



BHARAT HEAVY ELECTRICALS LIMITED

TRANSMISSION BUSINESS HVDC ENGINEERING & SYSTEMS

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SECTION - 1

Intent, Design criteria, System design and scope

1.1 Intent of specification

- 1.1.1 This specification is intended to specify the requirements for design, engineering, manufacture, assembly, stage testing, inspection, testing before supply, packing, forwarding, delivery at site, (unloading & storage at site is excluded from vendor's scope) complete erection of all equipment and accessories, testing of the system, trial run, commissioning of the system, final painting and carrying out acceptance test at site of **Oil Handling System** along with its accessories and auxiliary equipments / instruments etc. as mentioned in this section and in various other sections of this specification for **±800kV, 6000MW HVDC Raigarh – Pugalur Terminals** HVDC System Package of Power Grid Corporation of India Limited (POWERGRID).
- 1.1.2 The requirements specified under SECTION 2 and SECTION 3, of the specification shall be considered as part of this section. In case of variance between various sections, the requirements of Section 1 shall prevail.
- 1.1.3 It is not the intent to specify herein all the details of design and manufacture. However, the equipment shall conform in all respect to high standards of design, engineering and workmanship and shall be capable of performing the required duties in a manner acceptable to Purchaser / Owner, who will interpret the meaning of drawings and specifications and shall be entitled to reject any work or material, which in his/their judgment is not in full accordance with the specifications.
- 1.1.4 The bidder shall be deemed to have understood completely all the tender drawings and documents and quoted accordingly. Contract shall be on lump sum basis for the package. Within the scope of the contract, no variation shall be admissible to Contractor so far the inputs remain unchanged.
- 1.1.5 This specification makes it obligatory for the contractor to arrange / obtain necessary approval / clearance from statutory organizations wherever applicable for the plant / machinery / sub-systems under the scope specified



1.1.6 The system shall be designed to suit the extreme of outside conditions as given in “Section 3” of the specification.

1.1.7 The term ‘Owner’ appearing in this specification shall refer to Power Grid Corporation of India Limited (POWERGRID), the term ‘Purchaser’ shall refer to Bharat Heavy Electricals Limited (BHEL) and the term ‘Contractor’ shall refer to the successful Bidder.

1.2 Introduction

1.2.1 Oil Handling System shall comprise of following:

- i. **Ultra-High Vacuum type Transformer Oil Filtration plant of minimum 10000 LPH capacity** & shall be for outdoor services entirely self-contained, completely weather proof and shall be of mobile design complete with pneumatic tyre wheels with spring under the heavy base steel frame and tow bar suitable for rolling the machine on ground / along public roads. This shall also be fitted with over run brakes. The purification of oil required in case of Transformer/Reactors shall be by circulating the oil through vacuum filtration & purification machine. The machine shall be rested on manual screw jacks of adequate quantity & size.

The equipment shall be in a weather proof sheet steel enclosure and mounted on a trailer to be moved on roadway within the station. The enclosure is to be insulated and ventilated such that the plant can be operated at ambient temperatures of 0°C to 50°C. The plant has to be fully automatic and suitable for continuous operation.

- ii. A **Dry Air generator**- The plant shall be able to supply the necessary dry air for purging the tanks, releasing vacuum and performing tests on the tanks to check for leaks.
- iii. A **mobile oil tank of 15 kL** capacity with partition and **5 kL mobile tank** for loading/unloading of oil from drums shall also be provided.



1.3 Design Criteria

- i. Treated Oil shall acquire following characteristics after circulating through fully operational filter plant:

Table 0-1 Table for Oil Properties

Oil Properties	Before Treatment	After Treatment
		1 st Pass
Moisture Content (ppm.)	100	3 (maximum)
Dissolved Gases (% by Volume)	10	0.1 (maximum)
Dielectric Strength (kV)	20	70 (minimum)
Filtration Degree	--	0.5 micron (or less)

- ii. The weight of oil and volume of oil in converter transformer is approx. 127,000 Kg and 145,630 Lt. respectively.
- iii. During processing, Oil temperature shall be in the range of 40 to 80 °C. and processing temperature shall be automatically controlled. The vacuum level in the De-gassing chamber in single pass at rated flow at final stage shall not more than 0.15 torr/0.2m bar. Machine shall have a minimum of two (2) degassing chambers.
- iv. The plant shall also have an independent vacuum pumping system for evacuating / vacuum filling of oil in Transformer. The blank off vacuum for each pumping system shall be 10^{-3} torr. One additional vacuum measuring instrument with all accessories shall be supplied separately.



- v. The independent vacuum pump would be provided for creating and holding the transformer /reactor under vacuum for vacuum drying of windings and filling when required.
- vi. Vacuum level required for transformer evacuation for the purpose of oil filling is 0.76 torr (1m bar) for transformer oil heated up to 70-80 °C.
- vii. The Oil treatment plant shall be fitted with hoses for connection of oil lines and vacuum lines to transformers and reactors. The hoses shall not have a leakage rate exceeding 1torr liter/sec. Hose pipes for oil service shall be suitable for transformer oil application up to temperatures of 100°C, full vacuum and pressure up to 2.5 kg/cm². Trailer also shall be capable of accommodating these hoses and cable during transport in station.
- viii. The plant shall be suitable for cleaning and de-gassing of oil stored in storage tanks too.
- ix. An indicating panel with indicating lights showing which equipment are running is to be provided.
- x. In case of Heaters, to ensure that no overheating / localized heating occurs, the density of heat in the heater tank shall not exceed 2W/cm².
- xi. The dry air generator plant shall be mobile, automatic and designed to generate dry air to feed under pressure as heatless dryer. Suitable instrument along with accessories shall be provided to measure the dew point.

1.4 Scope of supply

The scope of the work under the contract shall be deemed to include all such items, which although not specifically mentioned in the bid documents and/or in the bidder's proposal, but are required to make the equipment/ system complete for its safe, efficient, reliable and trouble free operation.

Two sets of Oil Handling Systems (One each for Raigarh & Pugalur) are covered under the scope of supply. Each set shall be consisting of following:



1.4.1 Main Equipment

- (i) One **(1)** set, **10000 LPH capacity Ultra High Vacuum type oil filtration plant** complete with
- a. **2 X 100 % oil re-circulation pumps** of adequate capacity. One shall be working while the other shall be standby.
 - b. One **(1)** No. **Heater tank** containing three stage heating facility suitable for heating up incoming oil to desired temperatures before de-gasification.
 - c. One **(1)** Set of a suitable combination of **Roots blower and Rotary vane vacuum pump** with **inter-stage condensing units** to achieve desired level of High vacuum in the de-gassing chamber.
 - d. One **(1)** No. Self-priming type **outlet pump** suitable for supplying oil to the transformer/ reactor.
 - e. One **(1)** Set of **pipings** with accessories for interconnecting both independent vacuum systems and for operating the plant.
 - f. One **(1)** Set of suitable **cooling arrangement** for the plant.
 - g. One **(1)** Set of **Hoses** for the following operations
 - Oil Suction
 - Oil Discharge
 - Transformer vacuum connection
 - Compressed Air supply

The vacuum and oil hoses of sufficient length to reach between the oil system and transformer connections shall be supplied with plant

- h. One (1) no. **Control cum Annunciation panel** with the following minimum annunciation / alarms (audio / video)
- High temperature at heater outlet.
 - High differential pressure across filters.
 - Oil pump-1 trip.
 - Oil pump –2 trip.
 - Vacuum pump –1 trip.
 - Vacuum Pump-2 trip.
 - Loss of vacuum in degassing chamber.



- Loss of vacuum in transformer evacuation line.
 - No oil flow through heater.
 - High oil level in de- gasser.
 - Cooling Water pump trip.
- i. One (1) Set of **Transformer evacuation system** complete with Roots & Rotary vacuum pumps and accessories.
- j. One (1) set of **instruments** constituting the following minimum of requirement:
- i. Compound gauge at oil pump discharge.
 - ii. Compound gauge at filter inlet.
 - iii. Compound gauge at filter outlet.
 - iv. Pressure gauge at discharge pump outlet.
 - v. Pressure gauge at compressor outlet.
 - vi. Pressure gauge at air receiver.
 - vii. Pressure gauge at de-gassifier.
 - viii. Vacuum gauge at transformer evacuation line.
 - ix. Vacuum gauge in between roots vacuum pump & rotary vane vacuum pump
 - x. Panel mounted vacuum indicators at de-gassifier.
 - xi. Panel mounted vacuum indicators at transformer evacuating line.
 - xii. Sight glass at de-gassifier.
 - xiii. Temperature indicator cum controller at heater inlet.
 - xiv. Temperature indicator cum controller at heater outlet.
 - xv. Voltmeter.
 - xvi. Oil flow meter (positive displacement type.)
 - xvii. Ammeter.

In addition to the above whatever necessary instruments (Float switch, dial thermometers etc) as may be required for system design and smooth / efficient functioning of plant in line with description as given in clause 1.2, but not specifically mentioned herein, shall also be supplied by the bidder at no extra cost to the Purchaser. Such items shall be clearly brought out in the offer.

- k. One (1) set of miscellaneous valves/magnetic strainer/Filter press/Oil Flow meter/Flow switch/Pressure switches/Panel mounted vacuum measuring device for de-gassing chamber/vacuum gauges for vacuum lines/regulation and safety thermostats/thermometers etc and other minor items required for desired operation of the purification plant.
- l. Suitable length of power cable to reach the power points installed for this purpose on or adjacent to the transformers and other units requiring treatment shall be supplied with treatment plant



- m. One (1) lot of all **chemicals and consumables** required for commissioning of oil filled equipments i.e. Transformers / Reactors at the station.
- n. The contractor shall also supply the **first fill of lubricants** for the equipment under the scope.
- o. One **(1)** No. **Dry air** generator for transformer leak testing and purging complete with air compressor receiver and drying unit. Suitable instrument along with accessories shall be provided to measure the dew point.
- p. One **(1)** No. **mobile type Oil storage tank of 15 KL capacity with partition and one no. 5kL mobile tank for loading / unloading of oil from drums.**

1.4.2 Tools & Tackles

One complete set of tools, tackles and other minor items required for maintenance / upkeep and overhaul of the plant and also for replacement of various equipment/components at each site viz. Raigarh & Pugalur shall be supplied under this contract.

1.4.3 Spares

Filter Cartridges	1 Set at each site
Heater Element	1 Set at each site
O rings / Gaskets	1 Set at each site

1.5 Scope of Services

- 1.5.1 The scope of services includes commissioning of the system, conducting performance test to the satisfaction of the owner/purchaser and handing over of the fully operational system to the Owner/ purchaser.
- 1.5.2 It is the responsibility of the supplier to train at least two (2) site engineers of Purchaser/Owner in efficient handling of the plant. Handing over of the plant shall be deemed complete only upon certification from Purchaser/Owner to this effect.
- 1.5.3 The bidder shall ensure that sufficient quantities of commissioning spares are made available for timely completion of commissioning of the system. The bidder shall furnish a list of commissioning spares that shall be brought by him. The unused commissioning spares shall be returnable to the bidder.
- 1.5.4 After commissioning of the transformers and reactors the filtration plant shall be completely refurbished by the contractor for future use by the employer



and handed over to the purchaser/ owner. The scope of refurbishing shall include:

- 1 Functional checking of the plant.
 - 2 Supply and refitting at site of any damaged part of plant, which may require replacement such as gaskets, 'O' rings, Cartridge filter element, Filter press, Oil hoses, Vacuum hoses.
 - 3 Touch up painting of the plant.
 - 4 Submission of a detailed list of sub-supplier(s)'s/ dealer(s)'s addresses for various spare parts purchase. The addresses mentioned therein should be preferably be of the same place (region) or of nearby places for the convenience of the Owner.
- 1.5.5 During commissioning and at the time of refurbishing the plant the contractor shall bring his own tools and tackles (on returnable basis) which may be required for maintenance, overhaul, and replacement of various equipment/components to be supplied under this contract.

1.6 Approval of documents

1.6.1 Quality Plan

Quality plans have to be submitted to purchaser. These shall be approved by Purchaser/owner.

1.6.2 Field Quality Plan

Contractor shall submit the field quality plan for approval of Purchaser / Owner. Various checks required beginning receipt & storing of material to commissioning of system shall be mentioned in field quality plan.

1.6.3 Drawings and Data Sheets

- 1.6.3.1 Drawings / Technical Datasheets have to be submitted to purchaser. These shall be approved by purchaser/owner.
- 1.6.3.2 Bidder to furnish detailed calculations to establish the size, and capabilities of vacuum pumping system with respect to moisture and gas removal as desired in design criterion.
- 1.6.3.3 Schematic diagram of the oil filtration plant showing all the components.



- 1.6.3.4 Outline drawings indicating the principal dimensions and weight of the plant.
- 1.6.3.5 Technical data sheets for all major components with characteristic curves of the pumps showing total dynamic head, pump input power, efficiency and NPSH against capacity ranging from shut off to 125% of rated capacity.
- 1.6.3.6 Diagram showing the type of lubrication system, cooling system etc.
- 1.6.3.7 Complete descriptive and illustrated literature on the plant being supplied.
- 1.6.3.8 Design calculations.
- 1.6.3.9 Complete illustrative description with salient features and operating / troubleshooting instructions.

1.7 Inspection

Inspection call shall be given to purchaser. Inspection shall be carried out by purchaser/owner. Refer TB-391-316-000, “General technical requirements” (Section -3)

1.8 Delivery

Delivery dates as per L2 schedule.

1.9 Performance Guarantee

The contractor shall give guarantee of satisfactory and safe operation of the equipment / systems for One (1) year after complete commissioning and refurbishment of the plant.

SECTION 2

Equipment Specification

2.1 Oil Treatment Plant

- 2.1.1 The plant shall be suitable for treatment of new oil (as per IEC 60296 / IS 335) and reconditioning / servicing of used oil (as per IS 1866 / IEC 60422 for Oil in service) in **EHV Class** of HVDC Converter Transformers, shunt reactors and other type of oil filled equipment. At rated capacity this plant shall be capable of achieving desired properties of treated oil.



2.1.2 Except as modified by this specification, all equipment and instruments shall comply with the latest relevant national / international standard viz. IS, IEC, VDE, BS, ASIM etc. on the subject and the reference of standard shall be clearly indicated by the bidder in their offer.

2.1.3 All components of the plant shall have adequate strength and rigidity to withstand normal conditions of handling transport and usage. The Purification System will be fully assembled on heavy-duty steel base, which will be sufficiently braced to minimize vibration. A Drip Lip will be provided on the base to collect spillage & drippage.

2.1.4 The plant shall be suitable for carrying out the following operations:

- (i) Degassing, dehydrating and filtering of transformer oil under vacuum and to give required guaranteed parameters in a single pass of oil at rated flow.
- (ii) Evacuation of Converter Transformers and shunt reactors filled with Nitrogen gas for protection during shipping or land transportation simultaneous to the oil treatment under high vacuum.
- (iii) Filling of treated oil into Transformer / Reactor tank under high vacuum with the help of the plant.
- (iv) Completely evacuating oil from the Transformer / Reactor Tanks requiring drying out of insulation and to carry out drying procedure of insulation by Evacuating Transformer / Reactors Tank and by filling hot oil into the Tanks to effect continuous circulation with rated through put capacity continuously till the parameters are achieved.
- (v) The plant should be adaptable to spray the oil into the Transformer being dried out, as per clause (iv) above, to effect quick drying of insulation.
- (vi) The plant must also be capable to treat oil of Transformers / Reactors which are in service as the old / used oil has higher acidity and low interfacial tension. The degree of vacuum required is much higher than what is required for new oils. It is the most important function of the oil filtration plant to treat such oils and to give required guaranteed parameters in a single pass.

2.2 Operation

The insulating oil in the Transformer / Reactor tank shall be filled under high vacuum. The insulating oil to be filled in the tank shall be treated in the thermostatically controlled indirect type of heater up to 40-60 °C by an auxiliary fluid or any other suitable arrangement thus eliminating over heating or localize heating of oil. This preheated oil shall then be passed through ultra-filter working on effective and tested method of removal of solid impurities generally present in the transformer oil. It will also be subjected to vacuum at treatment in vacuum chambers having adequate vacuum at temperature at 60



°C of oil for removing dissolved moisture and gases. The separation of dissolved impurities shall be carried out under vacuum. This oil after purification in the vacuum chambers shall be pumped through a discharge pump with high suction and discharge into Transformer / Reactor tank.

2.3 Equipment Details

2.3.1 Inlet Pumps:

Electrically driven pumps of suitable capacity shall be provided for suction of oil for treatment to the filtration and purification machine. These pumps shall be single stage positive displacement gear type with suitable mechanical seals to ensure vacuum tightness. A built in pressure relief valve to re-circulate the oil to suction side in case of accidental pressure rise shall be provided. Suction lift of the pump shall be at least 5 meters of transformer oil at atmospheric temperature and pressure. It shall also have a bypass line with separate common bypass valve duly complete with lockable arrangement so that the flow rate through the filter can be adjusted as required. One gear pump of similar capacity with isolation valve shall also be provided in parallel to the first pump. The pump should be suitable for continuous operation of the machine and it shall be provided with an automatic arrangement through flow switch and a time delay circuit to stop the pump automatically in the event when the oil flow is not present during this delayed time of about 30 seconds thereby ensuring that the equipment will not operate without oil supply. Alternatively interlocking between the heater and the inlet pump may be provided in order to stop the pump when there is no oil flow through the heater and subsequently heater shall not be energized unless the oil is actually flowing. In this case flow will not be necessary before the heater.

2.3.2 Preliminary Filter with Magnetic strainer :

One coarse filter shall be provided before the inlet pump to prevent entering particles of any appreciable size into the system. This shall be connected to the suction of inlet pump. The incoming oil shall first pass through this filter/strainer. This shall be to prevent magnetic particles going into transformer with oil.

2.3.3 Heater Tank:

An oil heater of adequate capacity for heating up incoming oil shall be provided at the discharge side of inlet pumps.

The Heater vessel shall be of MS welded construction and thermally insulated with glass wool insulation. Electric heaters shall be provided in the heater vessel to heat up oil from lowest ambient temperatures to temperatures required for filtration/de-gasification operations in a single pass.



Electric heaters shall have indirect heating facility and their design should be such that overheating or localized heating is eliminated. It shall be possible to remove or replace the heater elements without disturbing the oil in the heating chamber. The total heating capacity shall be divided into three independent thermostatically controlled heating stages evenly balancing the three phases of power supply. The control switches and knobs shall be housed on a control panel.

Electrical heater elements shall be suitably designed for partial or full operation through a control arrangement in order to facilitate Transformer drying also through heated oil up to temperature of 90 °C. This shall be thermostatically controlled so that the temperature of oil during treatment of Transformer oil should not rise higher than 60 °C. The heating system shall be provided with a proportioning thermostat with indication to control the heating elements to maintain the desired oil temperature. This thermostat should be capable of activating the heater contactors through a series of time delay relays, on deviation from set point, which in turn will energize the required number of heating elements to return the oil temperature to the set point. On seeing this set point the elements should de-energise step by step through a time delay sequence.

An additional preset tamper proof safety thermostat set at the temperature little higher than the set point of first one as protection to safeguard malfunctioning of former thermostat. The readings of both thermostats should be visible from outside box.

The electrical switching of the heater shall be by suitable switches provided on main panel of the machine. The flow switch should be provided before the heater and an interlocking arrangement between heater and flow switch shall be provided so that heater should not be energized unless oil is flowing.

The heater body shall be so designed as to allow replacement of heating elements without draining the oil. Suitable pressure relief valve, vent and drain valves and two (2) dial type temperature gauges at inlet and outlet of heater shall be provided. The heater groups are to be interlocked with inlet pump (gear pump) i. e., unless the inlet pump is started, heaters cannot be switched ON.

Following shall also be provided with the heating system

1. Two number dial type thermometer to indicate temperature of inlet and outlet of heater.
2. Safety valve aeration valve and drainage valve.
3. Over heat protection with sound alarm to prevent damage to the oil due to overheating of the heater for any reason. The bidder shall submit heater power calculations justifying heating capacity offered.



2.3.4 Filter :

The filter body shall be fabricated of mild steel and shall be designed for leak tightness at full vacuum and high pressure. The oil shall flow from dirty oil chamber to clean oil chamber through the filter elements.

Cartridge elements used shall be suitable for transformer oil service and sub-micron filtration. The media shall be non-hygroscopic throwaway type cartridge filters of 0.5 micron rating, and of high dirt holding capacity, suitable for minimum 10000 LPH capacity. The filter shall be capable of removing 99% of all particles of 0.5 micron in size or larger.

The filter elements shall be easily removable for replacement when required. Compound gauge to indicate pressure across the filter, aeration, vent and drain valves and other accessories shall be mounted on the filter.

2.3.5 Filter Press :

For treating dirty oil, filter press of adequate rating is to be supplied for supplementing the capacity of Filter elements. These units should be designed for quick and easy replacement of filter media. A sludge outlet for receiving the solid impurities and cleaning the filter plate without opening the unit shall be provided. The unit shall also be provided with vent and drain valves, pressure gauge at inlet and outlet and other necessary accessories.

While passing the oil through the cartridge filter, oil should be passed through the filter press first and then through the cartridge filter. This would increase the life of filter elements. The bidder shall indicate the number of hours for which one set of cartridge type filters will be able to serve as per performance criteria as per general technical particulars. The rate for these filters shall also be given as per general technical particulars. Necessary arrangement shall be made to isolate the filter press from the oil line whenever it is so needed. Suitable arrangements with valves shall be provided to bypass the filtration system if and when required.

2.3.6 Degassing Chamber :

It shall be two stage sealed type and made up of fabricated mild steel sheet and should be of welded construction. The fill of raschig rings and trays for distribution shall be designed for efficient distribution of oil over large surface area.

The de gassing chamber shall be two staged, suitable for ensuring the desired oil properties. Arrangement for condensing lighter fractions (Aromatics) of the insulating oil shall be provided wherever required.

The degassing chamber shall have adequate height to allow long enough free fall



for complete de gassing. Design shall be such as to minimize foam formation. The de gassing chamber shall be provided with suitable level monitor for oil or foam level in the chamber and shall trip the inlet gear pump when the level rises above the desired maximum level in order to prevent foam / oil to enter the vacuum pumping system. When the oil reaches preset low level position the inlet pumps shall automatically start. Similarly discharge pump shall stop automatically when oil reaches low level. This is to prevent discharge pump running dry.

Adequately illuminated sight glass shall be provided through which oil flow in the de-gassifier can be viewed clearly. The de-gassifier shall be provided with vacuum gauges, vacuum breaking valves, oil drain valve, and main and auxiliary vacuum connections and other accessories. It shall be ensured that no leakage is from the vacuum break valve and the valves are not vigorously tightened. The main vacuum connection shall permit the use of the processing chamber, to act as a large trap when Transformers / Reactors is over filled and oil is drawn in to the vacuum line. An adequate control system shall be provided to stop the inlet pump. A sound alarm shall also be provided to give indication of this fact to the operator. The auxiliary vacuum connection shall provide a direct connection to the vacuum pump.

2.3.7 Vacuum Pumping System :

The plant shall be provided with two independent sets of vacuum pumps combinations for continuous duty, one pump combination creates vacuum in the degassing chambers of the plant and the other for purpose of evacuating Transformer / Reactor tanks for maintaining vacuum in them while oil is being treated by the plant. A combination of Roots blower and Rotary vane vacuum pump shall be provided. The capacity for each vacuum pump will be finalized during detailed engineering.

The Roots Blowers shall be of reputed make, suitable built-in labyrinth packing system, slinger rings, oil return chambers shall be provided between bearings and working chambers to prevent penetration of lubricating oil to the working chamber. The pump-motor set shall be dynamically balanced. The pumps shall be suitable for starting evacuation from atmospheric pressure and shall be supplied with necessary overflow valve.

The Rotary Vane Vacuum Pumps shall be installed after the Roots Blower. *An automatic by-pass valve across the roots blower shall permit operation of rotary vane pump alone to operate when so required.* The rotary vane pumps are provided with gas ballast valve to prevent contamination of vacuum pump oil with moisture. The vacuum pump shall also be provided with *suitable non-return valve device* such that in the event of power failure the vacuum in the degassing chamber shall be maintained and the *vacuum pump oil is not sucked back into the degassing chamber*. A high vacuum safety valve to prevent back streaming of oil and air intrusion shall be provided. The pump motors shall have return stop device.



For effective cooling, these pump combinations shall be adequately cooled through water jacket and radiator with a fan to take care of the tropical climatic conditions with high humidity in which the plant has to work in the field. Necessary water cooled condensing units to condense the lighter fractions (Aromatic) and return the same to the transformer oil shall be provided to reduce the loss of aromatics. Push buttons for starting / stopping the rotary pumps and selector switches to allow operation of the rotary pump without roots blower shall be provided. All necessary protections against over temperature of lubricating oil shall be provided.

2.3.8 Vacuum Pumping System for Transformer Evacuation:

An independent vacuum pumping system shall be provided for evacuating the transformer for oil filling. The design should be such as to ensure a pressure of 0.10 Kpa [0.76 torrs / 1 mBar] during transfer of oil into transformer at 70-80°C. The duration of evacuating the transformer oil shall not exceed one hour fifteen minutes (75 Min.). Vacuum rating of pumping system and capacity shall be adequate for meeting above parameters. The construction of the pump system consisting of a Roots Rotary combination of pumps shall be same as specified for de-gasser vacuum system.

2.3.9 Oil Extraction Pump :

Suitable pumping system shall be provided for extracting oil from de-gasser under vacuum and supplying to transformer/reactor etc., at discharge pressure of 1.5 kg/cm² at the outlet hose nozzle of the plant. The pump shall be either gland less centrifugal type with canned motors or a combination of gear pump and centrifugal pump with mechanical seals suitable for extracting oil from high vacuum degassing chambers. The oil extraction pump shall be located at a suitable level below the de-gasser chamber so as to ensure adequate suction head for the pump. The pump shall be supplied with double check valve assembly and solenoid operated non return valve in order to stop reverse flow of oil in case of power failure. The pumping system shall preferably be self - priming type alternatively priming device with safety interlock to protect pump against dry running shall be provided. Sampling valves shall be provided at the discharge of extraction pump for testing of oil properties. A re-circulation line with valves shall be provided to re-circulate a part of the purified oil to the inlet point if necessary during operation.

2.3.10 Dry Air Generator :

The plant shall be provided with a compressor, a drying unit and receiver with necessary drive motors, pressure gauges etc. for leak testing of transformer before commissioning and for purging of tanks, transformers, reactors before



filling of Oil.

The pressure and flow requirements of the compressor shall be suitable for cleaning of Filter Packs also.

The **compressor** shall be of **70 CFM** rating. The inlet pressure should not be below **5.5 kg/cm²** at max. Inlet temp. of 40 °C. Outlet dew point at atmospheric pressure should be better than - 40 °C. Supply Voltage shall be 230 V ± 15 %, 1 phase, 50 Hz or 415 V ± 15 %, 3 phase, 50 Hz. Suitable instrument along with accessories shall be provided to measure the dew point.

2.3.11 Ionic Reaction Column :

Provision at suitable places in the path of oil being processed shall be made for connecting on Ionic Reaction Column to be used for the removal of acidity and products of oxidation and ageing in used Transformer / Reactor oil. The ionic reaction column shall be supplied with the plant and it shall be possible to bypass this column when not required to be used.

The ionic reaction column shall be of suitable size, and activated alumina shall be used as adsorbent, for removal of the acidity from oil. The column should have sufficient amount of activated alumina in order to control the acidity of transformer oil to the desired recommended value. Necessary tools and apparatus required to regenerate the activated alumina shall also be supplied in order to provide facility of regeneration of activated alumina. Bidders shall furnish the complete details of the system and process.

2.3.12 Hoses for Transformer Oil, Vacuum, Air and Water :

Separate reinforced rubber hoses shall be provided for each operation of oil suction, oil discharge, transformer vacuum connection, compressed air supply.

All hoses shall be built around an earthed core or have built in earthed conductor to avoid static electricity accumulation. Vacuum hoses shall be **braided nitrile rubber** suitable for full vacuum without collapsing or kinking.

(i) Oil Hose :

For inlet and discharge service, hose shall be minimum 30 Mtr. long. The service end of the hoses shall be supplied with quick connect fittings and attached caps compatible with standard hose quick connect fittings for attachment to transformer and to the delivery tank.

(ii) Vacuum Hose :

The hose of reinforced nitrile rubber minimum 30 Mtr. long complete with aluminum flange and nitrile rubber gaskets shall be supplied for connecting vacuum pumping system of plant to the Transformer / Reactor tank.



2.3.13 Oil Sampling Valve:

Suitable valve shall be provided just before outlet valve to facilitate taking of oil sample for testing.

2.3.14 Flow Control Valve :

This valve is to be connected in shunt with oil inlet pump. Rate of flow of oil should be controlled with the help of this valve.

2.3.15 Airing Valve :

This valve has to be provided for airing the de-gassing chamber and the plant.

2.3.16 Oil Flow meter :

This should be a positive displacement type of reputed make. It should be direct reading type.

2.3.17 Pressure Release Valve :

A pressure release valve shall be provided to re-circulate the oil to suction side in case of accidental pressure rise when oil passes through the filters. The pressure relief valve should be set to operate at a pressure 5 psi more than the normal operating pressure of oil through the filters

2.3.18 Instruments :

The complete plant shall be supplied with all required measuring instruments locally mounted on the various equipments as well as necessary instruments, as per Section – 1, shall also be mounted on the control panel.

A. The following instruments shall be locally mounted

- (i) Two Nos. temperature measuring thermometers scaled in degree centigrade duly protected from external shocks installed at oil inlet and outlet of heater. Outlet thermometer to be provided with alarm contact. One thermometer to be provided for auxiliary oil heating system, if heating is of indirect type.
- (ii) Temperature actuated switches for the heaters and for other applications.
- (iii) Pressure indicators at the inlet and outlet of ultrafilter and at the discharge of pumps.
- (iv) Two nos. absolute pressure indicators one at the degassing chamber and the other for transformer tank.
- (v) Two nos. vacuum transmitters for vacuum gauges one for vacuum chamber and other for transformer evacuation system.
- (vi) Desiccators having reagents like activated alumina or charcoal on all vacuum instrumentation connection to prevent contamination by moisture oil.
- (vii) Level gauge on degassing chamber.
- (viii) Oil flow counter with a dual register oil totalizing meter in the discharge line for totaling upto 9999999 litres. The upper register shall contain 7 digits and shall be not resettable type. The lower register shall contain 8 digits, with the last one reading in tenths of a litre and shall be of resettable for each work.



This shall be located such that it is visible clearly to the operator viewing the control panel.

- (ix) Flow switches, flow indicators, thermocouples and all other necessary transmitters according to the requirements of instrumentation, controls and alarms on the control panel.

In addition to above, any other equipment/instrument required for satisfactory and efficient operation of machine shall be supplied by the contractor.

2.3.19 Control cum Annunciation Panel

- (i) The plant shall be fully automatic with a centralized control panel having provision of manual operation wherever required.
- (ii) The centralized control panel shall be complete with step down transformer, motor starters, contactors, pilot lamps, backup protection fuses and relays, indicating lamps, alarm provision and control switches etc. The panel enclosure should be of MS construction. It houses a sub-panel on which are mounted the air circuit breakers, all motor starters, heater contactors, control relays, fuses, fuse blocks, terminal strips and alarm horns.
- (iii) A mimic diagram with indication lamps showing on / off status of various equipments should be provided on the panel.
- (iv) All wiring shall be neatly routed and all wire terminations shall be suitably identified with ferrules. A complete wiring diagram for the plant indicating all devices, instruments, terminal blocks etc. shall be made out on a metallic plate suitably mounted so as to be readily available for guidance during operation / maintenance of the plant. This diagram plate shall be in addition to the wiring drawings which the bidder shall make available along with their instruction manuals.
- (v) Suitable interlocks shall be provided for safe and trouble free operation.

2.3.20 The plant shall receive 415 V, 3 phase, 50Hz, 4 wire power supply through flexible cable in the distribution panel located in the plant. The in-comer of the distribution panel shall be **switch fuse** unit.

The plant shall be adequately illuminated and ventilated for comfort of operator.

2.3.21 Casing:

The complete equipment along with controlling units shall be housed in suitable weather proof sheet steel enclosure, of rugged robust type with hinged doors complete with locking arrangement to facilitate easy operation and maintenance of the machine. A removable inspection cover shall be



provided to permit periodic inspection and lubrication of the machine.

2.3.22 Base Plate:

This shall consist of reinforced structural steel suitably designed for mounting the complete machine. Adequate arrangement shall be made in the base plate for drawing oil accidentally spilled during operation / maintenance. Suitable pulling hook and slinging arrangement (lugs) for lifting the complete machine through crane for purposes of loading / unloading in vehicle for transportation shall be provided in the base frame.

2.3.23 Inlet Recirculation By-Pass:

A recirculation piping and control system for oil piping shall be installed in the inlet piping, designed to function as follows:

- (a) On normal shut down of the inlet pump and heater (by the operator or by the high level switch in the process chamber) motorized valve shall close shutting off oil flow to the chamber, but the inlet pump shall continue to run (on time delay control) building up pressure which shall open a pressure control valve causing recirculation of oil through the heater (to cool the heater elements) and back to the inlet of the pump. At the end of the time delay period, the inlet pump shall continue to run unless the oil temperature is below the over temperature thermostat setting.
- (b) On over temperature alarm condition the heaters shall shut off and the motorized valve shall close, forcing the oil to re-circulate in the manner described above until the oil temperature drops below the present thermostat setting at which point the inlet pump shall stop.

2.4 Oil storage tank

- (i) The mobile oil storage tank with partition shall be designed and fabricated as per relevant Indian standard e.g., IS 803 or other internationally accepted standards.
- (ii) Transformer oil storage tank shall be tow able & rested on pneumatic tyres of adequate quantity and size. The tank shall be cylindrical shape and mounted horizontally and made of mild steel sheet of adequate thickness and diameter. Capacity of mobile storage tank shall be 15KL. Also 5KL mobile tank required for loading/unloading of oil from drums.
- (iii) The tank shall be designed for storage of oil at a temperature of 100°C.
- (iv) The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.
- (v) The tank shall also be fitted with manhole, outside & inside access ladder, silica-gel breather assembly, inlet & outlet valve, oil sampling valve with



suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tanks shall be provided so that the tank can be pulled from either end while completely filled with oil. Oil level indicator shall be provided with calibration in terms of Litres.



SECTION – 3

PROJECT DETAILS & GENERAL TECHNICAL REQUIREMENTS

Please refer TB-391-316-000 “General Technical requirements –section-3”and relevant clauses of technical specification



BHARAT HEAVY ELECTRICALS LIMITED
TRANSMISSION BUSINESS HVDC & SYSTEMS

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GENERAL TECHNICAL REQUIREMENTS-SECTION 3

3 General

The Works covered by the Specification shall be designed, manufactured, built, tested and commissioned in accordance with the Acts, Rules, Laws and Regulations of India. The Equipment(s) shall also conform to the general requirements detailed in the following standards, which shall form an integral part of the Specification, in addition to meeting the specific requirements called for elsewhere in the Specification.

The Supplier shall note that the standards mentioned herein are not mutually exclusive or complete in themselves, but are intended to complement each other, with minimum repetition, to define the requirements of the Specification. In the event of a conflict between requirements of any two clauses of the Specification/ documents or requirements of different codes/ standards specified, the more stringent requirement as per the interpretation of the owner shall apply, unless confirmed otherwise by the owner in writing based on a written request from the Supplier.

In case of conflicting requirements between this document (General Technical Requirements - Section 3) and equipment specification (Section 1 & Section 2), equipment specification shall prevail.

When specific requirements stipulated in the Specification exceed or change those required by the applicable standards, the stipulations of the Specification shall take precedence.

Unless specifically agreed to by the Purchaser prior to Award of Contract, the Work shall be in accordance with the standards indicated and the requirements of the Specification. The Supplier shall be held responsible for any deviation.

In case of conflict between the various standards, the decision of owner shall be binding & final.

3.1 Definitions

The following words and expressions shall have the meanings hereby assigned to them throughout this document

"Employer/Owner" means Power Grid Corporation of India Ltd.

"Purchaser" means Bharat Heavy Electricals Limited

"Supplier/Manufacturer" means the person or persons, firm or company assigned to execute the works as defined by the scope of supply, described here.

"Specification" refers to this document.



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3.2 Instructions to Suppliers

The supplier should be approved by Power Grid. If not, it is the responsibility of the vendor to be assessed and approved by Power Grid, before placement of order by BHEL. Any cost involved in vendor assessment/approval must be borne by the vendor himself.

The supplier shall submit the technical requirements, data and information as per the technical data sheets provided in the appropriate clause of bid document.

Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Specifications unless included in the list of exclusions. Materials and components not specifically stated in the specification but which are necessary for commissioning and satisfactory operation of the switchyard/substation unless specifically excluded shall be deemed to be included in the scope of the specification and shall be supplied without any extra cost. All similar standard components/parts of similar standard equipment provided, shall be inter-changeable with one another.

3.2.1 Technical requirements

The Supplier shall offer equipment whose similar equipment for similar applications have been in service for at least two years from as on the originally schedule date for the dead line for submission of first stage i.e. 19-05-2015 and should have been type tested as per relevant standards.

The suppliers who have supplied 400 kV equipment rated for 40 kA earlier to POWERGRID, may supply 50 kA/63 kA rated equipment subject to fulfilling specified requirements.

In case the supplier offers AC switchyard equipment from manufacturer(s) who have recently established production line in India for the offered equipment(s), based on technological support of a parent company or collaborator for the respective equipment(s) can also be considered provided the parent company (Principals) or collaborator meets the qualifying requirements stipulated above. In such cases the supplier shall have to fulfil the following conditions:

- i) The supplier shall be fully responsible for the equipments manufactured from such works.
- ii) Complete design and engineering of the equipments shall be the responsibility of the supplier.
- iii) The supplier shall furnish (jointly with the Subsidiary or collaboration partner) a legally enforceable undertaking to guarantee quality, timely supply, performance and warranty obligations as specified.

Whenever a material or equipment is specified herein by reference to a particular brand name, manufacturer, or vendor the supplier may supply another manufacturer's equivalent product if the products proposed are equivalent or superior to those named subject to approv-



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al of the employer.

3.2.2 Type Testing:

The bidder shall offer type tested equipment for the project and the Employer shall accept the equipment type test reports under the following conditions:

- (i) Type test in accordance with the relevant specified Standards & Technical specification
- (ii) The type tested equipment shall be of the same design, insulation class as per the equipment offered under this Contract. Technical justification will be submitted for differences between tested and offered equipment. Employer's interpretation for this shall be final.

In the event that equipment furnished includes important Modifications of, or significant departure from, the designs of equipment on which type test report has been furnished or if there is evidence that the equipment does not comply with the requirements of the Specifications, type test procedure was not properly followed as laid down in standards, the supplier shall conduct the type test without any cost implication to the Employer. In case equipments of same design and rating are supplied under this contract from different works, they shall be type tested separately. In the price bid, the type test charges shall be included in the contract price and no separate type test charges shall be indicated by the bidder.

Notwithstanding above, following broad categories shall be adhered to:

- a) Thyristor valves, converter transformers, 800kV wall bushings, Auto-transformers, shunt reactors, DC Smoothing Reactor, LT transformer (Except Dynamic short circuit Test) shall be type tested under this contract and type test report shall be approved by the Employer.
- b) For Converter transformer bushings, other bushings, switchgear, DC measurement device, AC/DC harmonic filter components, PLC/RI or other high frequency filter components, fundamental frequency blocking filter component, and DC surge arrester and AC filter arresters, tests performed **within 7 years** from first stage bid opening i.e. 28-07-2015 shall be considered subject to condition that either the type tests were performed on the identical equipment or performed on an equipment of similar type and design as mentioned in para (ii) above. A justification report, shall also be submitted by Contractor along with the type-test report for Employer's review.
- c) LT transformers (only for Dynamic Short Circuit Test), fibre-optic communication equipments, power/control/FO cables, HVAC equipments and switchgear, main ACDB, AC side surge arresters (excluding those used in AC filters), ventilation system and any other equipments not covered above (in a, b & c), tests performed **within 10 years** from first stage bid opening i.e. 28-07-2015 shall be considered subject to condition that either the type tests were performed on the identical equipment or performed on an equipment of same design as mentioned in para (ii) above. A justification report, shall also be submitted by Contractor along with the type-test report for Employer's review.
- d) For standard market products (like motors, air-compressors, air-conditioners, fans etc), of reputed make, which have good Market and on – site service credentials, once in life-time type test require-



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ment shall be applicable. However, it shall be justified that the product design has not been altered from the type-tested object.

Acceptance of the type test reports shall be at the discretion of the Employer. All type tests performed after the date of award of the Contract shall be witnessed by the Employer unless authority to proceed with the tests in his absence is received from the Employer in writing.

3.3 Standards

All equipment and materials, unless otherwise specifically required in the Specification, shall conform to latest revisions of the standards listed in the Specification, in force 15 days before at the deadline for submission of first stage i.e. 19.05.2015 for this project.

Generally the standards listed in annexure –c are applicable in accordance with the specific requirements of the technical section covering particular alternating current equipment or materials. Direct current equipment or materials shall also follow the general requirements of the standards listed in annexure -c, in addition to the specific requirements included in the specification.

3.4 Site information

	Particular	Raigarh	Pugalur
a)	Employer/Owner	Power Grid Corporation of India Ltd (POWERGRID)	
b)	Project Title	±800 kV, 6000 MW HVDC Raigarh – Pugalur Terminals	
c)	Location	11 km from Raigarh in State of Chattisgarh. Raigarh is the nearest railway station from Raigarh Site. The nearest Airport is Raigarh. The nearest port to Raigarh site is Paradip, Odisha.	Pugalur site is located about 32 Km from Pugalur in the state of Tamilnadu. The nearest Rail head is Pugalur. The nearest Airport is Coimbatore/ Trichi. The nearest port to Pugalur is Cohin.
d)	Nearest Rail Head	Raigarh	Pugalur
e)	Postal Address	To follow	To follow
f)	Design ambient temp.	50 °C	50 °C
g)	SEISMIC COEFFICIENT	Zone II Importance factor for the stations is 1.5 as per table no. 6 of IS-1893.	Zone II Importance factor for the stations is 1.5 as per table no. 6 of IS-1893.
h)	Site Wind Pressure	Zone II with basic wind speed of 39 m/s at 10 m height above mean ground level. The risk level coefficient/factor shall be taken as 1.07.	Zone II with basic wind speed of 47 m/s at 10 m height above mean ground level. The risk level coefficient/factor shall be taken as 1.07.
i)	Isokeraunic Level	50 days per year	50 days per year
j)	Relative Humidity	Max. 100%	
k)	Rain fall Intensity	In 24 hours: 200cm 80mm/hr (for drainage system Design)	In 24 hours: 1250mm, 50mm/hr (for drainage system Design)
l)	Solar Radiation	83 Cal/cm² per hour	



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m)	Air Pollution	<i>Heavily polluted for Raigarh and Pugalur terminals as per IEC 60815(1986). However leakage distance for AC equipment connected to 400 kV AC bus shall not be less than 10500 mm.</i>
n)	Leakage distance	<i>Leakage distance for all AC insulators & bushing shall not be less than 43 mm/kV of maximum normal operating phase to ground voltage at the insulator</i>

3.5 Site temperatures for design purposes

The Supplier shall assume the temperatures given below for the design of the works at the converter stations.

Description	Temperature in deg C	
	Raigarh	Pugalur
<i>Maximum dry bulb one hour average</i>	<i>50</i>	<i>50</i>
<i>Maximum dry bulb 24 hour average</i>	<i>40</i>	<i>40</i>
<i>Annual mean dry bulb temperature</i>	<i>30</i>	<i>30</i>
<i>Minimum dry bulb one hour average</i>	<i>0</i>	<i>0</i>
<i>Maximum wet bulb one hour average</i>	<i>33</i>	<i>33</i>
<i>Dry bulb temperature for low ambient condition</i>	<i>33</i>	<i>33</i>
<i>Wet bulb temperature for low ambient condition</i>	<i>23</i>	<i>23</i>

3.6 Documentation

All technical description, specifications, literature, correspondence, prints, drawings, instruction manuals, test reports(both factory and site), progress photographs, booklets, schedules and all supplementary data or documents furnished in compliance with the requirements of the Contract, shall become the property of the Purchaser/owner and the costs shall be considered as included in the Contract price.

The Supplier shall be responsible for any time delay, misinterpretation, error and conflict during design, manufacturing, testing and erection of the Works resulting from non-compliance with the requirements of this Specification.

The Purchaser/owner shall have the right to make copies of any documents, data, reports, information etc. supplied by the Supplier in connection with the Works. The Purchaser/ owner shall not impart the information of these documents to any other manufacturer or competitor but he shall be free to use these for preparation of technical papers, reports etc.

The Supplier shall submit consolidated list of all symbols used in any drawing, data and information under three separate headings namely Civil, Mechanical & Electrical. If symbols other than IS or IEC are used, the Supplier shall submit consolidated list of these symbols and their significance under a separate section.

The Supplier is not required to supply detailed drawings whose purpose is manufacture only but in case such information is specifically asked for by the Purchaser/owner during evaluation of Bid, finalization of Contract, design review by Purchaser/owner his appointed Consultant or during execution of the Contract, the Supplier shall comply with the same.

All drawings, documents manual etc. as specified in this section shall have to be provided separately for each station.

All documentation shall be in English language.



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Requirements for submission of documents, information and data by the supplier

General

The Supplier shall submit to the Owner/Purchaser all documents in accordance with an approved schedule of submissions and shall submit any further information (in the form of drawings, documents, manuals, literature, reports etc.) when asked by the Owner/Purchaser while commenting/approving any drawings/documents etc. All applicable documents shall be provided for each converter/repeater station separately.

The documents which are subject to the approval of the Owner/Purchaser shall be identified by the Supplier with the stamp "FOR APPROVAL". All other documents shall be submitted to the Owner/Purchaser for information and shall be identified by the Supplier with the stamp "FOR INFORMATION".

The sequence of submission of the documents shall be subject to the approval of the Employer. The sequence of submissions of all documents shall be such that the necessary information is available to enable the Employer to approve or comment the document.

The Supplier shall supply 5 hard copies of all drawings and documents. The final documentation for the project shall be supplied in six sets of hard copies (three to each site) and six sets of CDs to the Purchaser.

The entire plant documentation shall include all construction drawings, equipment specifications, design/study reports, O&M documents, factory test reports, etc. All the final/as built drawings shall be submitted in CAD format along with the complete final documentation.

In case a "SUBSEQUENT" revision of any document is made due to any reason whatsoever, a revision of the same, highlighting the changes shall be resubmitted for the Employer's specific approval/information.

Documents for approval

Approved documents shall be considered as the working documents. However the Specification and connected documents shall prevail over these documents in case a decision is required on interpretation.

Documents for information

The Supplier shall not delay the Works pending the receipt by the supplier of the comments on documents submitted to the Owner/Purchaser for information. However, the Owner/Purchaser shall have the right to comment on all the documents submitted by the Supplier, when, in the opinion of the Owner/Purchaser the document does not comply with the Contract or otherwise. The Supplier shall satisfactorily demonstrate that the information contained in the aforesaid document does meet the requirements of the Contract or revise the document in order that the information shall comply with the requirements of the Contract.

Drawings and data



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General

The Supplier shall submit to the Owner/Purchaser all assembly and detail drawings of equipment, station design, civil work, building, controls, protection, etc., as well as the corresponding computation where necessary in order to establish to the satisfaction of the Owner/Purchaser the Supplier's compliance with the requirements of the Contract.

Drawings, as set forth below shall be submitted to the Owner/Purchaser and shall be complete with all information necessary for complete interpretation of the drawings by the Owner/ Purchaser. All drawings shall show the materials, dimensions, finish, fits, clearances, tolerances, bolting and such other information as is necessary to demonstrate to the Owner/ Purchaser that all items covered by the drawings are in compliance with the requirements of the Contract.

Drawings may consist of several sheets as required in order to provide for the degree of detail required by the Employer, so that he may clearly understand such drawings.

Not later than 90 (ninety) days after completion of successful trial operation of the HVDC station, the Supplier shall supply copies of the last revision of all drawings produced for this project, stamped as "AS BUILT".

The Supplier shall provide separate sets of drawings for each control cubicle. Typical drawings for similar cubicles shall not be accepted. If there are several cubicles per system, then one common bill of material and one system schematic diagram may be provided. Such system schematic diagram shall show the control scheme for the particular system in its entirety and shall be laid out on the minimum number of drawings sheets consistent with clarity and legibility.

The Owner/Purchaser shall not accept typical drawings for control, protection and three-phase schematics, power circuits and single line diagrams. The Supplier shall supply complete set of such drawings for each system, even when drawings are duplicates.

Inspections plans and documentation

The Supplier shall submit in required number copies for the Owner's/Purchaser's approval an inspection plan (quality plan) describing the inspection system indicating the inspections to be carried out and their sequence in the manufacturing stages.

The inspection plan shall be such that it can be related to the manufacturing program. The plan shall also include a description of the inspection methods employed with reference to the Supplier's written inspection procedures.

Separate inspection plans describing the inspection systems for equipment supplied by each sub-Supplier, in the same form as that of the Supplier, shall be submitted for the approval of the Owner/Purchaser.

In addition to the inspection plans referred to above, the Supplier shall submit complete and satisfactory evidence of possessing a working scheme assuring the control of all critical activities pertinent to the assurance of quality, and objective evidence (by means of quality manuals and appropriate forms, etc.) of this capability to employ and maintain quality control to meet the required quality level of the manufacture and construction of the Works.



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Supplier's Quality Control Program in the context of this Clause means the implementation of a quality assurance program by means of which full conformance of material and workmanship to best quality standards can be achieved effectively and economically by the Supplier's control and surveillance of all essential inspection operations, and periodic verification of the results of the manufacture of equipment and the assembly, erection and installation of equipment at the sites.

Required number of copies of all test reports, including those supplied by Sub-Suppliers, and shall be submitted to the Owner/Purchaser for approval. The Supplier shall include in the report all additional data required by the Owner/Purchaser to permit a clear understanding of the reports.

All test reports shall be certified and shall contain the signature of the Inspector as having witnessed the test, unless such witnessing has been specifically waived by the Owner/ Purchaser. A certified test report shall be issued for each test.

Instruction manuals and operating manuals

The Supplier shall provide Instruction & Maintenance Manuals for each part of the Plant and Equipment included in the Works and Operating Manuals for each Station.

The Instruction Manuals and Operating Manuals shall be arranged in an organized library adequately cross referenced to facilitate issuing clauses of the manuals as required by the work i.e. erection instructions shall be required before operating & maintenance instructions.

All Manuals provided by the Supplier shall be fully detailed and specifically prepared for the Works and equipment provided. General manuals not specifically required for the work shall not be acceptable.

The instruction manuals shall at least contain:

- a) A general description of all components
- b) Storage instructions
- c) Erection instructions
- d) Pre-commissioning Instruction:
- e) Material and part list.
- f) Design clearances and settings
- g) Complete sets of drawings as finally issued
- h) Operating Instructions:
- i) Routine and Preventive Maintenance instructions with material requirement for each site
- j) Preventive Maintenance Schedule.
- k) Replacement instruction for all equipment

The operation manuals shall at least contain:

- a) Operator oriented functional descriptions of the equipment.
- b) Operator oriented description of the protection and control systems
- c) Description of the equipment auxiliary systems
- d) Fault finding and diagnostic tools
- e) User software interface tools for modification/augmentation etc.

Notes:



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The supplier may please note that all resubmissions must incorporate all comments given in the earlier submission by the Owner/Purchaser or adequate justification for not incorporating the same must be submitted failing which the submission of documents is likely to be returned.

If after the commissioning and initial operation of the substation, the instruction manuals require any modifications/ additions/changes, the same shall be incorporated and the updated final instruction manuals shall be submitted by the Supplier to the Owner/Purchaser.

The Supplier shall furnish to the Owner/Purchaser, catalogues of spare parts also.

3.7 Quality assurance requirements

Quality assurance programme

To ensure that the equipment and services under the scope of Contract, whether manufactured or performed at the Supplier's Works or at his Sub-supplier's premises or at the Purchaser's site or at any other place of Work, are in accordance with the specifications, the Supplier shall adopt a suitable quality assurance programme to control such activities at all points, as necessary. Such programme shall be outlined by the Supplier and shall be submitted by the supplier after the award of contract and finally accepted by the owner after discussions prior to commencement of manufacturing.

A quality assurance programme of the supplier shall generally cover the following:

- (a) Supplier's organisation structure for the management and implementation of the proposed quality assurance programme;
- (b) Design and Documentation control system;
- (c) Qualification data of Supplier's key personnel;
- (d) The procedure for purchases of materials, parts components and selection of sub-Supplier's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchased etc.
- (e) System for shop manufacturing and site erection controls including process controls and fabrication and assembly control;
- (f) Control of non-conforming items and system for corrective actions;
- (g) Inspection and test procedure both for manufacture and field activities;
- (h) Control of calibration and testing of measuring and testing equipment.
- (i) System for quality audits;
- (j) System for indication and appraisal of inspection status
- (k) System for authorising release of manufactured product to the Purchaser
- (l) System for maintenance of records;
- (m) Furnishing of quality plans (QP)/inspection and test plan (ITP) for manufacturing and field activities detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of equipment/component.

General requirements - Quality assurance

1. All services, materials, components and equipment covered under this specification shall be engineered, designed, procured, manufactured, erected, commissioned and tested at all the stages,



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as per a comprehensive Quality Assurance Programme. It is the Supplier's responsibility to draw up and implement agreed programme for system as a whole as well as for individual equipment. The detailed Quality Plans for manufacturing and field activities shall be drawn up by the Supplier and shall be submitted to the Employer for approval.

The Supplier shall furnish with his bid a list of approved suppliers for the information of the Employer.

2. Engineering and design quality Plan shall detail out the studies, overall detail design documentation and communicating, defining interfaces and controlling changes. To achieve quality, reliability and schedule objectives that project shall be designed so that it meets performance requirements. Manufacturing Quality Plan shall detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this Specification and standards mentioned therein and quality practices and procedures followed by Supplier's Quality Control Organisation, the relevant reference documents and standards, acceptance norms, inspection documents etc., during all stages of materials procurement, manufacture, assembly, and final testing/performance testing.
3. Field Quality Plan shall detail out for all the equipment, the quality practices and procedures etc. to be followed by the Supplier's site Quality Control Organisation, during various stages of site activities from receipt of materials/equipment at site onwards.
4. The Supplier shall also furnish copies of the reference documents/plant standards/ acceptance norms/tests and inspection procedure etc., as referred in Quality Plans along with respective Quality Plan. These Quality Plans and reference documents/standards etc. shall be subject to Employer's approval without which manufacture shall not proceed. In these approved QPs, the Employer shall identify customer inspection points (CIP), test/checks which shall be carried out in presence of the Employer's Engineer or his authorised representative and beyond which the work shall not proceed without consent of Employer or his authorised representative in writing. All deviations to specification, approved quality plans and applicable standards must be documented and referred to the Employer for approval and disposition.
5. No material shall be dispatched from the manufacturer's works before the same is accepted subsequent to pre-dispatch final inspection including verification of records of all previous tests/inspections by Employer's Engineer and / or his authorised representative, and duly authorised for dispatch issuance of Material Inspection Clearance Certificate (MICC). Before making request for issuance of MICC, the Supplier shall ensure that approval of type tests, data sheets, drawing etc. had already been obtained from Employer. All materials used or supplied shall be accompanied by valid materials certificates and tests and inspection reports. These certificates and reports shall indicate the sheet numbers or other such acceptable identification numbers of the material. The material certified shall also have the identification details stamped on it.
6. All welding and brazing shall be carried out as per procedure drawn and qualified in accordance with requirements of ASME section - IX/BS-4870 or other International equivalent standard acceptable to the Employer.
7. All the (sub)-Vendors proposed by the Supplier for procurement of bought out item list of which shall be drawn up by the Supplier and finalised with the Employer shall be subject to the Employer's approval. Quality Plans of the successful vendors shall be discussed, finalised and approved by the Employer and shall form part of the purchase order between the Supplier and the Vendor.



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8. The Employer reserves the right to carry out quality audit and quality surveillance of the systems and procedures of the Supplier's of their sub-Supplier's (sub-vendor's) quality management and control activities. The Supplier shall provide all necessary assistance to enable the Employer carry out such audit and surveillance.
9. As a part of quality assurance of engineering and design, the technical review meetings (TRMs) shall be conducted between the Employer and/or his consultants/representative and the Supplier and/or his subSupplier(s). The duration and cycle of such TRMs shall be as frequent and regular as required to meet the time schedules. The meetings shall be held at either at the Employer's office and/or at the office/manufacturing place of the Supplier/sub-Supplier or at any other place as agreed mutually.
10. The Supplier shall agree upon a schedule of submissions of documents concerning the Quality Assurance Program within two months of the effective date of the Contract. This schedule shall indicate the list of mutually agreed items/equipment for which quality Plans shall be submitted by the Supplier and the last dates for the submissions. It shall be ensured by the Supplier that the submissions are so programmed that all relevant approvals are obtained from the Employer for these documents in a timely manner before the material induction and commencement of the manufacture for any equipment.
11. The documents that shall be submitted by the Supplier to the Employer for review and approval as per the agreed schedule include:
 - a) QA Manuals
 - b) Quality Plans (Inspection & Test Plans) for all equipment/materials manufactured in the Supplier's works and/or in the sub-Supplier's works
 - c) Purchase Specifications for equipment procured from sub- Suppliers.
 - d) Supplier's assessment reports of his sub-Suppliers
 - e) Field Quality Plans for all activities at site
 - f) Reference documents referred to in Quality Plan.
 - g) Erection, commissioning, operation and maintenance manuals

12. QA Document Package

The Supplier shall submit the following Quality Assurance Documents to the Employer. These documents shall be as per the approved Quality Plans for the concerned equipment. The documents shall include, but not limited to, the following:

- a) Routine test reports & Acceptance test reports
- b) Type test reports
- c) Quality records etc. corresponding to items identified Quality Plan
- d) Inspection reports for Customer inspection points
- e) Reports on repair/modification carried out to make the item/equipment acceptable.
- f) Non-destructive examination result reports including radiography interpretation reports, wherever applicable.

The above documents are required to be submitted in required number of copies within three weeks after dispatch of equipment.



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Inspection and testing

1. In order to verify that all the manufacturing of equipment by the Supplier as well as materials & equipment being procured and provided by the Supplier are in complete conformance with the requirement of the Contract, the Employer and/or his duly authorized representative shall have access to the Supplier's premises or works at all reasonable times to inspect and examine the material, equipment and workman ship during its manufacture or installation. In addition to carrying out inspection the Employer and/or his authorized representative/Consultant all carry out quality audit on the Supplier's Quality Assurance System and conduct quality surveillance to check conformance to quality procedure/practice in general. The Supplier shall provide necessary facilities to carry out all the above activities at their works and the works of the sub- Suppliers.
2. The Supplier shall provide a detailed inspection schedule for those inspection stages identified as CIP and shall furnish updated schedules once every two months.
3. The Supplier shall give the Employer/Inspector six(6) weeks written notice, by telex or by letter, of the tentative date any material/equipment shall be ready for witness points, corresponding to Customer inspection points (CIP), when the Employer/Inspector is based in India. Final confirmation shall be given at least 15 days in advance. The Employer/Inspector, unless witnessing of the tests is waived, shall attend such tests, failing which the Supplier may proceed with the test which shall be deemed to have been made in the Inspector's presence. The Supplier shall forthwith forward to the Employer copies of duly certified test reports. Test reports of all tests corresponding to CIP performed in the supply shall be reviewed and approved, subject to satisfactory conduction and successful passing of the test, by the Employer or his authorised representative (even if the witnessing of the test was waived).
4. The Employer or his authorized representative shall, within fifteen (15) days from receipt of such reports, give notice in writing to the Supplier of any objection to any aspect of the test reports or any or all equipment and workmanship which in his opinion is not in conformance with the Contract. The Employer or his authorized representative shall advise his reasons for objections on completion and review of the activity. The Supplier shall give due consideration to such objection(s) and shall either make the modifications that may be necessary to overcome the said objection(s) or shall confirm in writing giving reasons therein that no modifications are necessary to comply with the Contract. However, the Supplier may proceed with the works/dispatch even before the receipt of written objection(s), if any, at his own cost & risk.
5. Whenever the Employer's inspection engineer undertakes the inspection, at a particular stage identified as Customer inspection point (CIP) in the Quality Plan, the acceptance of test reports/test results and the MICC where applicable shall be given immediately after the test if the results, including those for previous points identified as per clause 9.6 are found to be in conformity with the Contract. In case of any deviations, the Employer/Inspector at his discretion may refer the matter to the Employer's main office, together with the manufacturer's comments, who in turn shall communicate his final decision regarding the acceptance or otherwise to the Supplier within fifteen (15) days of the receipt of such test reports/results. In case the presence of the Employer/Inspector is waived, the acceptance of test results and issuance by the Employer of Material Inspection Clearance certificate wherever applicable, shall be given within fifteen (15) days after receipt of test reports/results for the CIP as well as for previous CIP's identified in the approved Quality Plan, provided such test reports/test results are found to be in order. The Employer/Inspector shall at his discretion and based on the outcome of any inspection and the re-



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quirements of the contract, have the right to 'accept', 'accept as noted' or 'reject' any equipment/material. The reasons/comments in case of each ruling shall be communicated to the Supplier in writing.

6. In all cases where the contract provides for tests, whether at the premises of works of the Supplier or of any sub-Supplier, the Supplier, except where otherwise specified, shall provide free of charge such items as labour, materials, electricity, fuel, water, apparatus and instruments as required to fulfil the requirements of the approved Quality Plan.
7. The inspection by Employer/Inspector or waiver of the presence of the Employer/Inspector, issue of CIP clearance certificate and issue of Material Inspection clearance certificate (MICC) thereon shall in no way limit the liabilities and responsibilities of the Supplier in respect of the agreed quality plans forming part of the contract. The Employer shall not be found to accept the material/equipment if on further testing it is found to be not in compliance with the requirements of the contract. The Supplier shall include in all orders to his sub-Suppliers, the requirements for any equipment, being supplied by the sub-Supplier for incorporation in his equipment to be subjected to inspection and testing by the Employer or is authorised representative. Copies of such orders or purchase specifications, blanked for prices, shall be forwarded to the Employer.
8. The costs of all tests specified in the Contract together with the same for all tests facilities, test samples and such like shall be to the Supplier's account.
9. The Employer/Inspector shall have complete authority to reject, on behalf of the Employer, any material, equipment or parts thereof considered unsatisfactory and not in accordance with the Contract. Accept, accept as noted or reject materials, equipment or any components thereof shall not relieve the Supplier of any of his obligations under the Supplier, nor impose any liability whatsoever on the Employer.
10. The Employer shall have the right to have Inspectors on the Sites, on a regular basis or from time to time as required at his sole discretion to monitor the quality and the progress of the work. Generally the site inspection shall be as per the approved Field Quality Plans (FQPs) and the Installation & Operation Manual(s). All quality related documents and test results shall be a part of plant documentation.

3.8 Materials and workmanship

Where the specification does not contain references to workmanship, it is understood that the equipment shall be new, of the best quality and in accordance with the purpose for which they are intended.

In case where the equipment, materials or components are indicated in the specification as "similar" to any special standard, the owner shall decide upon the question of similarity. When required by the specification or when required by the Purchaser & owner the Supplier shall submit for approval, all the information concerning the materials or components to be used in manufacture. Machinery, equipment, materials and components supplied, installed or used without such approval shall run the risk of subsequent rejection, it being understood that the cost as well as the time delay associated with the rejection shall be borne by the Supplier.

The design of the Works shall be such that installation, future expansions, replacements and general maintenance may be undertaken with a minimum of time and expenses. Each component shall



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be designed to be consistent with its duty and suitable factors of safety shall be used throughout the design.

All joints and fastenings shall be devised, constructed and documented so that the component parts shall be accurately positioned to fulfil their required function. In general, screw threads shall be standard metric threads. The use of other thread forms will only be permitted when prior approval has been obtained from the owner.

Whenever possible, all similar parts of the works shall be made to gauge and shall also be made interchangeable with similar parts. All spare parts shall also be made interchangeable and shall be made of the same materials and workmanship as the corresponding parts of the equipment supplied under the specification. All the equipment of the same type and rating shall be physically and electrically interchangeable.

All materials and equipment shall be installed in strict accordance with the manufacturer's recommendation(s). All factory assembled rotating machinery shall be checked for alignment and adjustments made as necessary. The spare equipment(s) shall be installed at designated locations and tested for healthiness.

The Supplier shall apply oil and grease of the proper specification as is necessary for the installation of the equipment. Lubricants used for installation purposes shall be drained out and the system flushed through where necessary in readiness for applying the lubricant required for operation. The Supplier shall apply all operational lubricants to the equipment installed by him. All insulating oil, lubricating material, grease and other consumables used in the Works/ Equipment shall be purchased in India unless the Supplier has any special requirement for the specific application for a type of oil or grease not available in India. If such is the case he shall declare in the proposal where such oil or grease or other consumables is available. In any case he shall identify equivalent Indian makes and inform the Purchaser & owner of the name of at least two Indian suppliers before handing over of the Works to the Purchaser. All consumables required upto operational acceptance shall be the part of supply scope of the Supplier.

The supplier shall perform all tests and inspection necessary to ensure that the material and workmanship conform to the approved design drawings and that such tests are adequate to demonstrate that the equipment shall comply with the requirements of the Specification & relevant standards. The supplier shall test the component parts at his plant or his Sub-supplier's plant, prior to packaging and shipping, to determine that the performance requirements have been met. All testing shall be in accordance with the Standards related to the piece of work.

3.9 Colour schemes

The Supplier shall propose a colour scheme for the equipment for the approval of the Employer. The decision of the Employer shall be final. However, the finishing colour shall be RAL 7035 for indoor panels and RAL 7032 for outdoor panels. The scheme shall include:

- Finishing colour of Indoor equipment
- Finishing colour of Outdoor equipment
- Finishing colour of various auxiliary system equipment including piping
- Finishing colour of various building items.
- Finishing colour of all cubicles.



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All steel structures, plates etc shall be painted with non-corrosive paint on a suitable primer. The galvanised structures in the switchyard shall not be painted. However galvanised structures in other areas may require painting for aesthetic reasons.

3.10 Clamps & connectors

- i) All power clamps and connectors shall conform to IS: 5561, and/or IEC standard and shall be made of materials listed below:

a)	For connecting ACSR conductors	Aluminium alloy casting, conforming to designation A6 of IS: 617 and shall be tested for all tests as per IS:617
b)	For connecting equipment terminals made of copper with ACSR conductors	Bimetallic connectors made from aluminium alloy casting, conforming to designation A6 of IS 617 with 2 mm thick Bimetallic liner and shall be tested as per IS: 617.
c)	For connecting G.I. Shield wire	Galvanised mild steel
d).1	Bolts, nuts & Plain washers.	Electro galvanised for sizes below M12, for others hot dip galvanised
d).2	Spring washers for items 'a' to 'c'	Electro-galvanised mild steel suitable for at least service condition-3 as per IS: 1573

- ii) Equipment shall be supplied with the necessary terminals and connectors, as required by the ultimate design for the particular installation. The conductor terminations of equipment shall be either expansion, sliding or rigid type. The requirements regarding external corona and RIV as specified for any equipment shall include its terminal fittings and the equipment shall be factory tested with the connectors in position. In case the connector is not available then equivalent connector may be used. If corona rings are required to meet these requirements they shall be considered as part of that equipment and included in the scope of Work.
- iii) Where copper to aluminium connections are required, bi-metallic clamps shall be used, which have been properly designed to ensure that any deterioration of the connection is kept to a minimum and restricted to parts which are not current t shall be furnished to the Employer.
- iv) Low voltage connectors, grounding connectors and accessories for grounding all equipment as specified are also included in the scope of Work.
- v) No current carrying part of any clamp shall be less than 10 mm thick. All ferrous parts shall be hot dip galvanised. Copper alloy liner of minimum 2mm thickness shall be cast integral with aluminium body for Bi-metallic clamps. When copper alloy is not cast integral with aluminium body, a bimetallic washer or strip shall be used to meet the functional requirement.
- vi) All casting shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off.
- vii) Flexible connectors, braids or laminated straps made for the terminal clamps for bus posts shall be suitable for both expansion or through (fixed/sliding) type connection of IPS Aluminium tube



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as required. In both the cases the clamp height (top of the mounting pad to centre line of the tube) should be same.

viii) Clamp shall be designed to carry the same current as the conductor and the temperature rise shall be equal or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/connector is designed with respect to the specified reference ambient temperature, shall also be indelibly marked on each component of the clamp/connector, except on the hardware.

ix) All current carrying parts shall be designed and manufactured to have minimum contact resistance.

x) TESTS

The following is the list of type tests.

- a) Temperature rise test (maximum temperature rise allowed is 35deg C over 50 deg C ambient)
- b) Short time current test
- c) Dry corona and RIV test as per annexure-A
- d) Resistance test and tensile test

3.11 Name Plates and Markings

All equipment mounted on front and rear side as well as equipment mounted inside the panels shall be provided with individual nameplates with equipment designation engraved. Also on the top of each panel on front as well as rear side, large and bold nameplates shall be provided for circuit/feeder designation.

All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring.

All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type, serial number and electrical rating data.

Name Plates shall be made of non-rusting metal or 3-ply lamicaid. Name plates shall be black with white engraving lettering.

All the panels shall be provided with nameplate mounted inside the panel. Stainless steel nameplates shall be installed on all apparatus and on all major equipment components. For indoor cubicles, nameplates made of aluminium shall also be acceptable. Name plates shall be white with black engraved lettering and shall carry all the applicable information specified in the applicable items of the Standards, together with any other relevant information which may be required. For groups of smaller items for which this is not possible e.g. switch bays etc. a common nameplate with the title and special instructions on it shall be provided. No scratching, corrections or changes shall be allowed on nameplates. Main equipments like converter transformer, CBs, Reactor, Filter gates etc shall have nameplates in Hindi also.

All equipment mounted on front and rear sides as well as equipment mounted inside the panels shall be provided with individual name plates with equipment designation engraved. Also on the top of



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each panel on front as well as rear sides large name plates with bold size lettering shall be provided for circuit / feeder / cubicle / box designation.

All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate tracing of the wiring. The nameplates shall be mounted directly by the side of the respective equipment and shall not be hidden by the equipment wiring.

The nameplate inscription and size of nameplates and letters shall be submitted to the Employer for approval.

The nameplates of the apparatus shall include, at least, the information listed below, together with any other relevant information specified in the applicable standards:

- a) A concise descriptive title of the equipment
- b) Rating and circuit diagram reference numbers
- c) Manufacturer's name, trade-mark, model type, serial number
- d) Instruction book number
- e) Year of manufacture
- f) Total weight (for capacitor racks indicate weight, for capacitors indicate quantity of liquid)
- g) Special instructions, if any, about storage, transportation, handling etc.

Each measuring instrument and meter shall be prominently marked with the quantity measured e.g. kV, A, MW etc. All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type, serial number and electrical rating data.

Danger plates and plates for phase colours shall be provided as per requirement. The Supplier shall devise a system to designate equipment and sub-systems. The nameplates/ labels displaying these designations shall be installed at appropriate locations. Wherever motion/ flow of fluids are involved, plates/ marks showing direction of motion/ flow shall also be provided.

Each main and auxiliary item of substation is to have permanently attached to it in a conspicuous position a rating plate of non-corrosive material upon which is to be engraved manufacturer's name, year of manufacture, equipment name, type or serial number together with details of the loading conditions under which the item of substation in question has been designed to operate, and such diagram plates as may be required by the Purchaser. The rating plate of each equipment shall be according to IEC requirement.

All such nameplates, instruction plates, rating plates of transformers, reactors, CB, CT, CVT, SA, Isolators, C & R panels and PLCC equipments shall be bilingual with Hindi inscription first followed by English. Alternatively two separate plates one with Hindi and the other with English inscriptions may be provided.

3.12 Provisions for Exposure to Hot and Humid Climate

Outdoor equipment supplied under the specification shall be suitable for service and storage under



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tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to the growth of fungi and mildew. The indoor equipments located in non-air conditioned areas shall also be of same type.

3.12.1 Space Heaters

The heaters shall be suitable for continuous operation at 240 V ac supply voltage & shall be connected to the supply through a fuse.

One or more heaters shall be provided, with thermostats or hygrostat, to prevent condensation in any compartment. The heaters shall be suitable to maintain the compartment temperature at approximately 10 deg. C, above the outside air temperature to prevent condensation.

Control cubicles installed in air-conditioned area need not be provided with space heaters. These cubicles shall, however, have space heaters in case of storage of cubicles for long duration.

3.12.2 Fungi Static Varnish

Besides the space heaters, special moisture and fungus resistant varnish shall be applied on parts which may be subjected or predisposed to the formation of fungi due to the presence or deposit of nutrient substances. The varnish shall not be applied to any surface of part where the treatment will interfere with the operation or performance of the equipment. Such surfaces or parts shall be protected against the application of the varnish.

3.12.3 Ventilation Opening

In order to ensure adequate ventilation, compartments shall have ventilation openings provided with fine wire mesh of brass or galvanized steel to prevent the entry of insects and to reduce to a minimum the entry of dirt and dust. Outdoor compartment openings shall be provided with shutter type blinds.

3.12.4 Tropicalisation

The service building and bay kiosk shall be air-conditioned whereas the valve halls shall have ventilation system with positive pressure. All equipments shall, however, be suitable for installation in a tropical monsoon area having hot, humid climate and dry & dusty seasons with ambient conditions as specified. All control wiring, equipment and accessories shall be protected against fungus growth, condensation, vermin and other harmful effects due to a tropical environment.

3.13 Painting and finishing of metal surfaces

All sheet steel work shall be phosphated in accordance with the IS:6005 "Code of practice for phosphating iron and steel".

Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning.

Rust and scale shall be removed by pickling with dilute acid followed by washing with running water rinsing with a slightly alkaline hot water and drying.



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After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying.

The phosphate coating shall be sealed with application of two coats of ready mixed, stoved type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.

After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after inspection of first coat of painting. The exterior colour of paint shall be of a slightly different shade to enable inspection of the painting.

A small quantity of finished paint shall be supplied for minor touching up required at site after installation of the panels.

In case the Supplier proposes to follow his own standard surface finish and protection procedures any other established painting procedures, like electrostatic painting etc., the procedure shall be submitted along with the Bids for Purchaser's review & approval. The Supplier shall use procedures for painting approved by the Employer during detailed Engineering.

3.14 Hot Dip Galvanising

The minimum weight of the zinc coating shall be 615 gm/ sq.m and minimum thickness of coating shall be 85 microns for all items thicker than 6 mm. For items less than 6 mm, requirements of coating thickness shall be as per relevant ASTM. For surfaces, which shall be embedded in concrete, the zinc coating shall be 900-gm/sq.m. Foundation bolts are to be galvanised with 610 gm/ sq.m Inserts plates/ edge protection angles / any other MS structural steel inserted in concentre shall be painted by using two or more coats of approved standard make synthetic enamel paint over a coat.

The galvanized surfaces shall consist of a continuous and uniform thick coating of zinc, firmly adhering to the steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, which is loosely attached to the steel globules, spiky deposits, blistered surfaces, flaking or peeling off, etc. The presence of any of these defects noticed on visual inspection shall render the material liable to rejection.

After galvanizing, no drilling or welding shall be performed on the galvanized parts of the equipment except the nuts may be rethreaded after galvanizing. Sodium dichromate treatment shall be provided to avoid formation of white rust after hot dip galvanization.

The galvanized steel shall be subjected to six one-minute dips in copper sulphate solution as per IS-2633.

Sharp edges with radii less than 2.5 mm shall be able to withstand four immersions of the Standard Preece test. All other coatings shall withstand six immersions.

The following galvanizing tests should be performed as per relevant Indian Standards.

- Coating thickness
- Uniformity of zinc
- Adhesion test
- Mass of zinc coating



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3.15 Control cabinets, junction boxes, terminal boxes & marshalling boxes for equipment

All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IS-5039/IS-8623, IEC-60439, as applicable, and the clauses given below:

1. Enclosure for control cabinets, junction boxes, Marshalling boxes & terminal boxes shall be made of stainless steel or aluminium and shall be dust, water and vermin proof. The box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation.
2. The enclosures of the control cabinets, junction boxes, terminal boxes & marshalling boxes located outdoor shall provide a degree of protection of not less than IP 55 as per IS-13947:Part I. One control cabinet, junction box, terminal box & marshalling box of each type shall be tested for the same.
3. Cabinets/boxes shall be freestanding floor-mounting type, wall mounting type, or pedestal mounting type as required. Equipments such as telephone exchange, Public address systems etc shall be kept inside cubicles.
4. Cabinets/ boxes shall be provided with double-hinged doors with padlocking arrangements. The distance between two hinges shall be adequate to ensure uniform sealing pressure against atmosphere. The quality of the gasket shall be such that it does not get damaged/cracked during the operation of the equipment.
5. All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM gaskets. The gasket shall be tested in accordance with approved Quality Plan. Ventilating louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.
6. All boxes/cabinets shall be designed for the entry of cables from the bottom by means of weatherproof and dust-proof connections. Boxes and cabinets shall be designed with generous clearances to avoid interference between the wiring entering from below and any terminal blocks or accessories mounted within the box or cabinet. A suitable horizontal cable gland plate positioned at least 150 mm above the base of the marshalling kiosk/box shall be provided for this purpose along with the proper blanking plates. Necessary number of cable glands shall be supplied and fitted on this gland plate. The gland shall project at least 25mm above gland plate to prevent entry of moisture in cable crutch. Gland plate shall have provision for some future glands to be provided later, if required. The glands shall be dust proof, screw on & double compression type and made of brass. The gland shall have provision for securing armour of the cable separately and shall be provided with earthing tag. The glands shall conform to BS: 6121 and shall be nickel-plated.

Boxes / cabinets to be located inside a building in a non air- conditioned area may be designed for the entry of cables from the bottom or from the top.

7. Earthing

The provision for earthing shall be generally as per requirements given in Clause 3.7.2.1



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8. Tests

- a) The Marshalling Kiosks shall be subject to routine tests as per IS: 5039
- b) The following routine tests shall also be conducted:
 - i) Check for wiring
 - ii) Visual and dimension check

Marshalling kiosk shall be provided with danger plate and a diagram showing the numbering/ connection/ ferruling by pasting the same on the inside of the door.

Marshalling kiosk shall also be provided with incoming MCB and one 15 Amp interlocked switched socket in addition to the MCB required.

3.16 Indoor control cubicles

The control panel, cubicles and desks shall be in accordance with the relevant IEC standards and shall be installed in air-conditioned space. Indoor electronic cubicles shall not generally require fans for cooling in order to operate successfully and correctly at the maximum ambient temperature. However, if it is absolutely necessary to install fans etc. in cubicles for cooling then these shall be driven by the same dc supply as used for control, and necessary redundancy, failure alarm etc. shall be incorporated. Louvers in the doors and side panels shall be permitted, if required.

The control and relay panels shall be suitable for numerical relays of modular type mounted in standard 19 inch racks located on the vertical front panel with rear doors for access or located on the front doors for front access type panels. Panels Cubicles shall be completely metal enclosed and shall be dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP 32 in accordance with IS-13947:Part I for cubicles located in air-conditioned areas. IP 31 may also be acceptable for these areas if the layout is arranged such that there is no possibility at all of any liquid entering the area. However, for ventilation reasons the cubicles may be provided with a ventilation hood at the top with a protection class of IP21.

Panels shall be free standing, floor mounting type and shall comprise structural frames enclosed completely with specially selected smooth finished, cold rolled sheet steel of thickness not less than 2.5 mm for weight bearing members of the cubicles such as base frame, front sheet and door frames, and 1.5 mm for sides, door top and bottom portions. There shall be sufficient reinforcement to provide level surfaces, resistance to vibration and rigidity during transportation and installation. The cubicles shall be provided with lifting lugs.

All doors, removable covers and plates shall be gasketed all around with neoprene gaskets. Ventilation louvers, if provided, shall have screens and filters. The screens shall be made of either brass or GI wire mesh with a graduation of 1 mm or less.

Design, material selection and workmanship shall be such as to result in a neat appearance, inside and outside with no welds rivets or bolt heads apparent from outside, with all exterior surfaces true and smooth. All cubicles located in any room shall be matched in appearance.



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The Supplier along with anchor bolts and necessary hardware for mounting the cubicles shall furnish metal sills in the form of metal channels properly drilled. Panels shall have an additional rolled channel plinth at the bottom with a smooth bearing surface. The panels shall be fixed on channels with intervening layers of anti- vibration strips made of shock absorbing material, which shall be supplied by the Supplier.

Supplier's standard practice for control panels shall be acceptable to the Employer/Purchaser subject to approval during detailed engineering and meeting all functional requirements of the specification.

3.16.1 Mounting

All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections. The equipment on front of panel shall be mounted flush. No equipment shall be mounted on the doors.

Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices and are readily accessible without use of special tools. Terminal marking on the equipment shall be clearly visible.

The Supplier shall carry out cut out, mounting and wiring of the free issue items supplied by others, which are to be mounted in his panel in accordance with the corresponding equipment manufacturer's drawings. Cut outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plate.

The centre lines of switches, push buttons and indicating lamps shall be not less than 750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall be not less than 450mm from the bottom of the panel

The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Like wise the top lines of all meters, relays and recorders etc. shall be matched.

No equipment shall be mounted on the doors.

At existing station, panels shall be matched with other panels in the control room in respect of dimensions, colour, appearance and arrangement of equipment (centre lines of switches, push buttons and other equipment) on the front of the panel.

3.16.2 Earthing

- 1) All panels shall be equipped with an earth bus securely fixed. Location of earth bus shall ensure no radiation interference for earth systems under various switching conditions of isolators and breakers. The material and the sizes of the bus bar shall be at least 25 X 6 sq. mm perforated copper with threaded holes at a gap of 50mm with a provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply of Supplier.



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er. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.

- 2) Provision shall be made on each bus bar of the end panels for connecting Substation earthing grid. Necessary terminal clamps and connectors for this purpose shall be included in the scope of supply of Supplier.
- 3) All metallic cases of relays, instruments and other panel mounted equipment including gland plate, shall be connected to the earth bus by copper wires of size not less than 2.5 sq. mm. The colour code of earthing wires shall be green.
- 4) Looping of earth connections, which would result in loss of earth connection to other devices when the loop is broken, shall not be permitted. Earthing may be done in such a manner that no circulating current shall flow in the panel.
- 5) VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.
- 6) An electrostatic discharge point shall be provided in each panel connected to earth bus via 1 Mega Ohm resistor.

3.16.3 Instruments, meters and recorders

Only digital displays and systems shall be provided. The requirements in this section are applicable to auxiliary systems only. All instruments, meters and recorders shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. They shall be calibrated to read directly the primary quantities. They shall be accurately adjusted and calibrated at the factory and shall have means of calibration, checking and adjustment at site.

3.16.4 Miscellaneous

- 1) The Supplier shall submit all type and routine test certificates to the Employer & Purchaser for approval before dispatching the equipment. Control and relay panels shall also be subjected to the following tests:
 - i) Mechanical operation test
 - ii) Verification of degree of protection as per IS-13947:Part I
 - iii) High voltage test
 - iv) Electrical control, Interlock and sequential operation test
 - v) Verification of wiring as per approved schematic.
- 2) Plug Point: 240V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.
- 3) Interior Lighting: Each panel shall be provided with a CFL lighting fixture rated for 240 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.



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- 4) MCB's: Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breakers (MCB).
- 5) Space Heater: Panels wherever required shall be provided with a space heater rated for 240V single phase, 50 Hz Ac supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with thermostat and switch fuse /MCB unit.

3.16.5 Terminal blocks and wiring

All internal wiring to be connected to external equipment shall terminate on terminal blocks. Terminal blocks shall be 650 V grade and have 10 Amps. Continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Markings on the terminal blocks shall correspond to wire number and terminal numbers on the wiring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.

Disconnecting type terminal blocks for current transformer and voltage transformer secondary leads shall be provided. Also current transformer secondary leads shall be provided with short circuiting and earthing facilities.

Spare terminals for Employer's use for upgrading to 6000 MW shall be provided wherever required. In addition, at least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.

The terminal blocks shall be suitable for connecting the conductors of external cable on each side.

Terminal blocks shall be of (at least) 650V grade and have 10 amps continuous rating. These shall be moulded, complete with insulated barriers, stud type terminals, complete with washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud terminals with locking type. The terminal blocks shall be of reputed make subject to Employer's acceptance.

Terminal block design shall include a white fibre marking strip with clear plastic, /clip-on terminal covers. Markings on the terminal strips shall correspond to wire numbers on the wiring diagrams.

Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. The current transformer secondary leads shall also be provided with short-circuiting and earthing facilities.

The conducting part in contact with the cable shall preferably be tinned or silver-plated however; nickel-plated copper shall also be acceptable. Insulating barriers shall be provided between the terminal blocks.

Manufacturer's standard practice for internal wiring of cubicles shall be acceptable to the Employer. However all external cabling requirements shall be strictly as per TS.

The Supplier shall furnish all wire, conduits and terminals for the necessary inter-phase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets.



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3.17 Degree of protection

The enclosures of the control cabinets, Junction boxes and Marshalling boxes, panels etc. to be installed as detailed here under:

The minimum requirements for panels are as follows:

Installed out door: IP- 55

Installed indoors in air-conditioned area: IP-32

Installed in covered area: IP-52

Installed indoors in non air-conditioned area where possibility of entry of water is limited: IP-41.

For LT Switchgear (AC & DC distribution Boards): IP-52.

The degree of protection shall be in accordance with IS:13947 (Part-I) / IEC-947 (Part-I) / IS 12063 / IEC 529. Type test report for degree of protection test, on each type of the box shall be submitted for approval

3.18 Welding and welders' qualifications

All welding shall be in accordance with the corresponding standards of the American Welding Society or the American Society of Mechanical Engineers DIN /International standard . Welding shall comply with powergrid approved quality plan.

Other standards to determine the quality of welding processes and qualifications of welders may be considered, provided that sufficient information is first submitted for the approval of the Employer.

Prior to the start of fabrication, the Supplier shall submit to the Employer for approval, a description of each of the welding procedures which he proposes to adopt, together with certified copies of reports of the results from tests made in accordance with these procedures.

The Supplier shall be responsible for the quality of the work performed by his welding organization. All welding operators shall be assigned to the work, including for repair of castings, shall pass the required tests for qualification of welding procedures. The Employer reserves the right to witness the qualification tests for welding procedures and operators and the mechanical tests of the samples. If the Inspector so requires, the Supplier shall furnish to the Inspector certified copies of reports of the mechanical test results of the samples.

The Supplier shall bear all his own expenses in connection with the qualification tests. If the work of any operator at any time appears questionable, such operator shall be required to pass appropriate re-qualification tests as specified by the Inspector and at the expense of the Supplier.

Strict measures for quality control shall be exercised throughout the Equipment/Works. The Engineer may call for an adequate NDT test of the work of any operator, who, in his opinion, is not maintaining the required standard of workmanship. Should this NDT test prove defective, all work done by that operator, since his last test shall be tested at the Supplier's expense. If three or more of these tests prove defective, the operator shall be removed from the project.

A procedure for the repair of defects shall be submitted to the Employer for his approval prior to any repairs being made.



3.19 MICROCOMPUTER SUB-SYSTEMS

3.19.1 HARDWARE

1. Computer Circuit Protection

All computer circuits shall be adequately protected from all external interferences such as induced current and voltages from other adjacent control panels or high power circuits, and voltage spikes that propagate in the system.

2. Programmer's Facilities

The following minimum facilities shall be provided for use in application software maintenance, program loading, program checking, program development and implementing changes.

- i) Program development systems including console, keyboard etc. with editors and compilers.
- ii) Interactive printers.

3.19.2 SOFTWARE

1. The provision of all the necessary software in an operational state shall be the responsibility of the Contractor. System performance shall be fully demonstrated during factory acceptance tests and during the final system acceptance tests.
2. The software provided shall be of modular design and shall accommodate the identified future system growth without need for software modification.
3. Programming, development/changes and the addition of new programs via test, maintenance and programmer's facilities shall be reduced to simple, easy to follow procedures. Protection against inadvertent damage or modification to on-line programs shall be provided.
4. The software shall include but shall not necessarily be limited to the following:
 - Real time multiprogramming / multitasking / multi-user operating system.
 - Application Software.
 - Man-machine software.
 - Error diagnostics/corruption detection software
 - Software design specifications, details of each software module, details of formats, logger formats etc., shall be submitted to the Employer for approval.
 - All software provided must be fully documented.

3.19.3 SOFTWARE PROTECTION/ SECURITY

Adequate protection systems shall be incorporated in the computer systems to prevent mutilation or corruption of the software due to any form of extraneous software interference or hardware/interface incompatibilities. Software supplied in CDs shall be well



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protected against corruption or destruction due to any extrinsic software. Operating systems shall also be suitably well protected.

3.20 Motors

All motors shall conform to IEC-60034-5 / IS Standard and with principal dimensions in accordance with IEC 60072-1 (1991), IEC 60072-2 (1990) and IEC 60072-3 (1994).

Motors rated 0.5 kW and above, and reversing motors, shall be rated 415 V, three phase, grounded neutral;

Motors rated below 0.5 kW shall be rated 240 V one phase;

All motors shall be designed to operate at full load dynamic conditions with a voltage range of variation of +10%, -20% and a frequency range variation of +5%, -10%. Motors shall also be designed to operate at 125% of the rated speed without mechanical damage, and to start with 80% of their rated voltage;

All motors shall be designed and rated for continuous operation at maximum ambient temperature of 50°C. The class of insulation shall be at least one class higher than used for defining the temperature rise of the motor;

Vertical motors rated 60 kW and above shall be provided with oil-lubricated self-cooled pivoted shoe-type thrust bearing. Vertical motors below 60 kW shall be provided with re-greasable anti-friction ball or roller bearings;

All anti-friction bearings shall be guaranteed to operate successfully for a minimum of 131,000 hours;

All bearings shall be quiet operating and statically and dynamically balanced;

All belts to be used shall be "V" type and designed for the maximum power to be transmitted and for the maximum speed. The selection of the "V" belt drive for any application shall also be based on the nature of the load and the type of the driving unit. Belts installed outdoors shall be suitably protected.

3.21 Conduits, pipes and accessories

The Supplier shall supply and install all rigid conduits, mild steel pipes, flexible conduits, hume pipes etc. including all necessary sundry materials, such as tees, elbows, check-nuts, bushings, reducers, enlargers, wooden plugs, coupling caps, nipples, gland sealing fittings, pull boxes etc. The size of the conduit/pipe shall be selected to limit the fill to a maximum of 40%. All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed in an approved manner to prevent damage to threaded portions and entrance of moisture and foreign materials.

PVC conduits shall be of high impact, heavy gauge (at least class 2) conduit conforming to BS-4607.

The outer surface of the steel conduits shall be coated with hot-dip zinc and chromate conversion



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coatings. The inner surface shall have silicone epoxy ester coating for easy cable pulling. Mild steel pipes shall be hot-dip galvanized. All rigid conduits/pipes shall be of a reputed make.

The hume pipes and accessories shall be of reinforced concrete conforming to class NP2 of IS-458. All tests on hume pipes shall be conducted as per IS-458.

Flexible conduits shall be of heat-resistant lead coated steel, water-leak, fire and rust proof.

3.22 Packaging & protection

All the equipments shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. On request of the Purchaser, the Supplier shall also submit packing details/associated drawing for any equipment/material under his scope of supply, to facilitate the Purchaser to repack any equipment/material at a later date, in case the need arises. While packing all the materials, the limitation from the point of view of availability of Railway wagon sizes in India should be taken into account. The Supplier shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. Any demurrage, warping and other such charges claimed by the transporters, railways etc. shall be to the account of the Supplier. Purchaser takes no responsibility of the availability of the wagons.

All coated surfaces shall be protected against abrasion, impact, discolouration and any other damages. All exposed threaded portions shall be suitably protected with either a metallic or a non-metallic protecting device. All ends of all valves and piping and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage.

3.23 Auxiliary supply

The sub-station auxiliary supply is normally met through a system having the following parameters. The auxiliary power for station supply, including the equipment drive, cooling system of any equipment, air-conditioning, lighting etc shall be designed for the specified Parameters as under. The DC supply for the instrumentation and PLCC system shall also conform to the parameters as indicated in the following:

Normal Voltage	Variation in Voltage	Frequency in Hz	Phase/ Wire	Neutral connection
415 V	± 10%	50 ± 5%	3 / 4 Wire	Solidly Earthed
240 V	± 10%	50 ± 5%	1 / 2 Wire	Solidly Earthed
220 V	198V to 242V	DC	-	Isolated 2 wire System
48 V	43.2V to 52.8V	DC	-	2 wire System (+) earthed

Combined variation of voltage and frequency shall be limited to ± 10%.

3.24 Lamps and sockets

Lamps



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All incandescent lamps shall use a socket base as per IS-1258, except in the case of signal lamps.

Sockets

All sockets (convenience outlets) shall be suitable to accept both 5 Amp & 15 Amp pin round Standard Indian plugs. They shall be switched sockets with shutters. Degree of protection for outdoor switch sockets shall be IP55.

Hand Lamp

A 240 Volts, single Phase, 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF Switch for connection of hand lamps.

Switches and Fuses

Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with switchfuse units. Selection of the main and Sub-circuit fuse ratings shall be such as to ensure selective clearance of sub-circuit faults. Potential circuits for relaying and metering shall be protected by HRC fuses. All fuses shall be of HRC cartridge type conforming to IS:9228 mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage.

3.25 Seismic force consideration

All structures shall be designed for seismic forces in accordance with IS-1893.

The seismic design of electrical equipment shall be performed using estimated actual earth/ ground motion, defined by a response spectrum, rather than the equivalent loads specified in typical Building Codes.

For brittle materials like glass, porcelain and glass fibre reinforced plastic the maximum calculated load should not exceed 2/3 of the guaranteed minimum rupture (breaking) strength (safety factor 1.5) as defined by the manufacturer/supplier of the material used. The minimum rupture value is defined as $(X - 2 \cdot \sigma)$, where X is the mean value and 'sigma' is the standard deviation. For load combinations in porcelain insulators and similar the following expressions shall be fulfilled:

$$\{F_t / (F_t)_b\} + \{M_b / (M_b)_b\} < 2/3 \text{ and} \\ \{F_c / (F_c)_b\} + \{M_b / (M_b)_b\} < 2/3$$

Where:

F_t, F_c, M_b : calculated maximum tensile force; compressive force and bending respectively

$(F), (F), (M)_b$: corresponding guaranteed strength values

(For normal operating loads, a higher safety factor more than 1.5 shall be used, normally 2.0-2.5



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depending on type of load as per recommendations of manufacturer).

Factor regarding importance of structures (I), as defined in IS-1893, shall not be taken less than 1.5.

3.26 Safety requirements

The requirements regarding provision of additional staircases and approachability as defined in the Fire Protection Manual, issued by the Regional Committees of the Tariff Advisory Committee shall be completely fulfilled. All other safety requirements shall be met as per the factories Act, TAC etc.



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ANNEXURE-A
Corona and Radio Interference Voltage (RIV) Test

1. General

Unless otherwise stipulated, all equipment (except Auto Transformer & Shunt Reactor) together with its associated connectors, where applicable, shall be tested for external corona both by observing the voltage level for the extinction of visible corona under falling power frequency voltage and by measurement of radio interference voltage (RIV). The test procedure shall be reviewed for different equipment during submission of MQP/ITP.

2. Test Levels:

The test voltage levels for measurement of external RIV and for corona extinction voltage are listed under the relevant clauses of the specification.

3. Test Methods for RIV:

- 3.1 RIV tests shall be made according to measuring circuit as per International Special-Committee on Radio Interference (CISPR) Publication 16-1(1993) Part -1. The measuring circuit shall preferably be tuned to frequency with 10% of 0.5 Mhz but other frequencies in the range of 0.5 MHz to 2 MHz may be used, the measuring frequency being recorded. The results shall be in microvolts.
- 3.2 Alternatively, RIV tests shall be in accordance with NEMA standard Publication No. 107-1964, except otherwise noted herein.
- 3.3 In measurement of, RIV, temporary additional external corona shielding may be provided. In measurements of RIV only standard fittings of identical type supplied with the equipment and a simulation of the connections as used in the actual installation will be permitted in the vicinity within 3.5 meters of terminals.
- 3.4 Ambient noise shall be measured before and after each series of tests to ensure that there is no variation in ambient noise level. If variation is present, the lowest ambient noise level will form basis for the measurements. RIV levels shall be measured at increasing and decreasing voltages of 85%, 100% and 110% of the specified RIV test voltage for all equipment unless otherwise specified. The specified RIV test voltage for 400 kV, 220 kV is listed in the detailed specification together with maximum permissible RIV level in microvolts.
- 3.5 The metering instruments shall be as per CISPR recommendation or equivalent device so long as it has been used by other testing authorities.
- 3.6 The RIV measurement may be made with a noise meter. A calibration procedure of the frequency to which noise meter shall be tuned shall establish the ratio of voltage at the high voltage terminal to voltage read by noise level meter.

4. Test Methods for Visible Corona

The purpose of this test is to determine the corona extinction voltage of apparatus, connectors etc. The test shall be carried out in the same manner as RIV test described above with the exception that RIV measurements are not required during test and a search technique shall be used near the onset and extinction voltage, when the test voltage is raised and lowered to determine their precise values. The test voltage shall be raised to 110% of RIV test voltage and maintained there for five minutes. In case corona inception does not take place at 110 %, test

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shall be stopped, otherwise test shall be continued and the voltage will then be decreased slowly until all visible corona disappears. The procedure shall be repeated at least 4 times with corona inception and extinction voltage recorded each time. The corona extinction voltage for purposes of determining compliance with the specification shall be the lowest of the four values at which visible corona (negative or positive polarity) disappears. Photographs with laboratory in complete darkness shall be taken under test conditions, at all voltage steps i.e. 85%, 100%, and 110%. Additional photographs shall be taken at corona inception and extinction voltages. At least two views shall be photographed in each case using Panchromatic film with an ASA daylight rating of 400 with an exposure of two minutes at a lens aperture of f/5.6 or equivalent. The photographic process shall be such that prints are available for inspection and comparison with conditions as determined from direct observation. Photographs shall be taken from above and below the level of connector so as to show corona on bushing, insulators and all parts of energised connectors. The photographs shall be framed such that test object essentially, fills the frame with no cut-off.

- 4.1 The test shall be recorded on each photograph. Additional photograph shall be taken from each camera position with lights on to show the relative position of test object to facilitate precise corona location from the photographic evidence.
- 4.2 In addition to photographs of the test object preferably four photographs shall be taken of the complete test assembly showing relative positions of all the test equipment and test objects. These four photographs shall be taken from four points equally spaced around the test arrangement to show its features from all sides. Drawings of the laboratory and test set up locations shall be provided to indicate camera positions and angles. The precise location of camera shall be approved by Purchaser's inspector, after determining the best camera locations by trial energisation of test object at a voltage which results in corona.
- 4.3 The test to determine the visible corona extinction voltage need not be carried out simultaneously with test to determine RIV levels.
- 4.4 However, both test shall be carried out with the same test set up and as little time duration between tests as possible. No modification on treatment of the sample between tests will be allowed. Simultaneous RIV and visible corona extinction voltage testing may be permitted at the discretion of Purchaser's inspector if, in his opinion, it will not prejudice other test.

5. Test Records:

In addition to the information previously mentioned and the requirements specified as per CISPR or NEMA 107-1964 the following data shall be included in test report:

- a) Background noise before and after test.
- b) Detailed procedure of application of test voltage.
- c) Measurements of RIV levels expressed in micro volts at each level.
- d) Results and observations with regard to location and type of interference sources detected at each step.
- e) Test voltage shall be recorded when measured RIV passes through 100 microvolts in each direction.
- f) Onset and extinction of visual corona for each of the four tests required shall be recorded.



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ANNEXURE-B

SEISMIC WITHSTAND TEST PROCEDURE

The seismic withstanding test on the complete equipment (for 132 kV and above) shall be carried out alongwith supporting structure.

The supplier shall arrange to transport the structure from his purchaser's premises / POWERGRID sites for the purpose of seismic withstand test only.

The seismic level specified shall be applied at the base of the structure. The accelerometers shall be provided at the Terminal Pad of the equipment and any other point as agreed by the Purchaser /Employer. The seismic test shall be carried out in all possible combinations of the equipment. The seismic test procedure shall be furnished for approval of the Purchaser.



ANNEXURE-C

GENERAL STANDARDS AND CODES

- IS-5 Colours for Ready Mixed Paints and Enamels
- IS-335 Insulating oil for Transformers and Switchgears.
- IS-2071 Methods of High Voltage Testing
- IS-12063 Classification of degrees of Protection Provided by Enclosures for Electrical Equipment
- IS-2165 Insulation Co-ordination
- IS-3043 Code of Practice for Earthing
- IS-3637 Gas Operated Relays
- IS-6103 Method of Test for Specific Resistance (Resistivity) of Electrical Insulating Liquids
- IS-6104 Method of Test for Interfacial Tension of Oil against Water by the Ring Method
- IS-6262 Method of Test for Power Factor and Dielectric Constant of Electrical Insulating Liquids
- IS-6792 Method for Determination of Electric Strength of Insulating Oils
- IS-8263 Method for Radio Interference Tests on High Voltage Insulators
- IS-8269 Methods for Switching Impulse Tests on High Voltage Insulators
- IEC-60060 High Voltage Test Techniques
- IEC-60117 Graphical Symbols
- IEC-60156 Method for the Determination of the Electric Strength of Insulating Oils
- IEC-60270 High Voltage Test Techniques
- IEC-60296 Specification for Unused Mineral Insulating Oils for Transformers and Switchgear
- IEC-60376 Specification and Acceptance of New Sulphur Hexafluoride
- IEC-60437 Radio Interference Test on High Voltage Insulators
- IEC-60506 Switching Impulse Tests on High Voltage Insulators
- IEC-60507 Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems
- IEC-60694 Common Clauses for High Voltage Switchgear & Control gear Standards.



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IEC-60815 Guide of the Selection of Insulators in respect of Polluted Conditions.

IEC-60865 Short Circuit Currents

IEC- 61803 Determination of losses in HVDC converter Stations

ASTM-D1275 Standard Test Method for Corrosive Sulfur in Electrical Insulating Oils

DIN 51353 Testing of Insulating Oils, Detection of Corrosive Sulfur, Silver Strip Method

TRANSFORMERS AND REACTORS

IS-1886 Code of Practice for Installation and Maintenance of Transformers

IS-2026 Power Transformers

IEC 61378-2 Converter Transformers: Transformers for HVDC applications

IS-3347 Dimensions for Porcelain transformer Bushing

IS-3639 Fittings and Accessories for Power Transformers

IEC 60076-6 Reactors

IS-6600 Guide for Loading of Oil Immersed Transformer

IEC-60076 Power Transformers

IEC- 60289 Reactors

IEC- 60422 Supervision and Maintenance guide for Mineral Insulating Oil in Electrical Equipment

IEC 60475 Method of Sampling Liquid dielectrics

IEC 60542 Application Guide for On-Load Tap-Changers

IEC 60567 Guide for the Sampling of Gases and of Oil from Oil-filled
Electrical Equipment for the Analysis of Free and Dissolved Gases

IEC 60722 Guide to the lightning impulse and switching impulse testing of
power transformers and reactor (compare IEC 60076 part 3)

IEC-60214 On-Load Tap-Changers

NEMA- TR-1 Transformers, Regulators and Reactors

CIRCUIT BREAKERS

IEC-62271-100 High Voltage Alternating Current Circuit Breakers



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IEC-61264 Pressurised Hollow Column Insulators

IEC-60427 Synthetic Testing of High Voltage Alternating Current Circuit Breakers

CURRENT TRANSFORMERS, VOLTAGE TRANSFORMERS AND COUPLING CAPACITOR
VOLTAGE TRANSFORMERS

IEC 61869-1 Current Transformers

IEC 61869-2 Voltage Transformers

IS-4379 Identification of the contents of Industrial Gas Cylinder

IS 9348 Coupling capacitor and capacitor dividers

IEC-61869-5 Voltage Transformers

IEC-60358 Coupling Capacitors and Capacitor Dividers

IEC-61869-4 Instrument Transformers Partial Discharge Measurements

IEC-60481 Coupling Devices for power Line Carrier Systems

BUSHINGS

IS-2099 High voltage porcelain Bushings for Alternating Voltages above 1000 V

IEC-60137 Bushings for Alternating Voltages above 1000V

IEC-61462 Composite Insulators

IEC-62199 Bushings for DC applications

SURGE ARRESTERS

IS-3070 Lightning arresters for alternating current systems: Metal oxide lightning arresters without gaps

IEC-99-4 Metal oxide surge arresters without gaps

IEC-60071 Part Insulation Co-ordination 1 to 5

CUBICLES AND PANELS & OTHER RELATED EQUIPMENT

IS-722, IS- Electrical relays for power system protection

1248, IS-3231, Electrical relays for power system protection

IEC-68.2.2 Basic environmental testing procedures Part 2: Tests: B: Dry heat

IEC-60529 Degrees of Protection provided by enclosures



IEC-60158 Low Voltage Control Gear Contractor

IS-8623 Specification for Switchgear & Control Assemblies

DISCONNECTING SWITCHES

IEC-60129 Alternating Current Isolators (Disconnectors) & Earthing Switches

IEC-60265 High Voltage Switches

CAPACITORS

IEC-60871 Shunt Capacitors

TELECOMMUNICATIONS AND LINE TRAPS

IS-8792 Line Traps

IS-8793 Methods of Test for Line Traps

IS-8997 Coupling Devices for PLC Systems

IS-8998 Methods of Tests for Coupling Devices for PLC systems. IEC-60353 Line Traps

IEC-60481 Coupling Devices for Power Line Carrier Systems

IEC-60495 Single sideboard power line carrier terminals

IEC-60663 Planning of (single Side-Band) Power Line Carrier Systems

CIGRE Tele-Protection

CCIR International Radio Consultative Committee

CCITT International Telegraph & Telephone Consultative Committee

EIA Electronic Industries Association

CONVERTERS

IEC-60700-1 Testing of Semiconductor Valves for High Voltage dc Power Transmission

PROTECTION AND CONTROL EQUIPMENT

IEC-60051 Recommendations for Direct Acting Indicating Electrical Measuring Instruments and their Accessories.

IEC-60255 Electric Relays

IEC-60297 Dimensions of mechanical structures of the



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482.6 mm (19inches) series

IEC-60337 Control Switches (low voltage switching devices for control and auxiliary circuits, including contactor relays)

IEC-60359 Expression of the Functional Performance of Electronic Measuring Equipment

IEC-60387 Symbols for Alternating- Current and Electricity Meters

IEC-60447 Standard Directions of Movement for Actuators which control the Operation of Electrical Apparatus

IEC-60521 Class 0.5, 1 and 2 Alternating Current Watt- hour Meters

IEC-60547 Modular Plug-in Unit and Standard 19-Inch rack Mounting Unit Based on NIM Standard (for electronic nuclear instruments)

IEC -61850 Communication networks and Systems in Substations.

MOTORS

IS-325 Three Phase Induction Motors

IEC-60034 Rotating Electrical Machines

MATERIAL AND WORKMANSHIP STANDARDS

IS-1363 Hexagon head bolts, of screws and nuts product grade C

IS-1364 Hexagon head bolts, screws and nuts of products grades A and B

IS-3138 Hexagonal Bolts and Nuts (M42 to M150)

ISO-898 Fasteners: Bolts, Screws and Studs

ASTM Specification and Tests for Materials

CLAMPS & CONNECTORS

IS-5561 Electric Power connectors

BUS HARDWARE AND INSULATORS

IS-2121 Fittings for Aluminium and steel cored Aluminium conductors for overhead lines

IS-731 Porcelain Insulators for Overhead Power Lines with nominal voltages greater than 1000 V

IS-2486 Insulator fittings for Overhead Power Lines with nominal voltages greater than 1000 V

IEC-60120 Dimensions of Ball and Socket Couplings of String Insulator Units



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IEC-60168 Tests on Indoor and Outdoor Post Insulators for Systems with Nominal Voltage Greater than 1000 V

IEC-60233 Tests on Hollow Insulators for use in Electrical Equipment 1000V

IEC-60273 Characteristic of Indoor and Outdoor Post Insulators and Post Insulator Units for System with Nominal voltage greater than 1000 V

IEC-60305 Characteristics of String Insulator Units of the Cap and Pin Type

IEC-60372 Locking Devices for Ball and Socket Couplings of String Insulator Units.

IEC-60383 Tests on Insulators of Ceramic Material or Glass for Overhead Lines With a Nominal Voltage greater than 1000 V

IEC-60433 Characteristics of String Insulator Units of the Long Rod Type

IEC-60471 Dimensions of Clevis and Tongue Coupling of String Insulator Units

STRAIN AND RIGID BUS-CONDUCTOR

IS-2678 Dimensions for Wrought Aluminium and Aluminium Alloys, plates and hot rolled steel

IS-5082 Wrought Aluminium and Aluminium Alloy Bars, Rods, Tubes and Sections for Electrical Purposes

BATTERIES AND BATTERY CHARGERS

IEC-60086 Primary Batteries

IEC-60086-2 Primary Batteries, Specification sheets

IEEE-484 Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations

IEEE-485 Sizing Large Lead Storage Batteries for Generating Stations and Substations

WIRES AND CABLES

IEC-60434 Rubber insulated cables with copper (part 1) Conductors

IS-694 PVC insulated cables for working voltages upto and including 1100 Volts

IS-1255 Code of Practice for Installation and maintenance of Power Cables, upto and including 33 kV rating

IS-1554 PVC insulated (heavy duty) electric (Part 1) cables for working voltage upto and including 1000V

IS-2982 Copper conductors in insulated cables and cords



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IS-3961 Recommended current ratings for cables

IS-3975 Mild steel wires, strips and tapes for armouring of cables

IS-5831 PVC insulation and sheath of electric cables

IS-6380 Elastomeric Insulation and sheath of electric cables

IS-7098 Cross-linked polyethylene insulated PVC sheathed (Part 1) cables for working voltage upto and including 1000V

IS-7098 Cross-linked polyethylene insulated PVC sheathed (Part 2) cables for working voltage from 3.3KV upto and including 33KV

IS-8130 Conductors for Insulated electrical cables and flexible cords

IEC-60096 Radio Frequency Cables

IEC-60183 Guide to the Selection of High Voltage Cables

IEC-60189 Low Frequency cables and wires with PVC Insulation and PVC Sheath

IEC-60227 Polyvinyl Chloride Insulated Cables of Rated Voltages up to and Including 450/750 V IEC-60228 Conductors of Insulated Cables

IEC-60230 Impulse Test on Cables and their Accessories

IEC-60287 Calculation of the Continuous Current rating of Cables (100% Load Factor)

IEC-60304 Standard Colours for Insulation for Low- Frequency Cables and Wires

IEC-60330 Methods of Test for PVC Insulation and Sheath of Electrical Cables

IEC-60331 Fire - Resisting Characteristics of Electric Cables

IEC-60332 Tests on Electric Cables under Fire conditions

IEC-60502 Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto 30 kV

IEC-60540 Tests methods for insulators & sheaths of electric cables & cords (electrometric & thermo-plastic)

IEC-7541 Tests on gases evolved during combustion of electrical cables

AIR CONDITIONING AND VENTILATION

IS-659 Safety Code for Air Conditioning

IS-1391 Room Air Conditioners



IS-6272 Industrial Cooling Fans

ASHRAE American Society of Heating, Refrigerating and Air Conditioning Engineers

GALVANIZING

IS-209 Zinc

IS-2633 Methods of Testing Uniformity of coating of Zinc coated articles

ASTM-A-153 Specification for Zinc Coating (Hot Dip) on
Iron and Steel Hardware

ASTM-A-239 Test Method for Locating the Thinnest Spot in a Zinc (Galvanized) Coating on Iron or
Steel Articles by the Preece Test (Copper Sulphated Dip)

ASTM-A-121-77 Zinc - coated (Galvanized) Steel Barbed Wire

PAINTING

IS-6005 Code of practice for phosphating of Iron & Steel

ANSI-Z551 Gray Finishes for Industrial Apparatus and Equipment

SSPC Steel Structure Painting Council

FIRE PROTECTION

TAC Fire Protection Manual Issued by Tariff Advisory Committee (TAC) of India

NFPA National Fire Protection Association

NBFU National Board of Fire Underwriters

STEEL STRUCTURES

IS-226 Structural Steel (Standard Quality)

IS-228 Method of Chemical Analysis of steels

IS-428 Methods of chemical analysis of Pig iron, Cast iron and plain carbon and low alloy steels

IS-802 Code of Practice for Use of Structural Steel in Overhead Transmission line Towers



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IS-806 Code of Practice for use of Steel Tubes in General Building Construction

IS-808 Dimension for hot Rolled Steel Beam, Column, Channel and Angle Sections

IS-814 Covered Electrodes for Metal Arc Welding of Structural Steel

IS-816 Code of Practice for Use of Metal Arc welding for General Construction in Mild Steel

IS-817 Code of Practice for training and Testing of Metal Arc Welders

IS-875 Code of Practice for design loads (other than earthquake) for Buildings & Structures

IS-1161 Steel Tubes for Structural Purposes

IS-1182 Recommended Practice for Radiographic Examination of Fusion Welded Butt Joints in Steel Plates

IS-1363 Hexagonal head bolts (Size range M5 to M36) IS-1364 Hexagonal head bolts, screws and nuts of product grades A and B

IS-1367 Technical supply condition for threaded fasteners

IS-1599 Method for Bend Test

IS-1608 Method of Tensile Testing of Steel Products

IS-1893 Criteria for earthquake resistant Design of IS-1978 Line Pipe

IS-2062 Weldable Structural Steel

IS-2595 Code of Practice for Radiographic Testing single coil rectangular section

IS-3063 Spring Washers for Bolts, Nuts & Screws

IS-3664 Code of Practice for Ultrasonic pulse echo testing by contact & immersion methods.

IS-7205 Safety Code for Erection of Structural Steel work

IS-9595 Recommendations for metal arc welding of carbon and manganese steels

ANSI- G8.14 Zinc Coating (Hot Dip) on Iron and Steel Hardware

ASTM-A36 Specifications of Structural Steel



OTHER CIVIL WORKS STANDARDS

IS-269 Specification for 33 grade Ordinary Portland Cement

IS-272 Galvanized steel wire chain link fences

IS-278 Galvanized Steel Barbed Wire for Fencing

IS-383 Coarse and Fine Aggregates from Natural Sources for Concrete

IS-432 Mild Steel and Medium Tensile Steel

IS-456 Code of Practice for Plain and Reinforced Concrete

IS-516 Methods of test for Strength of Concrete

(Part-I&II) Bars and Hard drawn steel wire for concrete reinforcement

IS-800 Code of Practice for use of structural steel in general bldg. construction

IS-806 Code of Practice for Use of Steel Tubes in General Building Construction

IS-1139 Hot rolled mild steel and medium tensile steel deformed bars for concrete reinforcement

IS-1161 Steel Tubes for Structural Purposes

IS-1172 Code of Basic Requirements for Water Supply, Drainage and Sanitation

IS-1199 Methods of Sampling and Analysis of Concrete

IS-1566 Hard-Drawn Steel Wire Fabric for Concrete Reinforcement

IS-1742 Building Drainage

IS-1785 Plain Hard-Drawn Steel Wire for Pre-stressed Concrete

IS-1786 Cold twisted steel bars for concrete reinforcement

IS-1811 Methods of Sampling Foundry Sands

IS-1893 Recommendation for earthquake resistant design of structures

IS-2062 Structural steel fusion welding quality

IS-2064 Selection, Installation and Maintenance of Sanitary Appliances

IS-2065 Water Supply in Building

IS-2090 High Tensile Steel Bars Used in Pre-stressed Concrete

IS-2140 Stranded Galvanized Steel Wire For Fencing



±800 KV, 6000MW HVDC terminals associated with HVDC Bipole link between Western region (Raigarh, Chhattisgarh) and Southern region (Pugalur, Tamil Nadu) – Madakathara/ North Trichur (Kerala)

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IS-247 Design and construction of Septic Tanks

IS-2514 Concrete Vibrating Tables

IS-2645 Integral-Cement Waterproofing Compounds

IS-3025 Methods of Sampling and Test for Water Used in industry

IS-4091 Design and Construction of Foundations for Transmission Line Towers and Poles

IS-4111 Ancillary Structure in Sewerage System IS-4990 Plywood for Concrete Shuttering Work IS-5600 Sewage and Drainage Pumps

Compliance with various CEA Regulations:

Construction standards

Central Electricity Authority (Technical standards for Construction of electrical plants and electric lines) Regulations, 2010

Safety Standards for Construction and O & M

Central Electricity Authority (safety Requirements for Construction, operation and maintenance of electrical plants and electrical lines) Regulations, 2011

Central Electricity Authority (Measures relating to safety and electricity supply) Regulation, 2010

Connectivity Standards

Technical standards for connectivity to the grid (Amendment) Regulation 2013

Technical standards for connectivity to the distributed generation sources

Technical standards for connectivity to the grid regulation, 2007

Material Regulations

Central Electricity Authority (Installations and operation of meters) (Amendment) Regulations, 2010

Central Electricity Authority (Installation and operation of meters) Regulations, 2006

These CEA regulations are available in the website www.cea.nic.in and compliance of these CEA regulations is mandatory