Chapter 35: Earthing and DSLP

Electrical measurements of the subsoil at various depths up to 20 meters shall be made at the site of each substation in order to determine the layered effects of the ground from which the effective ground resistivity and hence the expected resistance of the proposed earth grid system may be predicted. Wenner's 4 - Electrode method as per IEEE-Std. 81 may be followed for measurement of earth resistivity. The earthing system shall comprise a mesh grid formed by 40mm dia M.S. Rod conductor buried directly in the ground 700mm below FGL. The mesh system shall be designed such that the grid potential rise limits the step and touch voltage to a value not greater than the maximum tolerable touch potential. The mesh system shall be designed as per IEEE 80 and IS 3043 with fault clearance time of 1 second. The design of earth mat shall be submitted to AEGCL approval. The calculations shall be carried out considering with and without a layer of crushed stone of thicknes.

150mm. The resistance of the earth mat shall not exceed 1 Ω. The resistivity of the stone for gravelling shall be 3000 ohm-m under wet condition for which resistivity measurement shall be done. For measurement purpose, one sample of stones from each source (in case stones are supplied from more than one source) shall be used.

While designing the ampacity of the buried conductor suitable corrosion allowance shall be considered for Forty (40) years. The grid conductors and risers below ground shall be welded suitably for maintaining a high degree of mechanical rigidity and electrical connectivity.

The earthing system shall be designed so as to include all overhead line terminal towers, which shall be earthed by extending the system so as to envelope all towers within the earth system. Each tower shall be bonded directly to the earth system from at least two locations. Structures and masts for lighting and security surveillance equipment shall also be within the perimeter of the earth grid.

Where a metal substation fence is provided, this shall be bonded electrically to the earthling grid on each side at points adjacent to each corner. The location of the mesh conductors shall be such as to enable all items of equipment to be connected to the earth system via the shortest possible route.

The current density of the earth conductor shall be not greater than 45A/mm2. Single connections between equipment and the earth system shall carry the total short circuit current, but the cross- sectional area of branch connections may be reduced to take account of current distribution in two or more conductors. A distribution factor of 60 per cent shall be assumed for this purpose, i.e. the cross-sectional area of branch connections may be reduced to 60 per cent of the corresponding single conductor.

The grid voltage rise under fault conditions shall not exceed 10 kV.

Earthing and lightning protection system installation shall be in strict accordance with the latest editions of Indian Electricity Rules, relevant Indian Standards and Codes of practice and Regulations existing in the locality where the system is installed as below:

Code of practice for Earthing IS: 3043

Code of practice for the protection of Building and allied structures against lightning IS: 2309.

CEA Safety Regulations 2010 & Indian Electricity Act 2003 with latest amendments.

d) National Electricity Safety code IEEE-80

Details of Earthing System

EARTHING CONDUCTORS

General

All conductors buried in earth and concrete shall be of mild steel. All conductors above ground level and earthing leads shall be of galvanised steel. The minimum sizes of earthing conductor to be used are as indicated below table no A.

1. 1 Constructional Features

1.2.1 Galvanised Steel

a) Steel conductors above ground level shall be galvanised according to IS:2629.

b) The minimum weight of the zinc coating shall be 610 gm/sq.m for normal area and 900 gm/sq.m for coastal area as specified in Section-Project and minimum thickness shall be 86 microns.

c) The galvanised surfaces shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surfaces of steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured 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.

1.3 Tests

In accordance with stipulations of the specifications galvanised steel shall be subjected to four one minute dips in copper sulphate solution as per IS : 2633.

TABLE A

Sl No.	Item	Size	Material
a)	Main Earthing Conductor to be buried in ground	40mm dia M.S. Rod	Mild Steel
b)	Conductor above ground& earthing leads (for equipment)	75x12mm G.S. flat	Galvanised Steel
c)	Conductor above ground& earthing leads (for columns & aux. structures)	65x12mm G.S. flat	Galvanised Steel
d)	Earthling of indoor LT panels, Control panels and outdoor marshalling boxes, Junction boxes & Lighting Panels etc.	50x6 mm G.S. flat	Galvanised Steel
e)	Rod Earth Electrode	40mm dia, 3000mm long	Mild Steel as per IS:2062/ SAE1018
f)	Perforated Pipe Earth Electrode (in treated earth pit) as per IS.	50mm dia, 3000mm long	Mild Steel as per IS:2062/SAE1018
g)	Earthing for motors	25x4mm GS flat	Galvanised Steel
h)	Earthing conductor along outdoor cable trenches	50x6mm GS flat	Galvanised Steel
I)	**Earthing of Lighting Poles (for lighting poles outside switchyard)**	**50x6mm GS flat**	**Galvanised Steel**
j)	Isolator MOM Box	75X12 mm GS flat & Flexible copper braid	Galvanised steel and copper braid
k)	Insulator Guy Arrangement	75X12 mm GS flat	Galvanised Steel
l)	Earthing of Lightning mast and Column with peak	75X12 mm GS flat with Pipe Electrode in treated pit	Galvanised Steel

Equipment and Structure Earthing:

Earthing pads shall be provided for the apparatus/equipment at accessible position. The connection between earthing pads and the earthing grid shall be made by two short earthing leads (one direct and another through the support structure) free from kinks and splices.

Whether specifically shown in drawings or not, steel/RCC 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.

Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular interval.

Metallic conduits shall not be used as earth continuity conductor. Metallic conduits shall be earthed with GI wire of suitable size.

Wherever earthing conductor crosses or runs along metallic structures such as gas, water, steam conduit, etc. and steel reinforcement in concrete it shall be earthed.

Railway tracks within switchyard area shall be earthed at a spacing of 30m and also at both ends.

Earthing conductor shall be buried 2000 mm outside the switchyard fence. All the gates and every post of the fence shall be connected to earthing grid. The stone spreading shall also be done 2000 mm outside switchyard fence. The criteria for stone spreading shall be followed in line with requirement specified elsewhere in the specification.

Flexible earthing connectors shall be provided for the moving parts.

A continuous ground conductor of 16 SWG GI wire shall be run all along each conduit run. The conductor shall be connected to each panel ground bus. All junction boxes, receptacles, switches, lighting fixtures etc. shall be connected to this 16 SWG ground conductor.

50mm x 6mm GS flat shall run on the top tier and all along the cable trenches and the same shall be welded to metallic inserts holding the cable trays/ racks. All racks shall welded to the inserts. Further this flat shall be earthed at both ends and at an interval of 30 mtrs.

For 400kV, 220kV and 132kV, Each Surge Arrester shall be directly connected to two numbers perforated pipe electrodes with test link in treated earth pit (as per IS); each Voltage Transformer shall be directly connected to one number perforated pipe electrodes with test link in treated earth pit (as per IS); which in turn shall be connected to main earth mat. For 33kV, Each Surge Arrester, Voltage Transformer shall be directly connected to one number perforated pipe electrodes with test link in treated earth pit (as per IS)

which in turn shall be connected to main earth mat.

Lightning Mast and Towers with Peak shall be directly connected to two numbers perforated pipe electrodes with test link in treated earth pit (as per IS) which in turn shall be connected to main earth mat. Connection from earthing terminal to pipe electrode shall be done by 75x12mm GS Flat.

Each earthing lead from the neutral of the Transformer/Reactor shall be directly connected to two numbers perforated pipe electrodes with test link in treated earth pit (as per IS) which in turn shall be connected to main earth mat. The pit shall be filled with Bentonite powder mixed with lomy soil at a ratio 1:10. The electrodes shall be buried in Cement Concrete pit with a ISI marked cast iron cover. Connection from earthing terminal to pipe electrode shall be done by 75x12mm GS Flat. The transformer body and all accessories associated with transformer/reactor like cooling banks, radiators etc. shall be connected to the earthing grid at minimum two points by 75x12mm GS Flat.

Auxiliary earthing mat comprising of 40mm dia M.S. rods closely spaced (300mm x 300 mm) conductors shall be provided at depth of 300mm from ground level below the operating handles of the

M.O.M. Box of the isolators and Earth Switch. M.O.M. boxes shall be directly connected to the auxiliary earthing mat. Flexible copper braid connection to be provided between MOM box and GS flat to take care of soil sagging. The size of auxiliary earthing mat shall be of 1500mmx1500mm for 400kV, 220kV and 132kV and 900mmX900mm for 33kV. Factory welded auxiliary earthmat is preferable.

For Power Cable Metallic sheaths and armour of all multi core power cables shall be earthed at both equipment and switchgear end and with Link box as and when required. Sheath and armour of single core power cables shall be earthed at switchgear end only.

Metal parts of all equipment, other than those forming part of an electrical circuit, shall be connected directly to the main earth system at two points.

Gate posts forming part of the substation fence shall be bonded together with below ground connections and the gates themselves shall be electrically bonded to the posts at two points through flexible braids.

After installation of the earth system the Contractor shall measure the resistance of the substation. The method used shall preferably be the "fall of potential" method, requiring the availability of a local low voltage supply, but other methods using an earth resistance meter will be acceptable in the event of a local supply being unavailable.

The fencing of the switch yard also to be earthed by using GS flats of size 75x12mm at each post. The corner points of the switch yard shall be provided 40 mm dia MS rod of length 3000mm.

EARTHING

The spacing for the main earthmat shall be as per earthmat calculation prepared by contractor and approved by AEGCL during detailed engineering.

The main earthmat shall be laid in the switchyard area in accordance with the approved earthmat layout and earthing design calculation.

Wherever earthing conductor crosses cable trenches, underground service ducts, pipes, tunnels, railway tracks etc., it shall be laid minimum 500mm below them and shall be circumvented in case it fouls with equipment/structure foundations.

Tap-connections from the earthing grid to the equipment/structure to be earthed shall be terminated on the earthing terminals of the equipment/structure as mentioned in this chapter.

Earthing conductors or leads along their run-on cable trench, ladder, walls etc. shall be supported by suitable cleating at intervals of 750 mm. Wherever

it passes through walls, floors etc., PVC sleeves shall be provided for the passage of the conductor and both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.

Earthing conductor around the building shall be buried in earth at a minimum distance of 1500 mm from the outer boundary of the building.

Earthing conductors crossing the road shall be laid 500mm below road or at greater depth to suit the site conditions.

Earthing conductors embedded in the concrete shall have approximately 50mm concrete cover.

All exposed joints shall be at a minimum height of 150 mm above floor or ground level.

Jointing

Earthing connections with equipment earthing pads shall be bolted type. Contact surfaces shall be free from scale, paint, enamel, grease, rust or dirt. Two bolts

shall be provided for making each connection.

Connection between equipment earthing lead and main earthing conductors and between main earthing conductors shall be welded type. For rust protections, the welds should be treated with red oxide primer and afterwards coated with two

layers bitumen compound to prevent corrosion.

Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingression.

All weldings shall be electric arc welding. All welded joints

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

All arc welding with large dia. conductors shall be done with low hydrogen content electrodes.

The 75x12mm GS flat shall be clamped with the equipment support structures at 1000mm interval.

Insulating mats

The scope covers supply and laying of insulating mats■A■ conforming to IS: 15652-2006.

These insulating mats shall be laid in front of all floor mounted AC and DC switchboards and switchgear panels located in control room building/ Switchyard panel room.

The insulating mats shall be made of elastomer material free from any insertions leading to deterioration of insulating properties. It shall be resistant to acid, oil and low temperature.

Upper surface of the insulating mats shall have small aberration (rough surface without edges) to avoid slippery effects while the lower surface shall be plain or could be finished slip resistant without affecting adversely the dielectric property

of the mat.

Insulating mat (wherever applicable) shall be of pastable type, to be fixed permanently on the front of the panels except for the chequered plate area which shall not be pasted as per requirement.

Width of insulating mats shall generally be of 1.5 meters or as per site requirements. Length shall be supplied as per site requirements.

Direct Stroke Lightning Protection

Direct stroke lightning protection (DSLP) shall be provided in the EHV switchyard by lightning masts and shield wires. The arrangement shall be decided after approval of the DSLP calculations.

The lightning protection system shall not be in direct contact with underground metallic service ducts and cables.

Conductors of the lightning protection system shall not be connected with the conductors of the safety earthing system above ground level.

Down conductors shall be cleated on the structures at 2000 mm interval.

Connection between each down conductor and rod electrodes shall be made via test joint (pad type compression clamp) located approximately 1500 mm above ground level. The rod electrode shall be further joined with the main earthmat.

Lightning conductors shall not pass through or run inside G.I. conduits.

Lightning protection shall also be provided for various buildings like control building, FFPH, Township buildings as per relevant standard.

Transformer, Bus duct, SF6 to air bushing DSLP shall be provided by LM only.