



# **STEEL AUTHORITY OF INDIA LIMITED BHILAI STEEL PLANT**

**BHILAI**

**7.0 MT EXPANSION (CRUDE STEEL)**

**CONTRACT AGREEMENT**

**STEAM TURBINE GENERATOR, BACK-PRESSURE TURBINE  
GENERATOR, COOLING WATER SYSTEM AND POWER  
EVACUATION SYSTEM  
(EXCLUDING ENABLING WORKS)**

**(PKG.NO.: 011-01B)**

**VOLUME-III**

**(ELECTRICS AND C&I)**

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# VOLUME – III

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## **GENERATOR & ELECTRICS**

### **01.00 SPECIAL INSTRUCTIONS TO CONTRACTORS**

#### **01.01 Compliance with Specification**

All equipment and accessories covered under this specification shall conform to 'Technical Specifications' given in this document and 'General Technical Specifications'.

In case alternative type of equipment is offered, all technical particulars of equipment offered, number of such equipment supplied in India, reference list of installations where such equipment is in operation as per qualifying requirements, type test certificates of their collaborators, type test certificates of indigenously made equipment, extent of import content and availability of spares indigenously, along with any other data for considering the alternative equipment shall be furnished with the offer. The Employer, however, reserves the right to accept or reject the proposal without assigning any reason.

All equipment shall be suitable for voltage/frequency variations and other data given in Electrical System Design.

The Contractor shall be responsible for satisfactory working of system with guaranteed parameters. All the major equipment shall be installed, tested and commissioned under supervision of representative of manufacturer of respective equipment.

#### **01.02 Standards and Regulations**

The design, manufacture, performance, testing and installation (including safety, earthing and other essential provisions) of equipment and accessories covered under this specification shall, in general, comply with the latest issue of the following:

- Applicable Standards and Codes of Practices published by Bureau of Indian Standards.
- Central Board of Irrigation and Power
- Indian Electricity Act, 2003
- Central Electricity Authority
- Indian Electricity Rules
- Equipment specific statutory regulations
- Indian Factory Act

Equipment complying with other recognized Standards such as IEC, BS, VDE, DIN etc. will also be considered if it ensures performance equivalent to or superior to Indian Standards.

Equipment and accessories, for which Indian Standards are not available, shall be designed, manufactured and tested in accordance with the latest issues of recognized Standards such as IEC, BS, VDE, DIN etc.

In case of conflict between applicable Standards referred to in this part and technical specifications, the Technical Specifications shall govern to the extent of such difference.

**Make & Interchangeability**

This specification is issued for procurement of specified equipment and system preferably from indigenous suppliers who may make use of imported systems / sub-systems / equipment / parts and who have valid collaboration agreement with reputed foreign suppliers with experience in design and supply of similar systems as specified. The Contractor shall furnish division list of supplies from foreign and Indian sources indicating the name of the agency or make against the respective items. It shall be the responsibility of the successful Contractor to arrange the import license for the imported items offered and to co-ordinate the supply of equipment from foreign and Indian sources and execute the contract within the agreed time schedule.

The make of major equipment shall be limited to preferred makes indicated under chapter 'List of preferred makes'. Makes of all other equipment and accessories are subject to prior approval by the Employer.

Similar equipment and components shall be of same make; equipment of same type and rating shall be interchangeable.

The Employer has the option of selecting the manufactures of electrical equipment, instruments and controls and any other specialized items in the interest of standardization and the successful Contractor shall have to supply equipment of particular make, if so required.

**Safety**

All equipment shall be complete with approved safety devices wherever a potential hazard exists and with provision for safe access of personnel to and around equipment for operational and maintenance functions.

The design shall include not only those usually furnished with elements of machinery but also the additional covers, stairways, ladders, steel structural platforms for operator's control panels, handrails, partitions etc. which are necessary for safe operation of the plant. In addition, maintenance platform, wherever required, shall be included in the design.

All danger and caution notice boards shall be in Hindi and English.

The Contractor must take sufficient care in moving his construction plants and equipment from one place to another so that those may not cause any damage to the property of the Employer particularly to the overhead and underground cables and other service lines.

When the work is carried out at night or in the obscure day light, adequate arrangements for flood lighting in the working area shall be made by the Contractor at his own cost getting approved by the Employer.

The Contractor at appropriate places shall display the safety posters/regulations for the prevention of accidents. Notices and warning signs shall be displayed for all sources of dangers.

All electrical drives and equipment must be equipped with safety devices. The safety provisions shall conform to the recognized standards, safety codes and statutory regulations.

All safety measures as required to be adopted as per the statutory regulations and the safety rules of the plant shall be strictly followed by the Contractor during the execution of the Contract.

Adequate number of first aid boxes as defined in the State Factory Rules shall be provided and maintained at all the work sites.

**01.05 Coding/Numbering Scheme**

A coding scheme for identifying the drawings, plant and equipment, structures, spares and the Contractor shall adopt shipping documents in a sequential manner.

**01.06 Contractor's License**

The Contractor shall possess a valid and competent Contractor's license of specified voltages issued by the electrical licensing authorities of the Govt. of Chattisgarh or other States for carrying out electrical installation work of the type and magnitude covered in this document, in the state of Chattisgarh. The Contractor shall also be required to obtain labour license from Statutory Authority.

Copy of the license shall be made available to the owner/consultant for verifications during the execution of contract.

All linemen, wiremen, electricians, supervisors and engineers engaged by the Contractor or his sub-Contractor shall possess necessary valid license issued by the statutory authority and the same shall be submitted for verification, if called for.

**01.07 Compliance with rules, regulations, and obtaining statutory approval**

All equipment/materials shall be installed in accordance with the requirements of relevant standards, Indian electricity Rules, Indian Electricity Act, 2003 and also the Factory Act. It is the responsibility of the Contractor to see that the electrical installation supplied and erected by him shall be to the entire satisfaction of Chief Electrical Inspector, Central Electricity Authority or any other statutory body having jurisdiction in the area and also to the owner/ consultant.

The responsibility for obtaining all statutory approvals for the installation to be carried out rests entirely with the Contractor. It shall be the responsibility of the Contractor to prepare and submit all necessary drawings, calculations, test certificates and relevant details (other than those given by the owner/consultant) to the Electrical Inspector and obtain prior approval for commencing the work and for the complete installation work done.

The owner on submission of documentary evidence shall reimburse the inspection fee for statutory approvals.

**01.08 Type test certificate from CPRI or Govt. institute (conducted within 5 years before the date of LOI) for all the equipment shall be submitted, otherwise Type**

test of the equipment shall be carried out by the supplier at CPRI or Govt. institute without any cost implication to the Employer. In case any equipment is imported and for these item CPRI Test is not applicable, then certificate from International approved testing laboratories will be applicable.

## 02.00 SCOPE & BRIEF DESCRIPTION OF WORK AND ELECTRICAL SYSTEM DESIGN CRITERIA

### 02.01 General

The scope of work includes the basic engineering, detailed engineering, construction/manufacture or procurement, shop testing, packing, transportation, loading, delivery at site, unloading, storage at site, handling, erection, pre-commissioning tests and commissioning of all equipment/system including preliminary acceptance test, performance guarantee and post commissioning services, including insurance cover during transit, storage, erection and commissioning of **total electrical system for the following Plants/system** .

- a) Power and Blowing station (PBS-2) consisting of the following plants/units along with their auxiliaries.
  - 1X 25 MW Steam Turbo-Generators.
  - Cooling water system.
- b) 1 No. 4 MW Back Pressure Turbo-Generator along with its auxiliaries in the CDCP area at the new Coke oven plant.

The Contractor shall note that the Power and Blowing station (PBS-2) shall also have 2 nos. 150 t/hr. BF and LD Gas Fired Boilers adjacent to the TG building. The same shall be procured through separate contract. However Contractor shall note that the auxiliary power supply for these units shall be fed from the Power and Blowing station (PBS-2) Switch-boards(MSG-at 6.9kV level) through this contract.

The job shall be done on turnkey basis including.

- Supply of commissioning spares
- Supply of special tools and tackles for the equipment/systems supplied

After successful commissioning, the commissioning spares not used, will be the property of the owner

02.02 All civil and structural works for the electrical premises e.g Substation building, MCC room, control room, cable trench, cable trestle etc. and for all the electrical equipment foundations shall be carried out by the Contractor. Contractor shall take into consideration of the following while designing the civil buildings:

- Static and dynamic loading of the equipment
- Clearances, approach, safety exits required
- Recommended height of electrical rooms/buildings considering bus-duct height, ventilation ducts and civil beams height etc.
- Future provision of electrical equipment.

Contractor shall have to build all above aspects in his offer whether specifically mentioned in civil part or not.

Clearances from all the four sides of the walls shall be maintained as per good design practice.

02.03

**The major equipment covered under scope of work shall be as follows:**

1. Two nos. complete generator sets and their auxiliaries consisting of the following major equipment/systems for the new units.
  - Generator sets.
  - Equipment/systems/mechanisms to meet pollution norms like noise level, vibration level, etc.
  - Generator cooling systems.
  - Generator lubricating oil systems.
  - Complete excitation systems (brushless type), latest digital AVR (thyristor controlled with dual channels and associated electrical equipment having data interface with DDCMIS).
  - Generator line side terminal cubicles consisting of Surge Arrestors, PT, CT, Capacitor, Link etc.
  - Generator neutral cubicles with neutral side CTs.
  - IG-541 extinguishing and automatic injection system for the Generators.
  - Any other equipment/systems required for smooth running of generator sets.
2.
  - i. One no. Generator Transformer of rating 36 MVA, 11/6.9kV, ONAN type.
  - ii. Auxiliary Transformers of rating 2 MVA or 1 MVA, 6.6/0.433 kV, AN type.
3. Two nos. Interconnections between MSDS-I and PBS-II-
  - a. Tie-line-4- Interconnector between MSDS-I (Sec-IV-Cubicle 36) and PBS-II sections VII & VIII.
  - b. Reserve supply from MSDS-I (Sec-IV cubicle 66) to the Reserve 6.6kV board at PBS-II.
4. Contractor shall provide one set of Generator Control Desk each with respective MIMICs for controlling all the synchronizing breakers detailed as below:
  - i. For the 6.9kV switchboard(MSG) Breakers:
    - a. 2nos. 6.9kV Generator Breakers of TG-4 connected to Section VII & section VIII,
    - b. 2nos. Tie-line-4 feeder breakers of Section VII & VIII,
    - c. 2nos Sectionalizer breakers connected to Section VII
    - d. 1 no. breaker of Section VI(extended) connected to Section VII,
    - e. 2 nos. bus coupler breakers between sections VII & VIII and Extended Sections V & VI.
    - f. 2 nos. Inter-connector breakers connected to extended sections of Section-V & VI located at PBS-II,
    - g. 2 nos. breakers connected to the existing Sections V & VI located at the extended switchgear building at PBS-I.
  - The above Generator control desks shall be placed at PBS-II premises.
  - ii. For the 11kV switchboard at BPTG premises:



- a. One no. 11kV Generator Breaker of BPTG connected to the 11kV Board,
  - b. One no. Tie-line feeder breaker of the 11kV switchboard connected to the 11kV switchboard at CDCP area.
- The above Generator control desks shall be placed at BPTG premises.

- 5. Relay and Protection Panel for the Generating units, namely,
  - a. 1x25MW STG
  - b. 1X4MW BPTG.
- 6. 6.9kV Switch Boards(sections VII & VIII, Extended sections V & VI, connecting busduct) including the corresponding reactors, busducts and the isolators.  
HT busduct shall be provided for the following:
  - a. 3150A busduct between Generator Transformer and MSG
  - b. 2000A busduct for the
    - i. Incoming Tieline-4,
    - ii. Bus coupler between sections VII & VIII and
    - iii. Bus coupler between sections (extended)sections V & VI,
    - iv. Two nos. interconnectors between sections VII & V (ext.).
- 7. 11kV Switch Board at the BPTG station.
- 8. 6.6kV Switch Board at the CWPH area.
- 9. 415V Power cum Motor Control Centers (PMCCs) for CWPH and BPTG areas.
- 10. 415V Motor Control Center for the Steam Turbo Generator.
- 11. 415V Motor Control Center for the BPTG.
- 12. 415V Motor Control Center for the Cooling Water system.
- 13. 415V Motor Control Centers for the AC and Ventilation system.
- 14. 415V Power Distribution Boards.
- 15. Contractor shall provide an Electrical Auxiliary Control Panel(EACP) for Remote Control, metering & annunciation panel for the centralized control, metering and annunciation for all the 11kV, 6.9kV, 6.6 kV and 415 V incomers & bus-coupler feeders excluding the feeders mentioned in Sno. 4 above. Separate EACP panels shall be considered for PBS-II BPTG Plant at their respective locations as indicated below:
  - a. PBS-II area: 6.9kV outgoing feeders
  - b. CWPH area: 6.6kV Incomers & Ties, PCC Incomers and Bus-couplers.
  - c. BPTG area-11kV outgoing Transformer feeder, PCC incomers and bus-couplers.

However for 6.6kV motor feeders, no control shall be considered from EACP. The same shall be done from the DDCMIS.

Control, metering, alarm and annunciation of the MSDS-I Breakers shall be done from the EACP Panel at PBS-II. Necessary control wiring shall be done by the Contractor. Control philosophy shall be hardwired only. All the necessary additional protection for the same is also in the scope of the Contractor.

16. Hooking up for control, monitoring and protection of generators and power distribution equipment/systems with DDCMIS. Transducer panels for inputs/outputs from/to electrical equipment to/from DDCMIS. This shall be considered for all the generating sets and its auxiliaries.
17. A dedicated and separate SCADA system shall be provided for Electrical system of PBS II in the Main Control room of the Switchgear Building. The electrical parameters shall be hooked up in this SCADA system for metering, alarm, annunciation and control.

The major systems to be covered in the SCADA are as follows:

- a. All HT Breaker Status(ON/OFF/TRIP/Ready to Start) and all metering parameters.
  - b. All the LT switch gear in PMCC, MCC (I/c & B/c), all DBs (I/c & B/c) and all metering parameters.
  - c. All intelligent controllers in MCCs.
  - d. Generator protection and metering parameters.
  - e. All kinds of Transformer alarm, annunciation and protection.
  - f. All kinds of alarm and annunciation for batteries, charger and UPS.
  - g. All the MFMs.
  - h. Fault annunciation from all the communication type protective relays, meters. From this SCADA, all the relay parameters shall be monitored as well as their settings can be changed/configured.
18. The new SCADA System shall be hooked up with
    - a. The upcoming SCADA for PBS-II Boiler pkg-011-A.
    - b. Existing SCADA system (presently used for existing electrical system for Switch gear and generators).
    - c. TRT Generator relays (IEC 61850 compliant) located at the TRT building for hooking up all the parameters of TRT Generator at PBS-II.
    - d. Provision shall also be made for hooking up the entire HT substation with the upcoming centralized SCADA system as well as a separate gateway shall be provided in the relay for interfacing with the instrument SCADA of PBS-II, PBS-I & BPTG Station.

SCADA/PLC interfacing shall be as per TS and all networking equipment required for the completeness of the integration of the proposed SCADA with the above systems shall be in the scope of the Contractor.

Separate printers (Laser) shall be provided for both the stations.

Wherever signal is to be duplicated for hooking upto two different systems (DDCMIS & SCADA) Signal Multiplier (Optical/Galvanic Isolator) may be considered.

Furniture required to mount work station for SCADA including provision for operator chairs on the basis of one for each station in the new electrical

control room of PBS-II (Six chairs & six tables with sufficient drawers for storing documents for MMIs and generator protection Terminal)

19. The entire Contractor's equipment at BPTG station shall be hooked up with their BPTG station PLC/DCS as well as to the PLC / DCS at power and blowing station for complete control, monitoring, sequencing, metering and protections monitoring including alarm and annunciations. The Contractor in all their equipment at BPTG station shall make the necessary arrangement for the same. All cabling including terminations at both ends are included in the scope of the Contractor.
20. Two nos. DCDBs for generator control and protection as well as for HT/LT substation requirement for PBS-2 & CWPB areas. These DCDBs shall be fed from the DC system of Boiler Pkg-01A. Necessary cabling from the Employer's switchboard to the DCDB shall be considered in the scope of the Contractor.
21. One set DC System including battery, charger, DCDB, etc for BPTG station.
22. PDBs- Power supply to UPS, Battery chargers, illumination, etc shall be fed from PDB. A separate PDB shall be provided for crane, welding sockets, etc.
23. UPS system complete in all respects individually one set each for TG building, BPTG System and Cooling water control system.
24. UPS Distribution boards.
25. HT & LT motors including DC motors and actuators.
26. Motorized control/isolation valves with manual operating handles.
27. HT & LT power and control cabling including their termination at both ends and jointing/termination materials.
28. Signal and instrumentation cables, special cables, screened cables, fire optic cables, etc including their termination at both ends (supply as well as laying & termination shall be under Contractor's scope).
29. Cable trestle, supporting structures, conduits, prefabricated GI cable trays, cable racks, other associated accessories like cable glands, lugs, termination/jointing kits, ferrules, clamps including trefoil clamps for single core cables, cable markers, cable identification tags, and all other hardware material as per requirement.
30. Supply, laying of cables and termination at both the ends of all interconnecting power, control, signaling and instrumentation cables etc between Contractor's own equipment and between Contractor's equipment and Employer's equipment for all incoming power supplies etc. to make their system complete in all respect along with others

36. Local Push button stations.
37. Islanding and load shedding system shall be provided for grid islanding due to grid disturbances and load shedding shall be planned due to unbalanced of load requirement and generation during generator in islanding mode. Philosophy for the same shall be finalized during detail engineering.
38. Welding sockets, Power receptacles, etc.
39. Monorail arrangement for handling Transformers in Transformer Rooms.
40. Monorail for HT/LT motors and canopy over outdoor HT/LT motors.
41. Complete illumination of Power and Blowing station-TG building, extended Switchgear building, CWPH area and BPTG plant, Plant road and area illumination, etc and all other areas within limit with sufficient numbers of LDBs /SLDBs.  
Lighting fixtures of electrical rooms shall be industrial, energy efficient fluorescent type with electronic chokes. Control room shall have energy efficient CFL type lamps.
42. All erection materials, required during erection of generator and auxiliaries and all types of electrical equipment under Contractor's scope.
43. DC starter panels for DC motors.
44. HT Soft starters.
45. Complete electrics of material handling equipment like cranes, lifts, hoists, etc.
46. Complete electrics of air-conditioning and ventilation systems in all the premises under battery limit.
47. Water drainage pumps in required numbers with complete electrics including source feeders, pumps/motors, cable laying, etc.
48. Fire protection system including Fire Detection and Alarm System for the complete plant, etc.
49. One no. each of Thermo-vision camera, DC earth fault locator- Model Grouser fault finder, 300V DC.
50. Safety items.
51. Training courses for the Employer's personnel/Engineers to acquire necessary expertise in operation and maintenance of the Plant & Equipment of the electrical system for atleast for 120 mandays at works.
52. Complete relay coordination including relay setting calculations for all relays for complete Generation and Power Distribution system at various

voltage levels (415V, 6.9kV, 6.6 kV, 11 kV) are under the scope of the Contractor. Necessary system study if required to be conducted by the Contractor.

Contractor shall furnish unit rates of cables (Power, Control etc.) for Interconnection of 6.9kV cable from MSDS-1 to PBS-II & Reserve Supply (6.6kV) of various voltage grades and sizes for any addition / deletion in quantity during detail engineering stage.

Unit rate of cables shall be inclusive of supply, laying, cable trench, support structures, cable trays, cable accessories etc. Addition / deletion based on unit rate shall be applicable to cables only.

#### 02.04 **Installation, Testing and Commissioning**

The scope of the Contractor shall also include the following:

- Erection, testing, commissioning including transportation of all equipment and material which are in the scope of supply of Contractor.
- Supervision of erection, testing and commissioning of TG set their controls including electrics shall be by representatives of respective equipment manufacturer.
- Necessary coordination work required for erection, testing & commissioning and resolving problems of all equipment.
- Installation & testing of cabling system, including cable, trays/supports etc.
- Laying and termination of all interconnecting cabling required for completeness and commissioning of the plant.

#### 02.05 **Scope of Miscellaneous Activities**

Following miscellaneous works shall also be included in the scope of Contractor;

- Obtaining certificate from Chief Electrical Inspectorate of the state and CEA for installation and energising the complete electrical system and equipment covered under the package.
- Any modification or additional requirements by Statutory Authorities shall have to be carried out without time and cost implication to the Employer.
- Arranging any other statutory approval, if required.
- The Contractor shall provide and install GI cable trays as required for laying all cables under his scope of supply along with 30% spare trays for future use.
- For construction power supply, 415V source (single source/multi source) shall be provided by the Employer as per requirement within a distance of 200 meters. Contractor shall have to make their own arrangement for feeding to various load centers. This shall include required power and control cables, and breakers, etc.

#### 02.06 **Electrical system design criteria**

## General

The design, manufacture, assembly and testing as well as performance of the equipment shall conform to the relevant IS specifications (latest revision) and other relevant standards.

In case the Contractor is not in a position to comply fully with certain IS specifications, or in respect of certain items for which there are no IS specifications, the Contractor may base his proposals on IEC/BS/VDE/DIN recommendations or other reputed national or international standards subject to the approval of the Employer.

All equipment supplied and all work done including system design and detailed engineering shall also comply with the statutory requirements of the Government of India and the State Government.

All transformers shall be designed for short circuit withstand time for 5 secs. Suitable calculations for the same shall be furnished during detail engineering. However Type test certificates for 2 seconds shall be furnished.

All the Distribution transformers shall be of dry type. Technical specification of AN Transformer (Dry type) shall be as per GTS. All dry type (AN) transformers shall be located indoors.

PMCC / PCC incomers and Buscoupler connected to 2 MVA and 1 MVA transformers shall be of 4000A and 2000A respectively.

All PMCCs /PCCs shall be connected to Distribution Transformers through LT Busducts. The ratings of the bus ducts connected to 2 MVA and 1 MVA transformers shall be of 4000A and 2000A respectively.

Aluminum enclosure shall be provided for rating equal to or more than 3000A. MS enclosure may be provided for LT busducts of rating less than 3000A.

Busduct of 3000A and above rating shall be interleaved type. The minimum thickness of enclosure material shall be 2.5 mm.

Also Final Vector Group shall be decided during detail engineering.

All protections and CTs shall be provided as per the SLD. However, the same is tentative and the same shall be finalized during detail engineering.

Bushing CTs on HV, LV and neutral bushings of transformers shall be provided and same shall be decided during engineering.

All HT switchboards, LT PMCCs / PCCs and MCCs shall have auto changeover arrangement along with facility for trip selection type manual transfer with momentary paralling of the incomers and buscoupler through check synchronizing relay and guard relay.

Panels of all HT switchboards, LT PMCCs / PCCs and MCCs shall be single front only.

All PTs in HT& LT switchboards including Generator PTs shall be withdrawable type.

All HT & LT breakers shall have spring charging motors of 240 V AC.

All HT & LT motors shall have class F insulation with permissible temperature rise limited to class B.

The drive motor shall have at least 15% margin over the maximum power requirement of the driven equipment as per TS.

HT motors less than 2.0MW, condition monitoring equipment (temperature monitoring, vibration monitoring, etc.) to be envisaged. For more than 2.0MW, condition monitoring equipment (temperature monitoring, vibration monitoring and partial discharge monitoring, etc.) to be provided.

All protective relays shall be draw-out type and multifunctional microprocessor based numerical type with communication system with SCADA at control room for complete control, monitoring, recording, settings etc.

MCCs & PDBs shall be draw-out type with two incomers and one buscoupler. The incomers and buscoupler of PDBs and MCCs shall have ACBs.

All intelligent MCC rooms shall be Air conditioned.

Each LT PMCC switchboard shall be provided with two nos. breaker handling truck for withdrawing the breakers from the switchboard.

And each MCC switchboard shall be provided with one no. breaker handling truck for withdrawing the breakers from the switchboard.

Ammeters shall be provided on all Switchboards / MCCs for drives as per the following.

- Drives rated 7.5 kW and below 30 kW with Ammeter and metering current transformer (CT) in middle phase only.
- Drives rated 30 kW and above with Ammeter and selector switch ie. with metering current transformers (CTs) in all the phases.

### **Climatic Conditions**

Electrical Equipment selection and derating shall generally be based on ambient temperature of 50°C. For specific hot areas the ambient temperature conditions shall be taken into consideration and equipment suitably derated where necessary. In hot areas of higher temperature conditions, the equipment shall be adequately protected against damage from radiant heat and hot air.

The equipment offered shall be suitable for smooth, efficient and trouble free service in the climate prevailing at site.

Where explosion hazard due to fuel gas/oil is present, dust proof and flame proof/ increased safety type apparatus shall be used. All such equipment shall be certified by recognized statutory authority as fit for use that in particular location.

### Standard Voltage levels

Following power utilization standard voltage levels shall be adopted for various systems:

1.	Generation voltage	11 kV, 3 phase, 3 wire, 50 Hz, Un-earthed.
2.	Evacuation & transmission voltage	6.9 kV, 3 phase, 3 wire, 50 Hz, Un-earthed. 11 kV, 3 phase, 3 wire, 50 Hz, Un-earthed.
3.	Auxiliary supply	6600 V, 3 phase, 3 wire, Un- earthed. 415 V, 3 phase, 4 wire, solidly earthed.
4.	A.C. drive motors	6600 V, 3 phase, 3 wire, non effective earthed. 415 V, 3 phase, 4 wire, solidly earthed.
5.	DC drive motors	220 V, 2 wire, unearthed D.C.
6.	Instrumentation & control including protection interlocking system	240 V, 1 phase, A.C. (from UPS)
7.	Control and protection of HT and LT switchgears including ACBs of MCCs.	220 V, 2 wire, unearthed D.C.
8.	Control and indication for MCC feeders (other than ACBs)	230 V, 1 phase, line & neutral (through control transformers)
9.	UPS	240 V, 1 phase, 2 wire
10.	Metering	110 V, AC, PT supply
11.	Plant illumination	240 V, 1 phase, line & neutral
12.	Emergency illumination	220 V, 2 wire, unearthed D.C.
13.	Panel lighting and space heaters	240 V, 1 phase, 2 wire, 50 Hz, A.C. with one point earthed
14.	DDCMIS/PLC power supply	240 V, 1 phase, 2 wire, 50 Hz, A.C. (UPS supply)
15.	Welding socket / power receptacles	415 V, 3 phase, 50 Hz, A.C. outlets. 240 V, 1 phase, 2 wire, 50 Hz, A.C. with one point earthed.
16.	Special socket outlets for portable lamps for maintenance	24 V, 1 phase, 2 wire, 50 Hz, A.C. through suitable transformers
17.	Sockets for electrical tools, etc.	240 V, 1 phase, 2 wire, 50 Hz, with one point earthed

### Permissible variations

The system/ unit/ plant/ equipment shall be designed suitably for following variation in voltage and frequency:



Also refer GTS clause no. 1.01.03.02.

	<b>Voltage</b>	<b>Freq.</b>
Permissible variation with rated performance and control effectiveness maintained	For LT system:- +10% & -15% For HT system:- +6% & -9%	For LT system: +6 % & -6%. For HT system: +4% & -6%.
Permissible variation for control and regulation equipment with rated performance and control quality maintained	$\pm 15 \%$	$\pm 6\%$
Permissible voltage dip at HT switchgear bus during starting of HT motor	- 10 %	-----
Permissible voltage dip at LT switchgear bus during starting of LT motor	- 15 %	-----

### Symmetrical short circuit ratings

The three phase symmetrical short circuit ratings of the switchgear at different voltage levels envisaged are as follows:

	<b>Breaking Capacity</b>	<b>Making Capacity</b>
11kV & 6.6 kV	40 kA	100 kA
6.9kV	50 kA	----
415 V	50 kA	105 kA
220 V DC	10 kA	-----

The rated short circuits withstand duration for 11 kV, 6.9kV & 6.6kV switchgears will be 3.0secs, whereas for 415 V switchgears including MCCs, it will be 1.0 sec.

### Criteria for selection of voltage levels for drive motors & provision of Soft Starters

AC motors of ratings up to 160 kW will be fed at 415 V, 3 phase 50 Hz. AC motors of ratings larger than 160 kW shall be connected to the 6.6 kV unearthed system.

All HT motors shall be provided with soft starters- VVVF drive with soft starter facility where energy saving is possible to be employed, where energy saving is not possible, FCMA type soft starter with Vacuum contactor as a bypass to be employed.

All LT motors shall be fed from the respective PMCC/MCCs. Feeders catering to motors from 90kW capacity to 30 KW shall be consisting of MCCB/MPCB, power contactor and motor controller with Soft starters and DOL bypass, whereas, motors of 90kW and above capacity will be fed through air circuit breakers

(ACBs) with Soft starters and DOL bypass. Comprehensive micro processor based Numeric motor protection relay shall be provided in these ACB feeders. Motor rated below 30 kW shall be provided with MCCB / MPCB, power contactor and motor controller.

Separate starter panels shall be provided for DC motors.

02.07

### **Electrical auxiliary power distribution & Evacuation scheme**

The existing plant has two levels of HT Switchgear, namely MSG-Main Switchgear(6.9kV) that caters to the emergency loads of the Steel Plant, while ASG Auxiliary switchgear(6.6kV) feeds to the Power plant auxiliary loads. The existing plant has 3 X 12MW STGs and 1X15 MW STG units at PBS-I and running synchronized with 3 nos Tielines connected to MSDS-I and feeding the existing emergency load of the Steel Plant at 6.9kV voltage level through the existing 6.9kV switchboards having Sections I, II, III, IV, V & VI. Adopting the same philosophy, the proposed plant at PBS-II shall have 1 X 25 MW STG unit which will be connected to new 6.9 kV switchgear Sections-VII & VIII at PBS-2 with an inter connection to the existing sections V & VI of PBS-I network and a Tie line-4 from MSDS-I. The additional emergency load of the steel plant arising due to 7MT expansion shall be fed from the new bus sections VII & VIII and the extended sections V & VI which are located at PBS-II. The auxiliary switchgear(ASG) shall also be fed by two nos. outgoing feeders of Section VII & VIII. In order to protect/feed the ASG in case of outage of MSG, a 6.6kV Reserve Board shall be provided in PBS-II switchgear room. This board shall be connected to MSDS-I with outgoing feeders connected to all the ASG boards namely, ASG of Boilers(01A pkg) and CWPH. Power distribution scheme of the same is illustrated in the drawings- MEC/11/E&I(PP)/9101-11B/ELE/01,02,03&4 rev.0 (enclosed along with this Tender Specifications).

Interconnections between MSDS-I and PBS-II-

- c. Tie-line-4- Interconnector between MSDS-I and PBS-II sections VII & VIII. Tie Line 4 from PBS-II shall terminate at Sec-IV-Cubicle 36 at MSDS-I. Contractor shall include in their scope – Replacement (if required)/Dismantling of existing CAS-2 feeder (Breaker and reactor) by new breaker and reactor. All the necessary additional protection for the Tie-line 4 feeder at MSDS-I is also in the scope of the Contractor. Further all the necessary cabling for the interconnection from MSDS-I Reactor panel to the incoming panel of Sections VII & VIII is in the scope of the Contractor.
- d. Reserve 6.6kV auxiliary feeder for PBS-II: This feeder shall feed the Reserve board located at PBS-II from MSDS-I 6.6kV Switchboard-Sec-IV cubicle 66(Breaker-1500A, existing reactor-600A, 6%). Contractor shall include in their scope the Up-gradation/dismantling of the existing reactor rating of which shall be based on the load envisaged for PBS-II and Boiler 7.

BPTG Generator shall be synchronized at BPTG end from BPTG control room. Adequate space in BPTG Building / Control Room for housing all above equipment shall be considered by the Contractor.

Start-up cum power evacuation interconnection shall be provided at the incoming terminals of the 11kV BPTG Switchgear

- a. One station auxiliary supply shall be provided by the customer. Necessary cabling from customer panel to Contractor's panel is in the scope of the Contractor. Distance of 200mts to be considered for the same.
- b. HT Power & Control Cables between 11kV switch gear panel to BPTG.
- c. LT Power and Control cables from Contractor's Generator Relay, Control & synchronizing system, 11kV switchgear, etc. to their BPTG generator CT & PT Panels, and other associated equipment as required.

All power, control cables along with their laying and termination at both the ends for the above interconnections including Cable trenches, cable trestles, cable support structures, cable trays, other accessories etc. in the BPTG area shall also to be included in the scope of the Contractor.

To feed the auxiliary loads of TG-4, namely the STG MCC and PDB for TG house, four nos. 1000A feeders shall be made available by the Employer from the nearby Boiler Substation(PMCC). Contractor's scope begins from the outgoing terminal of the Boiler PMCC board. The necessary cable laying and termination at both ends is in the scope of the Contractor.

The Circulating Water Pump House (CWPH) shall have a 6.6kV switchboard with three sections two of which shall be fed from the MSG sections VII & VIII. One section shall be fed from the reserve board located in the PBS-II area. To feed the LT auxiliary loads PMCC/MCCs of the CW pump house, two nos. 2MVA transformers shall be provided as per the SLDs enclosed DRG.No.MEC/11/E&I(PP)/9101-11B/ELE/02, rev.0 & DRG.No.MEC/11/E&I(PP)/9101-11B/ELE/04, rev 0.

The proposed BPTG station at CDCP area shall have 1 X 4 MW BPTG unit and it will be synchronized with the plant supply at 11kV. The power supply scheme shall be as per the enclosed SLD DRG.No.MEC/11/E&I(PP)/9101-11B/ELE/03. The auxiliary loads –PMCC, DCDB, etc., of the BPTG station shall be fed from the BPTG HT switch board through distribution transformer as per the SLD enclosed.

Contractor shall note that the following:

- a. Distance between MSDS-I and PBS-II is 700mtr approximately. Two feeders, namely Tie-Line 4 and the Reserve supply feeder shall be routed along this distance. The cables shall be routed through underground Hume pipes at the road crossing near PBS-II, further shall be routed through underground cable trench upto the CAS-IV area after which the cables shall be laid on the existing cable gallery bridging CAS-IV to MSDS-I. The tentative cable route from MSDS-I to PBS-II is indicated in the enclosed drawing no. MEC/11/E&I(PP)/9101-01B/ELE/09, rev 00.
- b. Distance between PBS I & PBS II is 500mtr approximately. Two extension feeders namely Extensions of Section V & Section VI shall be laid along this distance. For the major part of this distance, Contractor shall use the upcoming cable gallery(pkg 01A) for laying the cables. However, for the remaining distance Contractor shall lay the cables underground and Terminate at the extended Switchgear

building. The tentative cable route from PBS-I to PBS-II is indicated in the OVERALL GENERAL LAYOUT DRAWING.

03.00

### PERFORMANCE REQUIREMENT AND GUARANTEE

The Contractor shall study the specification and satisfy himself thoroughly regarding the workability of the plant, equipment and systems offered and also take full responsibility for the guaranteed operation and performance of the same as well as for their smooth, safe and reliable working.

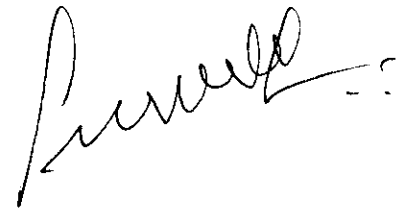
All equipment shall be guaranteed for workmanship, materials design and satisfactory performance to the parameters in accordance with the specification document and relevant clauses of the General Conditions of Contract. The guarantee for performance shall cover individual items and systems for their ratings/outputs.

Contractor shall also guarantee the integrated operation of all the systems and equipment covered in his scope as a whole including interfaces required to be established with other related systems and equipment.

The supplier shall conduct performance/acceptance tests on each of the major items of equipment supplied to demonstrate that the equipment and system supplied are capable of achieving the performance parameters specified. The total system performance shall also be guaranteed and demonstrated.

Should the tests specified show that the unit has failed to achieve the guaranteed parameters, the supplier shall carry out necessary modifications or part replacements to achieve the guaranteed parameters and for successful demonstration the tests shall be repeated, without any cost implications to Employer.

Loading of the various systems and their performance shall be demonstrated to the maximum possible extent.



## 04.00 TECHNICAL SPECIFICATION

### 04.01 TECHNICAL SPECIFICATION FOR SYNCHRONOUS GENERATORS & ACCESSORIES

#### 04.01.01 Type

The synchronous generators shall be totally enclosed driven by the steam turbine at 1500 /3000 rpm.

The generator shall be three phase, four pole/two pole, cylindrical rotor, wye connected machine with phase and neutral terminals brought out for connection to bus duct.

#### 04.01.02 Rating

The generator shall have following technical parameters:

	STG	BPTG
1. Maximum Continuous Rating		
i. Active output	: 25 MW	4 MW
ii. Apparent output	: 31.25 MVA	5 MVA
2. Rated terminal voltage	: 11kV	11 kV
3. Rated power factor	: 0.8 (Lag)	0.8 (Lag)
4. Rated frequency	: 50 Hz $\pm$ 6 %	50 Hz $\pm$ 6 %
5. Phases	: 3	3
6. Phase connection	: Star	Star
7. Line terminals brought out	: 3	3
8. Neutral terminals brought out	: 3	3
9. Rated speed	: 1500/3000 RPM	1500/3000 RPM
10. Short circuit ratio	: $\geq 0.52$	$\geq 0.52$
11. Class of insulation (stator/rotor)	: F (Temp. rise limited to class B)	F (Temp. rise limited to class B)
12. Cooling for stator/rotor	: CACW cooled	CACW cooled
13. Type of generator earthing	: Un-Earthed	Un-Earthed

The generator parameters listed above shall be guaranteed on the basis of continuous operation without exceeding the temperature limits listed below.

#### 04.01.03 Insulation and Temperature Limits

The generator stator and rotor windings inclusive of main and neutral leads shall be provided with Class F insulation but temperature rise shall be limited to class B.

The maximum permissible temperatures of different parts of the generator shall be as follows:

1. Stator Winding (By ETD)	: 120°C
2. Rotor Winding (By resistance)	: 115°C
3. Magnetic Cores (BY ETD)	: 120°C
4. Exciter (By ETD)	: 120°C

#### 04.01.04 System Operation

The turbine-generators will be connected to the MSDS Tie-lines/Plant Sub-stations. The generator shall be capable of operating alone or in parallel with existing generators and/or grid.

**04.01.05 Voltage & Frequency Variation**

The generator shall be capable of continuous operation at rated output and at rated power factor under any of the following conditions:

- a. Terminal voltage variation  $\pm 10\%$  of the rated value
- b. Frequency variation of  $-5\%$  to  $3\%$  of the rated value
- c. Absolute sum of combined voltage and frequency variation of  $\pm 10\%$

**04.01.06 3 - Phase Short Circuit withstand**

The generator shall also be capable of withstanding, without injury, a three phase short circuit at the terminals for there (3) seconds when operating at rated output and power factor, at 5% over voltage with fixed excitation.

**04.01.07 Capacity with one Cooler out of Service**

In the event of one cooler being out of service, and other cooler tubes 10 % choked, the generator shall be capable of carrying the rated load continuously, without the permissible temperature of the machine being exceeded. Four detectors, two each in water inlet and two in water outlet of each cooler are to be placed for temperature measurement of the Generator.

**04.01.08 Stator Housing**

The stator housing shall be of totally enclosed, having sufficient mechanical strength and rigidity deformation.

The housing shall have suitable provision for handling, lifting and/or jacking. Manholes with sealing arrangement shall be provided to facilitate inspection of terminals, internals etc.

All leads, including power, control and instrumentation cable shall be brought out of the generator housing through tight seals. Fire detectors are to be placed at appropriate positions of the stator housing.

**04.01.09 Stator core**

The stator core shall be fabricated out of CRGO/CRNGO sheet steel so that losses are minimum.

The core assembly and mounting arrangement shall be such that the transmission of the forced vibration of the core to the housing and foundation is effectively restricted.

The core assembly shall have adequate ventilation. Magnetic screens, if necessary shall be provided, to reduce the zone heating by leakage flux.

**04.01.10 Stator Winding**

The windings and all connections inclusive of phase and neutral leads shall be insulated for full voltage to ground.

In order to reduce the corona in the slot and where the stator bar leaves the stator core, a surface treatment corona grading system shall be applied which shall be carried into the end turn area.

Firm sitting of the stator bar in the slot shall be ensured by proper wedging fillers and refill springs (or as applicable). Adequate arrangement shall be provided for the slot wedges to compensate for any future shrinkages and ensure permanent firm seating of the bars in the slot during operation. The end turns shall be suitably braced and supported to withstand the forces during normal operation and sudden short circuit at generator terminals.

Semi conducting material treatment to be done for slot length of each bar to ensure that bar to slot discharges do not occur.

#### 04.01.11 **Terminal Connection**

All phase and neutral terminals shall be brought out from the bottom of the generator (non-driving end) and located in a non-magnetic steel terminal box. Phase terminal bushings shall be spaced to permit connection to isolated phase bus duct to provide complete phase isolation directly upto the generator housing. Adequate spacing shall be provided between phase and neutral bushings to permit connection of the neutral enclosure.

The bushing shall be high glass laminated fibre (HGL) type complete with silver plated terminal connectors.

#### 04.01.12 **Rotor**

The rotor shall be forged in one piece from alloy steel to ensure required mechanical strength and magnetic properties.

The forging shall be subjected to elaborate ultrasonic and mechanical tests to ensure freedom from any internal defect.

After assembly, the rotor shall be dynamically balanced and subject to 20% over speed for 2 minutes.

#### 04.01.13 **Rotor Winding**

Rotor winding shall be made of silver bearing solid copper conductors. Winding insulation shall correspond to Class-F, i.e. glass, mica nomex etc. with temperature limited to Class-B. Rotor winding shall be secured in the slots by suitable slot wedges and fillers. The overhung portion of rotor winding shall be held in position against centrifugal force by retaining rings.

The retaining rings shall be machined from high strength, non-magnetic alloy steel forging. The retaining rings shall be floating type, shrunk on rotor body and prevented from axial movement by snap rings/locknuts.

Suitable damper winding shall be provided on the rotor to permit increased asymmetrical electrical loading.

#### 04.01.14 **Bearing**

The generator shall be provided with journal bearings. The bearings shall be of split construction and forced lubricated from turbine oil system. Oil buffers shall be provided to prevent leakage of oil along the shaft.

Provision shall be made for hydraulic jacking of the shaft during start up and turning gear operation. Each bearing shall be provided with a well for thermometer in the return line and a sight glass with illumination to observe bearing oil flow.

Bearing shall be insulated from stator frame and foundation plate to prevent shaft current. Provision shall be made for bearing insulation measurement while the machine is in operation.

#### 04.01.15 **Fans**

Air shall be circulated in the generator in closed circuit by the axial fans located on rotor shaft at either end. The fans shall be shrunk on to their seats on the rotor shaft and locked against tangential or axial movement.

#### 04.01.16 **Temperature Measurement**

Embedded temperature detectors, resistance or thermocouple type shall be built into the machine for measurement of temperatures of various active parts, bearings and cooling medium etc. The minimum requirements are listed below. Twelve (12) detectors, uniformly distributed around stator, located between insulated coil sides in stator slots.

- Twelve (12) detectors, for stator core located in the end zones.
- Two(2) nos detectors in the rotor.
- One (1) detector in the Exciter.
- One (1) detector in air entering and one (1) in air leaving each cooler.
- One (1) detector in water inlet and one (1) in water outlet of each cooler
- Stator frame temperature detectors for 80°C & 100°C at both ends.

Two (2) detectors each generator bearings located on the lower bearing sleeve. All temperature detector leads shall be brought out to a terminal box suitably located on the outside of the generator frame for easy access. The leads shall be suitably fastened to the frame to prevent movement and shielded against stray field.

However, in case of design constraints, an indirect method may be adopted for the rotor temp. measurement

In addition to the ETD's, temperature switches shall be provided as required for alarm interlocks.

All the above temperature detectors shall be Duplex type.

#### 04.01.17 **Generator Excitation System**



**a) Type**

The excitation system shall be brushless type system to meet the performance requirements specified hereinafter.

**b) Performance Requirements**

The excitation system shall have sufficient reserve and redundancy to permit effective utilisation of generator capability over the entire operating range and under all service condition without any restriction.

The system shall function without hunting and shall be capable of preventing any abnormal change or oscillation in the generator voltage.

The system shall have high initial response to improve steady state and dynamic stability of the generator.

The excitation system shall be capable of maintaining generator voltage within  $\pm 0.5\%$  of the preset value over the entire load range of the machine.

The reference voltage set point shall be adjustable over a range of 85 to 110% of the nominal rated voltage under all load conditions.

The rated current and voltage of the excitation system shall be 110% of the machine excitation requirements at rated output. The ceiling voltage shall not be less than 150% of the machine excitation voltage.

The system shall be capable of supplying the field forcing requirement for at least 30 seconds in both AUTO & MANUAL Load.

The nominal exciter response ratio shall not be less than 2.

The static excitation system shall be designed with necessary provision for field forcing to be possible even for close-in faults.

Monitoring facilities to indicate faulty cards & abnormality shall be available.

The manufacturer of exciter is required to perform O.C, S.C and over speed balancing and H.V tests. Voltage ceiling of main exciter to be 1000 V.

**c) System Components**

The system shall comprise the following major components;

- PMG and main exciter
- Converter bridge
- Digital Automatic voltage regulator
- Field suppression system
- Metering and supervising equipment
- All required accessories

**Converter bridge**

100% standby converters bridge shall be provided along with a converter bridge monitor device.

The converter comprises fully controlled, 3 phase, full wave thyristors bridges (air cooled). The thyristors shall be electrically protected by ultra-high speed fuses and shall have individual fault indication. Arrangements shall be such that it is possible to change the thyristors or its fuse while the machine is in operation.

### **Automatic Voltage Regulator**

The automatic voltage regulator shall be of micro processor based digital type, high speed, continuous acting solid-state design. The regulator shall be responsive to average of 3-phase voltages. The regulator shall be separate auto-manual channel type with a follow-up circuit to ensure smooth transition from one mode of operation to the other.

The following features/ functions shall be incorporated in the regulator:

- Cross current compensation
- Slip stabilization
- Load angle limiter
- Stator current limiter
- Rotor current limiter
- Volt/Hz. ratio controller.

AVR shall be as per TS with two auto and two manual channels.

AVR shall be digital, thyristors controlled dual channel with associated equipment having open architecture type data interface with DDCMIS

### **Field Suppression System**

This comprises essentially a two-pole field breaker and non-linear field discharge resistor. A crow bar comprising two anti-parallel thyristors groups shall be included as additional over voltage protection.

#### **04.01.18 Generator cooling system**

Contractor shall include complete generator cooling systems including all associated equipment like piping, valves, air to water coolers, instruments, etc in his tender. Complete status and annunciations including all critical parameters shall be available in the control room in DDCMIS.

04.01.19 100%, 75%, 50% load imposition and load throw behavior of each Generators running in isolation or in group shall be furnished. Necessary system study if required shall be conducted by the Contractor.

#### **04.02 GENERATOR CONTROL EQUIPMENT**

##### **04.02.01 Generator Current Transformer**

To provide protection and metering for generator, suitable current transformers shall be provided in the separate panels after generator bushings. Separate cores of CTs shall be used for differential protection, over current protection and measurement purposes. CTs shall be bar primary type. Generally the measurement CTs shall have accuracy class as 0.2 whereas protection class shall be 5P20 and for differential CTs the class shall be PS. The knee point characteristics of differential CTs shall be matched with the relays. The technical parameters are elaborated below:

Type	:	Epoxy cast resin
No. of cores	:	As per requirement
Power frequency withstand voltage	:	As per IS
Impulse withstand voltage	:	As per IS

Short time rating of CTs shall be 3 secs.

04.02.02

### Generator Voltage Transformer

To provide power supply for metering, synchronization, AVR and protection purposes voltage transformer shall be provided. These will be connected after the generator outgoing terminals. VTs shall be of dry type cast resin design mounted in separate panels. High voltage side of VTs shall have fuses shall have fuses with fuse monitoring relays on low voltage side. Low voltage star winding shall have all three phases and neutral connections brought out to terminals. Accuracy class of this shall be 0.2. The technical parameters shall be as follows:

Rated continuous voltage	:	11 kV
Ratio	:	$\frac{11}{\sqrt{3}} / \frac{0.11}{\sqrt{3}} / \frac{0.11}{\sqrt{3}} \text{ kV}$
Burden	:	As per requirement-minimum 100 VA
Power frequency withstand voltage	:	As applicable for generator current trafo.
Impulse withstand voltage	:	As applicable for generator current trafo.
Over voltage factor	:	1.9 for eight hours.

04.02.03

### Surge Protection Equipment

The surge protection cubicle shall comprise of surge diverter and protective capacitor on each phase to protect the generator from the effect of transient over voltages. Surge protection equipment and VTs as described above shall be mounted in dust proof isolated phase compartment with provision for entry of main bus tap off into the compartments.

Protective capacitors shall be single pole units i.e. one per phase, non inflammable synthetic liquid impregnated type connected between each phase terminals and ground. Each capacitor shall be provided with a built in discharge resistor to drain the residual charge after being de-energized.

Surge diverters shall be of station class type and shall be of design specifically meant for protection of rotating machines, other salient particulars of surge diverters should be chosen in accordance with relevant IS-3070, Part-I, 1974.

## TECHNICAL PARTICULARS

### Surge diverter/Lightning Arrestor

1. Type	:	Station class
2. Service	:	Indoor
3. Rated voltage	:	15 kV (rms)
4. Nominal discharge current	:	10 kA
5. No. of surge arrestor per phase	:	One
6. Built in discharge resistor	:	Provided
5. Power frequency dry withstand test voltage	:	As per IS

### Surge Capacitor

1. Type	:	Single pole, non-inflammable
2. Service	:	Indoor
3. Rated Voltage (maximum)	:	12 kV
4. Capacitance to earth	:	0.25 $\mu$ F
5. No. of capacitor per phase	:	One

## 04.02.04

### GENERATOR BUS DUCT

The specifications of the above 6.9kV HT busducts shall be inline with that of Generator Bus-duct given below except for the Voltage rating that shall be read as 6.9kV and the insulation level that shall be 7.2kV.

## ELECTRICAL DESIGN

### Electric power supply

Rated voltage shall be 11 kV, 3 phase, 50 Hz which is non-effective grounded.

### Insulation level

Rated insulation voltage shall be 12 kV for 11KV busduct. One minute power frequency voltage shall be 28 kV. Peak impulse test withstand voltage -75kV.

### Short circuit strength

Rated short time withstand current not less than the system short circuit level specified for 3 sec. Rated peak withstand current not less than 2.1 times the system short circuit level.

### Rated current

Rated continuous current as specified while in enclosure and at specified ambient 50°C temperature with maximum temperature of bus bars limited to 85°C.

Neutral bus in LT with rating not less than half the rating of phase bus.

### **GENERAL ARRANGEMENT**

1. Generator busduct shall be phase segregated with tubular/ rectangular shaped enclosure. Enclosure shall be continuous type.
2. Comprising of following sections, as applicable, to make the installation complete and to match with the terminal equipment :
  - Generator lead-in section with flexible hood and links.
  - Straight section in standard length.
  - Matching section (length as required).
  - Generator transformer lead-in section with flexible links
  - Corner sections (horizontal and vertical)
  - Phase cross-over section (If required to match phase sequence of the board).
  - Link section.
3. Silica gel breathers at appropriate locations.
4. Space heaters and power supply arrangement for the space heaters
5. Earthing of busducts with continuous run of conductors
6. Generator neutral bus duct along with all the generator CTs, LAPT and all associated accessories, etc

### **CONSTRUCTION DETAILS**

1. Degree of protection for enclosure IP 52 or better inside machine hall/substations and IP 55 for semi-outdoor and outdoor installation.
2. Enclosure material: Aluminium of minimum thickness 3 mm. Contractor shall include enclosure with the thickness required for the shape and mechanical/ electrical strength point of view.
3. Maximum temperature of enclosure under rated operating conditions limited to 70°C
4. Bolted covers with gaskets for easy inspection and access to insulators and bus bar joints.
5. Rubber bellows at transformer end to take care of vibration (Flange on which rubber bellow shall be seated shall seam welded to avoid ingress of water into the transformer).
6. Hinged and gasketed inspection access cover at suitable intervals.
7. Seal off bushings and frames complete with bolts
8. Provision for draining moisture.
9. Provision for mounting on brackets.

10. Supply of GI supporting structures with necessary hardwares. Supporting structures shall be fabricated from standard steel sections and shall be hot dipped galvanised after fabrication.
11. Supporting structures shall cater to various static and dynamic loading such as weight of the bus duct, short circuit forces, wind load and seismic forces. Problem of induced magnetic heating and circulating current shall be avoided in isolated busducts.
12. For termination at generator end, suitable seal off bushings shall be provided, if required for air cooled generators.
13. Necessary supporting foundation including civil works to be provided

#### **Surface treatment**

Two coats of epoxy paint for outdoor and synthetic enamel paint for indoor application, preceded by de-rusting, cleaning chemically, degreasing, pickling in acid, cold rinsing, phosphating, passivating and spraying with two coats of zinc oxide primer.

#### **Shade of paint**

Interior : Black/white/light yellow

Exterior : Light grey shade 631 of IS - 5  
1978 (unless otherwise specified) and further stoved.

#### **BUSBARS AND CONNECTIONS**

1. Material Generator Busduct conductor shall be of Copper with Aluminium Enclosure of 3mm thick. Min. continuous rating of generator busducts --- 2000A.
2. Final operating temperature of both bus bars and joints under continuous operation in enclosure limited to 85°C by thermometer method.
3. Bus bar arrangement as per IS 5578 (1991).
4. Phase identification by colour at ends and at regular intervals.
5. Busbars shall be of welded construction.
6. Copper flexible busbars surface shall be tinned
7. Contact surfaces shall be silver plated.
8. Flexible connections for termination on equipment.
9. Expansion joints on straight runs with joints staggered in adjacent phases.
10. Bimetallic joints for jointing between dissimilar metals.

11. Busbar conductors shall be given coat of black mat.
12. Busbar support insulators of non-hygroscopic material having high impact and di-electric strength with an anti-tracking contour.
13. Enclosures shall be connected to each other by low resistance path adequate to carry rated current of the busbar at both ends.

### PROTECTIVE EARTHING

1. Aluminium earth bus of size 50 x 10 mm running throughout the length of the busduct, positively connected to the body of the busduct.
2. Provision at each end of busduct for terminating external earth conductor.

### INSULATORS

In isolated bus ducts, the magnitude of the short circuit forces expected on the bus conductors is calculated with pen bus arrangement (without enclosures). The type of insulators shall be selected in such a way that load on insulators shall be within it's safe strength with adequate factor of safety.

### HOT AIR BLOWING

Hot air blowing system/ adequate no. of Space heaters shall be provided for generator busducts. Complete system including all the equipment and associated electrical power supply arrangement shall be provided by the Contractor.

### TECHNICAL PARTICULARS OF GENERATOR BUSDUCTS

1.	Applicable Standard	IS : 8084
2.	Rated system voltage and frequency	11/6.9 kV, 50 Hz
3.	System earthing	Non effectively earthed
4.	System short-circuit level, kA (rms)	40 kA (for 3 sec)
5.	Type of busduct	Phase Segregated (Indoor+outdoor)
6.	Maximum voltage at which the busduct can operate continuously	12 kV/7.2kV
7.	Busbar material – Conductor Busbar Encloser	Copper Aluminium Sheet( 3 mm. min.)
8.	Busduct support structure required	To be provided
9.	Rated continuous current	3150A/2000A/630A.
11.	Rated short time withstand duration	3 secs
12.	Insulation level	
a)	Rated Voltage	11 kV
b)	Rated insulation voltage	12 kV
c)	Insulation class	
d)	One min. dry power frequency withstand voltage	As required/applicable
e)	Impulse withstand voltage	As required/applicable
13.	Supporting insulator	
a)	Type	Porcelain

b)	Max. distance between supports	To be worked out based on short circuit calculation
14.	Earth Bus	
a)	Material	Al
b)	Size	As per requirement
15.	Enclosure	
a)	Type	Continuous
b)	Degree of Protection	IP 52/IP55
c)	Material of Enclosure	Al
d)	Thickness	3 mm min.
16.	Accessories	
a)	Seal-off bushings	As per requirement
b)	Silica gel breather	To be provided

Length of the busduct shall be calculated by the Contractor based on approved layout and location of the generators and generator transformers.

Generator bus duct shall be suitable for air and water tightness test as per IS: 8084

Rating, type and detailed technical particulars of the generator neutral bus duct shall be as per requirement and as per standards prevailing.

#### 04.03 PROTECTION SYSTEM

The protection required for all the generators has been listed below. Selection of protective scheme will be based mainly on reliability (main & standby), sensitivity and selectivity. All main protections shall be fast acting type in order to clear the faulty system from the healthy system in earliest possible time to minimise damage to equipment and ensure continuity of power supply, if possible. Contractor shall suitably design tripping system covering different protection under different classes of tripping of generator and turbine.

Generator protection relays (GPR) shall be composite multifunctional microprocessor based numerical type with communication facilities with SCADA / DCS at control room. Each generator (STG and BPTG) shall be provided with two nos. GPRs connected in parallel in main and standby configuration. A separate protection panel shall be provided for relays.

The details of major protections are elaborated below.

##### Generator Protection

- Generator differential protection
- Generator stator earth fault protection
- Generator field winding earth fault protection
- Generator negative sequence protection
- Generator low forward power protection
- Generator reverse power protection
- Loss of excitation protection
- Generator pole slipping protection
- Generator under frequency protection
- Generator over-voltage protection



- Generator backup impedance protection
- Generator stator over-current protection
- Generator VT fuse failure protection
- Generator field over voltage protection
- Over fluxing protection

All the protection necessary for Generator transformer as per the SLD no DRG.No.MEC/11/E&I(PP)/9101-01/ELE/5, rev 0 are included in the scope of the Contractor.

#### 04.04 ELECTRICAL INPUTS/OUTPUTS OF DDCMIS

Contractor shall consider all the electrical inputs/outputs for DDCMIS. The transducers shall be mounted in the switchgears or in separate panels.

Required transducers and wirings to hook up analog and digital inputs and outputs shall be included in the scope of the Contractor.

Actual number of inputs/outputs to/from DDCMIS shall be finalized during detailed engineering stage.

#### 04.05 TECHNICAL SPECIFICATION FOR GENERATOR CONTROL, MIMIC & ANNUNCIATION DESK

Separate following generator control, mimic cum annunciation desk shall be provided for controlling, monitoring and annunciation.

- One at PBS-2 for TG-4, MSDS Tie-Line-4, inter connectors and sectionalizers.
- One at BPTG area for BPTG and one no. Tie line with the existing network of CDCP area.

The main purpose of the control desk is as follows:

- Synchronization and on/off of 11kV and 6.9 kV breakers for in Auto/Manual/Dead bus /Off mode.
- Control of generator excitation system including AVR.
- Indications of circuit breaker position (ON/OFF) by semaphore as well as LED lamps. Circuit breaker other status like trip/trip circuit healthy/breaker readiness/spring charge etc. Shall be through LED lamps.
- Generators and Feeders metering.
- Fault annunciation for generators, excitation system etc.
- Temperature scanner for generators.
- Monitoring and annunciation of generator transformer.
- Load controller for export of power (MW and MVar) to grid.

List of Equipment to be mounted on Generator Control Desk of each of the Generators. *(This list is tentative only and shall be finalised during detail engineering stage).*

For Generator Exciter field:

- Ammeter for Exciter field; analog type.
- Voltmeter for Exciter field; analog type

- Null voltmeter; analog type.
- Ammeter Generator field; analog type.
- Voltmeter analog type.
- Selector switch for voltmeter.
- 3 position bkr. Control switch. Trip-Neutral Close for exciter field circuit breakers.
- Exciter field circuit bkr. ON/OFF indication lamps.
- Speed raise / speed lower Push buttons.
- Excitation ON/OFF, illuminated push buttons.
- AVR Auto regulation ON, illuminated push buttons.
- AMR manual regulation ON, illuminated push button.
- AVR Auto ref. Raise- Push button.
- AVR Auto ref. Lower- Push button.
- AVR manual ref. Raise, Push button.
- AVR manual ref. Lower, Push button.
- AVR Auto Ref. Maximum, lamps.
- AVR Auto Ref. Minimum lamps.
- AVR manual Ref. Maximum, lamps.
- AVR manual Ref. Minimum, lamps.

For Generator/ MSDS Tie-Line/ Interconnectors feeder Metering Instruments.

- Ammeters for generator line current in R, Y, B phases; analog type.
- Voltmeter for generator line voltage, analog type, range -0-12 kV.
- PT phase selector switch for generator voltmeter dial engraved OFF-RY-YB-BR.
- Megawatt meter; analog type
- MegaVar meter; analog type,
- MVA meter; analog type,
- Power factor meter; analog type, range : 0.5 lag-1-0.5 each
- Generator frequency meter, analog type range; 45-50-55 Hz.
- Solid state multi function poly vector energy meter.
- Line frequency monitor transducer operated.
- Summation meter.

For Circuit breaker control/indication

- CB open lamp
- CB close lamp.
- CB trip ckt. Healthy lamp.
- CB auto trip lamp.
- 4 Position lockable synchronising selector switch (off/Auto-Dead bus Manual)
- 3 Position Breaker Control Switch Trip – Neutral-close.
- Semaphore Indicator for bkr. Position.

For Isolator control/indication

- Open lamp
- Close lamp.
- Open/ Close Switch.
- Semaphore Indicator for Isolator Position.

For Synchronising equipment.

- Double voltmeter – 144 mm<sup>2</sup> AC moving iron.

- Double frequency meter – 144 mm<sup>2</sup> vibrating reed type.
- Synchronoscope – 144 mm<sup>2</sup>
- Synchronising selector switch, 3 position, Auto-off-manual.
- Check synchronising relay (static/Microprocessor type).
- Guard relay for check synchronising relay.
- Synchronoscope cut off switches (ON/OFF).
- Reversing PT for bright lamp Synchronising.
- Indication lamp for check syn. Relay permissive.
- Synchronising lamp- white.
- Other aux. Equipment.

#### Other System for each generator

- IG-541 release into Generator, lamps.
- IG-541 supply indication.
- IG-541 Panel under test, lamps.
- Emergency trip Push buttons.
- Temperature scanner.
- Indicating lamp test Push buttons.
- Annunciation with accept, Reset, lamp test, first up reset push buttons.
- Auto synchronizer along with control multiplication relays.
- Load Controller.
- Watch (analog type).

#### Constructional Features for Protection Panel as well as Control Desk

- Control desk shall be upright, floor mounted and dead front and made of cold rolled sheet steel thickness 2.5 mm. It shall be provided with 75 mm base channel & 15 mm anti vibration pad.
- Will have bottom cable entry Double compression cable glands, lugs and gland plates.
- Provided with space heater and interior illumination lamp with switches.
- Anodised aluminium inscription plate both at back and front side of size to enable a person to read from 5 meter shall be provided.
- Painted after proper degreasing, pickling and chemical phosphatising.
- Lamp test facility to test all indicating lamps of the panel simultaneously.
- Earth bus securely fixed. 50 x 6 Aluminium ground bus for all panels
- Control desk will have mosaic type construction for both the horizontal and vertical plan and for relay panel rack type construction shall also be acceptable.
- The side rack and file cabinet shall be CRC sheet-20 gauge with front transparent lockable glass door. Inside shelves shall be tapered partitioned and shall be of RITTAL make or equivalent.

### **Wiring**

- Wired with 1100 volt grade multi-stranded copper wire PVC insulation having area 2.5 mm<sup>2</sup>. The CT & PT wiring shall be done with colour coded wires.
- Wire shall not be joined or tied between the terminal points. All wire termination shall be made with insulated sleeved crimping type lugs.
- No bunch will contain more than 12 wires.
- Wire end shall be fitted with moisture and oil resistant insulating material having glass finish with identification number clearly engraved in black.

### **Terminal Blocks**

- Stud type terminal blocks vertically mounted.
- Stud type terminal blocks shall be provided with brass studs of not less than 6 mm in diameter.
- In each terminal block 20% spare terminals shall be provided.
- CT terminal shall be suitable to terminate 4 mm<sup>2</sup> cable and shall be link type to facilitate shorting of CT wires during testing etc.

### **Control Supply**

- The control voltage shall be 220V DC
- For switching off supply disconnecting devices with auxiliary contacts for indication of control supply.
- One number 240 V single phase 5 A point in all panels for testing purpose.
- AC supply shall have single feeder
- DC supply shall have duplicate feeders

### **Mimic**

- Mimic diagram shall present comprehensive picture of the process/single line diagram, to denote different voltages.
- Mimic shall be painted on metal strip having thickness not less than 10 mm. The mimic representation, colour and size of diagram are subject to approval.

### **Annunciators**

- Static type alarm annunciators as described under control scheme chapter shall be provided in common aux. panel, charger panels, compressor panels etc.

## Technical Particulars

a) Panel	:	Sheet steel 2.5 mm thick
b) Enclosure	:	IP 54
c) Extendable feature	:	Yes
d) Illumination with door switch	:	Yes
e) Provision of cable glands	:	Yes
f) Inscription	:	Both sides-front and rear
g) Control supply	:	220 V DC
h) Signaling bus isolation	:	ON/OFF switch (stay put type)
i) Signaling supply isolation	:	By switch
j) Base channel provision	:	Yes
k) Control buses	:	As per circuit requirement
l) Relays	:	All relays shall be of microprocessor based Generator management type with self diagnostic feature and communication facilities at control room along with necessary PCs and software.
- Protective relays	:	Draw-out type
- Auxiliary relays	:	Non-draw-out
m) Hand reset contact with mechanical flag	:	Yes
- Master trip relay	:	Yes
- Auxiliary relays	:	As per circuit requirement.
n) 5 kV test on relays	:	Yes
o) Instrument size	:	96 mm <sup>2</sup>
p) Provision of test block for CT and PT circuit	:	Yes
q) PT secondary voltage	:	110 V
r) CT secondary current	:	1A

## Transducers

Various transducers (4-20 mA range) shall be provided either in separate transducer panels or mounted in control panels to facilitate remote monitoring of the parameters and to hook up with DCS system. All transducer shall be of duplex type.

## Specification of Items

### Indication lamps

- Shall be panel mounted with rear terminal connection
- Shall withstand 120% of rated voltage on continuous basis.
- Bulbs and lenses shall be replaceable from the front.
- Shall be LED type, with low voltage glow protection.

### **Semaphore indicators**

- Shall rotate  $\pm 45$  deg. on energisation.
- Shall be mounted in such a way that it forms part of mimic.
- Shall withstand 120% of rated voltage on continuous basis.

### **Control switches**

- Shall have four position viz. Trip, Close, Neutral after trip and neutral after close.
- Type of operation handles of switches shall be spring return pistol grip type.
- All switches shall be provided with inscription labels.
- All switches shall have a rating 10A/500V.
- Switches shall be dust protected, heavy duty switch board type
- Contacts shall be silver surfaced

### **Relays**

- Shall be contained in dust and moisture proof cases.
- Protective relays shall be draw-out type.
- All timers, under voltage frequency and differential relays shall be microprocessor based numerical type.
- Close/trip circuit supervision relays shall be suitable for connection in series with close and trip coil of breaker and trip supervision relay shall be suitable for monitoring the healthiness of tripping circuit on both breaker open and close conditions.
- All protective relays shall have provision for testing. The facilities provided shall be specifically stated in the offer.
- DC relays shall be suitable for operation between 70-110% of rated voltage.
- All protective relays, trip and timer relays, shall be provided with external hand reset positive action operation indicators with inscription.
- All protective relays which do not have built in hand reset operation indicators shall have additional aux. relays with operation indicators, for this purpose.
- All protective aux. and timer relays except lockout and interlocking relays shall be provided with self reset type of contacts.
- Short time delays in terms of milliseconds may be obtained by using copper slugs on aux. relays. Time delay in terms of milliseconds obtained by external capacitor resistor combination is not preferred.

- Tripping shall be initiated always by energisation of relays.

### **Meters and Recorders**

- Indicating meters shall be of 96 sq.mm size.
- Indicating meters shall have accuracy class of 1.0 or better.
- Shall withstand 120% of rated current continuously and 10 times rated current for 0.5 sec.
- Shall withstand 120% rated voltage for 0.5 sec. without loss of accuracy.
- MVAR meter shall have zero in the center of the scale. Watt hour and Var hour meters shall be of three phase, two element type shall be draw-out type and suitable for flush mounting.
- Separate 3 phase 4 wire type test blocks shall be provided for testing of energy meter without disturbing the CT-PT secondary connection.
- Recorders and summation meters etc. shall be supplied as a composite unit including transducers etc. so that same can be connected directly to CT PT circuits.
- All meters and recorders shall be enclosed in dust proof, moisture resistant black finished cases and shall be suitable for tropical use and flush mounting.
- Shall have means of calibration checking and adjustment at site.
- Shall be suitable for connection with instrument transformers having technical particulars given in single line diagram.
- Shall have reverse running stops.
- Shall be compensated for temperature errors.
- Shall be calibrated to read directly primary quantities without any multiplying factor.
- Multiplying factor if unavoidable shall be multiple of 10 and shall be subject to Employer's approval.
- Shall have sensitivity of 0.5%.
- Energy meters for unit aux. and excitation transformer and generator shall be digital type with 0.5 acc. class.

### **Alarm Annunciation**

- Shall be of static type with first in & first out arrangement.
- Shall be suitable to work on 220V DC
- All important parameters shall be annunciated

- Warning and emergency points shall be as per the list approved during detail engineering stage. In general all tripping points and alarm points of transformer, battery system, UPS system, etc. shall be annunciated.
- Test, accept and reset facilities (with push button) shall be provided on each panel.
- Test facilities include simultaneous testing of audio-visual indications.
- Shall be normally from one DC supply with manual changeover facility from one to another shall be provided on failure of one.
- Suitable audio - visual indication shall be provided on DC failure. Audio alarm with reset facility shall be provided. Visual indication shall be panel-wise.
- Spare annunciation points shall be wired upto terminal blocks. 20% spare facia shall be provided.
- Each point shall have two bunch LEDs in parallel.
- The cover plate of facia shall be flush with panel.
- Shall be capable to receive simultaneous signals.
- Shall be capable to receive signal during testing mode.
- Contractor shall ensure the non-appearance of spurious signals due to the influence of external electromagnetic/electro static interferences on the annunciation wiring, and switching disturbances from neighboring circuits within the panels.
- Scope of supply includes all interconnections, bell hooter, buzzer, alarm facility, push button etc. required to achieve complete function of above scheme.
- Sequence shall be as follows:
 

	Visual	Audio
On occurring of fault	Lamp flashing	ON
On accepting	Lamp steady ON	OFF
On reset	OFF	OFF
On test	Lamp flashing	ON
- All electrical annunciations connected with generator, generator systems and unit system shall be displayed in generator desk in line with turbine desks.

04.06

## GENERATOR TRANSFORMER

### Design

Design shall be generally as per IS 2026. Transformer shall be suitable for rated frequency 50 Hz, -5%, +5%. Insulation level shall be designed according to the voltages specified below.



Nominal system voltage =>	6.6 kV	11 kV
1. Max. system voltage (kV)	: 7.2	12
2. One minute power frequency withstand voltage (kV)	: 20	28
3. Peak impulse test withstand voltage (kV)	: 60	75

Transformers shall be capable of delivering rated current at an applied voltage up to 105% rated voltage without exceeding the temperature limits specified below. Overload capacity shall be as per IS 6600. Transformers shall be operable at its rated capacity at any voltage within  $\pm 10\%$  of rated voltage of the particular tap.

Permissible maximum temperature at rated output and principal tap over an ambient temperature of 50°C.

▪ Top oil (by thermometer)	:	45°C
▪ Windings (by resistance method)	:	50°C
▪ Maximum Hot spot temperature	:	55°C

Transformers shall be designed to withstand the thermal and dynamic stresses due to short circuits at its terminals. Unless otherwise specified the duration of short circuit shall be 5 seconds.

Disconnecting chamber at the cable and bus duct terminal box shall be provided.

Magnetic Circuit shall be made of low loss CRGO silicon steel shall be used. Laminations shall be annealed in a non-oxidising atmosphere to relieve stresses and restore the original magnetic properties of CRGO sheets after the cutting and punching operations.

Flux density at normal over voltage or frequency shall be such that under 10% over voltage condition it shall not exceed 1.6 tesla.

OLTC shall be provided with AVR and LDC in Auto mode.

Frequency response analysis shall be done on each of the Transformer during routine testing.

Over voltage capability of the transformers shall be as per IS and shall match with the connected equipment.

### Windings

Material shall be electrolytic grade work hardened copper of high proof stress with more numbers of radial supports. Completed core and winding shall be vacuum dried in full vacuum and impregnated immediately.

Insulating materials shall be compatible with transformer liquid under all service conditions. Leads to the terminal board and bushings shall be rigidly supported.

### Insulation

Interturn and inter coil insulation shall be designed such that dielectric stress is uniformly distributed throughout the windings under all operating conditions.

### **Tank**

Fully assembled transformer with its radiators, conservator and other fittings shall withstand for one hour a pressure corresponding to twice the normal head of liquid or to the normal pressure plus 35 KN/sq. m, whichever is lower, measured at the base of the tank. Tank shall be provided with inspection opening and cover/with handling equipment) to provide access to bushing connections. Form of cover shall be such as to prevent any stagnant water deposit and to drain gas bubbles towards the buchholz relay. Tank shall be capable of withstanding of 600 mm of mercury.

### **Conservator and Breather**

Conservator mounted on frame, integral with tank in such a manner that under all conditions and the lowest oil level the bushings remain under the head of liquid. Conservator volume shall be sufficient to maintain oil seal from ambient to oil temp. of 90°C.

Silica gel breather with inspection window and oil level shall be mounted at 1.4 m from ground level and connected to conservator.

Prismatic type oil level gauge shall be provided with max. and min. levels marked on it. Tap and valves shall not be fitted to oil gauge. 150 mm diameter dial type magnetic level gauge with alarm and trip contacts shall also be provided.

Breather shall be connected with rubber bellow inside the conservator tank for expansion and contraction of oil.

### **Buchholz Relay**

Buchholz relays shall be double float relay as per IS 3677. Shut off valves shall be provided on either sides of the buchholz relay.

Potential free, self reset independent alarm and trip contacts rated to make, break and carry 2 amps at 220 V DC shall be provided. No auxiliary relay shall be used to multiply the contacts. Contacts are to be wired to the marshalling box.

### **Cooling**

The cooling system provided shall be as per the data sheet.

Radiators shall be detachable type directly mounted and shall have flexible earthing arrangement. Bolted, gasketed and flanged connections shall be used for connecting the radiators to the tank.

Additional spare radiator fins shall be provided along with isolation valves.

The following accessories shall be provided for each radiator/radiator bank.

- Top and bottom shut off valves and blanking plates
- Bottom drain plug and top filling plug, air release plug

- Lifting lugs
- Neutral bushing CTs
- Thermometer pockets with thermometers in the inlet and outlet pipes (for separately mounted radiator banks).
- Top and bottom filter valves for each separately mounted radiator bank.
- Pressure reducing devices with alarm and trip .
- Air release devices
- Earthing arrangement
- Bi-directional rollers/rails
- Rail for transportation with provision for extension for HT station transformer
- Spare radiator fins along with isolation valves
- Any other accessories required.

### **Valves and connections**

Valves shall be of sluice type with hand wheels. They shall be made of gun metal and shall be provided with padlocking facility to lock in closed/open position, blanking plates or screwed plugs and clear indication of open and closed position.

### **Terminations**

It shall be possible to withdraw the transformer easily after disconnecting the connections without disturbing the OH line/cable/busduct terminations. For cable termination, air insulated cable box shall be provided which shall be suitable for the type and number of cables specified. Cable end box shall be self-supporting. For OH line termination, proper bushing shall be provided. For bus duct termination, proper matching flange arrangement shall be provided.

### **Bushings**

Bushing shall conform to IS 3347 and 2099. Clamps and fittings shall be made of steel or malleable iron shall be hot dip galvanized. Neutral bushings shall be provided as required for earthing of neutral point. All the HT bushings shall be provided with suitable connectors and clamps.

Minimum rated current of line bushings shall be 1.5 times rated current of the corresponding windings. Bushing rated 400A and above shall have non-magnetic clamps and fittings only.

Creepage distance for the bushing shall not be less than 25.4mm/kV of the higher system voltage.

### **Bushing Current Transformers**

Bushing CT shall be removable at site without opening transformer tank cover/active part. Secondary leads of 4mm<sup>2</sup> shall be brought to a weatherproof terminal box and from there to the marshalling box. The bushing CT shall be provided as per the SLD.

### **Oil temperature Indicator (OTI) / Winding Temperature Indicator (WTI)**

Digital display type thermometer shall be provided with alarm and trip settings, manual reset and maximum reading display. There shall also be two independent potential free contacts for alarm and trip signals.

### **Marshalling box**

All outgoing connections from the transformer i.e. buchholz relay, temp. indicators, level indicators, CT secondary, alarm contacts for annunciations, etc. shall be wired to a marshalling box. Degree of protection of enclosure shall be IP 55 class.

All other standard fittings and accessories like name plate, first fill of oil as per IS - 335 with 10% excess in drums, cooling system complete with accessories including detachable radiators, drain and sampling devices, air release device, lifting lugs, conservator with sump, drain valve and detachable end plate, dehydrating breather, etc shall be provided along with the transformer.

In addition, contractor shall supply all the accessories like bidirectional rollers, radiators, etc so as to complete the transformer in all respect.

Contractor shall also provide dedicated remote tap changer control panel for all the transformers with all indications, control, annunciations, etc.

### **On Load Tap Changer**

- A. Electrical Design
  - Generally as per IS 8468
  - Automatic motor operated, resistive transition impedance type.
  - Tap changer shall change the effective transformation ratio without providing phase displacement.
  - The tap changer shall have the same rating as the associated transformer with respect to rated current, rated voltage, no. of phases, insulation level, over loading capability and short circuit withstand capacity.
  - No. of steps and rated step voltage shall be as per Technical Particulars.
  - Shall be suitable for connection to line end of neutral and of the winding as specified.
  - DC control supply voltage shall be 220V DC.
- B. General Arrangement
  - Diverter switch contacts shall be housed in a separate oil chamber not communicating with the oil in the main tank of the transformer.
  - The oil used shall be transformer oil conforming to IS 355.
  - The OLTC oil chamber shall have oil filling and drain plug, relief vent and glass window for seeing the level. A oil surge relay (hand reset type) also shall be fitted, the outlet of which shall be connected to a separate conservation.
  - A mechanical tap position indicator shall be provided locally.
  - A mechanical operation counter shall be provided to indicate the number of operations completed.
  - The main contacts, switching contacts and transition contacts shall be of copper with maximum temperature rise of contacts at 150% of rated current of transformer limited to 20° C.

C. Control Features.

- The OLTC shall have the following control regimes,

- a) Local manual operation
- b) Local electrical operation
- c) Remote electrical operation through RTCC.
- d) Fully automatic operation through AVR.

- In manual regime, the OLTC shall be operable by a person standing at ground level. The electrical operation shall be inhibited automatically once manual operation is restored to.
- For electrical operation, a suitable 3 phase, 415V AC motor and associated starter with thermal O/L relays, fuses, etc. shall be provided.
- The manual electrical operation, either local or remote shall cause one tap movement only. The control switch is to be returned to the OFF position between successive operations.
- Once a switching sequence has started, it shall always be completed. The tap changer shall not stop in an intermediate position even in the event of control power failure.
- Mechanical stop shall be provided to prevent overrunning beyond the extreme tap positions. An electrical interlock through limit switches shall also be provided to cut off power for electrical operation.
- A reverse tap change signal during an operation shall be ignored till the mechanisms comes to rest and resets the circuit for a fresh operation.
- Emergency stopping provision shall be provided both at the local and remote control panels.
- An indication 'tap change in progress' shall be available at the remote control panel.
- Power and control circuit of motor shall be inter-locked.
- If control is set to 'automatic', it shall not be possible to operate the OLTC by manual electric or hand operating gear.

D. Local OLTC Control Cabinet

- Dust vermin and weather proof outdoor type with lockable door.
- Shall house the drive motor for OLTC, starter, local control equipment, indicators for tap position, counters, etc.

E. List of accessories for OLTC.

- Operation counter
- Local tap position indicator
- Conservator
- Dehydrating breather
- Drain plug and oil filling plug
- Local OLTC control cubicle

**Technical requirement of Power transformer**

1. Rated capacity	:	36 MVA
2. Cooling	:	ONAN
3. Voltage HV/LV	:	11kV / 6.9 kV
4. Duty	:	Outdoor
5. Specification to be complied with	:	IS 2026
6. Winding connection	:	Delta/ Delta
7. Vector group	:	Dd0
8. Termination	:	HV : Bus duct

		LV : Bus duct
9. Tap changer	:	OLTC ( 17 steps)
10. Impedance	:	12.5 %
11. Withstand time without injury for 3 ph. short ckt	:	5 secs
12. Overload capacity	:	As per IS
13. Radiator	:	Detachable
14. Transformer Losses		
No load losses	:	To be indicated by the Contractor
Load losses	:	To be indicated by the Contractor.

#### **04.07 11kV, 6.9kV & 6.6kV MAIN SWITCHBOARD/ EXTENSION PANELS, REACTOR & ISOLATOR PANELS AND 6.6 KV AUXILIARY SWITCH BOARDS**

##### **04.07.01 Constructional and other features**

The switchgear shall be of metal clad single bus bar for 11kV, 6.9 & 6.6 kV switchgear, self standing, dust proof construction, indoor cubicle type fitted with vacuum/SF6 circuit breakers, in fully draw out execution. Degree of protection shall be IP4X. The breakers shall be floor operated.

The circuit breakers shall be suitable for following duties:

- i) To withstand in rush magnetizing currents of transformers.
- ii) To withstand switching off over voltages caused due to break of lightly loaded low capacity cage type induction motors. It shall also withstand DOL starting of motors with large starting time, and repeated starting like one hot start and two successive cold starts.
- iii) Transients surge produced by one CB due to severe chopping during rapid interruption of inductive currents, e.g, motors, shall be within the limits allowable for overhauled motors according to IEC34 pt. 1 for that suitable surge absorber shall be provided.
- The controls, indicating lamps, relays and meters shall be mounted on breaker cubicle itself.
- All circuit breaker cubicles shall have maintenance facility at outgoing cable chamber, bus bar chamber, and access to line CTs by opening the rear end of each breaker cubicles (11, 6.6 & 6.9kV).
- Operation counter, close/open mechanical indications spring charged/discharged indication shall be provided.
- All circuit breakers shall have motor operated spring charged independent closing and shunt tripping from 220V DC. Closing coil shall be suitable to operate between 85-110% of voltage and tripping coil between 60-110% of rated voltage. Spring charging motor shall operate between 80-110%.
- All breakers cubicle shall have a 24V socket for maintenance.
- A manually operated device to enable charging of closing springs.

- All circuit breaker trucks shall have service, test and draw out positions. Test position shall engage only the auxiliary (control) contacts to close the CB during testing.
- Anti pumping features shall be provided.
- All live parts shall be insulated by tapping supported by suitably designed insulators. Proper insulation of bus bars upper and lower contacts of breakers, vacuum bottles (for VCB) and sealing of opening of bushings shall be provided to eliminate accidental contacts. Switchboard bus-bars shall be tapped by proper grade of insulating tape.
- Each cubicle shall have mimic diagram with metal strip.
- All VCB's of 11 KV, 6.9 KV & 6.6 KV sections inclusive of auxiliary switch gear sections (Pkg -011-01A) to have jaw type contracts for incoming Bus & breaker poles.
- Each cubicle shall be of compartmentalized construction and shall have separate compartments for bus-bars, CTs and outgoing cables, metering protection devices.
- All circuit breaker trucks of same rating shall be identical in all respects (except metering and protective devices) and shall be interchangeable with similar breaker panel.
- Continuous earth bus shall be provided throughout the board.
- Auto Bus Transfer (ABT) scheme shall be provided for HT substations using single microprocessor based unit capable of communicating with SCADA. ABT logic shall be as per Sec19 at page 43/206 of GTS Chapter-3.

04.07.02

#### **Auxiliary buses for control & protection**

- Buses shall be formed by Copper wire looping.
- Control supply buses for AC and DC
- Signaling supply
- PT secondary voltage
- Under voltage bus-1 for tripping of motors not meant for automatic restarting
- Separate buses shall be provided for control, indication and metering.

04.07.03

#### **Provision of surge suppressor**

- In case of breakers that give rise to over-voltage surges due to current chopping phenomenon, surge suppressors to be provided at the load side terminals of the breakers to limit the switching surges to value limited for as per IEC.
- Surge suppressors shall be provided for all HT VCB motor feeders.

04.07.04

#### **Annunciation scheme**

- Flag indications for all faults for which individual protective relays have been specified.
- 'Warning' signalling (as applicable) on individual panels :
  - a) All transformer warning/signaling conditions (group signal from corresponding transformer control panel/substation)
  - b) Loss of trip circuit supply
  - c) Earth-fault
  - d) Control supply failure
  - e) PT fuse failure/MCB tripping
- 'Emergency' signaling for tripping of HT breakers on fault
- One common signal for warning and one signal for emergency from each panel to be wired to a common annunciation panel of the switchboard, where specified.
- Annunciators for warning and emergency signalling conditions on individual panels of solid state facia window type. Common audio signalling with Accept, 'Reset' and 'Test' push buttons for the switchboard where common annunciation panel not specified. Audio signalling shall have distinct tones for 'warning' and 'emergency'.

04.07.05

#### **Busbar and connections**

- Power buses of high conductivity electrolytic grade Copper as per IS 613-1984. Bus bar shall be tinned at the joints.
- Control and auxiliary buses of electrolytic grade copper
- The continuous rating of the main horizontal bus not less than the rating of the incomer specified, where not specified, the rating to be selected for at least 125% of the maximum demand of the switchboard taking into account spare feeders.
- The vertical bus rating:
 

For incomer	:	Not less than that of horizontal bus
For outgoing	:	not less than that of the outgoing breaker,
- Final operating temperature under continuous operation in enclosure limited to 90° C by thermometer method.



- Cross section of main horizontal bus to be uniform throughout the switchboard and continuous in one transport unit.
- Bus bar arrangement as per IS-11353 - 1985, IS-5578 - 1985.
- Phase identification by colour in each panel.
- Bus-bar joints and tap off connections of bolted type with zinc bi-chromated high tensile steel bolts, nuts and spring washers, fish plates with accessories at the end of a transport unit for site connections.
- Busbar support insulators of non-hygroscopic material having high impact and dielectric strength with an anti tracking contour-preferably porcelain or cyclo-aliphatic type material.
- Busbar shall be insulated by Raychem sleeving with full voltage sleeving.

04.07.06

#### **Internal control wiring**

- Control wiring by 1100V grade PVC insulated, single core copper wire of minimum cross section 2.5 sq. mm
- Flexible wires protected against mechanical damage for wiring to door mounted devices.
- Wires identified at each and in accordance with schematic diagrams by interlocked type ferrules.
- Colour code for control wiring: AC - black ; DC - light grey
- All connections external to a feeder, all the auxiliary contacts of the HV breaker and at least 1 NO + 1 NC spare contacts of the relays, brought on to terminal blocks.
- Interconnection between panels of adjacent shipping sections to be brought out to a separate terminal block.
- Control wires shall be run in earthed metallic flexible conduits when laid in HV bus chamber.
- Not more than two connections on any one terminal.
- All tele-metering signals wired to terminal strips.

04.07.07

#### **External Terminations**

- Control Terminations
- 650V grade multi-way terminal blocks of non-tracking moulded plastic complete with insulated barriers, stud type terminals, washers, nuts and lock nuts and identification strips.

- Control terminals of minimum rating 10 amps and suitable to receive 2.5 sq. mm copper conductor.
- Terminal blocks in separate groups shall be provided for DCS, remote control panels, transformer marshalling boxes, local push button station etc.
- 20% spare terminals in each control terminal block.

#### 04.07.08 **Power Terminations**

- Suitable for accepting cable/bus trunking as specified.
- Sufficient space and support arrangement inside each panel to accommodate HT cable termination kits and sealing kits suitable for the type, size and number of cables to be terminated.
- Dummy panels to be provided adjacent to the switch panel, where the required number of cable terminations can not be accommodated in the cabling chamber of the main panel.
- Backup panels encompassing the control of critical drives of TGs, CWPH shall have the following provisions:
  - i. Start/stop Push buttons.
  - ii. 3 Position switch (L/R/A)
  - iii. Indication lamps.
  - iv. Alarm/hooter/buzzer
  - v. Ammeter.
- Where more than one cable has to be terminated per unit, the arrangement shall permit connection and disconnection of cables separately without disturbing other cables.
- Where specified, the following cable termination accessories, suitable for the type, size and number of cables to be terminated, to be supplied with the switchboard. :
  - Cable sockets with all HT terminals. (Socket set at such an angle that cable tails can be brought up for termination with minimum bending and setting.)
  - HT cable termination and sealing kits.
  - Double compression type, brass cable glands and crimping type tinned heavy duty copper lugs for HT, LT power and control cables.

#### 04.07.09 **Current Transformers**

- Separate sets of current transformers shall be used for differential protection, over current protection and measurement purposes.
- Pilot wire protection for the feeders of 6.9kV Switchgear shall consist of relays at both ends along with interconnecting cabling between them.

However, the remote side pilot relay shall be loose supplied by the Contractor for monitoring in the remote end breaker.

- Short time rating and insulation levels of CTs shall be similar to the rating of associated breakers.
- CT ratios specified are provisional. Where outputs and accuracies are not specified, these shall be such as may be required by the circuits in which they are used. Generally the protection CTs and metering CTs shall have 10P15 and 1.0 class respectively.
- CTs shall be window/bar primary type
- CTs shall have shorting link on secondary side to facilitate insertion of meters on secondary side without opening CT circuits.
- All protections and CTs shall be provided as per the SLDs. However, the same is tentative and the same shall be finalized during detail engineering.

#### 04.07.10 Voltage Transformers

- Voltage transformers shall be provided in incomer panel of the switchboard.
- High voltage side of VTs shall have fuses and low voltage side shall be provided with MCBs.
- Low voltage star winding shall have all three phase and neutral connections brought out to terminals and one phase shall be earthed.
- Insulation levels shall be similar to the rating of associated board.
- ACC class 1.0 shall be used.
- Shall be mounted on with-drawable truck.
- Preferred VA burden 100.

#### 04.07.11 Relays

- All relays shall be flush mounted in dust proof cases and shall be mounted on rear side of cubicle.
- ALL relays shall be Numerical type based on IEC-61850 communication protocol. The Numerical relay shall have protection, control and composite metering features including energy parameters like Voltage, current, pf, KW, KVAR, KVA, KWH, KVARH, KVAH also. with communication system with SCADA at control room for complete control, monitoring, recording, settings etc.
- All protective relays shall be draw-out type and micro processor based, IEC61850 Compliant, numerical type. Spare protective relays shall not be

provided except for generators. However, 20 % spare contacts shall be insured.

- All timers and protection relays shall have flag indicators.
- Master trip relay shall be hand reset type and shall have 3 NO and 3 NC contacts in addition to those required by the protection/control scheme.

#### 04.07.12 Indicating instruments

- **All indicating instruments shall conform to IS : 1248 - 1983 and IS - 2419 -1973.**
  - Shall be capable of withstanding system fault current taking account CT saturation.
  - Shall be back connected.
  - Shall be located in the upper part of the panel.
  - Shall have 144 sq. mm square flush case, non-reflecting bezels, clearly divided and indelibly marked scales, sharply out lined pointers and zero adjusting device. The scale shall span over 90°.
- The rated reading shall be marked in red.
- The full load reading of each ammeter shall occur at the most prominent part of the scale. The minimum scale reading shall not be more than 10%. Maximum reading shall be 15% full load for transformers panels and 600% full load for motor panels.

#### 04.07.13 Annunciators

- Solid state facia window type with white heat resistant plastic material, inscriptions, engraved in black.
- Lighting unit with dual LED lamps in parallel.
- Facia window and lighting unit in 'plug-in' type assembly.
- Control circuits of individual channels on glass epoxy coated plug in type PCBs in bin assembly, plug/sockets mechanically coded, to avoid wrong insertion.
- Fault ACCEPT, system RESET and TEST push buttons common for the system.
- Sequence of operation
- On incidence of fault - hooter ON, lamp FLASH
- On pressing ACCEPT PB - Hooter OFF, lamp STEADY

On pressing RESET PB LAMP OFF if fault has been cleared. Otherwise LAMP persists

#### 04.07.14 **Control Supply**

- Control supply buses shall run through the switchgear.
- Two DC feeders shall be taken in each board controlled by MCBs.
- In each panel for controlling of its DC supply MCCB shall be used.
- 240V AC supply shall be taken from a substation aux. board.
- Each section shall have separate feed with automatic changeover scheme.
- Each panel shall have one MCB for controlling its AC supply.
- Sub circuits shall be protected with HRC fuses.

#### 04.07.15 **Voltage Selection Circuit**

- Voltage selection circuit shall be formed to ensure that only one PT feeds the entire load of PT consumers. This shall be necessary to avoid paralleling of PTs, when more than one voltage source in 'ON'.

#### 04.07.16 **Earthing Devices**

- Either integral earthing switch or a separate earthing switch shall be provided to facilitate earthing of busbars and any feeder circuit.
- Earthing truck (if included) shall have PT and alarm provision.
- Rating of earthing device shall be in line with associated board.

#### 04.07.17 **Terminal Blocks**

- Stud type suitable to accommodate 2 cores of 2.5 mm<sup>2</sup> copper control cables.
- Size of terminals for bus wires - AC/DC incoming supplies shall be as per requirements.
- 20% spare terminals shall be provided in each panel.
- All terminals going out of the switchboard shall be brought to a separate terminal board marked 'External Connections'.

#### 04.07.18 **Small wiring and ferrules**

- All small wiring shall be carried out with 650 V grade single core cable having copper conductor, preferably stranded, of not less than 1.5 sq. mm cross section. However, wires going outside the switchboard shall have minimum 2.5 sq. mm cross section.

- Wiring across the hinges shall be through flexible cables.
- The wires shall be identified by numbered ferrules at each end, all in accordance with connection diagram.
- All ferrules shall be made of non-deteriorating materials.
- The ferrules shall be firmly located on each wire so that they cannot move freely on the wire.

#### 04.07.19 **Indicating Lamps**

- **LED indication shall be provided. The lamps shall be LED industrial duty with low voltage glow protection.**

#### 04.07.20 **Control and selector switches**

- Control switches for circuit breaker ON/OFF control-3 position spring return to neutral with lost motion device and pistol grip handle.
- Other control and selector switches - stay put type with wing type knobs.
- Ammeter selector switches - 4 position, make before break
- Voltmeter selector switches - 4 or 7 position as required.
- Rating : continuous - 10 amps  
           AC       - 4 amps, 240V  
           DC 11   - 0.5A, 220V, L/R - 40 ms
- Colour : Black

#### 04.07.21 **Push Buttons**

- Rating : continuous   - 10 amps  
                           AC       - 1.5 amps, at 240V  
                           DC 11   - 0.5A, 220V, L/R - 40 ms
- Colour :       ACCEPT - BLUE  
                   RESET - BLACK  
                   TEST - YELLOW

#### 04.07.22 **Control Circuit Protection**

- Preferably with MCBs, alternatively HRC link type conforming to IS 9224.

#### 04.07.23 **Protective Earthing**

- Continuous earth bus of minimum size 50 x6 mm copper or equivalent aluminium/galvanised steel section, designed to carry the peak short circuit and short time fault current as specified.
- Provided at the bottom extending throughout the length of the board, bolted/brazed to the frame work of each panel, with an earthing terminal at each end, for terminal at each end for terminating external earth conductor.
- Vertical earth bus for earthing individual functional units.
- All non-current carrying metal work (including metallic cases of instruments and other panel mounted components) effectively bonded to the earth bus.
- Hinged doors earthed through flexible earthing braid.
- Looping of earth connection resulting in loss of earth connection to other devices when the loop is broken, not permitted.
- With-draw able units provided with self-aligning, spring loaded, silver plated copper, scrapping earth contacts, of make before/break after type, ensuring earth continuity from service to the test position.

#### 04.07.24 **Spare feeders**

- i) 1 no. Transformer and 1 no. ID fan feeders in each section.
- ii) 1 no. each of BFP, CWP (Blower), CWP (STG) in any section.
- iii) 1no. spare feeder of each type and rating for other additional feeder if any.

#### 04.07.25 **Test and maintenance equipment**

- Each board to be supplied with
- 1 set of test plugs
- Three earthing Truck ( 1 no. for Bus earthing & 2 nos. for Feeder earthing, if integral earth switch is not provided in the board.
- 1 common transport trolley for interchanging with-drawable units, height of the trolley lifting arm adjustable for raising/lowering the units.
- Any other special purpose tools for maintenance.

#### 04.07.26 **Technical particulars and design parameters**

##### a. **11 kV Main Switch Board**

- |    |                         |   |                       |
|----|-------------------------|---|-----------------------|
| 1. | Type                    | : | Indoor, metal clad.   |
| 2. | Enclosure               | : | IP-4X                 |
| 3. | Thickness of sheet for: | : | 2 mm for cold rolled  |
|    | Enclosure               |   | 2.5 mm for hot rolled |

4.	Paint	:	Shade RAL-7032: Powder Coated
5.	Nominal system voltage	:	11kV
6.	Highest system voltage	:	12kV
7.	No. of phases & frequency	:	3, 50 Hz, $\pm 6\%$
8.	Min Bus-bar current rating	:	630 Amps
7.	System earthing	:	Un - earthed
8.	Circuit breaker rating	:	
a)	Continuous current rating at 50°C(min.)	:	630 Amps for Main switch board
b)	Short circuit rating for 3 sec.	:	40 kA
c)	Dynamic system stability	:	100 kA
9.	Bus-bar rating	:	40KA (3 sec)
10.	Power frequency with-stand voltage	:	20 kV rms for 1 min.
11.	Impulse withstand voltage	:	60 kV
12.	Control voltage	:	220V/110V DC
13.	Termination	:	XLPE cables
14.	CT ratio	:	Secondary current 1A
15	PT ratio	:	1100    110    110
			----- / ----- / -----
			$\sqrt{3}$ $\sqrt{3}$ 3
16.	No. of aux. contacts for Employer's use.	:	4 NO & 4 NC.
17.	Aux CT for remote metering	:	All motor feeders to have Aux CT
18.	Details and type of feeders	:	As per requirement + customer requirement + minimum 20% spare.

**a. 6.9kV / 6.6 kV Aux Switch Board**

1.	Type	:	Indoor, metal clad.
2.	Enclosure	:	IP-4X
4.	Thickness of sheet for: Enclosure	:	2 mm for cold rolled 2.5 mm for hot rolled
5.	Nominal system voltage	:	6.9/6.6 kV
6.	Highest system voltage	:	7.2 kV
7.	No. of phases and frequency	:	3, 50 Hz, $\pm 6\%$
8.	Min Bus-bar current rating	:	3150 Amps for Main switch boards 2000 Amps for Aux. Switch board.
7.	System earthing	:	Un - earthed
8.	Circuit breaker rating	:	
a)	Continuous current rating at 50°C (min.)	:	As per SLD
b)	Short circuit rating for 3 sec.	:	50 kA for Main board(6.9kV)with $I_{dc}$ component of 28kA 40 kA for Auxiliary board(6.6)kV
c)	Dynamic system stability	:	125 kA
9.	Bus-bar rating	:	As per SLD
10.	Power frequency with-stand voltage	:	20 kV rms for 1 min.
11.	Impulse withstand voltage	:	60 kV



12.	Control voltage	:	220V DC
13.	Termination	:	XLPE cables
14.	CT ratio	:	Secondary current 1A
15.	PT ratio	:	6900    110    110
			----- / ----- / -----
			$\sqrt{3}$ $\sqrt{3}$ 3
			6600       110       110
			----- / ----- / -----
			$\sqrt{3}$ $\sqrt{3}$ 3
16.	No. of aux. contacts for Employer's use.	:	4 NO & 4 NC.
17.	Aux CT for remote metering	:	All motor feeders to have Aux CT
18.	Paint	:	Shade RAL-7032: Powder Coated
19.	Details and type of feeders	:	As per requirement + customer requirement + minimum 20% spare.

#### 04.07.27      **Metering and Protections**

Metering and protection philosophy is indicated in the respective single line diagrams enclosed with the specification- SLD no. DRG.No.MEC/11/E&I(PP)/9101-01B/ELE/01, rev.0. However the same are tentative and shall be finalized during detail engineering stage.

#### 04.07.28      **For DCS interfacing**

The control, metering and indications of all the 11kV, 6.9kV and 6.6 kV breakers / panels shall be carried out from the DCS.

Following digital/analog input/output to/from shall be provided for DCS hook up.

INCOMER	:	MW, MVAR, MVA I, V, ON/OFF/TRIPPED STATUS & AVAILABILITY OF BREAKER.
LINE PT	:	V. UNDERVOLTAGE
BUS PT	:	V. UNDERVOLTAGE, VOLTAGE AVAILABLE (R, Y, B)
OUTGOING	:	
a) Transformer	:	I, MW, ON/OFF/TRIPPED STATUS & AVAILABILITY OF BREAKER BUCH/OTI/WTI ALARM & TRIP POINTS
b) Motor	:	I, MW, ON/OFF/TRIPPED/ READY TO START STATUS
BUSCOUPLER	:	I, MW, ON/OFF/TRIPPED STATUS & AVAILABILITY OF BREAKER.

Adequate numbers of CT- PT outputs and potential free contacts including aux. relays and aux. CTs shall be provided for this purpose.

Total running hours for all the HT motors shall be made available in DDCMIS.

Local/remote section shall be realized in DDCMIS for all the HT motors and big critical LT motors.

Above list is for guidance purpose and shall be finalized during detailed engineering stage. Contractor shall include complete wiring from breaker contacts, contacts of aux. relays, and contacts of trip relays for all the HT/LT motor feeders to provide control & annunciation in DDCMIS as well as to control panels for TGs.

It shall be possible to know tripping of all the 11kV/ 6.6 kV feeders and status of voltage, frequency, current, etc. prior and just after the tripping. Scanning time shall be selected between 0 and 3 seconds. It shall also be possible to take a print out of above parameters and recording of disturbances. It shall be possible to generate report for weekly, monthly and yearly generation and shiftwise alarm/trip events with date and time display.

Required transducers and wirings to hook up all above analog and digital inputs and outputs shall be included in the scope of the Contractor.

Actual number of inputs/outputs to/from DDCMIS shall be finalised during detailed engineering stage. Transducers shall be of dual out put type.

#### 04.07.28 **Reactor**

This section covers the technical specification for current limiting type air core reactors.

The reactors shall be complete in all respects and any device / attachments/fittings not included in this specification but essential for proper operation of the equipment shall be deemed to be within the scope of the specification, even if not specifically mentioned in this TS.

#### **Standards**

The reactors covered under this TS shall comply to the specification IS:5553 (Pt.3), 1990.

All reactors shall also conform to the latest Indian Electricity Rules as regards safety, earthing and other essential provisions specified therein for installation and operation.

#### **Design Criteria**

The following power supply system shall be applicable:

6.9 kV + 6%, -9% AC, 3 phase 50 Hz  $\pm$  6%, UNEARTHED NEUTRAL system with 3 phase symmetrical fault level of 50 kA for 3 sec.

#### **Selection Criteria**

Design and selection of reactors shall be done taking into consideration the fact that the reactors are called upon to operate continuously and hence all facilities to simplify inspection, testing, maintenance, cleaning can be carried out at site without prolonged shutdowns.

The reactors shall be complete with approved safety devices wherever a potential hazard to personnel exists and with provision for safe access of personnel to and

around equipment for operational and maintenance functions. Design and selection shall include all reasonable precautions and provisions for the safety of operating and maintenance personnel.

## Design Parameters and Constructional Features

### Design Parameters

1. Type of reactor & mounting : 3 numbers single phase reactors mounted vertically one on the top of the other. Natural draft-air cooled, without magnetic core or shield and cast-in-concrete with suitable mounting on Porcelain insulators
2. Fault level : 50 kA (rms) for 3 sec
3. System earthing : UNEARTHED NEUTRAL
4. Rated voltage : 6.9 kV
5. Rated frequency : 50 Hz
6. Material of conductor : Copper
7. Insulation level : 27 kV (rms) / 60 kV (peak)
8. Insulating material : Class A insulating materials as specified in IS: 1271-1985
9. Electrical Characteristics:
 

a) Rated impedance	6%	8%	12%
b) Rated continuous current Amp	600	1000	1500
c) Duration of short circuit current	3 sec.	3 sec.	3 sec.
d) Maximum current density based on rms. Value of initial symmetrical component of through fault current	93 A/mm <sup>2</sup>	93 A/mm <sup>2</sup>	93 A/mm <sup>2</sup>
10. Quantity : As shown in enclosed SLD

The reactors shall be designed to withstand without injury the thermal and mechanical effects of the short circuits between phases or between phase and earth at the terminals of any winding with full voltage applied across the other winding. It shall be able to withstand the through fault current of the system for 3 seconds.

The air core reactors shall be sheet steel enclosed and mounted below the corresponding breaker panel and above the corresponding isolator panel on suitable supporting insulators similar to the existing reactors. The terminals shall be connected to the circuit breaker and isolator through suitable bus links supported on porcelain insulators.

The reactors shall operate with minimum noise and vibrations. The structural parts shall be properly constructed and windings shall be braced properly so that the mechanical vibrations are kept to minimum and thus reducing the noise. The reactors shall be designed for minimum no-load and load losses within the economic limit.

All electrical connections and contacts shall have sufficient sections for carrying the rated current without excessive heating.

### **Winding**

The coils shall be of copper electrolytic grade of high conductivity and of 99.9% purity.

The windings shall be designed to withstand the basic insulation level of the system.

Necessary thermistor sensing device shall be given for alarm and trip.

## **04.07A ELECTRICAL SCADA**

- .01 Separate SCADA for Electrical System shall be provided for Electrical power Distribution monitoring, annunciation & metering for all 6.9kV, 6.6kV, Transformers, PMCC, MCC and DBs including Battery charger, UPSDB at PBS-II TG area. The SCADA shall comprise of Numerical relays, Redundant Data Concentrators and Analog and digital input modules. The numerical relays of 6.9 kV switchgear at PBS-II & BPTG areas will communicate to the Ethernet switch individually on star topology with copper cables at their respective locations. These switches shall be connected on a ring network with fibre optic cables. Refer drawing no.MEC/11/E&I(PP)/9101-01B/ELE/07, rev. 00.

The numerical relays shall acquire the following signals from the respective feeders:

- CB ON, CB OFF, CB TRIP, Trip-circuit Healthy, Protection operated, etc.

The number of Numerical Relays connected to each switch shall be four (4). The switches to which the Numerical Relays are connected shall have 50% spare ports.

The analog parameters of HT feeders shall be acquired from MFMs on Modbus Protocol to the Redundant Data Concentrators. The Redundant Data Concentrators shall also acquire the following signals as hard-wired:

- Battery Voltage, current, Alarms from UPS, charger, etc.
- Transformer WTI, OTI, TPI, PRV and other related Alarms.
- Status, alarms, measurement & analog parameter data related to LT Switchgear shall be interfaced to RTU on soft/hardwired.

- .02 The electrical SCADA shall have the following HMI at PBS TG control room:
- a. Two rack mounted industrial grade servers (RDBMS cum ISBR server) in hot-standby mode,
  - b. Operator Work Station-1 nos.
  - c. One laptop for IED parameterization.
  - d. One laser B/W printer with both side printing facility.

- .03 The electrical parameters communicable from the Intelligent MCC located in the PBS TG premises shall also be communicating to the redundant Data Concentrators at PBS-II. Necessary I/O cards to be supplied by the Contractor.

- .04 The electrical SCADA shall be hooked up with the DCS (protocol shall be OPC) for acquiring process parameters like Transformer Winding Temperatures, currents of HT drives, etc.
- .05 Supply, laying and termination of two separate single mode FO cable (6 cores) for the electrical SCADA is in the scope of the Contractor.

All networking equipment required for the completeness of the integration of the SCADA system and provision for its hook up to the following shall be in the Contractor's scope of work.

- a. The upcoming SCADA for PBS-II Boiler pkg-011-01A. Configuration of the same for the interface activity is in the scope of the Contractor.
- b. Existing SCADA system (presently used for existing electrical system for Switch gear and generators). Necessary HMIs shall be provided at both the locations – PBS-I & PBS-II.
- c. TRT Generator relays (IEC 61850 compliant) located at the TRT building for hooking up all the parameters of TRT Generator at PBS-II.
- d. Provision shall also be made for hooking up the entire HT substation with the upcoming centralized SCADA system as well as a separate gateway shall be provided in the relay for interfacing with the instrument SCADA of PBS-II, PBS-I & BPTG Station. The interfacing job shall also be carried out by the Contractor.

For interfacing of the Electrical SCADA system with the Plant SCADA systems, Contractor shall have to:

- Provide the details regarding signals to be exchanged with their memory map during the detail engineering stage.
- Ensure the presence of the SCADA supplier during the commissioning stage for ascertaining the communication of intended data through the proposed interface.
- Check and prove the Integrated Data communication of the entire SCADA.

- .08 The electrical SCADA system shall be time synchronized with the GPS based master clock system being supplied for DCS of PBS area.
- .10 One nos. relay parameterization, Disturbance record PC shall be provided in Boiler control room. This Industrial PC dedicated to access any of the relays connected in the ring for Relay Data and shall have the following facilities:
- a. Downloading of all the setting parameters, configuration files, programming logics and graphical mimics.
  - b. Energy reports & relevant software development.
  - c. Password protected uploading of setting parameters, configuration files, programming logics and graphical mimics.
  - d. Downloading of all disturbance recordings, events and recorded fault parameters.
  - e. Selective resetting of all alarms in the relays.
  - f. All the inputs (necessary for control, protection, metering, indication and annunciation) from the 11kV, 6.9kV & 6.6kV Switchboards shall be hooked up to the Electrical SCADA system, except the motors feeders which shall be controlled from DCS. However, for all these motor feeders, the other inputs necessary for protection, metering, indication and annunciation shall be hooked up to the SCADA also.
  - g. In similar line, all the necessary inputs for control, protection, metering, indication and annunciation from the PMCC & MCC incomers and

buscouplers, PMCC outgoing feeders shall be hooked up with the Electrical SCADA.

- h. Outgoing feeders of Intelligent MCC- all the necessary inputs for control, protection, metering, indication and annunciation shall be hooked up with the DCS on suitable communication protocol.
- i. Relay/release parameterization at 11kV, 6.9kV & 6.6kV level and PMCC level shall be done from the Electrical SCADA HMI at the control room and parameterization of the intelligent controllers of the Intelligent MCC shall be done from the OWS connected to the DCS at the control room.

**04.08 Technical specifications for the following equipment/system shall be read inline with GTS**

- a) DISTRIBUTION TRANSFORMER-DRY TYPE (1MVA/ 2MVA, 6.6/0.433kV),
- b) LT BUSDUCTS(2000A/4000A),
- c) LT PCC,
- d) LT MOTOR CONTROL CENTRE(Intelligent type),
- e) HIGH VOLTAGE SQUIRREL CAGE INDUCTION MOTOR,
- f) LOW VOLTAGE SQUIRREL CAGE INDUCTION MOTOR,
- g) DC MOTORS,
- h) ACTUATORS,
- i) ILLUMINATION,
- j) EARTHING,
- k) LOCAL CONTROL CABINETS (LCC),
- l) JUNCTION BOXES, ETC.

**04.09 DC SYSTEM (BATTERY, BATTERY CHARGER AND DC DISTRIBUTION BOARD)**

**Scope and mode of operation**

Each DC system shall consist of the following:

- Battery set – 1 Sets.
- Two sets of Float Cum Boost Chargers (FCBC)
- DC distribution switchgear (1 set with 2 sections and two incomers.)
- All interconnecting cables/wiring with connection accessories and other required items to make the system complete.

DC system shall be parallel redundant with load sharing type.

DC system shall have spare capacity for blowers.

Battery back up time shall be 60 Minutes for DC motor loads and 4 hours for other loads.

Sizing of DC system shall be done as per the following. However, same shall be finalized during detail engineering.

- a) DC system for DC motor loads and emergency lighting of the plant.  
Contractor's own equipment load requirement plus 125% of their load for Employer's Blower equipments and over and above to these 30% spare capacity for future use.
- b) DC system for control and protection of the plant.

Contractor's own equipment load requirement plus 40% of their load for Employer's Blower equipments and over and above to these 30% spare capacity for future use.

Normally the chargers connected to the battery shall supply the DC load and also keep the battery under float charge. On failure of supply from charger, the battery shall be taken over without any interruption.

When the battery requires boost charging, the charger will operate on boost charge mode while the second battery will supply the DC load on float mode through changeover arrangement.

Interfacing of DC system with DDCMIS of the respective unit shall be done by the Contractor. Separate DDCMIS cards shall be provided in each of the chargers to convert output voltage and current into 4-20 mA current signal.

The DC distribution switchgear shall feed the power from the charger/battery to the various consumers of the plant.

### **Battery and accessories**

Nominal voltage is 220 V DC. The no. of cells shall be chosen accordingly. Battery cell shall be Plant Type. The discharge test of all the batteries at the rate of 10 hours to the end cell voltage 1.85V per cell as per IS shall be carried out by the Contractor at site.

Following accessories shall be supplied

- Battery stand
- Acid for first filling
- Cell testing voltmeter 3 - 0 - 3 volts complete with leads
- Cell booster for charging 1 to 5 cells
- Level indicator
- Copper cell connectors (5 nos.)
- Bridging clamps for cutting out individual cells in the event of defect
- First aid box
- Torque wrench

### **Battery Chargers**

Float cum boost chargers for each battery shall be comprising of the following;

- MCCB, line contactor and overload relay on the AC side
- 3 phase full wave semi-controlled rectifier bridge complete with free wheeling diode, high speed protection fuses and snubbers
- Dry type double wound rectifier transformer with copper conductor and class 'B' insulation
- Filter circuit at the output
- MCCB on DC side
- Control and protection circuits

The design of float cum boost chargers shall be identical such that they can be interchangeable.

DC Voltmeter range 0-160V shall also be provided with a selector switch to measure +/-earth and -/earth voltages.

In float mode, the charger operates with a constant voltage controller and the output voltage of the charger shall be maintained within  $\pm 1\%$  of the set voltage for  $\pm 10\%$  input AC voltage variation, or 0 - 100% load variation, or both occurring simultaneously. The output voltage required can be set externally through potentiometers in the range 90-120% steplessly.

In boost mode, the charger shall be suitable to operate in a constant current as well as constant voltage mode with manual selector arrangement, controller suitable for two-rate charging. The charging current shall be externally adjustable from 20 to 100% steplessly.

Provision of charging with manual control of output voltage shall also be provided. Electronic current limit, adjustable between 85-105% of rated current shall be provided. During boost charging, the charger shall be cut-off as soon as over voltage occurs. Ripple content in the charger's output voltage shall not exceed 0.5% in float mode and 3% in boost mode.

Provision shall be provided to isolate the battery from the chargers. MCB may be provided for this purpose.

The supply to the charger will be at 415V  $\pm 10\%$ , 50 Hz. Charger shall be suitable for frequency variation as per IS.

Charger shall have a separate over voltage relay with a variable setting from 100 % to 120 % in steps of 5 % of  $V_n$ .

### DC Distribution board

The DC distribution board shall have double bus bar(two sections) arrangement. The DCDB shall be provided with all the instruments, AC/DC meters, indicating lamps, relays and other accessories.

The following relays shall be provided:

- AC input supply to charger failure
- Earth fault
- Float bus over and under voltage
- Boost bus over voltage
- Boost over current for each charger circuit
- All relays shall be in drawout cases and with mechanical hand reset operation indicator.

Above relays shall be provided to detect fault in any of the feeders. A separate over voltage relay shall also be provided in DCDB. Over voltage setting of the O/V relays shall be variable type with range of 235 – 250 V.

Fault rating shall be of 25kA.

The following indications shall be provided.

- AC supply ON (for 3 phases separately) for each charger
- DC supply ON for charger
- Boost/float mode ON for charger
- Supply ON for each outgoing distribution feeder



Each outgoing circuit shall be connected to bus bars. Each outgoing circuit shall have MCCB. The no. of outgoing circuits shall be as per the requirement plus 10 nos. for Employer's use and 20 % spare.

The following measurement shall be provided;

- AC input voltage and current of each charger (through voltmeter/ammeter S/S)
- DC output voltage and current of each charger
- Battery charging/drain current of each charger with necessary shunt
- Battery trickle charging current (through amplifier)
- DC bus voltage (through selector switch) to measure between Positive to Earth, Negative to Earth & positive to negative.

DC voltage and DC current transducers (4-20 mA) shall also be provided as per requirement of the DC system.

Static type annunciation shall be provided for the following;

- AC supply failure to charger
- Battery earth fault (+ve & -ve separately)
- Float bus over/under voltage
- Boost bus over voltage
- Boost over current for each charger
- Failure of thyristor/diodes for each charger
- Failure of blocking diode
- Output MCCB open for each charger
- Battery MCCB open
- Battery room exhaust fan OFF
- D.C.Voltage Low
- D.C.Voltage High
- A.C.Input Under Voltage

One repeat alarm point for all above annunciations shall be provided to facilitate annunciation of "Fault in Charger" in control room.

Switch board shall be floor mounting type sheet steel enclosed with degree of protection IP 52 or better. Board shall be compartmentalized design.

All power wiring shall be done through single core PVC insulated copper wires/buses. All control wiring shall be done through single core, PVC insulated copper wire of 2.5 sq. mm. All connections external to the panel/switch board shall be terminated in suitable terminal blocks. Inter panel wiring shall be only between terminal blocks.

#### Technical Particulars

- |    |                   |   |  |
|----|-------------------|---|--|
| 1. | No. of DC systems | : | Two Sets   |
| 2. | Voltage           | : | 220 V DC   |
| 3. | Type              | : | Lead Acid Plante type.   |
| 4. | Rating            | : | As per requirement of the Contractor<br>+30% cushion. To be estimated by<br>Contractor with 10 nos. spare feeders<br>in each board for Employer's use. |

#### 04.10 UNINTERRUPTED POWER SUPPLY SYSTEM (UPS)

##### **General System Description**

The 230V single phase true parallel redundant (Load Sharing) UPS system shall provide continuously operating uninterrupted power supply to critical AC loads such as control system, data acquisition system, annunciators and other critical services. The UPS system shall have by-pass system with static stabilizer (CVCF) type with manual bypass by 415/230V Isolation transformer. UPS shall be rated for 60 min. Battery back up.

**Each UPS shall include the following equipment but not necessarily limited to :**

- a) Two (2) sets of 100% rated Lead Acid Plante battery banks.
- b) Two (2) nos. 100% capacity Float Cum Boost battery chargers (FCBC) complete with associated incoming AC switchgear.
- c) Two (2) nos. 100% capacity inverter banks.
- d) One (1) No. DC switchgear, connecting above and also inverter banks stated above.
- e) One (1) no. 3 phase to 1 phase transformer and associated AC switchgear, 240V, 1 phase static voltage stabilizer and backup source static switch.
- f) Isolation Transformer
- g) One No. 240V Dual feed UPS ACDB.
- h) Two nos. Static Switches.
- i) One (1) no. four way manual bypass switch.
- j) 1X CVCF (Constant Voltage Constant Frequency-1Transformer+Rectifier+Inverter+2Static Switch)
- k) All inter connecting cables / wiring with connection accessories and other required items to make the system complete.

UPS system shall be parallel redundant with load sharing type.

UPS system shall have spare capacity for blowers.

Battery back up time shall be 60 Minutes.

##### **Mode of Operation**

###### **Normal Mode**

During the normal operation the UPS shall be used to provide power to the critical loads. The primary AC source shall be used to supply power to the rectifier charger. Three (3) nos. chargers shall feed regulated DC power to their individual inverter banks and simultaneously float charge the back up battery.

The individual inverters will operate in parallel and will share the load. The inverters are connected through static switches upto the paralleling circuit and a common bank static switch will connect up the paralleled output to the load.

###### **Emergency Mode – Parallel Redundant with by pass**

Upon failure of primary AC source supplying three phase power to the battery chargers, the input power to the inverters shall be supplied from the back up battery. When the AC power is restored, input power for the inverter and power

for recharging the battery shall automatically be supplied from the rectifier charger. The batteries shall supply the inverter whenever the chargers are unable to supply the sudden load demand or their response to the load change is slow.

In case of internal failure of one inverter, the same will be isolated from the load instantaneously by de-energising the corresponding inverter static switch. Simultaneously the second inverter will take on the full load without any disturbance in the load voltage. During this period of operation, if the second inverter also fails, automatic changeover to the Bypass system(CVCF), it shall be possible to bypass the same through manual bypass switch effectively transferring the load to the automatic voltage stabilizer in the backup supply path. These shall also be connected from the backup transformer output just before the stabilizer leading to the manual bypass switch, so that continuity of supply can be maintained in case stabilizer also fails.

The output of the UPS shall feed all the essential loads through the ACDB. The connection from the UPS to ACDB shall be through a switch and fast acting semiconductor fuses, trip fuses and micro switch with alarm contacts. The feeders shall be designed by the Contractor to suit the load requirements.

### **Battery Charger**

Three (3) nos. each of 100% capacity, battery chargers shall be provided for each UPS system. These chargers shall be of static type and shall be provided with suitable transformer and full wave, SCR type rectifiers. Chargers shall share automatically the load during parallel operation of the inverter system and shall maintain output voltage within plus or minus one percent of the nominal value from no load to full load.

Suitable ripple filtering circuits shall be provided to give a smooth DC output. The ripple content shall be limited to less than  $\pm 1\%$  on resistive load.

The rectifier charger shall have float, equalizing and boost charging facility as well as furnish the inverter input current. During float charging, the chargers shall furnish the continuous DC load as well as float charge its associated batteries and shall maintain a DC voltage that will pass the minimum current through the cells to keep them charged without overcharging. In order to change their current output, the chargers shall sense a DC voltage drop or rise at their output. During boost charging the DC load shall be fed by the float charger and an appropriate percentage of the battery cells shall float across the load terminal to take care of emergency DC load demand. Necessary blocking diode shall be provided so that boost charging voltage does not appear at the load terminals.

In the 'Boost' mode, the 'boost' chargers shall recharge the completely discharged battery to full capacity in eight (8) hours.

The chargers shall be current limiting and shall be provided with surge suppression networks for both float and boost charging. All equipment and devices required to protect the chargers from short circuits e.g. fast acting semiconductor fuses, trip fuses and micro switch with alarm contacts etc. shall be provided.

The charger section shall be complete with the AC input switchgear and DC switchgear wherein the outputs from the batteries and the battery chargers shall be interconnected forming the common DC bus. The DC bus shall be designed to withstand and short circuit discharge current of the battery.

### **Static Inverters**

The three (3) nos. 100% capacity, required kVA inverters shall be of IGBT based PWM technology with Digital control employing micro controllers and embedded software, integrated control modules including necessary oscillators, voltage regulators, current limiting and surge suppression networks. In addition the inverters shall have features of soft start, wave shaping, transient recovery etc. Any other equipment required for normal operation of the inverter shall be included irrespective of whether specified or not.

The inverter input voltage shall match with the battery and rectifier charger output voltages and shall be designed to operate over the entire range of variation of input DC voltage to accommodate decrease in battery voltage during discharge and to accept voltage increase under battery boost charge or equalizing charge conditions.

The inverters shall always work on their internal oscillators or frequency variations with either of the two inverters as master synchronizer and the other following it. Suitable selection facility shall be provided for selecting either of the two inverters as master/follower. In addition an independent mode of operation shall be provided for each inverter when the other is under fault/trouble/maintenance. The plant AC electrical system will provide a signal to each inverter to control the frequency and phase relationship of its output during normal operations. When this signal to an inverter deviates more than one hertz from the desired 50 Hz frequency, the inverter shall transfer automatically to its internal oscillator which will maintain inverter frequency at 50 Hz within 0.5%.

During operation on its internal frequency signal source, an inverter shall continuously monitor the frequency of the plant auxiliary AC electrical system. Upon restoration of the plant auxiliary AC electrical system to 50 Hz operation, each inverter shall automatically adjust the phase relationship between its output and the plant auxiliary AC electrical system and return to the plant auxiliary AC electrical system as its output frequency and phase relationship signal source. During operation on its internal oscillator an inverter shall inhibit transfer of the static transfer switch to the alternate source. The automatic adjustment of the phase relationship between the inverter output and plant auxiliary AC system shall be accomplished at a controlled rate which shall not exceed one hertz per second.

The two inverters shall be designed for normal continuous parallel operation. The inverter shall be designed for natural cooling for the maximum ambient temperature involved.

The DC input current shall never exceed twice the full load current except for a short circuit within the inverter.

The inverters shall include a separate voltage distribution and voltage monitoring system for all command and interlock logic. Selective protection shall be provided for each individual drive card and its associated interlock logic.

All the fuses used in inverter power and control circuits shall be fast acting type, operating in less than 5 ms. Indications and alarms shall be provided to enable fault to be located and rectified at the earliest. Lamps to indicate fault/trouble/failure of each subgroup shall be provided on the cubicle front and lamps for each logic card shall be provided on the card itself. Each logic card shall be provided with all monitoring and testing terminals, brought out on the front of the card, for quick monitoring/testing/trouble shooting. Test points shall be brought out on the front of the cubicle for the following measurements but not necessarily limited to these :

- a) Output voltage of each charger
- b) Input voltage to each inverter
- c) Prefilter output voltage of each inverter
- d) Postfilter output voltage of each inverter
- e) Output voltage of standby transformer.

### **Static Transfer Switches**

The static transfer switches shall use SCRs and other static devices, for automatic transfer of load from the Normal source to the Alternate source. The continuous capacity of each static switch shall be equal to the full load capacity of one inverter. maximum transfer time including sensing shall not be more than 1/4 cycle. The transition shall be "make before break" in both directions.

The voltage failure shall be sensed at the output of the static switch. Failure shall cause the static switch to transfer. The load from the working inverter shall be transferred to the alternate source, i.e. second inverter or auxiliary power supply source by static switches, when ever the output voltage of the inverter deviates more than  $\pm 10\%$  from nominal. However, transfer shall not be made to the alternate source on over current conditions. Transfer shall be permitted only if voltage of the alternate source is within  $\pm 2\%$  of nominal. contacts shall be provided to alarm deviation of the alternate source voltage beyond these limits.

Before transfer takes place, from any inverter to alternate source, whether initiated manually or automatically, synchronism of the output of the inverter with the alternate source shall have been automatically accomplished.

Return to normal shall be automatic for all externally caused transfer such as overload or clearing of a branch circuit fuse, but shall be manual for all internally caused transfers such as inverters, filter or normal path failure. Automatic transfer shall occur after approximately 2 seconds time delay during which normal source voltage must remain at 110V  $\pm 2\%$ . Time delay shall be field adjustable over the range of 1 to 10 seconds. Manual retransfer shall be initiated through push button.

The static switch shall be provided with fuses in both 'normal' and 'alternate' power source. Provision for annunciation of failure of fuse or failure of alternate source shall be made. The switch shall be provided with surge suppression networks and shall also be rated to withstand transient voltages upto 150% of rated voltage. The short time rating of the switch shall be 150% of the rated full load current for two (2) minutes.

### **Three phase/single phase Transformer and voltage stabilizer**

The transformer shall be dry type, double wound enclosed in a sheet steel panel 2 mm thick, if cold rolled or 2.5 mm thick if hot rolled. The cooling shall be by means of natural convection.

The transformer connection shall preferably be of Le blanc type with delta connected winding on the three phase side or of open delta connection type. Other alternatives shall also be considered, provided the connection has minimum unbalance on the primary side. The transformer shall be encapsulated in Class B insulation. The transformer shall be adequately rated for the duty involved. The actual value may be slightly increased to take care of any losses in the static voltage stabilizer.

The voltage stabilizer shall employ silicon solid state circuitry and shall maintain the specified output voltage for 0 to 100% load, with maximum input voltage variation as specified in technical particulars. The make and rating shall be subject to Employer's approval.

### Manual Bypass Switch

The manual bypass switch shall be a four (4) position switch. It shall be used to isolate a static switch from its load and alternate power supply and to take it out of service without power interruption to the load. It shall be of make before break type contacts, so that power supply to the loads is continuous during switch operations. It shall be capable of carrying rated continuous full load inverter current.

Basic particulars for design:

- Features and performance in line with IEEE446.
- 110% of the rated output for continuous.
- Suitable for connecting to a 415 V, 3 phase, 50 Hz, 4 wire, grounded neutral system with a symmetrical fault level of 40 kA rms.
- Three phase voltage and frequency controlled output
- With isolating transformer, rectifier, inverter unit and necessary DC batteries.
- DC battery shall be Lead acid plante cells type.
- Battery shall be suitable to maintain the power supply for at least 60 minutes in the event of mains failure.
- The changeover time shall be less than 0.25 cycles.
- Necessary distribution board for distribution of power from UPS output to individual consumers.

Permissible variations :

- Mains power supply system
- Voltage : + 10 % , -15 %
- Frequency : +3% , -5%
- Harmonic distortion : < 5%

Output of the uninterruptible power supply system while delivering a load of its rated capacity

- Voltage regulation : 1% (For 0-100% load)
- Frequency : (+/-) 0.5% (-do-)
- Efficiency : Above 80%
- 100% to 0% and 0% to 100% load : Volt dip +/- 10%

Protective features :

- Earth fault monitoring and protection
- Thermal overload protection
- Semiconductor high speed fuses for outgoing feeders.

#### Transformer

- Rating suitable for the application
- Dry type, with class H insulation
- $\pm 2.5\%$  with tapings on primary

#### Rectifier Protective features:

- Maximum current limiting
- Automatic reduction of current limit in the event of cooling fan failure
- Boost charging and float charging current limiting

#### Indications :

- Rectifier On
- Battery run-out timer/counter
- Low battery voltage or blown battery fuse
- High battery voltage
- Charging failure
- Failure in line voltage or auxiliary supply
  - Blown fuse, single phasing or over current
  - Fan failure
  - Battery on float charge /boost charge.

#### Inverter Protective features :

- Abnormal output voltage
- Abnormal link voltage
- Over current on output
- Over current on input or commutating failure
- Low battery voltage
- High transformer temperature
- Auxiliary supply failure
- Fan failure
- Logic failure
- Clock failure

#### Indications:

- Inverter On

#### Meters :

- Output voltage: Phase-neutral & between phases
- Output frequency
- Ammeter in each phase
- Battery current and voltage with indication of status.
- A repeat alarm point for all abnormalities shall be provided to facilitate annunciation of 'Fault in UPS' in control room.

#### Static by-pass switch Protective Feature :

- High speed fuses shall be provided for protecting the thyristor against accidental overload.

#### Indication :

- Load on inverter
- Load on by-pass
- Reserve within limits

**Alarms :**

- Reserve out of limits
- Static switch off

**Panel Constructional Details**

- Unitised construction
- Free standing, floor mounted and indoor type
- Dust and vermin proof
- Sheet steel clad
  - : Min 2.5 mm thick for panels
  - : Min 2.0 mm thick for doors and side covers
- With illumination lamps, door switches, space heaters and sockets for soldering
- All control block plug-in type with test sockets
- Units shall be self contained and serviceable
- Shall be split into a power unit and a control unit. The power unit shall contain reactors, where necessary, protective gear and switchgear, thyristor converters and gate control units. The control unit shall house all control, regulation measurement and error indication devices in single cubicle which shall be connected with the power unit by means of plug-in data links.
- The arrangement and layout shall facilitate easy and convenient supervision of the unit while running as well as quick detection of disturbances and trouble shooting.

**Enclosure and ventilation**

- Enclosure conforming to IP-41 class
- Units shall be provided with cooling fans and louvers at the bottom sides.
- Individual ventilation ducts for each unit shall be provided.
- UPS shall be suitable to meet the requirement based on approved calculation and in addition to above 5 kVA capacity shall be kept for Employer's use along with 4 feeders in the panel in each Unit.

**TECHNICAL PARTICULARS**

1. Application : Uninterruptible Power supply for DAS and other essential loads.
2. Ambient conditions : Min. temp: 15.6°C  
Max. temp: 50°C
3. Degree of protection as per IS 2147 : IP 41
4. Cable entry : Bottom
5. Input Supply Voltage : 415  $\pm$  10% 3phase 4 wire 50 Hz  $\pm$  5%
6. Input MCCB shall be of 40 kA for 1 sec.
7. All the input and output isolation through isolation transformer shall be provided in the UPS.
8. Max ripple current in output of battery charger/Inverter is less than 1%.



10. Space heater, door switch with panel illumination system shall be provided as per spec.
11. 100% fan redundancy shall be provided.
12. UPS input supply connection shall be Insensitive for its phase sequence.
13. Reverse Battery polarity protection shall be provided.
14. Online automatic battery open circuit test in regular interval through software programming shall be provided.
15. Redundant static switch on each ups module shall be provided.
16. Each UPS shall be provided with Alpha Numeric L.C.D display with fault logging facilities.
17. UPS shall be true parallel redundant type with out any common component so as to avoid any single point failure.
18. Criss cross facilities shall be achieved.
19. Asynchronous transfer facilities shall be provided.
20. MOD BUS interface connectivity shall be provided to hook up to plant DCS system.
21. Branch MCCB clearing capacity shall be provided with 30 % of UPS rating.
22. Frequency Synchronous window with Bypass shall be with 50 HZ  $\pm 6\%$ .

#### BATTERIES

1. Type : Lead Acid Plante type
2. Application : UPS System
3. Number of battery banks required : 1 Set
4. Number of cells in each bank in series : As per requirement
5. Ambient temperature : Min.temp. :15.6 deg.c  
Max.temp. :50 deg. c
6. D.C.nominal system voltage : 220 V
7. Ampere hour capacity of calculations rate to give final cell voltage of 1.85 volts/cell : Contractor to furnish along with battery at 27 deg.c, 10hr
8. Cell Voltage : a) Nominal : 2.00  
b) End discharge : 1.85
9. Mounting arrangement : Open type / multi tier
10. Charging method proposed : Float and boost
11. Emergency load duration : 60 minutes

#### BATTERY CHARGERS

1. Number required : 2 nos. per UPS
2. Type : IGBT based PWM Technology with Digital control.
3. Method of charging : Float and boost charge type
4. DC system voltage : 220 V
5. Automatic voltage regulator required(AVR) : Yes
6. Regulation with AVR :  $\pm 1\%$
7. Permissible harmonics :  $\pm 1\%$

- at rated continuous load
8. Minimum permissible power factor at rated continuous load : 0.9
  9. Cable entry from : Bottom
  10. Maximum time for boost charging : 8 Hours

#### INVERTERS

1. Type : IGBT based PWM technology with digital control employing micro controllers and embedded software.
2. Number required : Three per unit
3. Suitable for parallel operation/not operation : suitable for parallel
4. Service : Indoor
5. Output rating of each : As required
6. Output Voltage : 230V A.C.
7. Voltage regulation : Combined Voltage regulation  $\pm 2\%$  from 0 to 100% load at 0.8 power-factor with in 50 milliseconds.
8. Phase : Single phase
9. Frequency : 50 Hz
10. Frequency regulation :  $\pm 5\%$  for 0 to 100% load variation (continuous or step load change) and full range of input variation.
11. a) Transient voltage regulation on application or removal of 100% load :  $\pm 8\%$   
 b) Time to recover from transient to normal voltage : 50 milli seconds.
12. Duty : Continuous.
13. Overload capacity : 110% continuous  
 125% for 15 minute at 0.8 p.f  
 150% for one minute, 200% for 1 sec.
14. Short time rating : 1 second for short circuit at inverter output terminals.
15. Short circuit current : Shall be capable of withstanding short circuit withstandability current for the largest fuse to clear the fault in less than 1/45 cycle
16. Efficiency : Not less than 80% at rated load.
17. Cooling : Natural air cooled
18. Synchronization with alternate source required : Yes

#### STATIC TRANSFER SWITCH

1. Capacity Continuous : Make and carry full load current of inverter at 0.8 p.f
2. Type : Make before break
3. Voltage : 110V, single phase

- |   |  |
|---|--|
| 4. Short time rating                      | : Short circuit rating of the inverter for 1 second and 150% of full load current for 2 min.   |
| 5. Frequency                              | : 50 Hz  |
| 6. Retransfer                             | : Automatic retransfer shall occur after approximately 2 sec. time delay during which normal source voltage must remain at 110V +/-2%  |
| 7. Indication protection/<br>Annunciation | : i) Indicating lamp for static switch in normal position.<br>ii) Indicating lamp for static switch connected to alternate source<br>iii) Protection of all semiconductor devices against short circuit and transients.<br>iv) Annunciations for the following conditions<br>a) Static switch connected to alternate source.<br>b) Alternate source voltage deviation greater than +2% from nominal. |

#### MANUAL BYPASS SWITCH

- |                        |   |
|------------------------|---|
| 1. Capacity Continuous | : Make and carry full load current of inverters at 0.8 p.f.                                   |
| 2. Type                | : Make before break.  |
| 3. No. of positions    | : 4   |
| 4. Short time rating   | : Short time rating of the inverter for 1 second and 150% of full load current for 2 minutes. |
| 5. Transfer            | : Manual.   |

Sizing of UPS system shall be done as per the following.

- Contractor's own equipment load requirement plus 25 KVA load of Employer's Blowers equipment and over and above to these 30% spare capacity for future use.

#### 04.11 CABLE AND CABLE ACCESSORIES

Type 1 : 11kV (UE) & 6.6 kV (UE) / XLPE Cables suitable for 11kV/ 6.6 kV, single phase / three phase, 50 Hz, un-grounded system.

6.6 kV (UE) & 11kV (UE) heavy duty power cable, with compact circular stranded (rm/V) Copper conductor with extruded conductor shielding of semi conducting material, XLPE insulated, with insulation shielding over individual cores consisting of extruded semi-conducting compound followed by lapped semi conducting material and copper tape, cores stranded together with a holding tape provided with a common covering of extruded inner FRLS sheath of type ST2 compound, galvanised round steel wire armoured and FRLS PVC outer sheath of type ST2 compound for 6.6 kV & 11kV system as per IS : 7098 (Pt-II)-1985 as ammended upto date. Copper screen shall be suitable to carry 1 kA E/F current for one second.

The cable shall be of dry curing type.

Single core HT cables shall necessarily have non-magnetic (aluminium) armours.

The minimum size of all the 11kV & 6.6kV(UE) XLPE copper conductor cables shall be 185mm<sup>2</sup>.

Type 2 : 1.1 kV, PVC aluminium power cables suitable for 415 V, 3 phase, 50 Hz, solidly grounded system.

1.1 kV, heavy duty power cable multicore with standard sector shaped (sm) or with compact circular stranded (rm/V) or circular stranded (rm) aluminium conductors as applicable, PVC insulated of type C PVC compound suitable for 85 deg.C. operation as per IS:5831-1984, core stranded together provided with a common covering of FRLS PVC inner sheath of type ST2 PVC compound, galvanised round steel wire armoured and FRLS PVC outer sheathed of type ST2 PVC compound conforming to IS:1554 (Part-I) - 1976, as ammended upto date. Type AYWY.

Type 3 : 1.1kV PVC copper control cables

1.1 kV circular stranded (rm) annealed copper conductor, PVC insulated of type A PVC compound suitable for 70 deg.C operation, as per IS:5831 - 1984, cores stranded together provided with a common covering of FRLS PVC inner sheath of type ST1 PVC compound, galvanised round steel wire armoured and overall FRLS PVC sheathed of type ST1 PVC compound and multi-core to IS : 1554 (Part-I) - 1976, Type YWY :

### Cable Selection

In general, size and type of cables for specific applications shall be selected giving due consideration for the following:

- Thermal heating effect/permissible current carrying capacity.
- Voltage drop
- Short time current/overload requirement
- Protection system grading and short circuit current carrying capacity.
- Ambient conditions
- Cable grouping factors

In selection of the cables following ambient conditions shall be taken into account.

- Cables laid directly in ground in single way ducts or pipes buried underground.
- Thermal resistivity of soil : 150°C cm/W
- Soil temperature : 40°C
- Depth of laying (to the highest point of cable or grade cables & top surfaces of ducts) : 75 cm for 1.1kV  
90 cm for HT cables
- Horizontal formation axial spacing : 15 cm in case of cables laid in a group directly in ground and approximately touching in case of single way ducts or pipes.

Cables laid in free air/in conduits in free air.

Ambient air temperature : 50°C & as specified for the respective shops.

Cables laid in ventilated ducts/gallery

Ambient air temperature : 50°C.  
The minimum cross sectional area for HT power cables shall be 185mm<sup>2</sup>.

The minimum cross-sectional area of the cables used in LT power circuits shall be 6 mm<sup>2</sup> per core if with aluminium conductor or 4 mm<sup>2</sup> per core if with copper conductor. Maximum cable size shall be 240 sqmm for incomers to MCCs, PCCs etc.

For control circuits, PVC insulated and FRLS PVC sheathed multicore cables with copper conductors having a minimum cross-sectional area of 2.5 sqmm per core shall be used. The number of cores may be standardized as 2,3,4,5,7,10,14,19,24. Each core of control cable with 7 core and above shall be numbered at every 1 meter intervals.

In multi-core control cables, the following minimum reserve cores shall be kept at the engineering stage:

- |                    |   |                     |
|--------------------|---|---------------------|
| ▪ Upto 7 cores     | - | One reserve core    |
| ▪ 10 cores         | - | Two reserve cores   |
| ▪ 14,19 & 24 cores | - | Three reserve cores |

Sequential length marking shall be provided in outer sheath of all power and control cables.

Standard drum length for all types of power and control cables shall be offered. ISI marking at every meter of cable length shall be provided.

Cores of multi-core control cables shall be serially numbered.

For all cables, extra length of 2 metres will be left before jointing.

#### **Additional Tests on cable**

To prove the fire retardant low smoke characteristics, the following additional tests shall be conducted at works on any size of each type of cable namely, H.T/ power, L.T. power, control and instrumentation cables.

Oxygen index test as per ASTM D 2863. Minimum value of Oxygen index shall be 30.

Flammability tests on finished cable as per the requirements of IEEE-383 and IEC-332-1.

Smoke generation by inner/outer sheath fire as per ASTM D 2843. The cables shall meet the requirements of light transmission of minimum 40% after the test.

#### **HT Cable termination & joints**

Following type of cable termination and joints shall be used for HT cables in indoor and outdoor applications:

Heat shrinkable type.

The stress control and grading wherever necessary shall be by means of semi conducting heat shrinkable tubing. Environmental sealing between heat shrinkable material and cable surfaces shall be achieved by using hot melted sealants or

adhesives. Where such sealants or adhesives shall be exposed to high electrical stress, same shall be track resistant type.

The termination and straight joints for HT/LT cables shall be supplied in kit form. The kit shall include all insulating and sealing material apart from conductors fittings and consumable items. Necessary devices required for termination and joints shall be provided.

### **Specifications for miscellaneous materials**

#### **Connectors**

Cable termination shall be made with aluminium/ tinned copper crimped type solderless lugs of approved make for all aluminium conductor and stud type terminals.

#### **Cable identification**

Cable tags shall be of 2 mm thick, 20 mm wide aluminium strap of suitable length to contain cable number as per cable schedule.

#### **Ferrules**

Ferrules shall be approved interlocked type & size to suit core size mentioned and shall be employed to designate the various cores of control cable by the terminal numbers to which the cores are connected, for ease in identification and maintenance.

#### **Cable Glands**

Cable glands to be supplied shall be nickel plated brass double compression type. Glands for classified hazardous areas shall be certified by CMRS and approved by CCE, Nagpur.

#### **Cable clamps**

All cables shall be clamped with metal clamps and single core cables shall be clamped with trefoil clamps made of aluminium.

#### **Cable trays**

This shall be prefabricated hot dip galvanised sheet steel trays. Runner size shall be 50x50x6 and rung size shall be 25x5 at every 250 mm. At one meter interval two rungs shall be provided side by side to facilitate clamping. Galvanising content shall be 86 microns.

All the cable trays shall be hot dip galvanized GI trays, ladder or perforated as the case may be. Beside, Contractor shall also provide 900/450 bends of cable trays at the bends as per actual site requirement.

### **04.12 AC DISTRIBUTION BOARD / POWER DISTRIBUTION BOARD / AUXILIARY AC DISTRIBUTION BOARD**

ACDB / PDB shall be suitable for 415V, 3 phase, 4 wire, 600A, 50 kA (short time rating for 1 sec.) indoor type.

Board shall be single front, metal clad, front matched, dust and vermin proof, draw-out, fully compartmentalised and extensible on both sides, IP54 type enclosure.

It shall have isolated busbar chamber for main busbar at the top, running through out the length of the board. Chamber shall have removable cover.

Busbars shall have same cross section through out the length. Rating of the neutral busbar shall be 50% of the main busbar. Earth bus bar shall run in bottom chamber throughout the length of the panel.

Shall have Air Circuit Breaker (ACB) or Moulded case circuit breaker (MCCB) triple pole, air break type with independent manual quick make and quick break type. ACB/MCCB shall be capable of breaking rated current at 0.3 pf at rated voltage. ACB/MCCB shall withstand the fault current envisaged for 415V system.

The number of ACDBs/PDBs and their locations shall be decided based on consumers and shall be finalised during drawing approval stage.

Generally all boards will have following feeder arrangement. However, details of feeders e.g no. type and capacity, etc shall be finalized during detailed engineering.

Incomer	-	ACB/MCCB of 600A (or as indicated in SLD)
Outgoings	-	MCCBs of 400/250/125A (or as indicated in SLD)

Number and capacity of ACDB/PDB given in the enclosed Single Line Diagram is minimum and indicative. Contractor shall provide as per actual load requirement and same shall be finalized during detailed engineering.

All ACBs shall be EDO type with built in direct acting type microprocessor based numerical O/C, S/C & E/F releases. Minimum rating of all ACBs shall be 1000A.

#### **Auxiliary AC Distribution Board / Auxiliary Power Distribution Board**

These are required for feeding small loads. The board will be wall mounted type and other constructional features as given in above specification for ACDB.

Number of aux. ACDBs shall be as per requirement and shall be decided during detailed engineering stage.

### **04.13 FIRE DETECTION AND ALARM SYSTEM**

A microprocessor based analogue addressable type automatic fire detection cum alarm system shall be provided for complete power plant including all electrical and common facility premises.

In all the electrical premises multi-sensor addressable intelligent detectors in double configuration shall be provided except for transformer room and battery room where rate of rise cum fixed temperature type heat detectors shall be provided .

The system shall have self-monitored microprocessor panel incorporating the latest technological developments. The automatic fire detection cum alarm system shall operate taking into consideration the air change/air velocity of the ventilation system. Response indicators shall also be provided for all the detectors above false ceiling in control room.

Contractor to assess the quantity of interconnecting cables and wires, supporting arrangement and include the same on lump sum basis.

Following parts of fire detection and alarm system shall be provided:

- Main Fire Alarm Panel
- Personal computer with visual display unit, key board, mouse and printer
- Manual call points(indoor type)
- Manual call points (outdoor type) with canopies
- Hooters (indoor type)
- Hooters (outdoor type) with canopies
- Multi-sensor detectors (photo electric cum rate of rise and heat detector (type)
- Rate of rise cum fixed temp type heat detectors
- Isolators
- Relay modules
- Response indicators
- Area panels
- Maintenance-free Lead acid battery and battery chargers
- FRLS cables, conduits, junction boxes, earthing materials etc.
- Siren and hooter
- Infrared detectors
- Linear Heat Sensing Cables

### System Description

Microprocessor based control panel shall be provided to detect, differentiate and monitor the following conditions of the detectors.

- Fire
- Fault condition
  - Open circuit
  - Short circuit
- Low voltage condition of batteries.

Panels shall have provision to accommodate 20% extra locations or one loop for future use (whichever is more).



The system shall have display as well as print options. Fire alarm panel shall have mimic and text display.

The system shall also be suitable to work on UPS system. Employer will provide one feeder from their board. Requirement of UPS power shall be furnished by the Contractor.

There will be one number Main Fire Alarm Panel to be installed in main control room and a number of Area Panels (AP) to be installed in control rooms of Pump house. In case of detection of fire, the fire signal (audio-visual alarm) of particular area shall appear in the respective Area Panel. The signal from AP shall be duplicated in Main Fire Alarm Panel.

In all area panels and Main Fire Alarm Panel, audio fire telephone with public address system consisting of loudspeakers etc shall be provided to facilitate voice communication between main control room and other control rooms where fire panels shall be located. Public address system shall be used for emergency instructions.

For tripping of A/C, ventilation drives, signals shall be initiated from Area Panels only if two adjacent detectors give fire signal.

Number of loops in fire alarm system shall be finalised based on requirements / future use during detailed engineering stage. The Contractor to note that all loops shall be closed type. Panel shall have provision to adjust the sensitivity of the detectors from the panel itself. In main panel mimic LED lamps shall be provided to know at a glance operation of detectors in a particular area.

### **Main Fire Alarm Panel (MFAP)**

MFAP shall be located in main control room. Fire signal from all the area panels shall be repeated in MFAP. All annunciation of Fire Pump House panel shall also be repeated in Main Fire Alarm Panel. The panel at FPH shall be connected to network bus with suitable hooking devices. MFAP shall have text display.

### **Personal Computer and printer**

Personal computer with visual display unit along with key board and printer shall be provided to monitor all the data loggings of events, system diagnostics and to print out the required events / data logged with date, time, etc. Status of all the detectors shall be displayed on demand on VDU. VDU shall display alarm, pre-warning faults and location of the fire or faults like open circuits and short circuits.

VDU screen shall be of minimum 21 inch size, processor type shall be latest version of Pentium. Printer shall be laser jet type. Suitable furniture for PC and printer with revolving and rolling chair shall be included in the scope of the Contractor. In PC it shall be possible to have geographical mimic and graphic display for the complete area. PC and printer shall be located in main control room and connected to MFAP.

### **Networking**

The MFAP and APs shall be networked using RS 485 interface. A provision shall be kept to add/ remove panels from the network. Necessary cabling, interface cards,

hardware and software is included in the scope of the Contractor. In network connection, Contractor to provide two spare cores to be used in case of fault in working cores.

### **Power Supply**

Contractor to include all power supply cabling for the fire alarm panel from the existing power supply boards.

The fire alarm panel shall be provided with 24 V DC battery along with battery charger of adequate capacity so that if AC power fails, DC source will be available automatically without interruption. Batteries for above shall be lead acid sealed maintenance free type. Battery shall be capable to withstand the total normal requirement for a duration of 48 hours and for a duration of 30 minutes to meet alarm load requirement. Alarm load shall consist of normal detection equipment plus all sounders/siren etc. Boost/trickle charging facility shall be provided in the panel. Battery shall be kept separately in the control room at suitable place.

### **Detectors**

Detectors shall be of latest series intelligent type. Close loop shall be formed with connections of detectors. Each close area shall have isolator at entry points and exit points which will automatically open the part of loop on short circuit. Alert signal (first) and final fire signal (second) shall have differentiable sound. All detectors shall be mounted with a suitable junction box.

Heat and smoke detectors shall have similar bases which shall be push-twist type and fabricated type shall not be acceptable. Detectors and panels shall be compatible. It shall be possible to adjust sensitivity of detectors through area panel or MFAP.

In lead acid battery rooms rate of rise-cum- fixed type heat detectors shall be provided .

Remote response indicators shall be provided for all detectors located above false ceilings in control room. Required work for fixing of the indicator above ceiling shall have to be carried out by the Contractor. For detectors to be mounted in existing control room over the false ceiling, Contractor to take necessary precautions so that existing facilities shall not be disturbed.

In conveyor galleries infra red (IR) flame detectors shall be provided. Length of conveyor is approximately 110m. It shall have built in cleaning arrangement to facilitate removal of coal dust. In case Contractor desires to provide another type of cleaning system then same arrangement shall be described in the bid document. IR detectors shall be ember type suitable to detect moving fire. In each conveyor two detectors shall be provided. Contractor to submit unit rates for any addition/ deletion on above arrangement if required during detailed engineering stage. IR shall have corrosion resistant metal body and sensitivity checking feature. All required interfacing devices for IR detector shall be supplied. IR detectors shall be suitable to work in the event of vibration in any axis.

Detectors shall not foul with ventilation duct and shall not be located near diffuser. Detectors and fire panels shall have UL listing FM approval. Fire alarm panel shall be UL/FM/LPC/TAC approved.

Smoke detectors and heat detectors shall be installed as per latest practices indicated in IS:2189-1988, TAC and NFPA codes. Minimum two numbers of detectors for the smallest premise shall be provided. Coverage area shall conform to IS 2189-1988. Contractor shall select the spacing of detectors considering the air change factor of the ventilation/air conditioning system, height of room, beam depth etc. as per IS 2189-1988.

In cable shafts smoke detectors at top of the shaft shall be provided with required fixing arrangement.

### **Manual Call Points (MCP)**

MCP shall be provided at each entry /exit point of electrical room, emergency exit (to be provided under this package), transformer bay, Pump Houses, lift in the main building etc. MCP shall be analogue addressable, break glass type connected to its location card. Both indoor/outdoor MCP shall have glass cover and removal of glass shall initiate communication to area panel and main fire alarm panel.

Total numbers of call points and their locations shall be finalised during detailed engineering. Travel distance between two consecutive MCP shall not be more than 50 meters. Signal of the MCP shall appear at the Area Panel and Main Fire Alarm panel. At main entry points of buildings and electrical rooms minimum one number Manual Call Point shall be provided. In outdoor areas, MCP shall be suitable for outdoor location with rain canopy and shall be mounted on structure or wall at prominent places. Wherever existing supports are not available, Contractor shall consider steel structure support arrangement so that MCP shall be located at 1 meter from ground level.

Contractor to calculate the required length of LHS cables and number of interface devices, hooking up arrangement to control/ area panels based on belt lengths, drum location, belt width etc. All required fixing accessories for the items needed as per site conditions shall be included in the scope of Contractor.

### **Area Panel (AP)**

Area Panels with alphanumeric mode and LED indication for each zone shall be provided at locations shown in block diagram. APs shall have their own power supply unit and 24 V standby battery. APs shall have facility to display all alarm and fault conditions, status of all detectors of their respective area.

In each area panel one 'NO' contact (indicating operation of any devices or any alarm situation) shall be provided to facilitate monitoring in Plant's DCS system.

### **Linear Heat Sensing (LHS) Cable**

LHS cable shall be provided in cable galleries, along the length of galleries. LHS cables shall be digital type and Necessary braiding for mechanical strength shall be provided in LHS cables. Support arrangement shall be provided by the Contractor to suit site conditions. In LHS cable system Contractor to include all interface devices required to hook up to area panel.

### **Siren /Hooter**

Siren shall be mounted on suitable support near chimney (capacity 1 Km range to operate in case of confirmed fire is registered in the main fire alarm panel). Siren shall also be suitable for manual operation. Siren shall have three types of sound; first alarm (or alert), second fire (or emergency) and third clear. Contractor shall furnish details for above. Siren shall be connected to UPS power supply and all necessary arrangement shall be provided by the Contractor for this. Employer will provide only one UPS feeder from the DB located in main control room.

Hooter shall be connected in each zone internally as well as externally. External hooters may be clubbed together w.r.t. common entry/exit point of view for cable areas.

### **Cables & Cable laying**

Cables used for interconnecting hooters shall be limited to one premise only. All incoming-outgoing power supply cables & inter connecting cables used for the system shall be fire resistance low smoke (FRLS) type 1100 V grade PVC insulated, PVC inner and outer sheathed having 1.5 mm<sup>2</sup> copper conductor conforming to IS:1554 (Pt.-1). Three core cables (keeping one core as spare) shall be used for the detector/ device connection.

Fire cable routing shall be separated from other cables to the extent possible. All switches, cable ending junction boxes, multi-way junction boxes, FRLS connecting cables, panels etc. shall be included to make the system complete in all respect. This shall include wiring/cabling up to Area Annunciation panels. Cables for detection system shall be laid keeping sufficient space from illumination cables. Cable shall be laid as per approved cable routing and cable layout drawings and as per normal plant practice and manufacturer's guideline. Route markers for fire cables shall be separate and distinct from other markers.

### **Quantities of items**

No. of detectors, response indicators, manual call points, isolators, interconnected cables, incoming cables, conduit for laying of cables shall be provided by the Contractor as per the requirement to cover all the areas based on approved drawings. Quantities are to be calculated by the Contractor and shall be provided to meet all requirements. List of electrical premises has been enclosed, however Contractor to ensure coverage of detection network for all electrical rooms of the plant and cable galleries, basement and walkable cable tunnels. Contractor to cover all electrical rooms by Fire Detection System whether same is indicated specifically or not.

### **Interface Devices**

Contractor to include all interface/ hooking up devices for connecting output of LHS cables, alarm points, interlock points etc.

### **Interlocking with A/C & Ventilation system**

There will be interlocks to shut off the exhaust fans and simultaneous tripping of A/C and ventilation system. The fire signal from first detector will operate the audio-visual alarm whereas on confirmation of fire signal from the other detector the ventilation/air conditioning system shall be switched off automatically. Appropriate tripping relays and their contacts shall be provided by the Contractor for this

purpose considering zone wise operation, partitions in cable gallery/ basement and number of fans/ system operating in the electrical rooms.

Potential free contacts shall be made available for each zone for tripping of respective ventilation/air conditioning system. Location of above relay module shall be as finalised during detailed engineering stage. Contractor to consider all accessories such as cabling/ wiring, contact multiplication etc required to achieve the system requirement.

Contact of auxillary relays shall be made available in relay auxillary panel of the above mentioned places and shall be suitable to wire directly in MCC control circuit.

#### **04.14 MISCELLANEOUS ELECTRICS**

##### **HT MOTOR SOFT STARTER**

To avoid impact on electrical system due to heavy motor starting current, a soft start system limiting motor current to 2 to 2.5 times shall be provided to ensure voltage drop at motor terminals limited to 15% with a provision of DOL starting. Contractor to submit the voltage drop calculation, considering adequate fault level at 6.6kV board.

The soft start system shall be based on principle of flux compensated non-saturated magnetic amplifiers for control of motor starting current. Also, the starter should not introduce any harmonics into the system.

The flux compensated magnetic amplifiers shall work on principle of flux opposition and operate in the linear non saturable zone of magnetic circuit. The system will work on constant mode in the starting zone so as to result in smooth start.

The enclosure class shall be IP54.

The Sheet steel thickness shall be 1.6 mm.

The control circuit will utilize auxiliary contacts and timers for starting function.

Lamp indication shall be provided using LED type lamps.

Ammeter shall be provided on front door.

The cubicle will have cable entry and exit from bottom through gland plate.

Bypass device used shall be 6.6kV contactor.

##### **DC STARTER PANEL**

The starting resistors for the DC motors shall be enclosed in a metal clad naturally ventilated self standing panel(s) with sheet steel material of minimum 2.0 mm thick with degree of protection IP-54. It shall be dust and vermin-proof. The number of resistance steps shall be decided by the Contractor depending on application. Alternatively permanently connected resistor is also acceptable.

The resistor elements shall be made of unbreakable, corrosion proof, jointless stainless steel grids or ferro-chrome aluminium alloy. The grids shall be in punched form and suitable for use in tropical climate.

The enclosure protection of DC starter panel shall be IP54 and its resistor cubicle shall be of IP 33 enclosure protection.

## **ERECTION, INSTALLATION ACCESSORIES**

All support structures required for cables, busducts and for electrical equipment including conduits, inserts, shall be provided to complete the erection job in all respect. Cable tag markers, clamps, sealing compound, pull boxes, marshalling boxes etc. shall be considered as part of the Contractor's scope.

## **OTHER ITEMS**

All required safety items like shock treatment chart, first aid boxes, danger boards, boards indicating 'Man on Work, Do not switch ON', 'Do not switch OFF', 'EARTHED' etc. shall be provided in each electrical premises.

PVC floor of suitable voltage grades of 1 Mtr width in front of all the panels like HT switchboards, LT switchboards (PCCs), MCCs, PMCCs, DBs, control panels, etc

Wall mounted aux. AC and DC distribution boards shall be provided in sufficient number to facilitate proper distribution of the power supply to various users.

Industrial type, metal clad welding socket, 240V & 415V power sockets shall be provided in sufficient number to facilitate extension of power supply to various machine tools, welding sets etc. in all the areas and floors. In addition to above 24V AC sockets with portable hand lamps shall be provided for maintenance lighting. All cabling for sockets shall be laid in conduit.

Contractor shall include closing of all cable and panel openings through a Fire sealing material. This shall include closing of all bottom-opening of control room panels, MCC switch boards, wall openings in all the areas, etc. Contractor shall also include earthing of all equipments/system, wherever required, under his scope of supply.

Welding socket outlets shall be provided at every 60mt distance. The number of welding socket outlet shall be as per requirement and approach. Generally they shall be provided in such a way that using 30mt flexible cable with welding set, total plant area can be covered. They shall be fed from separate aux. ACDBs.

Contractor shall include painting of all the plant and equipment with approved shades and include primers as well as finishing paints.

Sufficient quantity of GI ladder type factory fabricated cable trays made from 2.5 mm thick hot welded steel sheets grade 'o' as per IS : 2062 shall be provided. Hot

dip galvanizing of 85 micron thick as per IS-2629, IS-4759 and IS- 209. Trays shall be of standard length of 3 m with max deflection not exceeding 1/400 of span with sufficient load bearing capacity. Wherever required, hot dip galvanized GI perforated tray shall also be provided.

All cable trays shall be hot dip galvanized GI trays ladder or perforated type as the case may be. Contractor shall also include 900/450 bends of the cable trays at the bends as per actual site requirement.

All cable supporting structures including all accessories shall be under scope of the Contractor.

## **05.00 ERECTION OF ELECTRICAL EQUIPMENT**

Contractor shall include erection of all the equipment under his scope of supply.

Erection of equipment shall have to be carried out as follows;

1. Procedure mentioned in manufacturer's manual
2. Under the expert supervision
3. Erection shall be as per prevailing statutory norms and regulations
4. Sequence and plan of erection as per the guidance of Employer's Site Incharge or their consultant
5. During erection of supplier's equipment, existing equipment /system shall not be disturbed.
6. Erection shall be in accordance with approved layout drawing and installation details.
7. Cable laying shall be as per approved cable layout drawings and work shall be carried out in a neat manner.

All erection-installation accessories required for erection/installation of equipment and handling equipment required for handling of equipment from store to installation site are included in the scope of work of Contractor as a whole.

## **06.00 INSPECTION AND TESTING**

### **06.01 INSPECTION**

#### **06.01.01 Extent of inspection**

The extent of inspection & testing by the Employer shall vary from equipment to equipment as per design requirements.

However, indicative extent of inspection for electrical equipment is furnished below.

Extent of inspection to be carried out shall be finalised with the Contractor after award of the contract on the basis of scope of supply, technical specification and approved GA drawings. However, in case of similar bulk manufactured items, methods of sampling for inspection of different lots shall be governed by relevant Indian or international standards.

In case of critical components, the Employer reserves the right to undertake 100% inspection.

Categories of Equipment	Extent of Inspection (as applicable from equipment to equipment)
i) Bought-out items	<p>Following standard bought-out items shall be accepted on the basis of manufacturers' test certificates:</p> <ul style="list-style-type: none"> <li>▪ LV current transformers</li> <li>▪ Standard AC motors upto 10 kW rating</li> <li>▪ Push button station</li> <li>▪ LT power and control cables</li> <li>▪ Starters</li> <li>▪ DC brakes</li> <li>▪ Thermocouples</li> <li>▪ Limit switches</li> <li>▪ Level switches and probes</li> <li>▪ Pressure switches</li> <li>▪ Pressure gauges</li> <li>▪ Conduits</li> <li>▪ Light fittings</li> </ul>

ii) Final inspection & testing:

- Verification of test certificates
- Visual, Workmanship & painting
- Dimensional
- Witnessing of routine/acceptance/type/ special tests as per relevant standards.
- Witnessing of proto-type tests, as applicable
- Verification of type test certificates for identical equipment

The inspection shall be carried out on the basis of QAP dully approved by Employer / consultant.

06.01.02 INSPECTION CATEGORIES

S.N.	DESCRIPTION	INSPECTION CATEGORY
1.	GENERATOR (EACH)	A
2.	GENERATOR EXCITATION SYSTEM & AVR	A
3.	GENERATOR CT, SAPT, NGT, NGR	B
4.	GENERATOR TRANSFORMER (EACH)	A
5.	Power/AUXILIARY TRANSFORMER (EACH)	A
6.	NGT+NGR	B
7.	CONTROL, PROTECTION & SYNCHRONISATION PANELS	A
8.	GENERATOR BUS DUCT	A
9.	LT MOTOR CONTROL CENTRE (LT MCC)/PMCC	A
10.	BATTERY BANKS FOR STATION DC SYSTEM AND UPS	A
11.	BATTERY CHARGER AND DC DISTRIBUTION BOARD	A
12.	UNINTERRUPTED POWER SUPPLY SYSTEM (UPS)	A



13.	HT MOTORS	A		
14.	LT MOTORS & ELECTRICAL ACTUATORS		B	
15.	SIGNAL & INSTRUMENTATION CABLES		B	
16.	CABLE ACCESSORIES			C
17.	AC DISTRIBUTION BOARD / AUXILIARY AC DISTRIBUTION BOARD		B	
18.	LDB/SLDB & LIGHT FITTINGS		B	
19.	FIRE DETECTION AND ALARM PANELS		B	
20.	LHS CABLE & DETECTORS		B	
21.	IG-541 FIRE EXTINGUISHING SYSTEM FOR GENERATOR		B	
22.	EMULSIFIER EQUIPMENT FOR HT TRANSFORMERS			C
23.	EARTHING AND LIGHTNING PROTECTION MATERIALS			C
24.	FIRE SEALING MATERIALS	A		
25.	LOCAL PUSH BUTTON STATIONS			C
26.	WELDING SOCKETS AND POWER RECEPTACLES	A		
27.	ESP TR SETS	A		
28.	ESP CONTROLLERS		B	
29.	DC STARTER PANELS			

All the equipment w.r.t. "Generator & Electrics" have been classified in three categories for inspection and issuing dispatch clearance by the Employer/consultant.  
The three categories are

#### Category-A

All the tests shall be inspected by the Employer/Consultant. Dispatch clearance shall be given by Employer/Consultant after the equipment is inspected and found as per requirement and as per TS. All types tests certificates shall be submitted by the Contractor in this case.

#### Category-B

Inspection shall be carried out by prime Contractor and inspection waiver certificate shall be issued by Employer/Consultant based on type test certificates and routine tests certificates furnished by the Contractor. Employer/Consultant shall issue dispatch clearance accordingly.

#### Category-C

Dispatch clearance shall be given by Prime Contractor without any certificates based on technical data sheet furnished by the Contractor.

### 06.02 Testing

#### 06.02.01 **General**

Test of all equipment shall be conducted as per latest BIS. Wherever no such standard exists, tests shall be as per International Standards like IEC/DIN/BS/IEEL/JIS, etc.

All routine tests shall be carried out at manufacturer's works in presence of Employer or his representative.

The Contractor shall submit type test certificates (not more than 5 years old) for similar equipment supplied by him elsewhere. In case type test certificates for similar equipment is not available, the same shall be conducted in presence of Employer or his representative, without any financial implications to Employer. Heat run test shall be conducted in one of each type of HT motor, dry type transformer and 6.6KV panel at works.

The type test and routine tests on the generators shall be as per prevailing standards and as per manufacturer's guidelines. However, Employer reserves the right to witness all or any of the tests.

The following type/routine tests on the generators and their auxiliaries shall necessarily be included along with all the other recommended tests and shall be performed by the Contractor without any additional cost implication to the Employer.

1. Balancing of the rotor
2. Over speed test
3. Runaway speed test
4. Measurement of the stator winding capacitance & tan delta
5. Determination of the synchronous reactance and short circuit ratio
6. Accuracy test of AVR
7. Sensitivity test of AVR
8. Response ratio test AVR

In addition to various routine tests to be done on the HT transformers (GTs & UATs), following routine tests shall be conducted specifically in presence of Employer/consultant;

1. Frequency Response Analysis of all the transformers
2. Heat run test of all the transformers

The Contractor shall be responsible for satisfactorily working of complete integrated system and guaranteed performance.

#### **06.02.02 Site Tests And Checks**

##### **General**

All the equipments shall be tested at site to know their condition and to prove suitability for required performance.

The test indicated in following pages shall be conducted after installation. All tools, accessories and required instruments shall have to be arranged by Contractor. Any other test which is considered necessary by the manufacturer of the equipment, Contractor or mentioned in commissioning manual has to be conducted at site.

In addition to tests on individual equipment some tests/checks are to be conducted / observed from overall system point of view. Such checks are highlighted under miscellaneous tests but these shall not be limited to as indicated and shall be finalised with consultation of client before charging of the system.

The Contractor shall be responsible for satisfactory working of complete integrated system and guaranteed performance.

All checks and tests shall be conducted in the presence of client's representative and test results shall be submitted in six copies to client and one copy to Electrical Inspector. Test results shall be filled in proper Performa.

After clearance from Electrical Inspector system/ equipment shall be charged in step by step method.

Based on the test results clear cut observation shall be indicated by testing engineer with regard to suitability for charging of the equipment or reasons for not charging are to be brought by the Contractor.

### **Trial Run Test**

After the successful test of each equipment as per standard test procedure the entire control system shall be put on trial run test on actual site conditions and operation of the system.

### **Acceptance Test**

The acceptance test on the system shall be carried out by the supplier as per mutually agreed test procedures to establish satisfactorily functioning of the system as a whole and each equipment as part of the system.

### **05.02.03 Site Tests**

The tests to be carried out on the equipment at pre-commissioning stage shall include following but not limited to the following :

### **GENERATOR AND AUXILIARY SYSTEMS**

The tests listed below are to be carried out on each of the generator sets.

#### **Tests prior to initial run**

1. Insulation resistance of bearings
2. HV testing of RTD
3. Measurement of the insulation resistance and polarization index of the stator winding
4. Measurement of the insulation resistance of the field winding including slip rings
5. High potential DC test on stator winding
6. High potential DC test on field winding
7. Measurement of rotor impedance
8. DC resistance measurement of the stator winding
9. DC resistance measurement of the field winding
10. Preliminary test of all systems

#### **Tests after initial run, machine non-excited**

1. Bearing temperature measurement up to rated speed
2. Balancing of the rotor
3. Over speed test
4. Measurement of shaft / bearing vibration
5. Check for mechanical vibration on parts of the system

### **Electrical test after initial run and prior to synchronization**

1. Primary tests of generator protection
2. Short-circuit saturation curve, checking of current in all relays & meters.
3. Open-circuit saturation curve, checking of voltage in all relays & meters.
4. Phase sequence test
5. Measurement of the voltage-balance
6. Measurement of the shaft voltage
7. Shaft / bearing vibration measurement; generator excited
8. Synchronization tests

### **Generator cooling system**

1. Pressure tests on all pipe lines of cooling to/from filters
2. Operation check of cooling circuit with measurement of inlet/outlet temperature during temp. rise test.
3. Bearing temperatures (all bearings) during rated operation.
4. Start / stop sequence test; integrated operation of the plant

### **EXCITATION SYSTEM**

1. All checks for PMG and main exciters as per instruction manuals
2. AVR-operation including automatic follow up of manual regulator and auto change over
3. Response tests of excitation system
4. De-excitation circuit
5. Insulation test
6. High voltage test
7. Performance test at reduced voltage (to the extent possible)
8. Check operation of all devices & function of all units/sub units.
9. IR Test.

### **AVR**

1. Accuracy test
2. High voltage test
3. Performance test at reduced voltage
4. Manual channel followed by auto channel
5. Range of voltage adjustment test for both auto & manual channel
6. Performance test of all limiters
7. IR test

### **CONTROL, RELAY AND METERING AND SYNCHRONISATION PANELS**

1. IR value test by megger
2. Checking of control cable connection.
3. Operational test of all components mounted on control panel.
4. Testing and calibration of indicating meters
5. Testing of all relays including aux. relays for their pick up drop up values, operation at all taps (current, voltage and time) etc. as per the manufacturer's commissioning manuals with the help of relay testing kits.
6. Setting of relays as per approved setting table and checking its operation for one below and one upper settings, in the scheme.
7. Measurement of current and voltage in relay operating coils by secondary injection in CT and PT circuit at switchboard.
8. Measurement of current and voltage in relay and meter circuits during loading of the primary circuit/system
9. Testing of all schemes for their functions as per approved drawings

10. Checking stability of differential protection schemes
11. Checking inter changeability of similar equipments
12. Verification of accessibility of all operating points including resetting knob of relays
13. Check operation of annunciation facias, operation of bell/hooter etc. and sequence of system
14. Check operation of relays at minimum/maximum control voltage as per the specification
15. Integrated testing of protective relays for operation of master trip relays and tripping of breakers from operating of master trip relay
16. Check dressing of cables, sealing of openings in gland plate and for provision of double compression glands
17. Check earthing connection of panels, fixing of panels and openings from side and bottom.
18. Testing of energy/TVM meters and operation of recorders
19. Test working of recorders on failure of AC supply (if applicable)

#### **GENERATOR CURRENT TRANSFORMER AND OTHER CURRENT TRANSFORMERS**

1. Testing of CT polarity and CT ratio by primary injection test and CT characteristics.
2. Measurement of knee point voltage and secondary winding resistance for the CTs used.
3. IR test on each winding, winding to earth and between windings.
4. Continuity check for all windings.
5. Check for connections to correct taps.
6. Checking of continuity and IR values for cables from CT to Marshalling Box.
7. Checking tightness of earthing connections.
8. Check output after loading of the main circuit.

#### **GENERATOR POTENTIAL TRANSFORMER AND OTHER POTENTIAL TRANSFORMERS**

1. IR test of primary winding by HV megger between windings and earth
2. IR test of secondary winding by LV megger between windings and winding to earth
3. Checking of voltage ratio
4. Verification of terminal markings and polarity
5. Checking of continuity and IR values for cables from PT
6. Checking tightness of earthing connections
7. Check output on charging of the system with connected meters/relays

#### **HT TRANSFORMERS (GT & UAT)**

1. IR test on each winding to ground and between windings.
2. Turns ratio test on each tap
3. Polarity and vector group test
4. Measurement of winding resistance by Kelvin bridge
5. IR, wiring and operational tests on all control devices in control cabinet, oil level indicator, winding and oil temp. indicators etc.
6. Checking of earthing wrt transformer tank (flexible from top cover to tank) other parts, neutrals.
7. Testing of buchholz relay for alarm and trip conditions.
8. For bushing CTs, tests applicable shall be as for current transformers.
9. Setting of oil/winding temperature indicators, level gauge and checking of

alarm/trip circuits.

10. Checking of insulators for cracks
11. Checking for oil leakage and arresting of leakages (if there)
12. Checking of operation of all valves and cooling fans
13. Group run test and autostarting of cooling fans
14. Checking for open position for all the valves (except drain and filter valves)
15. Filtration of oil by using line filter, vacuum pump, and heater set.
16. BDV test on oil samples from top and bottom.
17. Checking of oil for acidity, water content, tan delta, etc as per IS 335
18. Measurement of magnetising current and no load loss.
19. Measurement of PI value.
20. Checking of silica gel breather.
21. Checking of noise level at no load and at full load.
22. Conducting magnetic balance test
23. Heat run test
24. Frequency response analysis
25. Checking of other points given in manufacturer's commissioning manual

#### **MCC/ACDB**

1. IR test before and after HV test.
2. HV test with 2.5 kV megger
3. Functional test for all feeders
4. Testing and calibration of all meters
5. Checking and calibration of overload relays and protective relays as per supplier's commissioning manuals.
6. Check operation of contactors from local and remote points
7. Checking of interlockings between incomers/bus coupler and other feeders.
8. Test to prove interchangeability of similar parts
9. Tests to prove correct operation of breakers at minimum and maximum specified control voltages
10. Checking of earthing connection for neutral-earth bus, cable armour, location of E/F CT etc. as per the scheme.
11. Check test, service and drawout position of all the breakers and operations of mechanical flag indicator and electrical indication lamps.
12. Check functioning of various elect. schemes like autochangeover signalling etc.
13. Breaker : IR value checking with breaker ON. Phase to phase & phase to earth and between phases in off position

#### **GENERATOR BUSDUCTS**

1. IR measurement before and after HV test
2. Checking tightness of bolts with torque wrench
3. Checking for phase sequence marking
4. Check for clearances between phase to phase and phase to earth
5. Check for minor damages/cracks in supporting insulators/bushings
6. Checking of bus-bar cracks on bends by DP method and rectification of same
7. Checking for inspection openings/accessibility for replacement of insulator etc.
8. Check tightness of earthing connections on enclosure
9. Checking of silica-gel breather
10. Checking of working of space heater (if there)
11. Hot air blowing to remove moisture if required.

## **BATTERY**

1. Checking for completion of civil/ventilation requirement of battery room.
2. Checking of adequacy of charger output/requirement wrt current required for battery charging as per the manual.
3. Check availability of safety devices, water and first aid box.
4. Check polarity of connections between battery and charger.
5. Visual inspection test for level and leakages.
6. Checking of layout as per approved drawing.
7. Checking of IR value from positive to earth and negative to earth.
8. Checking of voltage per cell and total voltage between positive negative and earth to positive/negative and also tap cell voltage (as applicable).
9. Checking of tightness of connectors on each cell.
10. Checking of capacity test and hourly measurement of specific gravity and cell voltage

## **BATTERY CHARGER**

1. IR test
2. HV test
3. Checking voltage ratio of boost and float mode transformers
4. Checking for charging mode of batteries, constant current and constant voltage mode.
5. Load test on chargers by running of DC drives and by liquid resistance system.
6. Checking of tightness of earthing connections.
7. Check for all alarm conditions.
8. Checking and calibration of all indicating meters.
9. Check functional operation of charger, auto/manual change over from float to boost and boost to float etc.
10. Checking and setting of all relays
11. Check AC ripple in boost and float mode after charging.
12. Check polarity of cables connected to battery.

## **CABLES & CABLE SUPPORTING STRUCTURES**

1. Checking of continuity/phasing and IR values for all the cables before and after HV test.
2. High pot test and measurement of leakage current after termination of cable kits (for HT cables) and after jointing work of straight through joints.
3. Checking of earth continuity for armour.
4. Check for mechanical protection of cables.
5. Check for identification (tag number system) distance placement of cable marker, cable joint etc. as per the cable layout drawing.
6. Check earthing of cable structures.
7. Check clearances from ventilation duct and light fittings for cable structures.
8. Check proper fixing of cable structures.
9. Check for proper drainage and removal of water for cable tunnels, basements, channels

## AC MOTORS

1. IR test of stator and rotor windings.
2. Ensure that checking/testing of associated switchboard, cables, relays /meter interlocks as mentioned in relevant chapters are completed.
3. Check tightness of cable connection
4. Winding resistance measurement of stator and rotor.
5. Checking continuity of winding.
6. Check tightness of earth connections.
7. Check space heaters and carryout heating of winding (if required)
8. Check direction of rotation in de-coupled condition during kick start
9. Measure no load current for all phases.
10. Measurement of temperature of body during no load and load conditions.
11. Check for tripping of motor from local/remote switches and from electrical/technological protection.
12. Checking of vibration
13. Checking of noise level
14. Shaft voltage measurement (if required)
15. Tan delta test, if required
16. During load running, measurement of stator and bearing temperatures (if applicable) for every half an hour interval till saturation comes.
17. Checking tightness of foundation bolts
18. Check operation of speed switch (if there)
19. Check continuity of temp. detectors.
20. Check alignment, paralleling of shafts, level of lubricating oil etc. as per manufacturer's manual
21. Check for polarisation index of stator winding, R10/R1 by motorised megger (The value should not be less than 2.0). R60/R10 absorption co-efficient shall not be less than 1.5.

## DC MOTORS

1. IR measurement and heating the winding as per heating curve.
2. Check for earth connection
3. Winding resistance for field and armature.
4. Check running of drive at minimum and maximum specified voltage
5. Check auto start of drive on failure of AC supply (if applicable)
6. Check operation of overload relay
7. Measure vibration
8. Check temperature rise on body of drive after required period of continuous running
9. Measure load currents and no load currents (if possible)
10. Check direction of rotation
11. Check continuity of winding.
12. Measurement of RPM.

## ELECTRICAL ACTUATOR

1. Visual and dimensional
2. IR and operation of limit switches
3. Winding resistance

## EARTHING & LIGHTNING PROTECTION

1. Check tightness of all earth connections



2. Check earthing of all metallic equipment, cable trays, busbar supporting structures, all elect. equipments, etc. as per the requirement of IE rules and IS 3043
3. Measurement of earth resistance for each electrode.
4. Measurement of total earth resistance.
5. Measurement of earth loop resistance for E/F path of biggest LT drive.

#### **UNINTERRUPTED POWER SUPPLY (UPS)**

1. Visual check
2. IR value by megger
3. Current limit test
4. Ripple test
5. Supply variation
6. Functional test
7. Capacity test wrt time

#### **NGR**

1. Measurement of resistance
2. IR test by HV megger between terminals and earth
3. Checking of earth connection for terminal and for body
4. Check for isolator operation and continuity of aux. contacts, if applicable
5. Check for temp rise of enclosure and current flow in the resistances

#### **ESP**

1. Check for TR sets (as per transformers and instruction manuals)
2. Check for controllers (as per instruction manuals)
3. Check for insulator cracks
4. Check for ACPs (as per MCCs)

#### **ILLUMINATION**

1. Lux level measurement in each area/premise
2. Test for black spot, if any
3. Check operation of AC and DC emergency lighting
4. Checking of transformers

#### **MISCELLANEOUS**

1. Checking of continuity of the system
2. Checking of phase sequence between two sources of HT/LT switchboard/MCC/ACDB
3. Checking safe accessibility of all operating points
4. Check availability of DC emergency lighting
5. Check availability of control/aux. supply
6. Ensure availability of first aid box, rubber mats, rubber glove, etc.
7. Check working of exhaust fans
8. Check for safe movement of operators to control room, HT SWGR, LT SWGR, MCC, drives, valves, cable gallery etc. w.r.t. proper illumination, escape light, uncovered openings, etc
9. Placement of shock treatment chart, danger boards, provision of boards indicating 'Man on Work, Do not switch ON', 'Do not switch OFF', 'EARTHED' etc.
10. Check proper dressing of cables, mechanical protection of cables, placement of cable markers
11. Check sealing of all cable openings including conduit opening with fire resistance material

12. Check sealing of all openings at bottom of elect. panels.

## 07.00 DRAWINGS/DOCUMENT TO BE SUBMITTED BY THE CONTRACTOR

### Drawings /Data along with tender

All schematic drawings related with following schemes to be composite in nature thereby clearly indicating all inter connections in one layout.

- a) Generator control desk, synchronization, circuit breakers scheme, relay and protection
- b) Tie-lines, control desk, synchronization, circuit breakers scheme, relay and protection.
- c) Auxiliary transformers, LT MCC, soft starters, control panels.
- d) DCS, MCC control panel/backup panel.

1. Detailed scope of work with general description of the system & equipment offered specifying the important features and detailed design criteria and design philosophy including full details of reference data, assumptions, etc.
2. Description to be accompanied by single line diagrams and equipment layout to enable Employer to have proper appreciation of equipment offered and its operation.
3. Bill of Quantities ( un-priced ) in specified format, with division list of supplies from foreign and indigenous sources.
4. Specific exclusions, if any, from scope of work.
5. List of deviations from technical specifications,
6. Equipment wise List of commissioning spares and consumables with item wise description and quantity included in the main offer.
7. List of 2 years operation spares, recommended by the Contractor equipment wise (un-priced), in addition to the spares asked by the Employer, if any. The list shall indicate description and quantity for each item.
8. List of special tools and tackles, test jigs and special instruments required for operation and maintenance of equipment. For all other electrical equipment, individual list of special tools and accessories required is to be furnished for each item.
9. Work Schedule with bar chart indicating all activities for generator and electrics.
10. Phase-wise construction power requirements for erection / testing activities.
11. Questionnaire as asked, duly filled-in.
12. Capacity of UPS & DC system offered
13. Reference list of similar jobs carried out on generators, excitation systems & electrics
14. Dimensional details & weights of each equipment offered (tentative)
15. Filled up questionnaire

### Technical Data to be submitted with tender

- 1) Unit wise list of HT motors with ratings (working+stand-by)
- 2) No., name of capacity of switchboard, MCCs/DBs considered
- 3) List of HT and LT drives of each switchboard/MCC alongwith single line diagrams
- 4) List of H and LT drives with kW rating (working+stand by).

- 5) Connected load and Maximum demand of each section of switchboard/MCC.
- 6) List of performance tests proposed by the Contractor to demonstrate the guaranteed parameters for generator and other electrical equipment.
- 7) Specific energy consumption, maximum demand and annual energy consumption.
- 8) Type test certificates for major categories of equipment, issued by independent testing authority.
- 9) Technical catalogues of major equipment offered.
- 10) Services to be provided by owner at battery limit with specifications.

#### **Data/Drawings to be submitted by supplier after placement of order**

The Contractor shall furnish the following documents / data in soft copy and specified number of hard copies for approval. On approval, the same shall be supplied as soft copies in CDs, in addition to specified number of hard copies.

#### **General**

1. Name of co-ordinators with address, telephone/Fax numbers for all sub-Contractors, pertaining to electrical job.
2. List of equipment/tools and manpower proposed to be arranged for installation erection and site handling of the equipment.
3. **Name of site-in-charge with office/organisation and date of opening of site office.**
4. Quality control manuals
5. Detailed list of drawings and documents containing information on current state of the project.
6. Monthly progress report furnishing status of
  - a. Planning
  - b. Manufacture
  - c. Transport
  - d. Erection
  - e. Testing & commissioning

#### **A.**

#### **For Approval**

#### **Calculations**

1. Sizing of all equipment within 4 weeks of placement of order
2. Calculations for voltage drop and short time rating of cables
3. Relay settings with calculations and protection coordination charts.
4. Calculations to prove lux level of illumination for various premises/area of the plant.
5. Capacity calculation of UPS.
6. Capacity calculation of Battery and charger
7. Calculation w.r.t. generator busduct sizing, temp rise and insulator spacing.
8. Calculations for short time withstand of transformers.

#### **Drawings and documents**

1. Single line diagram indicating all electrical equipment like CT, meters, cable sizes, details of CT ratio, VA burden  $V_k$  value, type and nominal and short time ratings of breakers, busbars etc. for complete network (composite drawing).

2. Single line diagram of each MCC/DB, etc indicating drive, feeder details, protection, metering and control elements.
3. GA arrangement drawing showing busbar equipment mounting arrangement and dimensions of the MCC/DB.
4. Control schematics/philosophy with all interlock details and bill of materials.
5. Foundation plan and fixing details for each equipment
6. Type test reports for short ckt, temp. rise, enclosure class etc.
7. Generator busducts layout drawing.
8. Equipment Layout drawing for all areas in battery limit.
9. Drawing marking phase sequence from transformer to switchgear.
10. Cable tray layout
11. GA drawing for each all HT transformers (GT & UAT).
12. Technical data sheet for each HT transformer (GT & UAT)
13. Data sheets and characteristic curves of all equipment.
14. Front view and GA diagrams for all Control panel, LDB/SLDB, PDB, ACDB, DCDB, aux. ACDB and aux. DCDB.
15. Control schematics for annunciation points, fan cooling system, OLTC operation for GT & UAT.
16. Earthing layout drawing covering external grid internal/external rings and connections to equipment, structures etc.
17. Sequence of annunciator and list of annunciation points for the control panel.
18. Lighting layout for each of switchyard and plant outdoor areas, type of fittings, wiring arrangement, switching of fittings and single line diagram.
19. List of drawings, numbering system, size, proposed date of submission (To be submitted just after LOI)
20. Sequence of inspection plan and dispatch of materials to site.
21. List of electrical inputs/outputs to/from DDCMIS
22. List of performance tests proposed by the Contractor to demonstrate the guaranteed parameters.
23. Terminal plan of all feeders of MCCs/DBs
24. Quality Assurance plan for each equipment
25. Termination arrangement of bus duct
26. Switchboard/MCC wise drive list
27. Data sheets and characteristic curves of all equipment.F
28. Control and schematics drgs. for local/remote control/ protection for each equipment and drives.
29. Logic diagrams for start/stop of various mechanism/drives.
30. Interlocking schemes
31. Details of protection logic (various class tripping) indicating list of electrical and mechanical protection leading to tripping of switching devices/equipment.
32. Synchronisation schemes.
33. Battery and charger schemes.
34. Layout of electrical premises and bus ducts.
35. Cable tray layout
36. Earthing layout drawing covering external grid internal/external rings and connections to equipment, structures etc.
37. Generator auxiliaries P&I diagrams
38. Auto change over arrangement for HT/LT switchboard/MCCs
39. Sequence of annunciation and list of annunciation points for all the panels/desk of each areas.
40. Technical data sheet for each equipment

41. Complete schematic diagram of UPS systems
42. Complete schematic diagram of DC systems
43. Complete schematic diagrams of electrical actuators
44. Complete protection scheme for the unit
45. Complete annunciations scheme for the unit
46. Complete GA drawings, schematic drawings, wiring diagram and drawing of each and every components of excitation system
47. Quality Assurance Plan
48. Technical specification of generator.

#### **For Information**

##### **Within 4 weeks of order placement**

1. Exact dimensional details and weights of each and every equipment
2. Static & dynamic loading of each equipment, Flange details of Bus duct termination

##### **During detailed engineering**

1. **Details of painting for all equipment**
2. Panel-wise bill of material indicating type make and brief technical particulars of all items/ accessories mounted on the panels
2. /signal/annunciation control panels/switch boards/Local Control device/ I/O panels.
3. Cable indicating type of cables, from to via. route, total length, size of each cable and a final summary sheet indicating total requirement of all types of cables (for control, instrumentation). Core-wise control cable termination details indicating ferrule no./ terminal block no. for each cable / each equipment.
4. Internal wiring diagrams for all panels.
5. Catalogues for each type of equipment like transformers, control panels, relays, meters etc.
6. VI characteristics of and RCT value of CTs used in differential protection
7. Type test certificates for all the equipment.
8. Copies of test results conducted at works for all equipment
9. Details of test results conducted at site for all equipment
10. Installation and commissioning manuals for each equipment / devices.
11. Operation and maintenance manuals indicating trouble-shooting procedure for all equipment.
12. Spare part list number and ordering procedure for all recommended spares.
13. Details of transport arrangement and maximum size of transportable section (weight and overall dimensions) for electrical equipment.
14. Details of agency proposed to be fixed for doing erection, testing and commissioning job.
15. Overall GA of all the panels/equipment
16. As built drawings incorporating site changes along with reproducible as well as in electronic form in CDROM/DVDROM.
17. All the type test certificates, routine test certificates and site test results bound separately in requisite copies.

#### **Instruction Manuals**

Minimum ten copies of Instruction manual shall be furnished by the Contractor in addition to soft copy in CDROMs/DVDROMs.

**Instruction manual shall give step by step procedure for:**

- 1 Erection, testing and commissioning
- 2 Operation
- 3 Maintenance and
- 4 Repair.

**Maintenance instruction shall include:**

- 1 Diagnostic trouble shooting / fault location charts
- 2 Tests for checking of proper functioning.

**Instruction manual shall also contain:**

1. Manufacturer's catalogues with ordering specification for all items.
2. List of consumables with specifications, brand names and annual consumption figures.
3. Drawings relevant for erection, operation, maintenance and repair of the equipment.
4. Procedure for erection, storage, welding technique, material for construction, instrumentation, limits and tolerances, alignment, structures etc.
5. Procedure for ordering spares.
6. Operation and maintenance manual.
7. Quality manual covering quality related aspects and As Built Status.
8. List of spares supplied with individual equipment
9. As built drawings incorporating all changes till handing over the installation to the Owner.

## **08.00 LIST OF PREFERRED MAKES**

The list of preferred makes shall be as per GTS. For items not indicated in the GTS, Contractor shall have to obtain approval from the Employer.

**For Generator: ABB, Siemens, BHEL, Brush, Kawasaki, Toshiba, TDPL.**