NEERA BHIMA SAHAKARI SAKHAR KARKHANA LTD., (NBSSKL)

Shahajinagar, A/p. Redni
Tal.Indapur & Dist. Pune,
Maharashtra - 413114, India

Contact Person	D.N. Markad
Phone	02111-270200/270650
Fax	02111-270555

TURBO-GENERATOR AND AUXILIARIES FOR DISTILLERY PROJECT

AT

NEERA BHIMA SAHAKARI SAKHAR KARKHANA LTD., (NBSSKL)

ENQUIRY NO.: - 2021/TG Set/001

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CONSULTANTS

VASANTDADA SUGAR INSTITUTE,
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VOLUME-II

TECHNICAL SPECIFICATION AND SCOPE OF WORK

FOR TG SET WITH AUXILIARIES

FOR

SPENT WASH TREATMENT PROJECT

VOLUME-II
TECHNICAL SPECIFICATION & DRAWINGS
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1. SCOPE OF WORK, TERMINAL POINTS & EXCLUSIONS

1.1 Scope of Work

The scope of work for the turbo-generator package, consisting of One (1) No. **3.0 MW Nominal capacity** backpressure TG, covered under this specification shall include but not limited to the following:

1.1.1 Supply, Engineering, Design, fabrication, manufacture, assembly, shop testing and inspection at manufacturer's works.

Turbo Alternator set shall be install at Ground level.

Providing all labors, materials and equipment for testing at shop as required.

All spare parts required for the commissioning of the Turbo Generators and auxiliary system.

Special tools and tackles required for operation and maintenance, inspection, and repair of the equipment/systems offered.

1.1.2 Services under Scope of Supply

Inspection and expediting, handling, packing, forwarding, port clearance, transporting (including transport insurance), obtaining statutory approvals and documentation, (Including presentation and submission of drawings to the statutory authorities like the CEIG, etc., for approval, furnishing completion reports, arranging for inspection and obtaining safety certificates), erection and commissioning and performance testing.

1.1.3 Scope of supply and services of basic equipment

This section details out the scope of supply and services for one number Turbo -generator with auxiliaries as indicated. Components and services not specifically mentioned here but necessary to complete the stipulated work in all respects, regardless of any omission in this specifications or drawings, is deemed to have been included in this section.

All materials supplied under this contract shall be new and unused.

1.1.4 Scope of supply

1.1.4.1 Mechanical

One (1) No. Backpressure Turbine and auxiliary unit, comprising of,

1.1.4.1.1 Back pressure impulse reaction type steam turbine complete with casing, rotor, blading, bearings and glands.

1.1.4.1.2 Exhaust steam at 5.5 Ata for meeting the process steam requirements of the distillery plant. Necessary spray water pressure reducing station and de super heater in the exhaust line for maintaining the steam temperature to the specified value. Automatic vent with control valve with silencer and Relief Valves and non-return valve in the exhaust line.

1.1.4.1.3 Heavy duty reduction gear box of Double Helical design, if required, capable of continuously transmitting the maximum power generated by the turbine.

1.1.4.1.4 High speed coupling between the turbine and the gear box, and low speed coupling between the gear box and the alternator with acoustic cover made of solid castings.

Hydraulically operated stop and emergency valve with steam strainers.

1.1.4.1.6 Throttle valve and governing valves.

1.1.4.1.7 Microprocessor based Electro-Hydraulic governing system including speed changer.

1.1.4.1.8 Lube and control oil system with adequate redundancy and emergency provisions, common for turbine, gear box and alternator.

1.1.4.1.9 One oil reservoir complete with strainers, drains, maintenance openings, vents, connections to oil inlet, outlet and to oil purifier unit, oil level indicator, level switches and two 100 % (One working and one as stand by) oil vapour extractors.

- Two 100% oil coolers with necessary three way switching valves.
- Two 100 % oil filters individually for the lube and control oil with necessary two way change over valves.

- One main oil pump driven by Gear, one auxiliary oil pump driven by A.C motor, and one emergency oil pump driven by D.C motor.
- One duplex type centrifugal type oil purifier system.
- Emergency gravity lube oil system with overhead tank, piping, valves and instrumentation.

1.1.4.10 Base frame for turbine, gear box, and alternator with necessary bearing pedestals, shims, sole plates, keys, wedges, foundation bolts, all embedment and grouting materials, etc.

1.1.4.11 The following piping and its fittings and accessories shall be in included in the scope of the BIDDER.

- Steam Inlet piping to TG set: from steam distribution header to TG set inlet TSV HP piping is in the scope of supply. Inlet TSV and bypass both valves shall be motorized valves.
- Exhaust piping from turbine to terminal point of 5.5 ata header, with necessary Desuperheater. The minimum size of the piping shall be ID 450 x schedule 40. The material shall conform to SA 106 Gr.B specifications. Exhaust piping should be with one QCNRV and one manual control valve. Scope of supply is upto distillery steam distribution header including Desuperheater station. The supporting structure shall be designed for considering the exhaust steam pipeline, condensate return and cables going to distillery plant is in scope of supply.
- Supply, erection and commissioning of inlet and outlet steam piping shall be stress analyzed, supports for piping shall be as per IBR.
- Spray water piping from terminal point to desuperheater including spray water pressure reducing stations.
- Auxiliary cooling water supply and return piping between the TG auxiliaries and the Auxiliary cooling water supply and return headers, located Just outside the power house.(cooling tower, centrifugal pump with motor, necessary valves, piping, strainers is in scope of supply). The mains will be running below ground at approx. -1.5 meters, from the ground level. The underground piping shall be provided with wrapping & coating with asphalt / bitumastic based compound.
  - All gate, globe, and check valves and butterfly valves for the above systems.
  - Set of hot insulation turbine, piping and all other equipment under scope within the battery limit
  - Pipe supports, spring hangers and other accessories for the above system.
  - Metallic expansion bellows, steam traps and strainers, wherever required for the above system.
  - All safety valve exhaust piping to atmosphere with drip pan assembly.
  - All drains from take off point up to flash tank or to trench, as the case may be, along with all the valves and specialties. All vent piping with valves, wherever required.
  - Motorized Isolation valves shall to be provided.
- Bidder shall be submit heat and mass balance of turbine showing the inlet and outlet steam conditions (viz. pressure, temp and flow) and generation of power at alternator terminal.

1.1.4.12 Complete piping with valves and fittings as required along with pipe supports associated with turbine, lube and control oil system within the battery limits of the turbo generator system. Complete Oil piping from oil pump to inlet bearing via cooler and outlet from bearing to sump shall be SS304 grade.

1.1.4.13 Counter flanges for all inlet and outlet connections from and to the BIDDER's battery limit, including gaskets, bolts and nuts.

1.1.4.14 Adequate system of drainage from all steam spaces within the unit.

1.1.4.15 Blanking devices for the emergency stop valve for steam blowing and for hydraulic testing.

1.1.4.16 Special lifting tackles and special tools required for the normal maintenance work on the turbine, generator and all other equipment falling within the scope of supply.

1.1.4.17 Flushing oil and initial fill of lubricants.

1.1.4.18 The following accessories shall be in included in the scope of the BIDDER

- Dump condenser of 10 TPH capacity shall be provided for excess exhaust cooling with necessary pipping, condensate tank, condensate transfer pumps along with necessary instrumentation and control along with pipping up to deaerator inlet.

  The Dump condenser shall be of non-contact surface type condenser with suitably designed air evacuation system. The dump condenser shall be designed to operate with 35°C inlet cooling water. The turbine shall be provided with a dumping condenser of 10 TPH exhaust with suitable cooling tower & recirculation pumps.
  The cooling water for the condenser will be supplied from the cooling tower basin through cold water pumps. The tubes shall be provided with adequate support to prevent any major tube vibration and failing. The tubes shall be extended to the tube sheets at both the ends and flared at the cooling water inlet end. The condenser neck shall be connected to the Turbine exhaust hood. The thermal expansion of the condenser shall be suitably protected with properly designed stainless steel expansion bellow.
  2 Nos. (One operating and one stand-by) of 100% capacity electrical motor driven condensate pumps to pump the condensate from the condenser hot well shall be provided.

- Cooling tower for TG set of suitable capacity shall be provided with necessary centrifugal pump with motor, necessary valves, pipping, strainers etc. i.e complete system is in the scope of supplier.

  The system shall cater to the requirement of the condenser for the 3000 kW turbo generator, the auxiliaries of the turbo generator and the auxiliaries of the steam generator. A two Cell, induced draft, cross flow cooling tower of minimum 750 m^3/hr capacity, to meet the cooling water requirement for the power generation plant shall be provided.
  The hot water returning from the dump condenser, and the TG and the boiler auxiliaries to be cooled in the cooling tower designed for a temperature drop of 8°C with an approach of 5°C at the wet bulb temperature.
  The structure shall be designed adequately for wind and other loads and shall be as per seismic conditions. The cooling tower shall be complete in all respects such as induced draft fan, motors, gear reducers, lubrication systems etc. The fan blade to be of FRP construction so as to reduce energy consumption. Desk, ladders, handles etc. and access doors for each cell shall be provided. Complete isolation between the cells is essential. Chemical dosing system including necessary piping, vessels, valves etc. and pipe work for returning cooling water to a terminal point shall be provided. All electrical including motors, supports, cable and cable works, earthling including material etc. is to be included in the scope of supply.

- Power house crane for TG set of suitable capacity shall be provided with gantry girdle.

  One no. electrical operated overhead travelling crane of 15 tons SWL capacity conforming to Class II of IS specifications complete with rails, gantry, drives controls etc., shall be supplied. The crane rail centres shall cover powerhouse span and maintenance area. The crane shall be duly certified by the safety inspector following all the safety norms.

1.1.4.2 Electrical

1.1.4.2.1One (1) no. Three phase synchronous generator.

1.1.4.2.2The complete excitation system consisting of the brushless exciter mounted on the generator shaft and the digital automatic excitation regulation cubicle, with twin auto and one manual channels of AVR.

1.1.4.2.3 Sectionalized closed air circuit water (CACW) cooling system with interconnection ducting.

1.1.4.2.4 A single busbar distillery 415 V switchboard consisting of a generator cubicle & outgoing modules with feeders as per the specification and electrical schematic diagram.

1.1.4.2.5 A single busbar distillery 415 V sugar house switchboard/PCC consisting of bus bar trunking & outgoing modules with feeders as per the specification and electrical

schematic diagram.

1.1.4.2.6Generator protection, metering, control and synchronizing cubicles , and Digital
1.1.4.2.7Current and potential transformers for protection, metering and voltage regulation.
1.1.4.2.8 Battery, Battery charger of 24 V and DCDB with accessories All AC and DC motors, with in the battery limits, required for the successful operation of the plant.
1.1.4.2.9 All statuary approvals viz Elect Inspector ,Factory Inspector and Boiler Inspector etc is Supplier Scope
1.1.4.2.10 All Power and Control cabling within TG Island, for interconnection /interfacing of the equipment/panels within the scope of the BIDDER.
(This excludes the cabling between the MCC, motors and the Push button stations which are excluded from the scope of the BIDDER)
1.1.4.2.11Special tools for the Generator and accessories and slings for lifting.
1.1.4.2.12Complete engineering of TG systems shall be in the scope of the
1.1.4.2.13BIDDER, which shall include, but not limited to furnishing of the following details / drawings to enable the PURCHASER to procure the switchgears and other electrical items (not covered under BIDDER's scope), as required for the system completion :

- Single line diagram of TG auxiliary feeders
- Physical installation layout of all equipment in scope to how the locations of motors / loads and power / control panels
- Cable schedule for complete power & control cables Interconnection chart for control cables Cable tray and trench layout.
- Earthing layout drawings for the complete equipment in scope
- Requirements of local push button stations
- Power & control cables, local push button stations, earthing conductors and cable trays

1.1.4.2.14 Integral starters for all motorized valves.
1.1.4.2.15Installation approval and obtaining safety certificates from Electrical Inspectorate.

1.1.4.3 Instrumentation and controls
1.1.4.3.1 All pressure test points complete with root isolating valves and temperature test points complete with thermo wells and screwed plugs and chain for measurements.

1.1.4.3.2 Supply of all the analog field instruments (transmitters, local temperature gauges, local pressure gauges, thermocouples, RTDs, flow nozzles, Position Transmitters etc.), that are required for the monitoring / control of the various parameters for the operation of turbine / auxiliaries.
1.1.4.3.3 Supply of all the final control elements (on / off valves, control valves, motorised valves, I/P converters etc.
1.1.4.3.4 Supply of all Instrument and control cables and accessories like cable trays, conduits, supports etc.
1.1.4.3.5 Supply of a Digital local gauge panels housing the temperature gauges, pressure gauges, speed indicator etc. with all the accessories.
1.1.4.3.7 Supply of all the transducers related to power generation / monitoring for the generator and other feeders.
1.1.4.3.8 Submission of all the control schemes & interlocks / start / stop procedure in the form of logic diagram.
1.1.4.4 Civil
Supply of all foundation material and embedment required for the equipment within the scope of supply. Supply of all grouting materials required for the equipment falling under the scope of supply. The scope shall also include supply of all structural materials as required for mounting the base frames of the switchgears / panels under the scope of the BIDDER.

1.1.4.5 Consumables
Specifications including brand names and quantities of all consumable materials such as

lubricants, flushing oil, hydraulic fluids etc., required for start up, initial filling, commissioning and performance tests and yearly requirements of the same for normal operation are to be submitted by the BIDDER.

However, supply of all consumables required for start-up, commissioning, initial filling and performance tests is included in the scope and shall be supplied by the BIDDER at appropriate time.

1.1.4.6 Spare Parts

The supplier has to supply spare parts sufficient for two years of normal trouble free operation shall be in scope of supply.

The BIDDER shall include the commissioning spares along with the main equipment as per the BIDDER's experience, for replacement of damaged or unserviceable ones during the execution of the project at site, to avoid delay in the project schedule.

1.1.4.7 Special Maintenance Tools and Tackles

One set of special tools and tackles, as per the Annexure enclosed to this section, required for operation maintenance, inspection and repair, neatly packed in steel boxes complete with instructions for the Turbine, Generator and all other Equipment covered in this scope of work.

1.1.5 Scope of work for Erection and Commissioning

1.1.5.1 Unloading, handling and storage at site, pre-fabrication/assembly if any, erection, testing, commissioning, trial operation, final painting and guarantee performance testing of one (1) No. Turbo generator of rating as specified in this tender documents with all necessary accessories and auxiliaries as well as associated electrical and instrumentation and control equipment, as specified. The scope of work shall include all the systems and equipment included under clause 1.1.2.

1.1.5.2 Services Under Scope of Erection and Commissioning

1.1.6 Providing warehousing, testing facilities, facilities for BIDDER's personnel, obtaining approvals from statutory authorities and providing required documentation, data etc. All Equipment and Instruments required for erection, start-up, initial filling, commissioning and performance guarantee test. The CONTRACTOR shall arrange the visit of specialist for the commissioning of major auxiliary equipment:

- Oil Pump
- Generator
- AVR
- Battery & Battery charger
- Governor

Training of PURCHASER's personnel

1.2 **Terminal Points**

1.2.1 Mechanical

1. Steam

Main steam	:	From CSDH
Exhaust steam	:	TG Outlet up to distillery distillation header.
2. Cooling water for TG auxiliaries	:	From cooling tower.

1.2.2 Electrical

1. LT power At the outgoing terminals of 415V MDB Pannel.
2. Outgoing of Alternator to Breaker panel and Breaker to MDB by Bus Bar and Bus ducting
3. Entire earthing system.
4. 220V AC single Phase Supply At One point in the Power House.

1.2.3 Control and Instrumentation

Cable termination up to Junction Box and DCS at control room

1.3 Exclusions

1.3.1 Mechanical

Plant steam header, Steam and water piping beyond terminal points.
All air/water/steam piping and vessels other than those required within the scope of work.
Lubricants (other than the initial fill)
Fire detection and Protection System.

1.3.2 Electrical

All, plant communication system
Local Push Button (PB)stations

1.3.3 Control & Instrumentation

The control room with air-conditioners.

1.3.4 Civil

Design and Construction of buildings, foundations for all the equipment, trenches, other civil works and Soil investigation.

Annexure 1.1 - List of Two year Operational Spares

Sl. No	Name of the Spare Part	Qty.	Unit Price	Total Price
A	STEAM TURBINE & GEAR BOX	1 set		
1	Radial and Thrust Bearing Pads	1 set		
2	Reduction Gear Bearing	1 set		
3	Spring for Over speed Trip Device	1 set		
4	Gasket for Governor Valve & Emergency Stop Valve	1 set		
5	Labyrinth Packing with Spring (Outer Gland)	1 Set		
6	Oil Scrapper Rings for Oil Glands	1 Set		
7	HP Control Valve Gland Packing	1 Set		
8	LP Control Valve Gland Packing	1 Set		
B	GENERATOR			
1	1 set of rotating diodes of 6 Nos.	1 Set		
2	Bearing for AC Generator	1 Set		
3	Duplex RTDs for Bearing	2 Nos.		
C	MISCELLANEOUS			
1	Cooling Tubes for Air Cooler	10%		
2	Sheet Packing for Air Cooler	1 set		
3	Oil Seal for Main Oil Pump	2 sets		
4	Oil Seal for Aux. Oil Pump	2 sets		
5	Oil Seal for Emergency Oil Pump	1 set		
6	Elements for Lube Oil Filter	2 sets		
7	Packing for Lube Oil Filter	2 sets		
8	Elements for Control Air Filter	2 sets		
9	Packing for Control Filter	2 sets		
10	Control valve for each type			

10.1	Trim	1 No.		
10.2	Gasket	1 No.		
10.3	Gland packing	1 No.		
11.	Instruments			
11.1	I/P convertor	10% or min. 1 no. of each type		
11.2	Pressure gauges			
11.3	Temperature gauges			
11.4	Pressure switches			
11.5	Temperature switches			
11.6	Thermocouples			
12.	Gate, Globe & Check Valves			
12.1	For each size, rating, type & material10% (or min. 1 No.) for sizes NB 50 and below	1 No.		
12.2	For each size, rating, type & material10% (or min. 1 No.) for sizes NB 50 and below	1 No.		

Annexure 1.2 – List of Special Tools and Tackles

Sl. No	Item	No.
01	Spanner for Coupling Nut M30	1
02	Spanner for Coupling Nut M48	1
03	Spanner	1
04	Hook Spanner 100	1
05	Pin Spanner	1
06	Single end Ring Spanners	1 Set
07	Single end Open Jaw Spanners	1 Set
08	Double end Box Spanners	2
09	Allen Keys	6
10	Eye Bolts	5
11	Angle Screw Driver	1
12	Engineer Screw Driver	3
13	Cutting Plier	2
14	Pin Spanner	1
15	Solid Single end Box Spanner	3

Note: The above lists are the minimum requirement. Bidder to include any others spares / tools and tackles that are required for his equipment.

2. PERFORMANCE PARAMETERS

2.1 Performance Parameters for the backpressure TG

The following give the performance parameters for the backpressure TG:

Sl. No.	Description	
1	Turbine Type	Backpressure
2	Inlet Steam Parameters	
	Pressure (Ata)	43
	Temperature (^{0}C)	390
	Flow (Kg/Hr)	38000
3	Turbine exhaust Pressure at nozzle (ata)	5.5
4	Required steam temperature (^{0}C)	160
5	Cooling Water Inlet Temperature (^{0}C)	32
6	The economical steam rate required at percentage load (%)	80-100%
7	Power at the generator terminals (MW)	3.0 MW To be specified by Bidder
8	Power factor (lagging)	0.8
9	Generation Voltage (V)	440 +/- 10%
10	Amb. temperature for electrical equipment design (^{0}C)	50
11	Duty Requirements	8000
12	Atmospheric Conditions (as prevalent in a distillery)	Dusty

13	The maximum noise pressure level at 1.0 m distance for any equipment from the equipment surface shall be equal to or less than (db(A))	85
14	The minimum continuous load at which the TG is expected to operate as a percentage of the MCR load(%)	15

Notes :

1.0 Asbestos material shall not be used anywhere in the system.

2.0 The new TG shall run in island mode individually.

3. DETAILED TECHNICAL SPECIFICATION FOR STEAM TURBINE AND AUXILIARIES

3.1 General

This section of the technical specification defines minimum technical requirements for design, manufacturing, supply, installation testing and commissioning of the steam turbogenerator system with all the accessories and auxiliaries.

3.2 Conditions of Service

3.2.1 The steam turbogenerator will be installed in a separate power house, along with all their respective auxiliary equipment and systems.

3.2.2 The turbine controls shall be located in the control room, located adjacent to the turbogenerator, whereas important indicating instruments shall be provided nearthe respective turbines in the local gauge board. Emergency stop arrangementsshall be provided in the local gauge board.

3.3 Codes And Standards

3.3.1 All equipment, systems, hardware, and services covered under this specification shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment and systems, if required by virtue of their country of origin, shall also conform to the latest applicable INDIAN/ BRITISH/ AMERICAN/ GERMAN/ FRENCH/CSN standards. The following specific standards are applicable for the major equipment and system in the turbine package.

Turbine:

IEC Recommendation Publication No: 45

CSN 080030

DIN 1943

TEMA

ASME Section VIII

Piping:

ASME B31.1

Any other established national and international standards equal to or superior to the above may also be used.

3.3.2 The BIDDER shall furnish English translation of all standards for which his equipment and systems offered are conforming to.

3.3.3 In the event of any conflict between the codes and standards referred to, and the requirements of these specifications, the more stringent of the two shall govern.

3.4 Design and Engineering

3.4.1 The BIDDER must offer a very reliable and efficient system with state-of-the-art proven design with good performance over a long period. The BIDDER shall offer the system including (but not limited to) the following design and engineering features:

- Highest possible thermal and energy efficiency.
- State- of-the-art technology and well proven in actual operation over a long period.
- Rugged, conservatively designed, proven components and systems.
- Minimum outage for field maintenance and routine inspection .
- Better operability at various load conditions.
- Advanced instrumentation, control systems, shut-down and protection system, very reliable online supervisory and surveillance system, with diagnostics.
- Minimum requirement of operating and maintenance man- power and amenability to unattended automatic operation.
- Suitability for harsh tropical ambient conditions prevailing at site.
- Simple design and ease of installation.

The BIDDER may incorporate additional features and improvements to enhance the efficiency and reliability of the system.

3.4.2 The turbine shall be horizontal, single cylinder, backpressure type. The exhaust steam from the turbine will be at 5.5 ata.

3.4.3 All casings and stator blade carriers shall be horizontally split or otherwise and the design shall be such as to permit examination of the blading without disturbing shaft alignment or causing damage to the blades. The design of the casing and the supports shall be such as to permit free thermal expansion in all directions. The casing shall also permit the inspection of the bearings without dismantling of the casing. The exhaust branches shall be located on the Top half of the casing.

3.4.4 The turbine shall have solidly forged and machined rotor with integral disks. The rotor after fully machined and bladed shall be dynamic balanced accurately in the shop and shall be given a over speed test under vacuum. None of the critical speeds of the rotor shall fall within the range of 20% above and 20% below the normal running speed of the rotor. The BIDDER, shall analyze the complete coupled train for both lateral and torsional vibrations, and ensure proper separation margins. The rotor shall be designed to withstand the maximum shock loading that may occur during any power system disturbance. Such shock loading values shall be taken for the design of the gear box and the generator rotor. The BIDDER shall clearly describe in his offer, the construction of the rotor, the heat treatment proposed and the procedure for inspecting the shaft to ensure soundness and homogeneity of the material. The material of construction shall be consistent with proven practices and standards.

3.4.5 The blading shall be designed to withstand all vibrations, thermal shocks, and other loading that may be experienced during service and system disturbances. The blades shall be machined from forged bars or die forged and the materials used shall be chromium steels suitable for the temperatures encountered, resistant against corrosion and erosion and consistent with proven experience and standards. In the low pressure stages, if warranted where the moisture percentage is higher, additional protection against erosion shall be

provided.

The blading depending on the staging shall be adequately fastened as per the standard practice of the BIDDER, but such methods of fixing the blades shall be a proven one by long use in operation. The rotating blades are either shrouded or tied with lacing wires depending on the stresses and the excitation frequencies, and the offer shall indicate the arrangement.

3.4.6 Gland Sealing System

The glands shall preferably be of labyrinth type and sealed with steam. The gland packing shall be of 13% chromium stainless steel. The labyrinths shall be of multi-section spring backed type which would allow for any temporary deformation of the rotor shaft without overheating the rotor due to friction. Any other sealing system compatible with the operating conditions may also be furnished, but however the details of the offered system shall be furnished in the offer. The complete piping, valves, pressure gauges, regulators etc. required for the end seals shall be provided by the BIDDER. During the normal operation of the turbine the source of sealing steam will be from the turbine.

3.4.7 Bearings

The Turbine shall be provided with liberally rated hydrodynamic radial and thrust bearings. The radial bearings shall be split for ease of assembly, and of the sleeve or pad type, with steel shell backed, babbitted replaceable pads. These bearings shall be equipped with anti rotation pins and shall be positively secured in the axial direction. The thrust bearings shall be of, Mitchell tilting pad type, the steel backed babbitted multiple segment, designed for equal thrust capacity in both directions. A liberal flow of lube oil under pressure shall be supplied to all the bearings for lubrication and cooling. All bearings shall be accessible without having to remove cylinder covers. The metal temperatures of all the bearings shall be monitored by thermocouples with extension right into the white metal layer. Provision shall be made for measuring the temperature of the oil leaving the bearings.

3.4.8 Lubrication and control oil system

3.4.8.1 A pressure lubrication and control oil system shall be furnished for the turbo generator unit to supply oil at the required pressure to the steam turbine, gear box, generator and governing system. The lubrication oil system shall supply oil to the turbine generator under all the load conditions, including the turning gear operation. The oil system of the turbogenerator shall be designed with adequate redundancy and emergency provisions such that a failure of a single active component will not prevent the safe operation or a safe shutdown of the turbogenerator. Oil in the reservoir shall be maintained at an appropriate temperature when the TG set is idle by providing suitable electric heaters and temperature controls if required. For the hottest ambient conditions to be encountered at the site the oil outlet temperature at any bearing shall neither exceed the maximum permissible temperature for the bearing metal nor the maximum safe operational temperature of the oil.

3.4.8.2 The oil system shall include the following:

- One hundred percent (100 %) capacity centrifugal/gear type, Main oil pump shall be driven by A.C electric motor driven main oil pump.
- One (1) No. of one hundred (100 %) capacity A.C motor driven auxiliary oil pump of

centrifugal type, arranged to cut in automatically if the oil pressure falls to a preset value. This pump shall also meet the requirements during the start up and shutdown.

- One (1) D.C motor driven, centrifugal type, emergency oil pump of adequate capacity to provide adequate lubrication in the event of a failure of the A.C motor driven pump(s). This pump also shall cut in automatically at a pre set value of the oil pressure. The minimum capacity of this pump shall be to ensure a safe shutdown of the turbogenerator. All the above pumps shall be provided with mechanical seals.
- Two 100 % capacity (one working and one standby) water cooled oil coolers.
- Two 100 % duty oil filters arranged in such a way that it is possible to clean one oil filter while the other is in service. The filters and the coolers shall be arranged with continuous flow transfer valves.
- Oil storage and settling tank with adequate reservoir capacity, strainers, level indicators with float switches and alarm contacts, vent and oil mist eliminators and 2x100% capacity vapour exhaust fans.
- Flow and temperature indication for oil from every bearing.
- Centrifugal oil purifier with drives, interconnecting piping and valves.
- Emergency gravity lubricating oil system

If the system envisages separate control oil circuit from the lube oil system, there shall be independent two nos. of control oil pumps and 2 x 100 % duplex oil filters for the control oil circuit. The auxiliary oil pumps and the emergency oil pumps shall be arranged to have flooded suction.

Supply of the flushing oil and the first fill up of lube oil for the turbine and accessories shall be the responsibility of the BIDDER and preferably from the Indian market.

3.4.8.3 Oil coolers

The oil coolers shall be water cooled with a duplex arrangement and changeover valves. The coolers shall be of shell and tube type with removable tube bundle. The coolers shall be constructed in accordance with TEMA class C. The provided surface area shall be adequate to cool the oil with the inlet cooling water temperature indicated in the design basis, even with 20 % of the tubes plugged.

The cooler shall be of vertical type. The sizing of the coolers shall consider a tube side (water side) fouling factor of 0.0002 Hr.Sq.M.Deg.C/Kcal. The water velocity shall be not less than 1.5 M/sec. The coolers shall be amenable for easy inspection and maintenance and cleaning of one cooler while the other one is in service shall be possible. Necessary lifting lugs shall be provided. The cooler tubes shall be of admiralty brass, and the body and the tube sheets shall be of carbon steel conforming to IS 2062 Grade A or equivalent standards. The oil cooler shell side shall be designed for shut off head of the oil pumps and the tube side shall be designed for a pressure of 6 kg/Sq.cm (g). A corrosion allowance of a minimum of 3 mm shall be applied to the design thickness of each of the component, other than the tubes.

3.4.8.4 Filters

Full flow twin oil filters shall be used, for the lube oil, downstream of the coolers and shall be piped in a parallel arrangement with a continuous flow transfer valve with necessary two way change over valves. Filter size shall be 25 microns nominal for the lube oil. Filter cartridges shall have a minimum collapsing differential pressure of 3.5 Kg/Sq.cm. The

minimum design pressure for the filters shall be the maximum discharge pressure of the oil pumps. Differential pressure gauge with alarm shall be provided across the filters. The filters shall be either common or separate for the lube and control oil circuits. The filter grade for the control oil shall be 10 Microns nominal. If a common filter is used for lube and control oil, the filter grade shall be 10 microns nominal.

3.4.8.5 Oil reservoir

The interior of oil reservoirs shall be desalted and rust proofed with a permanent coating. Reservoirs with top mounted equipment shall have sufficient rigidity. All openings for piping shall be made dust and water proof. The oil reservoir shall be so located to permit draining of the contents by gravity and shall be equipped with fine and coarse mesh strainers. The oil drained shall be collected in a drain oil tank/collecting tank of suitable capacity located on the ground floor of the TG building and two numbers of drain oil pumps will be provided to pump the oil back to the oil reservoir (in case of overflow from the oil reservoir) to outside the TG building for disposal.

The reservoir made of carbon steel conforming to IS 2062 Grade A or equivalent material, and shall be of adequate capacity. The reservoir shall be provided with 2x100 % oil vapour extractors for proper ventilation. All necessary piping connections, valves and fittings, level switches and level gauges shall be provided. Corrossion allowance of 3 mm shall be considered while designing the system.

All necessary piping, valves and fittings for the complete oil system shall be provided by the BIDDER. The piping from the outlet of the filters and upto the user point shall be of stainless steel. The piping from the reservoir to the filters and the return oil piping shall be of carbon steel. The complete piping shall meet the requirements of API 614. The flanges provided in the stainless steel oillines downstream of oil filter shall be LJFF type if the flange is of carbon steel material or SORF if the flange is of stainless steel material. If stainless steel material is used they shall confirm to SA 182 F 304 specification.

3.4.8.6 Oil purifier

A centrifugal type oil purifier shall be provided for the removal of water, sediments and other oxidation products from the Lube oil system on a continuous basis. The purifier shall be a separate complete package, mounted on a skid, complete by itself with drive motor, piping, valves and fittings. The capacity of the purifier shall be atleast two (2) percent of the rate of normal flow through the reservoir. Feed to the purifier shall be from the drain end of the reservoir and it's operation shall be independent of the oil system.

3.4.8.7 Emergency Oil Tank

Emergency gravity lubricating system shall be provided to assure the lubrication at the time of an emergency due to the failure of the DC operated lube oil pump. This system shall draw lube oil from a overhead tank, under gravity, and shall be designed to supply oil for the coasting down period of the machine. The overhead tank shall be SS lined and the complete piping to and from the tank, shall be of SS 304 material. The tank elevation shall be finalised based on the oil pressure requirements at the bearings. The system shall be designed with continuous overflow circulation of oil to avoid

sludge formation in the tank. The Vent / overflow of the emergency overhead oil tank shall be brought down to the oil reservoir or to the collecting tank, if a separate tank is provided for collecting the oil overflow from the emergency oil tank. This is required to ensure that there is no dust ingress into the oil system while the oil is drained from the emergency oil tank.

3.4.9 Steam Turbine Governing System

The turbine governing system shall be electro-hydraulic designed for high accuracy, speed and sensitivity of response. The electrical/electronic and hydraulic components of the control system shall be selected on the basis of reliability over a wide range of operating conditions. All components used shall be well proven to assure overall system reliability and shall be designed for easy and quick replacement when necessary. The governor shall be configurable in the field. The governor shall ensure controlled acceleration of the turbo generator and shall prevent overspeed without tripping the unit under any operating condition or in the event of maximum load rejection. The governor shall have linear droop characteristics with a suitable range for stable operation and shall have provision for adjusting the droop in fine steps.
The governing system shall have the following important functions:

- Speed control
- Over speed control
- Load control
- Inlet Steam Flow

3.4.10 External Forces and Moments

The BIDDER shall furnish the allowable forces and moments on the turbine nozzles. As a minimum requirement the turbine shall be designed to withstand the external forces and moments calculated in accordance with the requirements of NEMA SM 23. The BIDDER Shall also furnish the thermal expansion movements on each of the nozzles in the turbine.

3.4.11 Thermal Insulation and Lagging

The steam turbine and the other high temperature parts, including piping supplied, shall be insulated with low conductivity inert material, where required, reinforced by stainless steel wire net between applied layers. The insulation shall be so arranged that it can be removed for access to the flange bolting, control valves and other parts that require periodic maintenance. The insulation shall be designed, such that the outer surface temperature of the insulation does not exceed 20 Deg.C above the ambient temperature.

3.5 Capacity And Performance Requirement

3.5.1 Turbine Generator Rating

The turbine rating and other performance criteria shall be as specified in the section on Performance Guarantee.

3.5.2 Extractions

The turbine shall be provided with exhaust at pressure 5.5 Ata and temperature 160^0C.

3.5.3 Economic Load

The specific steam consumption shall be the lowest for operating loads between 80 to 100%.

3.5.4 Over Loading

The system offered shall be suitable for an occasional over load of 10% of the rated capacity.

3.5.5 No load and Minimum load operation

The turbine shall be capable of operating under no load condition during loss of load for a maximum period of 60 minutes. The minimum load at which the turbine is required to operate continuously shall be 15% of the designed capacity.

3.5.6 Specific steam consumption

This guaranteed specific steam consumption/heat rate shall be for a load range of 80 to 100 percent of rated capacity and the testing shall be as per IEC Recommendations Publication 46.

3.5.7 Governing Characteristics

When the machine is operating with rated steam conditions and at rated speed, and the maximum load is thrown of, the operation of the electronic speed governor shall prevent the speed rising to a value at which the over speed trip is set to operate.
The speed governor droop, i.e. permanent speed variation from no load to rated output etc., shall be within the limits specified in IEC Recommendations Publication 45.

3.5.8 Parallel operation

The characteristics of the turbine shall be such that the turbine generator set can be run in parallel with the other generator, State power grid and/or with the machine to be added later on and possess no abnormal features either individually or collectively.

3.5.9 Speed adjustment

The turbine speed at no load shall be adjustable between 6% below and 6% above rated speed.
Means are to be provided whereby the speed of the turbine at no load can be raised in a controlled manner for the purpose of testing the over speed trip mechanism and provision made to ensure that such means do not interfere with the action of the speed governor in normal operation. The device to raise speed at no load must incorporate limiting means to prevent it from reaching a dangerous speed.

3.5.10 Over speed trip

In addition to the speed governor, the turbine and generator shall be protected against excessive over speed by a separately actuated overspeed device which operates the trip

system. In the event of sudden load rejection, should the speed governor fail to meet the requirements the overspeed trip shall operate to prevent any damage. The overspeed trip setting shall be stated by the BIDDER in his offer and in the operating instructions. The over speed trip mechanism shall be capable of being reset when the speed of the turbine has decreased to a speed not lower than the rated speed. The Over speed trip circuit shall be with 2 out of 3 logic.

3.5.11 Trip system

The turbine shall be provided with a trip system for the complete and rapid closure of steam valves effectively preventing all steam admission to the turbine independently of the closure of the governing valves. In order to avoid sudden re-admission of steam to the turbine the trip system shall be fitted with interlocking devices so that trip resetting cannot take place until steam admission can only be achieved as per normal starting up procedure. Trip Parameter shall have 3 Inputs Essential trip circuits to be provided are:

- Steam inlet pressure falling below pre-determined level.
- Steam temperature falling below pre-determined level.
- Lubricating oil pressure falling below pre-determined level.
- Axial thrust wear trip.
- High temperature trip for LP stage steam flow.
- Relative Shaft Vibration very high
- Bearing metal temperature very high
- Excessive differential expansion or axial displacement.

3.5.12 Maximum speed

An overspeed test of the turbine rotor shall be carried out preferably at the BIDDER's works. The overspeed tests shall be at a speed exceeding by 2% the maximum calculated overspeed that would occur if the speed governor failed and if the maximum overspeed was limited by the action of the overspeed trip device only. The duration of the over speed test shall be less than 2 minutes. The overspeed shall not be more than 20% of the rated speed.

3.5.13 Vibration

The foremost in the Turbine Supervisory Instrumentation system is the vibration measurement which provides the basic protection to the Turbogenerator. The system of vibration measurement shall include shaft radial vibrations at the radial bearings, axial displacement and thrust position, Speed, shaft eccentricity and differential Expansions. The shaft radial vibration measurement shall employ proximity probes in the X-Y configuration in two orthogonal directions in each bearing. For the measurement of the thrust position two proximity probes shall be employed in a dual voting arrangement. Vibration measuring and monitoring systems of reputed make (Bently Nevada make of the latest 3500 series system is preferred) shall be provided for measuring the shaft vibration of turbine, gearbox and generator. All the bearings of the turbine, gear box and generator shall be provided with the probes for measurement. The maximum allowable vibration under any specified operating conditions shall be indicated by the BIDDER. The detailed specification is indicated in Instrumentation section.

3.5.14 Critical speed

The critical speed for the combined turbine and generator train shall be sufficiently away from the rated speed to avoid any adverse effect on the operation of the unit over the range of operating speeds.

3.5.15 Hydraulic test

All parts subjected to steam pressure shall be tested hydraulically for a pressure of 1.5 times the working pressure. For those parts which are made of materials which may be damaged by such tests the test pressure shall be agreed by the PURCHASER and the BIDDER during contract stage.

3.5.16 Materials of construction

The selection of materials for parts of the machine shall be based on the experience of the BIDDER and experimentally determined data and shall conform that under conditions of stress, temperature and time the components will not fracture or deform to a greater extent than is permissible. The materials selected shall be clearly indicated in the turbine and auxiliaries data sheets.

3.5.17 Variation of steam pressure and turbine

The turbine shall be capable of accepting variations from the rated conditions within the limits specified by IEC Recommendation Publication 45.

3.5.18 Limit of lubricating oil temperature

The BIDDER shall furnish the permissible temperature for the bearing metal in his offer.

3.6 Safety

3.6.1 All controls shall operate in a fail safe mode.

3.6.2 All coupling and gears shall be provided with adequate guards.

3.6.3 Piping shall be arranged in such a manner as to avoid tripping or overhead problems. Piping or tubing of insufficient mechanical strength which is standing or hanging shall be protected from personnel traffic.

3.6.4 Surface temperature on any point shall not exceed 60 Deg.C.

3.6.5 Very high standard of safety shall be built into the set with high degree of redundancy.

3.7 Gearing

3.7.1 Gear Box

The reduction gear box between the turbine and the generator, if provided, shall be of proven design of double helical type with a minimum service factor of 2.2. The gear and pinion teeth shall be case carburized and ground to an accuracy class of 4 or higher to DIN Standards. The hardness of the teeth shall not be less than 58 in the Rockwell Hardness Scale. The overlap ratio shall be adequate to ensure a quiet operation. The gears shall be dynamically balanced before assembly. A turbine directly driving the alternator with out a gear box in between is also acceptable. The gear box shall be capable of transmitting the maximum rating of the set and be able to withstand 20% overspeed over a period of minimum five (5) minutes. The gear box shall also be designed for the short circuit condition of the generator. All bearings of the gear box shall be readily renewable and shall be possible

to inspect the bearings and the gears readily without disturbing the shaft alignment. Illuminated sight glasses shall be provided to inspect the lube oil drain from each individual bearing. The gear box design shall be as per the requirements of AGMA. The flexible couplings between the turbine and the gear box and between the gear box and the generator shall be of reputed make. Only flexible couplings will be acceptable at the above mentioned two locations. The power rating of the coupling shall be at least equal to the turbine rated power times the service factor in accordance with AGMA 514. Suitable acoustic cover made of solid castings shall be provided. The fasteners provided in the high speed and low speed coupling shall contain within the enclosure.

3.8 Base Frame

Suitable base frame either common or individual shall be provided for the turbine, generator and the gear box. Provisions shall be made to level each piece of equipment separately.

3.9 Control System for Steam Turbine

The detailed requirements are given in Section 11 of this specifications. It is the responsibility of the turbine BIDDER to provide all the controls, instrumentation and gauges required for the safe and efficient operation of the turbine system. All the systems supplied shall be the latest, most reliable and microprocessor based. The BIDDER shall furnish the complete technical information supported with catalogues and logic diagrams in his offer so as to enable easy understanding of
the systems offered.

3.10 Tests And Inspection

3.10.1 The PURCHASER/CONSULTANT shall be advised on the provisional test date at least 30 days in advance of the scheduled test date and the final test date at least 15 days prior to the tests. The PURCHASER / CONSULTANT may choose to witness the important tests.

3.10.2 The entire turbine generator package instruments controls and safety devices must be assembled and tested/calibrated to check all instruments, control and safety systems and total system operation thereby ensuring minimum commissioning/installation time at site. Instrument panels shall be tested by simulation techniques.

3.10.3 The BIDDER shall guarantee the PURCHASER and/or his representatives unrestricted entry to his/his sub-vendors works where the concerned equipment is being manufactured / tested / packed.

3.10.4 The BIDDER shall, in his offer, include a detailed quality plan indicating the various tests to be conducted both in the shop and at site. All tests called for by the applicable IEC recommendations and wherever necessary API Standards shall be conducted. As a minimum requirement the following tests shall be conducted.

- Hydrostatic test on turbine casing.
- Complete unit test.
- Over speed test under vacuum.
- Rotor static and dynamic balance.
- Check bearings and seals after the test.

3.11 Turbine Starting Time

The turbine shall have the following starting time from stand still to full load:

Cold start	45 Minutes
Hot Start After 8 Hrs Shutdown	20 Minutes

3.12 Piping, Valves and Specialties

3.12.1 General

The scope of work covered by this specification includes design, engineering, supply, fabrication, delivery, unloading, handling at site, erection, cleaning, testing, painting and commissioning of all piping system complete with accessories within the terminal points indicated elsewhere in the specification. The piping provided shall be complete in all respects including valves, specialties, supports, thermal insulation etc. as required.

3.12.1.1 The flow diagrams enclosed in the bid document are only intended to indicate the general scope and nature of work to be carried out and do not indicate the exact quantum of work to be carried out by the BIDDER.

3.12.2 Scope of Supply

3.12.2.1 For all the piping systems included in BIDDER'S scope of supply shall include but not limited to:

a. Pipes, Tubes, Headers and Manifolds.

b. Bends, Elbows, Returns, Tees, Laterals, Crosses, Reduces, Caps and Closures, Full & Half Couplings, Plugs, Sleeves & Saddles, Stubs & Bosses, Reinforcement pads, Unions, Weldolets, Sockolets, Threadolets and other similar fittings.

c. Valves

d. Flanges, Gaskets and Fasteners.

e. Complete assemblies of supports, anchors, guides, restraints etc, including welded attachments etc.

f. Auxiliary Steel, Concrete Foundations, Pedestals etc. as required for Hangers, Supports, Guides, Restraints, Anchors etc.

g. All Paints, Varnishes, Primers, Thinners and other Painting Materials.

h. Weather hoods for Pipes, Crossing Ceilings and Walls.

i. All instrument impulse piping and fittings up to the last root valve.

j. In case of temperature measurement points, BIDDER'S scope includes the supply of thermo well stubs with plugs.

3.12.2.2 BIDDER shall supply all necessary drains and vents including anti-flash funnels as required for the safe and effective draining / venting of the piping systems. It must be noted that the flow diagrams may not indicate all the drains and vents that would be required. It is BIDDER's responsibility to identify the requirements of drains and vent whether the same have been shown in the flow diagrams or not and supply the necessary pipe work, fittings, hangers and supports etc. The drains and vents indicated on the flow diagrams shall however be regarded as minimum requirements. The drains and vents shall be led up to the nearest floor drain in case of cold water systems and up to the flash tank in case of steam

and hot water systems, all as erected by the PURCHASER.

3.12.2.3 Wherever uninsulated pipes cross walls or roofs, the necessary weather hoods shall be supplied by the BIDDER as directed by PURCHASER. Where required, BIDDER shall make openings in floors, walls, gratings etc. for routing the pipes and provide proper finishing after piping is erected.

3.12.3 Scope of Erection

3.12.3.1 Where BIDDER's scope ends adjacent to equipment or piping installed by others, the final joint shall be made by the BIDDER. If at his terminal connections or at connections to online specialities, the same shall be erected by the BIDDER. Necessary gaskets and fasteners are included in BIDDER's scope of supply.

3.12.3.2 All valves, strainers, traps, flow nozzles orifices, orifice plate assemblies, flow meters, sight flow indicators and other online specialities supplied by others but which form a part of the piping systems erected by BIDDER shall also be installed by the BIDDER to render the systems complete within his terminal points.

3.12.3.3 BIDDER shall erect all instruments impulse piping and fittings from the tap-off point of the last root valve including the root valve as per the requirements of the flow diagrams.

3.12.3.4 BIDDER shall also install small accessory piping and any specialties furnished with or for equipment such as relief valves, built-in-bypasses etc.

3.12.3.5 BIDDER shall perform necessary internal machining of pipe for installing orifices, flow nozzles etc.

3.12.3.6BIDDER shall install thermowells to be supplied by PURCHASER prior to hydro testing of the piping systems. In the event of non-availability of thermowell in time, BIDDER shall provide necessary plugs to carry out the hydraulic testing of the piping systems.

3.12.3.7BIDDER shall thoroughly inspect and clean all valves and specialties before erection on the pipe lines.

3.12.3.8 BIDDER shall carry out blue matching of all high pressure flanges (greater than ASME 300 lbs rating or equivalent) erected by him. Any defects in the surfaces of flanges shall be rectified by him by lapping as directed by the PURCHASER.

3.12.3.9BIDDER shall check all fabricated components reaching site from his own works or components supplied by other Contractors / Vendors and ensure that they correspond dimensionally to the fabrication drawings / layout drawings. In the case of any defect in the piping components supplied by his works, he shall take necessary steps to rectify the defective components. In the case of components supplied by others, he shall notify PURCHASER immediately of the defects observed in order that timely action can be taken or the corrective measures to be adopted well in advance of erection.

3.12.3.10The following shall also be included in the erection and testing :

a. All welding consumables like welding electrodes, filler rods and wires, gases like oxygen, acetylene, argon, carbon-di-oxide, backing rings etc.

b. Films of radiographic examination of welds.

c. X-ray and Gamma-ray equipment including isotopes, dye penetrants, and other required non-destructive testing materials and equipment (all to be taken back by the BIDDER after completion of work).

d. All heating and stress relieving equipment, thermocouples, asbestos, blankets, cables, temperature recorders and charts, heat sensitive chalks and crayons etc. (all to be taken back by BIDDER after completion of work).

e. All machinery, equipment tools and tackles as required for transportation, handling, fabrication and erection (all to be taken back by BIDDER after completion of work).

f. All equipment and materials as required for cleaning, flushing, blowing out and testing of the piping systems. These shall include but not be limited to pumps and compressors with prime movers; instruments; pipe work with supports; valves, strainers and other specialities, blanks, plugs, spool pieces, dummy plates; electrical accessories etc. (All to be takenback by BIDDER after completion of work).

g. All scaffolding materials (to be taken back by BIDDER after completion of work).

h. Services of erection superintendent, supervisors and foremen, fitters and riggers, welders, transport and crane operators and other skilled and unskilled labour.

i. Following completion of erection, cleaning and testing, the plant will be placed under trial operation by the PURCHASER. During this period, all adjustments and repairs such as required shall be made by the BIDDER. On completion of the satisfactory operation, the plant will be placed on commercial operation by PURCHASER. The system supplied and/or erected by the BIDDER shall perform satisfactorily and continuously after the unit has attained its rated full load for a period of seven days. During this period, if any adjustment or repair is required found necessary due to faulty workmanship, the same shall be carried out by the BIDDER at no extra cost to PURCHASER.

j. All temporary piping, tools, tackles, instruments etc. required for cleaning, hydro testing, steam blow out etc., of piping shall be included.

3.12.4 Design Requirements

3.12.4.1 The equipment and work under this specification shall conform to the following standards / codes:

a. Indian Boiler Regulations.
b. Indian Regulations of Inspector of Explosives.
c. Applicable Standards for Structural Steel.

i. IS: 800 : Codes of Practice for use of Structural Steel in general Building Construction.
ii. IS: 2062Grade A: Structural Steel (Fusion Welding Quality)

d. American National Standard ASME code for “Power Piping” - ASME B 31.1 and all other associated ASME Standards.

e. Manufacturer's Standardization Society (MSS) USA Standard Practices.

f. American Society of Testing and Materials (ASTM) Specifications.

g. American Society of Mechanical Engineers (ASME) Codes.

h. Pipe Fabrication Institute (PFI) USA, Standards.

i. American Petroleum Institute Standards (API).

3.12.4.2 While routing piping, the following requirements shall be taken into account by the BIDDER:

3.12.4.3 All piping shall be routed so as to avoid interference with other pipes and their hangers and supports, electrical cable trays, ventilation ducting, structural members, equipment etc. Adequate clearances shall be ensured with respect to the above to accommodate insulation and pipe movements.

3.12.4.4All piping shall be grouped where practicable and shall be routed to present a neat appearance.

3.12.4.5 The 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.

3.12.4.6 Piping shall generally be routed above ground but where specifically indicated / approved by the CONSULTANT, the pipes may be arranged in trenches or buried. Pipes at working temperatures above the ambient shall however not be buried.

3.12.4.7 Wherever pipes are to be bent, the bends shall be free from wrinkles and bulges. The bends shall be made by cold bending.

3.12.4.8 Overhead piping shall have a minimum vertical clearance of 2.3 meters above walkways and working areas and 6 meters above roadways unless otherwise approved by the CONSULTANT.

3.12.4.9 Drains shall be provided at all low points and vent at all high points as per actual layout regardless of whether the same have been shown in the flow diagrams are not. Pipelines shall be sloped towards the drain points.

3.12.4.10 Provision shall be made while preparing piping layout to accept control valves, flow measuring elements and any other on line speciality or equipment supplied by others. Sufficient upstream and downstream lengths shall be provided for flow measuring devices, control valves, desuperheaters and other specialities as required by the Suppliers.

3.12.4.11 At all screwed valves and screwed connections on equipment, unions shall be provided to facilitate disassembly. Likewise, unions shall also be provided at suitable points on straight lengths of screwed pipelines.

3.12.4.12 All local instruments shall be located on pipelines as to render them observable from the nearest available platforms and accessible for maintenance.

3.12.4.13 Piping with operating temperatures above or below the ambient shall be routed so as to provide adequate flexibility for the pipes.

3.12.4.14 Tap-off on main lines for field routed pipework, if not indicated on PURCHASER's layout drawings, shall be suitably located by BIDDER to suit the layout evolved by him.

3.12.4.15 All steam tracer lines shall be provided with expansion loops to take care of differential expansion between the tracer and main line.

3.12.4.16 Stubs for instrumentation, drains, vents etc. wherever not located on PURCHASER's piping layout drawings shall be suitably located by BIDDER in accordance with the flow diagrams and layouts.

3.12.4.17 At all intersection joints, it is BIDDER's responsibility to design and provide suitable reinforcements as per the applicable codes and standards.

3.12.4.18 BIDDER is responsible for the complete design and engineering of all supports, guides, restraints and anchors as required for the piping systems erected by him. BIDDER's scope of work shall include but not be limited to the location of all required hangers, supports, anchors, restraints etc. and the design and detailed engineering of individual components of the assemblies as also all associated steel work, concrete pedestals, foundations, welded attachments to piping etc. which form a part of hanger / support system. While the designs shall conform to applicable codes and standards and shall be consistent with international practice. Information contained in PURCHASER's drawings regarding support location, type and detail etc. may be used for guidance. This does not however relieve the BIDDER of his responsibility for the design and engineering of the support system.

3.12.4.19 The design and engineering of all temporary pipe work as required for erection, cleaning, flushing, blowing out, testing and commissioning of the piping systems installed by the BIDDER is the responsibility of the BIDDER.

3.12.4.20 Pipelines of NB 40 size and below are regarded as field run piping. It is BIDDER's responsibility to plan suitable layouts for these systems in-site as per the requirements of this specification and in consultation with PURCHASER and / or CONSULTANT. BIDDER shall prepare isometric drawings indicating the layout of field run pipe work.

3.12.4.21 The BIDDER shall design and prepare all fabrication isometric drawings for all IBR piping and NB 50 and above Non-IBR piping. BIDDER shall also submit orthographic drawing with Bill of Material for Non-IBR piping of size NB 40 and below.

3.12.4.22 The BIDDER shall ensure that the design is as per ASME B 31.1 and in addition, shall meet the statutory requirement of Indian Boiler Regulations. The BIDDER shall furnish the calculations for reinforcement for nozzle openings and calculations for welded attachments carried out on the piping.

3.12.4.23 All pipe to pipe joints shall be by butt welding only and no couplings shall be used.

3.12.4.24 All flanges of pressure class 300 and less than 900 shall be of weld neck type. For class 900 and above the flanges shall be WNRTJ type.

3.12.4.25 Pipe fittings like elbows, equal tees and reducers shall be as given below:

a) For pipe size 50 NB and above shall be butt welded type.

b) For 40 NB and below shall be socket welded type.

3.12.4.26 Branch connections:

Equal Branch:

a) NB 50 & Above - BW equal tee as per ASME B 16.9

b) NB 40 & Below - SW equal tee as per ASME B 16.11

Unequal Branch:

a. Branch up to NB 40 SW half coupling as per ASME B 16.11 to be used, for run pipe size NB 50 and above.
b. Branch NB 50 and above, branch piping with suitable reinforcement shall be used. However no reinforcement pads shall be used for applications with design temperature exceeding 300 Deg.C.
c. Equal tee with reducing coupling or reducer to be used for run size NB 40 and below.
d. No branch welding shall be used for equal branch, and only tees as per ASME B 16.9 or ASME B 16.11 to be used.

3.12.4.27 All pressure tapings for pressure applications above 40 Kg/Sq. Cm shall be of size NB 25 with two root valves. For pressures 40 Kg/Sq. Cm and less the size shall be NB 15 with one root valve (refer Fig. 1 attached at the end of the section). For temperature above 400^0C irrespective of pressures, the root valve size shall be NB 25.

3.12.4.28 All thermos well boss shall be one (1) inch NPT.

3.12.4.29 Pipe Sizing and Layout

3.12.4.30 The design of the piping system shall be based on the ASME B31.1 code. In addition the statutory requirements of the IBR shall also be taken care of wherever required. Flexibility analysis shall be made for all piping systems with operating temperatures above 100 Deg.C. The correct locations of hangers and supports, with as applicable spring stiffnesses, shall be considered for the flexibility analysis. Suitable expansion loops, restraints and anchors shall be provided so as to ensure compliance with the applicable codes and to limit the stress and reactions to within the allowable values.

3.12.4.31 All piping shall be sized considering the allowable velocity and allowable pressure drop in the system. The indicative flow velocities in pipes shall be limited to the following values. However, if the available pressure drops are to be maintained, the piping system may have to be selected even with a lower velocity than the minimum indicated.

Allowable velocities for sizing of pipes

Particulars	Average velocity in Meter / Second		
Nominal pipe size	Below 50 mm	50 to 150 mm	200 mm & above
Saturated steam at atmospheric pressure	-	10-15	15-20
Saturated steam at 0-1kg/cm^2(g) pressure	15-20	17-30	20-30
Saturated steam at 1.1-7kg/cm^2(g) pressure	15-22	20-33	25-43
Saturated steam over 7kg/cm^2(g) pressure	15-25	20-35	30-50
Superheated steam at 0-7kg/cm^2(g) pressure	20-30	25-40	30-50
Superheated steam at 7.1-35kg/cm^2(g) pressure	20-33	28-43	35-55
Superheated steam at 35.1-70kg/cm^2(g)	22-33	30-50	40-61

pressure			
Superheated steam at over 70kg/cm^2(g) pressure	22-35	35-61	50-76
Compressed Air	7-10	10-15	18
Pump suction condensate	-	0.4-0.6	0.6-0.7
Pump suction boiler feed water	-	0.6-0.9	0.6-0.9
Pump suction viscous liquid	0.6-0.9	0.7-1.3	0.9-1.5
Pump discharge condensate	0.3	0.3-0.4	0.4-0.5
Pump discharge boiler feed water	0.9-1.2	1.2-2.1	1.5-2.2
Pump discharge general service	1.0-1.2	1.5-2.1	1.8-2.4
Pump discharge viscous liquid	0.9-1.0	1.5-2.4	1.5-2.4
Header general water service under 2.0kg/cm^2 (g)	1.0	1.0	1.2-1.4
Header general water service 2.0kg/cm^2 (g) and up	-	1.3-2.0	1.8-2.4

Note: The above velocity values are indicative and showing the maximum limits of the flow velocity. Lower velocities may be selected if found necessary.

3.12.4.31.1 Drains at all low points and vents at all high points shall be provided.

3.12.4.31.2 All local instruments shall be located on pipelines so as to render them observable from the nearest available platform.

3.12.4.31.3 All pipe of size NB 50 & below shall be schedule 80 thickness for all applications.

3.12.5 Materials

3.12.5.1 Pipe materials for various services and materials for fittings, flanges, fasteners shall not be inferior to the specifications given below. All piping except, for cooling water, raw water, safety and relief valve exhausts, vents and air services shall be of seamless steel. For cooling water, raw water and air services the piping could be of ERW.

3.12.5.2 Piping for services with metal temperatures equal to or greater than 400 Deg.C and less than 510 Deg.C, 1 1/4% chromium, 1/2% molybdenum ferritic alloy steel seamless pipe as per ASTM A-335 P-11 or P12. Piping for services with metal temperatures higher than 510 Deg.C shall conform to the specifications of ASTM A-335 P22 (2¼ chromium 1 molybdenum steel) or its equivalent.

3.12.5.3 Piping for services at temperatures less than 400 Deg.C for steam, boiler feed, condensate, drain piping etc., carbon steel piping as per ASTM A-106 Grade B.

3.12.5.4 HP and LP chemical dosing system: Stainless Steel to SA 312 TP 304 specifications.

3.12.5.5 Other Services including cooling water piping: Carbon Steel Piping as per ASTM A-106

Grade B.

3.12.5.6 For the safety valve exhaust piping, where the exhaust steam temperature is less than 400 Deg.C, the piping material shall be IS 1239 Black Heavy Class for size up to NB 150 and as per IS 3589 for size NB 200 and above.

3.12.5.7 For raw water applications the piping material shall be IS 1239 Black Heavy Class for size up to NB 150 and as per IS 3589 for size NB 200 and above.

3.12.5.8 For Service air applications the piping shall be IS 1239 Black Heavy Class.

3.12.5.9 For instrument air applications: Stainless steel confirming to SA 312 TP 304.

3.12.5.10 For piping system where IS1239 or 3589 pipes are used, the fittings shall be as per A 234 as per ASME B 16.9 and ASME B16.11. All flanges shall be as per ASME 16.5.

3.12.5.11 All materials shall be certified by proper material test certificates. All material test certificates shall carry proper heat number or other acceptable references to enable identification of the certificate with the material it purpose to certify. The heat number shall also be indicated on the material certified.

3.12.6 Fabrication and erection

3.12.6.1 Pipelines NB 50 mm and above size are deemed prefabricated. BIDDER shall prepare necessary fabrication isometric drawings. BIDDER's fabrication drawings shall take into account the requirements of this specifications as also all applicable codes and standards including statutory regulations such as Indian Boiler Regulations. Fabrication and erection of piping systems NB 50 mm and above size shall be as per BIDDER's fabrication drawings. In case of systems requiring statutory clearance, fabrication and erection shall commence only after the necessary clearance have been obtained from the statutory authorities. BIDDER's fabrication drawings including isometrics, if required, shall carry all details of fabrication, welding etc. as may be required for obtaining the necessary statutory clearances.

3.12.6.2 Piping NB 50 mm and above size shall be fully fabricated at BIDDER's Works which shall be adequately equipped with the required machinery, templates, gauges, tools and tackles etc. Bidders shall indicate in their offer details of the facilities available at their works for fabrication of pipe work. The extent of fabrication at works shall be such as to restrict field welding to circumferential line joints alone. Further, the number of circumferential line joints to be performed in the field shall be held to a minimum, limited by transport considerations and erection constraints.

3.12.6.3 Pipelines having size NB 40 mm and below are deemed field run and are hence fabricated in site. For bends, only socket weld elbows to be used.

3.12.6.4 All welded attachments on pipelines shall be of same material as the parent pipeline and shall be subjected to the same fabrication and welding procedures as the associated piping.

3.12.6.5 The use of companion flanges to connect two pieces of pipe and the use of odd or short pieces of pipe in making up long runs is prohibited except as noted on PURCHASER's piping drawings.

3.12.6.6 Where welded pipe or fittings are used, longitudinal welds in adjoining sections shall be staggered to a minimum of 90 degrees during fabrication. All piping shall be fabricated true to lines and elevations as indicated on the piping drawings.

3.12.6.7 Bends in seam welded pipe shall be oriented so that the seam is positioned along the neutral axis.

3.12.6.8 No welding shall be carried out on lined pipes.

3.12.6.9 Gas cutting for bolt holes including for U-clamp supports shall be prohibited.

3.12.6.10 Cutting of standard elbows to odd angles as required per layouts is included in BIDDER's scope.

3.12.6.11 Neither butt nor branch joints shall be closer than twice the pipe diameter to any other joint in the same pipe except where "weldolet" type fittings are used in which case the branch weld must be made to the "weldolet".

3.12.6.12 All pipe bends, where the pipe diameter is NB 65 and above, shall have a radius of five nominal pipe diameters unless otherwise specified on the PURCHASER's piping drawings. The pipe bends shall be true to angle and radius and shall maintain a true circular cross section of pipe without deformity or undue stretching. Crimping of pipes to form bends is not acceptable. Only cold bending which does not require stress relieving operation may be carried out at site. Any bending requiring preheating has to be done only at shop. Cold bending shall be done using pipe bending machine (manual or electric). Bends shall be free from wrinkles and bulges.

3.12.6.13 All welded branch connections shall be of suitable structural adequacy by virtue of the intrinsic weld connection, reinforcing plates or rings or material inherent in the branch. It is the BIDDER's responsibility to provide reinforcement wherever necessary for branch connections. Welded branch connections are not an acceptable alternative where tees have been specified.

3.12.6.14 All threads on piping components shall be taper pipe threads as per applicable standards. The nipples shall be fabricated by the BIDDER at site as required.

3.12.6.15 The first circumferential weld joint after a pipe bend shall be after a minimum straight length of two times the pipe diameter or 500 mm, whichever is less.

3.12.6.16 No external support shall be welded on valves and specialties except as provided by the Manufacturer.

3.12.6.17 Welding ends for butt-welding shall be as per Standard V-bevel with an included angle of 75 degrees.

3.12.6.18 The BIDDER shall check the bench marks provided by the PURCHASER. It shall be the BIDDER's responsibility to establish all layouts and levels using his own surveying instruments. The BIDDER shall protect the bench mark and shall not remove or disturb the bench mark without the approval of the PURCHASER.

3.12.6.19 All pipe flanges and contact surfaces shall be concentric with the axis of the piping. All flanges and fittings shall be accurately machined and drilled true to the template.

3.12.6.20 No welding / gas cutting shall be done locally to valves with soft seating components in order to prevent distortion of the soft seats.

3.12.6.21 All stub and other attachment to be welded on the piping system shall be carried out in the shop or in pre-fabrication yard and only insitu butt welding alone will be carried out.

3.12.6.22 Welding and Non-destructive examination

a. Welding, non-destructive examination of welded joints and repair of weld defect areas shall conform to Clause No.3.13.9, "Welding Specification for Fusion Welded Piping Systems".
b. Final welding of joints shall be undertaken only after the set up of piping is fully checked with respect to layout drawings.
c. At equipment terminal points, welding shall be carried out after taking into account specific requirement and / or recommendations of the equipment supplier.

3.12.6.23 Cleaning, flushing & blow-out

a. All piping including valves and specialties shall be cleaned by the BIDDER before and during erection to remove grease, dirt, dust scale and welding slag.
b. Before erection all fabricated pipe work, assemblies, sub-assemblies, fittings and components etc. shall be thoroughly cleaned internally and externally by blast cleaning or by power driven wire brushes. The brushes shall be of the same or similar material as the metal being cleaned.
c. After erection, all steam water and condensate lines shall be mass flushed with water. The cleaning velocities in water and condensate lines shall be 1.2 to 1.5 times the operating velocities in the pipelines. Use may be made of standby pumps wherever available for the purpose.
d. All compressed air pipe work shall be cleaned by blowing compressed air.
e. All fuel oil, tight oil and lubricating oil lines shall be cleaned by pickling. Alternately, these lines can be cleaned by steam blowing subject to the timely availability of steam for this purpose.
f. All auxiliary steam lines shall be steam blown to effectively remove scale and slag.
g. For purposes of steam blowing, PURCHASER will make available low pressure steam as required. It is BIDDER's responsibility to install necessary temporary pipe work for blowing and remove the same after blowing and render all other assistance to PURCHASER for carrying out the blowing operation.
h. Electrical tracers of fuel oil lines shall be installed only after steam blow out and cleaning of the FO lines. However, in the event for any reason steam blow out has to be done after installation of electrical tracing, then due care must be exercised regarding steam temperature to be used for blow out.

3.12.6.24 Inspection and testing

a. On completion of erection, the inside of all pipes, valves, fittings etc, shall be clean and free from loose scale and foreign matter before subjecting the line to any test / inspection.
b. All piping systems shall be tested hydrostatically pneumatically by the BIDDER after erection, at pressures given in the applicable codes listed in data sheet or as given in the line designation schedule.
c. The test pressures shall be maintained until all welded / flanged joints are inspected for leakage or at least for ten minutes. Mechanical equipment and pressure relieving devices should be blanked- off or removed from the line during pressure testing and control valves should be set in the open position for the duration of the test.
d. Orifice plates should not be erected until hydrostatic testing and cleaning operations are completed.
e. Lines having check valves should have the source of test pressure located on the upstream side.
f. Expansion joints, instruments, filters and similar equipment for which the maximum

permissible cold test pressure is lower than the hydrostatic test pressure applied to the system, shall be removed or blanked off from the line before testing. The BIDDER shall consult the PURCHASER / CONSULTANT for specific guidance.

g. Test pressure readings may be taken at the lowest point of the system being tested provided the effect of static head is taken into consideration.

h. When conditions require a test pressure to be maintained for a period of time, during which the testing medium in the system might be subject to thermal expansion, provision may be made for the relief of excess pressure thereto.

i. After hydrostatic test any leaky joints shall be cut out and repaired or completely replaced and test repeated until the test has been satisfactorily passed. If any valve is found to be leaking part the bonnet joint or steam gland packing, BIDDER shall replace the gasket or gland packing and retest the system to the satisfaction of PURCHASER.

j. After completion of hydrostatic test, safety valves, orifice plates etc., withheld for the hydrostatic tests, shall be installed in an approved manner. Orifice plates shall however be installed after completion of cleaning operations.

k. Clean water at a temperature of not less than dew point or 10 Deg.C whichever higher, nor exceeding 50 Deg.C should be used for hydrostatic test.

l. The rate of pressure increase must not exceed 7 bars per minute.

m. No one should be allowed near piping/equipment under test when the test pressure is near the yield strength or when test pressure over 35 bars is being applied. The pressure should be lowered by 10% before inspection for the leaks.

n. When draining the fluid, the pipelines should be vented slowly to avoid excessive vacuum.

o. A block valve is required on the line from the test pump to the pipeline/equipment under test.

p. Only calibrated test gauges should be mounted in the upright position. Pump discharge gauge must be visible to the pump operator for the duration of the hydro test.

q. The following test certificates shall be submitted to the PURCHASER / CONSULTANT for review:

3.12.6.25 Material

a. Chemical Composition

b. Mechanical properties such as tensile, flattening, bending, impact etc. as called for in the respective material specification standards.

c. Heat treatment in the case of pipes used for steam service.

d. Dimensions.

e. Hydrostatic Tests.

f. IBR approved Certificates.

g. NDT Reports.

h. Reports on Visual Examination.

3.12.7 Hangers and supports

3.12.7.1 All equipment covered under this specification shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed.

3.12.7.2 The BIDDER shall design, fabricate and furnish erection drawings for all hangers, anchors, guides, clamps, stops and supports, auxiliary structures, etc. required for the proper installation and support of the piping.

3.12.7.3 It is desirable that supports should as far as practicable, be arranged adjacent to the pipe joint.

3.12.7.4 Constant load hangers / spring hangers shall be provided wherever necessary for critical piping systems. The variation between hot and cold loads, if variable spring hangers are used, shall not exceed ± 25% of the rated load.

3.12.7.5 Lugs and additional structural members should be suitably welded to the pipes wherever necessary for hangers and restraints.

3.12.7.6 All bare pipes on racks and sleepers shall be clamped at intervals of at least 2 M.

3.12.7.7 Pipe clamps shall have a minimum thickness of 6 mm.

3.12.7.8 All rigid hangers shall provide a means for vertical adjustments after erection.

3.12.7.9 All components of hangers which move relative to the pipe during expansion shall be connected to the pipe clamps or lugs in such a way that these parts are outside insulation.

3.12.7.10 Vertical pipes near tanks should be supported from pad plates already provided on the tank shell.

3.12.7.11 All vertical lines shall be properly supported on the vertical run and additionally provided with adequate number of lateral restraints where the length of vertical run exceeds 5 M.

3.12.7.12 Except for small bore lines, pipes should not be supported from brick walls.

3.12.7.13 In selecting position and type of hangers, BIDDER shall endeavour to layout the work such that pipe load stress imposed on the supporting steel are kept to minimum.

3.12.8 Valves

3.12.8.1 General Technical Requirement

- All valves shall be suitable for the service conditions i.e. flow, temperature and pressure, at which they are required to operate. Valves performing similar duties and of same size, rating, material and type shall be interchangeable with one another.
- All rising stem valves shall be provided with back seat to permit repacking (of glands) with valves in operation. All valves shall preferably be of outside screw and yoke type.
- All gate valves shall be full bore type. In case of venturi construction is used, the minimum diameter of the flow passage at the throat shall not be less than 90% of the basic inside diameter at the valve end. Alternatively, parallel slide valves can also be offered. Reduced port valves (10" (valveend) x 8" (port) x 10" (valve end)) are not acceptable. It shall be ensured that the valve length shall strictly meet ASME B 16.10 standard, corresponding to the valve end diameter.
- Reconditioning of seating surface shall be possible without removing the valve body from the line.
- All valves shall be closed by rotating the hand wheel in the clockwise direction when looking at the face of the hand wheel.
- All valves shall have indicators or direction clearly marked on the hand- wheel so that the valves opening / closing can be readily determined.
- Manually operated valves shall be provided with gear operator of proven quality conforming

to some internationally accepted Standard and Make if the torque required to operate the valve exceed 13.8Kg.M.

- All valves with pressure seal bonnet shall be provided with bonnet pressure relieving device. The bonnet pressure relieving shall be provided with the pipe connecting the bonnet with the upstream or downstream of the valve with locked open isolation valve. The pipe connection in the upstream or downstream will be furnished. For the valve size NB 80 & below, the bonnet pressure relieving can be by drilling a hole in the seat ring or the disc.
- Integral bypass valve shall be provided for valves of size NB 250 and above with pressure class rating 300, 400 and 600. Integral bypass valve shall be forged gate or globe valve socket welded to ASME B 16.11. The material of integral bypass valve shall be A 182 F22 for alloy steel & SA 105 for carbon steel. The pipe used for mounting the integral bypass valve shall be seamless to A 335 Gr.P22 for alloy steel valves and SA 106 Gr.B for carbon steel valves with minimum schedule 80 thickness.
- Integral bypass valve shall be provided for valves of size NB 100 and above with pressure class rating 900 and above. Integral bypass valve shall be forged gate or globe valve socket welded to ASME B 16.11. The material of integral bypass valve shall be A 182 F22 for alloy steel & SA 105 for carbon steel. The pipe used for mounting the integral bypass valve shall be seamless to A 335 Gr.P22 for alloy steel valves and SA 106 Gr.B for carbon steel valves with minimum schedule 80 thickness.
- Bypass valves shall be motor operated if the main valve is motor operated, unless otherwise specified.
- When globe valves are provided as integral bypass valve, the direction of flow of fluid must be marked on the body of the main valve by stamping or embossing.
- Integral bypass valve shall be supplied in the condition of “As welded” with the main valve. The size of the integral bypass shall be minimum NB 25.

- All globe valves shall be of vertical stem type. The construction of globe valves shall facilitate for easy disassembly of the internals (stem and disc).
- The body, seat shall be inclined at such an angle from the vertical so as tofacilitate closing and to prevent chattering for check valves.
- Direction of flow shall be marked on the valve body by stamping or embossing and the tag Nos. for all valves shall be either riveted or punched on the valve body.
- Valves to be installed outside shall be required to have the stem properly protected against atmospheric corrosion. All valve end connections shall suitably be protected to prevent damage and entry of dirt till erected.
- The valves as well as all accessories shall be designed for easy disassembly and maintenance. Face to face dimensions shall be in accordance to ASME B 16.10 for valve size NB 65 & above.
- All valves under the purview of IBR shall be provided with IBR certificate. BIDDER to clearly distinguish the valves under the purview of IBR with suitable identification No asbestos or cadmium based material shall be used.
- All sampling and root valves furnished shall be of integral body bonnet type.
- For the valve size NB 650 and above & for pressure class rating 150, for the steam application, double offset, metal seated butterfly valve shall be used.

3.12.8.2 The materials, design and construction of all types of valves shall be subject to the approval of the PURCHASER.

3.12.8.3 All gate valves with pressure seal bonnet and used for steam application shall be provided with bonnet relief nipples, which will be connected to the piping upstream or downstream of the valve depending on the application.

3.12.8.4 The detailed Gate, Globe and check Valve specifications are enclosed in Annexure-3.1.1.

3.12.8.5 The valves used in the vacuum service shall be gland sealed valves.

3.12.9 Welding specification for piping system

3.12.9.1 Scope

3.12.9.1.1 This specification shall apply to all welded pipe joints of carbon and alloy steels including stainless steels for power plant piping system. This specification is applicable to shop fabrication, site fabrication & field erection. The welded joints are hereby defined as including:

3.12.9.1.1.1 All the line joints of the longitudinal and circumferential butt-welded and socket welded type.

3.12.9.1.1.2 All the attachment of castings, forgings and flanges to pipe.

3.12.9.1.1.3 Welded manifold headers and all other sub-assemblies.

3.12.9.1.1.4 Welded branch connection with or without saddles and reinforcement rings.

3.12.9.1.1.5 Fabrication of built-up fittings.

3.12.9.1.1.6 The attachment of smaller connections for drips, drains, instruments, branch lines, weldolets, sockolets, thermowells, couplings etc.

3.12.9.1.1.7 Closure of joints for inspection plugs and similar joints.

3.12.9.1.1.8 Any other similar joint not specified above but encountered during fabrication and / or erection stage. It is imperative that the CONTRACTOR makes every effort to secure the same high degree of competent supervision and workmanship during field erection as is intended for shop fabrication in view of the adverse field conditions of weather, piping location etc.,

3.12.9.1.2 The piping systems are generally classified as follows:

3.12.9.1.2.1 Alloy steel piping system for temperature above 400º C and all pressures.

3.12.9.1.2.2 Carbon steel piping system for temperature 400º C and below and pressure over 71Kg/sq.cm.

3.12.9.1.2.3 Carbon Steel piping system for temperature over 218º C and less than 400ºC and pressure over 17Kg/sq.cm. and upto 71kg/sq.cm.

3.12.9.1.2.4 Carbon steel pipe system for temperature 218º C and less and pressure 17 kg/sq.cm (g) and less.

3.12.9.1.2.5 Stainless steel piping.

3.12.9.1.3 Material specification for the above systems are generally covered by the following.

3.12.9.1.3.1 Alloy steel piping Ferritic alloy steel pipes to ASTM A335 Gr.P11, P12 & P22, A691 Gr. 11, 12 & 22 or equivalent and corresponding materials for fittings, flanges, valves etc.,

3.12.9.1.3.2 Carbon Steel Piping

Carbon Steel Piping to ASTM A 106 Gr. A, B, C, ASTM A 53 Gr. A, B, IS 1239, API 5L Gr. B,

ASTM A 672 Gr. B60 C1.22, IS 3589, IS 2002 Gr. 2A. or equivalent and corresponding materials for fittings, flanges, valves etc.,

3.12.9.1.3.3 Stainless Steel Piping

Stainless Steel Piping to ASTM A 312 TP 304, 316 etc. or equivalent and corresponding materials for fittings, flanges, valves etc.,

3.12.9.1.4Codes and Standards

3.12.9.1.4.1 The welding of fusion welded piping system shall comply with currently applicable regulations, codes and safety codes in the locality where it will be installed. It shall also conform to the latest applicable standards. Nothing in this specification shall be construed to relieve the BIDDER of this responsibility. In particular, the pipe welding shall conform to the latest edition of the following codes and standards.

3.12.9.1.4.2 ASME codes for power piping - ASME B 31.1.

3.12.9.1.4.2.1 Indian Boiler Regulation – IBR

3.12.9.1.4.2.2 ASME Boiler and Pressure Vessel Codes

Section I – Rules for construction of Power Boilers
Section II Part A – Ferrous material specifications,
Section II Part C – Specifications for welding rods, electrodes & filler metals
Section V – Non destructive examination
Section VIII – Rules for construction of pressure vessels
Section IX – Welding & Brazing qualification

3.12.9.1.4.2.3 Specification of the American Welding Society.

3.12.9.1.4.2.4 Standards of Pipe fabrication Institute.

3.12.9.1.4.2.5 BS 2633 specification for Class I arc welding of ferritic steel pipe work for carrying fluids.

3.12.9.1.4.2.6 Any other codes and standards which are required to perform the specified welding.

3.12.9.1.4.2.7 The above mentioned codes and standards form an integral part of this specification. In the event of conflict between this specification and the codes and standards listed above, this specification shall govern.

3.12.9.1.5Welding Processes

3.12.9.1.5.1 The welding process that are used in the fabrication of pipes and fittings are restricted to shielded metal arc welding and gas tungsten arc welding (argon arc) or a combination of the two.

3.12.9.1.5.2 Argon arc root pass shall be employed for all alloy steel, carbon steel piping and stainless steel piping system. Subsequent welding, after root pass can be carried out by manual shielded metal arc welding with coated electrodes. For pipes of wall thickness less than 6

mm, the entire welding shall be carried out by tungsten inert gas welding process. When using tungsten inert gas welding process, welding without addition of filler metal shall not be done.

3.12.9.1.5.3 For critical carbon steel piping system (Refer Exhibit), the TIG root pass shall be employed and subsequent welding after root pass can be carried out by manual shielded metal arc welding with coated electrodes.

3.12.9.1.5.4 For Non-critical carbon steel piping system (Refer Exhibit), the entire welding including root pass may be carried out by manual metal arc welding.

3.12.9.1.5.5 Where special welding techniques are recommended by equipment manufacturer for piping connecting to equipment, appropriate qualification test and welding technique shall be followed. The specific and detailed instructions of equipment manufacturer regarding welding, preheating, stress relieving etc., shall be strictly adhered to by the BIDDER at no extra cost to the PURCHASER.

3.12.9.1.6 Procedure and Performance Qualification

3.12.9.1.6.1 No production welding shall be undertaken until the procedure qualification test which are to be used have been established as per ASME boiler & pressure vessel code Section IX and / or IBR. The test results and specimens from qualification test of the welding process and welding operators shall be made available to the PURCHASER / CONSULTANT for approval. Where results of existing procedure qualification and of welders are acceptable to the PURCHASER / CONSULTANT, such results shall be kept on file and be subject as to review regularly. Where doubt exists regarding the acceptability of any qualification test, a retest may be required. All such qualification tests and
specimen testing shall be conducted in the presence of the PURCHASER / CONSULTANT.

3.12.9.1.6.2 The Cost of all procedure qualification test shall be borne by the BIDDER.

3.12.9.1.6.3 The BIDDER shall prepare a written specification containing the information detailed in Section IX of ASME form QW-482, 483 & 484 (WPS, PQR & WPQ). These documents shall be provided to the PURCHASER /CONSULTANT for review and approval. The BIDDER shall prepare certificate of welder performance qualification test containing the information detailed in ASME Section IX. These shall be kept on file and made available to the PURCHASER / CONSULTANT upon request.

3.12.9.1.7 Welders and Supervisors

3.12.9.1.7.1 Unless otherwise agreed, the BIDDER shall advise to PURCHASER /CONSULTANT in writing, at least 3 weeks before any welder is employed on the work, the names and qualifications of the proposed welders and welding supervisors. It shall be the BIDDER'S responsibility to ensure that the welders employed by them or their SUB-BIDDER, on any part of the contract either at their works or at site are fully qualified as required by the code. Each welder shall qualify for all types of welding and materials he may be called upon to weld.

3.12.9.1.7.2 Should the PURCHASER / CONSULTANT require to test or retest of any welder, the BIDDER shall make available at no extra cost to the PURCHASER, the men, equipment and materials for the test. The cost of testing the welds shall be borne by the BIDDER.

3.12.9.1.7.3 Welding supervisors shall have adequate qualifications and experience in supervising welding of pipe joints with knowledge of non-destructive testing.

3.12.9.1.7.4 All welding including the tacking of all welds shall be carried out by approved welders only. Any weld made by other than the unapproved welder shall be cut out and re-welded.

3.12.9.1.7.5 For the purposes of identification and to enable tracing the full history of each joint, records of weld completed by each welder has to be maintained by the BIDDER and records are to be handed over to the PURCHASER / CONSULTANT

3.12.9.1.7.6 For each welder, a record card shall be maintained showing the procedures for which he is qualified. These record cards shall be specified joint details, consumables and their repair frequency. The record shall be reviewed every fortnight by the PURCHASER / CONSULTANT and those welders whose work requires a disproportionate amount of repair shall be disqualified from welding. Re-qualification of welders disqualified more than two times shall be entirely at the discretion of the PURCHASER / CONSULTANT.

3.12.9.1.8Preparation of Weld Ends

3.12.9.1.8.1 The surfaces to be welded shall be smooth, uniform and free from fins, tears and other defect which would adversely affect the quality of weld. All weld faces and adjoining surfaces for a distance of at least 150mm from the edge of the welding groove or 12 mm from the toe of fillet in the case of socket weld or fillet welded joints shall be thoroughly cleaned of rust, scale, paint, oil or grease both inside and outside. Both inside and outside of pipe ends shall be prepared for welding by painting with one (1) coat of deoxaluminate or equal for a length of 50mm on either side of weld.

3.12.9.1.8.2 Unless otherwise specified, all pipe joints shall be butt-welded. All butt welds shall be full penetration welds. Wherever socket welding fittings are used, the connecting pipe will be socket welded.

3.12.9.1.8.3 Butt Joints

3.12.9.1.8.3.1 Butt joints shall be prepared as per ASME B 16.25 and / or IBR, unless otherwise specified.

3.12.9.1.8.3.2 While meeting alignment of pipe joints as per ASME B 31.1 and / or IBR, care shall be exercised that the trimming depth in case of excess misalignment does not interface with Radiography / Ultrasonic (RT / UT) interpretations. In such cases the trimming width from the tip of the edge preparation along the pipe shall be large enough (1:3 or max. 30^0) that it is well away from the weld face.

3.12.9.1.8.3.3 Unless noted otherwise, all butt welds shall be made without using backing rings.

3.12.9.1.8.4 Tee, corner and lap joints

3.12.9.1.8.4.1 Fillet welds shall have a throat dimension equal to the nominal thickness of either of the joint members.

3.12.9.1.8.4.2 Weld edges of full penetration groove welds for Tee joints shall be prepared with minimum included angle of 45 Deg.

3.12.9.1.8.4.3 The ends shall be prepared by machining, grinding or flame cutting. Where flame cutting is used, the effect on the mechanical and metallurgical properties of the base metal shall be taken into consideration. Flame cutting alloy steel pipes is not allowed. However,

flame cutting of carbon steel pipes is permitted. Wherever practicable, flame cutting shall be carried out by machine. Manual flame cutting edges shall be permitted only where machine flame cutting is not practicable and with the approval of the PURCHASER / CONSULTANT and such surfaces shall be ground or dressed to a smooth finish as required by the specification and to the satisfaction of the PURCHASER / CONSULTANT. Slag, scale or oxides shall be removed by grinding to bright metals at least 2 mm beyond the burnt area.

3.12.9.1.8.4.4 Thermal cutting of carbon steel piping shall be performed under the same conditions of preheat and post heat as for the welding of carbon steel material.
However post heat is not required when:

3.12.9.1.8.4.4.1 The heat affected zone produced by thermal cutting is removed by mechanical means immediately after cutting. However in any case of removing, slag, scale or oxide shall be removed by grinding to bright metals at least 2 mm beyond the burnt area, or,

3.12.9.1.8.4.4.2 Thermal cutting is part of fabrication, manufacturing or erection sequence leading to a weld end preparation where heating immediately follows.

3.12.9.1.8.5 For the piping systems that are supplied by the PURCHASER but being erected by the BIDDER, bevelling of pipes for butt welds shall be carried out as indicated on the respective pipe fabrication drawing, where required. For systems with BIDDER supplies and erects, the pipe ends shall be bevelled to confirm to applicable codes / standards. At connections to equipment the bevelling of piping shall confirm to the requirement of the equipment connections.

3.12.9.1.8.6 Any change in the joint configuration must be done with the acceptance of PURCHASER / CONSULTANT.

3.12.9.1.8.7 All weld joint fit-up shall comply with the tolerances specified on the design drawings or applicable codes and standards.

3.12.9.1.8.8 If the BIDDER uses the header arrangement with central location of Oxygen and Acetylene for cutting and edge preparation operation, the arrangements shall be in accordance with the best safety practices and standards and shall be approved by the PURCHASER / CONSULTANT.

3.12.9.1.8.9 Before fitting up the weld joint, the profile and dimensions of the weld end preparation shall be offered to the PURCHASER / CONSULTANT.

3.12.9.1.8.10 All fit-ups shall be offered to the PURCHASER / CONSULTANT prior to welding the root pass.

3.12.9.1.9 Welding of Pipes

3.12.9.1.9.1 All vertical welding shall be carried out in the "UP" direction unless otherwise approved by the PURCHASER / CONSULTANT.

3.12.9.1.9.2 The maximum face width of any manual arc or inert gas weld run shall be as per standard as specified in ASME.

3.12.9.1.9.3 No single run horizontal / vertical position manual metallic arc weld fillet shall exceed 8 mm in size.

3.12.9.1.9.4 Fillet welds shall have a throat dimension at least equal to the nominal wall thickness specified for the pipe. Each leg of the fillet weld shall have a length of at least 1.25 times in the nominal wall thickness of the pipe. Socket and fillet welds shall have a minimum of two (2) weld layers.

3.12.9.1.9.5 All tack welds shall be made using a qualified procedure and qualified welders. Any preheat requirement specified on the welding procedure shall also apply to tack welds.

3.12.9.1.9.6 All tack welds shall be examined visually for defects, and if found defective shall be completely removed.

3.12.9.1.9.7 As the welding proceeds, tack welds shall be either removed completely or shall be properly prepared by grinding or filling their stopping and starting ends so that they may be satisfactorily incorporated in the final weld.

3.12.9.1.9.8 Welded-on branches for all piping systems shall be of full penetration type connection.

3.12.9.1.9.9 Preheating prior to tack welding and welding shall be employed as a means of crack prevention and improving general weld reliability. At no time during welding, temperature of the joint shall not be allowed to fall below the minimum preheat temperature. Excessive preheating shall be avoided.

3.12.9.1.9.10 Irrespective of class of steel, root run shall be made without interruption other than for changing the electrodes or to allow the welder to reposition himself. Root runs made in the shop may afterwards be allowed to cool by taking suitable precautions to ensure slow cooling e.g. by wrapping in a dry asbestos blanket. Welds made at site shall not be allowed to cool until the thickness of weld metal deposited exceeds 1/3 of the final weld thickness or 10 mm whichever is greater.

3.12.9.1.9.11 When welding alloy steel, it is strongly recommended that interruption of welding shall be avoided. Where such interruption is unavoidable, either the preheat shall be maintained during interruption or the joint shall be wrapped in dry asbestos blankets to ensure slow cooling. Before recommencing welding, preheat shall be applied again.

3.12.9.1.9.12 No welding shall be done if there is impingement of rain, snow, sleet or high wind on the weld area.

3.12.9.1.9.13 Welded on bridge pieces and temporary attachment should preferably be avoided. Where approved by the PURCHASER / CONSULTANT, they may be used material of these shall be compatible with material which they are temporarily welded. All the weld pieces shall be removed after welding of pipe joint and the weld area ground flush and subjected to Magnetic particle / Dye-penetrate examination before applying any post weld heat treatment. These pieces shall be welded by qualified welders and with electrodes compatible with the parent pipe material. The preheating requirements shall be applied and maintained during the welding of pieces. These temporary attachments shall be removed by grinding, chipping or flame gouging. When arc flame gouging is used at least 3.2 mm of metal shall be left around the pipe surfaces, which shall be removed by grinding.

3.12.9.1.9.14 The arc shall be struck only on those parts of the parent metal where weld metal is to be deposited. When inadvertent arc strikes are made on the base metal surfaces outside the joint groove, the arc strikes shall be removed by grinding and shall be examined by liquid penetration or magnetic particle inspection procedures.

3.12.9.1.9.15 Oxides shall not be permitted to form during welding or heat treatment or both on the

internal surface of pipe, which will not be subsequently cleaned. Inert gas purging will be an acceptable method to prevent such oxidation. All joints in material which contain 1¼% or more chromium shall be purged to assure that less than 1% of oxygen is present on the joint under side before initiation of the welding. The purging operation may be terminated when 5mm thickness of weld metal is deposited into the joint. The BIDDER may submit examples of other procedures for consideration of the PURCHASER / CONSULTANT.

3.12.9.1.9.15.1 Argon gas used in GTAW process for shielding and purging gas purity shall be minimum of 99.95 %. Purging shall be carried out at the flow rate depending on diameter of pipe until six (6) times of the volume between dams is displaced. In no case shall the initial purging period be less than ten (10) minutes. After initial purging the flow of the backing gas shall be reduced to a point where only a slight positive pressure prevails. Any dams used in purging shall be fully identified and removed after welding and accounted for in order to avoid leaving them in the system.

3.12.9.1.9.16 Thorough check shall be exercised to maintain the required interpass temperature.

3.12.9.1.9.17 All equipment necessary to carry out the welding for supporting of the work, for the pre-heating and the post-heating including thermal insulation for retaining the heat and for the protection of the welder shall be provided by the BIDDER.

3.12.9.1.9.18 After deposition, each layer of the weld metal shall be cleaned with a wire brush to remove all slag, scale and defects to prepare for the proper deposition of the next layer. The material of wire brush shall be compatible with pipe material. Special care shall be taken to secure complete and thorough penetration of the fusion zone into the bottom of the weld. In case, where the weld joint on pipes 100 mm NPS and larger has to be radiographed as per the requirement of this specification, it is recommended that the root run be checked by liquid penetrant or magnetic particle procedures.

3.12.9.1.9.19 Gouging or back-gouging of butt welds may be carried out wherever feasible by grinding, chipping, machining or other approved methods, but the surface of cut must be cleaned to remove any carbon or oxidised metal before commencing the welding.

3.12.9.1.9.20 Repair of weld metal defects shall meet Cl. 127.4.11 of ASME B31.1 and / or IBR

3.12.9.1.9.21 Upon completion of welding, the joints shall be wrapped in dry asbestos blankets to ensure slow cooling unless post-weld heat treatment is applied immediately.

3.12.9.1.9.22 No welding or welded parts shall be painted, plated, galvanised or heat-treated until inspected and approved by the PURCHASER / CONSULTANT welds shall be prepared / ground in such a way that welds surfaces merge smoothly in to the base metal surface

3.12.9.1.9.23 Except where necessary to grained flush for non destructive examination purpose, the centre of reinforcement for butt welds shall be as below.

Component Thickness (mm)	Maximum Reinforcement (mm)
Up to 12	1.6
Over 12 to 25	2.4
Over 25 to 50	3.2
Over 50	4.0

The reinforcement shall be crowned at the centre and tapered on each side of the joined members. The exposed surface of the weld shall be ground where required to present a

workman like appearance and shall be free from depressions below the surface of the joined members. The exposed surface of the butt welds shall be free from under cuts greater than 0.5 mm in depth, overlaps from abrupt ridges and valleys and shall merge smoothly into the pipe surface at the weld toe. However, undercuts shall not encroach on the minimum section thickness.

3.12.9.1.9.24 All welds shall be subjected to the approval of the PURCHASER /CONSULTANT.

3.12.9.1.9.25 In the event of several unsuccessful repair attempts or if the PURCHASER / CONSULTANT feels that a satisfactory repair is not feasible, the joint shall be completely remade.

3.12.9.1.9.26 Post weld heat treatment shall be carried out as per Cl. 132 of ASME B 31.1 and / or IBR

3.12.9.2 Identification of Welds

3.12.9.2.1Whenever code symbol stamps are required on carbon steel and Ferritic alloy steel piping, they shall be applied directly to the pipe with low stress dotted design metal die stamps or to a small stainless steel plate especially provided for such marks. These plates shall be lightly tack welded to the pipe using electrodes (of diameter 3 mm or less) of the type specified for the material. Before making the required tack weld, the pipe material in the immediate surrounding area shall be preheated as required by electric means or propane or natural gas burners. Cooling shall take place under asbestos insulation in a draft free area. Stresses relieving of these welds are not required. Steel stamping directly on the surface of alloy steel piping with other than low stress die stamps shall not be permitted.

3.12.9.2.2 Seal welds

3.12.9.2.2.1 Seal welding shall be done by qualified welders and in accordance with approved drawings.

3.12.9.2.2.2 If necessary, threaded joints that are to be seal welded shall be made without the use of thread lubricating compound

3.12.9.3 Preheating

Preheating prior to tack welding and welding shall be employed as a means of crack prevention and to improve general weld reliability.

3.12.9.3.1 Carbon Steel

3.12.9.3.1.1 Welded joints in carbon steel piping where tensile strength is below 4900 Kg/Sq.Cm, the carbon content does not exceeding 0.3% and design thickness not exceeding 19mm need not be preheated except where the ambient temperature is below 16º C. For this condition the joint shall be heated to ambient temperature before any welding is performed. where the tensile strength is 4900 Kg/Sq.Cm or greater or where the carbon content exceeds 0.3%, Where the design thickness is 19mm and above, shall be preheated before any welding is performed as follows:

WALL THICKNESS (MM)	MINIMUM PREHEAT (º C) METAL TEMPERATURE
19 TO 38	100
38.1 TO 63	125
Above 63	150

3.12.9.3.1.2 At no time, during welding operation shall the temperature of weld area be allowed to fall below these temperatures. Before performing any tack welding which may be required in preparing carbon steel pipe for welding or other fabrication or before attaching thermocouples, the pipe area to which the tack weld is to be made shall be evenly heated to this temperatures preferably by resistance heating or induction coils. Propane or natural gas torches or preferably burner rings shall be employed where it is impossible to use electric heating. The use of oxy-acetylene gas is prohibited. The metal temperature in this procedure shall be determined by the use of thermocouples and potentiometers except that the temperature sensitive crayons shall be used as a temperature indicator in tack welding thermocouples. However, temperature indicating crayons may be used when approved by PURCHASER / CONSULTANT.

3.12.9.3.1.3 Weld joints for piping NB 100 and larger shall be heated by means of induction coils or resistance heating. Welded joints in smaller pipe shall be heated by means of electrical resistance coils or suitable propane or natural gas torches.

3.12.9.3.2 Alloy Steel

3.12.9.3.2.1 Weld joints in alloy steel piping shall be preheated before any welding is performed according to the following table.

MATERIAL	MINIMUM PREHEAT-METAL TEMPERATURE
1 Cr.0.5 Mo (SA335 P12)	150º C up to 38 mm thickness 200º C for over 38 mm and upto 63 mm thickness 250º C for over 63 mm thickness
1.25 Cr 0.5 Mo (SA335 P11)	150º C up to 38 mm thickness 200º C over 38 mm and up to 63 mm thickness 250º C for over 63 mm thickness
2.25 Cr 1 Mo (SA335 P22)	200º C up to 38 mm thickness 220º C over 38 mm and up to 63 mm thickness 250º C for over 63 mm thickness

3.12.9.3.2.2 At no time during the welding operation, shall the temperature of the welding area be allowed to fall below these temperatures. Before performing any tack welding which may be required in preparing alloy pipe for welding or other fabrication or before attaching thermocouple, the pipe area to which the tack weld is to be made shall be uniformly heated to the temperature indicated above preferably by resistance heating or induction coils. Propane gas or natural gas torches or preferably burner rings shall be employed where it is not possible to use electric heating. Heating by Oxy-acetylene gas is prohibited. The metal temperature in this procedure shall be determined by the use of thermocouples and potentiometers except that temperature sensitive crayons shall be used as temperature indicators in tack welding thermocouples.

3.12.9.3.2.3 Weld joints for piping NB 100 and larger shall be heated by means of induction coils or resistance heating. Welded joints in smaller pipe shall be heated by means of electrical resistance coils or suitable propane or natural gas torches.

3.12.9.3.3 Austenitic Stainless Steel

Welded joint in Austenitic Stainless Steel Piping need not be preheated except where the ambient temperature is below 0 º C. For this condition, the joint shall be heated to 40 º C by

propane, natural gas or electrical means before any welding is performed.

3.12.9.3.4 Pre-heat for dissimilar Material

When parts of two different materials are joined together, the material requiring higher pre-heat shall govern.

3.12.9.4 Stress Relieving

Stress relieving of piping material is required when so specified and shall be performed as specified in ASME and / or IBR.

3.12.9.4.1 General Requirement

3.12.9.4.1.1 A complete automatic temperature recording shall be made of preheating and stress relieving operations where propane gas burners or electrical resistance coils are employed. A complete temperature record of the preheating and stress relieving operations shall be made by means of box type potentiometer. Other means of recording the temperatures are permitted subject to PURCHASER / CONSULTANT approval.

3.12.9.4.1.2 Stress relieving may be performed locally or fully in furnace. Local stress relief shall be performed with electric induction or electric resistance coils. Suitable gas burning equipment using natural gas or propane may be employed.

3.12.9.4.1.3 At no time during stress relieving / preheating cycle shall any water or liquid cooling medium be employed.

3.12.9.4.1.4 Where members being joined are unequal in thickness the dimension of the heavier section shall govern the selection of width of the heated band and the duration of the holding period.

3.12.9.4.1.5 When local stress relief is performed, the area of the welded joint and the adjacent material extending for a distance of at least three (3) times the width and widest part of the weld on each side of the weld shall be heated by band.

3.12.9.4.1.6 For local stress relief using electrical methods the minimum of two (2) thermocouples tack welded to the surface of the potentiometer shall be used on the pipe under at least four (4) layers of asbestos paper. The hot junctions of thermocouples shall be located on either side of the joints at least 12 mm from the
edge of the joint but no further away than 100 mm. When employing induction heating, at least six (6) turns of induction cable shall be wrapped on top of the asbestos paper protecting the thermocouples with the first turn approximately of 150 mm from the centre of the weld.

3.12.9.4.1.7 Local stress relief using gas torches or ring burners may be employed. However the procedure shall be limited to pipe below 100 mm nominal bore and must be approved by PURCHASER / CONSULTANT.

3.12.9.4.1.8 The stress relieving shall be maintained for a period of time proportioned on the basis of one hour per 25 mm of wall thickness of the thickest section of the joint. The parts to be heated shall be brought slowly to the required temperature and the heating rate shall not exceed 150 ºC.

3.12.9.4.1.9 For tubing joints and for socket welded joints, pads, bosses and couplings,one (1)

thermocouple shall be positioned on the minimum distance of two (2) pipe wall thickness from the weld.

3.12.9.4.1.10 For welds used for attachment of base brackets, two (2) thermocouples shall be used for determination of pre-heating and stress relieving temperatures. They shall be tack welded directly to the header located 180 Deg. apart on the circumference of the header and the mid-way between adjacent legs.

3.12.9.4.1.11 Piping on both sides on any joint shall be adequately supported throughout the preheating, welding and stress relieving operations to prevent distortion.

3.12.9.4.1.12 After PWHT, the hardness of the weld metal and the parent metal shall be jointly measured with the digital hardness tester to verify satisfactory completion of the stress relieving process.

3.12.9.4.2 Carbon Steel

3.12.9.4.2.1 Welded joints on carbon steel pipe where the nominal pipe wall thicknes of the heaviest material being joined is greater than 19 mm or the carbon content of more than 0.25 % for piping system under IBR and 0.3 % percentage non-IBR, shall be stress relieved upon completion of the welding operation.

3.12.9.4.2.2 When the height of the boss above OD of the pipe is 19 mm or greater the weld shall be stress relieved.

3.12.9.4.2.3 When the wall thickness of the coupling or a pad is greater than 19 mm the weld shall be stress relieved.

3.12.9.4.2.4 When local stress relief is employed, the weld joints shall be heated to a temperature of not less than 615º C. This temperature level shall be maintained within the limits of 620 Deg.C +/- 5$_0$C for a period of time proportioned on the basis of one hour per 25 mm of wall thickness but in no case less than 30 minutes. The weld area shall then be allowed to cool and undisturbed in a still air to a temperature not exceeding 300º C.

3.12.9.4.2.5 All welded joints which are locally stress relieved in pipes of 100 mm NB and larger shall be heated by means of electrical induction coils or resistance heating. Welded joints in pipes smaller than 100 mm NB shall be stress relieved by means of electrical resistance coil or suitable propane or natural gas torches only.

3.12.9.4.2.6 When full furnace stress relieving is employed for a welded assembly, the entire fabricated section shall be heated uniformly and at no time during the subsequent heating cycle, shall the temperature be allowed to exceed 625º C or fall below 615º C. The furnace shall then be adjusted so that the material will cool at a controlled rate not to exceed 150º C until 300º C is reached. However, in no case the cooling rate shall not exceed 150º C per hour. At that time, the furnace may be shut off, the door opened and the piping material allowed to cool normally to handling temperature.

3.12.9.4.3Heating and Cooling

3.12.9.4.3.1 The carbon steel after having reached their specific stress relief temperatures may be cooled under wraps (i.e.) leaving the induction coils or resistance heaters and insulation in place. This means that at the stress relief temperature the power to the furnace or heating coils may be shut off and cooling takes place in the furnace or with all insulation and coils remaining on the pipe.

The stress relieving coils and insulation shall only be removed after the pipe has cooled

below 300º C.

3.12.9.4.3.2 For furnace stress relief, the doors of the furnace may be opened after the power is shut off at 300º C. The thermocouples controlling the temperature shall remain during the cooling cycle so that the excessive cooling, if it occurs, can be observed and immediately corrected. The rate of heating and cooling shall confirm to Cl. 132.5 of ASME B 31.1 and / or IBR. This stress relieving coils and insulation shall be removed only after piping has cooled to below 300º C or if stress relieved in a furnace, the pipe may be removed from the furnace and permitted to cool in still air at a temperature of not below 10º C.

3.12.9.4.4Alloy Steel

3.12.9.4.4.1 All welds in alloy steel piping shall be stress relieved after welding operation in accordance with the details given below:

MATERIALSTRESS RELIEVING	TEMPERATURE °C		REMARKS
	Min.	Max.	
1 Cr 0.5 Mo (SA 335 P12	640	660	Over 13 mm minimum wall thickness or Over 100 mm NB or over 15% C max.
1.25 Cr 0.5 Mo (SA 335 P11)			
2.25 Cr 1 Mo (SA 335 P22)	680	725	Over 8 mm minimum wall thickness or Over 100 mm NB or over 15% C max.

3.12.9.4.4.2 The welds need not be stress relieved immediately after welding. Immediately after welding, the material shall be wrapped in asbestos and allowed to cool in still air. Full stress relief shall be performed commensurate with alloy after the above slow cooling. The stress relieving procedure shall include the welding joints, and the adjacent material extending for a distance of at least 3 times the width of the widest part of the weld on each side of the weld. The stress relieving temperatures shall apply for local or furnace stress relieving.

3.12.9.4.4.3 Post weld heat treatment for dissimilar Material

When parts of two different materials are joined by welding, the post weld heat treatment shall be followed the higher PWHT temperatures.

3.12.9.4.4.4 Corrective action

In case of interruption during heat treatment of the weld joint due to power failure or any other reason the following action to be taken:

- During heating: Whole operation to be repeated from the beginning
- During soaking: Heat treat subsequently for the balance left over period
- During cooling: Re-heat to the required soaking temperature and cool at the specified rate.

3.12.9.4.5 Heating and Cooling

The low and medium alloy steels, after welding, shall be heated to their specific stress relieving temperature at a rate not to exceed 150º C per hour. The procedure for heating shall employ a suitable furnace, induction coils or electric resistance heaters and shall be controlled by at least two thermocouples.

3.12.9.4.6 Local Stress Relief

All welded joints in pipe 100 mm NPS size and larger shall be locally stress relieved by

means of electric induction coils or resistance welding. Welded joints in smaller pipe sizes shall be stress relieved by means of electric resistance coils or suitable propane or natural gas torches only.

3.12.9.4.6.1 For full furnace stress relief of a welded assembly, the entire fabricated section shall be heated uniformly to the temperature specified. The temperature shall be maintained for a period of time proportioned on the basis of one hour per 25 mm of wall thickness of the piece having the greatest wall thickness in the furnace charge, but in no case less than one hour.

3.12.9.4.7 Austenitic Stainless Steel

Joints in Austenitic stainless steel piping need not be stress relieved after welding.

3.12.9.5 Electrodes

3.12.9.5.1 The specification and size of the electrodes, voltages, amperages, thickness of beads and number of passes shall be as specified in the approved welding procedure or otherwise agreed in writing. In general, basic coated electrodes shall be used which shall be deposited with weld metal having the same or higher physical properties and similar chemical composition to the members being joined. For each batch of approved brand, certificate showing compliance with The specification shall be secured and shall be submitted to the PURCHASER / CONSULTANT for review before being released for use on project piping. All electrodes shall be purchased in sealed containers and stored properly to prevent deterioration. All low hydrogen electrodes shall be baked in mother oven between 300 to 350º C for one hour and stored in holding oven at 80 to 100º C before being used. The recommendation of the electrode manufacturer shall be followed.

3.12.9.5.2 For welding of all grades of steel and alloys by the GTAW process, a two (2) percentage thoriated tungsten electrode confirming to AWS / ASME section II part C classification shall be used.

3.12.9.5.3 Carbon Steel and Alloy Steel

All electrodes to be used in carbon steel and Alloy Steel shall conform to ASME SEC II PART C or IS 814 or any other equivalent codes.

3.12.9.5.4 As welding electrodes deteriorate under adverse conditions of storage leading to dampness in the electrode coating, they should be normally stored in air conditioned rooms or in hot boxes or ovens in their original sealed containers whose temperatures shall be maintained within specified limits. Thermometer shall be used to monitor the room temperature in which the electrodes are stored. The condition of electrodes shall be frequently inspected. The electrodes with damage to coating shall not be used. Electrode shall remain identified until consumed.

3.12.9.5.5 The type of electrode used should be only those recommended by the manufacturer for the use in the position in which the welds are to be made. Electrodes which have the areas of flux covering broken away or damaged shall not be used.

3.12.9.5.6 All piping coming under the IBR shall have root run carried out using “TIG” process and further run by attested electrodes for various material combination and the selection of electrodes shall be as specified in Exhibit.

3.12.9.6 Inspection and Testing

3.12.9.6.1 The PURCHASER / CONSULTANT shall have accessibility to inspect the welding area in other related operations at any time and at any stage of fabrication.

3.12.9.6.2 The PURCHASER / CONSULTANT may require non-destructive testing of any weld for reasons other than those given in the specification. The responsibility for the cost of such testing shall be mutually decided between the PURCHASER and the BIDDER.

3.12.9.6.3 The BIDDER shall inform the PURCHASER / CONSULTANT when the weld preparation and setting up for welding of various members selected by the PURCHASER / CONSULTANT is in progress so that the PURCHASER / CONSULTANT can inspect the assembly before welding starts.

3.12.9.6.4 The responsibility of PURCHASER's / CONSULTANT shall in no way reduce the BIDDER's responsibility to ensure that the work is carried out in accordance with the specification.

3.12.9.6.5 Examination methods of welds

3.12.9.6.5.1 IBR system - Alloy steel

Edge preparation	DPT 100%
Butt welding	
- for size over NB 50	RT 100%
- for size NB 50 and below	RT 10% minimum 2 joints per welder
Branch Welding	
- for branch size over NB 100UT 100%	
- for branch size NB 100 and below DPT 100 % or MPT 100%	
Fillet, Socket, Attachment and Seal DPT 100% or MPT 100%	

3.12.9.6.5.2 IBR system – Carbon steel - pressure 71 Kg/Sq. Cm(g) and higher, Temperature less than 400 º C.

Edge preparation	DPT 100%
Butt welding	
- for size over NB 50	RT 100%
- for size NB 50 and below	RT 10% minimum 2 joints per welder
Branch Welding	
- for branch size over NB 100 and branch thickness over 19 mm	UT 100%
- for branch size NB 100 and less and branch thickness over 19 mm	DPT 100 % or MPT 100%
- for all branch size with branch thickness 19 mm and less	DPT 10 % or MPT 10%
Fillet, Socket, Attachment and Seal DPT 100% or MPT 100%	DPT 10 % or MPT 10%

3.12.9.6.5.3 IBR system – Carbon steel – pressure less than 71 kg/Sq. Cm(g) and Temperature less than 400 º C up to 218 º C

Edge preparation	DPT 100%
Butt welding	
- for size over NB 50	RT 100% if Hydraulic test is not done

	for completed piping RT 10% if Hydraulic test is done for completed piping
- for size NB 50 and below	RT 5% made by each welder subject to a minimum of 2 joints per welder if Hydraulic test is not done for completed piping RT 2% made by each welder subject to a minimum of 2 joints per welder if Hydraulic test is done for completed piping
Branch Welding	
- for branch size over NB 100 and UT 10% branch thickness over 19 mm	
- for branch size NB 100 and less DPT 10 % or MPT 10%and branch thickness over 19 mm	
- for all branch size with branch DPT 10 % or MPT 10% thickness 19 mm and less	
Fillet, Socket, Attachment and DPT 10 % or MPT 10% Seal Welds	

3.12.9.6.5.4 IBR system – Carbon steel – pressure less than 17 kg/Sq.Cm(g) and Temperature less than 218 º C

Edge preparation	DPT 100%
Butt welding	
- for size over NB 100	RT 10% made by each welder subject to a minimum of 2 joints per welder
- for size NB 50 and below	RT 5% made by each welder subject to a minimum of 2 joints per welder
Branch Welding	
- for branch size over NB 100 DPT 10 % or MPT 10%	
- for branch size NB 100 and less DPT 5% or MPT 5%	
Fillet, Socket, Attachment and DPT 10 % or MPT 10% Welds	

3.12.9.6.5.5 Non - IBR system - For Alloy steel and carbon steel the NDE requirement shall be same as that given in Clause 3.13.9.5.1 to 3.13.9.5.4 above.

3.12.9.6.5.6NDE Requirement for austenitic stainless steel piping:

Edge preparation	DPT 10%
Butt welding	RT 2% (subject to minimum two joints per welder)

Legend:

RT : Radiographic Examination
UT : Ultrasonic Examination
DPT : Dye Penetrant Examination
MPT : Magnetic Particle Examination

Note: Prior to commencement, all Non-destructive examination shall be performed in accordance with written procedure to meet ASME / IBR and shall be acceptable to the PURCHASER / CONSULTANT.

3.12.9.6.5.7 Penalty Clause

Penalty, where NDT carried out is less than 100%, shall be as follows:

3.12.9.6.5.8 For every weld found defective an additional penalty joint will be marked for NDT

3.12.9.6.5.9 If the defects of any welder increased above 10%, then for every defective joint two (2) additional penalty joints (one joint on each side of the repair joint) will be marked for NDT.

3.12.9.6.5.10 If the defects of any welder exceeds 20%, then all welding joints shall be subjected to 100% NDT.

3.12.9.6.5.11 Selection shall be shift-wise. The cost of any such penalty works or additional NDT shall be fully born by the BIDDER.

3.12.9.6.5.12 In addition, at the discretion of the PURCHASER and the CONSULTANT and where requested by them, the BIDDER shall perform radiography and other tests of the joints of any other piping.

3.12.9.6.5.13 Where access holes for radiography have been provided in the piping, the BIDDER shall employ the single wall thickness radiography. The access holes shall be plugged and seal welded only after the radiograph is found acceptable and before to carryout stress relieving. If required necessary pre-heating to be carried out for seal welding.

3.12.9.6.5.14 Where no access holes for radiography are provided in the piping, the BIDDER shall employ the double wall double image technique with elliptical projection or double wall single image or single wall single image technique.

3.12.9.6.5.15 The BIDDER shall ensure that isotopes of sufficient strength and quality are used in order that the radiographs taken are of proper density, contrast and visibility.

3.12.9.6.5.16 Access hole plug welding shall be examined by liquid penetrant or magnetic particle test methods.

3.12.9.7 Qualification and Certification of Non-Destructive Examination Personnel

3.12.9.7.1 Organization performing code required, Non-destructive examination should be personnel competent and knowledgeable to the degree specified by the ASME or equivalent.

3.12.9.8 Acceptance and Standards

3.12.9.8.1 The acceptance level of faults for visual, magnetic particle, liquid penetration, ultrasonic and radiographic test methods and examination shall conform to the requirement of ASME and IBR.

3.12.9.9 Repair Welding

3.12.9.9.1 All defects in welds requiring repair shall be removed by flame or arc gouging, grinding, or machining. The major repairs may involve:

a) Cutting through the weld
b) Cutting out the length of pipe containing the weld, or
c) Removing the weld metal down to the root depending upon the magnitude of the defect.

3.12.9.9.2 After removing the defect, the welds shall be examined by same non- destructive testing methods as specified for the original weld and the same acceptance criteria shall hold good.

3.12.9.9.3 All repair welds shall be made using the same or other specified welding procedures as

those used in making the original welds including preheating and stress relieving as originally required.

3.12.9.9.4 All repair welds shall meet the requirement of the codes and standards specified and shall be acceptable to the PURCHASER / CONSULTANT

ANNEXURE 3.1.1 - TECHNICAL SPECIFICATION FOR GATE, GLOBE, CHECK VALVES (IBR & NON-IBR)

Sl. No.	Description	FCS – CL. 800, NB 50 & BELOW	ASME B 16.34 FCS – CL.1500 & ABOVE, NB 50 & BELOW	CARBON STEEL CCS – CL.150 & 300, NB 65 & ABOVE	CCS – CL. 600 , NB 65 & ABOVE	CCS – CL.900 & ABOVE, NB 65 & ABOVE
1	Basic Specification	ASME B 16.34	ASME B 16.34	ASME B 16.34	ASME B 16.34	ASME B 16.34
2	Construction					
2.1	Bonet/cover	Bolted Type	Seal welded Bonnet/ Cover.	Bolted Type	Bolted Type	Pressure Seal type
		Outside screw and yoke type with rising stem for gate & globe valves	Outside screw and Yoke type with rising stem for gate & globe valves	Outside screw and yoke type with rising stem for gate & globe valves	Outside screw and yoke type with rising stem for gate & globe valves	Outside screw and yoke type with rising stem for gate & globe valves
2.2	Disc.:					
2.2.1	Gate Valve	Solid Wedge Type	Solid Wedge Type	Flexible for NB 100 and above Solid or flexible wedge for size NB 80 and below Flat disc.	Flexible wedge for NB 100 and above Solid or flexible wedge for size NB 80 and below Flat disc.	Flexible wedge (double disc with spacer) or Parallel slide
2.2.2	Globe valve	Flat disc. or manufacturers' standard	Flat disc. or manufacturers' standard			
2.2.3	Regulating globe valve	Conical plug or manufacturers' standard Piston lift	Conical plug or manufacturers' standard Piston lift	Conical or throttling type plug	Conical or throttling type plug	Conical or throttling type plug
2.2.4	Non return valve			Swing disc type	Swing disc type	Swing disc type
2.3	Ends	Socket welded/screwed /flanged	Socket welded	Butt welded/ flanged	Butt welded/ flanged	Butt welded/ flanged
2.4	Seat	Integral type	Integral type	Integral type	Integral type	Integral type
2.5	others	Bonnet Back seat arrangement required	Bonnet Back seat arrangement required	Bonnet Back seat arrangement required	Bonnet Back seat arrangement required	Bonnet Back seat arrangement required
3.0	Materials					
3.1	Body, Bonnet, cover	SA 105	SA 105	SA216 Gr.WCB	SA216 Gr.WCB	SA216 Gr.WCB
3.2	Stem	13% Chromium Steel Heat treated and hardened to minimum hardness of 200 HB. Surface finish of 16 RMS or better in the area of stem packing	13% Chromium Steel Heat treated and hardened to minimum hardness of 200 HB. Surface finish of 16 RMS or better in the area of stem packing	13% Chromium Steel Heat treated and hardened to minimum hardness of 200 HB. Surface finish of 16 RMS or better in the area of stem packing	13% Chromium Steel Heat treated and hardened to minimum hardness of 200 HB. Surface finish of 16 RMS or better in the area of stem packing	13% Chromium Steel Heat treated and hardened to minimum hardness of 200 HB. Surface finish of 16 RMS or better in the area of stem packing
3.3	Hinge pin for check valve	-	-	13% Chromium Steel	13% Chromium Steel	13% Chromium Steel
3.4	Disc	ASTM A 105 hard faced with 13% chromium steel	ASTM A 105 hard faced with stellite to minimum hardness of 350 HB.	ASTM A 216 Gr. WCB / ASTM A 105 hard faced with 13% chromium steel	ASTM A 216 Gr. WCB / ASTM A 105 with disc & seat ring surface hard faced with	ASTM A 216 Gr. WCB / ASTM A 105 with disc & seat ring surface hard faced with stellite to

					stellite to minimum hardness of 350 HB	minimum hardness of 350 HB
3.5	Seat Ring	ASTM A 105 hard faced with stelite to minimum hardness of 350 HB	ASTM A 105 hard faced with stelite to minimum hardness of 350 HB	ASTM A 216 Gr. WCB / ASTM A 105 with seat ring surface hard faced with satellite to minimum hardness of 350HB	ASTM A 216 Gr. WCB / ASTM A 105 with seat ring surface hard faced with satellite to minimum hardness of 350HB	ASTM A 216 Gr. WCB / ASTM A 105 with seat ring surface hard faced with satellite to minimum hardness of 350HB
3.6	Back seat/stem guide bushing for gate and globe valve	-	-	-	-	13% Chromium Steel heat treated and hardened to minimum hardness of 250HB
3.7	Hand Wheel	Malleable Iron	Malleable Iron	Malleable Iron	Malleable Iron	Malleable Iron
3.8	Bolts	A193Gr.B7	A193Gr.B7	A193Gr.B7	A193Gr.B7	A193Gr.B7
3.9	Nuts	A194Gr.2H	A194Gr.2H	A194Gr.2H	A194Gr.2H	A194Gr.2H
3.10	Gland Packing	Alloy steel wire reinforced asbestos free material with stem corrosion inhibitor	Graphite Material	Alloy steel wire reinforced asbestos free material with stem corrosion inhibitor	Alloy steel wire reinforced asbestos free material with stem corrosion inhibitor	Graphite Material
3.11	Gasket	Spiral wound Asbestos free material with SS 304	Graphite Material	Spiral wound Asbestos free material with SS 304	Spiral wound Asbestos free material with SS 304	Graphite Material
4.0	Hydro static test	As per ASME B 16.34 & MSS-SP61	As per ASME B 16.34 & MSS-SP61	As per ASME B 16.34 & MSS-SP61	As per ASME B 16.34 & MSS-SP61	As per ASME B 16.34 & MSS-SP61
5.0	Seat Leakage	Maximum 2 ml of water per hour per 25mm of nominal valve size	Maximum 2 ml of water per hour per 25mm of nominal valve size	Maximum 2 ml of water per hour per 25mm of nominal valve size	Maximum 2 ml of water per hour per 25mm of nominal valve size	Maximum 2 ml of water per hour per 25mm of nominal valve size
6.0	Non destructive examination	Magnetic particle examination/Liquid penetrate examination on body and bonnet. Procedure and acceptance as per ASME B 16.34	Magnetic particle examination/Liquid penetrate examination on body and bonnet. Procedure and acceptance as per ASME B 16.34	Magnetic particle examination/Liquid penetrate examination on body and bonnet. Procedure and acceptance as per ASME B 16.34	Magnetic particle examination/Liquid penetrate examination on body and bonnet. Procedure and acceptance as per ASME B 16.34	Magnetic particle examination/Liquid penetrate examination on body and bonnet. Procedure and acceptance as per ASME B 16.34

Sl. No.	Description	FCS – CL. 1500, NB 50 & BELOW	ALLOY STEEL CAS-CL.150,300 & 600, NB 65 & ABOVE	CAS – CL.900 & ABOVE, NB 65 & ABOVE	FSS – CL. 800 , NB 50 & BELOW	STAINLESS STEELFSS-CL.1500 & ABOVE, NB 50 & ABOVE	CCS – CL.150 & 300, NB 65 & ABOVE
1	Basic Specification	ASME B 16.34	ASME B 16.34	ASME B 16.34	ASME B 16.34	ASME B 16.34	ASME B 16.34
2	Construction						
2.1	Bonet/cover	Seal welded Bonnet/ Cover	Bolted Type.	Pressure Seal type	Bolted Type	Seal welded Bonnet/ Cover	Pressure Seal type
		Outside screw and yoke type with rising stem for gate & globe valves	Outside screw and Yoke type with rising stem for gate & globe valves	Outside screw and yoke type with rising stem for gate & globe valves	Outside screw and yoke type with rising stem for gate & globe valves	Outside screw and yoke type with rising stem for gate & globe valves	Outside screw and yoke type with rising stem for gate & globe valves
2.2	Disc.:						

2.2.1	Gate Valve	Solid Wedge Type	Flexible for NB 100 and above Solid or flexible wedge for size NB 80 and below Flat disc.	Flexible wedge (double disc with spacer) or Parallel slide	Solid Wedge Type	Solid Wedge Type	Flexible wedge for NB 100 and above Solid or flexible wedge for size NB 80 and below Flat disc.
2.2.2	Globe valve	Flat disc. or manufacturers' standard	Flat disc.	Flat disc.	Flat disc. or manufacturers' standard	Flat disc. or manufacturers' standard	Flat disc.
2.2.3	Regulating globe valve	Conical plug or manufacturers' standard Piston lift	Conical or throttling type plug	Conical or throttling type plug	Conical plug or manufacturers' standard Piston lift	Conical plug or manufacturers' standard Piston lift	Conical or throttling type plug
2.2.4	Non return valve	-	-	Swing disc type	Swing disc type	-	Swing disc type
2.3	Ends	Socket welded/screwed /flanged	Butt welded/ flanged	Butt welded	Socket welded/screw ed/flanged	Socket welded	Butt welded/ flanged
2.4	Seat	Integral type	Integral type	Integral type	Integral type	Integral type	Integral type
2.5	others	Bonnet Back seat arrangement required	Bonnet Back seat arrangement required	Bonnet Back seat arrangement required	Bonnet Back seat arrangement required	Bonnet Back seat arrangement required	Bonnet Back seat arrangement required
3.0	Materials						
3.1	Body, Bonnet, cover	A182Gr.F22	A217Gr.WC9 for temperature above 4900C/A217 Gr.WC6,if temperature is 4900C & below	A217 Gr.WC9	A182 F316	A182 F316	A351 CF8M
3.2	Stem	13% Chromium Steel Heat treated and hardened to minimum hardness of 200 HB. Surface finish of 16 RMS or better in the area of stem packing	13% Chromium Steel Heat treated and hardened to minimum hardness of 200 HB. Surface finish of 16 RMS or better in the area of stem packing	13% Chromium Steel Heat treated and hardened to minimum hardness of 200 HB. Surface finish of 16 RMS or better in the area of stem packing	13% Chromium Steel Heat treated and hardened to minimum hardness of 200 HB. Surface finish of 16 RMS or better in the area of stem packing	13% Chromium Steel Heat treated and hardened to minimum hardness of 200 HB. Surface finish of 16 RMS or better in the area of stem packing	13% Chromium Steel Heat treated and hardened to minimum hardness of 200 HB. Surface finish of 16 RMS or better in the area of stem packing
3.3	Hinge pin for check valve	-	-	13% Chromium Steel	13% Chromium Steel		13% Chromium Steel
3.4	Disc	ASTM A 182F22 hard faced with stellite to minimum hardness of 350 HB.	ASTM A 217Gr.WC9/A STMA 182 F22 with disc & seat ring surface hard faced with stellite to minimum hardness of 350 HB.	ASTM A 217Gr.WC9/ASTMA 182 F22with disc & seat ring surface hard faced with stellite to minimum hardness of 350 HB.	A182F316	Stainless steel hard faced with satellite to minimum hardness of 350HB	A351Gr.CF8M
3.5	Seat Ring	ASTM A 182F22 hard faced with stellite to minimum hardness	ASTM A 217Gr.WC9/A STMA 182 F22 with seat ring surface hard faced with stellite to minimum hardness of 350 HB.	ASTM A 217Gr.WC9/ASTMA 182 F22 with seat ring surface hard faced with stellite to minimum hardness of 350 HB.	A182F316	Stainless steel hard faced with satellite to minimum hardness of 350HB	A351Gr.CF8M
3.6	Back	-	13%	13% chromium	-	-	-

	seat/stem guide bushing for gate and globe valve		chromium steel heat treated and hardened to minimum hardness of 250HB	steel heat treated and hardened to minimum hardness of 250HB			
3.7	Hand Wheel	Malleable Iron	Malleable Iron	Malleable Iron	Malleable Iron	Malleable Iron	Malleable Iron
3.8	Bolts	A193Gr.B16	A193Gr.B16	A193Gr.B16	A193Gr.B16	A193Gr.B16	A193Gr.B16
3.9	Nuts	A194Gr.7	A194Gr.7	A194Gr.7	A194Gr.2H	A194Gr.7	A194Gr.2H
3.10	Gland Packing	Graphite Material	Graphite Material	Graphite Material	Alloy steel wire reinforced asbestos free material with stem corrosion inhibitor	Graphite Material	Alloy steel wire reinforced asbestos free material with stem corrosion inhibitor
3.11	Gasket	Graphite Material	Graphite Material	Graphite Material	Spiral wound Asbestos free material with SS 304	Graphite Material	Spiral wound Asbestos free material with SS 304
4.0	Hydro static test	As per ASME B 16.34 & MSS-SP61	As per ASME B 16.34 & MSS-SP61	As per ASME B 16.34 & MSS-SP61	As per ASME B 16.34 & MSS-SP61		As per ASME B 16.34 & MSS-SP61
5.0	Seat Leakage	Maximum 2 ml of water per hour per 25mm of nominal valve size	Maximum 2 ml of water per hour per 25mm of nominal valve size	Maximum 2 ml of water per hour per 25mm of nominal valve size	Maximum 2 ml of water per hour per 25mm of nominal valve size		Maximum 2 ml of water per hour per 25mm of nominal valve size
6.0	Non destructive examination	Magnetic particle examination/Liquid penetrate examination on body and bonnet. Procedure and acceptance as per ASME B 16.34	Magnetic particle examination/Liquid penetrate examination on body and bonnet. Procedure and acceptance as per ASME B 16.34	Magnetic particle examination/Liquid penetrate examination on body and bonnet. Procedure and acceptance as per ASME B 16.34	Magnetic particle examination/Liquid penetrate examination on body and bonnet. Procedure and acceptance as per ASME B 16.34		Magnetic particle examination/Liquid penetrate examination on body and bonnet. Procedure and acceptance as per ASME B 16.34

LEGENDS:
FCS - FORGED CARBON STEEL
CCS - CAST CARBON STEEL
FAS - FORGED ALLOY STEEL
CAS - CAST ALLOY STEEL
FSS - FORGED STAINLESS STEEL
CSS - CAST STAINLESS STEEL

ANNEXURE 3.1.2 – BUTTERFLY VALVES

1 DESIGN REQUIREMENT

1.1 The butterfly valve shaft and disc shall be designed to withstand full differential pressure across the closed valve disc.

1.2 For butterfly valves, the disc shall rotate from the full open to the tight shut position. The disc shall be contoured to ensure the least possible resistance to flow and shall be suitable for throttling operation. While the disc is in the throttled position, valve shall not create any noise or vibration.

1.3 The butterfly valves shall be suitable for installation in any position (horizontal / vertical)

1.4 Sleeve and other bearings fitted into the valve body shall be of self-lubricated materials shall not have any harmful effect on water or rubber and coefficient of friction of the material shall not exceed 0.25, when run at the maximum bearing pressure.

1.5 All butterfly valves shall be closed by rotating the hand controls in the clockwise direction. The pulling force required on the hand wheel rim shall not exceed 25 kgf when operating the valve under full flow and operating pressure.

1.6 Gear operator shall be provided for butterfly valve size NB 200 and above.

1.7 All butterfly valves shall be provided with directly mounted actuators. Each manual actuator shall have all gearing totally enclosed.

1.8 Butterfly valve actuators shall be equipped with adjustable, mechanical, stop limiting devices to prevent over-travel of the valve disc in the open and closed positions.

1.9 Actuator, housings, supports and connections to the butterfly valve shall be designed with a minimum safety factor of 5, based on the ultimate tensile strength, or a minimum safety factor of 3, based on the yield strength of materials used.

1.10 The actuator shall be designed to control the butterfly valve in all positions from fully open to fully closed and from fully closed to fully open with control in any intermediate position.

1.11 The actuators for solenoid operated butterfly valves shall be designed to the shut off pressure of the valve i.e. 10 kg/sq.cm.(g).

1.12 The manual over ride arrangement with hand wheel shall be provided for solenoid operated butterfly valves to operate the valves in case of failure of pneumatic actuators.

1.13 The butterfly valve shall be provided with locking device in both open & close position of the valve.

1.14 The indication of the position of the disc shall be integral with shaft engraved on the body of the valve. The indication may be accomplished by a mark on the shaft. The design shall ensure that it indicates open, close and intermediate position of the valve correctly. Shaft to lever connections shall be designed so that the lever always correctly indicates the disc position.

1.15 All wetted surface of the butterfly valve internal shall be fully rubber lined extending upto the edges of the flanges without any joints.

1.16 Valve seats & "O" rings shall be of EPDM rubber of replaceable type.

1.17 The rubber lining thickness shall be as per manufacturer's standard. However, the minimum thickness shall be 3 mm.

1.18 No reclaimed rubber shall be used.

1.19 The seals, both on the body (sleeve) and on the disc shall be of the material specified. Necessary shaft seal shall be provided and adequately designed to ensure no leakage across the seal. This seal shall be designed so that they will allow replacement without removal of the valve shaft. The sealing ring on the disc shall be continuous type and easily replaceable.

1.20 Direction of flow shall be marked on the body of the valves.

1.21 No asbestos or cadmium based material shall be used.

2.0 PAINTING AND PROTECTION

All valves shall be uniformly coated with two coats of primer and two coats of epoxy on the internal & external unlined surfaces of the valve assembly (100 microns thickness).

3.0 NAME PLATE

All valves shall be provided with name plate. Name plate shall be of non- corrosive material with engraved black lettering on a white background. Name plate data shall be inscribed on the plate in such a manner that it cannot erode or peel off. Name plate shall be marked in accordance with MSS Standard SP-25 and ASME B 16.34 as minimum. BIDDER shall furnish the details that will be incorporated on the name plate along with the bid.

4 INSPECTION AND TESTING

4.1 All valves shall be hydraulically tested to 2.0 times the rated pressure for duration of ten minutes.

4.2 All valves shall be tested for seat leakage to 1.1 times the rated pressure. During the test, valve shall be drop-tight.

4.3 All valve major material shall be tested for chemical and mechanical properties as per the relevant codes and standards.

4.4 Performance test on valve with direct mounted actuator shall be operated three times from fully closed to fully opened position and the reverse under no flow conditions.

4.5 Ozone resistance testing on rubber compounds shall be performed in accordance with ASTM D 1149 using 50 PPHM minimum ozone concentration. The tests shall be conducted on unstressed samples for 70 hrs. at 40 Deg.C without visible cracking in the surfaces of the test samples after tests.

4.6 Volume expansion test on rubber compounds shall be performed in accordance with ASTM D 471. The rubber compound shall have less than 2% volume increase after immersing a sample in distilled water at 23 Deg.C + 1Deg.C for 70 hrs.

4.7 Rubber lining shall be spark tested for checking the continuity.

4.8 Magnetic particle testing on disc on the trunion portion.

4.9 Ultrasonic testing and dye penetrant testing on shaft.

5 The following table gives the specific technical requirements of Butterfly Valves

SPECIFICATION FOR CAST IRON BUTTERFLY VALVE

1.0	Basic Specification	-	AWWA C 504-80/ISO 5252/ BS 5155/API 609
2.0	Class	-	As per the requirement
3.0	Size	-	As per the requirement
4.0	Type	-	Wafer type for NB 600 & Below
			Double Flanged for above NB 600.
5.0	Installation	-	Outdoor
6.0	Ends	-	Wafer ends, drilling to suit ASME B 16.5, class 150 for NB 600 & Below
			Flanged as per BS 3293, class 150 for above NB 600.
7.0	Shaft Seal	-	"O" Ring Type
8.0	Material of Construction		
	a. Body	-	Cast Iron to IS 210 FG 260
	b. Shaft	-	ASTM A 182 Gr.304 / AISI 410
	c. Disc	-	ASTM A 536 Gr.65-45-12
	d. Disc / Seat Rings	-	EPDM
	e. Bolt	-	ASTM A 193 Gr.B7
	f. Nut	-	ASTM A 194 Gr.2H
	g. Handle	-	Malleable Iron
9.0	Bearings	-	Sleeve type of self lubricated material
10.0		-	Bonded or Replaceable

ANNEXURE 3.1.3 – SPECIFICATION FOR ELECTRIC ACTUATORS FOR VALVES

1 Intent

1.1 This exhibit is intended to cover the selection, design, manufacture and testing of electric motor actuators for valves.

1.2 The valves which are to be provided with electric motor actuators are indicated in Annexure – 3.3 of this volume of the specification.

2.0 General

2.1 Electric actuators shall essentially consist of electric motors, limit switches, hand wheel and gear train, mechanical position indicator, internal wiring , integral starters and terminal block.

2.2 Electric motors for the valve actuators shall conform to the requirements of Section-10 of this volume of the specification, in addition to the specific features specified here.

3.0 General Design Requirements

3.1 Actuators shall be sized so as to open / close the valve at the rated speed against the design differential pressure, at 90% of the nominal voltage.

3.2 Lost motion hammer blow feature shall be provided for seating / unseating the valve when the operating torque exceed 11 kg/m.

3.3 Operators shall be designed to be self locking (i.e. maintains the stem position) upon loss of electric power supply.

3.4 Motors shall be installed on the operator prior to shipment to the valve manufacturer.

3.5 Actuators shall be provided with lifting lugs for handling it along with the bonnet.

3.6 Operators shall be flange mounted on the valve bonnet. Welding of operators onto bonnets is not permitted.

4.0 Operating Speed

4.1 Except where the opening / closing times have been specified for valves in Annexure – 3.3 of this volume of the specification, all actuators shall have operating speeds as per the manufacturer's standards.

5 Manual Operation

5.1 All actuators shall have mechanically independent manual drive arrangement with hand wheel and motor declutching mechanism. The manual drive shall be provided with clutch and gearing as required to limit hand wheel effort to 23 Kgf maximum, along with suitable latch and locking arrangement to keep the hand wheel in engaged position during manual operation.

The hand wheel shall disengage automatically during motor operation.

6 Position Indicators

6.1 All actuators shall be provided with mechanical 3 point dial position indicators. Rising Stem Valves shall additionally have visual position indication through plastic Stem Covers.

6.2 Where indicated in Annexure-3.3, valves shall be provided with continuous remote position indicators of the potentio-metric type. The available voltage sources for the potentiometric position transducer are 415 V AC. The transducer shall be suitable for stabilised 4-20 mA current signal. The associated wiring for the transducer shall be housed in the limit switch compartment.

7.0 Limit Switches

7.1 Position Limit Switches

7.1.1 Each actuator shall have four (4) rotary drum position limit switches, two (2) for open and

two (2) for close position, each with adjustable setting between fully open and fully close positions. Each rotary drum position limit switch shall have two (2) normally closed (NC) and two (2) normally open (NO) independent contacts. The adjusting mechanism for the limit switches shall be easily accessible.

7.2 Torque Limit Switches

7.2.1 Each actuator shall have two (2) torque limit switches with suitable arrangement to limit the opening / closing thrust. The torque switch, actuated by the torque clutch when the valve is restricted during opening / closing, shall stop the motor thereby protecting the motor from overloading torque. The torque switches shall be set as near as possible to the 'pull out' torque of the motor without damaging the valve or the operator. Each torque switch shall have two (2) normally open (NO) and two (2) normally close (NC) independent contacts.
The torque limit switch adjusting mechanism shall be easily accessible.

7.3 Each contact of the limit switch shall be rated for interrupting not less than 5 amps current at 240 V AC.

7.4 Limit switches along with all necessary electrical wiring shall be housed in a weather proof NEMA-3 enclosure and shall have gasketed cover and space heater to maintain the temperature above dew point.

8.0 Electric Motors

8.1 Electric motors for the actuator shall be 415 V, 3 phase, Class F insulated, solidly earthed, squirrel cage induction motors. All motors shall be of the full voltage reversible type.

8.2 Electric motors for the actuators shall be specially designed for valve operation with high torque; low inertia characteristics. Motors shall be fifteen (15) minutes rated capable of four (4) consecutive starts.

8.3 All motors shall have TEFC enclosures with space heaters to maintain the internal temperature above dew point when the motor is idle. Space heaters shall be rated for 240 V AC.

8.4 The motors shall be capable of operating its valve against the maximum load on the valve disc with drive bearings in dry and dirty conditions.

8.5 Each motors shall be provided with two (2) direct temperature sensing thermostats to prevent thermal overload.

8.6 All motors shall have 'O' ring seals to provide complete environmental protection when the motor is idle.

9.0 Wiring

9.1 Motor power, heater and all control wiring shall be wired at shop to suitably rated master terminal blocks located within the limit switch compartment. All internal wiring shall be of 650 / 1100 V grade flexible stranded copper conductor cables with tropical fungicidal treatment and the insulation shall be flame resistant. Specific requirements of Integral Starter and Controller

10

10.1 The integral starter and controller shall be provided with the following devices / controls:

- Local / remote / off-selector switch
- Open / off / close control switch
- Emergency stop PB
- Mechanically interlocked forward / reverse contactors
- Overload relay
- Control transformer
- Indicating lamps for open / close position and stator off /on indications
- Auxiliary relays for control logic instruments.

10.2 From the PURCHASER's DCS, the following command (DOs) shall be made available:

- Local Permissive
- Stop
- Open
- Close

10.3 Following feedback signals (DIs) shall be arranged for PURCHASER's DCS:

- Valve closing
- Valve opening
- Valve opened
- Valve closed
- Torque switches operated
- Motor tripped

10.4 Thermostat of actuator and torque switches shall be used in the starter scheme to trip the starter.

11.0 Tests and Inspection

11.1 The contractor shall furnish type test certificates from a recognized test house certifying evaluation of accuracy reliability and repeatability.

11.2 Each valve actuator assembly shall be given a complete operational test at the valve manufacturer's shop to demonstrate that each operator is functional and all limit switches have been properly set.

11.3 Tests shall be also done for speed of travel, torque rating and calibration.

11.4 When practicable each valve assembly shall be shop tested to open and close against the maximum differential pressure specified in the specification.

ANNEXURE 3.1.4 – CONTROL STATIONS

1 General

All control valves in control stations shall be provided with a bypass valve for manual control. There shall be isolating valves on either side of the control valve as well on either side of the bypass valve. The bypass valve internals shall be identical to the control valve except that it shall be hand operated instead of diaphragm (pneumatic) operated. The noise levels at a distance of one meter from the control stations shall be less than 85 dB. All control stations shall be located in easily accessible areas with adequate space around for maintenance. A pressure reducing and desuperheating station shall be provided by the BIDDER for meeting the auxiliary steam requirements of ejector and gland sealing. Both the main valve and the bypass valve in the steam pressure reducing station shall be pneumatic operated. Also, in the steam pressure reducing station provided in the MP extraction, both

the main valve and the bypass valve in the steam pressure reducing station shall be pneumatic operated.

2 Control Valves and De-superheaters

All control valves and desuperheaters shall be with pneumatic actuator, side mounted hand wheel, smart positioner, position transmitter, two limit switches, air filter regulator, air lock valve and other accessories. BIDDER shall indicate the flow through the control valve at 100% lift with maximum upstream pressure and temperature. The control valves shall be selected such that the rated maximum flow shall be achieved at the 85 % lift. The minimum size of the control valve shall be NB 25. The gland packing and gaskets used in the control valve shall be of non-asbestos type. Also, cadmium or cadmium based material shall not be used. The actuators shall be selected for the shutoff pressure. All control valves and desuperheater accessories shall be mounted on the valve itself and interconnected by stainless steel tubing. All the desuperheaters shall be provided with y-type strainers in the spray water piping. Solenoid operated block valve shall be provided in spray water line. The general inspection and testing including hydraulically test shall be as per ASME B 16.34 and agreed quality plan. The seat leakage class shall be IV as per ASME B 16.104. BIDDER shall conduct performance test for valve opening and closing.

ANNEXURE 3.1.5 – SAFETY VALVES

The safety valve shall be full nozzle full lift and open bonnet type and selection and sizing shall confirm to the provisions of the IBR. In addition to meeting this requirements, the safety valves shall also meet the stipulations of ASME Section I with regard to the blowdown and overpressure requirements. The inlet of the safety valves shall be with flanged ends. The valves shall be supplied with lifting lever, test gag, cap and spring cover. The capacities of the safety valves provided downstream of pressure reducing stations shall be the maximum flow permissible thro' the control valves under 100 % valve opening with the rated full upstream pressure.

ANNEXURE 3.1.6 – METALLIC EXPANSION BELLOWS

1 General Requirement

1.1 The expansion joints are intended for installation wherever required for the piping in the scope of the bidder.

2.0 Design and Construction

2.1 The design of the Bellows shall meet with the requirements of EJMA standards. The bellows shall be designed for the specific design pressure and also for full vacuum. The cycle life of the bellows shall be a minimum of 10,000. The material of construction of the bellows shall be of stainless steel only.

2.2 Construction Details

2.2.1 Metallic Bellows

a. The metallic bellows shall be hydraulically or roll formed from perfect cylinders of single ply, SS 304.
b. The no. of longitudinal weld seams shall be minimum and there shall be no circumferential weld seal.
c. Cold formed stainless steel bellows shall not be heat treated.
d. All bellow elements shall be pickled after forming.

e. Equalising rings where required shall be either from high quality castings or from fabricated metal.
f. Flanged expansion bellows shall be provided with adequate pipe stubs.
g. Butt-welded expansion bellows shall have adequate length of pipe so that site welding does not impair or reduce the metallic expansion bellow efficiency.

2.2.2 Sleeves

a. Expansion bellows will be furnished with internal sleeves of the same material as the bellows and installed with sufficient clearance to allow full rated deflection. The sleeves shall be welded on the flow inlet end of the bellow only.
b. Bellows shall have external sleeves with an arrow indicating the direction of flow on the outside. The external steel covers provided to protect bellows from physical damage shall be suitable for supporting insulation, where necessary and shall be detachable.

2.2.3 Tie Bars

a. Bellows shall be shipped at neutral lengths and shall be provided with suitable knock-off type temporary tie bars, wherever required, to prevent damage and mis-alignment during the transit and also with permanent tie bars along with necessary nuts, bolts, etc.
b. Tie rods on pressure balanced type expansion bellows shall be adequately sized to prevent buckling in vacuum services or services with external loads.
c. The tie rods of tied lateral bellows shall be provided with suitable spherical washer and nuts for taking the lateral deflections.

3 Welding

All welding procedures and performance of all welders shall be qualified in accordance with the requirement of ASME B & PV Code Section IX. The welding of bellows along with collar, end pipes and middle pipes shall be done by argon welding.

4 Stress Analysis

4.1 The BIDDER shall submit the calculations for the bellow design and selection.

4.2 The BIDDER shall furnish the following data of bellows.

a. Axial compression in mm.

b. Axial expansion in mm.

c. Lateral deflection in mm.

d. Axial spring rate in Kg/mm.

e. Lateral spring rate in Kg/mm.

f. Torsional spring rate in Kgm/Deg.

g. Weight of the bellow assembly in Kg.

5 Inspection and Testing

5.1 Bellows shall be subject to all test and inspection required by the applicable codes and standards and those specified below. The bellows shall be fully shop assembled and performance test shall be carried out.

5.2 All welds shall be dipenetrant tested as per ASTM E 165 Method B.

5.3 Material test certificates for both chemical and mechanical tests as per code requirement shall be furnished.

5.4 The expansion bellow shall be assembled and hydro-statically tested at shop at 1.5 times the design pressure for a period of half-an hour.

5.5 The expansion bellow shall be subject to vacuum test at the shop at a pressure of 12 mmHg (abs) for a period of half-an hour.

5.6 All attachment welds and fillet welds in the bellow assembly shall be either magnetic particle tested or dypenetrant tested.

5.7 Test will be witnessed by PURCHASER / CONSULTANT unless otherwise waived.

5.8 Compliance certificate for spring rate test, cycle test and axial & lateral deflection of bellows shall be furnished.

6.0 Cleaning and Protection

6.1 Prior to inspection and shipment, the expansion bellow shall be cleaned from inside and outside to remove all manufacturing wastes, scrap, mill scale, rust, etc.

6.2 All exposed steel surfaces shall be given two coats of primer and two coats of enamel to prevent corrosion.

7.0 Name Plate

Name plate shall be provided with non-corrosive material with engraved black lettering on white background. Name plate data shall be inscribed on the plate in such a manner that it cannot erode or peal-off. Name plate shall indicate manufacturer's name, part number, design rating, date of manufacture and tag number.

8 Shipment

Shipping rods shall be furnished and installed before shipment to prevent joint deflection during shipment and erection. Shipping rods shall be tagged with instruction that they are to be left in place during erection but shall be removed before the system is placed in operation. Shipping bars shall be provided in yellow colour for each expansion bellow. Each expansion bellow shall be prepared for shipment in such a manner that the quality and cleanliness and finish shall be maintained during shipment.

ANNEXURE 3.2 – REQUIREMENTS FOR INSULATION AND LAGGING

1 Scope

This specification covers the technical requirements and essential particulars for the supply, application and finishing of the complete thermal insulation and its protective covering for pipes, valves, fittings including bends, equipment, etc. with working temperatures above 60 Deg.C upto 500 Deg.C. Unless otherwise specified the scope of supply of the BIDDER shall include, but not be limited to the following items:

a. Insulating materials for all types as specified/required.

b. Finishing materials of all types including cement, protective coating, sheeting, as specified / required.

c. Angles, irons, clamps, lugs, etc. for supporting insulation on pipes, ducts, furnace, valves & fittings and equipment.

d. Wire mesh, lacing/binding wires, bands, straps, screws, etc. as required.

e. Weather hoods.

2 Codes and Standards

The supply and application of thermal insulation to piping systems and equipment covered under this Specification shall comply with all currently applicable regulations and safety codes in the locality where the thermal insulation will be applied. The insulating materials shall also conform to the latest editions of the codes and standards listed below. Nothing in this specification shall be construed to relieve the BIDDER of this responsibility.

IS:6	:	Moderate heat duty fire clay refractories Group-A
IS:8	:	High heat duty fire clay refractories
IS:737	:	"Specification for wrought aluminum and Aluminum alloys sheet and strip (For General Engineering Purpose)
IS:3346	:	Method of determination of thermal conductivity of thermal insulation material.
IS:10556	:	Code of practice for storage and handling of insulating materials.
IS:14164	:	Industrial application and finishing of thermal insulating materials at temperatures above 80^0C and upto 700 Deg.C

American Society for Testing and Materials

IS:8183	:	"Specification for Bonded Mineral Wool"
IS 3150	:	"Hexagonal wire netting for general purpose".
IS 3144	:	"Methods of test for Mineral Wool Thermal Insulation Material"

3 General Design Requirements

The BIDDER shall furnish all required details of insulating materials and also furnish curves of thermal conductivity plotted against mean temperature. The BIDDER shall also state maximum permissible hot face temperature which the insulating material can withstand

without deterioration and the weight per unit volume of each material offered.

All exposed portions of the plant which operate at temperatures of 60°C and above during normal operation shall be thermally insulated so that the temperature on the outer surface of the cladding shall not exceed by more than 20°C above ambient, based on an ambient temperature indicated in site data.

Unless otherwise specified, the BIDDER shall calculate the insulation thickness based on the insulating material properties and the requirements of para B.3.2.

The specified insulation thickness shall not include the thickness of wire netting, finishing cement or any other finishing or weatherproofing application.

Where insulation thicknesses are specified in Table 1, the BIDDER shall provide same thickness.

Removable insulation arrangement shall be provided for manholes and hand holes.

Perfect leak tight arrangement of sealing shall be provided for points at furnace roof/ wall where superheater tubes penetrate. Detailed arrangement sketches shall be submitted for the approval of the PURCHASER / CONSULTANT.

Insulation shall not fill the contours of the expansion bellows.

Personnel Protection
Piping and equipment that are not insulated but having a surface temperature exceeding 50 Deg.C shall be insulated for personnel protection.

4 Insulation of Equipment and Piping

4.1 Material Specifications

4.1.1 Insulating Materials

a. The insulating materials and any component of the finished insulation job shall not react chemically singly or in combination, with water or moisture to form substances which are more actively corrosive to the applied surface than water or moisture alone. The materials shall not offer sustenance to fungus or vermin and must not pose a health hazard. The BIDDER shall submit with the Bid, details of application of protective coatings or other methods, he proposes to use for corrosion protection of insulated surfaces.

b. Compressed Resin bonded mineral wool mattress insulating material is specified in Table 1, it shall be of the required grade. The application density of insulation for temperature upto and including 400 Deg.C shall be 100 Kg/Cu.m. The application density for temperatures above 400 Deg.C shall be 125 Kg/Cu.m.

4.1.2 Sheeting Material

The sheeting material for all insulated piping and equipment shall be aluminium conforming to codes specified in Table 3.1. The thickness of aluminium sheeting to be used shall be as follows:

a. Pipes of 450 mm (18 in.) and above, over outside diameter of insulation - 1.219 mm

(18 SWG)

b. Pipes of 150 mm (6 in.) and above, over outside diameter of insulation but less than 450 mm (18 in) - 0.914 mm (20 SWG)

c. Pipes less than 150 mm (6 in) over outside diameter of insulation - 0.711mm (22 SWG)

d. Flues and ducts, not less than 1.0 mm

4.2 Piping

4.2.1 All vertical pipes shall be provided with suitable insulation supports to prevent the insulation from collapsing due to its own weight.Any welding required shall be done by the SUPPLIER with the prior permission of the PURCHASER/Engineer and only under his direct supervision. Where welding is not permitted, suitable clamped supports shall be used by the SUPPLIER. The insulation shall be applied starting from bottom to top.

4.2.2 The insulation shall be formed to fit the pipe and applied with edges pulled together tightly at the longitudinal joint and secured by lacing wire. The insulation shall be turned to bring this joint to the lower side. Adjacent length shall be butted closely and laced together with lacing wire. For insulation thickness of more than 75 mm, where application will be in two or more layers, each layer of mattress shall be backed up with wire netting chosen from 20 SWG galvanized steel wire and having hexagonal opening of 25 mm size. If the interface temperature is 400 Deg.C or more, the wire netting shall be from 20 SWG stainless steel wire and having hexagonal opening of 25 mm size.

4.2.3 The ends of all wire loops shall be firmly twisted together with pliers, bent over and carefully pressed into the surface of the insulation.

4.2.4 All insulation shall be protected by an outer covering of aluminum steel sheeting. All insulation sheeting joints shall be sealed and made effectively weather and water-proof. Extreme care shall be taken during the designing and installation of the insulation and the outer sheeting keeping in mind that the piping and equipment will be installed outdoors. All flat surfaces shall be adequately sloped to prevent pools of water collecting. The sheeting shall be protected internally with 2 coats of bitumastic paint. The jackets shall be installed with the longitudinal lap joints at 45 Deg.C below the horizontal for horizontal pipes and the joints sealed with bitumastic paint.

On vertical pipes the jacketing shall be applied working from bottom up. Each section of jacketing shall have a minimum lap of 50 mm longitudinally and circumferentially. Each circumferential joint shall be made weather-proof by securing with an aluminum/galvanized steel strap and sealing with bitumastic paint. Longitudinal lap joints shall be fixed with zinc plated screws on approximately 150 mm centers.

4.3 Valves and Fittings

4.3.1 All valves, fittings and specialties shall be covered with the same type and thickness of insulation as specified for the adjoining pipe, with the special provisions and/or exceptions as listed below.

4.3.2 All valves and flanges shall be completely insulated with removable type of boxes fabricated from aluminum sheets of same thickness as used on adjoining pipes. Pipe insulation adjoining flanges shall be beveled back to permit removal of the bolts and nuts. The insulation shall be applied after the finish has been applied over insulation on the adjacent piping.

4.3.3 Flanges on lines covered with the minimum thickness of insulation (lower temperature

range) shall not be insulated. Flanges on all other lines shall be covered with provisions for making the insulation removable and replaceable.

4.3.4 Unions shall not be insulated.

4.3.5 Non Metallic Expansion Joints shall not be insulated.

4.3.6 Safety valves, traps and safety valve discharge lines shall not be insulated. However, trap discharge lines shall be insulated for personnel protection.

4.3.7 Nozzles and other connections on tanks, heaters and other equipment shall be insulated in the same manner as the pipes.

4.3.8 Valves shall be insulated up to and including their bonnet flange.

4.3.9 Pipe hanger clamps shall be covered with insulation along with the pipe. When pipe hangers pass through insulation on piping outdoor, a metal hook placed withwaterproof sealing material shall be supplied and installed. Care shall be taken toensure that the upper bolts of hangers clamps are not insulated.

4.4 Equipment

4.4.1 Mineral wool blanket insulation to the specified thickness shall be provided. The SUPPLIER shall tack weld suitable 9 SWG wire lugs at least 25 mm longer than the required length to support the insulation in place. These lugs shall be bent and secured with the metal fabric of the blanket, after the insulation has been applied.
Where welding is not permitted, clamps of mild steel flats with bolts, nuts and lugs welded over the flat shall be used. The lugs shall be spaced at approximately 300 mm centres. Spacer rings, at 1000 mm shall be provided for fixing aluminum sheets. All blanket joints shall be butted tightly and the blankets shall be secured with 10 mm wide 25 SWG galvanized bands. After banding, all blanket edges shall be laced tightly.

4.4.2 All equipment shall have a smooth sheet aluminum jacket, applied in a manner similar to that specified for piping. All vertical and horizontal sheets shall be overlapped at a minimum of 50 mm. The longitudinal lapped joints of adjoining sections of sheets shall be secured with zinc plated screws. On all vessels over 2.5 meter diameter, the jacketing shall be further secured by circumferential bands at approximately one more centres. Each sheet joint shall be sealed with bitumastic paint. The roof sections shall overlap the side walls to prevent water seepage between insulation and the vessel wall. Side wall sheets shall be securely banded at inter-sections of the side wall and roof sections.

4.4.3 All equipment and vessel manholes, hatches, bolted or screwed cover plates, flanged ends, etc. shall have removable box type insulation, with same thickness of insulation as for adjacent surfaces. Insulation adjoining such equipment or vessel openings shall be tapered towards these openings to permit removal of bolts, screws, heads, covers or plates with no damage to adjacent surface insulation or cover.

4.4.4 The insulation applied to equipment shall be reinforced with 25 mm (1 inch) 20 SWG galvanized wire netting with hexagonal mesh. One course of wire netting shall be applied to the surface of the equipment, with an additional course per 40mm of thickness. All irregularities of the surface shall be filled and leveled over with insulating cement. Mineral wool blankets as specified shall be applied over the dry cement surface and secured with annealed wire lacings.

5 Guarantees

In addition to the guarantees called for in the PURCHASER's General Conditions of Contract

for Supply and Erection, the SUPPLIER shall also guarantee that if the specified maximum surface temperatures are exceeded on actual measurement the SUPPLIER shall either replace the insulation with a superior material or provide additional insulation thickness at the PURCHASER's/Engineer's discretion and at no extra cost to the PURCHASER.

6 Miscellaneous

Approval of the PURCHASER Engineer shall be obtained for samples of all insulation material and sheeting materials and necessary test certificates of approved national laboratories, shall be sent to the PURCHASER before dispatching these materials to Site. Insulation shall not be applied until specific approval is given by the PURCHASER/CONSULTANT.

TABLE 3.1 –
RECOMMENDED MINIMUM THICKNESS FOR THERMAL INSULATION (MINERAL WOOL)

NOMINAL DIA IN MM	OPERATING TEMPERATURE (^{0}C)								
	100	150	200	250	300	350	400	450	520
15	25	25	40	40	50	60	75	90	100
20	25	25	40	50	60	60	90	90	115
25	25	25	40	50	60	60	90	100	115
40	25	40	40	50	60	65	90	115	150
50	25	40	40	60	75	75	100	115	150
65	25	40	40	60	75	75	100	115	150
80	40	40	50	60	75	90	100	125	150
100	40	40	50	60	75	90	115	125	150
150	40	50	50	75	75	100	115	150	175
200	40	50	60	75	75	100	125	150	175
250	40	50	60	75	75	115	125	150	175
300	40	60	60	75	80	115	150	175	200
350	50	60	65	75	80	115	150	175	200
400	50	60	75	75	85	115	150	175	200
450	50	60	75	90	90	115	150	175	200
500	50	60	75	90	90	115	150	175	200
550	60	60	75	90	90	115	150	175	200
600	60	65	80	95	95	115	150	175	200
Above 600	60	65	80	95	95	115	150	175	200

Note: The table is given only as a guideline and the BIDDER shall select the thickness as per the calculations using IS Standard for conductivity.

ANNEXURE 3.3 – LIST OF MOTORIZED VALVES

The PURCHASER wishes to go in for automation of the plant operation to the extent possible. This calls for motor operation for a few of the important valves. Notwithstanding anything mentioned to the contrary, elsewhere in this specification, the following gives the list of minimum number of motor operated valves to be included in the offer. In case the BIDDER decides a few more of the valves need to be motor operated for the effective automation of the plant, the same can be added separately in the scope of supply under the heading" Additional Motor Operated Valves". The price

for the additional motor valves may also be given separately as "Optional price for the additional motor operated Valves".

- Isolation valves provided in the Upstream of the control Valve station provided in the MP extraction steam line
- Isolation valve provided in the Turbine Exhaust Vent piping.
- Turbine casing drain first isolation valves near turbine

EXHIBITS – PIPING WELDING ELECTRODES SELECTION

CRITICAL PIPING : STEAM, FEED WATER, CONDENSATE, DM WATER, MAKE UP WATER OIL ETC.,

Sl. No.	Material Combination						Root Run	Further	Remarks
	Specification	P. No.	Grade No.	Specification	P. No.	Grade No.	TIG	Run	
1	SA 106 GR.B	P1	1	SA 106 GR.B	P1	1	ER 70 S2	E 7018	
2	SA 106 GR.B	P1	1	SA 106 GR.C	P1	2	ER 70 S2	E 7018 A1	
3	API 5L GR.B	P1	1	API 5L GR.B	P1	1	ER 70 S2	E 7018	
4	SA 672 GR.60	P1	1	SA 672 GR.60	P1	1	ER 70 S2	E 7018	
5	SA 335 GR.P11	P4	1	SA 335 GR.P11	P4	1	ER 80 S B 2	E 8018 B2	
6	SA 335 GR.P12	P4	1	SA 335 GR.P12	P4	1	ER 80 S B 2	E 8018 B2	Alloy Steel
7	SA 335 GR.P22	P5	1	SA 335 GR.P22	P5	1	ER 90 S B 3	E 9018 B3	Stainless Steel
8	SA 312 TP 304	P8	1	SA 12TP304	P8	1	RT 347	E 347	

NON-CRITICAL PIPING : CW, ACW, SA, IA ETC.,

Sl. No.	Material Combination						Root Run	Further	Remarks
	Specification	P. No.	Grade No.	Specification	P. No.	Grade No.	TIG	Run	
1	SA 106 GR.B	P1	1	SA 106 GR.B	P1	1	E 6013	E 7018	
2	SA 106 GR.B	P1	1	SA 106 GR.C	P1	2	E 6013	E 7018	
3	IS 3589			IS 3589					
	IS 1239	P1	1	IS 1239	P1	1	E 6013	E 6013	
	IS2062			IS2062	P4				Carbon Steel
4	API 5L GR.B	P4	1	API 5L GR.B	P4	1	E 6013	E 7018	Alloy Steel
5	SA 672 GR.60	P5	1	SA 672 GR.60	P5	1	E 6013	E 6013	Stainless Steel
6	SA 672 GR.70	P8	2	SA 672 GR.70	P8	2	E 6013	E 7018	

4. SPECIFICATION FOR GENERATOR

4.1 Scope

4.1.1 The equipment shall include one (1) No. horizontal shaft three phase alternating current Synchronous Generator to have MCR to deliver the maximum output of 3.0 MW turbine at 0.8 PF, 415V, 50 Hz at site condition of 50 Deg. C ambient complete with both end supports and with brushless exciter (Without PMG), digital excitation regulation system, closed air circuit water cooled system and other accessories, spares and special tools that will be required for satisfactory erection and efficient operation of the system.

4.1.2 The generator to be coupled to the turbine matched in respect of speed, over speed, moment of inertia, overload capacities, coupling and other relevant requirements.

4.1.3 The generator is intended to be connected directly to the 415V switchboard. The BIDDER shall optimize the generator parameter to meet the system and circuit breaker requirement.

4.2 Standards

The synchronous generator and their components shall comply with the latest edition of the applicable standards listed below. In the event of any conflict between the standards referred to and the requirements of this specification, more stringent of the two shall govern.

IS:2253	-	Designation for type of construction and mounting arrangements of rotating electrical machines.
IS:4691	-	Degree of protection provided by enclosures of rotating electrical machinery.
IS:4722	-	Specification for rotating electrical machines.
IS:4728	-	Terminal marking of rotating electrical machines.
IS:4729	-	Rotating electrical machines, vibration measurement And evaluation of.
IS:4889	-	Methods of determination of efficiency of rotating electrical machines.
IS:5422	-	Specification of turbine type generators
IS:6362	-	Designation of methods of cooling for rotating electrical machinery.
IS:7132	-	Guide for testing synchronous machines.
IS:7816	-	Guide for testing of insulation resistance of rotating machines.
IEC-60034	-	Rotating electrical machines.
IEC 85	-	Thermal evaluation and classification of electrical insulation.
API 614	-	Lubrication and sealing.

4.3 General

4.3.1 The generator shall be of closed air circuit water cooled (CACW) type, with side coolers housed in a IP 54 enclosure and driven by Steam turbine. The necessary coupling bolts shall also form part of the supply.

4.3.2 The Nominal Output of the Unit shall be delivered at power factor from 0.8 PF. Generator shall be suitable for over loading of 110% for one hour in every 12 hours and 150% for 30 seconds. Generator shall be able to operate at full load with a variation of ±10% in voltage and ± 5% in frequency, with a continued voltage and frequency variation of ± 10%. Excitation System shall have a control accuracy of ± 0.5%.

4.3.3 Generation voltage of the Unit shall be rotation.

4.3.4 415V, 3 Phase R, Y, B in clockwise, nutral The rating and specification of all the required accessories should be suitable for 415V rated voltage.

4.3.5 The generator shall be suitable for operation over a range of voltage variation as mentioned at 2.3.2 and operate satisfactorily under system conditions stated above. The generator shall withstand on the sudden application of maximum load or sudden loss of maximum load and during momentary short circuits or sustained ground faults.

4.3.6 The generator shall be star connected and the main and neutral leads shall be brought out of the stator frame for insertion of current transformer for protection, metering and surge protection apparatus. The generator shall be suitable for grounding through grounding resistor. The BIDDER shall submit his proposal scheme to explain housing arrangements of various current transformers.

4.3.7 The short circuit ratio (SCR) shall not be less than 0.5.

4.3.8 The generator shall be capable of withstanding without damage a stator current of 150 % for a period of 30 seconds.

4.3.9 The generator shall be capable of withstanding without damage a three phase, a line-to-line, a line-to-earth or two line-to-earth short circuit for a period of three seconds, when operating at the rated speed and with an excitation corresponding to a 5 % over voltage at no load.

4.3.10 The maximum line charging capacity at rated voltage that can be obtained without negative excitation and with stable operation shall not be less than 35% of rated kVA.

4.3.11 The saturated rated direct axis sub transient reactance of generator should not be less than 14% and not more than 22%.

4.3.12 The moment of inertia of the generator shall be so selected that it meets the requirement of over speed.

4.3.13 The machine shall be capable of operating continuously on an unbalanced system such that, with none of the phase current exceeding the rated current, the ratio of the negative sequence component of current (I_2) to the rated current (I_N) does not exceed 0.1 and under fault conditions shall be capable of operation with the product of $(I_2/I_N)^2$ and time (t) in seconds not exceeding 15.

4.3.14 In the design of generator, each part shall be so proportioned that the maximum unit stresses therein resulting from any continuous operating conditions specified shall not exceed one third of the yield point or one fifth of the ultimate strength of the material whichever is less.

4.3.15 The design of the generator structure and housing in which resonance might become objectionable shall be so proportioned as to avoid the possibility of resonance with higher rated frequency or multiple and within the frequency variation.

4.3.16 The synchronous generator shall be designed and constructed so as to facilitate easy repair / replacement of generator stator bars and rotor pole winding at site without the necessity of going back to works for repairs. Suitable provision shall be made in the base frame of the Generator to facilitate easy removal of the rotor body by sliding it on the bed plate.

4.3.17 The equipment offered shall be suitable for manual and auto control from the machine control panels located in the control room.

4.3.18 The machine shall be suitable for low resistance earthing of the neutral through neutral grounding resistor to limit the maximum earth fault current to 50 A. The BIDDER shall indicate maximum allowable duration for clearing fault inside generator under this condition, to ensure that no damage occurs to the stator laminations.

4.4 Over Speed

4.4.1 The generator shall be designed so as to be capable of running at over speed of the turbine, and all parts of the generator and other equipment shall fully and safely withstand stresses resulting from over speed operation. The rotor shall be tested at 1.2 times the rated speed for two (2) minutes.

4.5 Insulation

4.5.1 The offer shall give a full description of the windings offered both as to the conductor and insulation. Detailed drawings shall be submitted showing the arrangement of conductors and the thickness and nature of all materials used both for insulation and mechanical protection in the slots of the stator. The insulation, after completion of winding, shall be VPI treated. The BIDDER shall furnish detailed write-ups on treatment methods and procedures. The BIDDER shall also furnish sufficient details on replacing, servicing / repairing of the generator, etc., in case of damage of the windings for VPI treated windings, giving time factor involved.

4.5.2 Insulation of minimum `F ' class as specified in IEC specification of the latest issue shall be used. The quality of the insulation must be such that it is non- hygroscopic and no deterioration will take place when subjected to the maximum, specified operating temperatures nor must it be permanently injured when exposed to this feature as the machine is to operate in a most tropical climate.

4.5.3 The end turns and coil connections shall have not less than full insulation, equivalent to, and of the same construction as the coil insulation in the stator slots. The coil and end turns shall be impregnated with high grade insulating varnish. Provision shall be made for tightly wedging the coils in the slots with the wedges which shall not shrink or buckle. Care shall be exercised that the blocking of air passages shall not occur.

4.5.4 The insulation and taping of the coils shall be such as to prevent permanent injury from exposure to dampness to provide adequate corona shielding, to withstand high temperatures without injury, to prevent the entering of magnetic particles and to prevent formation of zones.

4.6 Temperature Rise

4.6.1 Even though insulation of 'Class-F' must be used, when operating continuously at the maximum continuous rating at its rated 0.8 PF at any working voltages (±10%) and any frequency (±5%) in the range stipulated, the temperature rise shall not exceed Class-B limit

at full load. The SUPPLIER shall furnish temperature limit curve, for the specified voltage & frequency range.

4.6.2 The bearing metal temperatures shall be detected by means of duplex RTDs which shall be hooked upto the temperature scanner of the control panel in the control room.

4.6.3 Measurement of temperature shall be made as specified in IEC. The maximum temperature of inlet air shall be taken as 45 Deg. C and the maximum cooling water inlet temperature as 32 Deg. C. Temperature rises shall be within the Class 'B' insulation Temperature rise limits.

4.6.4 The machine shall further be capable of operating continuously at full load at 0.8 power factor at 415V at frequency 5% below normal, satisfactorily and without undue heating.

4.6.5 The machine shall be capable of generating more kW than the rated kW during operation of the machine from 0.8 lagging power factor to unity PF but within the kVA rating of the machine.

4.7 Efficiency And Output Guarantees

4.7.1 The guaranteed overall efficiency of the generator at rated terminal voltage and power factor at 75 Deg. C winding temperature, for the percentage rated output of 100%, 75%, 50% and 25% shall be as furnished. The efficiencies shall be determined by summation of losses method as specified in the latest edition of IEC Publication No. 60034.2 or IS:4889 or equivalent standards. A tolerance will be permitted in the determination of efficiencies as per IEC 60034.2.

4.7.2 The generator shall be guaranteed to be capable of giving its rated output under the conditions described earlier without exceeding the temperature rise as specified and without tolerance. If the temperatures are not within the specified limits, the vendor shall do the necessary modifications to bring the temperature within the prescribed limits before acceptance by the PURCHASER.

4.7.3 Guaranteed maximum temperature rise, for the stator and rotor windings of the machine, above inlet temperature of the cooling air not exceeding 40 Deg. C, when operating under rated load conditions with all coolers in service, shall be as follows:

a) Stator winding by embedded temperature detectors - 85 °C

b) Rotor winding by resistance-90 °C

4.8 Cooling

4.8.1 Generator shall be provided with adequate cooling systems based on air circulation principle; complete with fans etc., depending on the capacity of the units. The air passages in the stator, rotor fans, coolers, etc., shall be designed to give a smooth and quick flow of air. The BIDDER should submit drawings in detail to show the cooling system he proposes for the generator.

4.8.2 The BIDDER shall submit a detailed description of the cooling system taking note of the class of insulation and maximum permissible temperature, size of the unit. Justification for the adequacy shall be given in the description of the cooling system.

4.8.3 Duplex type RTDs of minimum two numbers each shall be provided in the cold and hot air passages.

4.8.4 The coolers shall be constructed out of admiralty brass and shall be located clear off the stator, preferably on the sides or on the bottom of the generator. Any leakage from the cooler shall be drained safely and properly and there shall not be any chance of the cooling water finding it's way to the stator / rotor windings. Suitable moisture detector device shall be used to detect and warn accidental leakage of water into the cooling air stream.
The coolers shall be designed for the shutoff head of the cooling water pumps which will be about 5 Kg/Sq. cm(g) and tested for two times the design pressure.

4.8.5 The cooler shall have ten percent plugging margin and shall be sectionalised and designed to be suitable for shutting off section by section for cleaning. The design shall be such that the generator can deliver 100% of rated output with one section out of service.

4.9 Construction

4.9.1 All parts of generator shall be designed and constructed to safely withstand maximum stresses during operation, over speed, short circuit conditions, out of phase synchronizing. The pedestal of each generator will be supported on the concrete foundation. All necessary accessories like shims, dowel etc., shall be included in the scope. All sole plates shall be interchangeable and suitably machined and prepared for use at site with minimum amount of work.

4.9.2 The BIDDER shall give full particulars of the extent to which the generator will be assembled for purpose of shipment and the work to be done at site.

4.9.3 Pedestal bearings shall be provided for alternator for ease of maintenance and shall be insulated from ground to prevent shaft currents.

4.9.4 After primer, the generator enclosure shall be given two coats of epoxy paint, shade RAL 7032.

4.10 Stator

4.10.1 The stator frame shall be a single piece to consist of a cylindrical casing of welded plate construction, reinforced internally in the radial and axial direction by stationary web plates making the entire frame perfectly rigid. Light non magnetic alloy end shields shall be bolted to the ends of the frame. Stator core shall be made up of segmental, annealed punchings of high quality silicon steel to give minimum electrical losses. The stator winding shall be of the double layer lap type with Class 'F' insulation.

4.11 Rotor

4.11.1 The generator rotor shall be forged from a single piece ingot of special alloy steel carefully heat treated to obtain excellent mechanical and magnetic properties. A comprehensive series of ultrasonic examinations on the rotor body shall be done to ensure that absolutely no inadmissible internal failures are present and that the material meets the quality standards. Rotors of four pole machines shall be made up of stacked laminations, mounted on the shaft.

4.11.2 The design and construction of the rotor shall be in accordance with the best modern practice and shall be fully described in the offer. The factor of safety on yield point of material shall not be less than 1.5.

4.11.3 The insulation between turns of field winding shall consist of special epoxy impregnated insulation and glass laminates shall be used for the insulation to ground.

4.11.4 The rotor spider shall be of steel constructions. To facilitate synchronization a shorted damper consisting of several round copper bars in each pole head shall be provided.

4.11.5 The field poles shall be provided with adequate damper windings to ensure stability under fault conditions and to meet (I_{22} x t) value of 15.

4.11.6 The rotor shall have pedestal bearings with oil cooling system so that the end shields could be removed without disturbing the bearings for inspection of the rotor/stator coils.

4.11.7 The assembly shall be dynamically balanced at shop at rated speed and maximum speed.

4.12 Earth Terminal

Two Nos. of Earth terminals shall be provided. The earth terminals shall be designed to terminate Galvanised Iron conductors.

4.13 Speed Regulation

4.13.1 The moment of inertia of the alternator together with that of the turbine shall be sufficient to ensure stability and the speed regulation specified in the section covering turbine for full load rejection. The fly wheel effect shall be incorporated in the alternator and turbines as integral part and not added in the shape of separate weights, rings or other means.

4.14 Shaft

4.14.1 The generator shaft shall be made of best quality forged alloy steel, properly treated. The shaft shall be of ample size to operate at all speed, including maximum over speed without vibration or distortion and shall be able to withstand short circuit, heavy momentary overloading and other stresses without damage. To prevent the flow of harmful shaft currents damaging the bearings, suitable shaft earthing shall be provided.

4.14.2 A complete set of test reports covering metallurgical strength, crystallographic and ultrasonic and baroscopic tests performed in each shaft during various stages of its manufacturing shall be furnished as also the complete specifications of the shaft material forging and its design parameters such as stresses and critical speed.

4.14.3 The generator shaft shall have a suitably shaped flange for coupling to the turbine. The coupling flange shall be forged integral with the shaft and the shaft coupling shall comply with the requirements of IEC for shaft coupling. All coupling bolts, nut and nut guards for coupling shall be included in the scope.
The alignment limit for the shaft shall be as per the latest NEMA / DIN standards.

4.15 Space heaters & RTDs

4.15.1 Suitably rated heaters shall be installed within the enclosure of the generator. Location and the maximum temperature of the heaters shall be such that no damage can be caused to any insulation. Heaters shall be suitable for operation on a single phase 230 V AC supply. A suitable double pole switch shall be mounted on or adjacent to the stator frame for the manual switching of the heaters.

4.15.2 Duplex type RTDs shall be provided in the following locations, which shall be hooked up to the temperature scanners:

a) Coil sides - 4 per phase.

b) Stator core - 4 Nos.

c) Bearings - 2 nos. each for DE and NDE

d) Cold & Hot air circuits - 2 Nos. per stream.

e) Exciter Field - 2 Nos.

4.16 Excitation System

4.16.1 A brushless exciter shall be used and it shall be mounted on the out board end of the generator frame. A digital excitation regulation system (with twin auto and a manual back-up channel) shall be provided to control the excitation of the synchronous generator by varying the current applied to the field of the main exciter.

4.16.2 The excitation regulation system shall be of the 'state-of-the-art' microprocessor technology, high speed, fully tropicalised, automatic excitation regulator. It should be complete with necessary cable entries, adjusting rheostats, auto /manual control facilities, on / off and raise / lower selector switches. The following minimum displays shall be made available in the operator pad / digital display unit:

a) Exciter Field Current

b) Exciter Field Voltage

c) Generator Voltage

d) Generator Power Factor

4.16.3 The excitation system shall be provided with the following minimum features:

a) Generator voltage control

b) Auto power factor control

c) Field current control

d) Excitation buildup during startup and field suppression shutdown

e) Limiter for the under excited range & delayed limiter for overexcited range

f) PT fuse failure detection and auto changeover

g) Diode failure supervision

h) Stator current limitation for lagging & leading loads

i) Rotor current limiter

j) Load angle limiter

k) Volts / Hz limiter

4.16.4 The system offered shall have the following facilities:

a) Two independent auto cum manual channels. Each channel will have it's own thyristor / power bridge arrangement.

b) Back-up manual mode for testing / emergency operations

c) Follow-on mode for each operation to have bump less transfer between auto channel and manual channel

d) Audible annunciation for internal faults and for channel changeover with accept provisions

e) RS485 Communication port with MODBUS protocol for configuration / setting option from PC / DCS

f) Digital display & keypad, for front panel operation

g) All necessary software for interfacing the system with PC / DCS

h) Self-diagnostic facility

4.16.5 Dedicated TB for hooking up of the following signals to DCS shall be provided:

- AVR – 1 ON/OFF
- AVR – 2 ON/OFF
- AVR – 1 Faulty
- AVR – 2 Faulty

4.16.6 AVR panel shall have an height of 2200 mm, including base channel of 100 mm.

4.17 Accessory Equipment

4.17.1 Main power terminal boxes shall be fully phase segregated and suitable for the envisaged type of connection arrangement.

4.17.2 The generator shall be provided with stator temperature sensors installed in the stator winding with leads and shall be brought out to the terminal boxes. RTDs shall be provided for hooking upto the temperature scanner in the control panel. Space heaters for anti-condensation shall also be provided. Necessary vibration transducer, displacement transducers with transmitters shall be provided which shall be hooked up to the control panel in the control room.

4.17.3 The BIDDER may propose to accommodate auxiliary equipment like current transformers, potential transformers, lightning arrestors and surge capacitors in the generator terminal boxes, if available as their standard practice. Requirements of such equipment shall be in accordance with IS / IEC standards and the specifications furnished

elsewhere in this document.

4.17.4 Terminal cubicles, if used for single core cable connections, shall be provided with non-magnetic type gland plates.

4.18 Protective Devices

4.18.1 The protective devices as listed under the topic Protection, Metering and Control cubicles and the schematic diagram shall be offered.

4.18.2 The BIDDER shall note the system conditions like voltage, frequency variations, SC level at the location of the proposed generating units and offer suitable generating equipment with necessary accessories required for satisfactory working of the generating units.

4.19 Tests

4.19.1 The generator shall be completely assembled at works and type tests as specified below shall be conducted on the assembled unit and auxiliaries as per the latest edition of IS / IEC. Detailed test reports shall be furnished.

4.19.1.1 Tests

The following tests shall be carried out on the machine:

a) Measurement of DC resistance of stator and rotor windings.

b) Insulation resistance of stator winding (before and after high voltage tests), rotor winding, bearings and embedded temperature detectors.

c) High voltage test of stator and rotor windings at industrial frequency.

d) Phase sequence.

e) Determination of open-circuit characteristics.

f) Determination of short-circuit characteristics.

g) Over speed at 120% for 2 minutes and vibration there of.

h) Pressure test on coolers for close - circuit cooling.

i) Determination of efficiency by separation of losses methods.

j) Vibration.

k) Impedance test of the rotor winding.

l) Stator winding capacitance and tan delta measurement.

m) Measurement of Shaft Voltage

n) Polarization Index

o) Wave form recording.

p) Shaft vibration measurement

q) Momentary over current test for 150% of rated current for 30 Secs.

r) Harmonics

s) Voltage balance test

t) Air gap

u) Noise test

v) Mechanical run test for temperature rise.

w) Temperature rise test at iron loss, copper loss with equivalent method including exciter.

In addition to the routine test, the following type tests shall also be carried out, if the generator manufacturer had not carried out the type tests on similar machine (kW rating & speed):

a) Instantaneous Three (3) phase short circuit test at rated speed and 30% voltage.

b) Determination of reactances and time constants.

4.19.1.2 Tests on Exciters

a) High voltage test

b) Measurement of resistances

c) Measurement of insulation resistance

4.19.1.3 Tests at Site

Site tests for generator shall include the following:

a) Mechanical run and vibration measurement.

b) Measurement of stator and rotor winding insulation resistance.

c) Over speed test

d) Measurement of shaft voltage

e) Measurement of stator and rotor winding resistance

f) Phase sequence test before excitation (with residual voltage) and after excitation

g) Open circuit and short circuit test

h) Load acceptance and rejection test at selected loads from no load to full

load.

i) Overall response of machine and excitation system

j) Adjustment of excitation regulator parameters

k) Synchronizing test

l) Dynamic checking of all protective functions

m) Checking and commissioning of various other auxiliary equipment.

n) Function of RTD and its circuits

o) Pressure tests on coolers

Tests on other equipment like CTs, PTs, LAs, shall comply with the routine tests etc., as per relevant standards.

Test reports for all the type tests on the generator, CTs, PTs, & LAs carried out on similar equipment already supplied shall be furnished for approval.

5. SPECIFICATION FOR PCC Panel

5.1 Introduction

5.1.1 This specification covers the design, manufacture and supply of 415V indoor type switchboard (MDB) incorporating draw-out Air Circuit Breakers of 4 pole

5.1.2 The 415V switchboard shall be capable of continuous and reliable operation at the full load rating specified where continuity of operation is of prime importance.

5.1.3 Workmanship shall be the highest grade and the entire construction in accordance with the best modern practice. The LT switchboard shall be capable of withstanding the severest stresses likely to occur in actual service and of resisting rough handling during transport.

5.1.4 The LT switchboards shall have incoming and outgoing feeders as shown in the enclosed single line diagram. Circuit breaker shall be suitable to withstand inrush magnetizing currents of Transformers and capacitor bank ON and OFF.

5.1.5 Circuit breaker shall be suitable for interruption of the motor current under all conditions, without causing over voltages / switching surges that may damage the motor insulation, owing to chopping currents / multiple re-ignition. Feeders meant for motor feeders shall also be additionally be provided with surge arrestor / suppressor, to protect the motor from over voltages and surges. The supplier shall furnish adequate details / documents / calculations to substantiate that the motor will not get affected by over voltages / surges under any circumstances of breaker operation.

5.2 Specific Requirement

5.2.1 LT Switchboard:

Rated voltage	-	415V, 3 phase, 4 wire
Rated frequency	-	50 Hz
Fault level	-	50 kA for 1 sec
Degree of Protection	-	IP 54
Highest System Voltage	-	500V
Clearance in air	-	As per IS/IEC
Busbar Material	-	High Conductivity Electrolytic grade Copper EC 91 E grade

Busbar Rating with Natural Cooling - As per SLD.

Condition	
Design Ambient	- 50 ° C
Maximum Busbar Temperature	- As per IEC.
Class & VA Burden rating for CT/ PT	- As required
Communication protocol for Relays	- MODBUS - RTU
Communication protocol for meters	- MODBUS - RTU
Earthing System	- Conventional

5.2.2 Breaker Requirements:

Design ambient	- 50 ° C

Breaker (TG, Tie & its Spare) rating for Natural Cooling Condition	- As per SLD
Rated Voltage	- 415, 3 phase, 4 wire
Rated frequency	- 50Hz
Fault level	- 50kA for 1 sec
Circuit Breaker Type	- Air
Highest System Voltage	- 500V
Clearance in air	- As per IS/IEC
Rated short circuit breaking capacity	- 50kA
Rated short circuit making capacity	- 50kA
Control Voltage	- 24V DC with single independent source

5.3 Standards

The design, manufacture and testing of the various equipment covered by this specification shall comply with the latest issue of the following standards:

IS:375	-	Marking and arrangement of switchgear busbars
IS:694	-	PVC insulated cable with copper conductor for voltages upto 1100 V
IS:722	-	Integrating meters
IS:1248	-	Electrical indicating instruments
IS:13118	-	General requirements of circuit breaker for voltages above 1000V.
IS:2705	-	Specifications for current transformers
IS:3156	-	Specifications for voltage transformers
IS:3231	-	Electrical relays for power system protection
IS:3427	-	Metal enclosed switchgear and control gear (1 kV to 52 kV)
IS:6865	-	Control switches and push buttons
IEC 44	-	Instrument Transformers
IEC 62271-100	-	Circuit Breakers
IEC 185	-	Current Transformers
IEC 186	-	Potential Transformers
IEC 255	-	Electric Relays

IEC 298	-	AC metal enclosed switchgear and controlgear for rated voltages above 1 kV and upto and including 52 kV.
IEC 376	-	Specification and acceptance of new sulphur hexafluoride
IEC 1036	-	Static Meters

5.4 Specific Requirements

5.4.1 Construction

5.4.1.1 The switchgear shall be metal clad, free floor standing, totally enclosed, dust and vermin proof with draw-out type circuit breakers. Vertical units shall be assembled to form a continuous line up of uniform height and depth.

5.4.1.2 The panel structure shall house the components contributing to the major weight of the equipment such as circuit breaker, main horizontal busbars and other of the components is adequately supported without deformation or loss of alignment during transit or during operation.

5.4.1.3 Each unit of the switchgear shall have necessary internal sheet metal barrier to form separate compartments for buses, instruments, relays, cable connections etc.

5.4.1.4 Adequate barriers shall permit personnel work safely within an empty compartment with the busbars energised. Checking and removal of components shall be possible without disturbing the feeder. All auxiliary equipment shall be easily accessible to facilitate their operation and maintenance. It shall be possible to set all relays and measuring instruments without de-energising the switchgear.

5.4.1.5 All doors and openings shall be fitted with dust excluding neoprene gaskets with fasteners designed to ensure proper compression of the gaskets.

5.4.1.6 When covers are provided in place of doors, generous overlap shall be assured between sheet steel surfaces with closely spaced fasteners to preclude the entry of dust.

5.4.1.7 The panels shall have a rear cable chamber housing the cable and connections. The design shall ensure generous availability of space for easy installation and maintenance. Cabling and adequate safety for working in one section without coming into accidental contact with live part in an adjacent section.

5.4.1.8 The LT switchboard shall be constructed only of materials capable of withstanding the mechanical, electrical and thermal stresses, as well as the effects of humidity, which are likely to be encountered in normal service. All insulating materials used in construction of the equipment shall be non-hydroscopic material, duly treated to withstand the effects of high humidity high temperature tropical ambient service conditions. Creepage distances shall comply to those specified in relevant standards.

5.4.1.9 Each panel shall be provided with space heater to prevent condensation and the same shall be equipped with differential thermostat to automatically cut in and cut out the heater so as to maintain interior temperature of 5 Deg. C. above the ambient and should have manual disconnect switch.

5.4.1.10 The height of the panel shall not be more than 2200 mm. The total depth of the panel shall

not exceed 1800mm and shall adequately cater proper cabling space. Adopter panel shall be planned as required.

5.4.1.11 Provision shall be made for permanently earthing the frames and other metal parts of the LT switchboard through a copper earth busbar running throughout the full length of the switchboard at the bottom. Draw-out type switching units shall have sliding ground contact. It shall be possible to earth the switchboard at two independent points on either ends for connections to the external earthing network of the plant.

5.4.1.12 It shall be possible to extend the switchgear in either direction at a future date. Ends of busbars shall be suitably drilled for this purpose.

5.4.1.13 Suitable eye bolt for lifting of panel shall be provided. On removing the eye bolts no holes offering access to panel shall be provided.

5.5 Busbars

5.5.1 The rating of busbars shall be as indicated in the SLD and shall be with natural cooling arrangement and not forced cooling arrangement. The short circuit rating of the busbars shall be 5`0kA for 1 sec.

5.5.2 The busbars shall be epoxy moulded sleeved and made of high conductivity electrolytic grade copper.

5.5.3 The busbar chamber shall be totally maintenance free.

5.5.4 The switchboard shall comprise 3 phase main busbars which shall extend through all units of the switchgear line up. The busbar mating surface shall be tinned. High tensile bolts and spring washers shall be provided at all busbar joints. The busbar shall be of uniform section throughout and shall be sized to continuously carry the rated current without exceeding the temperature rise, as recommended by IEC over the maximum ambient temperature specified in the design basis. Busbars shall be colour coded for easy identification of individual phases. The SUPPLIER shall submit temperature rise test report for the substantiating the selected size of busbars.

5.5.5 Busbars shall be supported at regular intervals and both, busbars and supports shall be adequately sized and braced to withstand short circuit level without deformation. All bus supports shall be non-carbonizing material resistant to acidalkalies and shall have non-hydroscopic characteristics.

5.5.6 For long busbars suitable expansion joints shall be provided. Thermal design of the busbars shall be based on the installation of the switchgear in poorly ventilated condition.

5.5.7 Busbars shall be housed in a separate chamber which shall be accessible for inspection only with special tools.

5.5.8 The rating of busbars (both main and incomer busbar) shall not be less than that of incomer breaker rating. The rating of busbars in outgoing feeders shall not be less than that of outgoing breaker rating and shall not be provided as that of the current transformer rating.

5.6 Circuit Breakers

5.6.1 Circuit breakers shall be triple pole, Air circuit breaker, draw-out type.

5.6.2 The breakers shall have motor operated spring charged mechanism with antipumping contactor. The control circuit shall be suitable for local as well as remote control. Provision for manual operation shall also be available.

5.6.3 The breaker sockets and plugs should be heavily silver plated. The breaker shall have adequate auxiliary contacts required by plant control schematics. Additional 30% spare contacts (minimum 10NO + 10NC) for future use shall be provided and wired up to terminal box. Auxiliary relays should be used to multiply the contacts.

5.6.4 All spare contacts of breakers shall be wired upto terminal blocks.

5.6.5 The operating mechanism shall be robust design with a minimum number of linkages to ensure maximum reliability. The operating mechanism shall be such that the breaker is at all times free to open immediately the trip coil is energised. It is to be ensured that all the three poles open/close in unison to avoid any eventuality of single phase operation of the generator. All controls shall be suitable for 85 % to 110 % for closing and 70% to 110 % for tripping of 110 V DC.

5.6.6 Two (2) numbers of tripping coils shall be used for tripping the circuit breaker and shall be planned with 24V DC supply. Two DC buses shall be provided, one for complete control, protection and tripping circuit-1 and other for tripping circuit-2.

5.6.7 Breaker shall be tripped through any of the trip coils available in the breaker through TNC switch / remote tripping impulse / master trip operated signal during normal operation.

5.6.8 No forced cooling shall be envisaged for the other circuit breakers for the currentrating specified.

5.6.9 The breaker shall have the distinct positions indicating:

`Service ' Position	:	With main auxiliary contacts connected
`Test' Position	:	With power contacts fully disconnected and control circuit contacts connected
`Isolated' Position	:	With both power and control circuit contacts fully Disconnected

5.6.10 The breaker trolley shall remain inside the cubicle even in the draw-out position.

5.6.11 The trolley of the circuit breaker is not required

- It shall not be possible to isolate it from the connected position or to plug it in from the isolated position with the breaker closed.
- The circuit breaker can be closed only when it is in one of the three positions or when it is fully out of the panel.
- It shall not be possible to open the breaker compartment door unless the breaker is drawn to the isolated position or test position.
- Inadvertent 'pushing in' of the draw-out circuit breaker in service position, with auxiliary circuit plug not in the position shall be prevented.

5.6.12 The breaker shall be able to function even under condition of phase opposition that may arise due to totally synchronization or otherwise as per relevant IS or IEC standard.

5.6.13 The tips of the main contact shall be adequately silver plated to withstand arcing.

5.6.14 The operating mechanism shall be electrically controlled spring operated.

5.6.15 Mechanism shall have anti pumping and trip free circuitry.

5.6.16 Local arrangement for operating the breakers both electrically and mechanically shall be provided.

5.6.17 Automatic safety shutters shall be provided to ensure the inaccessibility of live parts after the breaker is drawn out.

5.6.18 The circuit breaker trolley shall be provided with a heavy duty self aligning earth contact which shall make before and break after the main isolating contacts during insertion into and withdrawal from the service position of the breaker. Even in the isolated position positive earthing contact should exist.

5.6.19 Circuit breakers of identical rating shall be inter-changeable.

5.6.20 Circuit breaker shall have provision for manual re-charging.

5.6.21 ON / OFF indicator and number of operation centre shall be provided.

5.6.22 Mechanical lock along with cover shall be provided for closing lever / knob for the circuit breaker, which are identified for synchronising purpose.

5.7 Earthing Trolleys is not required

5.7.1 Bus earthing trolleys shall be provided along with switchboard. The bus earthing trolley shall be so interlocked that

- Castel key interlocks with source circuit breakers shall be incorporated in the bus earthing trolley to avoid insertion of trolley, when the bus is live.
- Insertion of trolley during live condition shall trip the source breakers.
- Closing of the source incomer breakers shall be inhibited when the Bus earthing trolley is in inserted position by providing a suitable mechanical key interlock.

5.7.2 Adequate number of cable earthing trolleys shall be provided to suit different feeder ratings. Similarly, suitable interlock shall be provided to avoid insertion of cable earthing trolley, when the cable side is in live condition (i.e) supply is extended from remote for incomer feeders. These interlocks shall also be of electro-mechanical type.

5.8 Current Transformers

5.8.1 The current transformer shall be cast-resin insulated type of adequate capacity and proper characteristics on secondary as specified. The current density should not be more than 1000 amps/sq. inch.

5.8.2 CTs shall withstand stresses originated from short circuit. They shall have ratios, output and accuracy as specified in the drawings. Not more than two cores shall be provided in the CT. All CTs to be of single core type in generator incomer, tie feeder and spare - 1 feeder. Other

CTs may be of multi core type.

5.8.3 CTs shall be preferably of bar primary type, they shall be mounted on the switchboard stationary part and suitable approach for maintenance shall be provided.

5.8.4 The secondary CT leads from all panels should be terminated on the front of the board on easily accessible shorting type terminal connectors so that operation and maintenance can be carried out when the panels are in service.

5.8.5 CTs shall be suitable for continuous loading of 120% of rated current.

5.8.6 CTs shall be subjected to heat run test for the CTs, which had not been type tested in the last three years.

5.8.7 Single CBCT shall be considered in at incoming / outgoing feeders covering all runs of cables as indicated in the single line diagram.

5.8.8 The Burden indicated for the current transformers shall be at lowest tapings.

5.9 Potential Transformer

5.9.1 The potential transformer shall be cast-resin insulated type. It shall be draw-out type and easily accessible so that the same can be attended to or replaced when the panels are in service condition.

5.9.2 The potential transformers shall be protected through HRC fuses on primary side and MCBs on secondary side. They shall have ratios, outputs and accuracies specified.

5.9.3 The draw-out mechanism shall disconnect the primary connection before the PT or its primary fuses become accessible.

5.9.4 All PTs shall be single phase type. They shall have voltage factor of 1.2 times continuous and 1.9 times for 8 hours.

5.9.5 The Line PTs will be mounted on the bottom of the respective panel and separate cubicle will be provided for bus PT.

5.9.6 Bus PT trolleys shall be supplied.

5.9.7 As the switchboards are intended to be in service with the unearthed system and to avoid ferro resonance effect, SUPPLIER shall select suitable method and provide in the switchboard to mitigate the above effect. A detailed write-up on the proposed method shall be furnished for CONSULTANT's review.

5.10 Integrating Meters

5.10.1 Integrating meters of the Trivector type capable of indicating all phase instantaneous parameters and recording KWH, KVARH and KVAH directly shall be provided. The meters shall show total harmonic distortion (THD) of current and voltage parameters.

5.10.2 These should be suitable for 3 phase, 4 wire 50 Hz circuits with unbalanced loading and with two sets of elements connected to current and potential transformers of specified ratio.

5.10.3 The Trivector meter shall be of digital type, class 0.2 or better with communication port, RS485 interface - MODBUS RTU protocol, for hooking up to PC / DCS.

5.10.4 Import / Export facility shall be provided in the TVM for all feeders.

5.11 Indicating Lamps

5.11.1 Indicating lamps shall be of cluster LED type low watt consumption, provided with series resistor where necessary and with translucent lamp covers. Bulbs and lenses shall be easily replaceable from the front.

5.11.2 Following indicators are required on the panel having lens colours as follows:

Breaker ON	:	RED
Breaker OFF	:	GREEN
Auto TRIP	:	AMBER
Trip Circuit Healthy	:	WHITE
Spring Charged	:	BLUE
Breaker in test position	:	WHITE
Breaker in service position	:	RED

5.11.3 Potential free contacts for the following function shall be provided in the synchronizing breaker panels for hooking up to synchronization panel:

- Breaker ON
- Breaker OFF
- Spring Charged
- Auto Trip

5.11.4 Potential free contacts for the following function shall be provided for all breakers for hooking up to DCS:

- Breaker ON / OFF
- Auto Trip
- Breaker trip coil - 1, 2 Healthy

5.11.5 Live line indications with proven design shall be provided at incoming and outgoing sides of all the feeders and bus bars. No PT supply shall be used for the above purpose.

5.12 Relays

5.12.1 All protective relays shall be back connected, draw out type, suitable for flush mounting and fitted with dust tight covers. All relays shall be mounted on the front of the panel and shall

be specified as per requirement. The current and the voltage coils shall be rated as specified.

5.12.2 All relays shall have built-in flag / indicator to indicate operation. All tripping relays shall be suitable to operate on the specified DC voltage.

5.12.3 Feeder / transformer / motor protection relays shall be of numeric / microprocessor type with self diagnostic facility, RS 485 communication port with MODBUS protocol for interfacing with PC / DCS, software for data downloading & configuration. Feeder / transformer protection relays shall have IDMT / highset over current & earth fault elements. Motor protection relay shall have highest over current & earth fault protection, locked rotor protection and current unbalance protection. Alpha numeric display shall be available for the relays and all fault data shall be displayed in natural language, without needing to refer codes / manuals.

5.12.4 Separate sensitive earth fault relay shall be provided for the feeders as called for in the single line diagram. Under no case shall this relay be combined with the main protection of the feeders.

5.12.5 Master trip relay, trip circuit supervision relays and auxiliary relays shall be provided, wherever specified. All the auxiliary relays shall be electromagnetic type.

5.12.6 All spare contacts of relays shall be wired up to terminal blocks.

5.13 Control Switches and Push Buttons

5.13.1 Control switches shall be of the heavy duty rotary type with name plates clearly marked to show the operation. They shall be semi-flushed mounting with only the front plate and operating handle projecting.

5.13.2 Circuit breaker control switches shall be of the spring return to neutral type, while local / remote selector switches and instrument selector switches shall be of the stay-put type.

5.13.3 Emergency push button shall be provided for each circuit Breaker in the panel with acrylic cover.

5.14 Internal Wiring

5.14.1 Internal wiring and inter-panel wiring for all circuits shall be carried out with 1100/660 V grade, single core, multi strand, PVC insulated copper conductor wire of minimum 2.5 Sq. mm for other control circuit.

5.14.2 The wiring shall be neatly bunched adequately supported and properly routed and terminated in the respective terminals with suitable lugs. There shall not be more than two wires connected at a terminal.

5.14.3 Wires shall be identified by numbered ferrules at each end. The ferrules shall be of ring type and non deteriorating material.

5.14.4 All control circuits shall have MCBs mounted in front of the panel and shall be easily accessible. No Fuses shall be envisaged for control supply.

5.14.5 Grey Colour for control wiring shall be used. For R, Y, B colour wiring shall be used for PT and for black coloured shall be used for neutral. Green coloured wire shall be used for

earthing.

5.15 Terminal Blocks

5.15.1 Terminal blocks for the LT connections shall be of 660V grade of stud type and of adequate current rating.

5.15.2 The insulating barriers shall be provided between adjacent terminals. Provision shall be made for label inscription on terminal block. Cables should never be terminated directly on components. Provision shall be made for CT terminals shorting links, remote ON/OFF pushbutton, remote ON/OFF indication and remote ammeter. 20% spare terminals shall be provided on each terminal block.

5.16 Cable Termination

5.16.1 The LT switchboard shall be designed to facilitate outgoing power connection through XLPE insulated armoured cables with bottom entry.

5.16.2 Ample space for connection of these cables shall be provided at the rear of the switchboard. The cable termination arrangement shall be of adequate size and design to receive the required number of cables as specified. Proper cable clamping arrangement shall be provided. Minimum height of 700mm shall be maintained between gland plate and the terminals for the LV cables.

5.16.3 Detachable gland plate of adequate thickness shall be provided for the cable entry into the panel. Sufficient space shall be provided to avoid sharp bending and easy connection. Gland plates to be made up of non-magnetic material, wherever single core cable are used. Aluminium gland plate shall be provided if single core cable are considered.

5.16.4 Suitable shrouds shall be provided to prevent accidental contact with live outgoing terminations of other feeders while carrying out maintenance on one feeder.

5.16.5 Bi metallic strip shall be provided wherever two different conducting material are used.

5.17 Labels

Name plates of approved design shall be provided to represent circuit designation for each feeder. Material for name plates shall be anodised aluminium. They shall be firmly secured with fasteners.

5.18 Painting

5.18.1 All metal surfaces shall be chemically cleaned, degreased and pickled in acid to produce a smooth clean surface, free of scale, grease and rust.

5.18.2 After cleaning, phosphating and passivation treatment, the surface shall be given two coats of zinc rich epoxy primer and baking in the oven.

5.18.3 After primer, it shall be given two coats of epoxy paint, shade RAL 7032, in semi matt finish. Sufficient quantity of touch up paint shall be furnished for application at site.

5.19 Tests

5.19.1 The 415V switchboard shall be tested for routine tests as per the relevant IS /IEC.

5.19.2 All the panels shall be tested in assembled condition

5.19.3 The routine tests shall be carried out in the presence of PURCHASER /CONSULTANT.

5.20 GENERATOR INCOMMER PANEL :-

1. It shall be fitted with 2 Nos of 3200 A Electrically operated draw out type, rating 415 V, 3 Ph, 4 wire, With continuous rating of 3800 A. and 50 KA RMS.
2. The Breaker Panel shall be connected through bus bar.
3. Panel shall have differential, Over current, Over Voltage, Over Frequency, Under Voltage, Reverse Power, Master Trip, and Breaker Discrepancy Relay and any other required.
4. All required Meters such as KWH Meter,Volt Meter, Ammeter, Frequency Meter, KW & PF metre, etc

5.21 PCC OR M D B :- Main Distribution Panel :-

1. It shall have 3 Phase , 4 Wire, 415 V , 3800 A continuous, S.C. ratio – 50 kA,
2. MDB Shall have1 No of 2500 Amp.ACB Electrically Draw out type as a MSEDCL Incomer.
3. MDB Shall have1 No of 1600 Amp.ACB Electrically Draw out type as a DG Incomer.
4. MDB Shall have1 No of 3200 Amp.ACB Electrically Draw out type as a Bus coupler.
5. Above MDB Breaker Feeders with protection of Under Voltage,Over Current ,Earth Fault Relay and shunt trip release with KWH Meters and Ammeters.
6. MDB shall have 15 outgoing feeders viz- 1250A x 4 Nos, 1000A x 6 Nos, 630 Amp.MCCBS =03 Nos. and 315 Amp. MCCBS =02 Nos. with Ammeter and KWH meter.
7. Panel shall be fabricated from 14 SWG cold rolled sheet steel with required nos of louvers with Mesh.
8. Panel shall be fully wired, entire control wiring of CT, PT and Meters
9. MDB shall be connected to generator incomer by Bus Bar.
10. APFC of 500 KVAR is to be installed in 10 steps out of which 4 steps are fixed with necessary relays, meters, etc.
11. Capacitors shall be mixed Dielectric type.

6. SPECIFICATION FOR PROTECTION, METERING, CONTROL CUBICLES

6.1 Scope

This specification covers the requirements of protection, metering, and control cubicles and the associated equipment mounted therein.

6.2 Codes and Standards

6.2.1 The design, manufacture and performance of equipment covered by this specification shall conform to the relevant Indian Standards and Codes. Where Indian Standards are not available, they shall conform to relevant British, IEC and American Standards.

6.2.2 The equipment shall conform to following standards in particular.

IS:1248	-	Direct acting electrical indicating instruments.
IS:2705	-	Auxiliary current transformers.
IS:3156	-	Auxiliary potential transformers.
IS:3202	-	Code of practice for climate proofing of electrical equipment.
IS:3231	-	Electrical relays for power system protection.
IS:5578 & IS:11353	-	Marking and arrangement of switchgear, busbars, main connection and aux. wiring.
IEC:44	-	Instrument Transformers
IEC:185	-	Current Transformers
IEC:186	-	Potential Transformers
IEC:255	-	Electrical Relays
IEC:1036	-	Static Meters

6.3 Scope of Work

The scope of design, manufacture, testing and supply of equipment covered under this specification shall include but not necessarily be limited to the following:

6.3.1 Design, engineering and fabrication of cubicles as per the specifications.

6.3.2 Supply and mounting of all the equipment and auxiliary equipment like auxiliary relays, test switches, test blocks, plugs, etc., necessary for satisfactory functioning of the control and protection system.

6.3.3 The protection system shall be provided with communication ports / auxiliary contacts to integrate the system with the PURCHASER's DCS for the purpose of Data Acquisition.

6.3.4 All internal wiring between all equipment upto the terminal blocks and the inter panel wiring.

6.3.5 Preparation and furnishing of all data / drawings / documents as per the requirement and specifications.

6.3.6 Testing at works of the cubicles and the mounted equipment.

6.4 Design Requirement

6.4.1 Constructional Features

6.4.1.1 The cubicles shall be of 'Simplex' type, with height of 2200 mm, including 100 mm base channel.

6.4.1.2 Cubicles shall be sheet steel enclosed dust and vermin proof type. Cubicles shall be floor mounting, free standing, formed on a framework of standard sections. The enclosure shall be of cold rolled sheet of minimum 3 mm for front and back and 2.5 mm thick for rest. The supporting structure shall be so designed to form a rigid structure.

6.4.1.3 All doors and openings shall be provided with neoprene gaskets.

6.4.1.4 The cubicles shall be suitable to be installed on a base frame supplied in one piece along with foundation bolts. Amply dimensioned oblong holes shall be provided at the bottom of all the cubicles for their installation on base frame, in addition the cubicles shall have an additional base channel at the bottom with smooth surface. Anti vibration type mounting shall be provided.

6.4.1.5 A suitable removable undrilled gland plate shall be provided for cable entry from bottom.

6.4.1.6 The degree of protection of the cubicles shall be IP 54.

6.4.2 Mounting

6.4.2.1 All instrument and control gears and relays shall be mounted on the front. All equipment shall be flush or semi-flush type.

6.4.2.2 Checking and removal of components shall be possible without disturbing the adjacent equipment. It shall be possible to set all the measuring relays “insitu”. All mounted equipment inside the cubicles shall have “identification tags” of self sticking engraved tapes; in addition identification numbers shall be painted on cubicle wall to give permanent identification mark. The mounting of terminal blocks and any other auxiliary equipment such as transducers, interposing CTs etc. shall be done in such a way so as to be readily accessible but without impeding the access to internal wiring and components.

6.4.2.3 The centre line of switches, push buttons and indicating lamps shall be not less than 750 mm from the bottom of the cubicle. The centre line of relays and meters shall not be less than 450 mm from bottom of the cubicle. All switches, push buttons, indicating lamps, relays, etc. shall be neatly arranged in a matching manner.

6.4.2.4 The cubicle shall be matched with other PURCHASER’s cubicles in dimension, colour and mimic.

6.4.3 Type

6.4.3.1 All the cubicles shall be of simplex type and shall consist of vertical front panels with mounted equipment and rear wiring access. Doors shall have handles with locking facility.

6.4.4 Wiring

6.4.4.1 All wiring shall be done with PVC insulated, 650V grade, single-core multi strands (minimum 3 strands) annealed copper conductors suitable for temperature and humidity specified. The cross section of the wires for voltage, current and control circuits shall be 2.5 Sq. mm and that for the alarm circuits shall be 1.5 sq. mm. The wires shall be vermin proof and shall be laid in plastic gutters.

6.4.4.2 Each wire shall be identified at both ends with wire numbers by means of PVC ferrules. Colour coding for the wires shall be as per IS:375. Each cable shall be identified with aluminium tags.

6.4.5 Terminal Blocks

6.4.5.1 The terminal boards shall be set at 50 Deg. to the side panels for easy access. Minimum 20% spare terminals shall be provided on the cubicles.

6.4.5.2 The terminals shall be suitable to receive crimped wires to give positive connection. All terminals shall be properly shrouded against accidental contact. Sufficient terminals shall be provided so that not more than one wire is connected to each terminal.

6.4.5.3 The terminal blocks shall be 600V grade 10 amps rated, one piece moulded complete with insulated barriers, stud type terminals, washers, nuts and lock nuts and identification strips.

6.4.5.4 Terminal blocks for the CT and PT secondary leads shall be provided with test links and isolation facilities. Also CT secondary leads shall be provided with short circuiting and earthing links.

6.4.5.5 Dedicated TBs for DCS connectivity as below shall be provided.

- GPR - 1, 2 Out Of Service (DI)
- DC Fail (DI)
- Master Trip Relay Operated (Dedicated TBs for heavy, medium and light faults, as applicable, shall be provided.) (DI)
- Trip Circuit Unhealthy (Dedicated TBs as above shall be provided)
- Breaker Trip Coil - 1, 2 Healthy (95/52) (DI)
- Voltage (AI)
- Current (AI)
- Frequency (AI)
- Mega Watt (AI)

6.4.6 Painting

6.4.6.1 All metal surface shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt. Fabricated structure shall be pickled and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under surface shall be made free from all imperfections before undertaking finishing coat.

6.4.6.2 After preparation of the under surface, the relay and control panel shall be spray painted with two coats of final paint. Colour shade of final paint shall be pebble grey, shade RAL 7032 with glossy finish and shall be duly approved by the PURCHASER before final painting is done. The finished panel shall be dried in stoving oven in dust free atmosphere. Panel finish shall be free from imperfections like pin holes, orange peels, run off paint etc. The vendor shall furnish painting procedure details for approval by the PURCHASER / CONSULTANT.

6.4.6.3 All unpainted steel parts shall be cadmium plated or suitably treated to prevent rust corrosion. If these parts are moving element then these shall be greased.

6.4.7 Cubicle Illumination

6.4.7.1 Compact fluorescent lamps working on 240 V AC, operated by door switches shall be provided for internal cubicle illumination, in each panel.

6.4.7.2 A 240V, 1-Phase, 5 Amp., 3 Pin Socket shall be provided in the panel corridor or interior of each cubicle with on-off switch for connection of hand lamps. This socket shall be metal clad type with a spring loaded flap.

6.4.8 Earthing

6.4.8.1 A continuous 25 mm x 3 mm copper (tinned) or equivalent aluminium / GI earth bus shall be provided running along the full lengths of the cubicles. Suitable arrangement shall be provided at the two ends on panel rear for connection to the plant earthing system. Earthing for T.G, MDB, Motors is In supplier scope and Earthing should be done as per Electrical Inspector norms.

6.4.8.2 Each cubicle and the equipment mounted on each cubicle shall be securely connected to the earth bus. For this purpose, the earth wire shall be looped from equipment to equipment and both ends of the earth wire shall be connected to the earth bus.

6.4.9 Space Heaters

6.4.9.1 Panel space heaters shall operate off 240 V AC and shall be supplied complete with on-off switch, fuse and thermostat. A common thermostat shall be provided for the entire panel. The thermostat shall maintain the internal temperature above the ambient temperature to prevent moisture condensation.

6.4.10 Mimic

6.4.10.1 Mimic diagram shall be provided on cubicles. Mimic diagram shall be screwed on to the cubicles and shall be made of anodised aluminum or plastic of approved fast colour. The mimic shall be 10 mm wide for horizontal run and 5 mm wide for vertical run.

6.4.10.2 Semaphore indicators used for isolator positions, they shall be so mounted in the mimic that isolator (or breaker) closed position shall complete the continuity of the mimic. The

mimic diagram shall incorporate red and green lamps for isolator position indication and controlling switches with indicating lamps for breakers.

6.4.10.3 Alternatively, automatic semaphore indicators for isolators and built in hand operated semaphore and position indicating lamps for breaker control switches may be provided.

a) The lamps will remain steady when the hand operated semaphore position corresponds with the breaker position.

b) The lamps shall flicker with a time delayed alarm if the semaphore position does not correspond with the breaker position.

6.4.10.4 The colors for various voltages in the mimic diagram shall be as per std..

6.5 Equipment Specifications

6.5.1 Transducers

Transducers with output of (4-20) mA shall be arranged by the BIDDER, wherever required.

6.5.2 Indicating Lamps

These shall be switchboard type of low power consumption, LED cluster type lamps and shall be supplied complete with necessary resistors. Lamps shall be provided with screwed translucent covers to diffuse light. The lamp covers shall preferably be unbreakable, moulded, heat resistant material and shall be provided with chromium plated bezels.

6.5.3 Control Switches

6.5.3.1 All control switches shall be rotary, back connected type having cam operation contact mechanism. Phosphor bronze contacts shall be used on switches.

6.5.3.2 The handle of control switches used for circuit breaker operation shall turn clockwise for closing and anti-clockwise for tripping and shall be spring return to neutral from close / trip with lost motion device. Each switch shall be provided with external red and green indicating lamps.

6.5.3.3 The no. of poles in any selector switch shall be restricted to eight (8) numbers, by providing multiplication contactors / relays to meet scheme requirement.

6.5.3.4 Four (4) numbers of push buttons with separate open indication, close indication and trip indication shall be provided for PURCHASER's use in the control panel. The above shall be used to trip the DG breaker, tie CB and other ACBs from control room during start up of the plant, as required by the PURCHASER.

6.5.4 Control MCBs

6.5.4.1 Control MCBs shall generally be mounted on the top half of the cubicles. All MCBs shall be provided with suitable identification labels.

6.5.5 Annunciation

6.5.5.1 The annunciator shall have first-in facility. Separate annunciators shall be provided for

alarm and trip functions.

6.5.5.2 Different coloured windows shall be used for alarm and tripping purpose. The hooter tones for alarm and tripping shall also different.

6.5.5.3 Trip annunciations shall be provided for the following:

- Restricted earth Fault protection
- Non directional instantaneous / IDMT over current.
- Loss of excitation
- Voltage controlled
- Over fluxing
- Local breaker backup
- Under voltage
- Over voltage
- Under frequency
- Over frequency
- Master trip operated (Dedicated windows for heavy, medium and light faults, as applicable)
- Emergency trip
- AVR trip
- EOP trip
- Generator trip due to turbine trip.
- Turbine tripped due to mechanical fault (Feedback generated from DCS)
- Winding temperature trip
- Bearing temperature trip
- Water leakage detector / Humidity sensor operated

6.5.5.4 Alarm annunciations shall be provided for the following:

- TCS of master trip relay unhealthy
- Gen CB trip coil unhealthy
- GCP PT fuse fail
- GRP PT fuse fail
- GPR out of service
- DC fail
- UPS fail
- Winding temperature alarm
- Bearing temperature alarm
- Hot air temperature alarm
- Cold air temperature alarm
- Stator core temperature alarm
- Exciter temperature alarm

6.5.5.5 The scheme shall include necessary acknowledge and reset push buttons.

6.5.5.6 Minimum ten (10) numbers of windows shall be provided as spare in each annunciator for PURCHASER's use. In case more number of windows are required, the SUPPLIER may plan annunciators at control panel as well as relay panel.

6.5.5.7 It shall be the responsibility of the SUPPLIER to demonstrate the above annunciations at site to the PURCHASER's engineers.

6.5.6 Relays

6.5.6.1 All relays shall be switchboard pattern, back connected draw out type suitable for flush mounting and fitted with dust tight covers.

6.5.6.2 A set of test block and test lead for necessary secondary injection tests shall be included. All relays in draw out cases shall have suitable spring loaded contacts for inserting test block.

6.5.6.3 The rating of the auxiliary contacts shall not be less than 5 amp at 240 V AC and 15 amp for 24 V DC.

6.5.6.4 Relay terminals to be of stud type / self-locking plug-in type.

6.5.6.5 The detailed list of protective relays for each cubicle is listed elsewhere. The relays shall be supplied with the necessary accessories to make the system complete.

6.5.7 Clock, Name and Identity Plates

6.5.7.1 One No. digital clock with minimum 50 mm height digital display shall be fitted in an attractive position on the complete cubicle assembly. The clock shall have a hand operated device for adjustment of clock hands from front.

6.5.7.2 All instruments, relays and other electrical devices mounted on the cubicle shall be provided with plates bearing the manufacturer's name, serial number and the electrical rating data.

6.5.7.3 Reverse engraved name plate at least 10 mm wide bearing suitable identification marks shall be fixed in the interior of the switchboard, at the test blocks, at the MCB blocks and at the cable terminals. Similar plates shall be fixed to the exterior of the switchboard in appropriate places to indicate the functions of control switches, push buttons, lamp and other equipment not incorporated in the mimic diagram.

6.5.7.4 Name plates bearing respective circuit designation of 50 mm width etched in 40 mm high letters shall be mounted on the top of the front side and back side of each cubicles shall be supplied and fixed in such a way that these can be removed and refitted when desired.

6.5.7.5 Each equipment shall have a rust proof metal tag permanently attached to it with the tag number.

6.5.8 Auxiliary PT and CTs

6.5.8.1 Necessary auxiliary potential transformers for open delta potential polarization and auxiliary current transformers, wherever required, shall be included in supply.

6.5.8.2 Auxiliary CTs required for summation of two or more feeders and auxiliary PTs required for galvanic isolation of different synchronising inputs shall be included.

6.5.8.3 The instrument transformers shall have the following accuracy class Potential Transformer Measurement Protection

	Positional Transformer	Current transformer
Measurement	0.2	0.2
Protection	3P	5P20

6.5.9 **Synchronization not required**

6.5.10 Trivector / power measurement metering

6.5.10.1 Integrating meters of the Trivector or equivalent types capable of indicating all phase instantaneous parameters and recording KWH, KVARH and KVAH directly shall be provided. They shall be capable of record / display of harmonic data up to 51st harmonics.

6.5.10.2 These should be suitable for 3 phase, 4 wire 50 Hz circuits with unbalanced loading and with two sets of elements connected to current and potential transformers of specified ratio.

6.5.10.3 The meter shall be of digital type, class 0.2 or better with communication port, RS485 interface - MODBUS RTU protocol, for hooking up to PC / DCS. Necessary softwares for downloading of stored parameters and analysis shall also be supplied. The meter shall also have digital and analog outputs.

6.1.1.1 Meters for frequency, power factor and MW should be of digital type.

6.5.11 Temperature scanners

Microprocessor based temperature scanner shall be provided to process the signals from RTDs of the generator windings / core / bearings / cooling air paths / exciter. The scanner shall have scrolling display with output relays for High-Alarm and High-Trip signals, individually for all channels. It shall be possible to set the parameters through membrane type keypad. Resolution for the complete range shall be not less than 0.1^0C with accuracy of better than ±1%. The scanner shall be provided with RS 485 communication port, suitable for MODBUS RTU protocol.

6.6 Details of Protective Relays

6.6.1 Protection of the generator shall be achieved through microprocessor based, composite protective digital relays, with one as primary and the other as back-up.

Both the relays shall include the following minimum protective functions:

- Over & Under voltage
- Under & Over frequency
- Field failure
- Voltage restrained over current
- Generator differential
- Stator standby Earth Fault protection
- Local breaker back-up / struck-up
- Voltage balance / PT fuse failure
- Over fluxing Protection
- Directional Over Current Relay

6.6.2 The SUPPLIER shall make available a set of output contact, duly configured for one stage of the following voltage / frequency function:

- Over voltage
- Over frequency
- Under voltage
- Under frequency

6.6.3 The following external signals shall be connected to the generator protection relays for time stamping:

- Generator master trip relays of minimum four (4) nos.
- Generator circuit breaker status
- Tie CB status
- Status of oil pump starter
- Turbine tripped due to mechanical fault (Feedback generated from DCS)
- Four (4) numbers of additional signals for PURCHASER's. use.

6.6.4 Both the generator protection relays shall have the following minimum features:

- Communication port, RS485 interface - MODBUS protocol, for hooking-up to DCS / PC, for down loading & parameter settings
- Necessary software, for processing of data.
- Event recording facility, for a minimum of 32 events.
- Disturbance recording & analysis facility
- All the events, disturbances and the fault records, generated both internally and externally with time stampings, shall be stored in the internal memory of the generator protection relays and shall be capable of being downloaded when required. It shall be responsibility of the SUPPLIER to demonstrate this feature to the PURCHSER's engineers, at site.
- Self diagnostic facility

6.6.5 The SUPPLIER shall provide a common PC, loaded with necessary software and interface units to receive signals from RS 485 and RS 232 communication ports, along with A4 inkjet colour printer. The PC shall be of latest configuration available in the market with minimum Pentium IV, 3 GHz, Main memory 1 GB, Hard disk, 160 GB SATA with 52 x CD R/W Drive, 1.44 MB FDD, optical scroll mouse, 1 serial, 1 parallel, 4 USB with 17" LCD monitor. This system shall be suitable for processing & displaying the signals from the generator digital relays & meters, from the RS485 communication ports with MODBUS RTU protocol.

6.6.6 Additional discrete relays shall be provided for the following main functions, even if the same is available in the composite relays:

- Restricted earth fault protection by employing two numbers of definite time sensitive earth fault relays with timer of 0 to 0.5 secs in steps of 50 msec, connected on phase (through CBCT) and neutral sides (through CT). The unit tripping shall be initiated only if any one of phase side or neutral side relay acts.
- Standby earth fault relay in addition to the above.
- Static / microprocessor based reverse power relay, with settable range of 0.5% connected from Class 0.2 core CT

6.6.7 Additional discrete relays shall also be provided for the following auxiliary functions:

- Master trip relays
- Trip circuit supervision relays for circuit breaker and all master trip relays
- DC supply failure relay
- Auxiliary relays, if required

6.6.8 Connection configuration of the protective relays shall be as shown in the enclosed 'Electrical Schematic Diagram'.

6.7 Inspection and Tests

6.7.1 Following tests shall be carried out on the control panel in the presence of PURCHASER or his authorized representative:

a) Checking of correctness of wiring of circuits and continuity.

b) Electrical control, interlock and sequential operation test.

c) High voltage test 2000 volts to earth for one minute.

d) Insulation resistance of the complete wiring with all equipment mounted on the cubicles.

e) Routine tests according to the standards followed by the manufacturer on the instruments, relays & other devices.

f) DC tests.

g) Turbine auxiliary cables from control panel to equipment shall be copper armored.

6.7.2 Certified copies of all routine test certificates shall be submitted to the PURCHASER before dispatch for review by the PURCHASER.

6.8 Drawing and Data

6.8.1 The BIDDER shall furnish all the data / drawings / documents specified in the list, furnished elsewhere in this document, for review by the PURCHASER / CONSULTANT.

6.8.2 The BIDDER shall submit for CONSULTANT / PURCHASER's approval the general arrangement drawings showing front, rear and side views, interconnection and wiring diagram as well as other drawings which may be deemed necessary by the PURCHASER. Approval of the GA drawing is required before the fabrication of panel starts. Approval of wiring and interconnection drawings is required before the manufacturer proceeds with the panel wiring.

6.8.3 Electrical Information and Drawings

6.8.3.1 The manufacturer drawings shall conform to the following requirements:

6.8.3.1.1 Drawing submitted for PURCHASER's review shall be of sufficient scope and

detail to permit understanding and checking of design by the PURCHASER.

6.8.3.1.2 The following drawings shall be dimensioned and drawn to scale:

a) Layouts of front and rear cubicles complete with identification markings for all mounted devices and complete list.

b) General construction showing section views, details and framing.

c) The above drawings shall incorporate the following details:

i) Power and control systems run ways.

ii) Outline including shipping dimensions.

iii) Mounting holes.

iv) Foundation details.

v) Sufficient details to demonstrate accessibility of equipment for operation and maintenance.

vi) Details of emblems, escutcheon and name plates (with exact lettering).

vii) Panel cutouts.

viii) Total weight of each panel section.

ix) Size and location of ground bus.

x) Location and size of internal lights, heaters, etc. maximum load (kW)

6.8.3.1.3 Bill of material shall correlate components to outline drawings and diagrams. Components may be identified by the manufacturer and his catalogue numbers.

6.8.3.1.4 Each device designation correlated to outline and wiring diagrams. Contact development diagrams of control, selector, etc., switches, push buttons.

6.8.3.2 Following schematic & wiring diagrams shall be furnished:

6.8.3.2.1 Each type of device internal wiring diagram.

6.8.3.2.2Control power supply circuit voltage and source requirement for uninterruptible or interruptible. Each control circuit breaker size and trip rating. Control supply one line diagrams (AC, DC and uninterruptible AC).

6.8.3.2.3Cubicle internal connection wiring diagrams shall show identification of devices, terminals and connecting wires.

6.8.3.2.4The system used for designation of control wiring shall show device identification with identified terminals arranged in substantially correct physical relationship and shall provide

sufficient information at each wire termination to locate the other termination without recourse to routing, supplementary tabulations or to information on function of wire.

6.8.4 Interconnection and External Connecting Wiring Diagram

6.8.4.1 The diagram shall show clearly any connections to be made in field (because of shipping sectionalizing). The vendor shall show all external cabling information contained in PURCHASER's control wiring diagrams (furnished after initial submission of the vendor's drawing and diagrams) and space shall be reserved for additional external wiring information.

6.8.4.2 Panel internal wiring shall not be looped directly from instrument to instrument the same shall be looped through the panel terminal block only.

7. SPECIFICATION FOR BATTERY AND BATTERY CHARGER

7.1 Scope

7.1.1 The work to be performed under this specification consists of design, manufacture, testing, delivery, installation, commissioning and guaranteeing the successful operation of the following.

a) 24 V , 150 AH, Battery charger consisting two nos. (2) of float cum boost chargers.

7.2 Battery Unit

7.2.1 General

7.2.1.1 The equipment offered shall be complete with all parts are usual for the efficient operation of the equipment, whether specifically mentioned or not. The construction shall be generally rugged and tough. The battery shall withstand high rate of discharge or over boost charge, accidental shorting and polarity reversals and severe shock & vibration.

7.2.2 Codes and Standards

7.2.2.1 The battery covered by this specification shall be built to generally conform to the latest revision of IEC:60896-2. The design, manufacture and performance of equipment comply with all currently applicable laws, regulations and safety course in the locality where the equipment will be installed. Nothing in this shall be conserved to relieve vendor of this responsibility.

7.2.3 Technical Specification / requirements:

1.	Type application	:	chargeable battery, Heavy -duty
2.	Type of installation	:	Stationary
3.	Performance	:	Long life batteries.
4.	AH efficiency	:	Better than 90%
5.	Self discharge/ week.	:	0.5 to 1% of rated capacity.
6.	Ambient temperature (max)	:	Indicated in design basis
7.	Terminal Posts	:	Shall be of solid brass and adequately dimensioned for strong construction with least Electrical resistance
8.	Type of connector	:	Heavy duty copper
9.	Type of connector Plates	:	The plates shall be of flat pasted, first class material and workmanship and shall be free from blow holes, cracks and other imperfections. The positive plate shall consist of a suitable bar with spines cast of suitably

			alloyed lead to give adequate mechanical strength. The construction and material shall be such as to reduce loss of active material to the minimum and to withstand normal internal stresses developed during service. Negative plate shall be of the pasted type and of adequate mechanical strength.
10.	Separating grills	:	The separators shall be impervious of the chemical action inside the cell and oxidation resistant. These shall be provided to separate the plates and insulate the plate from one another. The grills at the same time shall allow free circulation of electrolyte between plates. These materials shall be inert to react with electrolyte.
11.	Capacity	:	The battery shall be of 24V, sized for the following discharge cycle: a) One minute momentary load. b) One hour emergency load (including EOP motor load) plus 20A for PURCHASER use. c) Ten hour continuous load of all TG auxiliary requirements plus 25A for plant control & miscellaneous loads for PURCHASER use. d) The ageing factor, design margin & temperature rise factor for batteries shall be selected as per IEEE standards. e) The 'K' factor for batteries shall be selected as per the manufacturer's standard. The capacity shall be derived such that the depth of discharge does not exceed than 50% at any point of time.
12.	DC system	:	Unearthed
13.	Normal Voltage	:	24 V
14.	Full boost charge Voltage	:	30 V
15.	Fully discharged Voltage	:	24 V
16.	Boost charge current	:	To be decided by vendor
17.	Total number of cells	:	To suit the application
18.	Terminal Posts	:	Terminal posts shall be designed to

			Accommodate external bolted Connection conveniently and positively. Each terminal posts shall have two bolt holes of the same diameter, preferably at right angles to each other.
19.	Electrolyte	:	Electrolyte shall be sulphuric acid of specific gravity 1.160 / 1.180.
20.	Container	:	The containers shall be made from Poly propylene co-polymer material. They shall be sufficiently robust and free from flaws with leak proof.
21.	Safety Vent	:	Shall be self resealing with flame arrestor

7.2.4 Accessories

The battery shall preferably be complete with all devices required including the following:

a) Battery racks
These shall be constructed from good quality teakwood and painted with two coats of approved acid resisting paint. The construction of the racks, unless otherwise mentioned shall be suitable for fixing to a flat concrete floor. The racks shall be rigid, free standby type and free from warp. The complete racks shall be suitable for being bolted end to end to form a continuous row. Stacking arrangement shall be to occupy less room space.

b) Porcelain insulators, rubber pads etc.

c) Set of inter cell, inter-tier and inter bank connectors as required for the complete installation

d) Accessories for testing and maintenance

- One set terminals and cable boxes with glands for connecting cable as required.
- One set spare connectors
- One set spare nuts & bolts
- Suitable set of spanners

7.2.5 Tests

7.2.5.1 Routine tests and type tests (on at least four random samples) shall be carried out and test certificates shall be furnished.

7.2.5.2 All acceptance tests as per IEC shall be carried out at site.

7.3 Battery Charger

7.3.1 The equipment shall comply with the following standards.

IS 1248	:	Direct acting instruments electrical indicating

IS 3715 (Part 1 to 4)	:	Letter symbols for semi-conducting devices
IS 4411	:	Code for designation of semi-conductor devices
IS 5469	:	Code of practice for the use of semi-conductor junction (part 1 to 3) devices.
IS 7204 (part 1 to 4)	:	Stabilised power supplies D.C. output.
IS 12021	:	Control transformers for switchgear and control gear for voltages not exceeding 1000V AC
IS 13314	:	Solid state inverters run from storage batteries
IS 13703	:	Low voltage fuses for voltage not exceeding 1000V AC or(part 1 to 4) 1500V AC
IS 13947	:	Specification for low voltage switchgear and control gear (part-4/Sec-1)
IEC 60146	:	Semiconductor converters.

7.3.2 In case Indian standards are not available for any equipment, standards IEC/BS/VDE/IEEE/NEMA or equivalent shall apply.

7.3.3 Technical Requirements

7.3.3.1 The battery charger shall be an integrated system comprising of static rectifiers, DC Distribution Board, isolating and protection devices and all other equipment / accessories required for completeness of the system.

7.3.3.2 The battery chargers shall be suitable for input power supply of 415V ±10%, 3 Phase, 4 wire 50 Hz and frequency of 50 Hz ± 5%.

7.3.3.3 The panel shall have an isolator at the incomer, to facilitate panel maintenance.

7.3.3.4 The battery charger shall be suitable for installation and satisfactory operation in a pressurized or non-pressurized room with restricted natural air ventilation. The design ambient temperature shall be as specified in the design basis and altitude as specified in the project information.

7.3.3.5 Dedicated TB for hooking up of the following signals to DCS shall be provided:

- FCBC – 1 ON/OFF
- FCBC – 2 ON/OFF
- FCBC – 1 Faulty
- FCBC – 2 Faulty

7.3.3.6 The battery charger assembly shall have an height of 2200 mm with base channel of 100 mm.

7.3.4 System Operation

7.3.4.1 The battery chargers #1 and #2 shall operate in parallel feeding the DC load and flow charging the batteries under normal operation. However, in case of failure of either of the chargers, the other charger shall float charge the battery while feeding the complete DC load. In case of AC mains failure, the battery shall continue to supply the load.

7.3.4.2 The process of change over from float to boost charging and from boost to float charging shall be selectable by an auto / manual selector switch. In auto mode, the change over shall be initiated through a current sensor. In manual mode, the change over shall be performed manually using push buttons. Manual switch shall have priority over automatic switching. When boost charging mode is selected, the battery shall be charged by constant current mode or by constant voltage mode as per battery manufacturer's recommendation. Selection of constant current mode or constant voltage mode shall be fully automatic. A digital timer shall be provided for initiating the change over to float mode by default after a preset time period.

7.3.4.3 In the event of failure of the charger feeding the load, when battery is being boost charged by the other charger, DC supply to the loads shall be maintained from the battery through tapcell (if required) or through a contactor.

7.3.4.4 Interlock shall be provided in each charger to disconnect the charger from both the DC load and the charger operating under float mode.

7.4 Design Basis

7.4.1 Each charger shall be sized for the most stringent of the following duty conditions, whichever is higher:

a) The charger shall be sized considering off line boost charging current in Amps of 0.2 Ah (C_{10}) of VRLA battery.

b) With on line float charging of battery, the charger current in Amps shall be 1.15 x Average DC load + Float charging current.

c) The loading conditions shall be as elaborated in battery specifications.

d) Initial charging of uncharged battery assembly to fully charged condition.

7.4.2 Silicon blocking diodes shall be provided in the charger output circuit to prevent back-feed from battery into the charger and filters.

7.4.3 Filter circuits consisting of smoothing choke and condenser to limit the ripple content at the output to the maximum of 1/2 - 1% of the DC voltage.

7.4.4 Protection against reverse battery connection and DC earth fault relay shall be provided.

7.4.5 Internal cooling shall be preferably by natural ventilation. If forced air cooling is considered, a redundant air cooling fan shall be provided.

7.4.6 All electronic power devices like thyristors, transistors, diodes etc. shall be rated under operating conditions for at least 150% of the maximum current carried by the device. All electrical components such as transformers, reactors, contactors, switches, busbars etc. shall be rated for at least 125% of the maximum required rating. No electronic device shall experience a PIV greater than 50% of its rated value.

7.4.7 The DC system shall be unearthed. However, a high impedance earth fault relay shall be provided for the protection of the battery.

7.5 Charger Performance

7.5.1 The automatic voltage regulating equipment shall regulate the battery voltage within +1% of the set value from no load to full load for AC voltage and frequency variation of +10% and +5% respectively.

7.5.2 The output voltage dynamic response of the charger unit with battery disconnected shall not vary more than +10% of nominal output voltage in the event of step load of up to 50% of the rated output. The output voltage shall be restored within the steady state limits within 250 msec.

7.5.3 The maximum noise level from the charges measured at 1 metre distance in any position, at any load between 0-100% shall not exceed 75 dB (A).

7.6 Controls

The controls shall be provided but not limited to the following:

a) ON / OFF control switch for AC supply to charger (push buttons are not acceptable)

b) Push buttons for float and boost charging mode selection

c) Potentiometers under float mode for voltage and current adjustment

d) Potentiometers under boost mode for voltage and current adjustment

e) Auto / manual selector switch to select mode of operation

f) Others as required.

7.7 Charger Panel Metering and Indication

These shall include but limited to the following:

a) Meters

Charger -1

- AC input Voltmeter with selector switch
- AC input Ammeter with selector switch
- DC output Voltmeter
- DC output Ammeter
- DC Voltmeter with selector switch (battery voltage)
- DC Ammeter (battery)
- DC Earth leakage Ammeter (mA).

Charger -2

- AC input Voltmeter with selector switch
- AC input Ammeter with selector switch
- DC output Voltmeter
- DC output Ammeter

b) Lamps

Chargers - 1 & 2

- AC power ON (1 lamp for each phase)
- Float charger ON
- Quick charger ON
- Charger fault

7.8 Alarms & Protections

Following annunciations shall be provided and also potential free contacts for the following shall be made available for hooking up to annunciation and control panel:

- DC under voltage
- DC over voltage
- DC earth leakage
- AC incoming power supply failure
- AC input fuse blown-off
- Thyristor / diode failure
- DC output fuse blown-off
- DC battery fuse blown-off
- Filter capacitor fuse blown-off
- Short circuit
- Reverse Polarity
- Battery current limiter

7.9 Charging Panel

7.9.1 The charger shall be fabricated with 2.0 / 2.5 mm thick sheet steel and structural steel. It shall be free-standing with suitable louvers for ventilation and must be suitable for use in tropical climate. Hinged doors shall be provided at the front and back where required.

7.9.2 Inter panel sheet steel barriers shall be provided. The sheet steel used for fabrication shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid.

7.9.3 All instruments shall be switchboard type & back connected. Stranded copper wires 2.5 sq. minimum shall be used for secondary wiring. The insulation for all equipment where provided shall be heat resistant, moisture proof and tropicalised. All fuses shall be provided

inside the panel. All fuses shall be link type. Diazed fuses will not be acceptable.

7.9.4 All potential free metallic parts shall be earthed with soft drawn copper conductor. An earth bus of 25 x 6 sq. mm Sq. Copper. (or equivalent Al.) shall run through the panel. The main earth connection shall be brought out to two terminals for connection to station earthing system.

7.9.5 All live parts shall be properly shrouded. This shall ensure complete safety to personnel intending routine maintenance by opening the panel doors. Busbars shall be colour coded. All the equipment inside the panel shall have suitable name plates.

7.10 Mechanical Requirements

7.10.1 The battery charger set shall be assembled in a free standing type sheet metal cubicle completely wired for indoor installation.

7.10.2 Access to internal equipment shall be through a hinged door equipped with latches.

7.10.3 Louvers shall be provided for ventilation as necessary The ventilation openings shall be screened to prevent access to insects and other foreign material.

7.10.4 The charger compartment shall be provided with a door operated light, 11W CFL for internal illumination.

7.11 Painting

7.11.1 Painting shall include atleast one coat of anti corrosive prime, one coat of finishing under coat and two coats of flint / pebble grey, shade RAL 7032. The painting shall have to render the surface scratch resistant.

7.12 Tests

7.12.1 Di-electric Tests:

a) A DC voltage equal to 2U + 1,000 V where U represents the highest input or output voltage. This voltage shall be applied to the two interconnected output terminals.

b) An AC voltage equal to 500 V applied between the live parts of the low voltage circuits and the rack.

7.12.2 Heat Run Tests:

Each of the two charger shall be subjected to heat run test at rated load and voltage for a period not less than 8 hours. The other charger during this test shall be energized under zero load current condition. The temperature of electronic power devices shall be measured and the device junction temperature shall be calculated.

7.12.3 Functional Tests:

Following functional test shall be carried out at charger:

a) Floating and boost voltage regulation

b) Check of current limit

c) Check of change - over operation by simulation of chargers failure

d) Operation of alarms

e) Measure of ripple voltage at zero and full load.

7.12.4 Parallel Operation

Parallel operation of both chargers, sharing of the load and automatic isolation of faulty charger shall be checked.

7.12.5 Charger efficiency

Efficiency shall be determined by measurement the active power input and output of 50%, 75% and 100% load.

7.12.6 Noise Tests

Audible noise shall be measured at one meter distance in at least 4-5 positions shall be measured and shall be within the permissible limits.

7.13 Packing and Dispatch

The equipment shall be properly packed for transportation by ship / rail or trailer. As the equipment may be stored outdoors for long periods before installation, the packing shall be suitable for outdoor storage under severe temperature conditions.

8. SPECIFICATION FOR CABLES AND ACCESSORIES

8.1 Scope

8.1.1 This specification covers requirements for the supply of PVC cables for Medium Voltage, XLPE cables for Medium and High Voltage Systems and cable accessories for high voltage systems.

8.2 Standards

8.2.1 The cables shall comply with the latest edition of the following standards :

IS:1554 (Part-I)	:	PVC insulated (heavy duty) electric cables for working voltages up to and including1100V.
IS:1753	:	Aluminium conductors for insulated cables
IS:3961 (Part-II)	:	Recommended current ratings for cables PVC insulated and PVC sheathed heavy duty cables
IS:5831	:	PVC insulation and sheath of electric cables
IS:7098 (Part-I)	:	Cross-linked Polyethylene insulated PVC sheathed cables for Working Voltage up to and including 1100V
IS:7098	:	Cross-linked Polyethylene insulated PVC sheathed cables for Working Voltage from 3.3 kV up to and including 33 kV (Part-II)
IS:8130	:	Conductors for insulated electric cables and flexible cords
IEC:183	:	Guide for Selection of HV Cables
IEC:227	:	PVC Insulated Electrical Cables
IEC:502	:	Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto 30 kV
IEC:885	:	Electric Test methods for Electrical Cables

8.3 General Construction

8.3.1 The cables shall be brand new and in good condition. These shall be suitable for laying in trays, trenches, ducts, conduits and underground buried installation with uncontrolled backfill and possibility of flooding by water. Extra PVC / Rubber end caps for each XLPE Cable size shall be supplied.

8.3.2 All LT power and control Cables shall be with PVC insulation and stranded copper conductor for sizes upto 6 sq. mm and XLPE insulation with aluminium conductor for higher sizes.

8.3.3 PVC Cables

8.3.3.1 All power / control cables for use on medium voltage systems shall be heavy duty type, 1100 V grade with aluminium / copper conductor, PVC insulated, inner sheathed, armoured and

overall PVC sheathed.

8.3.3.2 The construction of the conductors shall be 'stranded' for all cables. Conductors of nominal area less than 25 Sq. mm shall be circular only. Conductors of nominal area 25 Sq. mm and above may be circular or shaped.

8.3.3.3 The core insulation shall be with PVC compound applied over the conductor by extrusion and shall confirm to the requirement of Type 'A' compound of IS:5831. Control cables having 5 core and above shall be identified with prominent and indelible 'Arabic Numerals' on the outer surface of the insulation. Colour of the numbers shall be white with a spacing of maximum 500 mm between two consecutive numbers.

8.3.3.4 The inner sheath shall be applied over the laid-up cores by extrusion and shall be of PVC confirming to the requirement of Type ST1 PVC compound of IS:5831.
The extruded inner sheath shall be of uniform thickness of size not less than those specified in IS.

8.3.3.5 For multicore cables, the armouring shall be by single round galvanized steel wires where the calculated diameter below armouring does not exceed 13 mm and galvanized steel strips where this dimension is greater than 13 mm.

8.3.3.6 The outer sheath for the cables shall be applied by extrusion and shall be PVC compound conforming to the requirement of type ST1 compound of IS:5831. To protect the cables against rodent and termite attack, suitable chemicals shall be added into the PVC compound of the outer sheath.

8.3.4 LT XLPE Cables

8.3.4.1 All cables shall be of heavy duty type, 1100V grade with aluminium conductor, XLPE insulated, inner sheathed, armoured and overall PVC sheathed.

8.3.4.2 The construction of the conductors shall be stranded and compacted circular /sector shaped.

8.3.4.3 The core insulation shall be with cross-linked polyethylene unfilled insulating compound. It shall be free from void and shall withstand all mechanical and thermal stresses under steady state and transient operating conditions.

8.3.4.4 The inner sheath shall be applied over the laid up cores by extrusion and shall conform to the requirement of Type ST2 compound of IS:5831. The extruded inner sheath shall be of uniform thickness of size not less than those specified in IS.

8.3.4.5 For multicore cables, the armouring shall be by single round galvanized steel wires where the calculated diameter below armouring does not exceed 13 mm and galvanized steel strips where this dimension is greater than 13 mm.

8.3.4.6 The outer sheath for the cables shall be supplied by extrusion over the armouring and shall be of PVC compound confirming to the requirement of Type ST2 compound of IS:5831. To protect cable against rodent and termite attack, suitable chemicals shall be added into the PVC compound of the outer sheath.

8.3.5 HT XLPE Cables **Not Required**

8.3.5.1 All cables shall be with Copper / aluminium Conductor, XLPE insulated, screened, sheathed, armoured and overall PVC sheathed. Insulation of cables shall be of 11 kV, Unearthed (UE)

grade.

8.3.5.2 The construction of the conductors shall be stranded and compacted circular for all cables.

8.3.5.3 The cables shall be provided with both conductor screening and insulation screening. The conductors shall be provided with non-metallic extruded semi-conducting shielding.

8.3.5.4 The core insulation shall be with cross-linked polyethylene unfilled insulating compound. It shall be free from void and shall withstand all mechanical and thermal stresses under steady state and transient operating conditions and insulation shall be dry cured.

8.3.5.5 The insulation shielding shall consist of non-metallic extruded semi-conducting compound in combination with a non-magnetic metallic screening of copper. The insulation screen shall be strippable without application of heat. The copper screen shall be capable of carrying the single line to ground fault current of 1 kA for a duration of one (1) second, for three cores together.

8.3.5.6 The conductor screen XLPE insulation and insulation screen shall all be extruded in one operation by 'Triple Extrusion' process to ensure perfect bonding between the layers. The core identification shall be coloured strips or by printed numerals.

8.3.5.7 The inner sheath shall be applied over the laid up cores by extrusion and shall conform to the requirement of Type ST2 compound of IS:5831. The extruded inner sheath shall be of uniform thickness of size not less than 0.7 mm for all sizes of cables.

8.3.5.8 For multicore cables, the armouring shall be by galvanized steel strips and armouring for single core cables shall be with hard-drawn aluminium round wire of 2.5 mm diameter.

8.3.5.9 The outer sheath for the cables shall be supplied by extrusion over the armouring and shall be of PVC compound confirming to the requirement of Type ST2 compound of IS:5831. To protect cable against rodent and termite attack, suitable chemicals shall be added into the PVC compound of the outer sheath.

8.4 Testing

8.4.1 The cables shall be tested and examined at the manufacturer's works. All the materials employed in the manufacture of the cable shall be subjected, both before and after manufacture of the cable, to examination, testing and approval by PURCHASER / CONSULTANT. Manufacturer shall furnish all necessary information concerning the supply to the PURCHASER.

8.4.2 After completion of manufacture of cables and prior to despatch, cables shall be subjected to type, routine, acceptance and special tests as detailed below. The test reports for all cables shall be got approved from the PURCHASER / CONSULTANT before despatch of the cables.

8.4.3 All routine tests, acceptances tests, type tests as well shall be carried out on PVC cables as listed in IS:1554, Part-I.

8.4.4 The inner and outer sheath of XLPE cables shall be subjected to all the tests applicable for PVC cables. The test requirement for insulation and sheath of PVC cables shall be as per latest revision of IS:5831.

8.4.5 The following tests shall be carried out on XLPE cables as per IS:7098, Part-I/II.

8.4.5.1 Type Tests

8.4.5.1.1 Tensile test

8.4.5.1.2 Wrapping test

8.4.5.1.3 Conductor resistance test

8.4.5.1.4 Test for armour wires

8.4.5.1.5 Test for thickness of insulation and sheath

8.4.5.1.6 Physical tests for insulation

8.4.5.1.7 Physical tests for PVC sheath:
a) Fire resistance
b) Cold-impact
c) Bleeding and blooming

8.4.5.1.8 Partial discharge test

8.4.5.1.9 Bending test

8.4.5.1.10 Heating cycle test

8.4.5.1.11 High voltage tests

8.4.5.2 Acceptance Tests:

8.4.5.2.1 Tensile test

8.4.5.2.2 Wrapping test

8.4.5.2.3 Conductor resistance test

8.4.5.2.4 Test for thickness of insulation and sheath

8.4.5.2.5 Partial discharge test

8.4.5.2.6 High voltage test

8.4.5.3 Routine Tests:

8.4.5.3.1 Conductor resistance test

8.4.5.3.2 Partial discharge test

8.4.5.3.3 High voltage test

8.5 Packing and Marking

8.5.1 Cable shall be despatched in wooden drum of suitable barrel diameter, securely battened, with the take-off end fully protected against mechanical damage. The wood used for

construction of the drum shall be properly seasoned, sound and free from defects. Wood preservatives shall be applied to the entire drum.

8.5.2 On the flange of the drum, necessary information such as manufacturer's name, type size voltage grade of cable, length of cable in meters, drum No. cable code, ISI Certification mark, gross weight etc., shall be printed. An arrow shall be printed on the drum with suitable instruction to show the direction of rotation of the drum.

9. Auxiliary Oil Pump (AOP) is required

9.0 SPECIFICATION FOR INSTRUMENTATION AND CONTROL

9.1.1 This specification covers the design, supply, erection, testing and commissioning of the following:

Field instruments with all accessories along with test equipments like hand held communicator, required for controlling and monitoring the Turbine and its auxiliaries through PURCHASER's DCS.

9.1.2 Electronic governor - Woodward 505XT with voithactuator

9.1.3 Turbine gauge panel

9.1.4 Instrumentation cables, cable tray and other accessories required for signal transmission from field instruments, all final control elements to Field Junction Boxes (including junction box) / BIDDER'S panel.

9.1.5 Instrumentation control cables, cable tray and other accessories from Motorised valves with integral starters to BIDDER's junction boxes.

9.2 General

9.2.1 All equipment supplied shall be of field proven quality both with respect to design and materials.

10.2.2 BIDDER shall prepare and submit a P & I Diagram for the system within the scope of his supply, showing all the instruments and alarm / interlock / trip operations. Each instrument shall be given individual tag numbers. Symbols shall be as per ISA S5.1

9.2.3 BIDDER shall supply complete boiler control data to the PURCHASER / CONSULTANT to specify those instruments not appearing in the BIDDER's scope of supply but are an integral part of the turbine control system.

9.2.4 BIDDER shall clearly define and submit a write-up on the operational sequence /details recommended by him, which should be in line with the requirements mentioned in this specification.

9.2.5 It is proposed to achieve the control of the entire Power plant consisting of the boiler, turbine and the other auxiliaries by a DCS (to be provided by the PRUCHASER).

9.2.6 The Start / Stopping sequence, safety interlocks, control logics, field parameters display and logging, pertaining to Turbine and its auxiliaries and other operations are to be realised by the DCS.

9.2.7 The operating value of field instrument shall fall at middle of the selected range.

9.2.8 All field instrument enclosure shall have minimum IP 65 protection.

9.2.9 The instrumentation control of the Turbine and its auxiliaries shall include the following as a minimum:

a. Turbine and its auxiliary drives' interlocks

b. Turbine protection and safety interlocks
c. Governing system interlock

Apart from the above controls, the temperature, flow, pressure, level and analytical signals from various other areas of the turbine shall also be made available for the purpose of monitoring and alarm.

Electrical signals from Generator safety relays and power distribution breakers status, generator and grid voltage, current, KW, KVAR, power factor, frequency shall be monitored in DCS.

Sub-systems like the vibration monitoring system and electronic governing system shall be individually controlled by the microprocessor based instruments and the information of the same shall be communicated to the DCS through serial data transfer technique for monitoring purpose.

BIDDER shall be responsible for proper implementation & commissioning of instrumentation and control system in co-ordination with DCS vendor.

9.2.10 BIDDER shall be responsible for proper implementation & commissioning of instrumentation and control system including the tuning of all control loops in co-ordination with DCS vendor.

9.2.11 Laying of Instrumentation cables from all field instruments , Motorised valves and all other panels supplied by BIDDER to BIDDER's junction boxes.

9.2.12 Instrumentation signal cables shall be considered for all analog input and output signals, Instrumentation control cables shall be considered for all digital input and output signals.

9.2.13 Dedicated junction boxes or field mounted marshalling cabinets shall be considered for analog input signals, analog output signals, Digital input signals and Digital output signals

9.2.14 Minimum distance of 300mm shall be maintained between digital and analog signal cables.

9.2.15 Instrument air tubing material shall be SS316 for all control valves and power cylinders.

9.2.16 All control valve and power cylinder positioner shall be SMART type with HART protocol communication.

9.3 Specification for field instruments

9.3.1 Temperature Gauges

Temperature gauges shall have white dials made of non-rusting, plastic material with black figures. Gauge Dial size shall be 150mm. Temperature gauges shall be filled type and manufactured as per SAMA classification. Temperature bulb shall be stainless steel and suitable for selected the thermowell. Gauge stem shall have adjustable gland and union. The gauge bushing shall be suitable for ½" NPT (F) connection.

9.3.2 Temperature Elements (RTD)

Temperature elements shall be spring loaded and shall have stainless steel sheath. Elements shall have weather proof screw heads and suitable cable entry connection. RTD shall be 3 wire platinum element type with 100 ohm resistance at 0 °C, calibrated as per IEC 751/DIN

43760. RTD shall have an accuracy of + 0.25%. Element sensors shall be duplex with two separate cable entries.

9.3.3 Temperature Elements (T/C)

Temperature elements shall be spring-loaded, mineral insulated and shall have stainless steel sheath. Elements shall have weather proof screw heads and suitable cable entry connection. Thermocouple shall be grounded K Type (Chromel-Alumel) as per IEC-584-2/IS-7358. Thermocouple shall have an accuracy of +0.25%. Element sensors shall be duplex with two separate cable entries.

9.3.4 Thermowells

All temperature gauges and elements shall be provided with thermowells. The well material shall be SS304 and fabricated out of bar stock. Thermowell shall be chosen to fit the element stem or gauge bulb without any gap so that measurement lag is minimal. Thermowell immersion length shall be above half of the line size, as a minimum and shall be minimum 400 mm if it is to be mounted on
vessels/tanks. Wherever the line size is less than 4", it shall be blown to 4" to install the thermowell. Thermowell coming on pipes and vessels under IBR shall be certified by IBR.

9.3.5 Pressure Gauges

Pressure gauges shall have white dials made of non-rusting, plastic material with black figures. Dial size shall be 150mm and shall have screwed bezel, external zero adjustment, over range protection and blow out disc. Process connection shall be ½" NPT bottom entry. Micrometer adjustment shall be provided for pointers. The sensing element shall be SS 316 and movements shall be SS 304. Pulsation damper shall be floating pin type, externally mounted and externally adjustable. Pulsation damper material shall be SS 304.

9.3.6 Pressure Switches

Pressure switch element shall be diaphragm or bellow type with SS316 material of construction as minimum. It shall be able to withstand over pressure of 130% of working pressure as a minimum. Body of switch shall be cast-aluminium. Process and electrical connection shall be ½" NPT (F). Switch differential setting shall be fixed and contact rating shall be suitable for 230 VAC at 5 Amps. Switch contact shall be DPDT type.

9.3.7 Level Gauges

Level gauges shall be of reflex type with body and cover material of carbon steel as a minimum and shall have tempered borosilicate glass. All gauge glasses shall have a rating equal to or more than the vessel design pressure and temperature.
Level gauge shall have check valve and union. Maximum visibility length shall not exceed 1200mm for a single gauge.

9.3.8 Level switches

Level switch shall be external cage float type with flanged head. It shall be able to withstand over pressure of 130% of working pressure as a minimum. Electrical connection shall be ½" NPT (F). Process connection shall be minimum 11/2" flange connection and rating equal to or more than the vessel design pressure and temperature. Switch differential setting shall be fixed and contact rating shall be suitable for 230 VAC at 5 Amps.

9.3.9 Flow element (Orifice Plates and Flow Nozzles)

Liquid Flow measurement shall be normally done with thin square edged concentric orifice plate mounted between a pair of weld neck flanges of minimum 300 pounds rating with flange taps as per ANSI B16.36. The material of the orifice plates shall be normally SS 316. Vent and drain holes shall be provided wherever necessary.

Steam flow measurement shall only be done with flow nozzles. Flow nozzle shall consist of a convergent portion, of a rounded profile, and a cylindrical throat as per ISA 1932.

Air and Gas flow measurement shall be done by using Venturi meter or Aerofoil.

Flow nozzle and Orifice plate sizing shall in general, follow BS 1042. Orifice diameters and Nozzle throat shall be selected so that d/D radio is between 0.2 to 0.7. BIDDER shall submit the sizing calculations for orifice plates, for CONSULTANT's approval. The operating flow shall be 70% of selected range. Honed metering runs or integral orifice type shall be installed in lines with 40 mm nominal diameter or below.
All Meter runs shall have sufficient straight line (Up stream and down stream length) as per BS-1042.

9.3.10 Pressure / Differential Pressure Transmitters

Pressure / differential pressure transmitter sensor shall be electronic, state of art type sensor. Element material shall be SS316 and it shall be able to withstand over pressure of 130% of working pressure as a minimum. Body of transmitter shall be cast-aluminium. Transmitter shall be SMART with HART protocol and shall have an integral output meter (digital) with accuracy of minimum +/- 0.25% span. Process and electrical connection shall be ½" NPT (F)

9.3.11 Current to Pressure Converters

Current to pressure converter shall be feedback balance type. Transducer shall be suitable for vibration environment. The electronic and pneumatic parts shall be housed in cast aluminium enclosures. The process connection shall be ¼" NPT (F) and electrical connection shall be ½"NPT (F).

9.3.12 Electronic field indicator

Bar graph Indicator shall be flush mounted type with necessary mounting accessories. Enclosure shall conform to IP-65. Indicator power supply shall be 230VAC and suitable for 4-20mA input signal. 4 digit display, with back lightLCD shall be provided.

9.3.13 Electronic digital field indicator

Digital Indicator shall be panel mounted type with necessary mounting accessories. Enclosure shall conform to IP-65. Indicator power supply shall be 230VAC and suitable for universal input signals. 4-digit display, with back light LCD shall be provided.

9.3.14 Level transmitters (Hotwell Level) **not required,** Level transmitter displacer material and torque material shall be SS316. It shall be able to withstand over pressure of 130% of working pressure as a minimum.

Body of transmitter shall be cast-aluminium. Transmitter shall be SMART with HART protocol and shall have an integral output meter (digital) with accuracy of minimum +/-

0.5% of span. Process connection shall be 2" flanged and electrical connection shall be ½" NPT (F)

9.3.15 Temperature Transmitters

Temperature transmitter shall be remote mounted type. Transmitter shall be SMART with HART protocol and shall have an integral output meter (digital) with accuracy of minimum +/- 0.2% span. Linearity shall be better than 0.03%.

Body of transmitter shall be die-cast aluminium. Process and electrical connection shall be ½" NPT (F). It shall with stand upto ambient temperature of 65 deg. C

9.4 Specification for Instrumentation Cables

All cables shall have PVC insulated primary insulation of 85 °C PVC as per IS-5831 Type C. Inner and outer jacket shall be 90 °C PVC to IS-5831 Type ST-2 and shall be fire retardant. Oxygen index of PVC shall be over 30% and temperature index shall be over 250 °C. Insulation grade shall be 1100 V and shall meet insulation resistance, voltage and spark test requirements as per BS 5308 and IS-1554.

The cables shall be twisted and armoured. Armour over inner jacket shall be galvanised steel wire as per IS –1554 part 1.

Inner jacket and outer jacket colour of the cables shall be black. Outer jacket colour of the signal cable shall be light blue. The colour of the cable shall be as per IS-8784.

The completed cable maximum DC resistance of the conductor shall be 12.3 ohm/Km at 20 °C for 1.0 Sq.mm conductor. The mutual capacitance of the pair or adjacent core shall not exceed 250 pF/m at a frequency of 1 KHz. The capacitance between any core and screen shall not exceed 400 pF/m. L/R ratio of adjacent cores shall not exceed 40 micro henry/ohm for cables with 1.0 Sq.mm.

The drain wire resistance including shield shall not exceed 30 ohm/Km. Running length of the cable shall be printed atleast at every meter interval.

9.4.1 Signal Cables (Pair/Triad)

The single pair/triad and multi pair/triad cables shall be of 1.0 Sq. mm conductor size, made of electrolytic copper conductor of 7 strands with each strand of 0.43 mm diameter. All signal cables shall be shielded. Multi pair cables shall be both individually and overall shielded. Shield shall be aluminium backed Mylar/Polyester tape bonded together with the metallic side down, helically applied with either side having 25% overlap and 100% coverage. The minimum shield thickness shall be 0.05 mm. The drain wire shall be provided for both individual pair and over all shields and shall be 0.5 Sq.mm multi stranded bare tinned annealed copper conductor. The drain wire shall be in continuous contact with aluminum side of the shield. Pair identification shall be blue and white. Triad identification shall be blue, white and brown.
All Signal cable from TG Set to Marshaling Box is In scope of TG set Supplier.

9.4.2 Control Cables
The control cable shall be 1.5 Sq.mm conductor size made of electrolytic copper conductor of 7 strands with each strand of 0.53-mm diameter. The control cable shall be over all shielded. Shield shall be aluminium backed Mylar/Polyester type. Each core shall be identified by colour or by number at regular intervals.

9.5 Specification for Instrument Hardwares

9.5.1 Junction Boxes

Junction Boxes shall be weatherproof type and die-cast aluminium with 6 or 12 branch cable and two main cable entry. Junction Box shall have required number of terminal blocks suitable for 2.5 Sq.mm cable and one number of earthing lug. Hinged type doors shall be provided.

9.5.2 Cable Glands

All cable glands shall be nickel plated brass and shall be double compression type. The cable glands shall be weatherproof. Cable gland size shall be suitable for cable sizes mentioned in the BOM. Rubber ring, metallic ring, metallic cone and outer and inner nuts in the cable glands shall be armoured cables.

9.5.3 Impulse Pipe

Impulse pipe size shall be ½" NB as per ANSI B 36.10 and schedule shall be 80. Pipe shall be seamless pipe and grade material shall be B and A106. All pipe threads shall confirm to American standard taper as per ANSI B 1.20.1 NPT.

9.5.4 Pipe Fittings

Dimensions of socket welded/screwed fittings shall confirm to ANSI B 16.11 and suitable for pipe thickness. All screwed fittings shall confirm to American standard taper as per ANSI B 1.20.1. Fittings material all be A105 and rating shall be 3000#.

9.5.5 Globe Valves

½" socket welded/screwed globe valves shall be manufactured as per BS 5352. Body material shall be A105 and trim material shall be ASTM A182 GR F316. Rating of valve shall be 800#.

9.5.6 Impulse Tube

½" OD X 0.065" thickness or 6mm OD X 1mm thickness seamless stainless steel tube material shall be as per ASTM A269TP316. Tube hardness shall be suitable for easy bending.

9.5.7 Tube Fittings Nomenclature of all tube fittings shall be as per ISA RP42.1. Fittings shall be of flareless compression type and three piece constructions consisting of ferrules, nut and body. Fittings shall be suitable for the supplied SS tubes OD and thickness.

9.5.8 Valve Manifolds

3-valve manifold shall have two main block valve and an equalising bypass valve. The valves shall be needle valves. The material of construction shall be SS316. The process connection shall be ½" NPT (F) to ANSI B1.20.1. The manifold shall be suitable for coupling to differential pressure transmitters.

9.5.9 Air Filter Regulators

The body of the filter shall be anodized aluminium. The filter shall have 5 micron sintered

bronze/ceramic filter element and shall be provided 2" size pressure gauge. The filter shall have manual drain and suitable mounting accessories.

9.5.10 Cable Trays

The cable tray (perforated) shall be made out of galvanized mild steel sheets of2.5mm thickness. The width shall be so selected that 50% of tray space is available for future use. Tray shall be suitable to mount clamps for cable bending at every 500mm.

9.6 Electronic Governor

The speed / load / extraction control loops and all necessary interlock for safe rolling and synchronizing shall be the part of electronic governor. The governor should be capable of switching over bumplessly from load to speed control (or) vice versa whenever operating parallel with grid or cut off from grid. The governor shall also take care of 100% load throw condition (or) grid cut off conditions and shall keep turbine running safely with house load. All governing signals from signal source to final I/H converter including cabling & power supply shall be redundant.

9.7 Turbine gauge panel

The panel shall be consists of the following minimum indications for the local indication purpose

- Main steam pressure Indication
- Main steam temperature Indication
- Nozzle pressure Indicator
- Exhaust pressure Indication
- Speed indicator
- Boiler Pressure Indication
- Exhaust Temperature Indication

9..8 Applicable Standards

9.8.1 Design and terminology shall comply, as a minimum, with the latest edition of following codes and standard practices and publications.

ANSI	:	American National Standards Institute.
B 2.1	:	Pipe Threads
B 16.5	:	Steel pipe flanges and flanged fittings
B 16.104	:	Control valve leakage classification
MC 96.1	:	Temperature measurements, thermocouple.
BS 1042	:	Measurement of fluid flow in pipes
DIN 43760	:	Temperature Vs Resistance curves for RTDs.
IBR	:	Indian Boiler Regulations
IEC	:	International Electrical Commission
IS-5	:	Indian Standard

- Colors for ready mixed paints ISA

ISA : Instrument Society of America

- Standards and Practices of Instrumentation

9.9 Instrument List

The following details given for the instrument list for the turbine:

Sl. No.	Instrument Description	Qty	Vender Acceptance		Remarks
			Yes	No	
A	**Inlet steam and Bleed steam instrument**				
1	Turbine inlet steam pressure transmitter				
2	Turbine inlet steam pressure gauge				
3	Turbine inlet steam temperature element				
4	Turbine inlet steam temperature gauge				
5	Turbine inlet steam flow nozzle				
6	Turbine inlet steam flow transmitter				
7	Turbine exhaust steam pressure gauge				
8	Turbine exhaust steam pressure transmitter				
9	Turbine exhaust steam pressure switch high				
10	Turbine exhaust steam temperature element				
B	**Lube Oil Scheme for Turbine**				
1	Main oil tank level gauge				
2	Overhead oil tank level gauge				
3	Over head oil tank level high switch				
4	Over head oil tank level low switch				
5	Main oil tank level Low switch				
6	Main oil tank level high switch				
7	DP indicator cum switch across lube oil filter				
8	MOP discharge pressure gauge				
9	AOP discharge pressure gauge				
10	EOP Discharge Pressure Transmitter				
11	EOP discharge pressure gauge				
12	Lube oil to thrust bearing pressure gauge				
13	Lube oil to turbine FJB pressure gauge				
14	Lube oil to turbine RJB pressure gauge				
15	Lube oil to gear box pressure gauge				
16	Lube oil header pressure gauge				
17	MOP/AOP Discharge Pressure Low Switch				
18	Lube oil header pressure very low switches				
19	Lube oil header pressure low switch (Barring Gear)				
20	Lube oil header pressure transmitter				
21	Lube oil (oil cooler) inlet temperature element				
22	Lube oil (oil cooler) outlet temperature element				
23	Lube oil (oil cooler) inlet temperature gauge				

24	Lube oil (oil cooler) outlet temperature gauge				
25	Lube Oil Cooler inlet Pressure Gauge				
26	Lube Oil Cooler outlet Pressure Gauge				
27	ESV open limit switch				
28	ESV Closed limit switch				
C	**Turbovisory Scheme for Turbine**				
1	Turbine speed sensor				
2	Turbine thrust bearing temperature element (active) Duplex Type				
3	Turbine thrust bearing Temp. element (non-active) Duplex type				
4	Turbine front bearing temperature element Duplex				
5	Turbine rear bearing temperature element Duplex				
6	Gear box high speed bearing temperature Duplex				
7	Gear box low speed bearing temperature Duplex				
8	Gear box low speed thrust bearing temperature Duplex				
D	**Local Gauge Panel for Turbine**				
9	Digital speed indicator				
10	Inlet steam pressure indicator				
11	Wheel Chamber Pressure Gauge				
12	Exhaust steam pressure Gauge				
13	Lube oil pressure Gauge				
14	Inlet steam temperature Gauge				

* Vendor to fill up and include this instrument list in their Offer.

NOTE: The instrument list covers only minimum requirements. Any other instruments that are required for the specific design of the Turbine shall also be included.

10. SPECIFICATION FOR ERECTION OF MECHANICAL EQUIPMENT

10.1 This specification broadly covers the requirement for erection of the turbine and generator which is to be carried out in the best workmanship like manner.

10.2 The BIDDER shall, as a first field activity, check the turbine, generator and all auxiliaries foundations for the correctness of the same as per the drawings and satisfy himself in all aspects, such as location of foundation consolidation of foundations, absence of voids, levels, correctness of bolt holes, pockets levels and centre lines etc. If any minor modifications are required the same shall be carried out by the BIDDER.

10.3 Before starting erection job on turbine floor BIDDER shall ensure that turbine area is sufficiently enclosed against ingress of dust and wastes, and that all debris have been cleared off from the floor.

10.4 Where turbine holding down bolts carry washers and where these plate washer rest on concrete surface such concrete surface shall be finished and dressed true to get full surface contact between the concrete surface and the plate washers as required.

10.5 BIDDER shall provide his tool stores for special tools and instruments at a convenient location in the turbine hall.

10.6 BIDDER shall set up longitudinal and axial centerlines, and two or more level bench marks accurately on turbine floor which shall be certified by PURCHASER / CONSULTANT. This certified turbine centre line and datum level shall be reference for turbine and all auxiliary erection and alignment work.

10.7 Where required by manufacturers the concrete surfaces shall be chipped and finally dressed up true to obtain the required contact between sole plates and concrete surfaces. The fine dressing of the concrete shall be with Prussian blue match checks.

10.8 BIDDER shall ensure that while lifting turbine/generator, piping and other auxiliaries for transporting, slings shall be put over the points indicated on the equipment.Slings over casing shall have gunny bags or soft wood packings to avoid the scratches and nicks on the equipment. Slings / D-Shackles of proper sizes shall be used for all lifting and rigging purposes. All care shall be taken to safeguard the equipment against any damage.

10.9 BIDDER shall thoroughly clean all machine surfaces/slings, surfaces/keys, brackets sole plates etc. and apply antiscuffing paste or other recommended equivalent before assembly of the said parts. The components whose surfaces are coated with protective coating are to be thoroughly cleaned.

10.10 The BIDDER shall carry out all necessary checks such as accuracy of levels, centre lines, bolt positions, supports etc., sufficiently in advance to ensure correctness of installation of all equipment covered in the scope of work. When setting heat exchangers and vessels operating under temperatures attention shall be paid to the thermal expansion provisions indicated on the drawings and instruction manuals.

10.11 Checking of Equipment after Grouting

Equipment grouting is an important activity, and the grouting application and curing shall be done as per the instructions of the grouting material manufacturer.

The placing tools and space that receive the grout shall be thoroughly cleaned of dirt, debris, mud, loose scales and rust. Forms shall be used to contain the grout materials at places not enclosed by the frame members. Place and pack the grout mortar in layers, and solidly compact each layer into place. The anchor bolts and nuts shall not be tightened until the grout cures.

After the grout is set and cured, the BIDDER shall check and verify the alignment of equipment, alignment of shafts of rotating machinery, the slopes of all bearing pedestals, centering of rotors with respect to their seating bores, couplings etc. as applicable and the like items to ensure that no displacement had taken place during grouting. The values recorded prior to grouting shall be used during post grouting check-up and verifications. Such pre and post grout records of alignment details shall be maintained by the BIDDER in a manner acceptable to the PURCHASER.

10.12 Shaft Alignment

All the shafts of rotating equipment shall be properly aligned to those of the matching equipment to the required accuracy. The equipment shall be free from excessive vibration so as to avoid over-heating of bearing or other conditions which may tend to shorten the life of the equipment. All bearings, shafts and other rotating parts shall be thoroughly cleaned and suitably lubricated before starting.

10.13 The BIDDER shall maintain a record in the form acceptable to PURCHASER/CONSULTANT of all the operations carried out on each weld and maintain a record indicating the number of welds, the names of the welders who welded the same. All site joints shall be subject to acceptance of PURCHASER / CONSULTANTs. Any joints declared rejected shall have to be redone at the BIDDER's cost.

10.14 All electrodes shall be dried in the electric electrode drying oven to the temperature.

10.15 The BIDDER shall carry out the tightening of the bolts on the equipment and piping covered under this specification by using either the calibrated torque wrench method or the turn of nut method. The methods used, the tools and the equipment deployed shall be subject to the approval of PURCHASER / CONSULTANT. The bolting work shall be carried out by competent technicians.

10.16 The BIDDER shall install all necessary platforms, stairways and ladders required for the safe and convenient operation and maintenance of all the equipment, valves etc. covered in this specification at no extra cost.

10.17 The BIDDER shall completely erect and test all the equipment for the complete E&M portion including hangers and supports, valves & accessories in accordance with the approved drawings. This included all necessary bolting, welding, testing and cleaning. System shall be demonstrated in condition to operate continuously in a manner acceptable to PURCHASER / CONSULTANT.
Welding shall be used throughout for joining pipes except where flanged screwed or other type joints are lines & elevation as indicated in the drawings.

10.18 While erecting the field run pipes the BIDDER shall check the accessibility of valves, instrument tapping points and maintain minimum head room requirements and other necessary clearances for adjoining work areas.

10.19 The BIDDER shall be responsible for correct orientation of all valves so that seats, stem and hand wheels will be in desired location.

10.20 All supports & hangers for the pipes shall have to be fabricated and provided for approximately every three metre (3 mtr.) of pipe. However in any case sufficient numbers shall be provided so that the deflection of pipe between hangers shall not exceed the limits indicated in the drawings. Maintenance flange shall be provided in 6M space.

10.21 The BIDDER shall make all necessary arrangements including making of temporary closures on piping / equipment for carrying out the hydro-static testing on all piping / equipment with motor operated pump.

10.22 All piping flanges are required to be blue matched using surface plate to obtain at least 80% contact area to obtain leak proof joint and to be approved by the PURCHASER / CONSULTANT before installation.

10.23 All welded joints of pipes shall be cleaned of welding slags, & burrs by hand file wire brushes and flexible grinders wherever required and using white cloth. No cotton waste shall be used while cleaning the equipment / piping.

10.24 The BIDDER shall dismantle the valves & actuator for overhauling, servicing and lubricating wherever required as advised by PURCHASER/CONSULTANT. The BIDDER shall also lap or grind the valve seat for ensuring the satisfactory performances of valves at no extra cost. All consumables such as gaskets, gland packing which form the permanent part of equipment shall be in the BIDDER's scope.

10.26 The hanger assemblies shall not be used for attachment of rigging to hoist the pipes into position. Other means shall be used to securely hold the pipe in position till pipe supports are completely assembled and attached to the pipe & building structure.

10.27 All temporary rigging shall be removed in such a way that pipe supports are not subjected to any sudden load. During hydro static testing of pipes, all piping having variable spring type supports shall be secured in place by temporary means while constant spring type support hangers shall be pinned or blocked solid during the test.

10.28 The BIDDER shall carry out the pre-commissioning activities such as chemical cleaning of piping system, water flushing, oil flushing of oil systems, flushing of control fluid system. The scope of pre-commissioning activities covers installation of all temporary pipings, supports, valves bankings, tanks, pumps & all other accessories & services to complete the process.

10.29 The BIDDER shall carry out the edge preparation of weld joints at site in accordance with the details acceptable to PURCHASER / CONSULTANTs. Wherever possible machining or automatic flame cutting will be allowed only wherever edge preparation otherwise is impractical. All slags/burrs shall be removed from cuts and all the hand cuts shall be ground smooth to the satisfaction of PURCHASER / CONSULTANTs.

10.30 BIDDER shall carry out all the electrical pre-commissioning tests on the generator, excitation system, as stipulated by the relevant specification and codes.

10.31 The BIDDER shall hand over all parts/materials remaining extra over the normal requirement with proper identification tags, in a packed condition to the PURCHASER / CONSULTANT.

10.32 The work to be carried out is of highly sophisticated nature requiring best quality precision workmanship, engineering and construction management. It should also ensure successful and timely commercial operation of equipment installed. The BIDDER must have

adequate quantity of precision tools, construction aids in his possession. BIDDER must also have adequate trained, qualified and experienced supervisory staff and skilled personnel.

10.33 All temporary scaffolding shall be removed before the start of the commissioning activities to prevent fire hazards.

11. SPECIFICATION FOR ERECTION OF ELECTRICAL EQUIPMENT

11.1 Scope

The specification covers the installation, testing and commissioning of all electrical equipment and accessories required for efficient and trouble free operation.

11.2 Standards

The electrical installation work covered by this specification shall unless otherwise stated comply with the requirements of the latest edition of relevant Indian Standard, statutory regulations and codes of practices.

a) Indian Electricity Rules.

b) Tariff advisory committee

c)	IS-10118	:	Code of practice for selection, Installation & maintenance of switchgear and control gear
d)	IS-6600	:	Guide for loading of oil immersed transformers
e)	IS-3043	:	Code for practice for earthing
f)	IS-2309	:	Code of practice for protection of building and allied structures against lightning
g)	IS-2274	:	Code of practice for electrical wiring Installation
h)	IS-6665	:	Code of practice for industrial lighting

11.3 General Requirements

11.3.1 The installation shall be carried out by an electrical BIDDER holding a valid license as required by the State Government. The BIDDER shall provide particulars of the license held by him or his SUB-BIDDER to the PURCHASER. The installation shall require approval of the Chief Electrical Inspector to the Government of the State and the BIDDER shall prepare all necessary drawings / documents in obtaining the approval. He shall also fully assist the PURCHASER in obtaining approval from any other statutory authorities for the successful commissioning of the Power plant and the Substation.

11.3.2 Any modification in the equipment or installation that may be demanded by the inspector shall be carried out at no additional cost to the PURCHASER.

11.3.3 In accordance with the specific installation instructions or as directed by the PURCHASER, the BIDDER shall unload, erect, assemble, install, wire, test and commission all electrical equipment included in this contract. Equipment shall be installed in a neat workman like manner with highest regard for safety.

11.3.4 Erection materials, tools, testing instruments or any other machinery of any nature shall not be supplied by the PURCHASER. The BIDDER shall arrange for the same in a timely manner and he shall not be allowed to claim for any delay or extra cost of any nature.

11.3.5 Consumable materials of any nature required for the erection job shall also have to be

arranged by the BIDDER.

11.3.6 Clearing the site after completion of erection as well as regular clearance of unwanted materials from site, returning all packing material and excess material shall also be covered under the scope of work.

11.3.7 All equipment and instruments of indoor and outdoor, shall be inscribed with number, nomenclature, danger boards and other instructions.

11.3.8 The BIDDER shall touch up the surface for all equipment, which are scratched and / or damaged during transportation and erection. The paint used shall match exactly the surface being touched up.

11.3.9 The BIDDER shall employ skilled and semi-skilled laborers for erection, installation & testing as required. All electricians, cable jointers, wiremen, welders and others employed shall be suitably qualified possessing valid certificates / licenses recognised by the competent authorities.

11.3.10 The BIDDER shall also furnish a list of Engineers / Supervisors and staff employed by him for erection and installation jobs, giving in brief, qualification and experience of such staff and indicating whether they hold such competency certificates / licenses to supervise the electrical installation jobs as required under Indian Electricity Rules & State electrical Inspectorate Rules.

11.3.11 The BIDDER shall set up his own workshop and other facilities at site to undertake fabrication jobs, pipe bending, threading etc.

11.3.12 The BIDDER shall be responsible for recording of all readings and observations during erection, testing and commissioning, in registers or on prescribed proforma. These shall be carried the presence of PURCHASER's representative. All such test data and records shall be duly signed by the BIDDER's Engineer / PURCHASER's representative and shall be submitted to PURCHASER in triplicate.

11.3.13 The BIDDER shall carry out all tests at site for outdoor and indoor Electrical equipment and commission the installation in the presence of PURCHASER's representative. The BIDDER shall be responsible for final adjustment of relays, instruments, meters breakers etc. and also for submission of relay settings and calculations.

11.4 Equipment Erection

11.4.1 All support insulators, Circuit breakers, Isolators, Instrument Transformers, etc. shall be properly handled and erected as per the relevant codes of practice and manufacturer's drawings and instruction manuals.

11.4.2 Handling equipment, sling ropes etc. should be tested before erection and periodically for strength.

11.4.3 For cleaning the inside and outside of hollow insulators, only muslin or leather clothes shall be used.

11.4.4 Necessary Junction boxes for CTs and PTs shall be supplied and installed.

11.5 Power & Control Cables

11.5.1 BIDDER's scope of work includes unloading, laying, fixing, jointing, bending and terminating of cables. BIDDER shall also supply all the necessary hardwares for jointing and terminating of cables. Cable shall be laid on cable racks in built up trenches, on cable trays and supports in conduits and ducts or bare on walls, ceiling etc. Where specific cable layouts are not shown in the drawing BIDDER shall route these cables as directed by PURCHASER.

11.5.2 It is the BIDDER's responsibility to ensure that he acquaints himself with the nature of the ground conditions of the project site.

11.5.3 Markers shall be installed at all road crossing and joint positions. Their provision and installation shall be included in the areas.

11.5.4 All necessary care must be taken by the BIDDER while designing and installation of cables.

11.5.5 BIDDER shall install, test and commission the cables specified in accordance with the latest revisions of Indian Standards.

11.5.6 All cable work and the allied apparatus shall be designed and arranged to reduce the risk of fire and any damage that may cause in the event of fire. Wherever cables pass through any floor or wall opening suitable bushes supplied shall be sealed using fire resisting materials to prevent fire spreading.

11.5.7 Standard cable installation tools shall be utilised for cable pulling. Maximum pull tension shall not exceed the manufacturer's recommended value. Cable grips, reels or pulleys used shall be properly lubricated. The lubricant shall not injure the overall covering and shall not set up undesirable conditions of electrostatic stress.

11.5.8 Sharp bending and kinking of cables shall be avoided. The bending radius for various types of cables shall not be less than those specified by manufacturer.

11.5.9 Power and control cables shall be laid in separate cable trays. The order of laying of various cable in trenches shall be as specified below :

a) 415V cables on top tier.
b) Control cables in bottom most cable tier.

11.5.10 Where cables cross roads and water, oil, gas or sewage pipes the cables shall be laid in reinforced spun concrete pipes. For road crossing the pipe for the cable shall be buried at not less than one metre depth. Cable shall be protected at all times from mechanical injury and from absorption of moisture.

11.5.11 Some extra length shall be kept in each cable run at a suitable point to enable one or two straight through joints to be made at a later date, if any fault occurs.

11.5.12 No cable joints shall be envisaged.

11.5.13 All glands shall be of double compression type.

11.5.14 Metal sheath and armour of the cable shall be bonded to the earthing system of the station.

11.5.15 Each cable shall be identified with its designation number as indicated in the drawings.

11.5.16 Cable clamps shall be of 3 mm thick galvanised MS spaced at every 1.0 M interval.

11.6 Cable Trays, Accessories and Tray Supports

11.6.1 Cable trays shall either be run in concrete trenches or overhead supports from building steel, floor slab, etc.

11.6.2 Cables shall be clamped to the cable trays in both horizontal runs and vertical runs by suitable prefabricated clamps.

11.6.3 All cable trays and fitting will be ladder type and fabricated from MS Sheet /Structures. They shall be hot dip galvanised.

11.6.4 Cable trays shall be suitably supported at an interval of not more than one metre.

11.6.5 Trays shall have rungs at not more than 300 mm interval and additional rung for clamping at not more than 900 mm interval.

11.7 Switchgear, Control and Relay Panel

11.7.1 Switchgear, Control and Relay panel, etc. shall be installed in accordance with the latest edition of IS:10118 and manufacturer's instructions.

11.7.2 The panels shall be installed on finished surfaces. The correct level shall be ascertained before final grouting.

11.7.3 The BIDDER shall take utmost care in handling delicate equipment and mechanism like instruments, relays. Dragging shall be avoided as for as possible. Proper pipes shall be provided underneath when dragging for short distance. Wherever the instruments and relays are supplied separately, they shall be mounted only after the associated control panels have been erected and aligned. Any damage to relays and instruments shall be immediately reported to the PURCHASER. BIDDER shall also make all necessary adjustments as specified by the manufacturer for proper functioning of the equipment.

11.7.4 BIDDER shall also carry out the following :

11.7.4.1 Cleaning of internal parts like chambers, insulators etc. by vacuum cleaners.

11.7.4.2 Prepare base for mounting the equipment including leveling.

11.7.4.3 Drying of equipment in case of low insulation resistance.

11.8 Battery and Battery Charger

11.8.1 Battery charger shall be installed and tested in strict compliance with the manufacturer's instruction.

11.8.2 Each cell shall be inspected for breakage and condition of cover seals as soon as received at site.

11.8.3 Battery should be maintenance free sealed type.

11.8.4 Contact surfaces of battery terminals and intercell connectors shall be cleaned, coated with protective grease. Each connection shall be properly tightened.

11.8.5 Each cell shall be tested with hydrometer and thermometer.

11.8.6 Successful Bidder shall arrange for necessary charging and discharging equipment and carry out the charging and discharging process as per manufacturer's instruction.

11.8.7 The reading during charge / discharge test shall be recorded and results submitted.

11.8.8 Each cell shall be numbered with number plates furnished by the SUPPLIER.

11.8.9 All connections between cells, cell connectors, battery charger, etc. shall be carried out.

12. PERFORMANCE GUARANTEE

The Turbo generators to be supplied shall fulfill the following guarantee parameters, under the normal steam flow conditions as given below:

12.1 Steam Parameters And Flow Condition

Sl. No.	Particulars	Unit	Value
1	Inlet steam pressure at the turbine stop valve	Ata	43
2	Inlet steam temperature at the turbine stop valve Deg.C	^{0}C	390
3	Normal Steam flow Conditions		
i	Inlet flow	TPH	38
ii	Exhaust steam	TPH	38
4	Exhaust parameters Pressure	Ata	5.5
	Temperature	^{0}C	160

12.2 Guarantee Parameters applicable to the TG

Sl. No.	Particulars	Unit	Value
1	Power output at generator Terminals	kW	3000
2	Power Consumption of auxiliary Equipment	kW	To be Specified
3	Cooling Water flow	M^3/hr	To be Specified
4	Maximum temperature rise Deg.C in the generator windings above max. inlet temperature of cooling air of 40 Deg.C		Stator 85 (by ETD method) Rotor 90 (by thermometer method)

Apart from the above, the ability of the machine to provide the maximum extraction flows shall be demonstrated.

The above guarantees shall be furnished for the design ambient condition and cooling water inlet temperatures specified elsewhere in this bid document.

Correction Curves

The results of the performance test shall be corrected to the specific conditions by correction factors, which shall be defined by means of correction curves. All correction curves shall be submitted by the BIDDER. A certified copy of the correction curves, giving the corrections to the steam turbine generator unit performance for variations in the inlet steam conditions, condenser cooling water inlet temperature, power factor, ambient conditions etc. as may be applicable to the plant shall be submitted, by the BIDDER within Ten (10) weeks from the date of the contract.

Other Requirements

The guarantee tests and tolerances permissible shall be in accordance with the International Standards acceptable to the PURCHASER such as PTC 6, DIN 1943.

13. DRAWINGS AND DOCUMENTS TO BE SUBMITTED

13.1 Along with the Bid

The bidder shall submit in his Technical Bid the drawings, diagrams, graphs, curves and all such information which are necessary to fully understand the offer both technically and commercially. As a minimum requirement the following information shall be supplied with the technical Bid giving sufficient details to fully describe the scope of work and the services offered.

- List of all equipment under scope of supply.
- Terminal point details
- Time schedule for the design, manufacture, delivery, erection, testing, commissioning and trial operation indicating important milestone activity.
- Process flow diagrams and piping and instrumentation diagrams for the various systems including lube oil system and the gland sealing system.
- General Arrangement of the turbo generator including the auxiliary equipment, and panels with overall dimensions and sections.
- Details of critical equipment and instruments including capacity, make design parameters codes and standards followed.
- Motor list and the preliminary electrical load list of AC and DC power consumers including power demand.
- Electrical single line diagram for the complete electrical system including power generation and distribution within the battery limit.
- Turbine characteristic curves with correction curves.
- Generator characteristic curves
- Write up on the control and the safety aspects of the plant with logic diagram including alarm and shutdown facilities.
- Write up and catalogues on excitation regulation system.
- Proposed mounting arrangements of current and potential transformers.
- Typical GA of generator along with coolers.
- Battery sizing calculations
- List of items manufactured in the SUPPLIER's own works, and the list of bought out items and the names with addresses of the sub-SUPPLIERs with their experience details.
- Details of the collaboration and license agreement (if any).
- Details regarding the materials of construction of the TG and its Auxiliaries.
- I/O list and I/O requirement for the entire turbine .
- Instrument Air & Power Consumption for the TG package.
- List of calibration and diagnostic equipment.
- Proposed detailed training program of PURCHASER's operating personnel for operation and maintenance of various equipment/systems indicating clearly the man-months considered for each category of personnel
- Illustrative catalogues and literature for the various plant and equipment.
- Any other information relevant to the subject tender.

13.2 Drawings and Information required from Successful Bidder during Contract Stage

The drawings and documents to be furnished by the successful BIDDER after the award of the contract shall include but not limited to the following. A drawing / document submission schedule clearly identifying the documents to be submitted and the purpose of the submission (for information/approval etc.) shall be furnished after discussions and in consultation with the CONSULTANT and PURCHASER.

13.2.1 General

Detailed time schedule in the form of Network or bar chart for the design, manufacture, delivery, erection testing and commissioning period with critical milestone activities and other important intermediate dates for uninterrupted progress of the project.

- Technical Specifications and data sheets for the Boughtout items
- Test certificates & inspection reports
- TG operation and maintenance manual including catalogues, bought out items, start up procedures and O&M manuals of boughtout items.
- All drawings / documents shall have a title block indicating, Project, Customer, Consultant, Title, Drawing Number, Revision Index and details, etc.,
- Quality Plans.
- Tie-in data
- List of approved vendors.
  included in the tender. They should be preferably as per the list
- Erection manuals and installation procedures for all equipment and systems.
- As Built drawings.
- Any other drawings and documents as required for statutory approval Other drawings, calculations and documents as indicated in the various sections of this bid document
- Proposed detailed training program of PURCHASER's operating personnel for operation and maintenance of various equipment/systems.

13.2.2 Process and Mechanical

- Heat Balance Diagrams at all operating conditions
- Write-up and Specification of Governor Piping and instrument diagrams for Steam System, Lube oil system, Control Oil system, Cooling Water System, Instrument Air system, etc.
- Scheme for Turbo supervisory System
- Start-up and shut-down curves for the Turbo generator.
- Floor wise plans and Cross-section of Powerhouse Layout showing equipment .
- General Arrangement of Turbo generator.
- All Sectional Elevation and Plan of Turbo generator.
- G.A of Lubricating Oil Skid
- Allowable Forces & Moments , Displacements at piping connecting points in the turbine
- Piping Line list and schedule Valve schedule & Data sheets for control valves, safety valves Piping Layout and Isometric Drawings with supports, hangers and the flexibility analysis results for the critical piping.
- Insert plate drawing for pipes & equipment supports
- G.A. drawings of Control valves, Isolation valves, Non-Return valves, Safety Valves, etc.
- Thermal Insulation schedule
- Expansion Bellow data sheets and drawings.
- Drain Trench Layout in the Power House building

13.2.3 Electrical

- Electrical single line diagram for Generator, & DCDB
- Data sheets, duly filled-in in the format furnished in bid documents

- Relay, metering, synchronizing and control panels, drawings complete with AC and DC wiring diagrams and Terminal Block details
- Motor / Load Schedule

- Battery & Battery charger, DCDB & DC starter schematic & GA drawings
- Battery sizing calculations
- LT Motor Characteristic curves
- Generator Data sheet with Capability curves, Short Circuit curves, Overload characteristics, Negative Phase sequence withstand, & Lamination Earthfault withstand
- HT panel GA & Wiring diagrams
- AER drawings and details
- Cable schedule and interconnection chart for cables with BIDDER's scope
- Relay coordination details and calculations
- GA and write-up of Generator Cooling system
- Engineering drawings & documents including
  - Single line diagram of TG feeders
  - Control schematic diagrams for different types of feeders
  - Physical installation layout of all equipment in scope to show the locations of motors / loads and power / control panels
  - Cable schedule for complete power & control cables pertaining to MCC
  - Interconnection chart for control cables pertaining to MCC
  - Cable tray and trench layout for the complete scope
  - Earthing layout drawings for the complete equipment in scope
  - Requirements of local push button stations
  - Bill of materials for power & control cables, local push buttonstations, earthing conductors and cable trays to enable the PURCHASER to procure the materials

13.2.4 Control & Instrumentation

- Instrument list, Instrument Schedule, Instrument Summary, deviation in vendor list for approval.
- Technical specification / catalogs for instruments.
- Instrument loop schematic drawing.
- Sizing calculation for flow elements and control valve.
- Dimensional drawings for control valves along with valve characteristics drawings.
- Logic diagram for protection and interlocking system.
- Interconnection diagram between instruments and control panel, JB grouping, cable schedule, loop drawings
- Instrument installations, Hook-up diagram.
- Control scheme and write up.
- Detailed List of Closed loop and open loops I/Os pertaining to the boiler and its auxiliaries including the Annunciation.
- GA of local gauge panel and any other panel offered by the BIDDER

13.2.5 Civil & Structural

- Drawing showing the outline of foundation in plan and Section and loading details, pocket sizes etc.
- Point of action of static and dynamic loads in plan and elevation.
- For foundations subjected 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 points of application.
- Max. allowable amplitude of vibrations in the vertical and horizontal direction.

14. LIST OF APPROVED MAKE OF COMPONENTS

14.1 MECHANICAL

TURBINE

a. Triveni
b. Mann Turbo
c. Turbo tech PE Pvt ltd.

14.1.1 BELLOWS
a. FLUIDLYNE
b. LONE STAR
c. METALLIC BELLOWS PVT. LTD.

14.1.2 BUTTERFLY VALVES
a. AUDCO
b. KSB

14.1.3 CENTRIFUGAL PUMPS
a. KSB
b. SULZER

14.1.4 CONTROL VALVES
a. MIL CONTROLS

14.1.5 GATE, GLOBE & CHECK VALVES (HIGH PRESSURE), CL.900 & ABOVE
a. AUDCO INDIA LTD.
b. BHARAT HEAVY ELECTRICALS LTD.
c. KSB VALVES

14.1.6 GATE, GLOBE & CHECK VALVES (LOW PRESSURE), CL.600 & BELOW
a. AUDCO INDIA LTD.
b. BHARAT HEAVY ELECTRICALS LTD.
c. KSB VALVES.

14.1.7 GEARBOXES
a. TRIVENI – LUFKIN

14.1.8 GOVERNORS
a. WOODWARD

14.1.9 LUBE OIL SYSTEM
a. ESKAY INDUSTRIES
b. LINCOLN HELIOS
c. LUBE SYSTEMS
d. SOUTHERN LUBRICANTS

14.1.10 RELIEF & SAFETY VALVES
a. BHARAT HEAVY ELECTRICALS LTD
b. TYCO SANMAR.

14.1.11 SPRING HANGERS
a. BHEL

b. L&T
c. PIPE SUPPORTS INDIA (P) LIMITED (MYRICKS)
d. SARATHI

14.1.12 STEAM TRAPS
a. PENNANT
b. UNIKLINGER

14.1.13 VALVE ACTUATORS (ELECTRICALLY OPERATED)
a. AUMA
b. ROTARK

14.2 ELECTRICAL

14.2.1 AUTO EXCITATION REGULATION SYSTEM (DIGITAL)
a. ABB UNITRON

14.2.2 a. CSPC
b. WOODWARD 505XT with voithactuator

14.2.3 BATTERY
a. EXIDE

14.2.4 BATTERY CHARGER
a. CALADYNE
b. HBL NIFE
c. SERVI LINK
d. ORLICON
e. UNIVERSAL
f. CHAABI

14.2.5
a. AREVA

14.2.6 DC DISTRIBUTION BOARD & EOP STARTER
a. VEE VEE CONTROLS

14.2.7 FEEDER & MOTOR PROTECTION (HV) RELAYS
a. ABB
b. AREVA
c. CSPC
d. EASUN REYROLLE
e. L&T - SEL
f. SIEMENS

14.2.8 GENERATOR
a. TDPS

14.2.9 GENERATOR PROTECTION RELAYS
a. AREVA
b. SIEMENS

14.2.10 HT CABLES

a. CCI
b. KEI
c. POLYCAB
d. TORRENT
e. UNIVERSAL

14.2.12 INSTRUMENT TRANSFORMERS
a. INSTRANS
b. KALPA (PTs & CTs of rating upto 1000/1A)
c. KAPPA (PTs & CTs of rating upto 1000/1A)
d. PRAGATHI

14.2.14 LT SWITCHGEAR COMPONENTS
a. L &T

14.2.15 DCS -
a. ABB
b. Yokoguwa.
c. Allen Braidley

14.2.15 LT POWER & CONTROL CABLES
a. POLYCAB
b. FINOLEX

14.2.16 MASTER TRIP & AUXILIARY RELAYS
a. ABB
b. AREVA
c. EASUN REYROLLE

14.2.17 METERING & CONTROL CUBICLES
a. SVEE VEE CONTROLS

14.2.18 MOTORS (Subject to Compliance of Specified Efficiency Figures)
a. SIEMENS

14.2.19 POWER QUALITY METER (PQM)
a. SCHNEIDER
b. SIEMENS

14.2.20 RELAY PANELS
a. AREVA
b. EASUN REYROLLE

14.2.21 ROTOR EARTH & SENSITIVE DIRECTIONAL EARTH FAULT RELAYS (MICROPROCESSOR / NUMERIC VERSION)
a. AREVA
b. CSPC

14.2.22 TRI VECTOR METER
a. SECURE

15.2.23 TRANSDUCERS FOR GOVERNOR
a. WOODWARD

14.2.24 XLPE CABLE TERMINATION KITS
- a. M-SEAL
- b. RAYCHEM

14.3 INSTRUMENTATION

14.3.1AIR FILTER REGULATOR
- a. PLACKA INSTRUMENTS AND CONTROLS
- b. SHAVO NORGEN (INDIA) PVT. LTD.

14.3.2 ELECTRONIC BAR GRAPH INDICATOR
- a. MASIBUS
- b. YOKOGAWA

14.3.3 FLOW NOZZLE / ORIFICE
- a. DELTA ENGINEERING
- b. STAR MECH

14.3.4 INSTRUMENT CABLES
- a. CORDS CABLES
- b. DELTON CABLES
- c. ELKAY
- d. FINE CORE CABLES
- e. ICON CABLES
- f. TCL
- g. THERMOPADS

14.3.5 I/P CONVERTORS
- a. MTL (model 425).

14.3.6 LEVEL GAUGES
- a. CHEMTROLS ENGINEERS P LTD.
- b. V.AUTOMAT

14.3.7 LEVEL SWITCH
- a. CHEMTROL ENGINEERS PVT LTD
- b. V-AUTOMAT

14.3.8 POWER CYLINDERS
- a. ROTEX
- b. R.K.CONTROLS

14.3.9 PRESSURE GAUGES
- a. GENERAL INSTRUMENTS
- b. WAREE

14.3.10 PRESSURE SWITCH & TEMPERATURE SWITCHES
- a. INDFOSS
- b. SWITZER

14.3.11 PRESSURE, TEMPERATURE & D.P.TRANSMITTER
- a. ABB

b. HONEYWELL AUTOMATION INDIA LTD.
c. YOGOKAWA INDIA LTD

14.3.12 REMOTE PANEL MOUNTED INDICATORS
a. ACCSYS
b. YOKOGAWA INDIA LIMITED

14.3.13 RTD AND THERMO COUPLES
a. GENERAL INSTRUMENTS
b. PYRO ELECTRIC

14.3.14 SOLENOID VALVES
a. ASCO
b. IMI NORGREN
c. ROTEX

14.3.15 SWAS
a. ABB
b. FORBES MARSHALL
c. HONEYWELL AUTOMATION
d. ROSEMOUNT
e. YOKOGAWA (INDIA) LIMITED

14.3.16 TEMPERATURE GAUGES
a. GENERAL INSTRUMENTS
b. WAREE