazardous duty Version	:	FM Standards.



13. Nameplate : Tag number, service engraved in stainless steel tag plate
14. Accessories : a) As required for field mounting
e) Handheld configurator
f) Mounting U-bolts, nuts, bolts, prefab cable etc.
g) 3/4" ET cable gland

5. Ultra sonic type Flow Meter

Ultra sonic type flow elements shall be provided for measurement of CW flow.

- i) Ultrasonic Flow meter shall be dual path transit time clamp-on type.
- ii) The flow meters shall be of proven reliability, accuracy and repeatability requiring a minimum of maintenance. They shall comply with relevant international standards and shall be subject to approval.
- iii) All accessories required for mounting/erection of these instruments shall be furnished, erected and installed as necessary for completeness of the system though not specifically asked for. Also the equipment shall include necessary cables, flexible conduits, junction boxes required for the purpose.
- iv) Flow meters shall be provided with suitable environment protection devices/structures such that they shall be suitable for continuous operation in the operating environment of a coal fired utility station without any loss of function or departure from the specification requirements.

Type	Transit time Clamp On Ultrasonic meter
Mounting Style	Dual path with two sets of transducers on the same pipe
Flow measurement	Instantaneous Flow rate as well as totalized flow
Power supply	230 V AC
Outputs :	
Analog Current	Isolated 4-20mA linear outputs for each path
Binary	Contact relay outputs, 2 NO + 2 NC for alarm
Communication ports	RS 232 C digital Hand held terminal port
Display/Indication	Flow meter with LCD screen backlight based local display and keypad. If required, transmitter shall be suitably located away from the sensor for better access and visibility.
Recording / Totalizing /Logging Facilities	Yes. Should be able to compute cumulative flow over intervals selectable by owner i.e., daily, weekly, monthly etc. The data shall be stored in the memory of flow computer for access in future
Software features	Compensation for any cross path errors Programming, configuration, shall be possible from front panel.
Diagnostics	False signal tolerance , power supply failure etc
Protection class	IP-65 or better, Weather protection against direct sunlight, rain etc for Flow meter and suitable for Cooling water for Transducer
Accuracy	+/- 1%
Electrical connection	Plug and socket
Accessories	All mounting hardware required like clamping fixtures, mechanism to remove the transducers online, interconnecting cables etc All weather canopy for protection from direct sunlight and direct rain. Material of all fittings shall be SS316.

**6. Rotameter**

01. Type	:	On-line and by-pass
02. Metering tube	:	Borosilicate glass
03. Float	:	AISI 316-SS unless the process fluid demands some other material.
04. Packing material	:	Teflon
05. Body MOC	:	CS or SS as per fluid condition.
06. Scale	:	Graduated- Engraved black on white background.
07. Process connection	:	Flanged (RF) to line size as per ANSI standards.
08. Accuracy	:	± 2% of full scale detection or better for on-line type and ±4% of full-scale detection or better for by-pass type.
09. Nameplate	:	Tag number, service engraved in stainless steel tag plate
10. Accessories	:	Slip-on orifice plate of 316-SS and taps of CS / SS as per application requirements. Applicable CS / SS Isolation valves and SS Range Orifice - for bypass type rotameters.
11. Pressure Rating	:	As per application
12. Flow & Scale length	:	To be decided by Contractor.

7. Orifice Plate

01. Type	:	Ring joint / Flange type or other required type (To be decided by Contractor)
02. Material I	:	316 SS connection office
03. Application	:	Low fluid velocity flow measurement
04. Design Standard	:	BS-1042, Part-I
05. Number of Tapings	:	One additional pair of taps for performance test. (i.e. for control measurement, 3+1 pair of taps to be provided, for monitoring measurement, 2+1 pair of taps to be provided)
06. Diameter Ratio	:	Between 0.4 to 0.7
07. Accessories	:	Flanges, gaskets, nuts & bolts, root valves jack screw etc.

8. Flow Nozzle

	:	flow element shall have 3 pair of differential pressure tapping
01. Application	:	High fluid velocity flow measurement
02. Design Standard	:	ASME PTC 19.5
03. Number of Tapings	:	One additional pair of taps for performance evaluation (i.e. for control measurement, 3+1 pair of taps to be provided, for monitoring measurement, 2+1 pair of taps to be provided)
04. Diameter Ratio	:	Between 0.4 and 0.7
05. Accessories	:	Meter run pipe, nipples and root valves. (Inspection port assembly for nozzles used in plant performance purpose)

9. Sight Glass

01. Type	:	Flap-type
02. End connection	:	Screwed / Flanged
03. Material:		
a) Body	:	SS-304
b) Cover Plate	:	SS-304
c) Indicator	:	SS-316
04. Sight Glass	:	Toughened Borosilicate
05. Gasket	:	Neoprene
06. Bolts & Nuts	:	High tensile steel



- 07. Hydraulic Test Pressure : 1.5 times maximum working pressure
- 08. Accessories : As required

- 10. Gauge Glass** : flow element shall have 3 pair of differential pressure tapping
- 01. Type : Reflex
 - 02. Glass : Toughened borosilicate. Resistant to mechanical and thermal shocks.
 - 03. Body material : SS-304 / 316 / Carbon steel – As per process requirements (Flanged Connection)
 - 04. Pressure rating : Twice the maximum working pressure
 - 05. Temperature rating : 300 °C
 - 06. Bolts and nuts : Rust proof alloy steel
 - 07. Accessories : Suitable ball check valves of SS- 304/316 body, gaskets, companion flange etc.

11. Flow Switches

Indicating, Differential pressure, flapper type on line flow switches for line sizes up to 80 mm with an accuracy of +/-0.5% of span and dial size of min. 50 mm having 316 SS flapper/SS 316 bellows housed in die cast aluminium. Micro switch with adjustable range with 2 SPDT contacts rated for 0.2 A, 220 V DC. IP 65 or equivalent degree of protection for enclosure. The material of accessories shall be SS. Repeatability shall be +/-0.5% of span. Over range protection shall be 50% above maximum flow. Setting shall be tamper proof external adjustment & scale shall be provided for setting. Range spring & orifice plate shall be SS 316 for DP type. NPT for sizes below 2" & for sizes above 2" ANSI 150 RF shall be provided. Accessories like nameplate, mating flanges with gaskets, bolts & nuts, pipe assembly with orifice plate, etc. 5 way manifold, pipe, fittings (DP type), etc. shall be supplied

IV TEMPERATURE INSTRUMENTS

1. Thermocouples

- 01. Type : a) Type-T (Copper Constantan) or Type-K (Chromel Alumel) [As per specification requirement]
b) Duplex
c) Ungrounded
- 02. Wire gauge : 16 AWG
- 03. Standard : ANSI-MC 96.1.
- 04. Protecting Tube:-
 - i) O.D. : 8 mm (approx.)
 - ii) Material : 316-SS Seamless
 - iii) Filling : Magnesium Oxide (Purity above 99.4%)
- 05. Response time : a) Less than 2 to 6 seconds. .
b) Less than 10 seconds for control.
- 06. Head:
 - i) Type : IP-65 universal screwed type. (Explosion proof for NEC Class-1, Division 1 area)
 - ii) Material : Die cast aluminum or better
 - iii) Terminal blocks : Nickel plated Brass - screw type / silver plated
 - iv) Cable connection : 3/4" ET gland and grommet.
 - v) Others : Terminal head cover with SS chain and suitable gasket
- 07. Accessories : a) Adjustable nipple-union-nipple with thermowell connection



- b) Compression fittings/unions
- c) Flanges etc. (for flanged connections only)
- c) SS 316 forged thermowell as per ASME PTC code.
- 08. Nameplate : Tag number, service engraved in stainless steel tag plate
- 09. Static Pressure Limit : As per application.
- 10. Length : As per application
- 11. Limits of error @ 0 Deg Ref.: For K type + 1 Deg C or 0.4% (Greater Value)
For T type + 0.5 Deg C or 0.4% (Greater Value)

2. Resistance Temperature Detector

- 01. Type : Platinum (Duplex), ungrounded class 'A'
- 02. Resistance : 100 ohm at 0 °C
- 03. Base : Wound on ceramic (anti-inductive)
- 04. Wiring : 3 Wire
- 05. Protecting Tube :-
 - i) O.D. : 8 mm (approx).
 - ii) Material : SS-316, Seamless
 - iii) Filling : Magnesium oxide (Purity above 99.4%).
 - iv) Length : As per application
- 06. Response time : a) 1 to 2 seconds
- 07. Head:
 - i) Type : IP-65 universal screwed type. (Explosion proof for NEC Class-1, Division 1 area)
 - ii) Material : Die cast aluminum or better
 - iii) Terminal blocks : Nickel plated Brass-screw type / silver plated
 - iv) Cable connection : 3/4" ET gland and grommet.
 - v) Others : Terminal head cover with SS chain and suitable gasket
- 08. Accessories : a) Adjustable nipple-union-nipple with thermowell connection
b) Compression fittings/unions
c) Flanges etc. (for flanged connections only)
d) SS 316 forged thermowell as per ASME PTC code.
- 09. Nameplate : Tag number, service engraved in stainless steel tag plate
- 10. Standard : Standard DIN 43760
- 11. Limit of error : @ 0 Deg C ± 0.06 Ohm
@ 100 Deg C ± 0.13 Ohm
@ 200 Deg C ± 0.20 Ohm
@ 300 Deg C ± 0.27 Ohm

3. Field Mounted Temperature Transmitters

- 01. Working Principle : Smart
- 02. Type : Two wire
- 03. Input : Universal (T/C of different types, PT 100 RTD and other RTDs)
- 03. Output Signal : Simultaneous transmission of digital and 4-20 mA DC signal with HART.
- 04. Signal Processing Circuitry : Microprocessor based Solid State Electronic
- 05. Span and Zero : Adjustable in field, Non-interacting facility for elevation and suppression of zero.
- 06. Enclosure Class : IP-65 (Explosion proof for NEC Class-1, Division 1 area)
- 07. Output Indicator : LCD type



08.	Span Adjustability	:	Yes
09.	Nameplate	:	Tag number to be engraved on metallic tag plate rigidly fixed to the body.
10.	Body	:	Die Cast aluminum
11.	Operating Voltage	:	18-36 V DC
12.	Load	:	600 Ohms at 24V DC (Min.)
13.	Performance	:	
	i) Accuracy	:	0.2% of span
	ii) Repeatability	:	±0.05% of span
	iii) Cold Junction Compensation	:	Built-in
	iv) Calibration	:	As per N.I.S.T Monograph 125 for T/C and European Curve Alpha = 0.00385 for RTD
14.	Accessories	:	a) Universal mounting bracket suitable for pipe and surface mounting. b) Hi-tensile Carbon Steel U-bolts.

4. Thermo Well

Thermo wells Pipe/equipment mounted temperature test wells of 316 SS with a process connection of M33x2 thread or 150 RF flanged and instrument connection of 1/2" NPT (F) in general or 150 RF flanged.. Accessories like name plate, plug with chain, etc. shall be provided. Material of accessories shall be SS. Thermowell shall be hex head of barstock assembly. In case flanged wells are required for any specific application, the same shall be supplied as required. The thermo well construction shall meet the ANSI 19.3 (latest) requirements. Thermo well shall be designed such that the resonant frequency is above the exciting frequencies generated by vortex shedding in the process fluid. All Test thermo well shall have the plug of SS316.

For measurement of pulveriser outlet temperature tungsten carbide block thermowells abrasion resistant not tungsten carbide coated thermowell shall be used. Also the terminals of Thermocouple shall not be at the top of Mills itself. The thermocouple wires are to be laid up to JB through SS tubing of required diameter and the head shall be placed nearer to the JB. Compensating cable exposed to atmosphere in the conventional method melts away due to high temperature at the top of Mill.

For measurement of sea water temperature SS with titanium sleeve thermo wells or better, shall be used.

5. Temperature Switch

01.	Type	:	Mercury filled-in
02.	Sensing Element Material	:	Bellow / Bourdon AISI SS-316
03.	Bulb Material	:	AISI SS-316
04.	Capillary	:	Stainless steel armored
05.	Movement Material	:	AISI SS-304
06.	Case material	:	Epoxy coated steel plate or die-cast aluminum alloy with neoprene gasket and clear glass where applicable cover conforming to IP-65. (Explosion proof for NEC Class-1, Division 1 area).
07.	Scale	:	Black lettering on white background
08.	Over range Protection	:	120 %
09.	Instrument connection	:	Bottom
10.	Switch configuration	:	Two SPDT
- Lead wires (3+3 Nos.) are to be brought externally to the male connector wherein the female pug connector will be inserted to connect the control room cables for easy removal & re - calibration



11.	Switch rating	:	240V, 5A AC/220V, 0.5A DC
12.	Switch type	:	Snap acting, shock and vibration-proof.
13.	Adjustability	:	a) Internal Set point adjustable over span range b) Differential adjustable by 10% of span (minimum)
14.	Cable connection	:	3/4" ET compression gland.
15.	Compensation	:	a) Capillary compensation with invar wire throughout the capillary length. b) Case compensation
16.	Performance:		
	i) Scale Accuracy	:	±1.0 % of full scale
	ii) Repeatability	:	< 0.5 % of full range
	iii) Response time	:	Less than 40 seconds with thermowell
17.	Capillary length	:	5 meters (minimum) for local mounting/15 meters for local panel mounting.
18.	Nameplate	:	Tag number, service engraved in stainless steel tag plate
19.	Accessories	:	Mounting accessories, 3/4"ET cable gland

6. Temperature Gauge

01.	Type	:	Mercury filled-in remote mounting system Capillary armoured / rigid system type (backward entry / bottom entry)
02.	Sensing Element Material	:	Bourdon - AISI-316 SS
03.	Capillary Armoring	:	Stainless steel flexible
04.	Movement Material	:	AISI 304 SS / Direct Bourdon tip connection to pointer spindle
05.	Bulb Diameter and Length	:	As required
06.	Bulb Material	:	AISI 316
07.	Capillary	:	Stainless Steel
08.	Thermometer	:	M 20 x 1.5 Male adjustable gland on stem to suit associated Thermowell
09.	Case Material	:	Stainless steel bayonet type with clear glass cover conforming to IP-65.
10.	Dial Size	:	150 mm in general (100 mm for SWAS gauges)
11.	Scale	:	Black lettering on white background in 270 Deg. arc.
12.	Mounting	:	Surface/Panel
13.	Over range Protection	:	125 % of range or more
14.	Instrument connection	:	Bottom connection for local mounting and back connection for panel mounting.
15.	Range	:	50% ~ 70% range of operating temperature of application approximately.
16.	Compensation	:	Case compensation
17.	Zero adjuster	:	Micrometer screw adjustable from front.
18.	Window	:	Shatterproof toughened glass.
19.	Performance	:	Accuracy of ± 1 % of full-scale deflection or better.
20.	Enclosure Class	:	IP-65
21.	Capillary	:	5 meters (local)/15.0 meters (local panel) - armored stainless steel
22.	Preferred Feature	:	Capillary Compensation
23.	Accessories	:	a) Forged SS 316 thermowell weldable or screwed as per ASME PTC code b) Installation accessories as required.
24.	Nameplate	:	Tag number, service engraved in stainless steel tag plate
25.	Immersion length	:	Adjustable up to 300 mm including bulb length or as per application

**F. ANALYSERS****I. GAS ANALYZER****1. Opacity Monitor**

01.	Type	:	Insitu dry visible light (through LED)
02.	Principle of measurement	:	Transmission & absorption (Dual beam type)
03.	Light source	:	Modulated high intensity LED
04.	Display	:	4½" digital display back Lit LCD
05.	Measurement range	:	0-999 mg/m ³ , 0-999 mg/Nm ³ , 0-100% opacity
06.	Measurement averaging	:	Selectable 10 sec to 60 minutes
07.	Accuracy	:	2%
08.	Resolution	:	1% of opacity
09.	Linearity	:	1%
10.	Repeatability	:	1%
11.	Flue gas temperature	:	350 °F (max 600 °F)
12.	Ambient temperature	:	0 - 60 °C
13.	Operating temperature	:	Transmitter & receiver- 0-90°C, Electronic unit - 70°C
14.	Mounting	:	Transceiver on opposite side of the duct
15.	Analog output	:	4-20mA DC with HART (in 500 Ω) to DCS
16.	Alarm output	:	2 SPDT potential free contacts rated at 5A 230V AC / 0.5 A 220 V DC Alarm set points programmable through keyboard
17.	Power Supply	:	(90-250) V AC, 50 Hz, 1 Phase
18.	Automatic misalignment Detection	:	Required
19.	Automatic compensation of lens contamination	:	Required
20.	Purge air Failure	:	Purge air to be provided from instrument / service air and to be monitored for failure.
21.	Span and Zero Check	:	Automatic periodic with manual override
22.	Housing	:	Corrosion resistant epoxy painted Aluminium rated at IP-65.
23.	Fail safe shutter	:	Automatic fail safe shutter against power and air failure
24.	Input normalization	:	Correction for temperature, pressure, oxygen and water vapour. Correction for sunlight variations
25.	Preferred Features	:	Power supply on LED visible from front
26.	Accessories	:	a) Mounting pads suitable for mounting projector and receiver units on duct flanges, etc. b) Phenolic nameplate c) Tubing & fittings to connect to Boiler side service air header available at '0'm. d) Computer interface with RS 485 port is required.
27.	Diagnostics	:	Faulty sensor, Purge air failure, ADC failure, low intensity levels etc.
28.	Process connection	:	Flange
29.	Conversion of light unit Weight to unit mg / Nm ³	:	Iso kinetic samplings shall be taken for arriving conversion equation

**2. SO_x, NO_x, CO, CO₂ & Moisture Analyzer**

01.	Type	:	Insitu Probe type combined analyzer
02.	Gases to be measured	:	SO _x , NO _x , CO, CO ₂ and Moisture
03.	Principle of measurement	:	Infrared absorption
04.	Flue gas Temperature	:	350 ° F
05.	Ambient temperature	:	60 ° C
06.	Mounting	:	On duct
07.	Measurement range	:	0-3000 ppm fully selectable for each gas
08.	Units of measurement	:	PPM, mg / m ³ and mg / Nm ³
09.	Power Supply	:	(90-250) V, 50 Hz, 1 Phase
10.	Display	:	4½" digital display back Lit LCD
11.	Measurement of averaging	:	10 sec to 60minutes
12.	Accuracy	:	± 2% of measurement or 5 ppm whichever is greater or better.
13.	Repeatability	:	1% of full scale
14.	Response time	:	30 seconds or better for 90% of full scale
15.	zero & Span drift	:	Less than 2 ppm in 24 hours
16.	Calibration	:	Zero and Span calibration in manual and automatic mode. Auto calibration unit shall be supplied so as to take care of each gas calibration. Automatic calibration interval shall be fully selectable.
17.	Analog output	:	4-20 mA DC (in 500 Ω) to DCS for each channel with HART
18.	Alarm output	:	2 SPDT potential free contacts rated at 5A 230V AC / 0.5 A 220 V DC Alarm set points programmable through keyboard
19.	Input normalization	:	Required—online [With pressure and temperature sensor] and also provision for key pad entry of inputs
20.	Probe material	:	Stainless Steel 316L
21.	Enclosure	:	Corrosion resistant epoxy coated Aluminium housing rated to IP-65 for Transceiver and control unit.
22.	Accessories	:	a) All tubing & fittings for connecting gas cylinders and auto units b) Calibration gas "Zero and Span" cylinders for SO ₂ , NO _x CO ₂ and CO filled in 10 Ltrs. Of WC carbon cylinder with necessary SS regulator, SS gauges, SS tubings and SS fittings etc. as required. c) Mounting flanges, gasket etc. d) All tubing's and fittings to connect to Boiler side instrument / service air header available at '0'm for purging. e) Cylinder ownership certificates, pressure test and explosion proof certificates to be given for refilling the gases by owner for future calibration. f) Any optical filter windows if available to be placed in optical path for checking zero and span gas values.



3. Oxygen Analyzer

01. Type	:	In-situ, Zirconium sensor, micro-processor-based transmitter, field repairable to measure % O ₂ in flue gas from boiler. Electronic units & Probe shall be separate. Head mounted electronic type is not to be supplied.
02. Range	:	0.1-10% / 0.25-25% by volume
03. Output	:	Simultaneous transmission of digital & 4-20 mA DC linear / Isolated for the range assigned HART protocol.
04. Probe Length	:	1800mm (approximate depending on duct size)
05. Process Temperature	:	850 ° F approx. / as per application
06. Measurement Reference	:	Instrument Air
07. Accuracy	:	± 1% of F.S. or better
08. Response Time	:	Less than 5 (five) seconds
09. Amplifier Housing	:	IP-65
10. Calibration	:	Automatic periodic
11. Calibration Frequency	:	Once every 24 hours
12. Power Supply	:	(90-250) V, 50 Hz, 1 Phase
13. Material for Gas Carrying Components	:	Stainless Steel
14. Read Out	:	Local indicating Meter
15. Protection	:	Automatic cell protection against reducing atmosphere
16. Alarm Facility	:	1 - HI and 1 - LO independently adjustable over span through keypad. Contact rating 5A at 230V AC / 0.5A 220 V DC (minimum). Potential free SPDT contacts for two alarm levels. Set points programmable through keyboard
17. Preferred Features	:	a) HI and LO alarm LED visible from front. b) Power Supply On/Failure LED visible from front c) Display for faulty sensor
18. Accessories	:	a) Mounting flanges, adaptor plate and protection shield b) Gasket, nuts and bolts c) Cable with conduit from cell to amplifier (as required) and other special cables (if any) d) Automatic calibration kit (complete with all accessories and standard Gas Cylinders) zero and span. For mid range value i.e 6% of O ₂ with 94% of N ₂ Standard gas cylinders to be supplied for each analyser in addition to zero and span gas cylinders e) All tubings and fittings for connecting calibration gas cylinders and auto units. f) All tubings and fittings to connect to Boiler side instrument / Service air header available at '0' m for purging. g) Cylinder ownership certificates, pressure test and explosion proof certificates to be given for refilling the gases by owner for future calibration.
19. Load resistance	:	500 ohms or more
20. Sensor heater control	:	



- Circuit if required : To be provided with thermocouple fixed nearer to the sensor for feedback of heater temperature to be furnished.
21. Display : 3½" or more, seven segment backlit LCD.
22. Parameters to be displayed : % O₂, Cell temperature, cell mV, Alarm set points and alarms.
23. Analyzer Electronics Mounting : Wall mounting
24. Environmental Protection : IP – 65 or better
25. Zirconia cell protection at the end of probe : Stainless steel diffuser assembly to be provided or better.
26. Probe protection : SS shrouding with adequate required thickness to be provided to safeguard the probe from erosion of flue gas.
27. Calibration facility : Auto / manual calibration for behaviour of Zirconia sensor or periodical basis to be made available. Zero span gas cylinders required for calibration and all necessary accessories shall be indicated.
28. Configuration : shall be possible from the converter itself. If separate HART communicator is essentially required for configuration, 1 no. HART communication shall also be supplied common for all analyzers.

4. Co & Moisture Analyzer

01. Type : Insitu Probe type combined analyzer
02. Gases to be measured : CO, and Moisture
03. Principle of measurement : Infrared absorption
04. Flue gas Temperature : 140 Deg C / 300 Deg C 850 ° F
05. Ambient temperature : 60 ° C
06. Mounting : Across duct. Transmitter and receiver using flange
07. Measurement range : 0-6000 ppm fully selectable
08. Units of measurement : PPM, mg / m³ and mg / Nm³
09. Power Supply : (90-250) V, 50 Hz, 1 Phase
10. Display : Back lit LCD
11. Measurement of averaging : 10 sec to 60minutes
12. Accuracy : ± 2% of measurement or 5 ppm whichever is greater or better
13. Repeatability : 1% of full scale
14. Response time : 30 seconds or better for 90% of full scale
15. Zero & Span drift : Less than 2 ppm in 24 hours
16. Calibration : Zero and Span calibration in manual and automatic mode. Automatic calibration interval shall be fully selectable.
17. Analog output : 4-20 mA DC (in 500 ohm resistor) to DCS for each channel with HART
18. Alarm output : 2 SPDT potential free contacts rated at 5A 230V AC / 0.5 A 220 V DC Alarm set points programmable through keyboard
19. Input normalization : Required—online [With pressure and temperature sensor] and also provision for key pad entry of inputs
20. Probe material : Stainless Steel 316L
21. Enclosure : Corrosion resistant epoxy coated Aluminium housing rated to IP-65 for Transceiver and control unit.



22. Accessories :
- a) All tubing & fittings for connecting calibration gas cylinders and auto units.
 - b) Calibration gas “zero and span” cylinders for NO_x and CO filled in 10 Ltrs. of WC carbon cylinders with necessary SS regulator, SS gauges, SS tubings and SS fittings etc. as required.
 - c) Mounting flanges, gasket etc.
 - d) All tubing's and fittings to connect to Boiler side instrument / service air header available at '0'm for purging.
 - e) Cylinder ownership certificates, pressure test and explosion proof certificates to be given for refilling the gases by owner for future calibration.
 - f) Any optical filter windows if available to be placed in optical path for checking zero and span gas values.
 - g) Auto calibration unit
 - h) Check cell with known CO composition of two different values 500 ppm and 1000 ppm to be supplied with each analyser for validation.

5. H2 + Co2 Analyzer

- 01. Type : Thermal Conductivity or Multimode oscillation
- 02. Range Selection : Minimum 2 Nos.
- 03. Typical range : As required
- 04. Output : 4-20mA DC (Isolated) & HART
- 05. Operating ambient temp. : 10 ° C to 50 Deg. C
- 06. Power Supply : (90-250) V, 50 Hz, 1 Phase
- 07. Sample gas flow control : Required
- 08. Reference gas flow : Required
- 09. Reference gas pressure regulator : Required
- 10. Cell response : 95% of change in 30 Sec.(Appox.)
- 11. Accuracy : 2% of full scale
- 12. Repeatability : 1% of full scale
- 13. Local Indicator : Indicating meter of 1% accuracy
- 14. Alarm facility : Dual (High & Low) independently adjustable.
- 15. Contact rating : 0.5A at 220 V AC
- 16. Enclosure : Flame Proof
- 17. Accessories : Calibration gas, mounting accessories and others as required to be provided
- 18. Linearity : + or – 1% FS

II. STEAM AND WATER ANALYZERS (SWAS)

All Analyzers shall be of microprocessor based design. The general technical specification of the analyzers is provided in this section. Contractor in his offer shall indicate the sample flow requirement of each analyzer and the total quantity of cooling water required for the system.

1. Conductivity Analyzer

A. SENSOR

- 01. Type of Cell : Flow through type /removable (Mith drawable with sealing value)
- 02. Conductivity Range : 0-1 µs/cm to 0-10,000 µs/cm



03. Cell Constant : Range programmable for the application.
04. Temperature : 0.01 / 0.1 / 1.0 depending upon range
Compensation : Manual and Automatic (Integral) upto 0-120°C with PT-100 Sensor
05. Process Connection : Screwed
06. Wetted Parts : Electrodes ... HASTALLOY
Insulators ... KYNAR & VITON
07. Pressure Rating : 10 kg/cm²
08. Accessories : Tee / Vessel (PVC or HASTALLOY)
09. Cable : Upto transmitter in flexible conduct
10. Sizes for sample inlet port, Sample outlet port, Cell port : To be furnished by the Contractor.
11. Special construction : Cell working in vacuum applications like Hot Well requires special type.
- B. TRANSMITTER**
01. Type : Microprocessor based & Smart
02. Mounting : Flush Panel
03. Protection Class : IP-65 or better
04. Output : Simultaneous transmission of digital and 4-20 mA DC (isolated) , HART protocol for configuration and diagnosis
05. Display : i) 4½" Digit LCD display or process variable in Engineering unit, Temperature, Alarm status, Units of measurements etc.
ii) Character Height 18 mm
06. Zero / Span Adjustment : Front Panel Membrane type Keyboard.
07. Temperature Compensation : Manual or Automatic - selectable through keyboard
08. Diagnostic : Self diagnostic programme for electronics, measuring electrode, open wiring etc.
09. Alarm : Dual alarm set point, hysteresis and time delay adjustable on membrane keyboard.
2Nos. SPDT potential free contacts rated 5A 240V AC / 0.5A 220V DC
Set point programmable through keyboard
10. Enclosure : Polypropylene , Weather proof corrosion resistant NEMA 4X
11. Cable Termination : Internal (cable entry through conduit)
12. Accuracy : ± 0.25% of measured range
13. Repeatability : ± 0.5% output range
14. Stability : ± 0.5% of output range / month non-cumulative
15. Power Supply : (90-250) V, 50 Hz, 1 Phase
16. Operating Temp. : 0 - 50°C
17. Accessories : a) For cation conductivity analyzer Dual Ion-Exchange column, resin, etc. (minimum 12 months requirements).
b) Phenolic Nameplate
c) Ammonia removal equipment
d) Automatic temperature comparative in the range of 010 to 100 °C
e) Sample coolers
f) Portable test Kit.
18. Load : 500 ohms or more at 24V DC
19. Software security lock for programming the : To be provided



20. Analyzer : To be indicated in LCD display for correction
21. Instrument : Through HART configuration and through the
Configuration : keyboard.

2. PH Analyser

A. SENSOR

01. Type of Cell : Flow through type and maintenance free
02. Process Connection : Screwed
03. Type of measurement : General purpose
04. Temperature : Automatic (Integral) upto 0-120°C with PT-100
Compensation : Sensor
05. Preamplifier : Integrated not be separate
06. Range : 0-14 pH
07. Measuring Electrode : Cartridge type
and Liquid Junction
08. Pressure Rating : 10 kg/cm²
09. Accessories : Tee / Vessel (PVC or HASTALLOY)
10. Cable : Upto transmitter in flexible conduct

B. TRANSMITTER

01. Type : Microprocessor based & Smart
02. Mounting : Flush Panel
03. Protection Class : IP – 65 or better
04. Output : Simultaneous transmission of digital and 4-20 mA DC
(isolated) , HART protocol for recorder for
configuration and diagnosis
05. Display : i) 3½" Digit LCD display of process variable in
Engineering unit, Temperature, Alarm status,
Units of measurements etc.
ii) Character Height 18 mm
06. Calibration : Two-point calibration with standard buffer
solutions.
07. Temperature : Manual or Automatic - selectable through
Compensation : keyboard
08. Diagnostic : Self diagnostic for "Calibration required"/
"Calibration O.K.", electrode checking etc.
09. Alarm : Dual alarm set point, hysteresis and time delay
adjustable on membrane keyboard.
2Nos. SPDT potential free contacts rated 5A
240V AC / 0.5A 220V DC
Set point programmable through keyboard
10. Enclosure : Polypropylene , Weather proof corrosion resistant
NEMA 4X
11. Cable Termination : Internal (cable entry through conduit)
12. Accuracy : ± 0.02 pH or better
13. Repeatability : ± 0.1% or better
14. Response Time : 7 seconds for FSD or better
15. Stability : ± 0.01 pH/month/non-cumulative
16. Power Supply : 240 V AC, 50 Hz
17. Operating Temp. : 0 - 50°C
18. Accessories : a) Ultrasonic Electrode Cleaner.
b) Phenolic nameplate giving tag number,
service, etc.



- c) Pre-amplifier, special cable, ultrasonic cleaner, etc.
- d) Buffer tablets.
- 19. Load : 500 ohms or more at 24V DC
- 20. Software security lock for programming the Analyzer : To be provided
- 21. Error code : To be indicated in LCD display for correction
- 22. Instrument Configuration : Through HART configuration and through the keyboard.

3. Silica Analyzer

- 01. Type : Colorimetric monitor, gravity / pumped feed Microprocessor based (With auto request shut of feature case of sample loss or power loss built in phosphate inhibit feature).
- 02. Operating range : 0-50/500/5000µg/liter (field adjustable).
- 03. Output : Simultaneous transmission of digital and 4-20 mA DC (isolated), with load 500 ohms & HART for for configuration and diagnosis
- 04. Display : 5½" Digit LCD display of process variable in engineering unit
- 05. Accuracy : ± 1 % of span
- 06. Repeatability : ± 2% of F.S.D. or better
- 06A sensitivity : 0.2 Micrograms /litre
- 07. Calibration : Manual & automatic
- 08. Operating ambient Temperature : 0-50 °C
- 09. Ambient humidity : Up to 95% relative humidity
- 10. Mounting : Flush panel
- 11. Life of light source : 10,000 hours (min.)
- 12. Power supply : (90-250) V, 50 Hz, 1 Phase
- 13. Alarm Facility : 2 SPDT potential free contacts rated 5 A 230V AC / 0.5A 220V DC. Alarm set points independently programmable through keypad.
(Snap action micro switch)
- 14. Alarm for :
 - a) Monitor mal-function
 - b) Monitor on standby
 - c) Monitor auto-zeroing
 - d) Concentration high
 - e) Loss of sample
 - f) Concentration low
 - g) Loss of reagent
- 15. Preferred features :
 - a) HI and LO alarm in LCD display.
 - b) Power supply on/failure LED visible from front.
 - d) 3 channel instrument is preferred. Auto sampling facility with necessary valves & solenoids in the sample lines shall be provided
- 16. Accessories :
 - a) Reagent cabinet
 - b) Sample strainer
 - c) Solenoid valves, pressure gauges
 - d) Phenolic name plate
 - e) Reagents & consumables



- f) Special cables upto transmitter with flexible conduit if required
- g) Chilling plant
- h) Automatic temperature compensation between 5 Deg C to 50 Deg C
- i) Sample rate set values
- j) RF/EMI shielded weather and corrosion proof case
- k) Others as required
- 17. Minimum detection limit : less than 0.5 micro g/l
- 18. Cycle response time : 10 minutes.
- 19. Construction : Reagent bottles processor, sample testing bench on a compact cabinet
- 20. Reagent consumption : To be specified by the Contractor.
- 21. Cycle time : Twelve (12) minutes or better

4. Sodium Analyzer Assembly

- 01. Type of Cell : Continuous Flow Through Sample type with sodium responsive type electrode and reference electrode have P4 adjustment facility
- 02. Flow Chamber : Plexi Glass Body or equivalent
- 03. Operating Range : 0.05 - 1.0 ppm
- 04. Measuring Electrode : Sodium Selective Glass Electrode
- 05. Output : 4-20 mA DC (isolated) into 600Ω & HART for recorded and DCS
- 06. Temperature Compensation : Automatic upto 60 deg.C
- 07. Read Out : Digital Indicating meter
- 08. Accuracy : ± 5% full scale
- 09. Response Time : 2 minutes or better
- 10. Sensitivity : 0.1 PPB
- 11. Operating Ambient Temperature : 0 - 50 °C
- 12. Ambient Humidity : Up to 95% relative humidity
- 13. Mounting : Flush Panel
- 14. Calibration : Manual through Zeroing solution
- 15. Power Supply : (90-250) V, 50 Hz, 1 Phase
- 16. Alarm Facility : 2 HI and 2 LO independently adjustable over span.
2 SPDT snap action micro switch 5A 240 AC, 0.2 A 220 VDC
- 17. Accessories (Preassembled, pre-wired and pre-tubed in enclosure) :
 - i) Phenolic tag plate etc.
 - ii) Sample filter.
 - iii) Pressure regulator & flow meter
 - iv) Automatic calibration kit
 - v) Reagents and consumables
 - vi) Special cables upto transmitter with flexible conduit
 - vii) Flow regulator
 - viii) Sample rate set values

5. Phosphate Analyzer Assembly

- 01. Type of Cell : Flow Through
- 02. Flow Chamber : Plexi Glass Body or equivalent
- 03. Operating Range : 0.1 – 10/20/50 Selectable manually
- 04. Measurement Principle : Colorimetric Detection system (Microprocessor based)



- 05. Output : 4-20 mA DC linear & HART
- 06. Temperature : Automatic
- 07. Read Out : Digital Indicating meter
- 08. Accuracy : $\pm 4\%$ of FSD
- 09. Response Time : 3 minutes or better
- 10. Operating Ambient Temperature : 0 - 50 °C
- 11. Ambient Humidity : Up to 95% relative humidity
- 12. Mounting : Flush Panel
- 13. Calibration : Manual through Zeroing solution
- 14. Power Supply : (90-250) V, 50 Hz, 1 Phase
- 15. Alarm Facility : 2 HI and 2 LO independently adjustable over span.
- 16. Accessories :
 - i) Phenolic tag plate etc.
 - ii) Sample filter.
 - iii) Pressure regulator & flow meter
 - iv) Automatic calibration kit
 - v) Reagents and consumables

6. Hydrazine Analyzer

- 01. Type : Electrochemical(Microprocessor based)
- 02. Operating Range : 0-50, 0-100, 0-200 ppb
- 03. Output : Simultaneous transmission of digital and 4-20 mA DC (isolated) HART protocol. For recorded and DCS
- 04. Display : 4½" Digit LCD display or process variable in Engineering unit, Temperature, Alarm status, Units of measurements etc.
- 05. Accuracy : $\pm 4\%$ of FSD or better
- 06. Reproducibility : 2% of FSD or better
- 07. Drift : 2 ppb/month or better
- 08. Temperature Compensation : Automatic up to 120°C
- 09. Operating Ambient Temperature : 0-50°C (maximum)
- 10. Response Time : 2 minutes or better
- 11. Mounting : Flush Panel
- 12. Pressure Rating : 5 Kg/Sq. cm
- 13. Power Supply : (90-250) V, 50 Hz, 1 Phase
- 14. Alarm Facility : 2 HI and 2 LO independently adjustable over span. (2 SPDT –Snap action micro switch) 5A 240 AC, 0.2A for 220 V DC)
- 15. Preferred Feature :
 - i) 2 Hi and LO alarm LED visible from front
 - ii) Power supply on/failure LED visible from front
- 16. Accessories :
 - i) Flow regulator
 - ii) Sample rate set value
 - iii) Phenolic nameplate etc.
- 17. Load : 500 ohms or more at 24V DC
- 18. Software Security locks for Programming the analyzer : To be provided
- 19. Error code : To be indicated in LCD display for correction
- 20. Instrument Configuration : Through HART configuration and through the keyboard
- 21. Enclosure : IP – 65

**7. Dissolved Oxygen Analyzer**

01. Type	:	Electro-chemical, Microprocessor based.
02. Range	:	0-0.1, 0-1.0, 0-10.0 ppb manually selectable range
03. Type of Cell	:	Flow through sampling type (continuous)
04. Enclosure	:	IP-65 or better
05. Output	:	Simultaneous transmission of digital and 4-20 mA DC (isolated) HART protocol for recorder and DCS
06. Temperature Compensation	:	Automatic up to 65°C temperature of Chiller unit output shall be suitable to this sensor.
07. Ambient Temp.	:	50 °C
08. Display	:	4½" Digit LCD display or process variable in Engineering unit, Temperature, Alarm status, Units of measurements etc.
09. Mounting	:	Flush panel
12. Readable Distance	:	3 meters (minimum)
13. Power Supply	:	(90-250) V, 50 Hz, 1 Phase
14. Sample	:	Flow rate approx. 500 ml/minute
15. Alarm Facility	:	Dual alarm set point adjustable on membrane keyboard. 2 Nos. SPDT potential free contacts rated 5A, 240 V AC / 0.5A, 220 V DC.
16. Preferred Feature	:	a) HI & LO Alarm LED visible from front. b) Power supply on/failure LED visible from front. c) In-built calibration facility.
17. Accessories	:	a) Phenolic nameplate giving tag no., service etc. b) Reagent Cabinet (if applicable) c) Reagent Reservoir (if applicable) d) Flow Stability e) Automatic temperature compensation f) Sample cooler assembly with shut off valve at cooling water inlet with thermometer and reduction valve at sample cooler g) Other as per requirement including piping etc.
18. Accuracy	:	± 1% of full scale or better
19. Repeatability	:	± 0.1% of full scale or better
20. Stability Zero & Span	:	± 1% of full scale per month or better
21. Sensor response time	:	90% in 15 secs or better
22. Load	:	500 ohms or more at 24V DC
23. Software Security locks for Programming the analyzer	:	To be provided
24. Error code	:	To be indicated in LCD display for correction
25. Instrument Configuration	:	Through HART configuration and through the keyboard

8. Ammonia Analyzer Assembly

01. Type of Cell	:	Flow Through ion-selection Electrode
02. Operating Range	:	Contractor to specify (ppm) 7 rerangeable
03. Measuring Electrode	:	Ammonia ion-Selective probe
04. Output	:	4-20 mA DC (isolated) into 600Ω & HART for recorder and DCS
05. Repeatability	:	± 2% of reading
06. Read Out	:	Digital Indicating meter
07. Accuracy	:	± 5% of reading or better



- 08. Response Time : less than 5 minutes
- 09. Operating Ambient Temperature : 0 - 50 °C
- 10. Ambient Humidity : Up to 95% relative humidity
- 11. Mounting : Panel
- 12. Calibration : Fully automatic two point, plus Manual initiation on demand
- 13. Power Supply : (90-250) V, 50 Hz, 1 Phase
- 14. Alarm Facility : 2 HI and 2 LO independently adjustable over span. (ZSPDT micro switch)
- 15. Accessories :
 - i) Phenolic tag plate etc.
 - ii) Sample conditioning system & filter.
 - iii) Pressure regulator & flow meter
 - iv) Automatic calibration kit
 - v) Reagents and consumables
 - vi) Special cables upto transmitter with flexible conduit
 - vii) Others as required

9. Chloride Analyser

- i. Type : Continuous flow through sample type-
Microprocessor based
- ii. Analyser power supply : 240V AC, 50 Hz
- iii. Analyser output :
 - a) 4-20mA DC spare output.
 - b) 4-20mA DC isolated output for DCS.
- iv. Accuracy : Better than + 5 microgram/litre of full scale.
- v. Sensitivity : 0.1 ppm.
- vi. Range : Contractor to specify for process requirement & rerangable.
- vi. Annunciation contacts:.
 - a) Number : 2 SPDT
 - b) Type : Snap action micro switch.
 - c) Rating : 5A, 240V, AC, 0.2A, 220V DC.
 - d) Mounting : Flush.
- vii. Terminal points : All component piped & wired.
- viii. Accessories :
 - a) Flow regulator.
 - b) Flow gauges.
 - c) Sample rate set valves.
 - d) Other accessories as required to make the system complete

G. ELECTRICAL SYSTEMS METERS AND ACCESSORIES

A. Push Button

- 01. Type : Shrouded square format
- 02. Face Dimension : 32 x 32 mm (maximum)
- 03. Contact Configuration : 2 NO + 2 NC
- 04. Contact Addition : Add-on block up to 4 each with 2 pairs of contacts
- 05. Contact Material : Hard Silver Alloy
- 06. Contact Rating : 500V / 10 A



07.	Utilization Category	:	AC11 / DC11
08.	Insulation Voltage	:	2 KV for 1 minute between terminals and earth
09.	Mechanical Life	:	1 million operations
10.	Construction	:	Aluminum shrouding with plastic lens
11.	Colors	:	Red, Green, Yellow, Black, etc.
12.	Connection	:	Screw terminals
13.	Enclosure Class	:	IP-52
14.	Legend	:	Engraving

B. Illuminated Push Button

01.	Type	:	Square format
02.	Face Dimension	:	32 x 32 mm (maximum)
03.	Contact Configuration	:	2 NO + 2 NC (minimum)
04.	Contact Addition	:	Add-on-Block up to 4 each with 2 pairs of contacts
05.	Contact Material	:	Hard Silver Alloy
06.	Contact Rating	:	500 V/ 10A
07.	Utilization Category	:	A C11 / DC11
08.	Insulation Voltage	:	2 KV for 1 minute between terminals and earth
09.	Mechanical Life	:	1 Million Operations
10.	Lamp	:	LED with built-in resistors as required
11.	Lamp Rating:-		
	a) Voltage	:	240 V AC
	b) Watt	:	2 Watt (approx.)
12.	Lamp and Lens Replacement	:	From front
13.	Construction	:	Transparent Plastic Lens
14.	Color	:	Red, Green, Amber, Yellow etc.
15.	Connection	:	Screw terminals
16.	Enclosure Class	:	IP-52
17.	Legend	:	Engraving

C. Selector Switch

01.	Type	:	2/3/4 position stay put type with rotary lever actuator.
02.	Face Dimension	:	32 x 32 mm (maximum)
03.	Contact Configuration	:	4 pair of contacts
04.	Contact Addition	:	Add-on-Block up to 4 each with 2 pairs of contact
05.	Contact Material	:	Hard silver Alloy
06.	Contact Rating	:	500 V / 10 A
07.	Utilization Category	:	AC11 / DC11
08.	Insulation Voltage	:	2 KV for 1 minute between terminals and earth
09.	Mechanical Life	:	1 million operation
10.	Construction	:	Aluminum shrouding
11.	Connection	:	Screw terminals
12.	Enclosure Class	:	IP-52

D. Indicating Lamp

01.	Type	:	LED with built-in resistor (LED must not glow if the voltage is less than 180 V)
02.	Face Dimension	:	32 x 32 mm (maximum)
03.	Voltage	:	230 V, 50 Hz, 1 Phase
04.	Watt	:	2.5 Watt (approximate)
05.	Lamp and Lens Replacement	:	From front
06.	Construction	:	Transparent Plastic lens
07.	Color	:	Red, Green, Amber, Yellow etc.
08.	Connection	:	Screw terminals



09. Legend : Engraving

E. Indicating Meters (A.C)

01. Type : Rectifier type taut band
02. Face Dimension : 96 x 96 mm
03. Scale : Radial arc of 240 Deg.
04. Accuracy : 1.5% of full scale.
±0.5 Hz for frequency meter
05. Input : 0-1/0-5A for current measurement, 0-240V, 50 ± 2.5 Hz for voltage measurement
06. Zero Adjustment : Screw on meter face
07. Enclosure : Shielded Case IP-52
08. Mounting : Flush Panel
09. End Scale Suppression : 6 times the measuring range only for motor ammeters

F. Indicating Meters (D.C)

01. Type : Taut band moving coil
02. Face Dimension : 96 x 96 mm
03. Scale : Radial arc of 240 Deg.
04. Accuracy : 1.5% of full scale
05. Input : 0-75 mV for current measurement. Direct reading for voltage measurement.
06. Zero Adjustment : Screw on meter face
07. Enclosure : Shielded case IP-52
08. Mounting : Flush Panel
09. End Scale Suppression : 2 times the measuring range only for motor ammeters.

G. Auxiliary Relay

01. Type : Plug-in type with base/DIN rail Mounted
02. Coil voltage : 230 V, 50 Hz, 1 Phase
03. Contact Configuration : 2 NO & 2 NC (Minimum), additional contacts as per requirement
04. Contact rating : 250V/5A (A.C/D.C.)
05. Operating range : 80 to 110% of rated voltage
06. Insulation : 2 KV for 1 minute between terminals & earth.
07. Mechanical life : 20 million operations
08. Enclosure : Transparent cover
09. Connection : Screw terminals.
10. Mounting : Projection mounting inside panel /DIN rail mounting

H. Coupling Relay

01. Type : Miniature plug-in type/ DIN rail Mounting
02. Coil voltage : 24 V D.C. / 48V DC
03. Contact : 2 NO & 2 NC (Minimum)-Additional contact as per requirement
04. Contact rating : 250 V/5A (A.C)/220V/2A (D.C)
05. Operating range : 70 to 110% of rated voltage.
06. Insulation : 2 KV for 1 minute between terminal & earth.
07. Mechanical life : 20 million operations
08. Coil protection : Diode
09. Indication : Coil on LED
10. Enclosure : Transparent cover
11. Connection : Screw terminals.
12. Mounting : Projection mounting inside panel / DIN rail mounting

**I. Distribution Boards**

01. Type	:	Fixed, Modular.
02. Power distribution	:	Through MCCB
02. Enclosure	:	Sheet Steel, IP54
03. Mounting	:	Free standing (Can be attended from both front & back)

J. Electrical Junction Box

01. Type of Enclosure	:	Dust tight, Weatherproof and Waterproof, generally conforming to IP 65.
02. Material	:	16 SWG sheet steel hot-dip galvanized / Cast aluminum LM6.
03. Type of Cover	:	Solid unhinged with retention chain
04. Number of Paint	:	One base + two finish coatings of anti corrosive epoxy
05. Mounting	:	Surface
06. Cable Entry	:	Conduit Knockout/Threaded Hub
07. Gasket	:	Neoprene
08. Grounding	:	Brass earth lug with green screw head External-2 Nos, Internal-1no.M6.
09. Number of Drain Holes	:	Two at bottom capped.
10. Tag Plate	:	a) JB Number b) Cable Numbers on top c) Cable numbers with ferrules (side)
11. Accessories	:	a) Rail mounted Terminal blocks with makers b) Cable gland

K. Cable Gland

01. Type	:	Double compression
02. Entry Thread	:	ET
03. Material	:	Brass
04. Finish	:	Cadmium Plated.
05. Protection	:	IP – 54 or better
06. Accessories	:	Neoprene gasket, locknuts, reducers etc.

L. Cable Tray

01. Material	:	Mild steel
02. Thickness	:	not less than 2.5 mm
03. Finish	:	Hot dip galvanized
04. Perforation	:	As per MFR standard.
05. Cover	:	Suitable for tray

M. Digital Display Unit

To display the digital value of any analog process parameter with sign and decimal point of any analog input assigned through operator. Accuracy shall be $\pm 0.25\%$ of reading; type of display – LED; Seven segment or dot matrix as option; five digits, sign and decimal point; Range & offset – programmable or configurable; digit size shall be minimum of 50mm; colour of display shall be Red or Green; enclosure shall be IP32 or equal; all DDUs shall be mounted on the Unit Control Panel. The DDUs common for both Units shall be mounted in the Center of Control room with suitable arrangement. Which will be decided during detail engineering

N. Hybrid Recorders

Microprocessor based Chartless Hybrid Recorder with an accuracy of $\pm 0.2\%$; response time of 0.5sec (for 10% to 100% change); data storage in Hard disk – Hard disk shall have a capacity to store data of all points, at an average interval of 30 secs (settable), for one week. data retrieval through USB port or RS232/485/ethernet with associated software (to be loaded in the PC); Alarms for each Channel; no. of Channels



shall be 48; shall accept universal inputs (T/C, RTD, DC volts, 4-20mA, etc); scan rate of 20 ms scanning with 48 channel (1 Nos.) for boiler parameters, 20 ms scanning with 48 channel (3 Nos.) for generator, 20 ms scanning with 48 channel (2 Nos.) for turbine parameters ; display shall be coloured LCD or fluorescent tube with user selectable span; programmability (selection of input & scan/storage rate) shall be through Front panel keyboard; the recorder shall have the capability of being drawn out from the front side of the housing for maintenance and shall have electrical connection of plug-in type; material of casing shall be die-cast aluminium with epoxy coating and with a non-glare shatter proof Glass; enclosure shall be IP32 The quantity of Hybrid recorders shall be decided during detail engineering. The recorders are all to be connected through Ethernet cable to a PC with necessary software for downloading the data from recorder and also the PC shall be capable of viewing the data / uploading the configuration on the recorder. The Ethernet cable of sufficient quantity with necessary connectors, windows based software for file transfer from recorder to PC are also to be supplied.

O. Interposing Relays (IPR)

Electro magnetictype IPRs with plug-in type connections, suitable for channel / rail mounting in cabinets; coil rating 24V D.C; 2 set of silver plated Change over contacts rated for 0.2A 220VDC. Freewheeling diode across relay coil (copper) and self reset type status indicator flag (electronic) shall be provided. All relays shall be mounted in IPR cabinet & relay base (silver plated) internally wired to the external cabling termination block in IPR cabinet. Wiring connection shall be cage-clamp & termination shall be suitable for 0.5 sq. mm to 2.5 sq. mm size wiring. Facility to simulate relay operation manually shall be provided. Relays of different contact interrogation voltages shall be separated by a barrier in IPR cabinet. Accessories like name plate (SS) with tag & service inscription, relay base mounting rail/channel, nuts & bolts, etc. shall be supplied. In each cabinet, a DC Voltmeter shall be provided to check the Field Interrogation voltage.

H. CONTROL VALVE, FITTINGS AND ACCESSORIES

1. Control Valve

01. Pipe material	: Contractor to furnish
02. Pipe size	: Contractor to furnish
03. Pipe thickness	: Contractor to furnish
04. Fluid	: Contractor to furnish
05. Flow	: As per application
06. Inlet pressure	: As per application
07. Outlet pressure	: As per application
08. Inlet Temperature	: As per application
09. Specific Gravity	: As per application
10. Viscosity	: As per application
11. C _v Calculated	: As per application
12. C _v Selected	: As per application
13. % opening	: As per application
14. Vapor pressure @ inlet temperature	: As per application
15. Noise	: As per application
16. Valve type	: Globe
17. Valve model	: Contractor to furnish
18. Body size	: Contractor to furnish
19. Port size	: Contractor to furnish
20. Body material / Rating	: Contractor to furnish
21. End Connection	: Contractor to furnish
22. Bonnet type	: Contractor to furnish
23. Packing Material	: Contractor to furnish
24. Trim material / type	: Contractor to furnish



25.	Characteristics	:	Contractor to furnish
26.	Plug / Ball / Disk material	:	Contractor to furnish
27.	Seat / Stem material	:	Contractor to furnish
28.	Actuator type	:	Pneumatic Diaphragm
29.	Actuator model	:	Contractor to furnish
30.	Supply air / Power fail condition	:	FO / FC / FL
31.	Positioner type	:	E / P Positioner (Digital smart position)
32.	Opening / Closing time	:	Contractor to furnish
33.	Actuator bench range	:	Contractor to furnish
34.	Position transmitter	:	To be provided
35.	Limit switch	:	To be provided
36.	Air lock relay	:	To be provided
37.	Handwheel	:	To be provided
38.	Air set	:	To be provided
39.	Solenoid valve	:	To be provided
40.	Solenoid valve model	:	Contractor to furnish
41.	Local control station	:	To be provided
42.	Junction box	:	To be provided
43.	ANSI / FCI leakage class	:	Class IV
44.	IBR certificate	:	To be provided

2. Solenoid Valve

01.	Operating Principle	:	Electromagnetic (noiseless) Latch / release coil shall be used in the required application where the safety is to be ensured.
02.	Coil voltage rating	:	240 V AC / 110V AC / 24 V DC / 48 V DC / 220 V DC (As required).
03.	Ways	:	3 ways (normally open + normally closed) [general], other depending on requirement
04.	Port size	:	1/2" NPT / As per site requirement
05.	Body	:	SS Bar Stock
06.	Trim	:	AISI SS-316
07.	Manual Operator	:	In built
08.	Duty	:	Suitable for continuous energization
09.	Sealing	:	Airtight and leak proof
10.	Ambient Temperature	:	0 - 50 °C
11.	Fluid Temperature	:	0-150 °C or as per application
12.	Coil Enclosure	:	Stainless Steel
13.	Insulation	:	Class-H
14.	Coil Casing	:	IP-65 (Explosion proof for NEC Class-1, Division-1 area)
15.	Mounting	:	On pipe or on panel
16.	Cable Connection	:	3/4" ET Compression gland
17.	Accessories	:	Mounting brackets, nuts and bolts
18.	Special feature	:	i) Temperature operated fuse at Explosion proof enclosure. ii) Solenoid valve directly integral to actuator body shall have NAMOOR interface.
19.	Pressure Rating	:	As per application

3. Power Cylinders (Pneumatic)

01.	Mounting Type	:	a) Fixed position mounting (End mounting). b) Trunnion mounting
02.	Control Signal	:	0.2 to 1 Kg/Sq. cm. from I/P converter for modulating purposes. 24V/48VDC operated solenoid valve operating on pneumatic line. The



- Pilot solenoid will have separate coils for open closing purpose.
03. Supply Air : 0-7 Kg / Cm².
04. Selection : Based upon thrust / torque, stroke length, angular movement, full-scale travel time, repeatability, space factor etc. Provision for air-to-open and air-to-close operation.
05. Casing : IP-65.
06. Accessories (as required) : a) Air lock relay
b) Hand wheel.
c) Air filter regulator with gauge.
d) Volume Booster.
e) Limit Switches.
f) Positioner with Input, Output and supply pressure gauges.
g) Pilot Solenoid Valve (Double Coil type)
h) Position Transmitter (4-20 mA DC linear output).
07. Fail-safe operation : Stay put, open or close position on pneumatic / electrical power supply failure as per process safety criteria.
08. Repeatability : Better than 0.5% of full travel.
09. Hysteresis : Less than $\pm 1\%$ of full travel.
- 4. Air Filter Regulator**
01. Filter Element : Sintered Bronze
02. Filter Size : 5 microns
03. Input Air : 10.0 Kg/Sq. cm (maximum)
04. Output : Adjustable from 0-2.0 Kg / Sq. cm or 0-7.0 Kg / Sq. cm (continuous) as applicable.
05. Effect of Supply : Maximum 0.02 Kg/Sq. cm for a change pressure variation in supply pressure of 4 Kg/Sq. cm
06. Bowl Material : Metallic cover around high temperature area/clear transparent polycarbonate with metallic cover for ordinary applications.
07. Accessories : 2" dial size output pressure gauge
08. Desirable Feature : No perceptible drop of pressure on opening the drain port.
- 5. Seamless Stainless Steel Tube**
01. Reference : ASTM A-312 TP 304
02. Size : 12 mm OD /10 mm ID
03. Materials : AISI 304 SS
04. Type : Cold drawn fully solution annealed, pickled passivated, de-scaled, hydraulically cleaned
05. Properties : The tube shall be suitable for bending and capable of being flared by hardened and tapered steel pin. The expanded tube shall show no cracking or rupture.
06. Test Pressure : Burst pressure 400 Kg/Sq. Cm
07. Tolerance : ± 0.13 mm for outside diameter
 $\pm 15\%$ for wall thickness
08. Test : Flare, Hardness, Ball and Bubble Test
- 6. Stainless Steel Tube Fittings**
01. Reference : ASTM-A-182
02. Type : Double Compression



03.	Material	:	316 Stainless Steel Forgings (as per process hook-up drawing)
04.	Ferrule	:	316 Stainless Steel
05.	Pressure Rating	:	250 Kg/Sq. cm
06.	Temperature Rating	:	-100 to +400 °C
07.	Type of Fittings	:	Male / Female connector, elbow, cross, equal tee, straight connector, bulkhead union, ferrule etc. as required to suit installation.
08.	Size	:	To suit SS tubing and end connection

7. G.I. Pipe

01.	Reference	:	IS-1239, Part-I
02.	Type	:	Medium grade, threaded at both ends protected with end caps
03.	Material	:	Continuous ERW galvanized MS pipe
04.	General	:	Pipe shall be galvanized both inside and outside
05.	Size	:	1/2", 3/4", 1" as required

8. G.I. Pipe Fittings

01.	Reference	:	IS-1239, Part-II for material, dimension, thread etc.
02.	Style	:	Threaded
03.	Type of Fittings	:	Equal tee, three piece union, unequal tee, straight socket, 90 Deg. elbow, reducing socket cap. etc. to suit installation.
04.	Size	:	1/2", 3/4", 1" as required

9. C.S. Pipe

01.	Reference	:	ASTM-A 106 Gr. B / Gr. C for Material ANSI B36.10 for dimensions
02.	Material	:	Cold drawn seamless black C.S.
03.	Type	:	Plain ends
04.	Schedule	:	160, 80 as required
05.	Size	:	15 NB, 25 NB etc.

10. C.S. Pipe fittings

01.	Reference	:	ASTM-A 105 for Material ANSI B 16.11 for Dimensions
02.	Material	:	Carbon Steel
03.	Type	:	Socket Weld / Screwed
04.	Ratings	:	3000 lbs / 6000 lbs / 9000 lbs
05.	Size	:	As required to suit relevant Process Hook-up drawings(1/2", 1").
06.	Type of Fittings	:	Reducing coupling, male-female reducer, straight coupling, equal tee, three piece union, elbow, cap etc.

11. A.S. Pipe

01.	Reference	:	ASTM-A 335 Gr. P22 for Material ANSI B36.10 for dimensions
02.	Material	:	Cold drawn seamless A.S.
03.	Type	:	Plain ends
04.	Schedule	:	XXS,80,160 as required
05.	Size	:	15 NB, 25 NB etc.

12. A.S. Pipe Fittings

01.	Reference	:	ASTM-A 182 F22 for Material ANSI B 16.11 for Dimensions
02.	Material	:	Alloy Steel



03. Type	:	Socket Weld / Screwed
04. Ratings	:	3000 lbs / 6000 lbs / 9000 lbs
05. Size	:	1/2", 1".
06. Type of Fittings	:	Reducing coupling, male-female reducer, straight coupling, equal tee, three piece union, elbow, cap etc.

13. C.S. Globe Valve

01. Reference	:	ASTM A-105 for material
02. Type	:	Globe
03. Pattern	:	Straight through
04. Construction	:	Forged Body Cadmium Plated
05. End Connection	:	Socket Weld / Screwed
06. Proof Pressure	:	400 Kg/Cm ²
07. Material	:	Body - CS or equivalent (Cadmium plated) Stem - Hardened Steel Plug - AISI 316 SS
08. Packing	:	Teflon Bush
09. Bonnet	:	Inside screw, same as body material.
10. Bar Handle	:	Aluminum
11. Basic Specification and Testing	:	As per ANSI B 16.34
12. Accessories	:	Plugs for all ports

14. S.S. Globe Valve

01. Reference	:	ASTM A-105 for material
02. Type	:	Globe
03. Pattern	:	Straight through
04. Construction	:	Forged Body
05. End Connection	:	Screwed / Double Compression Fitted
06. Proof Pressure	:	400 Kg/Cm ²
07. Material	:	Body - SS 316 Stem - 410SS Plug - AISI 316 SS
08. Packing	:	Teflon Bush
09. Bonnet	:	Inside screw, same as body material.
10. Bar Handle	:	Aluminum
11. Basic Specification and Testing	:	As per ANSI B 16.34
12. Accessories	:	Plugs for all ports

15. Condensate Pot

Fabricated from 4" Sch.160, Alloy Steel pipe with 3 nos. 1/2" SW connection, one in the side and other two are on top and bottom. Condensate pot shall be used for steam services.

16. Instrument Manifolds**Technical Particulars**

01. Type	:	a) Two valve manifold b) Five valve manifold
02. Mounting	:	Remote 2" Pipe Mounting
03. Construction	:	Single block (bar stock)
04. Material	:	Forged body and bonnet AISI 316 stainless steel
05. Ports	:	1/2 " NPT (F)
06. Rating	:	420 Kg/Sq. cm at ambient



07.	Operating Temperature	:	(-) 30 to (+) 170 Deg C
08.	Packing	:	PTFE Wafer
09.	Seat & Stem	:	AISI 316 SS
10.	Plug	:	AISI 316 SS free to turn on stem / 17-4 PH
11.	Handle Bar	:	AISI 316 SS
12.	Connection	:	Straight
13.	Accessories	:	i) Plugs for all ports ii) Mounting Bracket, bolts, nuts

17. Air Header**TECHNICAL PARTICULARS**

		<u>For Panel</u>	<u>For Field</u>
01.	Material of Construction	: Cast Brass	Cast Brass
02.	Inlet Connection	: 2" NPT (M)	1" NPT (M)
03.	Header Take-off	: Brazed Brass Port	Brazed Brass Port
04.	Take off connection	: 1 / 2" NPT (M)	1/ 2" NPT (M)
05.	Take-off Valves	: Brass Valves on Nipple	Brass Valves on Nipple
06.	Tube Take-off	: Tube Adapter on Valve	Tube Adapter on Valve
07.	Drain	: Drain valve at Lowest Point	Brass Drain Valve

18. S.S. Pipe

01.	Reference	:	ASTM-A 312 TP316 ANSI B36.10
02.	Material	:	SS 316 cold drawn seamless
03.	Type	:	Plain ends
04.	Schedule	:	80S,40S as required
05.	Size	:	15 NB, 25 NB etc.

I. CONTROL AND INSTRUMENT CABLE**1. Thermocouple Compensating Cable**

01.	Conductor	:	Solid conductor
02.	Conductor size	:	16 AWG
03.	Type	:	KX, TX, RX (as required)
04.	Conductor Insulation	:	HRPVC Type-C (IS-5831,1984) 0.6 mm thick
05.	Voltage grade	:	600V (peak value)
06.	Twisting	:	Pair twisted with lay of 75 mm
07.	Twisting Direction	:	All Pairs in the same direction. Lapped to form bunch with mylar tape.
08.	Individual Pair & Overall Shield	:	Aluminium mylar tape with a thickness of 2.35MIL and 25% overlapped edges.
09.	Drain wire	:	Annealed Tinned copper wire, Stranded. Size 0.5 Sq. mm. (No. of strands / size:- 7 / 0.3mm)
10.	Inner Sheath	:	Extruded FRLS PVC Type ST2 of IS-5831,1984 Thickness as per IS-1554 Part-I 1976
11.	Armoring	:	G.I. Wire/Strip as per IS-3975
12.	Outer Sheath	:	Extruded FRLS PVC (anti rodent, anti termite & moisture resistant properties) Type ST2 of IS-5831, 1984



13. Rip Cord : Thickness as per IS-1554Part-I 1976
14. Temperature Range : Yes
15. Insulation at 20⁰ C : Up to 85 °C
16. Capacitance at 800 Hz : 100 MOhms / Km [Min]
17. Codes & Standards : 70 nf / km [Typical]
a) IEC 332-1
b) ANSI MC 96.1
c) IS-8784-1987
18. Tests : a) Oxygen Index: Min.29 at room temp. (ASTM-D-2863)
a) Acid Gas Gen.: Max.20% by weight as per IEC 754 Part-I
b) Temp Index : Min 250 DEG C at 21Oxy. Ind. (ASTM-D-2863)
c) Smoke Density Rating: Max.60% (ASTM-D-2843).
d) Flammability Test : as per IEC 332 Part-I
e) Swedish Chimney Test-S-424-1475
f) Insulation Test Core to core :1.0 KV r.m.s for1 Min
g) Insulation Test Core to armour :1.0 KV r.m.s for1 Min
h) Insulation Resistance 100 M Ohm / Km Min
i) Type test for material

2. Instrumentation Pair Signal Cable

01. Conductor type : Stranded (7) annealed tinned copper
02. Conductor size : 0.5 Sq.mm
03. Resistance : 39 Ohms / Km (max.) at 20 °C
04. Conductor Insulation : HRPVC Type-C (IS-5831,1984) 0.6 mm thick
05. Voltage grade : 600V (peak value.)
06. Twisting : Twin twisted with lay of 75 mm
07. Twisting Direction : All pairs in the same direction. Lapped to form bunch with mylar tape.
08. Individual Pair & Overall Shield : Aluminium mylar tape with a thickness of 2.35MIL and 25% overlapped edges.
09. Drain wire : Annealed Tinned copper wire, Stranded. Size 0.5 Sq. mm. (No. of strands / size:- 7 / 0.3mm)
10. Inner Sheath : Extruded FRLS PVC
Type ST2 of IS-5831,1984
Thickness as per IS-1554 Part-I 1976
11. Armoring : G.I. Wire/Strip as per IS-3975
12. Outer Sheath : Extruded FRLS PVC (anti rodent, anti termite & moisture resistant properties)
Type ST2 of IS-5831, 1984
Thickness as per IS-1554, Part-I 1976
13. Rip Cord : Yes
14. Temperature Range : 85 °C
15. Insulation at 20 Deg.C : 100 MOhms/Km [Min]
16. Capacitance at 800 Hz : 70 nf/km [Typical]
17. Codes & Standards : a) IPCEA-S-61-402
b) IEC 332-1
c) ASTM-B-33
d) IS-8130-1984



18. Tests :
- Oxygen Index: Min.29 at room temp. (ASTM-D-2863)
 - Acid Gas Gen.: Max.20% by weight as per IEC 754 Part-I
 - Temp Index: Min 250 ° C at 21Oxy. Ind. (ASTM-D-2863)
 - Smoke Density Rating: Max.60% (ASTM-D-2843).
 - Flammability Test: as per IEC 332 Part-I
 - Swedish Chimney Test-S-424-1475
 - Insulation Test Core to core: 1.0 KV r.m.s for 1 Min
 - Insulation Test Core to armour: 1.0 KV r.m.s for 1 Min
 - Insulation Resistance 100 M Ohm / Km Min
 - Type test for material
 - Fire resistance test to IS 5831 for 20 Minute CPVC insulation & sheath of electrical cable.
 - Rodent & termise proof
 - Thermal Stability of 200 OYC to IEC 54o for 100 Nos.

3. Fiber Optic Cable

A	Fiber:	
1	Type	Multile single mode/Multi-Mode Fiber to avoid usage of any repeaters.
2	Core Diameter	62.5 ± 3 microns
3	Cladding Diameter	125 ± 2 microns
4	Fiber Proof test	As per Manufacturer's standard
5	Coating Diameter	As per Manufacturer's standard
6	Number of Fibers/core	Four OR Six (Colour Coded) with min. 100% spare core (Fibers)
7	Standard	As per Manufacturer's standard
B	Numerical Aperture	0.275
C	Bandwidth & Attenuation:	
1	Bandwidth @ 850 nm	160 MHz-Km min
2	Attenuation @ 850 nm	4.0 dB/Km max
D	Cable Construction: Optic Fibre cable shall be galvanised corrugated steel taped armoured, fully water blocked with central dielectric material	
1	Outer Colour	Black
2	Outer Jacket	Polyethylene 1.0 to 1.5mm thick, Flame retardant & UV resistant.
3	Inner Jacket	Core-locked flame retardant polyethylene
4	Filler / Strength member	As per Manufacturer's standard
5	Central Strength member	Glass reinforced plastic (GRP) and Buckle resistant



E	Stripping Ability	All layers easily removed with Commercially available tools
F	Installation:	
1	Minimum bending radius	As per IEC/EIA & other international standard
2	Maximum Tensile Load	As per IEC/EIA & other international standard
3	Method of laying	Directly laid in cable trays / duct bank / clamped with available structure
4	Pulling	Ordinary cable grips
G	Storage Temperature	- 20⁰ C to 60⁰ C
H	Operating Temperature	- 20⁰ C to 65⁰ C
I	Test Specification (EIA – STD – RS - 445 or Equivalent):	
1	Impact Resistance	50 impacts
2	Crush	440 N/Cm
J	Moisture Resistance	Water blocking layer
K	F.O. Cable Testing	All Fiber Optic Cables shall be Tested as per IEC/EIA & other international standard using Optical Time Domain Reflector (OTDR) meter

4. Data cable:

Data transmission cables are control & signal cables used in electronics of computer system, electronic control equipment etc.in power plant data processing system. The cable has an overall screening which suppresses external electrical influences and ensures precise pulse transmission. The screen braiding of tinned copper wires is wrapped around the core or inner sheath.

i) Min. bending radius for flexing	: 15x cable diameter.
ii) Temp. Range	: (-30 to +80) deg.centigrade
iii) Loop resistance	: Max.78.4 ohm/km.
iv) Inductance	: 0.65 mH / Km.
v) Coupling	: 200 pF / Km.
- Co axial and fibre optic cables are also used as data cables.

NOTE: All cables near high temperature zone shall be high temp cables, which shall be terminated at a junction box in normal temperature zone. Thermocouple extension cables and copper conductor cables for high temperature applications shall be with insulation of individual conductor and outer sheath of extruded FEP (i.e. Teflon) as per VDE 0207 Part 6 and ASTM D 2116. The thickness of insulation shall be 0.5 mm nominal (i.e. 0.4 mm minimum). These cables shall be single / Multipair twisted & shielded.



5. Specification For Co-Axial Cables Cable-C

Co-axial cables are used for high frequency equipments and systems for transmission and reception purposes and computers. Co-axial cable should have minimum following characteristics:-

Construction	:	Solid silica coated, annealed copper conductor.
Di-electric	:	Low loss solid polyethylene foam, semi and spaced construction.
Outer conductor	:	Braided or longitudinal tube of Copper or Aluminium giving 100% coverage with slight overlap.
Outer sheath	:	PVC Diameter over Di-electric : 7.24 sq.mm. Outer diameter : 10.29 sq.mm. Nominal impedance : 75 ohms Nominal capacitance : 20.5 pF/ft.
Nominal attenuation	:	8 dB at 1000 MHz Per 100 ft.

6. Extension Cables

1.	Applicable Standards	:	ANSI MC96.1; IS:1554 (Part-I) IS:5831-1984
2.	Type	:	Single / Multipair twisted and shielded type as per ANSI MC96.1
3.	Conductor Size	:	.31sqmm, solid alloy (16 AWG)
4.	Conductor Diameter	:	1.29 mm
5.	Insulation	:	PVC insulated, heavy duty, Self extinguishing type. Colour coded extruded PVC inner sheathed with overall PVC sheathed Type ST2 FRLS as per Insulation of each wire with high grade 0.6 mm 85 deg.C PVC Type C as per IS: 5831, voltage grading shall be 1.5 kVVDE 0207 PART 4 / IS: 5831.
6.	Lay	:	Twisted pairs within 75 mm max. lay.
7.	Shield	:	Single pair cable assembly only. Multiple pair - each pair and cable assembly. Each conductor shall be individually and overall shielded. 2.35 MIL thick combination aluminium Mylar tape and 7 strand 20 SWG drain wire. Hundred percent cover over insulated conductors, shield tape on pair assembly shall be applied in such a way as to give total shield isolation from all other pair shields
8.	Intermediate Sheath	:	Soft extruded PVC, IS:5831 Type 4



9.	Conductor Identification	:	See "Cable Details" as below
10.	Armour	:	Galvanised steel wire/strip to IS:3975
11.	Multiple pair identification	:	Each pair numbered every 250 mm

Power Cylinders (Pneumatic)

Mounting Type	:	a) Fixed position mounting (End mounting). b) Trunnion mounting
Control Signal	:	0.2 to 1 Kg/Sq. cm. from I/P converter for modulating purposes. 24V/48VDC operated solenoid valve operating on pneumatic line. The Pilot solenoid will have separate coils for open closing purpose.
Supply Air Selection	:	0-7 Kg / Cm ² . Based upon thrust / torque, stroke length, angular movement, full-scale travel time, repeatability, space factor etc. Provision for air-to-open and air-to-close operation.
Casing	:	IP-65.
Accessories (as required)	:	a) Air lock relay b) Hand wheel. c) Air filter regulator with gauge. d) Volume Booster. e) Limit Switches. f) Positioner with Input, Output and supply pressure gauges. g) Pilot Solenoid Valve (Double Coil type) h) Position Transmitter (4-20 mA DC linear output, LVDT or non contact type).
Fail-safe operation	:	Stay put, open or close position on pneumatic / electrical power supply failure as per process safety criteria.
Repeatability	:	Better than 0.5% of full travel.
Hysteresis	:	Less than □1% of full travel

J. Miscellaneous Instruments**01. Nucleonic Type Density Meter (For Ash Handling Plant):-**

Type	:	Nuclear type radiation
Application	:	Abrasive Slurries & Corrosive Chemicals
Accuracy	:	< 1% of Span
Orientation	:	As per requirement.
System Type	:	Radiation Source & Scintillation Detector
Meter Material	:	SS 316L/ Aluminum with PVC coating
Connection material	:	SS 316L
Compensation	:	Temp. Compensation required
Type (Transmitter)	:	SMART, 2 Wire HART based
Operating Principle	:	As the density increase, the lower the radiation field at detector and vice versa.
Output	:	With photomultiplier, 4-20 mA, DC
Electrical Connection	:	½" NPT
Enclosure Class	:	IP 66
Local Display	:	Provided



Accessories : Radiation Survey Meter and all erection/installation hardware

02. Non - Nucleonic (Vibration) Type Density Meter (For DM & AHP Plant):-

Application : Liquid Density measurement

Detector

1. Orientation : As per requirement.

2. Case Material : SS 316/ Cast Aluminum alloy

3. Wetted part material : SS 316

4. Operating Principle : Vibration Density measurement

Converter

1. Output : 4-20 mA DC isolated.

2. Electrical Connection : ½" NPT

3. Enclosure Class : IP 65

4. Local Display : Digital 5 digit, density display with temp. compensation.

5. Accuracy : +/- 1%

6. Response time : < 1 minute.

7. Power Supply : 240 V AC, +/- 10%, 50 Hz. From UPS

03. Pull Chord switch

Type : Addressable Type

Body : Cast Iron

Contact rating : Continuous 10 Amp, Breaking 2 Amp. (240 V AC)

No. of contact : 2 NO + 2 NC

Reset facility : Manual Reset

Type of enclosure : Die Cast Aluminum

Degree of protection : Explosion proof for NEC class 1, Division 1 area

Local trip indication : Required

Accessories : 1. Canopy over lever of pull Cord switch.
2. Linking of switchesthrough a single cable for each section.
3. Each pull cord switch shall be provided with red LED indication lamp for prominent visible indication of tripping.
4. "One number indicator panel which shall display the exact number of safety switches (pull cord and belt sway switches) operated in a loop of conveyor. It shall also monitor the condition of field cable connecting the switches in series & generate signal if field cable is found broken or short. The indicator panel shall display the operated switch number. The same indication shall also be available in CHP operator station.

04. Belt Sway Switch

Type : Addressable Type

Body : Cast Iron

Contact rating : Continuous 10 Amp, Breaking 2 Amp. (240 V AC)

No. of contact : 2 NO + 2 NC

Reset facility : Auto Reset

Type of enclosure : Die Cast Aluminum



Degree of protection : Explosion proof for NEC class 1, Division 1 area
Accessories : 1. Canopy
2. The belt sway switches shall be provided with a common bridging push button which may be kept pressed to bypass the limit switch before restarting the conveyor.

05. Zero Speed Switch

Type : Microprocessor Based
Body : Cast Iron
Contact rating : Continuous 10 Amp. (240 V AC)
No. of contact : 2 NO + 2 NC
Reset facility : Manual Reset
Type of enclosure : Die Cast Aluminum
Degree of protection : Explosion proof for NEC class 1, Division 1 area
Accuracy : +/- 5%
Repeatability : +/- 1%
Differential : +/- 5%
Accessories : Canopy

06. Chute Block Switch

Type : RF Based
Sensor Material : SS 316
Mounting : Flanged
Insulation Material : PTFE
Contacts : 2 NO + 2 NC
Type of enclosure : Die Cast Aluminum
Degree of protection : IP 66
Electrical Connection : ¾ " ET
Repeatability : 0.05%
Local Indication : To be provided
Accessories : a) Neoprene Gasket and Stud Bolt
b) SS Tag plate, Nickel plated brass double Compression type cable gland

07. Dew Point meter

Type : 2 Wire Loop Powered Dew point Transmitter
Overall Range : -60 °C to +20 °C Dew point
Accuracy : ± 2 °C Dew point
Material : SS316 (wetted parts)
Features : AUTOMATIC CALIBRATION
• Can be Configured for Linear 4-20mA signal in °C & °F Dew point, ppm(v), ppb(v), g/m3
• Temperature Compensation
• Failure Diagnostics
• Long Term Stability
• Fast Response
• IP 66 / NEMA4X Protection
• Supplied with Calibration Certificate Traceable to National & International Humidity Standards
• Sensor protection with sintered filter
• Local LCD Display for Dew Point

08. Junction Boxes

Type : Flame proof/weather proof
Enclosure : IP-65/Explosion/Flame Proof as per area classification.



Material	:	FRP with protective Coating
Cable entry	:	Bottom or Side
Cable glands	:	Double compression type – Nickel plated brass with PVC hoods.
Mounting	:	Indoor/Outdoor
No. of terminals	:	As required with standardization with 20% spare of each size & type.
Terminals	:	Phoenix/Wago (screw less cage clamp type spring loaded)
Grounding	:	Two terminals for body and shield ground
Door	:	Hinged, lockable type.

Suitable mounting clamps and other accessories shall be in scope of bidder.

The brackets, bolts, nuts, screws, glands, lugs required for erection shall be of brass, included in bidder scope of supply. High voltage & insulation resistance test shall also be conducted.

M6 Ni plated Brass earthing stud shall be provided (external 2 nos. internal 1 no.)
Gasket (Normal)- Neoprene thickness 6.0 mm

09. Recorders (Chartless)

Type	:	Micro-processor based, Digital TFT display type
No. of Channels	:	Forty Eight (48) point).

- 6 Nos. of recorders** shall be supplied for BTG and the parameters shall be decided during detailed Engineering. Quantities of recorders for BOP packages shall be decided during detailed Engineering. (Simultaneous parameter display preferred)

Input Signal	:	Fully configurable multi range (Programmable) universal (input)
Recording method	:	Continuous with different colour, for each channel
Display colour	:	Selectable from 30 Colours
Bar graph facility	:	To be provided
Digital indication	:	To be provided
Accuracy	:	+/- 0.1 % for reading for DCV Input And 0.1 Deg for TC/RTD input
Programmability	:	Front key board
Data Storage	:	hard disk/ Flash Memory
Data Retrieval	:	Compact 4 GB flash Memory card and USB port with 8 GB USB drive.
Scan rate	:	< 20 m second for individual channel.

Selection of scan time for individual channel is required.

Power Supply	:	240 VAC 1 Phase UPS
Ambient Temperature	:	0-50 Degrees
Mounting	:	Front panel mounted weather & Dust proof IP 65
Application software	:	Yes, To be provided
Internal Memory	:	400 MB or more
Screen	:	> 10.5" colour LCD TFT
Resolution	:	> 640 X 480 Pixels
Type of Display	:	i) Trends
ii) Bar Graph	:	
iii) Digital display/ values	:	
Event Sampling	:	1/2/5/10/30/60/120 sec.
Zoom & Scroll Facility	:	Required



OWS and printer connectivity port	:	Required
	:	Necessary software shall be supplied for uploading the data.
Communication	:	MODBUS/PROFIBUS ports connectivity between recorder and third party systems

10. Digital Indicator

Type	:	Programmable electronic digital indicator with floating point decimal.
Input	:	4-20 mA DC/1-5V DC/RTD/T/C.
Number of inputs	:	One
Range	:	As per requirement/adjustable by end user through key pad available on the indicator.
Number of digits	:	Four plus sign
Digit height	:	20 mm or larger
Display	:	Fluorescent red
Input over range/open	:	All digits to flash sensor (T/C)
Input hold time	:	0.7 seconds max.
Accuracy	:	+0.05% of span
Power supply	:	240V AC, 50Hz
Mounting	:	Flush panel, compatible for mounting on mosaic grid panel
Size	:	96x48 mm
Other Particular	:	Indicator receiving thermocouple signal shall have automatic cold junction compensation.
	:	Retransmission Output 4-20 mA isolated required.
	:	24 V DC inbuilt power supply
	:	Alarm contact with 2 NO/NC contact (rating 5A/230 V AC)

11. Receiver Indicators (Single/Dual Channel)

Type	:	Analogue indicator
Input Signal	:	Universal input (T/C, RTD, 4-20 mA, Voltage)
Scale	:	Range fully configurable and programmable
Measurement Accuracy	:	+ 0.2% of span + 1 count
Resolution	:	0.5% Span
Dead band	:	+ 0.2% of span
Repeatability	:	0.2% of span
Full scale response time	:	Less than two(2)seconds
Power Supply	:	240V AC, 50 Hz
Connection	:	Plug in type
Accessories	:	Mounting Bracket for Bins
Other Particulars	:	Indicator receiving thermocouple Signal shall have automatic cold junction compensation.
	:	Retransmission Output 4-20 mA isolated required.

12. Temperature Scanner

Type	:	Microprocessor based Electronic Digital Scanner.
No. of channels	:	16/24 (as per the application)
Input	:	RTD /Thermocouple/4-20mA
Accuracy	:	+ 0.1 of FS + 1 count
Number of digits	:	4 digit (7 segment display with Engg. Units)
Digit height	:	12 mm or larger



Display color	:	Fluorescent red/green
Display mode Input over range/open sensor	:	All digits to flash
Mounting	:	Panel mounting
Zero and Span	:	Adjustable by digital calibration
Serial communication	:	Isolated RS232/485 for modbus-RTU communication
Memory Capacity	:	5MB Flash
Alarm output	:	Required
Contact rating	:	2A at 220 V AC
Power supply	:	240 V AC/24 V DC
Properties	:	i. Any channel shall be configured for Data Logging ii.Channel to Channel online Isolation shall be provided iii Real Time RTC Interface for Printer shall be provided
Operation Modes	:	Auto/manual mode, Run mode, Verify mode, Calibration Mode, Program mode.

13. Humidity & Temperature Sensor with LCD display for AC Plant

Humidity Sensor	
Measurement range	: 0-100%r.h.
Range of use	: 0-100%r.h.
Measurement accuracy at 23° C 0-100% r.h.	: +2%
Temperature dependency	: <0.05% r.h./ ° C
Output signal, linear (terminal I1)	: DC4-20mA = 0-100%r.h.
Temperature Sensor	
Range of use	: 0-50° C & -35 to 35° C
Sensing element	: Pt1000 class A
Measurement accuracy at 15-35° C	: +0.5K
Output signal, linear (terminal I2)	: DC4-20mA = 0-50° C & -35 to 35° C
General Sensor Data	
Power supply	
Operating voltage	: AC 24V +20%
Degree of Protection & Safety Class	
Degree of protection of housing	
With enclosed cable gland	IP 65 to IEC 529
Safety class	: III to EN 60 730
Environmental Condition	
Temperature (housing with electronics)	: -40 to 70° C
Humidity	5 to 95% r.h. (noncondensing)
Location	: In each AHU room and Control room