

**TECHNICAL SPECIFICATION
FOR
GROUNDING & LIGHTNING PROTECTION
SYSTEM**

(A) GROUNDING SYSTEM

1.0 SCOPE

The scope of work is inclusive of but not limited to the followings:

- 1.1** Design and engineering of earthing mat and earthing system for complete 220KV GIS sub-station & Switchyard , 33 KV power evacuation system including supply, delivery, installation, testing and successful commissioning of the same.
- 1.2** Design and Engineering of Electronic earth pit separately as per OEM recommendation for UPS/ Relays/ Battery charger/ SCADA/ LMS, transducer panels etc.
- 1.3** Beside switchyard earthing system with main earth mat, its connections to different risers below and above ground upto equipment and different structures and other important installations are also within the scope of bidder.
- 1.4** Requirement of earthing material for existing substation under scope of contract shall be accessed through site visit & to be guided by supply & Erection schedule.
- 1.5** The earthing grid for sub-station shall be designed in terms of IS: 3043 and IEEE Standard Documents Number 80-1986/2000. However Earth mat design based on uniform spacing method is to be submitted for approval during detailed engineering.
- 1.6** Neutral points of system of different voltages, metallic enclosures and frame works associated with all current carrying equipments and extraneous metal works associated with electric system shall be connected to a single earthing system unless stipulated otherwise.
- 1.7** The successful LSTK contractor shall perform test to determine soil resistivity and resistivity of surface layer to be laid and perform following mathematical calculation along with conclusions and shall be submit to IOCL, Panipat Refinery:
 - I. Ground resistance
 - II. Step Potential
 - III. Touch Potential
 - IV. Ground Potential Rise
 - V. Mesh Potential
- 1.8** The earthing design shall comply to latest IE rules and CEA guidelines.

2.0 DESIGN CRITERIA

- 2.1** The earthing system of sub-station shall be designed to ensure equipment safety, personnel safety and should facilitate proper operation of protection system during earth fault in the system due to stipulated fault current for specified duration.
- 2.2** The specification given below is for reference purposes. The LSTK contractor shall ensure compliance of all statutory requirements, CEA guidelines, HVPNL requirements, IE rules for proper and complete design.

- 2.3** Neutral points of different voltages, metallic enclosures and frame work associated with all current carrying structures/metal works associated with electrical system shall be connected to single earthing system unless stipulated otherwise.
- 2.4** The following particulars shall be taken into account for calculation & design of earth mat as per proposed system.
- I. Fault Current (KA)
 - II. Fault duration (second) (for conductor sizing calculation of main earthgrid)
 - III. Fault duration (second) (for calculation of attainable and tolerable step and touch potential)
 - IV. Crushed-stone/gravel resistivity
 - V. Main (ground grid) earth mat conductor size and material
 - VI. Riser material (above ground) for equipment, columns and Aux. structures
 - VII. Riser material (below ground)
 - VIII. Pipe Earth Electrode (in treated earth pit) as per tech. spec.
 - IX. Earth electrode in non-treated pit Depth of burial
 - X. Current Diversity factor
 - XI. Earthing of indoor LT panels.
 - XII. Control Panels & Outdoor Marshalling Boxes, MOM Boxes, Jn. Boxes & Lighting Panels etc.
 - XIII. Earthing conductor inside cable trenches.
 - XIV. Thickness of crushed stone/gravel
 - XV. Size of crushed stone/gravel
- 2.5** Safe touch & step voltage within the provision of IS-3043 , IEEE 80-1986/2000
- 2.6** For the purpose of finding out actual soil resistivity, it is to be measured preferably in dry season by the successful contractor in presence of the representative of IOCL, Panipat Refinery. On the basis of actual soil resistivity of the substation earth mat shall be designed accordingly and as per approved earth mat design and approved layout drawing, the substation earth mat shall be laid accordingly.
- To get the actual soil resistivity of the entire Sub-Station area, to arrive the designed average soil resistivity, measurement shall be done with different number of electrode spacing, preferably in steps of 2, 5, 10, 15, 20/25 meters etc. by following wengers four electrode method in line with guide line as laid down. The resistivity for these spacing shall be noted and taken as the resistivity for that particular direction. In a similar manner, resistivities for at least ten locations, covering the entire switchyard area (including control room building), are to be measured. The average resistivity thus obtained shall be used for the design of the earthmat.
- a) Length of main earth mat conductors, pipe/rod earth electrode and auxiliary mat shall be considered for design purpose of Earthing system.
 - b) The design shall ensure that the grid resistance shall be less than one ohms (Ω)

- c) Design shall ensure that potential gradient along the surface during short circuit is limited to a value considered safe for human being. The potential gradient to be achieved shall be less than the safe touch and step voltage.

3.0 EQUIPMENT AND STRUCTURE EARTHING

- 3.1** Earthing pads shall be available of the apparatus/equipment at accessible position. The connection between earthing pads and the earthing grid shall be made by short and direct earthing leads free from kinks and splices. In case earthing pads are not provided on the item to be earthed, same shall be provided in consultation with OEM and IOCL.
- 3.2** Whether specifically shown in drawing or not, steel/structure columns, metallic stairs etc. shall be connected to the nearby earthing grid conductor by two earthing leads. Electrical continuity shall be ensured by bonding different sections of hand-rails and metallic stairs.
- 3.3** Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular. Apart from intermediate connections, beginning points shall also be connected to earthing system.
- 3.4** Metallic conduits shall not be used as earth continuity conductor.
- 3.5** Separate earthing conductor shall be provided for earthing lighting fixtures, receptacles, switches, junction boxes, lighting conduits etc.
- 3.6** Wherever earthing conductor crosses or runs along metallic structures such as gas, water, steam conduits etc. and steel reinforcement in concrete it shall be bonded to the same. Light poles, junction boxes on the poles, cable and cable boxes/glands, lockout switches etc. shall be connected to the earthing conductor running along with the supply cable which in turn shall be connected to earthing grid conductor at a minimum two points whether specifically shown or not.
- 3.7** Railway tracks within switchyard area shall be earthed at a spacing of 30 mm and also by both the ends.
- 3.8** Earthing conductor shall be buried 500 mm inside the switchyard fence. Every alternate post of the fence and gates shall be connected to earthing loop by one lead.
- 3.9** Flexible earthing connectors shall be provided for the moving parts.
- 3.10** All lighting panels, junction boxes, receptables fixtures, conduits etc. shall be grounded in compliance with the provision of I.E. rules.
- 3.11** A continuous ground conductor of 16 SWG GI wire shall be run all along each conduit run and bonded at every 600 mm by not less than two turns of the same size of wires. The

conductor shall be connected to each panel ground bus. All junction boxes, receptacles, lighting fixtures etc. shall be connected to this 16 SWG ground conductor.

- 3.12** 50 mm x 6 mm MS flat shall run on the top tier and along the cable trenches and the same shall be welded to each of the racks. Further this flat shall be earthed at both the ends at an interval of 30m. The MS flat shall be finally painted with two coats of Red Oxide primer and coats of post office and red enamel paint.

- 3.13** Table below provides general guidelines for selection of Earth Conductor for each Equipment

S.N.	Description/location	Size
1	Earth mat	40 mm (min) solid MS rod -- to be selected by the contractor based on the calculations.
2	Power Transformer	100 X 8mm
3	Station transformer	50x6mm
4	415V panel	50x6mm
5	Lighting panel	25x3 mm
6	Junction box	7/8 SWG
7	Metallic fence	25x3 mm
8	Transformer yard fence and gate	50x6 GI flat with the help of flexible copper braid.
9	HV/LV/ LV Neutral cable box	50x6 GI flat
10	OLTC Drive mechanism body	25X3 GI flat
11	Battery charger panel	25X3 GI flat
12	DCDB	25X3 GI flat
13	Outdoor Circuit breaker, CT, PT & CVT	50 X 6
14	Secondary terminal Box of outdoor CT, PT & CVT	25 X 6 mm
15	Isolator Mechanism box, earth switch box	25 X 6 mm
16	Gantry tower and structure	75 X 10 mm
17	Electronic Earthing	As per recommendations of OEM

4.0 INSTALLATION OF EARTHING CONDUCTOR LAY OUT:

- 4.1** The grounding grid shall be constructed by use of corrosion resistant mild steel rod.
- 4.2** Wherever earthing conductor crosses cable trenches, underground service ducts, pipes, tunnels, railway tracks etc. It shall be laid 300mm (min) below them and shall be circumvented in case it fouls with equipment/structure foundation.
- 4.3** All non-current carrying steel/metal parts in the switchyard shall be connected to the grounding grid including equipment except lightning arrestors, Reactors, power transformers, CVT/PT etc which shall be earthed directly through earth electrode. This electrode shall in turn be connected to earthing grid through galvanised bolts and nut. Each earthing lead from the neutral of the transformer shall be directly connected to two galvanised pipe electrode treated earth pit which in turn shall be connected to station earth grid. LSTK Contractor shall submit detail equipment earthing drawing of all equipment along with detail pipe electrode drawing to be used in conjunction with treated pit with test link,

treated pit without test link and non-treated pit and structure earthing drawings for approval of consultancy firm as listed in Clause 10.6 of Section-1 Chapter-1 and IOCL Panipat.

- 4.4** All points in steel earthing system shall be made by welding except the points with bolted connection which should be provided for separating the earthing grid for testing purpose. The point for testing purpose should be so placed that the earth grid can be frequently supervised.
- 4.5** Connection between equipment earthing lead and main earthing conductors and between main earthing conductors shall be welded type. For rust protection, the welded surface shall be treated with Barium Chromate and then Welded surface shall be painted with red lead and coated with two layers of bitumen compound to prevent corrosion.
- 4.6** Earth pit of earth electrode without having any test link shall be at least 400x400 mm. in size and 375 mm. deep and earth pit with test link shall be at least 700x700 mm. in size and 375 mm. deep. The earth pit shall be constructed with RCC (M-15) in surrounding wall and floor (minimum wall thickness 125 mm. and floor thickness 100 mm.) with a removable cover slab of 75 mm. thick with RCC (M-15) (0.8% reinforcement by volume of concrete). Cover slab shall be plastered with cement mortar (1:4) on all sides.
- 4.7** To provide testing facility with Clip-on type earth resistance measuring meter one test link with ACSR panther conductor having compression type joint with socket of total length of about 300 mm. (combined) shall be incorporated between earth pit and neutral of the Reactor/transformer, CVT/PT/LA, Grid corners etc. which in turn shall be connected to main earth mat. The socket shall be connected with the flat through bimetallic strip. Two earth pits shall be provided for transformer neutral to be connected through two nos. flat. One flat shall be directly connected to one earth electrode through welding and the other flat shall be connected with other earth pit through a testing link. All accessories associated with transformer/reactor like cooling banks, radiators etc shall be connected to the main earthing grid at minimum two points.
- 4.8** The earthing conductor around control building shall be buried in earth at a minimum distance of 1500 mm from the outer boundary of the building and which in turn shall be connected to switchyard main earth grid conductor as per approved earthing lay out drawing for control room to be submitted separately.
- 4.9** Steel to Copper connection if any shall be brazed type and shall be treated to prevent moisture ingress.
- 4.10** Bending of earthing rod shall be done preferably by gas heating.
- 4.11** All ground connections shall be made by one welding except the point with bolted connection which should be provided for separating the earthing grid for testing purpose. The point for testing purpose should be so placed that the earth grid can be frequently supervised for rust protection, the welded surface shall be protected with bitumen paint riser (M.S.Flat) above ground shall be painted with Zinc rich paint above anti Oxide primer. All

welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load to it. Artificial cooling shall not be allowed.

- 4.12** All C & R panels, PLCC and its Battery charger shall be earthed by 50x8 mm GS Flat (2nos flat one each on opposite side) to MS earth Bus of 50 x 8 mm. MS Flat runs on the top of the tier and all along the cable trenches and the same shall be welded to each of the racks. Further this Flat shall be earthed at both ends at an interval of 30 mtr. The MS Flat shall be finally painted with two coats of Red oxide primer and two coats of bitumen compound.
- 4.13** Earthing conductor for main ground grid in outdoor areas shall be buried at least 600 mm below finished ground level or more as per design consideration for green field Sub-Station. For existing substation it should be laid matching with existing earth mat grid level.
- 4.14** Earthing conductor or leads along their run on cable trench, ladder, wall, etc. shall be supported by suitable welding / cleaning at interval of 1200 mm. Wherever it passes through walls, floors, etc., galvanized steel sleeves shall be provided for passage of conductor and both end of sleeves shall be sealed to prevent passage of water through sleeves.
- 4.15** Earthing conductor, i.e. grid perimeter ground conductor shall be buried 1000 mm (min.) outside the switchyard fence. All gates of every alternate post of fence shall be connected to earthing grid. Gravel / crushed stone spreading shall also be done 1000 mm (min.) outside the switchyard fence. However criterion of gravel / crushed stone spreading shall be followed in line with requirement of approved drawing & schedule of works.
- 4.16** Flexible earthing connectors shall be provided for moving parts.
- 4.17** Tap connection from earthing grid to equipment /structures to be earthed shall be terminated on the earthing terminal of the equipment/structures as per approved drawings.
- 4.18** Auxiliary earth mat of same dia of the main earth mat and total size 1500x1500 mm with 500x500 mm closely spaced conductor shall be provided at a depth of 300 mm from the finished ground level below the operating handle of MOM box of all isolators. MOM box shall be directly connected to auxiliary mat which in turn shall be connected to main earth mat grid at two points.
- 4.19** The earth mat design shall be based on uniform spacing method. However closely spaced corner mesh shall be provided at all corners of the main earth mat in addition to main earth grid conductor to minimize ground potential rise and to control perimeter gradients and step potential, two or more parallel conductor of same dia of main earth mat shall be buried all along the perimeter.
- 4.20** All above ground conductive metal parts that might accidentally energized shall be connected to main earth mat.
- 4.21** Pipe electrode shall be used in the following area (application wise) :

(a) Pipe electrode in treated pit with test link (Test pit) :

Application: Reactor/Power Transformer's Neutral, Earthing Transformer/ Station Service Transformers' Neutral, Grid Corner, LA, CVT, PT.

(b) Pipe electrode in treated pit without test link :

Application: Lightning Mast, Shield wire down corner, Control room building / Integrated GIS building corners.

(c) Rod Earth electrode in non-treated pit :

Application: Coupling Capacitor, Grid periphery (other than grid corner).

- 4.22** Earthing conductors crossing the road shall be laid 300mm below road or at greater depth to suit site condition.
- 4.23** Earthing conductors embedded in the concrete shall have approximately 50mm concrete cover.

(B) LIGHTNING PROTECTION

1.0 DESIGN OF LIGHTNING PROTECTION

- 1.1** Direct stroke lightning protection (DSLPP) shall be provided in the EHV switchyard by shield wires. The final arrangement shall be decided after approval of the DSLPP calculations. The LSTK Contractor is required to carry out the DSLPP calculations and submit the same to the consultancy firms at mentioned in clause 10.6 of Section-1 Chapter-1 and IOCL, Panipat Refinery for approval at detailed engineering stage after award of contract. Reznick method of lightning protection shall be followed.
- 1.2** The specification given below is for reference purposes. The LSTK contractor shall ensure compliance of all statutory requirements, CEA guidelines, HVPNL requirements, IE rules for proper and complete design.
- 1.3** The lightning protection system shall not be in direct contact with underground metallic service ducts and cables.
- 1.4** A 40 mm dia. (min), 3000mm long MS earth electrode with test links, CI frame & Cover shall be provided to connect down conductor of towers with peak. The test joint shall be directly connected to the earthing system.

- 1.5 Conductors of the lightning protection system shall not be connected with the conductors of the safety earthing system above ground level.
- 1.6 Down conductors used for lightning protection shall be cleated on the structures at 2000mm interval.
- 1.7 Connection between each down conductor and rod electrodes shall be made via test joint (pad type compression clamp) located approximately 150 mm aboveground level.
- 1.8 Lightning conductors shall not pass through or run inside G.I. conduits.
- 1.9 All metallic structures within a vicinity of 2000 mm in air and 5000mm below ground shall be bound to the conductors of lightning protection system.
- 1.10 In addition to Earth wires above the EHV switchyard, ESE Lightning conductor shall provides zone of Protection. Snapping of Earth wire does not make accidental situations during Lightning.
- 1.11 This ESE Lightning Protection system requires an Air terminal, down conductor, Lightning Counter & an Earthing System. If the structure is more than 30m height then 2 no's of down conductor shall be used for side flashing. The Earthing system should not exceed more than 10Ω.
- 1.12 A 40mm dia (min) M.S Earth Electrodes with Test Links, HDPE Cover shall be provided to connect down conductor. The test Link shall be directly connected to earthing system
- 1.13 Conductors of Lightning Protection system shall not be connected with conductors of Safety earthing system above ground level. Lightning Earth Pits shall be connected other earthing conductor below ground level by using Equipotential bonds which will not allow Surge current to flow from Lightning pits to other Earth pits
- 1.14 Connection between each down conductor & Test link shall be located approximately 2000mm above ground Level.
- 1.15 The Down conductor should be high conductivity bare copper tape with minimum size of 75 Sq.mm
- 1.16 **Constructional Features**
Galvanized Steel (Applicable for exposed G.S. flats)
(a) Steel conductors shall be galvanized according to IS: 2629.
(b) The minimum weight of zinc coating shall be 610gm/sq. m. and minimum thickness shall be 86 microns.
(c) The galvanized surfaces shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surfaces of steel. The finished surface shall clean and smooth and shall be free from defects like discolored patches, bare spots, unevenness

of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surfaces, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

1.17 Tests

The LSTK Contractor shall perform all routine and acceptance tests and inspection at manufacturer's works by TPI agency to ensure that material and workmanship are according to the relevant standards. LSTK Contractor shall have to demonstrate all type tests compliance by submission of valid type test reports conducted at NABL accredited labs within five years period. If same is not available the type test to be performed on sample basis as per applicable IS standards. All liasoning co-ordination, arrangement of testing instruments shall be in the scope of LSTK contractor including all associated costs.

- (a) The galvanized steel shall be subjected to four one-minute dips in copper sulphate solution as per IS: 2633.
- (b) Zinc Coating thickness : As per IS: 4759
- (c) Uniformity of zinc coating : As per IS: 2633
- (d) Adhesion Test : As per IS: 2629
- (e) Mass of zinc coating : As per IS: 6745
- (f) Chemical Analysis: As per IS: 513 & IS: 1079

1.18 The accessories for GSS (galvanised stray stranded) Groundwire such as Tension Clamps, Copper braided wire etc. shall conform to & meet the test requirements of IS: 2121.