

**VOLUME : IIF/2**

**SECTION-IX**

**TECHNICAL SPECIFICATION  
FOR  
ERECTION - CABLING, GROUNDING AND  
LIGHTNING PROTECTION SYSTEM**

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## SECTION-IX

### TECHNICAL SPECIFICATION FOR ERECTION - CABLING, GROUNDING AND LIGHTNING PROTECTION SYSTEM

#### 1.00.00 SCOPE OF WORK

1.01.00 The scope of work covers complete and efficient design, supply, erection, testing and commissioning of Plant lightning protection system, all cabling and electrical grounding works. The scope shall broadly cover, but not be limited to :

1. Main Power House Building
2. Boiler area, ESP stack
3. Transformer yard
4. All auxiliary buildings (including electrical rooms of respective buildings) and structures as details in the Lead Specification.
5. Overhead interplant cable trestle and pipe cum cable trestle.
6. All electrical equipment as described in Volumes II-F/1 & II-F/2.

1.02.00 The scope of work shall also include all civil and structural works necessary for successful installation and commercial operation of all electrical equipment to be erected under this specification.

#### 2.00.00 SCOPE OF SUPPLY

2.01.00 The scope of supply shall include but not be limited to the followings

2.01.01 Timely procurement and transportation to site in properly packed condition of all materials and miscellaneous items required to complete the erection work under this specification.

These materials and miscellaneous items shall include but not be limited to the following :

- a) Galvanised steel pre-fabricated cable trays, coupler plates, nuts, bolts & washers, reducers, covers, wall brackets, hanger clamps, straight run, elbows, bends, etc.
- b) Galvanised steel rigid/flexible conduits and accessories, ferrules, lugs, glands, terminal blocks, galvanised sheet steel junction boxes, cable fixing clamps, nuts & bolts, etc. as required.
- c) Cable termination and jointing kits as necessary.

- d) All necessary erection materials, consumables and sundry items including arc welding rods to complete the installation for satisfactory and trouble free operation.
- e) Mild steel rods, galvanised steel flats, galvanised steel rods, lead coated copper tube suitably brazed with galvanised steel Bend ring galvanised steel wires, etc. required for grounding and lightning protection system shall be supplied in standard lengths.
- f) Fire Stop mortal seal, fire retardant cable coating system .
- g) Any item of works or erection materials which have not been specifically mentioned but are necessary to complete the work involved shall be deemed to be included in the scope of this specification and shall be furnished by the contractor without any extra charge to the Purchaser.

2.01.02

- a) Main Ground Mat

Laying underground conductors and arc welding the conductors at each crossing and straight run (lap joint). The conductors at the periphery of the mat shall be 1 no. 40 mm diameter M.S. rod and the internal cross conductors of the mat shall be 1 No. 40 mm diameter M.S. rod. Suitable pigtailed shall be provided .Diameter of the ground grid conductors as indicated above is minimum . However bidder shall select the actual diameter of conductor with supporting calculation.

- b) Grounding Electrode

Fabrication and driving into ground 40 mm. diameter 3000 mm long M.S. rod and connecting them to the grounding mat by arc welding.

- c) Column Grounding

- i) Concrete Columns

Erection of 1 no. 40 mm. dia. M.S. rod from grounding mat to all concrete columns including necessary fixing, welding of one end of the rod with ground mat and the other end with the column above ground by welding with a short GS flat to edge angles.

- ii) Steel Columns

Erection and connection of 1 No. 40 mm diameter M.S. rod from grounding mat to all steel columns including necessary fixing, welding of one end with ground mat and the other end with the column above ground with a short GS flat.

Diameter of the Earth Electrode as indicated above is minimum. However bidder shall select the actual diameter of conductor with supporting calculation

d) Risers

Erection and connection of all risers from underground mat to above ground levels where the ends will be left free for connecting to the equipment. Each riser will be 1 No. 40 mm dia. M.S. rod and Minimum 300 mm above grade level/concrete floor level.

Diameter of the Earth Riser as indicated above is minimum. However bidder shall select the actual diameter of conductor with supporting calculation

e) Electronic Equipment Grounding

Internal ground connection of electronic panels shall be insulated from the enclosure, frame, chasis and to be terminated to an insulated ground bus.

Insulated ground bus (400x100x10mm) of all electronic panels shall be connected by insulated wire to an insulated common electronic ground bar as shown in the Grounding Notes and details drawing.

All connection made above shall be in the form of a radial distribution system without any parallel ground paths.

Electronic equipments and systems, metal enclosures of all electronic panels shall be connected to a grounding system with which is isolated and separate from the electrical equipment grounding system. Separate Earth pit shall be made of 3M X 3M min 40 mm dia ground rod.

f) All other ancillary works in connection with the items of work described above which are not specifically mentioned but are necessary to complete the work, shall be under the scope of this specification.

2.01.03

a) Air Terminal

Installation of vertical 20mm dia galvanised steel rod (except for chimney). The projected length of the rod shall be as required to protect the object. (on which the rod is fixed from lightning stroke).

Installation of air terminal at top the stack/chimney for lightning protection shall be 20mm dia coated solid copper rod.

b) Horizontal Air Terminal

Erection of horizontal air terminal of 75X 10 mm GS flat conductor in such a way that no part of of the roof will be more than nine meters from the nearest roof conductor.

c) Down conductor

Erection of down conductor 75 X 10 mm GS Flat and 25 X 3 mm GS flat (Conveyor Gallery) conductor. one end of this down conductor connected with air terminal rod/ horizontal conductor at the top of roof/structure and other end connected to the nearest 40mm dia MS

rod riser through test link located at approximately 1500mm above ground level.

d) Electrode (for Lightning protection)

Fabrication and driving into ground 40 mm. diameter 3000 mm long M.S. rod and connecting them to the grounding mat by arc welding.

e) Risers (for Lightning protection)

Erection and connection of all risers from underground mat to above ground levels where the ends will be left free for connecting to the equipment. Each riser will be 1 No. 40 mm dia. M.S. rod and Minimum 300 mm above grade level/concrete floor level.

Diameter of the Earth Riser as indicated above is minimum. However bidder shall select the actual diameter of conductor with supporting calculation

f) Shielding Mast

Erection of shielding mast at the top of steel columns cap plates of power house building.

g) All other ancillary works in connection with the items of work described above which are not specifically mentioned but are necessary to complete the work, shall be under the scope of this specification.

2.02.00 All materials and accessories to be supplied by the Bidder shall be brand new ones of reputed make.

2.03.00 Necessary drawings, data sheets and Technical leaflets on each piece of material.

2.04.00 **Scope of Services**

The scope includes but is not limited to the followings;

2.04.01 Furnishing of all erection tools and tackles, testing equipment, implements, supplies, hardware and transport for timely and efficient execution of the erection work.

2.04.02 The items of erection work shall be performed with respect to the following equipment/materials :

a) Power Cables

b) Cables laid directly buried in ground

c) Control, instrument and special cables

d) Supply and erection of entire cable tray and cable shaft arrangements indoor as well as outdoor area and all associated civil and structural works including foundation and cable trenches for complete plant.

- e) Supply and Erection of Grounding system.
- f) Supply and Erection of Lightning Protection system.

**3.00.00 GENERAL REQUIREMENTS**

**3.01.00 Codes and Standards**

- 3.01.01 All cable and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) and IEC except where modified and/or supplemented by this specification.
- 3.01.02 Cable and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.
- 3.01.03 The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

**3.02.00 Erection Schedule**

- 3.02.01 The entire erection work shall be carried out in a phased manner. A schedule of the work showing the sequence of erection shall be submitted by the tenderer for this purpose.
- 3.02.02 The erection schedule, as approved by the Owner's Engineer shall be strictly followed by the contractor. If, for any reason beyond the control of the Contractor, the work is held-up then the Contractor shall bring it to the notice of the Owner's Engineer without any delay.

**4.00.00 DESIGN CRITERIA**

**4.01.00 Grounding System**

4.01.01 Grounding shall follow the relevant standards/codes amended till date as below:

- a) Indian Electricity rules
- b) National Electrical Code
- c) Code of Practice of Earthing IS 3043
- d) Protection of building and allied structures against lightning IS 2309
- e) IS- 732, IS 226, IS 2629, IS 2633 & IS 4759
- f) IEEE -80 ,IEEE-665

The station grounding system shall be an interconnected network of MS conductor and MS ground rods. The system shall be provided to protect plant personnel and equipment from the hazards, which can occur during power system faults and lightning strikes

4.01.02 The main objectives of grounding system are to :

- a) Provide safety to personnel from contact of dangerous potential caused by ground fault.
- b) Ensure sufficient grounding current for effective relaying.
- c) Stabilize circuit potential with respect to ground.

#### **Design Basis**

The station grounding system shall be designed in compliance with the IEEE-80/ IEEE- 665 considering fault current of 50kA for 1 sec. and shall be subject to approval of owner.

Actual soil resistivity measurement shall be carried out at proposed site for new units during dry season.

The surface Resistivity shall be considered as 3000-ohm meter for Gravel and 1000 ohm-meter for concrete.

- a) Major items of equipment, such as generator, switchgear, transformer, motor, relay panels and control panels etc shall have integral ground buses or connection points which shall be connected to the under ground grid.
- b) Electronic panels and equipment, where required, shall be grounded utilizing an insulated ground wire connected in accordance with the manufacturer's recommendations. Where practical, electronics ground loops shall be avoided. Where this is not practical, isolation transformers shall be furnished. All indoor and outdoor electrical equipment and associated non current carrying system, metal works, support structures, buildings columns, fence, neutrals, masts, arrestors, etc shall be connected to the plant ground system.
- c) Instrumentation cable screens shall be single point bonded to the instrument earth network to minimize the effects of electrical interference.
- d) For Signal/case/intrinsically safe signal, grounding of control room instruments, separate earth pit not connected to main ground grid shall be used. Control cabinets shall be connected to this separate earth pit.
- e) A grounding conductor (steel wire armor) shall be routed parallel to all power conductors operating above 240 volts.
- f) All ground wires installed in conduits shall be uninsulated.
- g) Embedded grounding grid of 75x10mm GI flat at basement/grade slab as well as upper floor/suspended slabs shall be provided.
- h) In addition mild steel ground pads at different locations i.e. on wall/floor/ceiling inside the buildings/tunnels/trenches shall be provided. These pads will be in turn connected to below ground level earth mat

through galvanized steel flat or riser. Each ground pad shall have provision for connection of at least two 75x10mm GI flats.

- i) Treated earth pit shall be provided for system earthing at locations where generator and transformer neutrals are grounded. Two pits shall be provided for each neutral.
- j) Dedicated treated earth pit shall be provided for lightning protection system.
- k) Clean earthing for instrumentation shall be provided with dedicated earthing system and separate treated earth pits below the main control room, feed water pump house in turbine house etc.
- l) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.

4.01.03 In order to meet the above objectives, ground grid mesh will be provided for the main plant complex, viz., switchyard, transformer yard adjacent to power house building, power house building and boiler area up to stack, auxiliary buildings, etc.

All electrical equipment, non current carrying metal parts, structures, building steel, lightning protection system, generator/transformer neutrals will be connected to this station ground grid.

The major aspects to be considered for grounding system design are given below :

4.01.04 Ground Grid Conductor

- a) Ground grid conductor of mild steel rod shall be used.
- b) The minimum conductor section is determined on the basis of ground fault current. This section is then increased by an allowance to account for the soil corrosion loss of 0.3 mm per year over the design life of 30 years. However, the minimum size shall be one (1) no. 40 mm dia mild steel conductor.

4.01.05 Underground Grid

- a) The ground grid mesh is designed to keep the touch and step voltages within safe limits as per recommendation of IEEE 80 & IEEE665.
- b) The ground grid conductors will be buried in earth at a minimum depth of 1000 mm. The length of ground conductors below earth will be sufficient to ensure a ground resistance less than 0.5 ohm.
- c) The ground grid conductor will be so laid as to provide short and direct connection to building steel and major electrical equipment.
- d) Ground rods shall be provided at the points where system neutrals/lightning protections are connected to the ground grid.

- e) All ground grid conductor connections will be welded type.
- f) Main Plant ground grid shall be connected with the other auxiliary building /area ground grid at least at two (2) points.
- g) For test pits, the Electrode will be 100 mm dia. Heavy duty C.I. pipe with perforations. Electrodes installed in test pits will have disconnecting facilities

4.01.06 Above Ground Connections

- a) Galvanised steel flats shall be used for all connections above earth.
- b) Inside building, ground conductors will be run for each floor supported on building steel and/or cable trays. These ground conductors in turn will be connected to the station ground grid through riser (at least two) coming up along building columns/cable shafts.
- c) Two separate and distinct ground connections will be provided for each electrical equipment in compliance with I.E. Rules.
- d) All connections above ground will be welded type except connection to equipment/structures which shall be bolted type.

4.01.07 Equipment Ground Lead

Equipment ground connections will be sized to carry the available ground fault current. Considerations shall also be given to mechanical ruggedness of the connections and to limit the number of sizes.

4.01.08 Electronic Equipment Grounding

Internal ground connection of electronic panels shall be insulated from the enclosure, frame, chassis and to be terminated to an insulated ground bus.

Insulated ground bus of all electronic panels shall be connected by insulated wire to an insulated common electronic ground bar.

All connection made above shall be in the form of a radial distribution system without any parallel ground paths.

Electronic equipments and systems, metal enclosures of all electronic panels shall be connected to a grounding system with which is isolated and separate from the electrical equipment grounding system. Separate Earth pit shall be made by 3M X 3M MS Rod.

4.01.09 The minimum ground conductor sizes for various equipment and structures are given in Annexure-B.

4.01.10 Entire erection of grounding work shall be carried out in such a way as to be capable of withstanding the intended services of carrying full short circuit level currents to ground mat without any damage/deformation.

4.02.00 **Lightning Protection System**

Lighting protection system design shall be as per IS:2309

4.02.01 The main purposes of lightning protection system are to :

- a) Provide protection to structures from lightning strokes.
- b) Provide a low resistance-conducting path to lightning discharge.

4.02.02 Lightning protection shall be provided for Power House building, auxiliary building , chimney, cooling tower and other structures.

4.02.03 Lightning protection will also be provided for building/ structures where the overall rise factor exceeds  $10^{-6}$  as per IS:2309.

4.02.04 For metal structures which are electrically continuous down to the ground level, no lightning protection is required except adequate grounding connections.

4.02.05 **System Design**

- a) Air termination network with down conductors and earthing electrodes will be provided on the basis of IS Code of Practice.
- b) Horizontal air termination shall be so laid out that no part of the roof will be more than 9 meters from the nearest conductor.
- c) Shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 Degrees.
- d) Down conductors will run along the outer surfaces of the building and shall have a test joint about 1500 mm above ground.
- e) An earth electrode will be provided at the connection point of the down conductor with the station ground.
- f) Galvanised steel rods and flats will be generally used for air termination and connections. All connections will be welded type.
- g) For air terminals of chimney, lead coated copper tube suitably brazed with G.S. Band ring shall be provided.

4.03.00 **Cabling System**

4.03.01 Erection of cabling work shall be carried out in such a way as to provide a reliable and assured electric power supply system to all station auxiliaries.

4.03.02 Cable routing will be done on unit basis as far as possible.

4.03.03 Cables will generally be laid on cable trays, cable trench, cable rack, overhead supported from building steel/structures or cable bridge/cable trestle. Cables shall be run in concrete trenches in transformer yard and in those electrical rooms at ground level, which are without any spreader room below. However cable trench shall be avoided as far as possible in outdoor areas. Cables buried directly in ground are not acceptable.

- In indoor pumps, mechanical equipment areas overhead cable trays shall generally be used.
- 4.03.04 For outdoor area cable shall be laid both in cable trench and cable trays within overhead pipe bridge. However cable trench shall be avoided as far as possible in outdoor areas and cable rack shall be used in Pipe Bridge for outdoor area cable interconnection
- 4.03.05 For underground crossing of railways, road, etc. additional protection shall be provided in form of hume pipe or concrete encased rigid steel conduits (duct bank).
- 4.03.06 A.C. and D.C. circuit will not be run in same cable. Further, separately fused circuit will run in separate cables.
- 4.03.07 Cables for redundant equipment system shall be run in separate trays, as far as possible.
- 4.03.08 Erection of cabling work shall be executed keeping in view all necessities and requirements of fire fighting codes for Generating Stations having an adverse industrial environment.
- 4.03.09 Suitable embedded steel inserts shall be provided on wall/floor/ ceiling surfaces for welding of cable tray bracket in order to make the cable tray system withstand horizontal/vertical accelerations due to seismic forces for indoor trays and also wind load for outdoor trays such as on Boiler platforms in addition to normal tray cable loadings.
- 4.04.00 All erection work to be carried out under this specification shall conform to the notes and details given in Annexure-A & drawing attached to this specification.
- 5.00.00 **SPECIFIC REQUIREMENTS - SUPPLY**
- 5.01.00 **Equipment and Material**
- 5.01.01 Equipment and material shall comply with description, rating, type and size as detailed in this specification, drawings and annexures.
- 5.01.02 Equipment and materials furnished shall be complete and operative in all details.
- 5.01.03 All accessories, fittings, supports, hangers, anchor bolts etc. which form part of the equipment or which are necessary for safe and satisfactory installation and operation of the equipment shall be furnished.
- 5.01.04 All parts shall be made accurately to standard gauges so as to facilitate replacement and repair. All corresponding parts of similar equipment shall be interchangeable.
- 5.02.00 **Pre-fabricated Cable Trays**
- 5.02.01 Cable trays shall be pre-fabricated ladder type sheet steel with hot dip galvanising furnished in standard length of 2.5 metres.

- 5.02.02 Cable trays shall be of standard width specified in Annexure-A and drawings.
- 5.02.03 Cable trays shall be complete with all necessary hot dip galvanised sheet steel accessories such as coupler plates, ground continuity connections, nuts, bolts, washers, hangers, clamps, etc. Also horizontal/ vertical bends, horizontal/ vertical Tee, Reducers, Horizontal cross-pieces, protective covers shall be supplied along with straight runs in order to take care of cable tray alignments in different routes.
- 5.02.04 All fittings like horizontal/ vertical elbow, horizontal crosspiece, reducer, horizontal tee, etc. should be prefabricated.
- 5.02.05 Cable trays, fittings & accessories as well as elbows, reducers, tees, crosses, etc. shall be fabricated out of 14 gauge (2 mm thick) hot rolled mild steel sheets.
- 5.02.06 Contractor shall supply 16 gauge (1.6 mm thick) perforated type hot rolled mild steel sheet covers for vertical cable shafts up to a height of 2.5 metres from floor level. The perforated covers used for the vertical raceways may be of one or more pieces along the width of the raceway, depending on the width of the raceway and shall be bolted to the structural framework of the raceway.
- 5.02.07 The cable trays, fittings and accessories including all bolts, nuts, screws, washers, etc. shall be hot dip galvanised after fabrication as per IS:2629. Galvanising shall be uniform, clear, smooth and free from acid spots. Should the galvanising of the samples be found defective, the entire batch of steel will have to be regalvanised at Contractor's cost.
- The amount of zinc deposited shall not be less than 610 gms per square metre of surface area and in addition the thickness of the zinc deposit at any spot whatsoever, shall not be less than 75 microns. The Owner reserves the right to measure the thickness of zinc deposit by Elcometer or any other instrument and reject any component, which shows thickness of zinc at any location to be less than 75 microns.
- 5.02.08 Each 2.5M long section of all types of cable trays & each fittings like elbow, tees, crosses, etc. shall be provided with two nos. hot dip galvanised side coupler plates & associated bolts, nuts and washers on each side.
- 5.02.09 The Contractor shall perform all tests necessary to ensure that the material and workmanship conform to the relevant standards and that such tests are adequate to demonstrate that the equipment will comply with the requirement of this specification.
- The tolerance on dimensions shall be in accordance with appropriate Indian Standards. The extent of the tests to be performed by the contractor shall include but not be limited to the following:
- Deflection Test
- A 2.5 metre straight section of each type of cable trays shall be simply supported at the two ends. A uniformly distributed load of 100 Kg per metre will be applied along the length of the tray. The maximum deflection at mid span shall not exceed 7 mm.

- 5.02.10 For other details refer CABLING NOTES AND DETAILS annexed to this specification.
- 5.03.00 **Conduits and Accessories**
- 5.03.01 Conduits shall be of rigid steel, hot-dip galvanised, furnished in standard length of 5 metres, threaded at both ends.
- 5.03.02 Conduits diameter upto and including 25mm size shall be of 16 SWG and conduits above 25 mm diameter shall be of 14 SWG. Minimum diameter of conduits shall be 20 mm.
- 5.03.03 Each piece of conduit shall be straight, free from blister and other defects, internal surface shall be of smooth finish and covered with capped bushings at both ends.
- 5.03.04 The contractor shall provide and install all rigid steel conduits, mild steel pipes, flexible conduits rigid PVC pipes, etc. complete with accessories such as tees, bends, adapters, locknuts, pull boxes, conduit plugs, caps, etc as required for the cabling work.
- 5.03.05 Steel conduits with interior coating of silicon epoxy ester for ease of wire/cable pulling shall be seamed by welding and flo-coat metal conduit/hot-dip galvanised. These shall be supplied in standard length of 5M with minimum wall thickness as specified in IS:9537. In chemical handling areas, Battery Room, etc., the exterior surface shall be further coated with chromate and polymer for better resistance to corrosion. Conduits, fittings & accessories shall have ISI mark.
- 5.03.06 For sizes above 63 mm mild steel pipes with necessary fittings & accessories shall be provided and installed by the contractor. Pipes shall be manufactured by electric welding process. These pipes shall be of heavy duty class as per IS:1239 and shall have ISI mark. Pipes shall be supplied in lengths of approximately 5 metres. Pipes, fittings & accessories shall be hot dip galvanised both on inside and outside.
- 5.03.07 Flexible conduits shall comply with IS:3480. They shall be made with bright, cold-rolled, annealed and electro-galvanised mild steel strips. Flexible conduits shall be used between embedded conduits/pipes and the motor terminals. Flexible conduits shall also be used between fixed conduit and any equipment terminal boxes where vibration is anticipated or equipment that require regular removal.
- 5.03.08 Rigid PVC conduits conforming to IS:4985 shall generally be used for control & instrumentation cables in some areas where cable trays do not exist and where the runs are straight ones generally the PVC pipes with special Bell Mouthing shall be of 110 mm, 160 mm & 200 mm outside diameter and shall be suitable for working pressure of 6 kg/sq. cm. The length of each pipe shall be 5 to 6 metres. Necessary fittings & accessories as may be required for the installation shall also be provided.
- 5.04.00 **Junction Boxes**
- 5.04.01 Glass Fibre Reinforced Junction Boxes

1. No. of Ways:12 / 24 / 36 / 48 with 20% spare terminals.
2. Design:

Junction boxes shall be Glass Fibre Reinforced with saturated polyester informing to standards like DIN 16911 type 803 / 16913 type 834, 5 self extinguishing in accordance with ASTM D 635 / UL 94 VO.

Junction boxes for use in outdoor or damp locations shall be sturdy construction. Temperature resistance between – 10 to 100 deg C. Impact resistance shall be greater than 7 Nm, (EN 50 014). Protective insulation shall be in line with VDE 0100, dielectric strength shall be greater than 10 KV/mm, halogen free toxicity, the enclosure and door cover shall be painted and electrostatically powder coated (preferably in RAL 7032). Earth connection (studs size shall be M 6) shall be provided on the cover as well as door.

Doors:

With integrated viewing window of 3 mm resistant plexi – glass or equivalent. The doors shall have industrial heavy – duty hinges. The doors shall be easily but firmly lockable with quick release fastener.

- a) Protection Class :

Protection Category shall be IP 66 to EN60 529. There shall be guaranteed perfect seal to meet Protection class IP 66 providing sealing arrangement like highly elastic foamed in special type seal like polyurethane / chloroprene. The sealing rubber shall not have aging effect and shall retain its sealing characteristics for more than 20 yrs. Bidder shall indicate this in data sheet. The rubber seal should be pasted at its place with pasting technology for like more than 20 yrs ( double sealing arrangement is preferred).

- b) Mounting clamps and accessories :

Suitable for mounting on walls, columns and structure. Brackets, bolts, nuts, screws, glands and lugs required for erection shall be of brass. The accessories like mounting plants etc. of steel shall be powdered coated. The support rails for terminal box shall be zink coated.

- c) General :

- i) JBs shall have small canopy at the top.
- ii) There shall be rainwater collection arrangement from top and side of the outer ages to ensure that any leakage in to the junction box shall be avoided and it shall fall outside.
- iii) Cable entry shall be from bottom side only.
- iv) Ensure gland plate sealing perfect. It shall be of the same quality and arrangement as that of door to cover arrangement.

5.04.02 Steel Junction Boxes :

- a) No. of Ways:12 / 24 / 36 / 48 with 20% spare terminals.
- b) Design :
- Junction boxes shall be designed in accordance with NEC, article 370, paragraph 18, 20 or equivalent standards.
- c) Enclosure :
- Junction boxes for use in outdoor or damp locations shall be sturdy steel construction. The enclosure and door cover shall be surface finished clean, degreased, phosphated, deep coated primed (preferably in RAL 7044) and electrostatically powder coated (preferably in RAL 7032). Earth connection (studs size shall be M 6) shall be provided on the cover as well as door. The sheath steel thickness shall be minimum 2 mm.
- d) Doors :
- The doors shall be hinged and lockable. The doors shall have industrial heavy – duty hinges. The doors shall be easily but firmly lockable with quick release fastener.
- e) Protection Class :
- Protection Category shall be IP 66 to EN60 529 / 10.91 complies with NEMA 4. There shall be guaranteed perfect seal to meet Protection class IP 66 providing sealing arrangement like highly elastic foamed in special type seal like polyurethane. There shall be an arrangement like multifold protection channel for additional stability and prevention of ingress of dust and water when the enclosure is open.
- The sealing rubber shall not have aging effect and shall retain its sealing characteristics for more than 20 yrs. Bidder shall indicate this in data sheet. The rubber seal should be pasted at its place with pasting technology for like more than 20 yrs (double sealing arrangement is preferred).
- f) Mounting clamps and accessories:
- Suitable for mounting on walls, columns and structure. Brackets, bolts, nuts, screws, glands and lugs required

- 5.04.03 The junction boxes shall have the following indelible marking
- Circuit nos. on top by white-stenciled paint at site.
  - Circuit nos. with ferrules (inside) as per approved drawing.
  - Danger sign in case of 415V circuit.

**5.05.00 Terminals**

- 5.05.01 Multiway terminal blocks of approved type, complete with screws, nuts; washers and marking strips shall be furnished for connection of incoming/outgoing wires.

5.05.02 Each control cable terminal shall be suitable for connection of 2 nos. 2.5 sq.mm. stranded copper conductors without any damage to the conductor or looseness of conductors.

**5.06.00 Cable Termination & Jointing Kits**

5.06.01 The Bidder shall supply cable termination and jointing kits in requisite quantity for H.T. Power Cables, L.T. Power, Control Cables, Instrumentation Cables, etc. along with all accessories & consumables required for making termination and joints complete. All the materials and components of the termination/joints shall be suitable and compatible with the type of cables for which the terminals/ joints are intended.

5.06.02 The straight through joints of H.T. and L.T. cables shall be of Tapex/ Paracast/Parawrap type. The end termination kits for H.T. cables shall be of Raychem/3M/Elastimold type. Cable joint or end terminations on Electrical equipment shall be suitable for Indoor & Outdoor use, as the case may be.

5.06.03 Glands and lugs required for termination of H.T., L.T. and instrumentation cables shall be supplied by the Contractor in required quantity.

**5.07.00 Cable Glands**

Cable glands shall be tinned brass gland, double compression type complete with necessary armour clamp and tapered washer, etc. Cable glands shall match with the sizes of different HT/LT/Control cables.

**5.08.00 Cable Lugs**

Cable lugs shall be suitable for termination of different cross-sections of H.T./L.T./Control/Instrumentation cables and shall be of following types :

- i) Aluminium tubular terminal end for solderless crimping to aluminium conductors.
- ii) Copper tubular terminal end for solderless crimping to copper conductors.

Solderless crimping of terminals shall be done by using corrosion inhibiting compound. The cable lugs shall suit the type of terminals provided on the equipment. Lugs for control/instrumentation cables shall be PVC insulated/sleeved type.

- iii) Cable lugs for control cable termination shall be insulated. These lugs shall be pin type/flat type/ring type/U type to suit the terminals provided in the panels.

**5.09.00 Consumables and Hardware**

5.09.01 The Contractor shall furnish all erection materials, hardware and consumables required to complete the installation.

5.09.02 The materials shall include but not be limited to the following :

- Consumables : Welding rods & gas, oil and grease, cleaning fluids, paints, electrical tape, soldering materials, etc.
- Hardware : Bolts, nuts, washers, screws, brackets, supports, clamps, hangers, saddles, cleats, sills, shims, etc.  
5.09.03 Supply of cement, sand, stone, etc. required for the execution of the contract shall be the responsibility of the Contractor.

#### 5.10.00 **Testing Equipment**

5.10.01 The major testing equipment that are required to be provided by the Contractor are listed below :

- a) Insulation Tests
  - i) Power operated Meggar - 1 KV and 10 KV grade
  - ii) Hand operated Meggar - 1 KV grade
- b) Hand driven earth Resistance Meggar, range 0-1/3/30 ohms.
- c) High potential testing set - roller mounted type
- d) Tong testers of suitable ranges.
- e) Contact resistance measuring set for micro-ohms.
- f) Torque wrench of various sizes.
- g) Multimeters, test lamp, field telephone with buzzer set, different gauges, etc.

5.10.02 The list of equipment is indicative only. Any other test equipments required will be arranged by the Contractor.

#### 6.00.00 **METHODS AND WORKMANSHIP**

6.01.00 All work shall be installed in a first class, neat workmanlike manner by mechanics/ electricians skilled in the trade involved.

6.02.00 The erection work shall be supervised by competent supervisors holding relevant supervisory license from the Government.

6.03.00 All details on installation shall be electrically and mechanically correct.

6.04.00 The installation shall be carried out in such a manner as to preserve access to other equipment installed.

#### 7.00.00 **INSTALLATION**

7.01.01 Installation work shall be carried out in accordance with good engineering practices and also as per manufacturer's instructions/ recommendations where the same are available.

- 7.01.02 Equipment shall be installed in a neat workmanlike manner so that it is level, plumb, square and properly aligned and oriented.
- 7.01.03 Cable installation work shall mean erection of cable trays/racks, supports, hangers, junction boxes, conduits, laying of cables either in ground or on trays inside trenches tunnels/overhead trays in conduits, etc. dressing and clamping, jointing and termination inclusive of supply of necessary jointing/termination kits, lugs, glands, ferrules, tapes, etc. and other accessories, grounding of cable armour. In case of direct laying in ground, all excavation work, necessary back-filling, supply of bricks and protective concrete slabs, removal of excess earth shall be part of the installation work.
- 7.01.04 Grounding installation work shall mean erection, jointing/ brazing/ welding, connection and painting, testing of ground conductors including supply of necessary steel/copper.
- 7.01.05 Lightning protection system installation work shall mean erection, jointing, welding, connection and painting, testing of air termination network, down conductors, shielding masts, connection to ground grid, electrodes, risers, horizontal conductors, etc. of lightning protection system.
- 7.02.00 **Cable Trays**
- 7.02.01 Pre-fabricated cable trays and accessories shall be assembled & erected at site. Adequate spaces will be provided to facilitate installation of cable system and to allow routine inspection and modification after installation.
- 7.02.02 Cable trays either inside concrete trenches or inside buildings and racks inside cable shafts shall be aligned and leveled properly. All tray runs shall be installed parallel to the trench/building walls and floors except otherwise noted in the approved drawings.
- 7.02.03 As far as practicable, cable trays shall be supported from one side only in order to facilitate installation and maintenance of cables from the other side.
- 7.02.04 The cable trays shall be supported in general at a span of exceeding 1.25 metres horizontally and 1.0 metre vertically.
- 7.02.05 Sufficient spacing not less than 250 mm shall be provided between trays and maintained to permit adequate access, for installing & maintaining the cables.
- 7.02.06 Complete cable tray support structure after installation shall be inspected/ tested for welding strength, straightness, accuracy, use of proper sizes and compliance to drawings.
- 7.02.07 Complete cable tray and accessory installation work shall be inspected/tested for proper alignment, leveling, use of proper accessories, high quality workmanship, etc.
- 7.02.08 The Contractor shall remove the RCC/steel trench covers whenever required and shall again place the same in their positions after the erection work in the particular area is completed or when further work is not likely to be taken up for some time.

- 7.02.09 Whenever any pipe/conduit/cable tray emerges out or enters into a building care should be taken to ensure that no water enters into the building.
- 7.02.10 Cable trays in areas subject to excessive coal dust, oil spillage, mechanical damage or accessible to personal contact shall be provided with raised sheet metal tray covers, installed on upper tray in horizontal run and front in vertical run.
- 7.02.11 Cable trays/racks shall be so arranged that they do not obstruct or impair clearances of passage way.
- 7.02.12 Cable tray/conduit system will be so designed as to accommodate maximum pulling tension and minimum bending radius of cable.
- 7.02.13 Cable tray/conduit system will be constructed to prevent drainage of water into equipment or building.
- 7.02.14 Cable tray/conduit system shall be electrically continuous and grounded.
- 7.02.15 Different voltage grade cables will be laid in separate trays when trays are run in tier formation. Power cables will normally be on top trays and control/instrumentation cable on bottom trays.
- 7.03.00 **Cable and Conduits**
- 7.03.01 The Contractor shall install, terminate and connect up all cable and conduits as per drawings and cable schedules.
- 7.03.02 The drawings shall be strictly followed except where obvious interference occurs. In such cases, the routing shall be changed as directed and/or approved by the Engineer.
- 7.03.03 Approximate lengths of cable and conduit runs will be shown by the contractor in the cable schedule for guidance only. Before commencement of work the Contractor shall take actual measurements and prepare his own cable-cutting schedule to reduce wastage to a minimum.
- 7.03.04 The Contractor shall also maintain and submit when requested, a record of cable insulation value when drawn from store, after laying, before and after termination/jointing.
- 7.03.05 Where direct heat radiation exists, heat isolating barriers, shall be adopted for cabling system.
- 7.03.06 Cabling/wiring in offices, laboratories, control rooms etc. shall be taken through concealed G.I. or rigid PVC pipes as directed by the owner's Engineer.
- 7.03.07 At certain places where hazardous fumes/gasses may cause fire to the cables, cable trenches after installation of cables shall be sand filled.
- 7.04.00 **Conduit and Accessories**
- 7.04.01 Conduit/pipes shall be used only in short lengths in certain areas where required and/or as directed by the Engineer.

- 7.04.02 The Contractor shall furnish all conduits complete with accessories as required.
- 7.04.03 Conduits shall be flexible type in general. However, rigid type steel conduit if required shall also be supplied by the Contractor.
- 7.04.04 Except for inside an enclosure wherever the cable enters or leaves the conduit, the conduit end shall be sealed by suitable sealing compound, having fire withstand capability.
- 7.04.05 The entire metallic conduit system, when embedded or exposed shall be electrically continuous and grounded.
- 7.04.06 Where it is possible for water or other liquids to enter conduits, sloping of conduit runs and drainage of flow points shall be considered.
- 7.04.07 Pull boxes will be installed between termination points where required to facilitate cable pulling, but at a maximum interval of 30 meters.
- 7.04.08 Conduits shall be firmly fastened within 900 mm of each junction box/pull box/cabinet/fitting, etc. Conduits shall be supported at least every 2000 mm.
- 7.05.00 **Cables : Storage and Handling**
- 7.05.01 Cable drums shall be stored on hard and well-drained surface so that they may not sink. In no case shall the drum be stored on the flat, i.e., with flange horizontal.
- 7.05.02 Rolling of drums shall be avoided as far as practicable, for short distance, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum.
- 7.05.03 In absence of any indication, the drums may be rolled in the same direction as it was rolled during taking up the cable.
- 7.05.04 For unreeling the cable, the drum shall be mounted on jacks or on cable wheel. The spindle shall be strong enough to carry the weight without bending.
- 7.05.05 The drum shall be rolled on the spindle slowly so that the cable should come out over the drum and not below the drum.
- 7.05.06 While laying cable, cable rollers shall be used at an interval of 2000 mm. The cables shall be pushed over the roller by a gang of people positioned in between rollers over a suitable distance. Care shall be taken so that kinks and twists or any mechanical damage does not occur in cables. Only approved cable pulling grips or other devices shall be used. Cables shall not be dragged on ground or along structure while laying out from cable drums.
- 7.05.07 Cable shall not be pulled from the end without having intermediate pushing arrangement. Bending radius of the cable during installation shall not be less than what is specified by the manufacturer.
- 7.05.08 Empty cable drums shall be returned to the owner.

**7.06.00 Cable Laying**

- 7.06.01 Cable shall generally be installed in ladder type prefabricated trays except for some short run in rigid/flexible conduit for protection or crossings.
- 7.06.02 Cables laid on trays and risers shall be neatly dressed and clamped with self-locking type fire resistant nylon ties at an interval of 750 mm. for horizontal and vertical runs, in case of both power, control and instrumentation cables.
- 7.06.03 All single core power cables for 3 Ph. AC circuits shall be laid in trefoil formation and suitably clamped with self-locking type fire resistant nylon ties at an interval of 750 mm.
- 7.06.04 All H.T. multicore power cables and L.T. multicore power cables with cross-sectional area including & above 95 sq.mm shall be clamped individually by self-locking type fire resistant nylon ties.
- 7.06.05 L.T. power cables of cross sectional area less than 95 sq. mm. and all control and Instrumentation cables shall be clamped in bunches with self-locking type fire resistant nylon ties. The number of cable in one bunch shall not exceed eight (8).
- 7.06.06 Prior to laying of cables inside the indoor and outdoor trenches, the contractor shall properly clean the trenches.
- 7.06.07 In outdoor areas, buried cables shall be laid and covered with sand/riddled earth and protected from damage by bricks at sides and precast slab at top.
- 7.06.08 When buried cables cross road/railway track, adequate protection shall be provided in the form of hume/galvanised iron pipes laid at a minimum depth of 1 meter below ground.
- 7.06.09 After completion of installation and prior to connection, all power cables shall be subjected to a high potential test.

**7.07.00 Cable Tags & Markers**

- 7.07.01 Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedules. Cables and conduits shall be tagged at their entrance, bends, every 30.0M and exit from any equipment, junction box. When a cable/conduit passes through a wall, tags shall be fitted on both sides of the wall.
- 7.07.02 The tags shall be of aluminium with the number punched on it and securely attached to the cable by not less than two turns of 16 SWG G.I. wire. For single core cable the wire shall be of non-magnetic material.
- 7.07.03 The location of cable joints, if any, shall be clearly indicated with cable marker with an additional inscription 'cable-joint'.
- 7.07.04 The Contractor shall furnish and install all tags and markers stated above.

- 7.07.05 For buried cable, the marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change of direction.
- 7.08.00 **Cable Termination and Connection**
- 7.08.01 The termination and connection of cables shall be done strictly in accordance with manufacturer's instruction, drawings and/or as directed by the Engineer.
- 7.08.02 The work shall include all clamping, fitting, fixing, soldering, tapping, compound filling, cable jointing, crimping, shorting and grounding as required for the complete job. All equipment required for all such operations shall be of Contractor's procurement.
- 7.08.03 Furnishing of all consumable materials such as soldering material, electrical tape, sealing material as well as cable jointing kits shall be included in the offer.
- 7.08.04 Cable joint kits for all cables shall be supplied by Contractor under this specification. Responsibility for proper termination shall lie on the contractor. Guarantee for termination shall also have to be given by Contractor.
- 7.08.05 The equipment will be generally provided with blank bottom plates for cable/conduit entry and cable end box for power cables.
- 7.08.06 The Contractor shall perform all drilling, cutting on the blank plate and any minor modification work required to complete the job.
- 7.08.07 If the cable end box or terminal enclosure provided on the equipment is found unsuitable and requires major modification, the same shall be carried out by the contractor.
- 7.08.08 Control/instrumentation cable cores entering control panel/ switchgear/ MCC, etc. shall be neatly bunched and served with PVC perforated tape to keep it in position at the terminal block.
- 7.08.09 The Contractor shall put ferrules on all control cable cores in all junction boxes and at all terminations. The ferrules shall carry terminal numbers as per drawings. All ferrules shall be coloured, plastic & interlocked type.
- 7.08.10 Spare cores shall be similarly ferruled, crimped with lug and taped on the ends. Spare cores shall be ferruled with individual cable number.
- 7.08.11 Termination and connection shall be carried out in such a manner as to avoid strain on the terminals.
- 7.08.12 All cable entry Points shall be properly sealed and made vermin and dust proof. Unusual opening, if any, shall be effectively closed. Sealing work shall be carried out with approved sealing compound having fire withstand capability for at least three hours.
- 7.09.00 **Termi-point Connection**
- a) The conductor (solid or stranded) is forced against the contact area of the 2.4 x 0.8 mm or 1.6 x 0.8 mm connection pin by means of a

tin-coated bronze clip, which maintains a constant pressure. In the Maxitermi-point method, 2.4 x 0.8 mm pins is used without exception.

- b) The conductor is "shot" onto the pin together with the clip. The resulting friction causes both the wire and the contact area of the pin to be cleaned and any oxide layers to be penetrated.
- c) Apart from this the wire and the clip are deformed in such a way that a gas-tight connection with very good electrical and mechanical properties is established.
- d) A special manually or pneumatically driven gun is required. Up to 3 adjacent connections can be "shot" onto one pin. In most cases only one clip at the base of the pin is attached. The sections above usually remain vacant. Any part of a connection pin may be reused several times after removal of the existing clip connection. Contact areas below existing connections that have become vacant can be reused by pushing the connections above the vacant space downwards, so that the new connection can be "shot" on above the top connection. The single jumper wires need not be specially prepared as the end insulation is stripped within the tool.
- e) This connection method requires special insulation of the wires. The diameter of solid conductors is 0.8 mm the cross-section of stranded conductors 0.5 Sq.mm.
- f) The conductor is deformed greatly when attached and is to be shortened by 3 mm when disconnected and reused.
- g) Strips and special tools for termi-point connection shall be supplied by the Contractor.

**7.10.00 Cable Joints**

7.10.01 Cable shall be installed without joints as far as practicable.

7.10.02 If however jointing becomes necessary, it shall be made only by qualified cable jointer and strictly in accordance with manufacturer's recommendation.

**7.11.00 Grounding**

7.11.01 The Contractor shall carryout the interconnection among various peripheral earthing grids/mats, steel structures, lightning protection system as well as grounding of all electrical equipment, etc. The grounding work shall be carried out as per provisions of I.E. rules Indian standards and enclosed grounding and lightning protection notes and details.

7.11.02 The grounding shall be done by conductors of adequate sizes (size shall be selected by the bidder with supporting calculation) and the same shall be connected to the risers of main ground mat.

7.11.03 For fabricated cable trays, a separate ground conductor (50x6 mm G.S. flat) shall run along the entire length of each route of cable tray being suitably clamped on the cable tray. Individual cable trays of each section shall be

connected to above ground conductor through 50x6 mm G.S. flat to maintain continuity of ground path.

7.11.04 All ground conductor connections shall be made by electric arc welding/ brazing unless otherwise specified. Ground connections shall be made from nearest available station ground grid risers. The rods/connection shall be coated with cold galvanizing /weather resistance anti corrosive paints.

7.11.05 All ground conductors shall be painted black for easy identification.

7.11.06 Equipment ground connections, after being checked and tested by the Engineer, shall be coated with anti-corrosive paint.

7.11.07 Whether specifically shown or not, all conduits, trays, cable armour and cable end box, electrical equipment such as motors, switchboards, panels, cabinets, junction boxes, lockout switches, fittings, fixtures, etc. shall be effectively grounded.

7.11.08 If there is no provision to ground the L.T. transformer neutral at transformer end, to make an effectively earthed 415V system the neutral bus of all 415V distribution boards shall be connected to ground grid at two different and distinct points.

7.11.09 The underground mat will be made of mild steel rods laid underground in length and breadth of the area at a depth of minimum 1 metre below grade level. All crossings and straight run shall be arc welded for good electrical continuity. Ground conductors, when crossing underground trenches, directly laid underground pipe and equipment foundation, if any, shall be at least 300 mm below the bottom elevation of such trenches/pipes as shown in the relevant drawing.

The Contractor will plan and organise works to lay the grounding mat in the same sequence in which the building and equipment foundation is being done.

7.11.10 Ground Electrode

Ground electrodes will be 40 mm dia ( minimum) and 3 metre long M.S. rod. These are to be fabricated and driven into the ground by the side of mat conductor. All connections to the conductors shall be done by arc welding process.

7.11.11 Risers

Risers are required for connecting the equipment and structures with the ground mat. These will be 1 No. 40 mm dia ( Minimum) M.S. rod. laid from ground mat to above ground level properly clamped or supported along the outer edge of the concrete foundation. Connection to the ground mat shall be done by arc welding and the other end is to be kept free at least 300 mm above grade level/concrete floor level unless otherwise shown.

7.11.12 Column Grounding

All columns are required to be grounded by 1 no. 40 mm dia ( Minimum) M.S. rod from ground mat. Laying, supporting along with foundation, connecting at

ground mat are within the scope of this specification. At least 300 mm length of the above rods shall be left free above the grade level/concrete floor level for connection with columns.

**7.11.13 Electronic Equipment Grounding**

Internal ground connection of electronic panels shall be insulated from the enclosure, frame, chassis and to be terminated to an insulated ground bus.

Insulated ground bus of all electronic panels shall be connected by insulated wire to an insulated common electronic ground bar.

All connection made above shall be in the form of a radial distribution system without any parallel ground paths.

Electronic equipments and systems, metal enclosures of all electronic panels shall be connected to a grounding system with which is isolated and separate from the electrical equipment grounding system. Separate Earth pit shall be made by 3M X 3M MS Rod.

**7.12.00 Painting**

**7.12.01** The Contractor shall paint steel fabrications at site with two (2) coats of red oxide primer and two (2) coats of battleship grey (shade no. 632 of IS:5) synthetic enamel paint.

**7.13.00 Galvanising**

**7.13.01** The galvanising shall be uniform, clean, smooth, continuous and free from acid spots. Should the galvanising of the samples be found defective, the entire batch of steel has to be regalvanised, at Contractor's cost. The amount of zinc deposit shall not be less than 610 grams per square metre of surface area and in addition, the thickness of the zinc deposit at any spot whatsoever shall not be less than 75 microns. The Owner reserves the right to measure the thickness of zinc deposit by Elkometer or any other instrument and reject any component which shows thickness of zinc at any location less than 75 microns.

**7.14.00 Excavation and Back Filling**

**7.14.01** The Contractor shall perform all excavation and backfilling as required for buried cable and ground connections.

**7.14.02** Excavation shall be performed up to the required depth. Such sheeting and shoring shall be done as may be necessary for protection of the work.

**7.14.03** The Contractor shall make use of his own arrangements for pumping out any water that may be accumulated in the excavation.

**7.14.04** All excavation shall be backfilled to the original level with good consolidation.

**7.15.00 Steel Fabrication**

**7.15.01** All racks, trays, supports, hangers & brackets wherever necessary shall be fabricated by the Contractor.

7.15.02 Steel for fabrication shall be straightened and cleaned of rust and grease. All fabrication shall be free of sharp edge and burns so as not to cause any damage to personnel or cables.

7.16.00 **Cleaning up of Work Site**

7.16.01 The Contractor shall, from time to time, remove all rubbish resulting from execution of his work. No materials shall be stored or placed on passage or drive ways.

7.16.02 Upon completion of work, the Contractor shall remove all rubbish, tools, scaffoldings, temporary structures and surplus materials etc. to leave the premises clean and fit for use.

8.00.00 **TESTS**

8.01.00 Shop Tests

8.01.01 All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant Indian Standards at manufacturer's works.

8.01.02 Tests on panels/junction boxes shall include :

- a) Wiring continuity tests.
- b) High voltage and insulation tests.
- c) Operational tests.

8.02.00 **Site Tests**

8.02.01 Contractor shall thoroughly test and meggar all cables, wires and equipment to prove the same are free from ground and short circuit.

8.02.02 If any ground or short circuit is found, the fault shall be rectified or the cable and/or equipment replaced.

8.02.03 All power cables after installation and prior to connections shall be subjected to High Potential tests. Also the insulation resistance values shall be measured both before and after Hipot test for comparison. The leakage current shall also be measured during the Hipot test at site.

Cable cores shall be tested for :

- a) Physical damage
- b) Continuity
- c) Correctness of connections as per relevant wiring diagram
- d) Insulation resistance to earth
- e) Insulation resistance between conductors
- f) Proper earth connections of cable glands, cable boxes, cable armour, screens etc.

- 8.02.04 All equipment shall be demonstrated to operate in accordance with the requirements of this specification.
- 8.03.00 **Test Certificates**
- 8.03.01 Type test certificate on any equipment, if so desired by the Owner, shall be furnished. Otherwise the equipment shall have to be type tested, free of charge, to prove the design.
- 9.00.00 **DRAWINGS, DATA & MANUALS**
- 9.01.00 To be submitted with the Bid
- 9.01.01 Make, type and catalogue number of different electrical items and accessories along with technical leaflets, data sheets etc.
- 9.01.02 Typical General arrangement drawings showing constructional features, fixing arrangement of pre-fabricated cable trays.
- 9.01.03 Bill of Materials for cable trays and accessories, conduits & accessories.
- 9.01.04 Layout of Grounding system & lightning protection system showing connection and other details along with backup design calculations and detailed write up.
- 9.01.05 Bill of materials for grounding and lightning protection system.
- 9.01.06 Drawing showing details of equipment grounding.
- 9.02.00 **To be submitted after Award of Contract**
- 9.02.01 Make, type & catalogue number of cable termination kits, joints & accessories.
- 9.02.02 Detail dimensional drawings showing constructional features, grounding, fixing arrangement etc.
- 9.02.03 Bill of Materials for Pre-fabricated cable tray and accessories, Conduits & accessories.
- 9.02.04 Dimensional G.A. drawings and data sheets for different equipment and items supplied under this specification.
- 9.02.05 Layout drawing of Grounding system and Lightning protection system showing connection details along with backup design calculation and detailed write up.
- 9.02.06 Bill of material for grounding system and lightning protection system.
- 9.02.07 Drawing showing details of equipment grounding system.

**ANNEXURE-A**

**NOTES AND DETAILS  
FOR  
CABLING SYSTEM**

**1.00.00 GENERAL**

1.01.00 These notes and details shall be read and construed in conjunction with Specification and the drawings meant for cable tray details and supporting arrangements in Trench, Racks etc., enclosed elsewhere. In case of conflict between these notes and drawings, the latter shall prevail.

1.02.00 The Cabling System installation work shall conform to the requirements of the latest revisions of the following standards/codes

- a) Indian Electricity Rules, 1956, with up to date amendment.
- b) I.S. Code of Practice.

**2.00.00 CABLE ROUTING/LAYING**

2.01.01 Cables shall generally be laid on ladder type cable trays either in trenches or overhead supported from building steel/structures except in some cases cables may have to be laid underground and for short runs in conduits for protection or crossing.

2.01.02 For interplant connections, the cables may be directly buried or routed through an overhead cable bridge or cable trenches/tunnels selection being dependent on site constraints.

2.01.03 For underground crossing of railways, roads etc. hume pipes shall be used and shall be laid at a depth of minimum 1000 mm such that cables shall not be damaged.

2.01.04 In boiler area, trench will be avoided as far as practicable. The cable racks shall be supported from Boiler structure in vertical configuration with suitable cover to avoid deposition of coal dust as far as practicable.

2.01.05 Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. Power cables shall be on top trays and Control/Instrumentation cables on bottom trays, and it is recommended that trays for cables of different voltage levels be stacked in descending order with higher voltage level above.

2.01.06 Cables for redundant equipment/system shall be run in separate trays in separate route.

2.01.07 Cables from two different services viz. supply from station board and supply from unit board shall be fully segregated to prevent simultaneous damage due to fire in one of the services.

- 2.01.08 Low level signal cables and other special Instrumentation and Control cables shall run in separate trays. In general, a minimum of 1500 mm clearance shall be maintained between these cables and noise generating equipment (large motors, generators, transformers etc.).
- 2.01.09 The cable spreaders of each unit shall be compartmentalized by provision of fire proof partition wall.
- 2.01.10 The floor of the cable spreader rooms will have to be made water proof so that water does not percolate to lower levels in the event of fire fighting operations. Adequate arrangement for efficient drainage of water shall be provided. The cable raceways should also be suitably curved to avoid water entry through this place.
- 2.01.11 Cabling System for CHP
- a) Cable in CHP area shall be generally routed through the conveyor gallery / tunnel, TP / Buildings by separate supporting structures, Pipe cum cable bridge. The cables shall be laid in vertical trays.
  - b) In substation & Switchgear room cable shall be laid in horizontal cable trays installed in cable vault room.
  - c) Cables may also be routed through hume pipes to enter into various buildings from the nearest overhead cable trestle/substation building..
  - d) Overhead cable trestle/cable bridge shall be provided for routing of cables between the following Sub-Stations/buildings:
    - i) Main CHP Substation Building and Crusher House.
    - ii) Main CHP Substation Building and Pump House.
    - iii) Wagon Tippler Substation Building and TP.

The bottom of the steel supporting structure shall be generally at 2.5m above the grade level except for road crossing and rail crossing where the same shall be 6.5 m and 9.0m respectively above grade level.
  - e) Cable trays shall be laid out horizontally in sub-station buildings and pump-house whereas the same shall be installed vertically inside transfer points, crusher house, conveyor gallery/tunnel etc. The cable trestle shall have a minimum 600mm clear walk way all along its routes and shall have maintenance platforms as required.
  - f) Separate trays shall be provided for H.T., L.T., control and instrumentation cables. LT multicore Power cables shall be laid touching each other in single layer & touching formation and single core cable in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil centre lines and clamped at every two meter while control and instrumentation cables shall be laid in maximum of two layers formation. Single core HT power cables shall be laid on trefoil formation with a distance of four times the diameter of cable between trefoil centre lines and clamped at every two meter and Multi core power cables shall be laid in single layer & touching formation. Normally cable trays shall be designed with 70%

fill-in criteria and conduit 40% fill-in criteria. Same cable laying philosophy shall be considered in other areas of the plant, if not specifically mentioned.

**2.02.00 Cable Trays/Supports**

2.02.01 Cable trays and covers shall be pre-fabricated type, constructed from minimum 14 SWG sheet steel for trays and 16 SWG for covers and hot-dip galvanized after fabrication.

2.02.02 Cable tray supports shall be cantilever type for each installation. All supports and hardware shall be hot-dip galvanized.

2.02.03 Standard cable tray width shall be 600 mm. However, trays with 450, and 300, 150 mm width may be used in some places considering the requirement and space restrictions. For instrumentation and control purpose, some perforated type cable trays of width 150 and/or 100mm may be used particularly in Boiler Platform area, and 600, 450, 300 mm perforated trays may be used depending on site requirement.

2.02.04 Cable trays shall be ladder type with 250 mm rung spacing, 100 mm depth and rung width not less than 50 mm.

2.02.05 All weld for cable tray supports shall have a min. throat thickness of 6 mm.

2.02.06 Cable trays in areas subjected to excessive coal dust, or mechanical damage will have hot-dip galvanized sheet metal tray cover installed on front tray in vertical run and inverted 'V' type on upper tray in horizontal run.

Where covers are used on trays containing power cables, consideration should be given to ventilation requirements. Areas where corrosive chemicals are likely to be handled, cable tray and covers shall be epoxy painted.

**2.03.00 Conduits**

2.03.01 Conduits shall be rigid steel coated type; minimum size of conduit shall be limited to 19mm.

2.03.02 Steel conduits with interior coating of silicon epoxy ester for ease of wire pulling shall be seamed by welding and flo-coat metal conduit/hot-dip galvanized. These shall be supplied in standard length of 5M with minimum wall thickness as specified in IS:9537 Part-II. In chemical handling areas, Battery room etc., the exterior surface shall be further coated with chromate and polymer for better resistance to corrosion.

2.03.03 Conduit runs shall be supported at an interval of 750 mm for vertical run and 1000 mm for horizontal run.

2.03.04 Conduits shall be sized so that conduit fill (ratio of total cable area to conduit area) shall not exceed the following :

One Cable	:	53%
Two Cable	:	31%
Three Cables & Up	:	40%

- 2.03.05 Conduit runs shall be provided with necessary bends as required.
- 2.04.00 **Installation**
- 2.04.01 The Contractor shall install terminate and connect up all cables and conduits with supporting arrangements as per drawings, cable schedules and interconnection chart/drawings.
- 2.04.02 The HV power cables of 11 KV/6.6/3.3 KV shall be laid in trays or racks as follows :
- a) In single layer only.
  - b) Multi core cables to be laid in touching with each other.
  - c) Single core cables to be laid in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil centerlines and clamp every two meter.
- 2.04.03 1100V grade power cables shall be laid in single layer in trays.
- 2.04.04 1100V grade mutlicore power cable shall be laid in touching formation to each other.
- 2.04.05 1100V grade Single core cables to be laid in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil centerlines and clamp every two meter.
- Control and Instrumentation cables can be laid up to a maximum of two layers in each tray.
- 2.04.06 Normally cable trays shall be designed with 70% fill-in criteria and conduit 40% fill-in criteria. Same cable laying philosophy shall be considered in other areas of the plant, if not specifically mentioned.
- 2.04.07 The trays shall be run with a vertical spacing of 300 mm for overhead cable trays as well as inside cable trenches. A minimum of 225 mm clearance shall be provided between the top of tray and beams, cold piping, 500 mm clearance for hot piping/object to facilitate installation of cables in tray.
- 2.04.08 Adequate pull boxes shall be provided in conduit run to facilitate cable pulling in long runs and also to ensure that there will be no more than 270 Deg. bends between pull points.
- 2.04.09 Cable tray/conduit system shall be installed to accommodate cable manufacturer's recommended maximum pulling tension and minimum bending radius.
- 2.04.10 All openings in the floor and wall for cable access shall be sealed after installation of the cable system with non-inflammable materials, as follows :
- i) Fire stop/Penetration seal shall be installed in the cable spreaders and cable raceways.
  - ii) Similarly in the trenches fire stop/penetration seals shall be provided at suitable interval to avoid spread of fire.

- iii) For all H.T., L.T., Relay and Control panels, Control desk, instrumentation panels, battery charger, D.C. Dist. boards and other miscellaneous panels, fire-stops should be provided below base plate.

2.04.11 All floor/wall openings for cable entry to the electrical equipment and accessories shall be sealed with non-inflammable materials, after completion of cable installation. Thickness of such materials shall be equal to the thickness of floor/wall unless specified otherwise.

2.04.12 The portion of galvanised steel, which, if required, undergoes any welding at site shall be coated with two (2) coats of cold galvanising anti-corrosive paint after welding.

2.04.13 Refer Clause No. 3.00.00 below for details of fire-proof sealing and fire protection coating.

#### 2.05.00 **Identification**

2.05.01 The complete cabling system shall be properly identified. Methods for identification of cabling system shall be furnished to the successful EPC Contractor shall strictly adhere to the said methods.

2.05.02 Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.

2.05.03 Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanised iron plate, projected above ground level.

2.05.04 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, at each bend and at every thirty (30) metres in cable tray/trench runs. Cable tags shall also be provided inside the switchgear, MCC, control & relay panels etc. wherever required for cable identification, such as where a number of cables enter together through a gland plate.

#### 3.00.00 **FIRE-PROOF SEALING / FIRE PROTECTION COATING SYSTEM**

3.01.00 The Fire proof sealing / fire stop system / fire protection coating system is required to prevent spreading of fire from one place to other place (or one zone to other zone) through the openings in wall / floor, cables laid in trays / racks and openings below Electrical Switchgear / MCC / Distribution boards / Cabinets / Panels, etc.

#### 3.02.00 **Scope of Work**

3.02.01 The scope of work includes but is not limited to the following supply and services:

- i) Fire Stops in wall / floors.
- ii) Fire stops below switchgear / MCC / Switchboards, junction boxes / panels / cabinets, etc. which are floor mounted type.
- iii) Fire retardant coating to be applied for installed cables.

- iv) Minor civil / structural works for installation of the entire work.
- v) All necessary erection materials, consumables and sundry items to complete the entire work for satisfactory and trouble free operation.
- vi) Any special tools & tackles.
- vii) Conducting the type test of fire proof sealing system in presence of Owner's engineers.
- viii) All relevant Drawings, Data sheets and instruction manuals.
- ix) Fire proof barrier walls.
- x) Fire proof doors.

**3.03.00 Design Criteria**

**3.03.01 Fire Proof Sealing System**

The material / components used for fire-proof sealing system shall be provided to meet the following requirements:

- i) Life expectancy should not be less than 30 years from the date of installation.
- ii) Free from shrinkage or cracking or asbestos in composition and should achieve smoke and gas tightness during fire and should be modifiable.
- iii) Not to generate toxic gas and harms to the personnel handling the system.
- iv) Prohibition of production of acid or alkali during gas generation.
- v) Will not produce suffocating / corrosive gas.
- vi) Repellant to paste / rodent / termite.
- vii) Expansion co-efficient - very low which is to be comparable with masonry concrete.
- viii) Not soluble / reactive to acid, water, alkali.
- ix) Thermal conductivity - low.
- x) The material in contact with the cables in the fire-proof sealing system shall be compatible with the material used for outer sheath of cables.
- xi) It should not have any adverse effect on the cables and should not alter the current carrying capacity of the cables.

- xii) Retrofit in design to accommodate not less than 15% more addition of cables depending upon the size of cables, physically and chemically stable.
- xiii) Capable of withstanding vibrations, drop-loads, foot traffics, mechanical loads, etc.
- xiv) The F.P.S. system shall maintain its integrity and perform satisfactory even after
  - a. Remaining in water for a long time.
  - b. Accelerated thermal aging.
  - c. Sustaining vibrations.
- xv) The design and construction of F.P.S. system shall specifically take into account the fact that under seismic disturbances, normal load, short circuit and fire conditions, the cable / cable trays will be subject to movement, expansion and oscillation and this shall not result in any damage or cause dislocation of the F.P.S. system or the material constituting the FPS System.
- xvi) Non-hygroscopic, non-inflammable and shall not get affected over a period of time due to humidity, moisture and ozone etc. and should not contain volatile solvents which may cause a fire hazard during application.
- xvii) The fire rating shall not be less than two (2) hours and the system shall be stable after applicable of water jet in the exposed side in order to extinguish fire.

**3.03.02 Fire Protection coating to be applied on installed Cables:**

The cables shall be coated with fire protection material of 2 mm dry thickness at the strategic locations as follows so as to limit the spread of fire:

- i) At fire stops in walls and floors on either side upto 500 mm length.
- ii) At fire stop below Electrical Switchgears/ MCCs/ Panels/ Cabins, etc. on one side coating of 500 mm length, i.e., on the cable vault side / cable trench side.
- iii) Length of 500 mm on all sides of the junction/crossing of cabling work in open cable routes/ cable trench.
- iv) In fire risk areas and where specified at suitable intervals as decided upon site conditions in open cable routes.
- v) Where necessary and specified at site intervals along cable routes in cable trenches.
- vi) The coating shall be applied evenly on the cables only.

**3.03.03 The fire protection coating shall have the following properties/composition:**

- i) Asbestos free, non-volatile, not eatable by vermin, harmless and non-irritant to skin of human.
- ii) Not affecting the current carrying capacity of the cables and the properties of the installed cables.
- iii) It shall delay fire damage to cables and prevent flame spreading meeting the requirement of IEEE - 383.
- iv) Coating material shall show no signs of cracking and peeling when the coated cable is bent to the radius of minimum 12 times the diameter of the maximum size cable at 180°C.
- v) The limiting oxygen index of the material shall not be less than 60% as per ASTM D - 2863.
- vi) Life expectancy equivalent to the cable installations.

3.03.04 The various openings in the cable vault, vertical/ horizontal raceways of cables penetrating walls/ floors and the bottom of Electrical switchgears/ MCCs/ distribution boards/ Cabinets/ Panels shall be provided with fire stop systems. Cables passing through the openings at various locations are laid on various tiers of the cable trays/ racks in the bunch formation. Bidder shall visit the site to assess and get acquainted with the type of cable installation where fire stops and fire protection coating are to be provided. In case steel frames are required to be fabricated and fixed in the openings, the fabrication of frame & fixing of the same shall have to be done by the Contractor without any extra cost. The necessary steel section for fabrication of frames shall be supplied by the Contractor without any extra cost. Any civil works required to be done in the openings shall be carried out by the Bidder. Bidder shall also include one set of tools & accessories required for addition or removal of cables after the seal is made.

3.04.00 The bidder shall quote the unit rates for provision of supply, installation, testing & commissioning of the fire proof seals as given in the specification. Bidder is requested to quote the unit rates per square metre (i.e., area) basis of the area of the fire sealing material.

3.05.00 **Type Test On Penetration Seals**

3.05.01 The type tests for fire proof/ penetration seal for floor and wall opening/ fire stop system for bottom of electrical switchgear/ MCC/ panel base are as under:

- i) Fire rating test.
- ii) Hose Stream test.
- iii) Accelerated aging test.
- iv) Fire rating test on the penetration seal system built out of accelerated aged components followed by hose stream test.
- v) Temp. rise test for cable in the fire stop.

- vi) Water absorption test followed by fire rating test.
- vii) Flame Resistance test for fire retardant coating material.
- viii) Anti-rodent test.

3.05.02 Fire Rating Test

This test shall be carried out to prove the guaranteed power rating duration of the system in respect of stability, integrity and insulation characteristics of the complete system. The penetration seal system as a whole conforming to ASTM 814 and as per BS:476 Part-8 shall be built with the necessary component. The fire test shall be built with the necessary component.

The test specimen of the penetration seal built with 9-10 nos. armoured cables of various sizes passing through the seal shall be fitted to the gas fired furnace and shall form the upper most face of the furnace. The gas fired furnace shall have provision to achieve standard time temperature characteristics for fire tests as mentioned in BS-476 Part-8, according to which the temperature required to be maintained are as under:

<u>Heating time in minutes</u>	<u>Temperature in the furnace</u>
30 minutes	821°C
90 minutes	886°C
120 minutes	1029°C
150 minutes	1062°C
180 minutes	1090°C
210 minutes	1113°C
240 minutes	1133°C

The pressure inside the furnace at the time of test shall be more than 2 mm water gauge. The penetration shall be subjected to fire test with surface exposed to controlled fire in the furnace conforming to time / temperature characteristics as mentioned above. During the test, the temperature of both the faces of the penetration seal i.e. one which is exposed to fire and the other unexposed, shall be measured by calibrated thermocouples after regular interval of 5 minutes. At least 3 thermocouples shall be provided for temperature measurement of each face.

3.05.03 The results at the end of the tests shall be interpreted or failure criteria as under:

- i) The system is deemed to have failed to maintain stability if there is a total collapse of the penetration seal.
- ii) In case cracks are seen on the face of the penetration seal or cracks through the sealing system through which the flame / or gas can pass,

the system is deemed to have failed to maintain integrity. The development of crack is characterized by ignition cotton wool held near the seal on the unexposed surface at a distance of about 30 mm from the aperture.

- iii) In case the mean temperature rise of unexposed surface of seal exceeds 140°C above the initial temperature or temperature of unexposed surface exceeds 180°C, the system shall be deemed to have failed in respect of insulation characteristics.
- iv) Temperature measurement on the unexposed side of the penetration seal specimen shall be measured by the thermocouple on the surface of penetrating items and on fire stop material in accordance with ATME-814/UL 1479 at a distance of 25 mm from fire stop material and penetration items respectively.

#### 3.05.04 Hose Stream Test:

The intention of the hose stream test is to ascertain whether the penetration seal assembly maintains its stability on application of water jet after withstanding the fire for 3 hours i.e. the guaranteed fire rating duration.

The test apparatus for this test shall be similar to the one used for carrying out the fire rating test. The penetration seal system shall be subjected to the action of hose stream at the nozzle pressure of 30 psi supplied for a duration of 1.5 sec./ sq.ft. of exposed area. The hose stream shall be applied with 1.1/8" dia. nozzle at a perpendicular distance of approximately 17 ft. from the centre of the assembly on a line approximately 270 deg. from the line normal to the centre for the test assembly. The water stream shall be applied within 4 minutes and 30 seconds after completion of fire rating test.

However, this period shall not exceed more than 10 minutes in case of practical difficulties experienced by testing stations. The application of water stream shall be maintained through out the test duration and shall traverse the complete fire stop system.

The fire stop assembly is deemed to have passed the hose stream test successfully if no through projection of water is noticed on the unexposed surface of the seal. Further on completion of hose stream test, the appearance of the penetration seal system shall not alter substantially indicating thereby that the stability of the system has been maintained.'

#### 3.05.05 Accelerated aging test

The intention of accelerated aging test is to ascertain whether the artificial aging of the systems and components thereof results into change in the mechanical properties or in the form. In order to simulate aging, artificial aging shall be resorted to.

For the purpose of subjecting the penetrations seal system components to accelerated aging, the system / components shall be stored for 336 hours in air furnace where the temperature of the inside air, shall be maintained at 100 degree centigrade. However, for system components in pliable form, system component shall be stored for 448 hours in air furnace where temp. of air inside the furnace shall be maintained at 75°C. It is assumed that the changes occurring during test period would roughly correspond to the effect on aging over a period of about 40 years.

After completion of 336 hours / 448 hours, the mechanical properties such as tensile strength element, elongation and hardness of the material (as may be applicable) shall be tested. This results shall be compared with corresponding values before subjecting to accelerated aging test.

The change in the form of system / components shall also be compared with the form before the tests to ascertain whether the system / components thereof have undergone any permanent change.

In case the mechanical properties before and after the accelerated aging do not indicate substantial change, the system shall be deemed to have passed the accelerated aging test. Similarly the variation in the form of the system components at the end of the test shall not indicate permanent deformation which is likely to affect the ceiling properties of the system.

**3.05.06 Fire Rating test After Accelerated Aging:**

Intention to this test is to ascertain whether the penetration seal built out of components already subjected to accelerated aging still passes the fire rating test for guaranteed fire rating duration.

The test apparatus for this test shall be similar to the one used for fire rating test mentioned above. The assembly or the penetration seal shall be carried out with the components which were subjected to accelerated aging test based on the test procedure mentioned above. In case there is a problem of co-ordination with the test station, the prototype assembly may be subjected to aging in manufacturer's works under the conditions mentioned above and live fire test should be carried out at manufacturer's works in presence of Owner's representative.

In live fire test, the temperature of fire shall be of the order of 1000 deg.C at the end of 3 hours. The test shall be carried out at atmospheric pressure.

The interpretation of test results for failure shall be similar to those mentioned under fire rating test/live fire test at (1) - (c) above.

**3.05.07 Temperature rise test for cable in the fire stop:**

This test shall be carried out to ascertain whether due to inadequate dissipation of heat at the location of fire stop, the temperature of cable conductor or outer sheath in contact with the fire stop, rises beyond the acceptable limits due to which whether any derating is required for cables.

Fire stop systems shall be erected with, at least 8-10 armoured cables, specially power cables. While laying the cable through penetration seal, thermocouple shall be placed on the outer surface of cable in contact with the fire stop system. The location shall be selected where there exists possibility of inadequate dissipation of heat from cables to the atmosphere due to fire stop components. Two thermocouples shall also be located on the two surfaces of the fire penetration seal system. Similarly thermocouples shall also be placed on the other surface of cables where there exists contact of free air without any obstruction so as to enable adequate nature cooling.

In case the temperature of outer surface of the cable in contact or inside the fire stop system does not exceed 75 degree centigrade, it is inferred that no derating of cable is required for cable when used in conjunction with the particular fire stop system.

Test shall be repeated with reduced current till the temperature of cable outer surface in contact with fire stop system is limited to 75°C. The rate of the current so guaranteed by the cable manufacturer as free air rating shall be the derating factor.

**3.05.08 Water Absorption Test:**

The test specimen shall be immersed in fresh clean water at a temp. of 20°C. The test specimen must be separated from the bottom and sides of the soak tank by at least 10 mm and it shall be covered by approximately 25 mm of water. At the end of the 24 hours soak period, the specimen shall be removed from the water and mopped up with a damp cloth.

Fire rating test after water absorption is to ascertain whether the penetration seal subjected to water absorption still passes the fire rating test for guaranteed fire rating duration.

The test apparatus for this test shall be similar to the one used for fire rating test at Sr. No.1. In case there is problem of coordination with test stations, the prototype assembly may be subject to water absorption test at manufacturer's works followed by live fire test which should be carried out at manufacturer's works in presence of Owner's representative. In line fire test, the temp. of furnace shall be of the order of 1000°C at the end of 3 hours. The test shall be carried out at atmospheric pressure.

**3.05.09 Flame Resistance Test for fire Retardant Coating Material:**

Sample strips shall be of ½ " wide, 12" long and approximately 70 mills in thick (without any reinforcement). Each strip shall be held vertically (clamped at the top) in a natural gas burner flame, (blue cone of flame touching bottom edge of sample) for 10 minutes. The flame shall then be removed and observation shall be recorded. In case, any flaming of the samples should cease after the removal of gas burner. White charred length of the sample should not exceed 1 & ½".

3.05.10 Anti-Rodent Test:

Physical tests:

- a) This test shall be carried out to ascertain the anti-rodent properties of the components of the Fire proof sealing system.
- b) This test shall be carried out at approved test station performing sealing system tests on pharmaceutical products. The complete Fire Proof sealing system shall be subjected to attack of insect / vermin such as rat for about 20 days.
- c) At the end of the test condition of the surface of Fire Proof sealing system the test material shall be compared with the surface condition before commencement of the test. The fire stop shall be deemed to have passed this test in case no marks of growth are seen on the surface.

3.05.11 Test Certificates

Certified copies of all tests carried out at works and at site shall be furnished in requisite number of copies.

Test reports shall be complete with all details and shall also contain limit values specified in the relevant standards, wherever applicable, to facilitate review of Test Report/ Certificates.

The fire proof sealing system shall be installed only after receipt of approval of the test reports.

3.05.12 Testing Charges

The bidder has to indicate that unit rates for conducting the type test successfully alongwith the offer, which will be considered for evaluation of tender.

**ANNEXURE-B**

**NOTES & DETAILS  
FOR  
GROUNDING & LIGHTNING PROTECTION SYSTEM**

1.00.00 **GENERAL**

1.01.00 These notes and details shall be read and construed in conjunction with grounding and lightning protection drawings and specification. In case of conflict between these notes and drawings, the latter shall prevail.

1.02.00 The grounding and lightning protection system installation work shall conform to the requirements of the latest editions of the following standards/codes :

- a) Indian Electricity Rules, 1956.
- b) National Electrical Code, 1985.
- c) Code of Practice for Earthing (IS: 3043)
- d) Protection of Buildings and Allied Structures Against Lightning (IS: 2309)
- e) IEEE 80

2.00.00 **GROUNDING SYSTEM**

2.01.00 **Main Grounding Mat/Grid**

2.01.01 The main ground grid shall be buried in earth at a minimum depth of 1000 mm below finished grade level unless stated otherwise. The size of ground grid conductor shall be bare 40 mm dia. mild steel rod (minimum). The actual diameter of ground grid conductor shall be selected by EPC contractor with back up calculation.

2.01.02 A minimum earth coverage of 300 mm shall be provided between the ground grid conductor and the bottom of trenches, tunnels, underground pipes, foundations, railway tracks etc. The ground grid conductor shall be re-routed in case it fouls with equipment foundations.

2.01.03 In some cases, it may happen that the construction work of cable trench, foundation and laying of underground pipes are being taken up after the grounding mat has been laid. It may be required to cut a portion of grounding conductor to avoid fouling with cable trench, equipment foundations, underground pipes etc. In this case, the ground conductor shall be properly rerouted and rejoined/reconnected with the main grounding mat during the construction/laying of above underground objects and good electrical continuity of grounding conductor shall be ensured.

2.01.04 Grounding conductors crossing the road may have to be laid at greater depth to suit the site conditions.

- 2.01.05 Grounding conductor around the building shall be buried in earth at a minimum distance of 1200 mm from the outer boundary of the building.
- 2.02.00 **Grounding Electrodes**
- 2.02.01 The ground electrodes shall be 40 mm dia, 3000 mm long mild steel rod. These shall be fabricated and driven into the ground by the side of grounding mat conductors and connected to the ground mat conductors.
- 2.03.00 **Risers**
- 2.03.01 All risers/pigtail from the ground grid shall be 40 mm dia mild steel rod and shall be projected 300 mm above grade level/concrete floor level unless otherwise shown.
- 2.04.00 **Earthing Conductor**
- 2.04.01 75x 10 mm galvanised steel flats shall be run as main earthing conductors above ground along building columns, walls, steel structure, etc. for equipment and other structures earthing.
- 2.04.02 These earthing conductors shall be interconnected between them and to the main ground grid through risers/pigtail. The connection between earthing conductor and riser shall be made above ground.
- 2.04.03 Earthing conductors along their run on column, wall etc. will be supported by suitable welding/clamping at intervals set exceeding 750 mm.
- 2.04.04 Earthing conductors shall be embedded in concrete floor of the building without having direct contact with the reinforcement rods.
- 2.04.05 At the crossing of building walls, floors etc. the earthing conductor shall be passed through galvanised conduit sleeves. Both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.
- 2.05.00 **Grounding of Equipment And Structures**
- 2.05.01 All indoor and outdoor electrical equipment and associated non-current carrying metal works, supporting structures, building/ boiler columns, fence, system neutrals, lightning masts/arresters shall be connected to the plant ground system.
- 2.05.02 Two separate and distinct ground connections shall be provided for grounding electrical equipment frameworks in compliance with I.E. rules.
- 2.05.03 All Electrical equipment will be furnished with two (2) separate ground pads with tapped holes, bolts and spring washers. The connection between these ground pads and the grounding grid shall be made by short and direct earthing conductors free from kinks and splices.
- 2.05.04 Miscellaneous devices such as junction boxes, pull boxes, pushbutton stations, lockout switches, cable end boxes, lighting fixtures, receptacles, switches etc. shall be effectively grounded whether specifically shown or not.

- 2.05.05 The generator neutrals, transformer neutrals, earthing terminals of lightning arresters, coupling capacitor shall be directly connected to rod electrodes through riser which in turn, shall be connected to station grounding mat.
- 2.05.06 Grounding mat comprising closely spaced conductors shall be provided below the operating handles of isolator and circuit breaker operating box located in outdoor high voltage substation. The operating handles shall be properly bonded with flexible conductors.
- 2.05.07 Metallic conduits and pipes shall not be used as earth continuity conductor. These shall be grounded at both ends.
- 2.05.08
- a) The cable trays inside the cable trenches shall be grounded thru' one (1) no. 40 mm dia M.S. Rod at an interval of ten (10) metres. One end of this rod is connected with riser from grounding mat and the other end which is projected inside the cable trench shall be connected with one (1) 50 x 6 mm G.S. flat which runs horizontally along the cable trench. This earthing conductor shall be securely attached to each tray section of cable tray/trays forming a solidly grounded tray system through 50 x 6 mm G.S. flats.
  - b) A continuous 50 x 6 mm G.S. flat earthing conductor shall run along the supporting structure of overhead cable trays/cable shafts. This earthing conductor shall be attached to each section of cable tray/trays through 50 x 6 mm G.S. flats.
- 2.05.09 Fence within the ground grid shall be bonded to the plant ground system at regular interval not exceeding ten (10) metres. Fence gate shall be separately grounded with flexible connection to permit movement.
- 2.05.10 The street lighting poles, junction boxes mounted on the poles, flood light supporting structures etc. shall be connected to ground grid at minimum two points.
- 2.05.11 The steel columns, metallic stairs, hand-rail etc. of the building where electrical equipment are located shall be connected to the nearby ground mat by earthing conductor. Electrical continuity shall be ensured by bonding the different sections of handrails and metallic stairs.
- 2.05.12 The railway tracks within plant area shall be bonded across fish plates and the rail tracks shall be connected to grounding grid at different locations. The rail tracks leaving the plant boundary shall be made electrically discontinuous from the rail tracks inside the plant area by providing suitable arrangements at fish plate joints.
- 2.05.13 The overhead crane rails shall be grounded at both ends. In addition all joints shall be bonded to provide electrical continuity.
- 2.05.14 The flexible earthing connection of jumpering wire shall be provided where flexible conduits are connected to rigid conduits to ensure continuity.

**2.06.00 Earthing of Cable**

2.06.01 The metallic sheaths, screens and armour of cables shall be earthed at both switchgear/MCC/DB and equipment ends.

**2.07.00 Jointing And Connection**

2.07.01 All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode. The contact surfaces shall be thoroughly cleaned to provide good electrical continuity.

2.07.02 The bending of the large diameter ground conductor where necessary shall be done by gas heating.

2.07.03 The projected portion of riser/pigtail above ground shall be coated with two coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.

2.07.04 The connections between the riser/pigtail and earthing conductors (galvanised steel flats) and between the earthing conductors above ground level shall be made by electric arc welding.

2.07.05 The portion of galvanised steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanising anti-corrosive paint after welding.

2.07.06 The earthing connections to equipment grounding pads/terminals and some removable structures shall be bolted type with GI bolts and nuts. The contact surfaces shall be thoroughly cleaned (to free from scale, paint, enamel, grease, rust) before connection to ensure good electrical contact.

2.07.07 Equipment/structures ground connections after properly checked and tested shall be coated with weather resistant paints/cold galvanising paints.

2.08.00 The sizes and materials of ground conductors used in grounding system are listed below :

<b>Description</b>	<b>Size</b>	<b>Material</b>
a) Main Grounding Grid Conductor	40 mm dia Rod (Min)	Mild Steel
b) Riser/Pigtail From Grounding Grid/Mat	40 mm dia Rod (Min)	- Do -
c) Electrode	40 mm dia Rod (Min) - Do - 3000 mm long.	

Description	Size	Material
d) Conductor used for connection of various equipment/structures as listed below		
i) E.H.V. Substation quipment	Flats 75x 10 mm	Galvanised Steel
Generator Frame & Gen Neutral	75 x 10 mm Flat	- Do -
Generator Exciter Frame	75 x 10 mm Flat	- Do -
GT, ST, UT Frame	75 x 10 mm Flat	- Do -
GT, ST, UT Neutral	75 x 10 mm Flat	- Do -
Aux. Power Transformer Frame	75 x 10 mm Flat	- Do -
ii) 11 kV/3.3kV Equipment	75 x 10 mm Flat	- Do -
iii) 11 kV/3.3kV Switchgear	75 x 10 mm Flat	- Do -
iv) 415 V PMCC	75 x 10 mm Flat	- Do -
v) Structures, Bus Duct Control Panels, Cable Trays etc.	75 x 10 mm Flat	- Do -
vi) 415V Motor Control Centres, Distribution Boards etc.	75 x 10 mm Flat	- Do -
vii) Local Panels, Lighting Panels	50 x 6 mm Flat	- Do -
viii) Motors :		
All HT Motors	75 x 10 mm Flat	- Do -
LT Motor Above 90 kW	50 x 6 mm Flat	- Do -
LT Motors Above 30 kW Upto 90 kW	35 x 6 mm Flat	- Do -
Above 5 kW Upto 30 kW	25 x 3 mm Flat	- Do -
Upto 5 kW	8 SWG Wire	Galvanised Iron
ix) Miscellaneous Items, viz. Push Button Station, Junction Boxes etc.	8 SWG Wire	- Do -

Note: Sizes of GS Flat as indicated above are minimum. However Bidder shall calculate each of them and submit for approval.

**3.00.00 LIGHTNING PROTECTION SYSTEM**

**3.01.00 Air Terminations**

3.01.01 The vertical air terminal rods shall be installed at the roof of buildings (including power house main building), at the top of chimney and cooling towers to protect these objects from lightning strokes.

3.01.02 The vertical air terminal except for chimney shall be made of 20 mm dia galvanised steel rod. The projected length of the rod shall be as required to protect the object (on which the rod is fixed) from lightning stroke.

3.01.03 The air terminal rods provided at the top of chimney/stack for lightning protection shall be 20 mm dia lead coated solid copper rod.

3.01.04 The air terminal rod shall be properly fixed on the top of the building/structure to withstand very high wind pressure. In case the air terminal rod is embedded at the top of roof of building: the portion embedded inside the concrete shall not touch the reinforcement bars and shall be duly insulated from them.

3.01.05 All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size 75 x 10 mm galvanised steel flats.

3.01.06 The shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 degrees.

3.01.07 Horizontal air termination (i.e. G.S. Flat conductor) shall be so laid that no part of the rod will be more than nine (9) metres from the nearest roof conductor.

**3.02.00 Shielding Masts**

3.02.01 The shielding mast for lightning protection shall be installed at the top of steel columns cap plates of power house main building.

3.02.02 The shielding mast shall be made of galvanised steel pipe and the height of the same shall be decided considering the zones to be protected.

3.02.03 Each shielding mast shall be connected to grounding grid by a down conductor 75 x 10 mm. Galvanised steel flat run along the building column. In addition all power house building columns joints shall be electrically bonded.

**3.03.00 Down Conductors**

3.03.01 The down conductors shall be 75 x 10 mm galvanised steel flats. The sizes of down conductors and horizontal conductor provided for lightning protection of conveyer gallery shall be 25 x 3 mm galvanised steel flats. One end of this shall be connected with air terminal rod/horizontal conductor at the top of roof/structure and other end connected to the nearest 40 mm dia. mild steel rod riser from ground electrode.

3.03.02 Each down conductor shall have an independent earth termination. In no case conductors of the lightning protection system shall be connected with the conductor of grounding system above ground level.

3.03.03 The connection between each down conductor and rod electrode (by means of 40 mm mild steel rod riser) shall be made via test link located at approximately 1500 mm above ground level.

3.03.04 The down conductor shall be laid straight and sharp bends shall be avoided as far as practicable. These shall be cleated on outside of the building wall and column/structure at about 750 mm intervals unless stated otherwise in the drawing.

3.03.05 At all supports for down conductor along the column/wall of the buildings; chimney etc. the portion embedded inside the building concrete should not touch the reinforcement bars.

3.03.06 All exposed metallic parts of the buildings shall be bonded to the down conductors. Such parts shall include ladders, balconies, conduits etc.

3.03.07 The down conductors shall be protected at the ground level against mechanical injury by means of non-metallic pipes, viz. PVC pipes filled with bituminous compound.

**3.04.00 Electrodes (for Lightning Protection)**

3.04.01 The electrodes shall be 40 mm diameter 3000 mm long mild steel rod. These shall be driven into the ground.

3.04.02 All the electrodes shall be interconnected by means of one (1) 40 mm dia mild steel rod which will be laid under ground at a minimum depth of 1000 mm below finished grade level unless stated otherwise. This ground mats/electrode in turn shall be connected to main grounding grid.

**3.05.00 Riser (for Lightning Protection)**

3.05.01 All risers connected to grounding mat shall be 40 mm mild steel rods and shall be projected 300 mm above grade level unless stated otherwise.

**3.06.00 Jointing & Connection**

3.06.01 All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode.

- 3.06.02 The projected portion of riser above ground shall be coated with two (2) coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.
- 3.06.03 The joints in the lightning conductors shall be kept to a minimum and there shall be no joint in the underground portions of conductors.
- 3.06.04 All the joints shall be done by arc welding process overlapping of the conductors at straight joints shall not be less than 150 mm. The contact surfaces shall be cleaned properly before jointing.
- 3.06.05 The portion of galvanised steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanising anti-corrosive paint after welding.
- 3.06.06 The bolted joint of the test link shall be covered with thick coating of bitumen paint after successful testing.
- 3.06.07 The air terminal rods and shielding mast shall be coated with weather resistant anti-corrosive paint (zinc chromate followed by two coats of aluminium paint).
- 3.06.08 The steel to copper connection shall be brazed type.
- 3.07.00 **Lightning Protection of 400kV GIS & Other areas**
- 3.07.01 The lightning protection of outdoor switchyards/substation shall be done by lightning masts on the top of steel towers. In addition, shield wires shall be used where required. The shield wire shall be strung across the top of the steel tower and/or powerhouse structure.
- 3.07.02 The shield wire which shall be brought down up to bottom of steel tower shall be connected to the earthing conductor (50 x 6 mm galvanised steel flat) which in turn connected to the riser (from the main grounding mat/grid).
- 3.07.03 The lightning protection of inflammable liquid storage tanks wherever required, shall be provided with horizontal conductors strung between tall poles covering the entire zones or with air terminal rods mounted on top of poles/structure. These horizontal conductors/vertical air terminal rods shall be connected to rod electrodes, which in turn shall be connected to station ground mat.
- 3.07.04 The lightning protection of conveyor gallery shall be provided with horizontal conductors (25 x 3 mm G.S. Flat) run along the length of the conveyor gallery at the top of gallery roof. This conductor shall be connected to riser and grounding electrode (40 mm dia G.S. Rods) at an approximate interval of 30 mm through two down conduction (each 25 x 3 mm G.S. Flats).

3.08.00 The sizes and materials of earthing conductors to be used in lightning protection system are listed below :

<b>Description</b>	<b>Size</b>	<b>Material</b>
a) Vertical Air Termination	20 mm dia Rod (Chimney)	Lead Coated Copper rod.
b) Vertical Air Termination (Except Chimney)	20 mm dia Rod	Galvanised steel
c) Horizontal Conductor	i) 75 x 10 mm Flat ii) 25 x 3 mm Flat	- Do - - Do -
d) Down Conductors	i) 75 x 10 mm Flat ii) 25 x 3 mm Flat	- Do - - Do -
e) Riser From Electrode/ Grounding Mat	40 mm dia Rod	Mild Steel
f) Electrode for Lightning Protection	40 mm dia Rod 3000 mm long	- Do -

**Note :**

In addition to above, all materials as required such as G.I. pipes of appropriate length, diameter and thickness will be provided for lightning masts of Power House building and Switchyard.

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**SECTION-X**

**TECHNICAL SPECIFICATION  
FOR  
ERECTION INDOOR AND OUTDOOR ELECTRICAL EQUIPMENT**

**CONTENT**

<b>CLAUSE NO.</b>	<b>DESCRIPTION</b>
1.00.00	SCOPE OF WORK
2.00.00	SCOPE OF SUPPLY
3.00.00	TESTS
4.00.00	DRAWINGS, DATA AND MANUALS

**ATTACHMENT**

ANNEXURE-A	SCHEDULE OF PRECOMMISSIONING TESTS OF TRANSFORMER AND OTHER EQUIPMENT
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**SECTION-X**

**TECHNICAL SPECIFICATION  
FOR  
ERECTION INDOOR AND OUTDOOR ELECTRICAL EQUIPMENT**

**1.00.00 SCOPE OF WORK**

1.01.00 The scope of work shall cover complete and efficient erection, testing and commissioning and putting into successful commercial operation of all Outdoor and Indoor electrical equipment supplied.

1.02.00 The scope of work shall also include all civil and structural works necessary for successful installation and commercial operation of all electrical equipment to be erected under this specification.

**2.00.00 SCOPE OF SUPPLY**

2.01.01 The work involves timely procurement and transportation to site in properly packed condition of all hardware, materials and miscellaneous items required to complete the erection job under this specification.

Miscellaneous steel structures, tray supports, hangers & brackets for cable trays, mounting of local panels, push button stations etc. shall be supplied. Any material or accessory, which may not have been specifically mentioned but which is usual and/or necessary shall be supplied.

2.01.02 All hardware, materials and accessories to be supplied by the Bidder shall be brand new ones of reputed make.

2.01.03 Spare Parts

2.01.04 All relevant drawings, data sheet and technical leaflets on each piece of devices.

**2.02.00 Scope of Services**

The work includes but is not limited to the followings:

2.02.01 Furnishing of all erection tools and tackles, testing equipment, implements, supplies, consumables and hardware for timely and efficient execution of the erection work. Hydraulic jacks or motorized jacks necessary for lifting of heavy equipment shall be provided by the contractor.

2.02.02 Transport vehicles necessary for efficient transportation of equipment from stores to site of erection and excess materials back to stores.

2.02.03 Complete assembly, erection and connection, testing and commissioning, putting into successful and satisfactory commercial operations of the Outdoor and indoor Electrical Equipment and accessories listed below but not limited to:

A. Power Plant System

- a) Steam Turbine Synchronous Generators, Cubicles for Generator Excitation System & Accessories
- b) Generator Transformers
- c) Unit Transformers & Unit Aux Transformers
- d) Station Transformers & Station Aux Transformers
- e) CHP Aux. Transformer , AHP Aux. Transformer and Water System Aux. transformer
- f) L.T. Transformers (dry and Oil filled)
- g) Lighting Transformers
- h) Stringing and Connections
- i) Neutral Grounding Resistor Cubicles
- j) Generator Busduct and auxiliary equipment.
- k) 3300V , 6600V & 11000 V Busduct
- l) 415 V Busduct
- m) 11000 V Switchgear
- n) 6600 V Switchgear
- o) 3300 V Switchgear
- p) 415 V Switchgears, Switchgear cum MCCs.
- q) Motor Control Centres, A.C/D.C Distribution boards, Main lighting distribution boards and miscellaneous items.
- r) Battery and Battery Chargers, Uninterrupted Power Supply Panels
- s) Electrical Control Desks/Panels, Relay Panels, Data logger Panels etc.
- t) Miscellaneous Local Panels.
- u) Illumination system
- v) 11KV, 6.6kV & 3.3KV Power cable, 1.1KV Power & control cable, FS Power and Control cables, special cables including cabling system
- w) 360KV Lightning Arrestors & 400KV BPI

- x) 400kV GIS type indoor switchyard includes circuit breakers, disconnecting switch, current transformers, CVT, lightning arrester, Wave trap , Relay panel, Cabling , bay marshalling box, SAS, SCADA system , grounding , stringing.
  - y) Extension of 400kV outdoor type switchyard includes circuit breaker , disconnect switch , current transformer , capacitive voltage transformer , lightning arrester , coupling capacitor , wave trap , SAS , Relay panel , cabling , bay marshalling box , SCADA system , grounding , stringing etc.
  - z) Intercommunication and Telephone system
  - aa) All electrical equipment and systems integral with mechanical equipment, systems and subsystems.
  - ab) Any other equipment , but not specified herein but require for the completing the EPC Contract same shall be in the scope of EPC contractor.
- 2.02.04 The entire erection work shall be carried out in a phased manner. A schedule of the work showing the sequence of erection shall be submitted by the tenderer for this purpose.
- 2.02.05 The erection schedule, as approved by the Owner's Engineer shall be strictly followed by the contractor. If, for any reason beyond the control of the Contractor, the work is held-up then the Contractor shall bring it to the notice of the Owner's Engineer without any delay.
- 2.02.06 All erection work of equipment shall be carried out in a neat and efficient way so as not to impair their normal functioning in any way.
- 2.02.07 The pre-commissioning checks as well as commissioning of different equipment shall be carried out as per guidance of actual manufacturer's supervisor and or as per written instructions in Erection manuals. In case of any site related problem in commissioning activities, contractor shall seek advice of owner's Engineers.
- 2.02.08 All erection work under this specification shall be carried out strictly in accordance with the approved drawings.
- 2.02.09 In order to avoid concentration of stresses, all sharp edges of clamps, connectors etc. shall be rounded off.
- 2.03.00 **Methods and Workmanship**
- 2.03.01 All work shall be installed in a first class, neat workmanlike manner by mechanics/electricians skilled in the trade involved.
- 2.03.02 The erection work shall be supervised by competent supervisors holding relevant supervisory license from the Government.

- 2.03.03 All details on installation shall be electrically and mechanically correct.  
The installation shall be carried out in such a manner as to preserve access to other equipment installation.
- 2.04.00 **Consumables and Hardware**
- 2.04.01 The Contractor shall furnish all erection materials, hardware and consumables required for the completion of the installation.
- 2.04.02 The materials shall include but not be limited to the following :
- a) Consumables : Welding rods & gas, oil and grease, cleaning fluids, paints, electrical tape, soldering materials etc.
  - b) Hardware : Bolts, nuts, washers, screws, brackets, supports, clamps, hangers, saddles, cleats, sills, shims etc.
  - c) Materials : Junction boxes, terminal blocks, connectors, ferrules, lugs, brass glands, rigid/flexible conduits, cables, ground wires etc.
- 2.04.03 Supply of cement, sand, stone etc. required for the execution of the contract shall be the responsibility of the Contractor.
- 2.05.00 **Testing Equipment**
- 2.05.01 The major testing equipment that are required to be provided by the Contractor are listed below :
- a) Insulation Tester :
    - i) Power Operated Megger -1 KV and 10 KV Grade
    - ii) Hand Operated Megger – 1 KV Grade
  - b) Hand driven Earth Resistance Meggar, range 0 - 1/3/30 Ohms.
  - c) High Potential Testing Set - roller mounted type for LV, HV & EHV equipment
  - d) Tong testers of suitable ranges
  - e) Contact resistance measuring set for Micro-ohms.
  - f) Torque wrench of various sizes
  - g) Multi-meters, test lamp, field telephone with buzzer set, spirit level, different gauges etc.
  - h) Insulating oil testing set of range 0 - 60 KV.
  - i) Stream line filter for transformer.

j) Current Transformer for primary injection set

k) Relay testing and checking bench

2.05.02 Other test equipment as required will be arranged by the contractor.

**2.06.00 Installation – General**

2.06.01 Installation work shall be carried out in accordance with good engineering practices and also manufacturer's instructions/recommendations where the same are available.

2.06.02 Equipment shall be installed in a neat workmanlike manner so that it is level, plumb, square and properly aligned and oriented.

2.06.03 All erection work shall be carried out in strict compliance with manufacturer's instructions and shall include all necessary adjustments, checks and measurements.

2.06.04 All internal wiring of the equipment which has been left incomplete because of shipping split or which requires minor modifications shall be carried out by the contractor.

2.06.05 The contractor shall record results of all erection tests and measurements. The contractor shall submit copies of those test results to the Owner for his reference and record.

2.06.06 High voltage test of transformer oil shall be carried out taking samples from individual transformer and also from each insulating oil drum. If the result of di-electric test is not to the satisfaction of the Engineer, oil filtration, heat run and conditioning shall be carried out for the concerned transformer to improve the dielectric strength of oil and insulation to the acceptable value.

2.06.07 The storage and installation of transformer with all its accessories shall be carried out in strict compliance with manufacturer's instructions. Extreme care shall be taken to avoid ingress of moisture and foreign particles into the transformer tank.

**2.07.00 Steel Fabrication**

2.07.01 All racks, supports, hangers and brackets wherever necessary shall be fabricated by the contractor.

2.07.02 Steel for fabrication shall be straightened and cleaned of rust and grease. All fabrication shall be free of sharp edges.

**2.08.00 Painting**

2.08.01 The Contractor shall paint all racks, supports and miscellaneous steel fabrication with two (2) coats of red oxide primer and two (2) coats of synthetic enamel paint of approved shade (say battle ship grey IS shade # 632).

**2.09.00 Foundation & Civil Works**

- 2.09.01 Equipment foundations, equipment mounting structure foundation, panel foundations and other civil work will be provided by the Contractor.
- 2.09.02 The Contractor shall check these foundations before commencement of erection to ensure their suitability.
- 2.09.03 All final adjustment of foundation levels, chipping and dressing of foundation surfaces, setting and grouting of anchor bolts, sills, inserts and fastening devices shall be carried out by the contractor including minor modification of civil work as may be required for erection.
- 2.10.00 **Cleaning up of Work Site**
- 2.10.01 The Contractor shall, from time to time, remove all rubbish resulting from execution of his work. No materials shall be stored or placed on passage or drive ways.
- 2.10.02 Upon completion of work, the Contractor shall remove all rubbish, tools, scaffoldings, temporary structures and surplus materials etc. to leave the premises clean and fit for use.
- 3.00.00 **TESTS**
- 3.01.00 **Site Tests**
- 3.01.01 Contractor shall thoroughly test and meggar all cables, wires and equipment to prove the same are free from ground and short circuit after erection and installation at site.
- 3.01.02 If any ground or short circuit is found, the fault shall be rectified or the cable and/or equipment replaced.
- 3.01.03 All equipment shall be demonstrated to operate in accordance with the requirements of this specification.
- 3.01.04 All equipment shall be subject to High Potential test.
- 3.01.05 All protective relays shall be checked for correctness of operations.
- 3.01.06 All current transformers shall be subjected to Primary Injection test.
- 3.01.07 Generator Bus-duct Polarisation Index (P.I. value) shall be measured.
- 3.02.00 **Pre-commissioning Tests at Site**
- 3.02.01 The installation of different type of equipment and accessory shall be tested by the contractor after completion of his erection work with an advance notice to the Engineer concerned so that he may witness the same also.
- 3.02.02 The test result of any installation or equipment or its parts, if considered unsatisfactory to the Engineer, the concerned installation/equipment and its accessories shall be properly rectified and tested again to the satisfaction of the Engineer by the Contractor at his own cost.

- 3.02.03 The site tests to be carried out by the contractor on completion of installation/erection of equipment are broadly listed in Annexure-A for ready reference by contractor.
- 3.02.04 The major testing equipment which will be necessary for carrying out pre-commissioning tests at site are already listed in this specification.
- 4.00.00 **DRAWINGS, DATA AND MANUALS**
- 4.01.00 **To be submitted with the Bid**
- 4.01.01 Make, type and catalogue number of different equipment and accessories along with technical leaflets, data sheet curves etc.
- 4.01.02 Type test certificates.
- 4.02.00 **To be submitted after Award of Contract**
- 4.02.01 Dimensional drawings and data sheets for different equipment supplied under this specification.
- 4.02.02 Technical leaflets and data sheet on each piece of equipment/device.

## ANNEXURE-A

### SCHEDULE OF PRE-COMMISSIONING TESTS OF TRANSFORMER & OTHER EQUIPMENT

#### 1.0 Transformers

- a) Drying out by using Streamline filter, centrifuge and heater set.
- b) Insulation resistance of oil in both main and OLTC chamber.
- c) Insulation Resistance of windings
- d) Checking of Phase Sequence Test
- e) Continuity Test
- f) No load voltage ratio at all tap positions
- g) Checking of Vector Group
- h) Tap changer operation check (Mechanical and Electrical) including indication and alarm circuits.
- i) Magnetising Current Check at 415V, 3 $\phi$ , 50 c/s, supply for all the three phases.
- j) Measurement of Winding resistance
- k) Cooler control, indication and alarm circuits
- l) Breather (Check for Silicagel)
- m) Buchholz relay operation
- n) Low oil level for Main tank/OLTC chamber
- o) Physical line connections as per phasing diagram
- p) Neutral connection to earth effectively.
- q) Calibration of different temperature indicators, relays and switches.

#### 2.0 Circuit Breakers

- a) Insulation resistance test on each pole by H.V. Meggar.
- b) Insulation resistance test on control circuit.
- c) Measurement of closing time & tripping time.
- d) Checking of all joints for gas leakage in case of SF6 insulated breaker.
- e) Measurement of contact resistance for all the Three Phases.

- f) Checking the auxiliary circuits associated with circuit breaker.
- g) Functional check of breaker operation electrically at 70% and 110% of rated D.C. supply voltage.
- h) Checking of Interlocks provided in Control Circuits and tripping through simulated protective relay contacts.
- i) Measurement of resistance of closing and tripping coils.

### **3.0 Lightning Arrester**

- a) Check for connections to ground and line.
- b) Continuity check (in case of Metal Oxide Silicon type only).
- c) Operation check of discharge counter.

### **4.0 Grounding**

- a) Continuity of grounding connection.
- b) Testing of Earth Resistivity of Individual Electrode.
- c) Testing of Earth Resistivity of the combined earthing system.

### **5.0 Switchgears**

- a) Physical checking of various parts/equipment/loose components to be mounted.
- b) I.R. test on Power Circuit.
- c) I.R. test on control Circuit.
- d) Measurement of resistance of the closing and tripping coils. Checking the close trip operation at 70% and 100% of the rated auxiliary DC voltage.
- e) Measurement of Insulation Resistance of Bus-bar System.
- f) Measurement of control resistance ( in micro-ohms) for all the three phase of circuit breaker.
- g) Measurement of I.R. of Control Circuit.
- h) Functional check of circuit components.
- i) Continuity check of different circuits.
- j) Calibration test of Relays and Meters.
- k) Space heater operation
- l) Annunciations

- m) High Voltage test on Bus & Breaker cubicle on HV/MV Switchgear.
- n) Primary and secondary Current injection /PT injection.
- o) Auto/Manual Changeover.

#### **6.0 MCC/Distribution Board/Panels**

- a) Physical checking of various parts/connections.
- b) Measurement of Insulation Resistance of Bus-bar System.
- c) Measurement of I.R. of Control Circuit.
- d) Functional check of circuit components.
- e) Checking of overload relay setting & other protective devices.
- f) Primary and secondary Current injection /PT injection.
- g) Auto/Manual Changeover.
- h) Continuity check of different circuits.
- i) Calibration test of Relays , O/L relays and Meters.
- j) Space heater operation
- k) Annunciations

#### **7.0 Battery**

- a) Physical checking of various parts/connections/loose components to be mounted.
- b) Acid filling, charging/discharging cycles.
- c) Checking of Electrolyte position in each cell.
- d) Checking of polarity, voltage, specific gravity, temperature etc.

#### **8.0 Battery Charger**

- a) Insulation resistance test.
- b) Test on transformer (I.R., voltage ratio).
- c) Automatic voltage regulator & annunciator operation & testing.
- d) Load test.
- e) Functional check of battery charger.
- f) Calibration test of relays and meters of battery charger.

- g) Space heater operation check.
- h) Annunciations.

#### **9.0 Motor**

- a) Insulation test of winding by Meggar.
- b) Proper direction of rotation.
- c) RTD, BTD operation.

#### **10.0 Neutral Grounding Resistor**

- a) Insulation resistance test.
- b) Ohmic value check.

#### **11.0 Relays & Meters**

- a) Calibration test.
- b) Operation/Performance test.

#### **12.0 Disconnecting Switch**

- a) Insulation Resistance test on each pole by H.V. Meggar.
- b) Insulation Resistance test on Control Circuit.
- c) Measurement of contact resistance for all the Three Phases.
- d) Checking the auxiliary circuits associated with Disconnect Switch.
- e) Functional check of Disconnecting Switch operations electrically at 70% and 110% of rated D.C. Supply voltage.
- f) Manual checking of operations (close - open) by handle for both main and earthing switches.
- g) Checking of interlocks (mechanical and electrical) for both main switch and earthing switch.

#### **13.0 Current Transformer**

- a) Insulation Resistance test on each winding by Meggar to earth and between windings.
- b) Checking of all ratios on all cores by Primary injection set.
- c) Polarity check on each winding.
- d) Continuity test

- e) Check for connection to correct taps.
- f) Oil level check

**14.0 Potential Transformer**

- a) Checking of voltage ratios on all windings.
- b) Polarity checking on each winding.
- c) Insulation resistance test on each winding by Meggar to earth and between windings.
- d) Check for connection to correct taps.
- e) Oil level check

**15.0 UPS**

- a) Physical checking of various parts/connections/loose components to be mounted.
- b) Functional check of UPS.
- c) Calibration test of relays and meters of UPS.
- d) Load test
- e) Space heater operation check.
- f) Annunciations.

**16.0 Generator, excitation System & Accessories**

As recommended by manufacturer.

**Note :**

Apart from the tests listed herein and also as mentioned elsewhere in the specification, if any other test (tests) is (are) necessary as per relevant standards, CBIP recommendations, Code of Practice, Manufacturer's recommendations etc., the same shall have to be carried out by the Contractor without any implication within the quoted price.