

**GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS**



**TECHNICAL SPECIFICATION FOR
MAINTENANCE FREE EARTH FOR ELECTRICAL INSTALLATION**

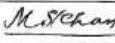


RDSO/PE/SPEC/PS/0109(REV.0)-2008, Amendment '1'

SN	Amendment		Revision		Reason
	Number	Date	Number	Date	
1.	'1'	28.10.2010	-	-	Clause No. 8.1.2.3 (Conductive mixture) Modified and Clause No.14 (Guarantee) deleted as per Railway Board's letter No. 2006/Elect.(G)/150/9/Pt. Dated 10.09.2010

**ISSUED BY
ELECTRICAL ENERGY MANAGEMENT DIRECTORATE
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Approved by

Executive Director EEM


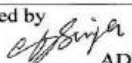

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Technical Specifications for Maintenance Free Earth for Electrical Installation

FOREWORD

Earthing is essential in any electrical installation to provide safety. The conventional GI pipe earthing system employing charcoal & salts are provided for various applications as per IS:3043. Corrosion of metallic parts is comparatively fast besides maintenance by way of watering of earth pits and chiselling of corrosion prone parts & their replacement require monitoring which may not always be feasible in certain crowded and inaccessible areas.

This document is intended to provide guide lines for installation & testing of long lasting earthing system for various applications to meet requirement of rules 51, 61 of Indian Electricity Rule, 1956.

1.0 SCOPE

This specification covers components, enhancing material & jointing used and procedure for constructing the earth pit for maintenance free earthing system to ensure that the resistance to earth is near zero consistent throughout the year.

2.0 REFERENCES

This specification requires the reference to the following documents:

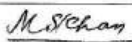
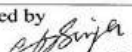

IS 3043-1987	Indian standard code of practice for earthing
IEEE 80	IEEE guide for safety in AC sub-station grounding
IEEE 837	Standard for qualifying permanent connections used in substation grounding.
Indian Electricity Rules 1956 with latest amendments	

Wherever, reference to any specification appears in this document, it shall be taken as a reference to the latest version of that specification unless the year of issue of the specification is specifically stated.

3.0 APPLICATIONS

Earthing systems covered in this document shall be for providing effective grounds for

- i) Sub-Stations
- ii) RTUs, supply control posts
- iii) Transformer and Generator neutral earths
- iv) Lightning arrester earths
- v) Equipment earths including panels

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- vi) In applications for PRS, UTS, FOIS, COIS, ATMs and data processing centre etc.

Note: -These specifications do not cover earthing requirements for Indian Railway's telecom & signalling installations.

4.0 SELECTION OF EARTH SYSTEM

S.N.	Installations/ Current Capacity	IR Value Required	Soil Type/ Resistivity	Earth System
1.	House hold earthing/ 3kA	8 ohm	Normal Soil/ upto 50 ohm-mtr	Single Electrode
			Sandy Soil/ between 50 to 2000 ohm-mtr	Single Electrode
			Rocky Soil/ More than 2000 ohm-mtr	Multiple Electrodes
2.	Commercial premises Office buildings/ 5kA	2 ohm	Normal Soil/ upto 50 ohm-mtr	Single Electrode
			Sandy Soil/ upto 2000 ohm-mtr	Multiple Electrodes
			Rocky Soil/ More than 2000 ohm-mtr	Multiple Electrodes
3	Transformers, substation earthing, LT line equipment/ 15kA	1 - 2 ohm	Normal Soil/ upto 50 ohm-mtr	Single Electrode
			Sandy Soil/ upto 2000 ohm-mtr	Multiple Electrodes
			Rocky Soil/ More than 2000 ohm-mtr	Multiple Electrodes
4	Transformers, substation earthing, HT line equipment/ 40kA	less than 1 ohm	Normal Soil/ upto 50 ohm-mtr	Single Electrode
			Sandy Soil/ upto 2000 ohm-mtr	Multiple Electrodes
			Rocky Soil/ More than 2000 ohm-mtr	Multiple Electrodes
5	Lightning arresters, extra high current applications etc./ 50kA	less than 1 ohm	Normal Soil/ upto 50 ohm-mtr	Single Electrode
			Sandy Soil/ upto 2000 ohm-mtr	Multiple Electrodes
			Rocky Soil/ More than 2000 ohm-mtr	Multiple Electrodes
6	PRS, UTS, RTUs,FOIS, COIS, ATMs and data processing centre etc./5KA	less than 0.5 ohm	Normal Soil/ upto 50 ohm-mtr	Single Electrode
			Sandy Soil/ upto 2000 ohm-mtr	Multiple Electrodes
			Rocky Soil/ More than 2000 ohm-mtr	Multiple Electrodes

Note :- Single/multiple electrode in above earth system shall be either rod earth electrode or concentric pipe earth electrode as per clause 8.1.

5.0 TYPE OF SOILS

Soil can be classified in to various types, though based on the size of the particles it contains:

5.1 Normal soil

Black cotton soil, vegetable soil, garden soil, loamy garden, soil shallow black , soil medium black soil ,deep black soil and marshy soil etc having low soil resistivity value (up to 50 ohm meter)

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5.2 Sandy soil

This type has the big particles and the size of the particles does determine the degree of aeration and drainage that the soil allows. It is granular and consists of rock and mineral particles that are very small. Therefore the texture is gritty and sandy soil is formed by the disintegration and weathering of rocks such as limestone, granite, quartz and shale, thus resulting in over-drainage. It warms very fast in the spring season. Coastal area, silt soil, red sandy soil, sandy clay and coastal alluvium etc having soil resistivity up to 2000 ohm-meter are considered as sandy soil.

5.3 Rocky soil

The area containing rocks, pebbles, uneven hard surface laterite soil, lime stone, sand stone, gravel, granite and chalk etc having soil resistivity more than 2000 ohm-meter is considered as rocky soil. This type of soil does not absorb moisture and are extremely poor conductor.

6.0 LOCATION OF EARTH ELECTRODE

Where there is option, site should be chosen in one of the following types of soil in the order of preference given:-

- Wet marshy ground;
- Clay, loamy soil, arable land.
- Clay and loam mixed with varying proportions of sand, gravel and stones;
- Damp and wet sand, peat.

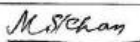
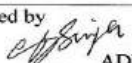

Dry sand, gravel chalk, limestone, granite, very stony ground and all locations where virgin rock is very close to the surface should be avoided,

7.0 MEASUREMENT OF EARTH ELECTRODE RESISTANCE

The earth resistance shall be measured using fall of potential method as per para 37 of IS:3043.

8.0 EARTHING SYSTEM

The earthing system includes earth electrode, installation of earth electrode in suitable pit size, construction of earth pit with cover for the installation, connection of earth electrode with equipotential earth bus and connection of equipment to equipotential earth bus.

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8.1 Earth electrode

The earth electrode is the main component of the earthing system which is in direct contact with the ground and thus provides a means of releasing or collecting any earth leakage currents. The material should have good electrical conductivity and should not corrode in a wide range of soil conditions. For an effective earthing system, two types of earth electrodes can be used as described here:

8.1.1 Rod earth electrode

8.1.1.1 High tensile-low carbon steel rod having diameter not less than 17mm complying with requirements of BS 4360 Grade 43A or EN10025:2-004 S275JR, molecularly bonded by 99.99% pure high conductivity copper on outer surface with copper coating thickness 250 micron or more, Length 3000 mm (minimum). Length of the electrode may be increased in multiple of 1 meter to reduce earth resistance if required. To increase the length, pieces of similar rod shall be either exothermally welded to basic 3 meter electrode or connected using socket of suitable size. These sockets shall also be molecularly bonded by 99.99% pure high conductivity copper on inner & outer surface with copper coating thickness 250 micron or more.

8.1.1.2 Copper bus bar of size 250 mm x 50mm x 6 mm having electrical conductivity of 101% IACS, minimum 99.9% copper content shall be exothermally welded to rod with 4 holes of 12 mm dia. (2 on each side) for connecting earthing conductor.

8.1.1.3 Current carrying capacity: The design of the electrode should be such as to have more than 15kA current carrying capacity for 1 second.

8.1.2 Concentric pipe earth electrode:

8.1.2.1 Primary conductor

MS pipe with 25 - 50 mm diameter, class B, ISI mark as per IS-1239, Length 2000 or 3000 mm as per table at para 8.1.2.7.

8.1.2.2 Secondary conductor

MS pipe with 40-100 mm diameter, class B, ISI mark as per IS-1239, Length 2000 or 3000 mm as per table at para 8.1.2.7.

8.1.2.3 Conductive mixture

For hermetically filling inside the cavity i.e. between secondary conductor & primary conductor, crystalline compound is to be injected in the electrode assembly. It is a combination of high conductivity metal alloys, copper & aluminium powder, conductive carbon/cement and bonding material etc. mixed

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in different proportion. The mixture is forced (pressurized) filled inside the earth electrode in the paste form and after solidification of the same, the end caps are welded. The metal alloys shall help in conducting the current and conductive carbon gives anti corrosive property. Bonding material should provide strength to the mixture. Resistivity of the mixture shall be less than 0.2 ohm-meter. Resistivity shall be tested by making a 20cm cube of the material and checking resistance across the opposite face of the cube.

8.1.2.4 Complete electrode shall be molecularly bonded by 99.99% pure, high conductivity copper on outer surface with copper coating thickness 300 micron or more.

8.1.2.5 Its surface shall be clean and free from any visible oxide layer or foreign material.

8.1.2.6 Copper bus bar of size 250 mm x 50mm x 6 mm having electrical conductivity of 101% IACS, minimum 99.9% copper content shall preferably be exothermically welded to earth electrode or connected with the help of two number stainless steel nut bolts of appropriate size having 4 holes of 12 mm dia. (2 on each side) for connecting earthing conductor.

8.1.2.7 Current carrying capacity: The design of the electrode should be such as to have more than following current carrying capacity in kA (for 1 second):


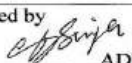

S.N.	Current Capacity	Primary Conductor diameter	Electrode dimensions (dia. x length)
1.	3 kA	25 mm	40 mm x 2000 mm
2.	5kA	25 mm	40 mm x 3000 mm
3	15kA	25 mm	50 mm x 3000 mm
4	40kA	40 mm	80 mm x 3000 mm
5	50kA	50 mm	100 mm x 3000 mm

Note:- For more than 50KA applications, multiple electrodes of 50KA capacity shall be installed and connected.

8.2 Earth enhancement material:

Earth enhancement material is a superior conductive material that improves earthing effectiveness, especially in areas of poor conductivity (rocky ground, areas of moisture variation, sandy soils etc.). It may contain conductive cement, graphite, hydrous aluminium silicate, sodium montmorillonite etc and shall not contain bentonite. It improves conductivity of the earth electrode and ground contact area. It shall have following characteristics-

- It should have low resistivity preferably bellow 0.2 Ohm-meters. Resistivity shall be tested by making a 20cm. cube of the material and checking resistance across the opposite face of the cube.

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- ii) It shall not depend on the continuous presence of water to maintain its conductivity.
- iii) It should be a little alkaline in nature with pH value >7 but <9, test certificate from NABL approved laboratory to be provided for the composition so designed.
- iv) It should have better hygroscopic properties to absorb moisture. It should absorb and release the moisture in dry weather condition and help in maintaining the moisture around the earth electrode.
- v) It should have capacity to retain >10% moisture at 105°C. Test certificate from NABL approved lab to be submitted for the composition so designed.
- vi) It should have water solubility < 5%. Test certificate from NABL approved lab to be submitted for the composition so designed.
- vii) It should be granular with granule size 0.1 mm to 3 mm.
- viii) It should be non toxic, non reactive, non explosive & non corrosive.
- ix) It shall be thermally stable between -10 degree centigrade to +60 degree centigrade ambient temperature.
- x) It shall not decompose or leach out with time.
- xi) It shall not pollute the soil or local water table and meets environmental friendly requirement for landfill.
- xii) It should expand & swell considerably and removes entrapped air to create strong connection between earth electrode and soil.
- xiii) It should be diffuses into soil pores and creates conductive roots enlarging conductive zone of earth pit.
- xiv) It shall be permanent & maintenance free and in its "set form", maintains constant earth resistance with time.
- xv) It shall not require periodic charging treatment or replacement.
- xvi) It shall be suitable for any kind of electrode and all kinds of soils of different resistivity.
- xvii) It shall not cause burns, irritation to eye, skin etc.
- xviii) Minimum quantity of earth enhancement material to be supplied :
 - For 5' x5'x 10' earth pit – Min. 75 kgs per pit
 - For 300mm bore type earth pit – Min 50 kgs per pit
- xix) The Earth enhancement material shall be supplied in sealed, moisture proof bags. These bags shall be marked with Manufacturer's name or trade name, quantity, batch no & date of manufacture.

8.2.1 Backfill material

Normally the excavated soil shall be used if it is free from sand, gravel and stones. In case the excavated soil contains sand, gravel and stones these shall

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be removed by appropriate methods such as hand picking, sieving etc. Small proportion of sand in the soil may be permissible. Material like sand, salt, coke breeze, cinders and ash shall not be used because of its acidic and corrosive nature. If the excavated soil contains sand, gravel and stone in large proportion and it is not feasible to remove these economically, good quality soil from other place may be used for backfilling.

While backfilling the soil shall be thoroughly compacted with at least 5 kg compactor. In case the soil is dry, small quantity of water may be sprinkled only to make it moist enough suitable for compacting. Large quantity of water may make the soil muddy which is not suitable for compacting and after drying the soil may contain voids which may permanently increase earth resistance.

8.3 Equipotential bus & Earthing Conductor

- (i) A copper bus bar of size 300mm x 25mm x 6mm to be installed in the equipment room as equipotential bus and must be connected with preferably copper strip of 25mm x 3mm (suitable length) from instrument to the bus bar. The connecting terminal of the earth electrode to the bus bar must be connected by copper strip of 25mm x 3mm (suitable length) buried inside a trench of 300mm width x 600mm depth (from the earth pit to the nearest wall). It shall be duplicated. However, it shall be ensured that only minimum required length is used and any extra length is cut away to keep the earth impedance minimum.
- (ii) It shall be high conductivity copper having electrical conductivity of 101% IACS i.e. minimum 99.9% copper content. The maximum specific resistance of the copper strip earthing conductor shall be 17.241×10^{-7} ohm cm at 20°C.
- (iii) At a temperature of 20°C, its density shall be 8.89 gm/cm³
- (iv) Its surface shall be clean and free from any visible oxide layer or foreign materials.
- (v) It shall preferably be connected to earth electrode and earth bus bar with the help of exothermic welding or at least two number stainless steel nut bolts of appropriate size.
- (vi) Normally a single length of copper strip shall be used for each duplicate copper strip earthing conductor and no joint should be used. However in situation requiring greater length one joint in each copper strip shall be permitted. The joints shall be made by exothermic welding of at least 10mm overlapping portion of the strips.

8.4 Construction of unit earth.

- i) Make 5ft x 5ft x 10ft earth pit. If it is not possible to make such a pit due to non availability of clear space at locations like ATM, High mast lighting tower, Passenger information systems, PRS etc. or in rocky soil, min. 300

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mm bore up to 10 ft deep can be made using earth auger or any other method. Earth pit larger than specified size can be made, if required.

- ii) Sleeve the soil digged and remove the gravels and stones. If soil quality is good (without Murum and rocks) then add some quantity of earth enhancement material in the soil for using as backfill.
- iii) If the soil seems unusable (containing large quantity of gravel, stones, murum, sad etc.) then replace the soil with black cotton soil.
- iv) Insert the electrode at the centre of the earth pit and arrange to keep it vertical in the pit.
- v) Arrange for adequate quantity of water supply for the earth pit. (Approx. 600 litres)
- vi) Fill the pit with the backfill and keep on adding the earth enhancement material surrounding the electrode and simultaneously watering the pit.
- vii) With a steel bar or pipe, keep on poking the soil gel and stirring intermittently for removing the air pockets and proper settlement of the pit.
- viii) The procedure to be repeated till completion of the filling of the earth pit along with the packing material and sufficient watering adequate ramming.
- ix) The pit should be very compactly rammed and watering for 2-3 days and addition of soil if required be done.
- x) Make trench of 600 mm (depth) x 300 mm (wide) from the earth pit to the nearest point of connection.
- xii) Construct inspection chamber with cover for the installation.
- xiii) Measure the earth resistance as per IS 3043:1987 code of practice. Earth resistance value shall be less than 1 ohm in non-rocky/non-sandy surface by single electrode Installation and in rocky surface by multiple electrode installation (not more than three electrodes & its individual earth pits). For earthing purpose, if solid rocky layer is found within 10 feet from ground level while digging the earth pit then it is considered rocky surface. Coastal area, silt soil, red sandy soil and sandy clay are considered as sandy surface.
- xiv) If required resistance is lower than the resistance of single earth electrode then multiple earths can be constructed and interconnected.

8.4.1 Construction of ring earth by providing multiple earth pits

- i) Wherever it is not possible to achieve required earth resistance with one earth electrode/pit due to difficult/rocky soil conditions, provision of ring earth consisting of more than one earth pit shall be done. The number of pits required shall be decided based on the resistance achieved for the earth pits already installed. The procedure mentioned above for one earth pit shall be repeated for other earth pits.

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- ii) The distance between two successive earth electrodes shall be min. 3mtrs / length of electrode which ever is higher. and max. up to twice the length of the earth electrode.
- iii) These earth pits shall then be inter linked using 25X3 mm copper strip to form a loop preferably using exothermic welding or with the help of at least two number of stainless steel nut bolts of appropriate size.
- iv) The interconnecting strip shall be buried no less than 600mm (0.6m) below the ground level. This interconnecting strip shall also be covered with earth enhancing compound.

8.4.2 Inspection chamber

- i) A 300X300X300 mm (inside dimension) concrete box (wall thickness min. 50 mm)with smooth cement plaster finish shall be provided on the top of the pit. A concrete lid 25 to 50 mm. thick, with pulling hooks, painted black shall be provided to cover the earth pit. PVC sleeve of appropriate size shall be provided in concrete wall to take out earthing connections.
- ii) The masonry work shall be white washed inside and outside.
- iii) Care shall be taken regarding level of the floor surrounding the earth so that the connector is not too deep in the masonry or projecting out of it.
- iv) On backside of the cover, date of the testing and average resistance value shall be written with yellow paint on black background.

9.0 MARKING:

The marking shall be clear, distinct and visible to the naked eye from a distance of about 1 meter; the size of marking shall be of minimum 25 mm. Following information shall be legibly and indelibly marked on the packed sets:



- a) Specification no.
- b) Name of the manufacturer
- c) Batch no. & Date of manufacturer
- d) Current carrying capacity

10.0 TESTS-

Following tests shall be done on one sample-

10.1 Testing of copper coating shall be done as described below:-

- i) The copper coating mentioned in clause 8.1 shall not be less than the prescribed thickness at any point and shall comply with the adherence requirement in para (ii) & (iii) below.
- ii) Length of the electrode with one end cut to a 45 degree point shall be driven between two steel clamping plates or the jaws of a vise set 0.04 in (1.02 mm)

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less than the diameter of the electrode, so as to shear off sufficient metal to expose the bond between the copper coating and electrode. Peeling of the coating by the steel plates or the jaws of the vise is acceptable, but there shall be no other evidence of separation of the coating from the metal core.

- iii) At room temperature, a length of the electrode is rigidly held in a clamp or vise and the free end is bent by applying a force normal to the electrode at a distance from the clamping device equal to 40 times the diameter. The magnitude of the force and the direction of application of force shall be such that the electrode is permanently bent through a 30-degree angle. While bending of the electrode there shall be no evidence of cracking of the copper coating.
- 10.2** Material composition of rod shall be tested as per standards mentioned in clause no. 8.1.1.1.
- 10.3** MS pipes shall be tested as per IS:1239.
- 10.4** Copper bus bars of shall be tested for percentage of copper as per IS:14644.
- 10.5** Current carrying capacity test on rod electrode shall be done as per clause no. 8.1.1.3 and for concentric pipe electrode as per 8.1.2.7.
- 10.6 Corrosion Test :** As per IS:2119, salt spray test for analysis of effect of corrosion for the specific electrode shall be done through NABL approved testing lab, preferably for 500 hrs. or more.
- 10.7** Exothermic weld material shall be tested as per provisions of IEEE 837.
- 10.8** Electrical properties test on conductive mixture as per clause no. 8.1.2.3.
- 10.9** Physical, chemical & electrical properties test on earth enhancement material as per clause no. 8.2.
- 10.10** Toxic content tests for cadmium, lead, mercury, hexavalent chromium, polybrominated biphenyls (PBBs) & polybrominated diphenyl ethers (PBDEs) on conductive mixture & earth enhancement material.

Certificates from NABL approved laboratories shall be submitted with test results of above tests. Test certificates shall not be more than three years old.

For dimension, weight and specific resistance average of 3 readings shall be taken. Average value shall be within specified limits and individual values shall not go beyond double of tolerances.

11.0 ACCEPTANCE TESTS

- 11.1** Following shall constitute acceptance tests and shall be done on 100% sample basis for all the tests mentioned below except where otherwise indicated–

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- a) Physical check for earth electrode as per clause no. 8.1.1.1 for rod type electrode and as per clause no. 8.1.2.7 for concentric pipe type electrode.
- b) Physical check for copper bus bar as per clause no. 8.1.1.2 for rod type electrode and as per clause no. 8.1.2.6 for concentric pipe type electrode.
- c) Dimensional and construction feature tests of inspection chamber (Cl. no. 8.4.2)
- d) Earth enhancement material as per clause no. 8.2(xviii) & 8.2(xix).
- e) Earth resistance measurements as per clause no. 7.0.

11.2 Rejection:

In case the any component tested and inspected in accordance with this specification, fail to pass the tests or comply with the requirement of the specification, another two component from the same lot shall be inspected in accordance with the specification and if one of them also fail to pass the test, the whole lot of that component shall be rejected subject to the discretion of the purchaser or his nominee.

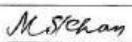
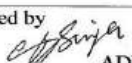

12.0 INSPECTION:

All the gauges/ test & measuring instruments shall be under calibration control at the time of inspection and proof to this office shall be produced.

Inspection and testing shall be carried out by the inspecting authority nominated by the purchaser to ensure that all the requirements of this specification are complied with for the acceptance of the materials offered by the supplier for inspection.

The purchaser or his nominee shall have right of free access to the works of the manufacturer and to be present at all reasonable times and shall be given facilities by the manufacturer to inspect the manufacturing process at any stage of manufacture. He shall have the right to reject whole or part of any work or material that does not conform to the terms of this specification or any other specification or requirement applicable and may order the same to be removed / replaced or altered at the expense of the manufacturer. All reasonable/complete facilities considered necessary by the inspecting authorities for the inspection shall be supplied by the manufacturer free of cost.

The manufacturer shall at his own cost prepare and furnish the necessary test pieces and appliances for such testing as may be carried out at his own premises in accordance with the specification. Failing the existence of facilities at his own premises for the prescribed tests, the manufacturer shall bear the cost of carrying out the tests in an approved laboratory, workshop or test house.

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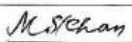
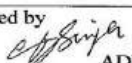

13.0 COMPLETION REPORT & CERTIFICATION:

- 13.1** The last documents for the completion of the procedure will be submission of the work completion report to the concern Railway authority. After testing the earth values of the pits and proper recording in presence of Railway authority, certified grounding self adhesive certificate shall be provided for all installations and the same will be displayed / pasted at the place of installation.
- 13.2** The complete layout with dimensions of the earthing & bonding system shall be submitted by the supplier in appropriate size (in three copies) after commissioning showing commissioning date, earth resistance, specification no. and manufacturer's name.

14.0 GUARANTEE: (Deleted)

15.0 INFRINGEMENT OF PATENT RIGHTS:

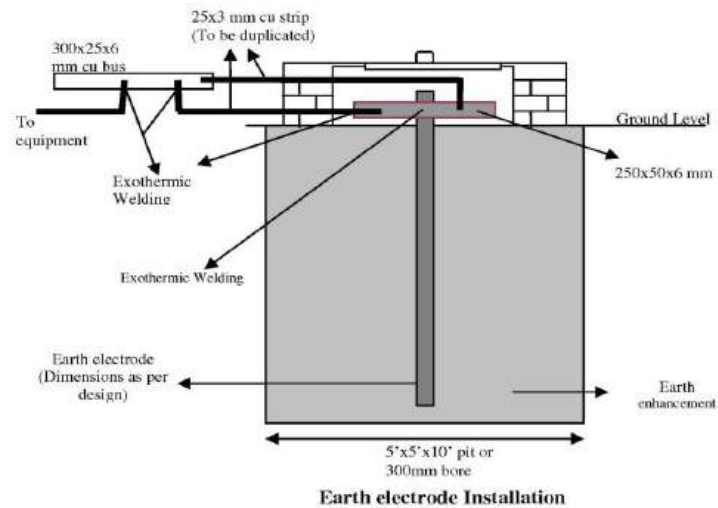
Indian railways shall not be responsible for infringement of patent rights arising due to similarity in design, manufacturing process, use of the components, used in design, development and manufacturing of escalator and any other factor which may cause such dispute. The responsibility to settle any issue lies with the manufacturer.

Prepared by  SSE/EEM	Checked by  ADE/EEM	Issued by  Dir./EEM
--	---	---

Signature of Tenderer

Annexure - A

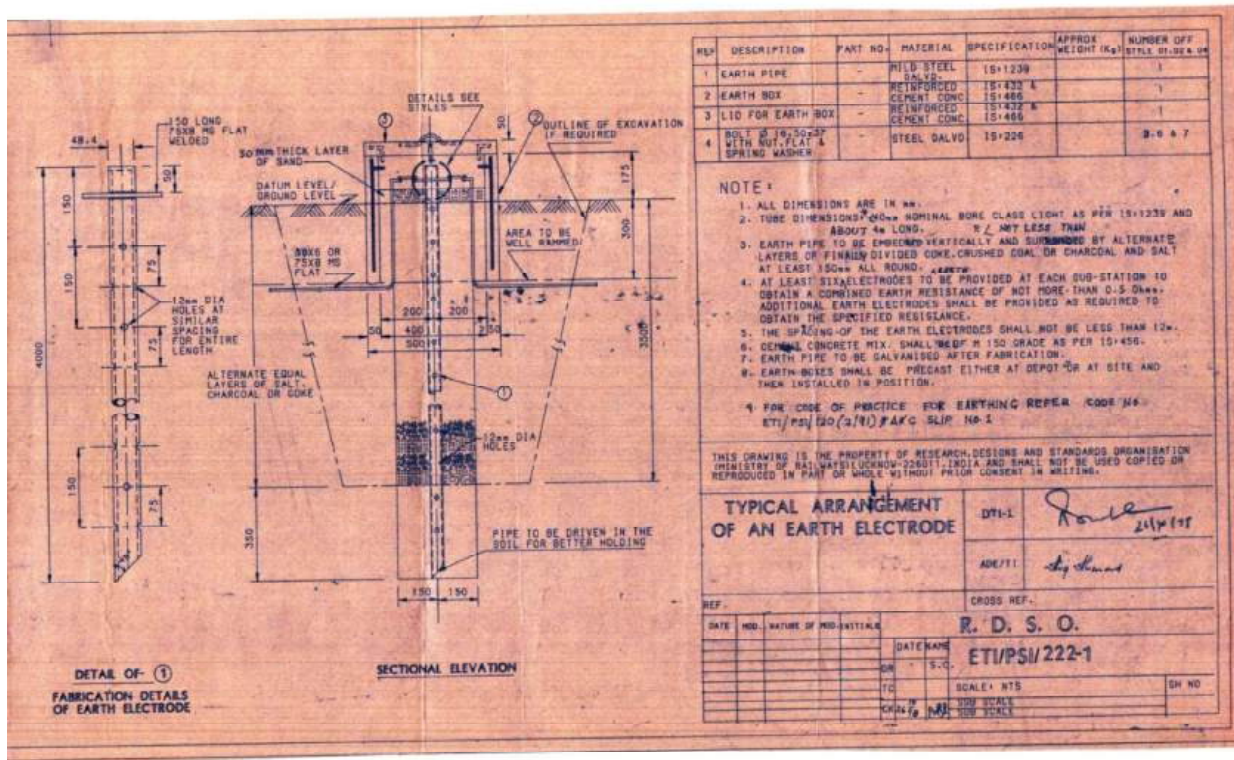
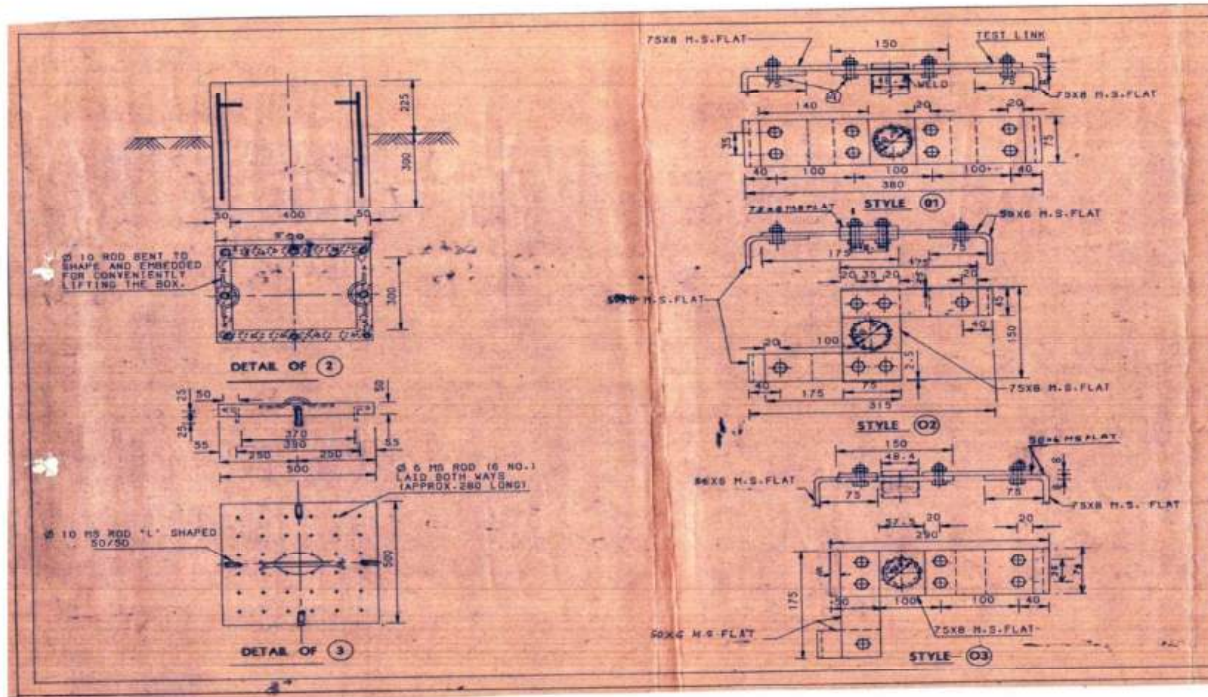
General Arrangements for Earth System



Prepared by <i>M. S. Khan</i> SSE/EEM	Checked by <i>eff. Singh</i> ADE/EEM	Issued by <i>[Signature]</i> Dir./EEM
--	---	--

Signature of Tenderer

Annexure-VI

Typical arrangement of an earth electrode Drawing No. ETI/PSI/222-1Typical arrangement of an earth electrode Drawing No. ETI/PSI/222-1



REFERENCE COPY

[illegible]



भारत-सरकार/Government of India
रेल मंत्रालय/Ministry of Railways
दक्षिण मध्य रेलवे/South Central Railway



महाप्रबंधक(विद्युत)/ General Manager[E]
मुख्यालय कार्यालय/Headquarters office
सिकंदराबाद/Secunderabad-500 025

शक तिथि/Saka Date: 21st Chaitramasa,1944
दिनांक/Date: 11.04.2022

संख्या/No.77/2/P/Earth(T).

CEE/CN/SC, CPD/RE/SC, GM/ELECT/RVNL/SC, CGGM/RITES/DELHI
Sr.DEE/M/SC, HYB, BZA, GNT, GTL & NED.

Technical Circular No.05/2022

Sub:- Provision of earth electrodes for equipments like CLS control panels,
service buildings, DG sets, water coolers, lifts and escalators etc.

At present for power maintenance equipments earthing in following SCR Drawing No.SK.No.A3/10/M/R is used. As the earth electrode given in drawing is not as per CPWD specification or CORE/ALD specification decided that the above SCR drawing is withdrawn with immediate effect. For good quality electrodes, the following specification & drawing of CORE/ALD shall be used for all feature stores/works procurement. At locations other than sub-station.

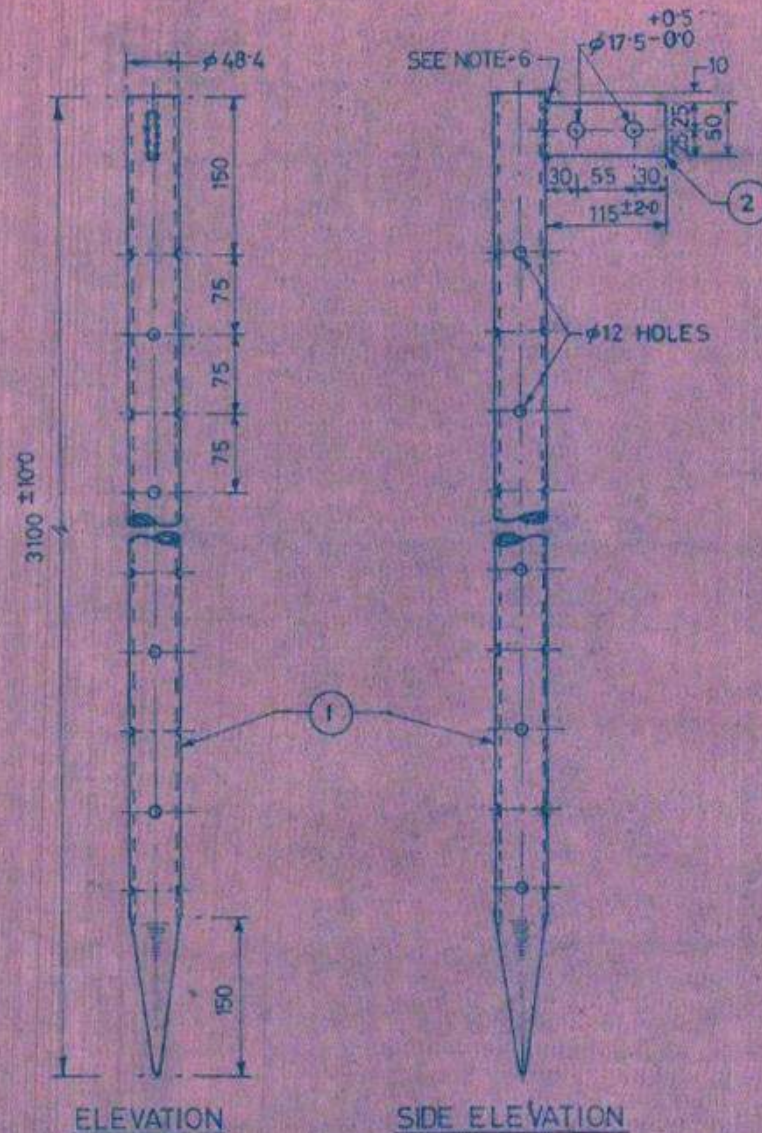
Drawing No.ETI-OHE-P-7021;

Specification No.TI_LKO(PSI/38/2020 Dt.235/08/21 or latest. Copy of the drawing and specification is enclosed as Annexure-A & B. For substations earth electrode of 4M length confirming to RDSO drawing ETI/PSI/222-1 & RDSO Spec No.RDSO-TIOLKO(PSI)/38/2020 dated 25/8/21 to be adopted. Copy of Drawing and spec enclosed as Annexure D & B.

Further, to get quality electrodes, decided that the earth electrodes shall be procured from CORE/ALD approved sources only. List of CORE approved sources is enclosed as Annexure -C. In all future estimates earth electrodes as per above drawing only shall be included. For works tender/estimate rates, latest LOA from CPD/RE tenders may be obtained and adopted for all works for which tenders not called but detailed estimates sanctioned also shall follow above earth electrodes drawings as well as sources adopted including earth works sanctioned under Umbrella works for quarter service buildings etc. For procuring through stores rates may be obtained from any of the approved sources and indents placed for earth electrodes. No deviation for the above drawings on the approved sources will be allowed. List of Core approved sources along with latest drawing as well as specifications can be downloaded from CORE/ALD website or may be obtained from CPD/RE/SC.

Encl: as above.

(सीएच सुरंजन रेड्डी/Ch.S.Reddy)
Digitally Signed by
Chilukuri Suranjan Reddy
Date: 12-04-2022 16:49:58
Reason: Approved



REF. NO.	DESCRIPTION	PART NO.	MATERIAL	SPECIFICATION	APPROX. WEIGHT/kg	NUMBER OFF
1	EARTH ELECTRODE	7021	STEEL TUBE GALVANISED	IS:1239&3043 ETI/OHE/13		1
2	M.S.FLAT PIECE 50x10 THICK, 115 LONG		MILD STEEL GALVANISED	IS:12062(GRA) ETI/OHE/13		1

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. TUBE DIMENSIONS:- 40mm NOMINAL BORE, CLASS LIGHT AS PER IS:1239.
3. EARTH ELECTRODE CONFORM TO IS:3043.
4. TO BE GALVANISED AFTER DRILLING AND FABRICATION.
5. LOWER END OF PIPE SHAPED AS SHOWN BY SQUEEZING AND IF NECESSARY BY CUTTING OF DEFORMED MATERIAL.
6. ALL WELDS ARE 6mm FILLET WELDING AND SHOULD BE UNIFORM, CONTINUOUS AND NONPOROUS CONFORM TO IS:816.
7. USAGE:- TO BE USED IN EARTHING STATION.

REFERENCE COPY

THIS DRAWING IS THE PROPERTY OF RESEARCH DESIGNS AND STANDARDS ORGANISATION (MINISTRY OF RAILWAYS), LUCKNOW-226 011, INDIA AND SHALL NOT BE USED, COPIED OR REPRODUCED IN PART OR WHOLE, WITHOUT PRIOR CONSENT IN WRITING.

EARTH ELECTRODE

JD/OHE

ADE/OHE

J.C. Brown
18.8.84

REF: RE/33/P/7021 (MOD.'F')

CROSS REF. ETI/OHE/P/7020

DATE	MOD.	NATURE OF MOD.	INITIAL	R. D. S. O.			REV
				DATE	NAME	ETI/OHE/P/7021	A
				DR	13.8.84		
				TC	13.8.84		
						SCALE: 1:5	
2/1/90	A	SPEC. OF STEEL AT REF. 2 CORRECTED	CHICK	17.8.84		SUB-SCALE:	

File No.RDSO-TIOLKO(PSI)/38/2020-O/o PED/TI/RDSO



Government of India,
Ministry of Railways
Research Designs & Standards Organisation,
Manak Nagar, Lucknow- 226 011

Telephone: 2465763 (O).
42805(Off.)
Fax : 91-0522-2465763
E-mail:dti.psi.rds@gmail.com



File No. RDSO-TIOLKO(PSI)/38/2020

Date: 25.08.2021.

To,

1. The Principal Chief Electrical Engineer,

- (i) Central Railway, Station Building, Mumbai CST – 400 001.
- (ii) Eastern Railway, Fairlie Place, Kolkata-700 001.
- (iii) East Central Railway, Hajipur-844 101.
- (iv) East Coast Railway, Bhubaneswar-751 023.
- (v) Northern Railway, Baroda House, New Delhi - 110 001.
- (vi) North Central Railway, Allahabad-211 015.
- (vii) North Eastern Railway, Gorakhpur-273 012.
- (viii) North Frontier Railway, Mailgaon - 781 011.
- (ix) North Western Railway, Jaipur – 302 017.
- (x) Southern Railway, Park Town, Chennai- 600 003.
- (xi) South Central Railway, Railnilayam, Secunderabad-500 371.
- (xii) South Eastern Railway, Garden Reach, Kolkata-700 043.
- (xiii) South East Central, Railway, Bilaspur-495 004.
- (xiv) South West Railway, DRM's Office, Hubli-580 028.
- (xv) Western Railway, Churchgate, Mumbai-400 020.
- (xvi) West Central Railway, Jabalpur- 482 001.
- (xvii) Konkan Railway, Belapur Bhavan, Sector-11, CBD Belapur, Navi Mumbai 400614.

2. Chief Administrative Officer, CORE Allahabad-211001

Sub: Revised Technical Specification for Earthing of Power Supply Installations for 25 & 2X25
Traction System.

Ref: (i) Final draft uploaded on RDSO website on 22.07.2021.

(ii) Draft of the specification uploaded on RDSO website on 01.04.2021.

In continuation of the above references it is communicated that the revised Technical Specification for Earthing of Power Supply Installations for 25 & 2X25 kV Traction System. i.e. specification no. TI/SPC/PSI/ERTHNG/0210 has been issued by this office. Copy of the same has been uploaded on the www.railsaver.gov.in and can be downloaded.

2. The said specification shall supersede the specification no. ETI/PSI/120 (02/91) with A&C slip no. 01.
3. This is issued with approval of the competent authority.

(Gyan Prakash Katiyar)
Director TI-3
For Director General (TI)

Encl: NIL

675764/2021/O/o PED/TI/RDSO

Specification No. TI/SPC/PSI/ERTHNG/0210

Page 1 of 36

कर्षण संस्थापन निदेशालय

TRACTION INSTALLATION DIRECTORATE



भारत सरकार, रेल मंत्रालय

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

Specification No. TI/SPC/PSI/ERTHNG/0210

TECHNICAL SPECIFICATION

FOR

EARTHING OF POWER SUPPLY INSTALLATIONS

FOR 25 & 2X25 kV, AC 50 Hz, Traction System.

{ This specification supersedes the specification no.

ETI/PSI/120(02/91) with A & C slips no. 1(10/93) }

Effective From: 20.08.2021

ISSUED BY

TRACTION INSTALLATION DIRECTORATE

RESEARCH DESIGNS AND STANDARDS ORGANISATION

LUCKNOW - 226011

675764/2021/O/o PED/TI/RDSO

Specification No. TI/SPC/PSI/ERTHNG/0210

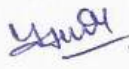


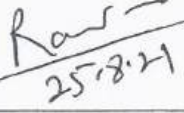
Page 2 of 36

Specification No. TI/SPC/PSI/ERTHNG/0210

Technical Specification for Earthing of Power Supply Installations for 25 & 2X25 kV, AC 50 Hz, Traction System.

Revision history

Revision	Specification no.	Total pages (including annexure)	Date of issue
First issue	ETI/PSI/120 (02/91)	18	17.03.1992
Revision -01	Issue of A & C slips no. 1	02	20.10.1993
Revision - 02	TI/SPC/PSI/ERTHNG/0210	36	20.08.2021

	Prepared by	Checked by	Reviewed by	Approved by
Signature			 23/8/21	 25.8.21
Date	23.08.21	23/08/21		
Designation	<u>SSE/SCADA</u>	<u>DTI/3</u>	<u>ED/TI</u>	<u>PED/TI</u>

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1.0 SCOPE

- 1.1 This specification supersedes the specification no. ETI/PSI/120(02/91) with A&C slip no. 01.
- 1.2 This specification caters for general arrangements of earthing system and equipment earthing at Traction Sub-Stations, Switching stations and Auxiliary transformer stations of 25kV as well as 2X25kV system. Low voltage (LT) electrical power distribution system, 25 kV overhead equipment system as well as signal and telecommunication equipment do not come within the purview of this specification.
- 1.3 It is to be noted that "The Make in India Policy of Government of India shall be applicable."

2.0 TERMINOLOGY

The following terms wherever occurring in this specification shall, unless excluded or repugnant to the context, have the meaning attributed thereto as follows:-

- 2.1 Combined Earth resistance: The resistance of an earth electrode (s) with respect to earth, with the earth electrode (s) connected in the metal work of electrical equipment other than parts which are normally live or carry current and the masts/ structures but without connection with the traction rail(s).
- 2.2 Earth: The conductive mass of the earth, whose electrical potential at any point is conventionally taken as zero.
- 2.3 Earth Electrode: A conductor (mild steel (MS) pipe) or group of conductors in intimate contact with and providing an electrical connection to earth.
- 2.4 Earthing Grid: A system of a number of interconnected, horizontal bare conductors buried in the earth, providing a common ground for electrical devices and metallic structures, usually in one specific location.
- 2.5 Equipment Earthing: Earthing of all metal work of electrical equipments other than parts which are normally live or current carrying. This is done to ensure effective operation of the protective gear in the event of leakage through such metal work, the potential of which with respect to neighboring objects may attain a value which would cause danger to life or risk of fire.
- 2.6 Mesh Voltage (E mesh): The maximum touch voltage to be found within a mesh of an earthing grid.
- 2.7 System Earthing: Earthing done to limit the potential of live conductors with respect to earth to values which the insulation of the system is designed to withstand and thus to ensure the security of the system.
- 2.8 Step Voltage (E step): The potential difference between two points on the earth's surface separated by distance of one pace that will be assumed to be one metre in the direction of maximum potential gradient.
- 2.9 Power Supply Installation: The electrical equipments and associated structures provided at a Railway Traction Substation or Switching Station or Auxiliary transformer station on the 25 kV & 2X25kV overhead equipment.
- 2.10 Traction Rail – Traction Rail means a non-track circulated rail of a wired track, not required for signaling purposes and which may be earthed. In non-track circulated sections, both the rails of a wired track are traction rails and in single rail track circulated sections, the traction rail is the non-track circulated rail
- 2.11 Touch Voltage (E touch): The potential difference between a grounded metallic structure and a point on the earth's surface separated by a distance equal to the normal maximum horizontal reach of a person, approximately one metre.

3.0 OBJECT OF EARTHING

The object of an earthing system is to provide as nearly as possible a surface under and around a station which shall be at a uniform potential and as nearly zero or absolute earth potential as possible. The purpose is to ensure that generally all parts of the equipment other than live parts are at earth potential and that attending personnel are at earth potential at all times. Also by providing such an earth surface of uniform potential under and surrounding the station, there can exist no difference of potential in a short distance big enough to shock or injure an attendant when short circuits or other abnormal occurrences take place. The primary requirements of a good earthing system are:

- i) It should stabilize circuit potentials with respect to ground and limit the overall potential rise.
- ii) It should protect men and materials from injury or damage due to over voltage.
- iii) It should provide low impedance path to fault current to ensure prompt and consistent operation of protective devices during ground faults.
- iv) It should keep the maximum voltage gradient along the surface inside and around the substation within safe limits during earth faults.

4.0 GOVERNING SPECIFICATIONS:

Assistance has been taken from the following standards/specifications in the preparation of this code of practice:

- i) IS: 3043- 2018 code of practice for earthing (latest edition).
- ii) IEEE Guide for safety in AC substation grounding, IEEE standard 80- 2013.

5.0 TYPICAL VALUE OF EARTH RESISTANCE

At each power supply installation, an earthing system as specified in this specification shall be provided. The combined resistance of the earthing system (with the connection to the running rail(s) disconnected) shall be not more than the following values:-

SN	Name of the Station	The limit of combined earth resistance in ohms
1.	Traction substation	0.5
2.	Switching station	2.0
4.	Auxiliary transformer station	10.0

6.0 EARTH ELECTRODES

- 6.1 The earth electrode shall normally be of mild steel galvanized perforated pipe of not less than 40 mm nominal bore, of about 4 m length provided with a spike at one end and welded lug suitable for taking directly MS flat of required size at the other end. The pipe shall be embedded as far as possible vertically into the ground, except when hard rock is encountered, where it may be buried inclined to the vertical, the inclination being limited to 30 degree from the vertical. The connection of MS flat to each electrode shall be made through MS links by bolted joints to enable isolation of the electrode for testing purposes. A typical arrangement of an earth electrode shall be as per Drawing number ETI/PSI/222-1 (Annexure-VI).
- 6.2 Earth electrodes shall be embedded as far apart as possible from each other. Mutual separation between them shall usually be not less than 8.0 m (which is twice the length of the electrode).
- 6.3 If the value of earth resistance specified in clause 5.0 cannot be achieved with a reasonable number of electrodes connected in parallel such as in rocky soil or soil of high resistivity, the earth surrounding the electrodes shall be chemically treated. The earth electrode shall be surrounded in an earth pit by alternate layers of finely divided coke, crushed coal or charcoal and salt at least 150 mm all round. Though substantial reduction in earth resistance can be achieved by coke treated

electrode, yet as this method results in rapid corrosion not only of electrode but also of steel frame work to which it is bonded, coke treatment shall be used only where absolutely necessary and such electrodes shall not be situated within 8.0 m of other metal work.

- 6.4 In high embankments, it may be difficult to achieve earth resistance specified in clause 5.0 even after chemical treatment of electrodes. In those locations, use of electrodes longer than 4 m so as to reach the parent soil is recommended. Mutual separation between them shall usually be twice the length of the electrode.
- 6.5 As far as possible, earth electrodes for Traction Sub-Stations/ Switching Stations shall be installed within and adjacent to perimeter fence. At large sites, apart from securing a sufficiently low resistance and adequate current carrying capacity a reasonable distribution of electrodes is also necessary.

7.0 EARTHING ARRANGEMENT AT TRACTION SUBSTATION for 25kV & 2X25kV System (160kmph).

7.1 Earthing Grid.

- 7.1.1 An earthing grid is formed by means of bare mild steel rod of appropriate size as indicated in clause 7.1.2 buried at a depth of about 600 mm below the ground level and connected to earth electrodes. The connection between the earth electrode and the grid shall be by means of two separate and distinct connections made with 75 mm x 8 mm MS flat. The connection between the MS flat and the MS rod shall be made by welding, while that between the earth electrode and the MS flats through MS links by bolted joints. The earth electrodes shall be provided at the outer periphery of the grid as shown in Annexure-II. As far as possible the earthing grid conductors shall not pass through the foundation block of the equipments. All crossings between longitudinal conductors and transverse conductors shall be jointed by welding. The transverse and longitudinal conductors of the earthing grid shall be suitably spaced so as to keep the step and touch potentials within acceptable limits; the overall length of the earthing grid conductors shall not be less than the calculated length (refer Annexure- I & XI).
- 7.1.2 The size of the earthing grid conductor shall be decided based on the incoming system voltage and fault level (refer Annexure I & XI). The fault level considered shall take into account the anticipated increase in fault current during the lifespan of the station. The size shall be as given below.

SN	System voltage (kV)	Fault level (MVA)	Diameter of the grid conductor (MS rod) in mm (For 25kV and 2X25kV TSS)
1.	66	Upto 4000 above 4000 upto 5000 above 5000 upto 6000	32 36 40
2.	110	Upto 6000 above 6000 upto 8000 Above 8000 upto 10000	32 36 40
3.	132	Upto 7000 Above 7000 upto 10000	32 36
4.	220	Upto 12000 Above 12000 upto 16000 Above 16000 upto 20000	32 36 40
5.	For earthing grid at SP & SSP of 2X25kV System 32 mm Diameter of the grid conductor (MS rod) is to be used.		

7.2 Buried rail.

7.2.1 A steel rail of section 52 kg/m (the one used for the railway track) and length about 13m shall be buried near the track at the traction substation at a depth of about one metre to form part of the earthing system. Two separate and distinct connections shall be made by means of 75 mm x 8 mm MS flat between the earthing grid and the buried rail. The buried rail shall also be connected by means of two separate and distinct connections made with 75mm x 8 mm MS flat to the traction rail(s) in a single - rail track circuited section and to the neutral point (s) of the impedance bond(s) in a double - rail track circuited section.

7.2.2 In cases where the feeding post is located separately away from the traction substation, the buried rail shall be provided at feeding post (where one terminal of the secondary winding of the traction power transformer of the substation is grounded).

7.3 System earthing.

7.3.1 For Traction Power Transformers

(a) In case of 25kV Traction System

One terminal of the secondary winding (25 kV winding) of each traction power transformer shall be earthed directly by connecting it to the earthing grid by means of one 75mmX8mm MS flat, and to the buried rail by means of another 75mmX8mm MS flat in case of 21.6/30.24MVA transformer. In case of 30/42MVA Transformer, two numbers 75mmX8mm MS flat to be directly connected to earthing grid, and to the buried rail by means of another two numbers 75mmX8mm MS flat.

(b) In case of 2X25kV Traction System with 38/53/63MVA Single Phase Dual LV Winding Traction Power Transformer at TSS:

In these transformers there are two secondary windings. The inner terminals of these two secondary windings are to be solidly connected to each other. This connection is to be connected with two no. 75X8mm MS Flats. One MS flat is to be connected with Buried Rail & another with the Earthing grid (Annexure-VIII).

(c) In case of 2X25kV Traction System with 60/84/100MVA Scott Connected Transformer at TSS:

At these TSSs, the autotransformer has been used. The neutral Bushing of this Autotransformer is to be connected with two no. 75X8mm MS Flats. One MS flat is to be connected with Buried Rail & another with the Earthing grid. (Annexure-IX)

7.3.2 One designated terminal of the secondary of each potential, current and auxiliary transformer shall be connected to the earthing grid by means of two separate and distinct earth connections made with 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system.

7.4 Equipment earthing.

The metallic frame work of all outdoor equipments such as transformers, circuit breakers, interrupters and isolators as well as steel structures shall be connected to the earthing grid by means of two separate and distinct connections made with MS flat of size as indicated below; One connection shall be made with the nearest longitudinal conductor, while the other shall be made to the nearest transverse conductor of the grid.

SN	Equipment	System Voltage and fault level	Size of MS flat	
			For 25kV system	For 2X25kV system
1.	Equipment on the primary side of traction power transformer.	66 kV, upto 3000 MVA 110 kV, upto 5000 MVA 132 kV, upto 6000 MVA 220 kV, upto 10,000 MVA	50 mm x 6 mm	75 mm x 8 mm

		66 kV, above 3000 upto 6000 MVA 110 kV, above 5000 upto 10000 MVA 132 kV, above 6000 upto 12000 MVA 220 kV, above 10000 upto 20000 MVA	75 mm x 8 mm	75 mm x 8 mm
2.	Equipments on the secondary side of traction power transformer.		50 mm x 6 mm	75 mm x 8 mm
3.	Fencing uprights /steel structures		50 mm x 6 mm	75 mm x 8 mm
4.	Door/fencing panels		6 SWG G. I. Wires.	

7.5 Earthing inside control room.

An earthing ring shall be provided inside the control room by means of 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system. This earthing ring shall be run along the wall on teak wood blocks fixed to the wall at a height of about 300 mm from the floor level. The earthing ring shall be connected to the main earthing grid by means of two separate and distinct connections made with 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system. The earthing ring shall also be connected to an independent earth electrode by means of two separate and distinct connections made with 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system. The metallic framework of control and relay panels, LT AC and DC distributions boards, battery chargers and such other equipments shall be connected to the earthing ring by means of two separate and distinct connections made with 8 SWG galvanized iron wire. The connections shall be taken along the wall and in recesses in the floor. All recesses shall be covered with cement plaster after finishing the work. Connections between the MS flats shall be made by welding.

7.6 Earthing of SCADA/RTU Equipments

A separate earth electrode shall be provided as per clause 6.1 & 6.2 of this specification. The RTU body/frame shall be suitably connected to this earth electrode using two no. 8SWG bare copper wires. The earth Resistance of this electrode shall be between 2 ohm to 10 ohm or better, depending upon the soil resistivity. This earth electrode shall not be connected to any other earthing arrangement.

7.7 Earthing of lightning arrester.

In addition to the earth electrodes provided for the main earthing grid, an independent earth electrode shall be provided for each lightning arrester. This earth electrode shall be connected to the ground terminal of the lightning arrester as well as to the main earthing grid by means of two separate and distinct connections made with 50mm x 6mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system, for the LV side lightning arresters, and with 75 mm x 8 mm MS flat for the HV side lightning arresters. The earth electrode shall be provided as close as possible to the lightning arrester and the connections shall be as short and straight as possible avoiding unnecessary bends. For lightning arresters provided for the traction power transformers, there shall also be a connection as direct as possible from the ground terminal of the lightning arrester to the frame of the transformer being protected; this connection shall also be made by means of two separate and distinct connections made with 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system, for LV side arresters, and with 75mm x 8mm MS flat for HV side lightning arrester.

7.8 Earth Screen.

The area covered by outdoor substation equipments shall be shielded against direct strokes of lightning by an overhead earth screen comprising 19/2.5 mm galvanized steel stranded wire strung across the pinnacles of the metallic structures. The earth screen wires shall be strung at a height as indicated in the approved traction substation layouts (not less than 2.5 m above the live conductors) and shall be solidly connected to the traction substation earthing grid at each termination by means of 50mm x 6mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system.

7.9 Earthing of fencing uprights and panels

Each metallic fencing upright shall be connected to the traction substation main earthing grid by means of two separate and distinct connections made with 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system. In addition, all metallic fencing panels shall be connected to the uprights by means of two separate and distinct connections made with 6 SWG G. I. wire. All the metallic door panels shall also be connected to the supporting uprights by means of two separate and distinct connections made with 6 SWG G. I. wire.

7.10 Earthing at the point of 240 V ac 50 Hz supply for oil filtration plant.

The 240 V ac 50 Hz distribution board for power supply to oil filtration plant shall be connected to the main earthing grid by means of two separate and distinct connections made with 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system.

8.0 EARTHING ARRANGEMENT AT SWITCHING POST

8.1 For 25kV System:

- (a) A minimum number of three earth electrodes (excluding the earth electrode provided separately for control room and RTU equipments (refer clause 8.5 & 8.6) shall be provided at each switching station, and they shall be interconnected by means of 50 mm x 6 mm MS flat forming a closed loop main earthing ring. This ring shall be connected by two separate and distinct connections made with 50 mm x 6 mm MS flat, to the traction rail in a single rail track circuited section and to the neutral point of the impedance bond in a double-rail track circuited section of the nearest track, so as to limit the potential gradient developing in the vicinity of the switching station in the event of a fault.
- (b) In addition to above earthing, separate earthing station of Buried Rail, near the switching posts is to be provided as per the SMI No. TI/SMI/0032 Rev.02. (Annexure-X)

8.2 For 2X25kV System (Transformer capacity at TSSs: 38/53/63MVA or 60/84/100MVA):

- (a) Earthing Grid at the SP/SSP is also to be prepared by taking the fault current of 12kA and duration of 3 seconds. The Formula for the calculation is at Annexure-I and sample calculation at annexure-XII. The Buried rail as mentioned in Para 7.2.1, is required to be provided at the SP/SSP.
- (b) Neutral of the Autotransformer installed at the SP/SSP also to be connected with two no. 75X8mm MS Flats. One MS flat is to be connected with Buried Rail & another with the Earthing grid. The reference for the connection arrangement can be taken from Annexure-IX.

8.3 System earthing.

One designated terminal of the secondary of each potential, current and auxiliary transformer shall be connected to the main earthing ring/earthing grid by means of two separate and distinct connections made with 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV System .

8.4 Equipment earthing.

- 8.4.1 All masts, structures, fencing uprights and all outdoor equipment pedestals including auxiliary transformer tank shall be connected to the earthing ring by means of two separate and distinct connections made with 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system. All fencing panels shall be connected to the supporting uprights by means of two separate and distinct connections made with 6 SWG G. I. wire. All the metallic door panels shall be connected to the supporting uprights by means of two separate and distinct connections made with 6 SWG G. I. wire.
- 8.4.2 The metal casing of potential and current transformers shall be connected to the mast/ structures by means of two separate and distinct connections made with 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system.
- 8.4.3 The ground terminal of lightning arrester shall be connected directly to the earth electrode by means of two separate and distinct connections made with 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system. The earth electrode shall be so placed that the earthing leads from the lightning arrester may be brought to the earth electrode by as short and straight a path as possible.

8.5 Earthing inside remote control cubicle.

An earthing ring shall be provided inside the remote control cubicle by means of 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system. The earthing ring shall be run along the wall on teak wood blocks fixed to the wall at a height of 300 mm from the floor level. The earthing ring shall be connected to an independent earth electrode by means of two separate and distinct connections made with 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system. The metal casing of LT, AC and DC distribution board, battery chargers, terminal board and other such equipments shall be connected to the earthing ring by means of two separate and distinct connections made with 8 SWG GI wire. The connections shall be taken along the wall and in recesses in the floor. All recesses shall be covered with cement plaster after finishing the work. Connections of earth strips to each other shall be made by welding.

8.6 Earthing of SCADA/RTU Equipments

A separate earth electrode shall be provided as per clause 6.1 & 6.2 of this specification. The RTU body/frame shall be suitably connected to this earth electrode using two no. 8SWG bare copper wires. The earth Resistance of this electrode shall be between 2 ohm to 10 ohm or better, depending upon the soil resistivity. This earth electrode shall not be connected to any other earthing arrangement.

9.0 EARTHING OF NEUTRAL OF LOCAL POWER SUPPLY SYSTEM

At traction substations and switching stations where power supply at 415 V/ 240 V, ac 50 Hz is taken from the local supply authority and having neutral earth at some distant point in the premises of the supply authority, the neutral of such supply shall also be earthed by means of two separate and distinct connections made with 6 SWG GI wire by connecting to an independent earth electrode.

10.0 EARTHING ARRANGEMENT AT AUXILIARY TRANSFORMER STATION

- 10.1 The combined earth resistance at an auxiliary transformer station shall not be more than 10.0 ohms. Normally, one earth electrode is sufficient at each auxiliary transformer station. The earth electrode shall be connected to the mast on which the auxiliary transformer is mounted by means of two separate and distinct connections made with 50 mm x 6 mm MS flat in case of 25kV system

and with 75mm X 8mm MS Flat in case of 2X25kV system. In addition, the mast shall be connected to the nearest traction rail or to the neutral point of the impedance bond in a double rail track circuited section by means of 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system.

- 10.2 The earthing terminal on the transformer tank shall be connected to the mast on which the transformer is mounted by means of two separate and distinct connections made with 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system. One terminal of the secondary winding of the auxiliary transformer shall be connected to the earthing terminal on the transformer tank and as well as to the mast by means of 50 mm x 6 mm MS flat in case of 25kV system and with 75mm X 8mm MS Flat in case of 2X25kV system. These connections shall be as short and straight as possible and avoiding unnecessary bends.

11.0 METHOD OF JOINTING

All the joints between the MS flats, MS rods or between MS flat and MS rod shall be made by welding only. No soldering shall be permitted. For protection against corrosion. All the welded joints shall be treated with red lead and afterwards thickly coated with bitumen compound.

12.0 PAINTING OF MS FLATS.

For protection against corrosion, all the exposed surface of earthing connections (MS flats) above ground level shall be given all around two coats of painting to colour grass green, shade 218 of IS:5.

13.0 CRUSHED ROCK SURFACE LAYER.

At the traction substations and switching stations, a surface layer of crushed rock shall be provided to a thickness of about 100mm. If considered necessary from the point of view of containing the step and touch voltages within the acceptable limits, higher thicknesses may be provided depending on calculation based on site conditions.

14.0 STEP AND TOUCH VOLTAGES

- 14.1 The formulae for calculating the tolerable touch and step voltages, estimated mesh and step voltages, earth resistance, earth potential rise, size of earthing grid conductor and length of buried grid conductor are given in Annexure-I & XI.
- 14.2 The design for earthing grid shall be done separately for each location depending on the conditions obtaining and those foreseen.

15.0 REFERENCE DRAWINGS

The following drawings (latest versions) issued by RDSO in connection with this specification may be used for reference:

SN	Description	Drawing No.	Enclosed at
1.	Typical return current connection of buried rail at traction substation	ETI/PSI/0212-1	ANNEXURE-III
2.	Typical earthing layout of sub sectioning and paralleling station	ETI/PSI/201-1	ANNEXURE-IV
3.	Typical earthing layout of sectioning and paralleling station	ETI/PSI/202-1	ANNEXURE-V
4.	Typical arrangement of an earth electrode	ETI/PSI/222-1	ANNEXURE-VI
5.	Typical earthing arrangement of an auxiliary Transformer station	ETI/PSI/708	ANNEXURE-VII

Note: Drawings as per the revision at the time of issue of specification are enclosed. The latest version of the drawings should be followed.

ANNEXURE-I

FORMULAE FOR CALCULATION OF EARTHING GRID BASED ON IEEE GUIDE FOR SAFETY IN AC SUBSTATION GROUNDING, NO. IEEE 80-2013 & IS: 3043-2018**1.0 Tolerable Touch and Step Voltage**

$$1.1 \quad E_{touch} = (1000 + 1.5C_s \rho_s) \frac{0.116}{\sqrt{t_s}} \quad \text{V (for 50 kg body)}$$

$$1.2 \quad E_{step} = (1000 + 6C_s \rho_s) \frac{0.116}{\sqrt{t_s}} \quad \text{V (for 50 kg body)}$$

Where,

Symbol	Representation
C_s	$0.09 \times \left(1 - \frac{\rho}{\rho_s} \right) \div \left(1 - \frac{0.09}{2 \times h_s + 0.09} \right)$
ρ_s	Resistivity of surface material (crushed rock) in Ω -m
ρ	Resistivity of earth (Soil) in Ω -m
t_s	Duration of shock current in seconds (to be taken as 0.5 seconds)
h_s	Thickness of the crushed rock surface layer in m

2.0 Estimated mesh and step voltage

$$2.1 \quad E_{\text{mesh}} = \frac{\rho \cdot K_m \cdot K_i \cdot I_G}{L} \quad \text{Volt}$$

$$2.2 \quad E_{\text{step}} = \frac{\rho \cdot K_s \cdot K_i \cdot I_G}{L} \quad \text{Volt}$$

Where,

Symbol	Representation
K_i	Correction factor for grid geometry, which accounts for the increase in current density in the grid extremities, = $0.644 + 0.148 \times n$
I_G/L	Average current per unit length of buried conductor in amperes / metre
K_m	$K_m = \frac{1}{2\pi} \left[\ln \left(\frac{D^2}{16hd} + \frac{(D+2h)^2}{8Dd} - \frac{h}{4d} \right) + \frac{K_{ii}}{K_h} \ln \frac{8}{\pi(2n-1)} \right]$
K_{ii}	1, for grids with earth electrodes along the perimeter, or for grids with earth electrodes in the grid corners, as well as both along the perimeter and throughout the grid area. 1/ {(2n) ^(2/n) }, for grids without earth electrodes or grids with only a few earth electrodes, none located in the corners or on the perimeter.
K_h	$\sqrt{1 + h/h_o}$

K_s	$\frac{1}{\pi} \left[\frac{1}{2h} + \frac{1}{D+h} + \frac{1}{D} (1 - 0.5^{n-2}) \right]$ for values of h between 0.25 and 2.5m
ho	1 metre (reference depth of grid)
D	Spacing between parallel conductors of grid in m (same spacing in both directions)
n	$n_a \times n_b \times n_c \times n_d$ $n_a = \frac{2.L_c}{L_p}$ $n_b = 1$ for square grids $n_c = 1$ for square and rectangular grids $n_d = 1$ for square, rectangular and L-shaped grids Otherwise $n_b = \sqrt{\frac{L_p}{4 \times \sqrt{A}}}$ (Since in Indian Railways, there are square or rectangular grids, other formulas of IEEE-80 are not mentioned here)
h	Depth of earthing grid conductors in metres
d	Diameter of earthing grid conductor in metres
L	Total length of earthing system conductor Lc + Lr for grids without earth electrodes or with only a few electrodes located within the grid but away from perimeter Lc + 1.15 Lr for grids with earth electrodes along the perimeter
Lc	Total grid conductor length in m
Lr	Total earth electrode length in m
Lp	Peripheral length of grid in m
ρ	Resistivity of earth in Ω -m
A	Area of the grid in m^2
I_G	As defined in para 4.1 below.

Note: The estimated values of mesh and step voltage should be less than the tolerable touch and step voltages respectively.

3.0 Earth resistance:

$$R_g = 0.443 \frac{\rho}{\sqrt{A}} + \frac{\rho}{L}$$

Where,

Symbol	Representation
L	Total length of buried conductors in m
A	Area occupied by the earthing grid in m^2
R_g	Station ground resistance in ohms
ρ	Resistivity of earth (soil) in Ω -m

4.0 Earth Potential rise:

$$4.1 \text{ Earth potential rise} = R_g \times I_g$$

Where,

Symbol	Representation
R_g	Station earth resistances in ohms
I_g	$C_p \times D_f \times I_g$
C_p	Corrective projection factors accounting for the relative increase of fault currents during the station lifespan: for a zero future system growth $C_p = 1$
I_g	r.m.s. value of symmetrical grid fault current in amperes.
D_f	Decrement factor for the entire duration of faults (to allow for the effects of asymmetry of the fault current wave).
	1.0 for fault current duration of 0.5 second or more.

5.0 Size of earthing grid conductor

$$A = \frac{I\sqrt{t}}{80}$$

Where

Symbol	Representation
A	Cross sectional area of earthing grid conductor in square millimeters.
I	r.m.s value of fault current in amperes.
t	Duration of fault current in second <ul style="list-style-type: none"> To be taken as 01 second for the calculation of grid conductor size on the basis of HV side Fault MVA. To be taken as 03 second for the calculation of grid conductor size on the basis of LV side fault current, which is 6kA for 25kV System and 12kA for 2X25kV System.

Note: -

- To allow for the effects of corrosion, the size of the grid conductor selected shall be such that its cross section area is nearly twice that calculated above.
- The earthing grid conductor size to be calculated on the basis of both primary and secondary side fault current and the higher between them should be selected for designing the grid.

6.0 Minimum length of buried grid conductor

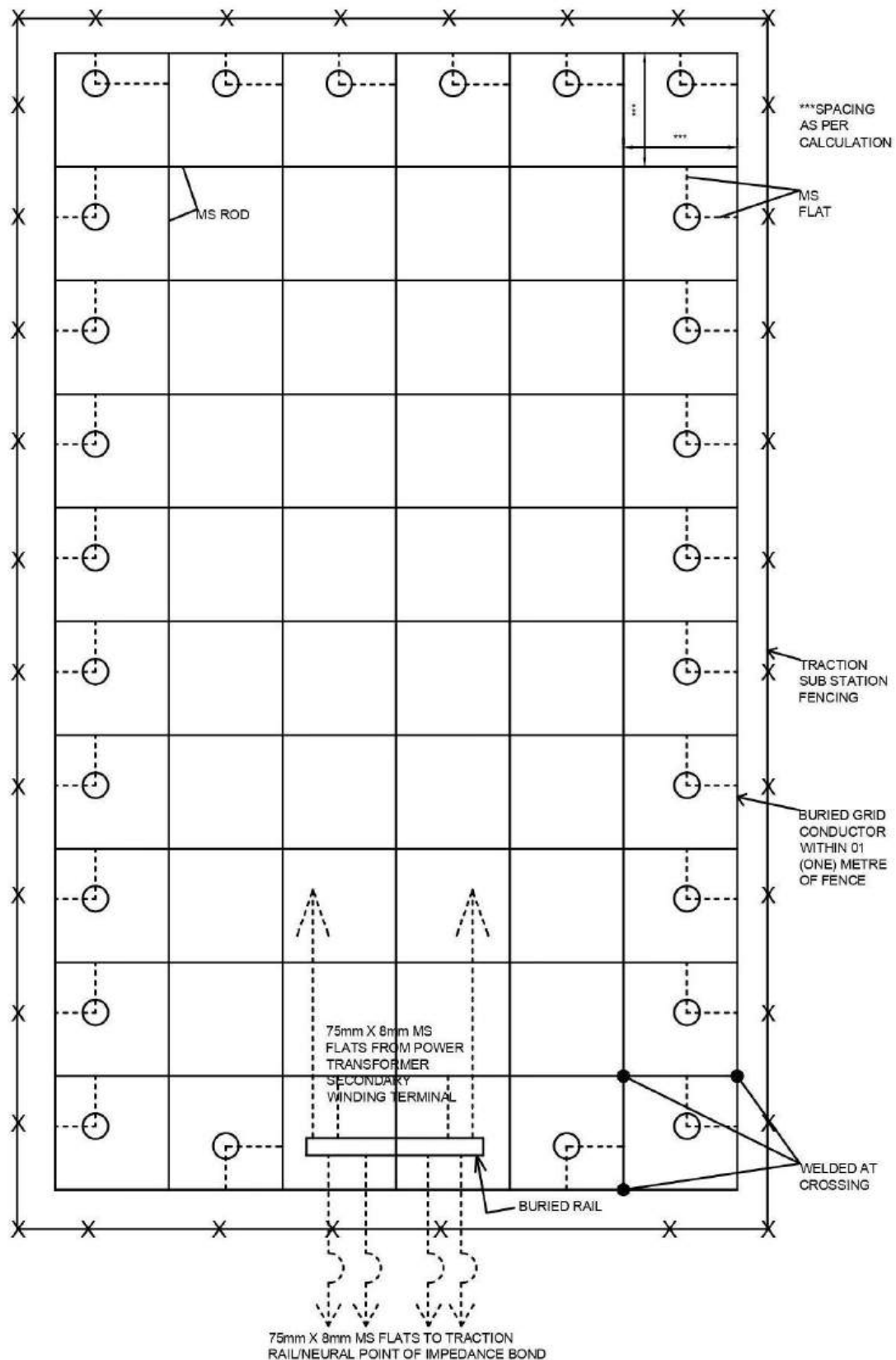
$$L > \frac{K_m \times K_i \times \rho \times I_g \sqrt{t_s}}{\{116 + 0.174 C_s \times \rho_s\}} \quad \text{for } E_{\text{mesh}} < E_{\text{touch}}$$

Where,

Symbol	Representation
L	Minimum length of buried grid conductor including earth electrodes in metres.
t_s	0.5 second (assumed maximum duration of shock).
Cs, Km, Ki, ρ , I_g and ρ_s have been defined earlier.	

Annexure –II

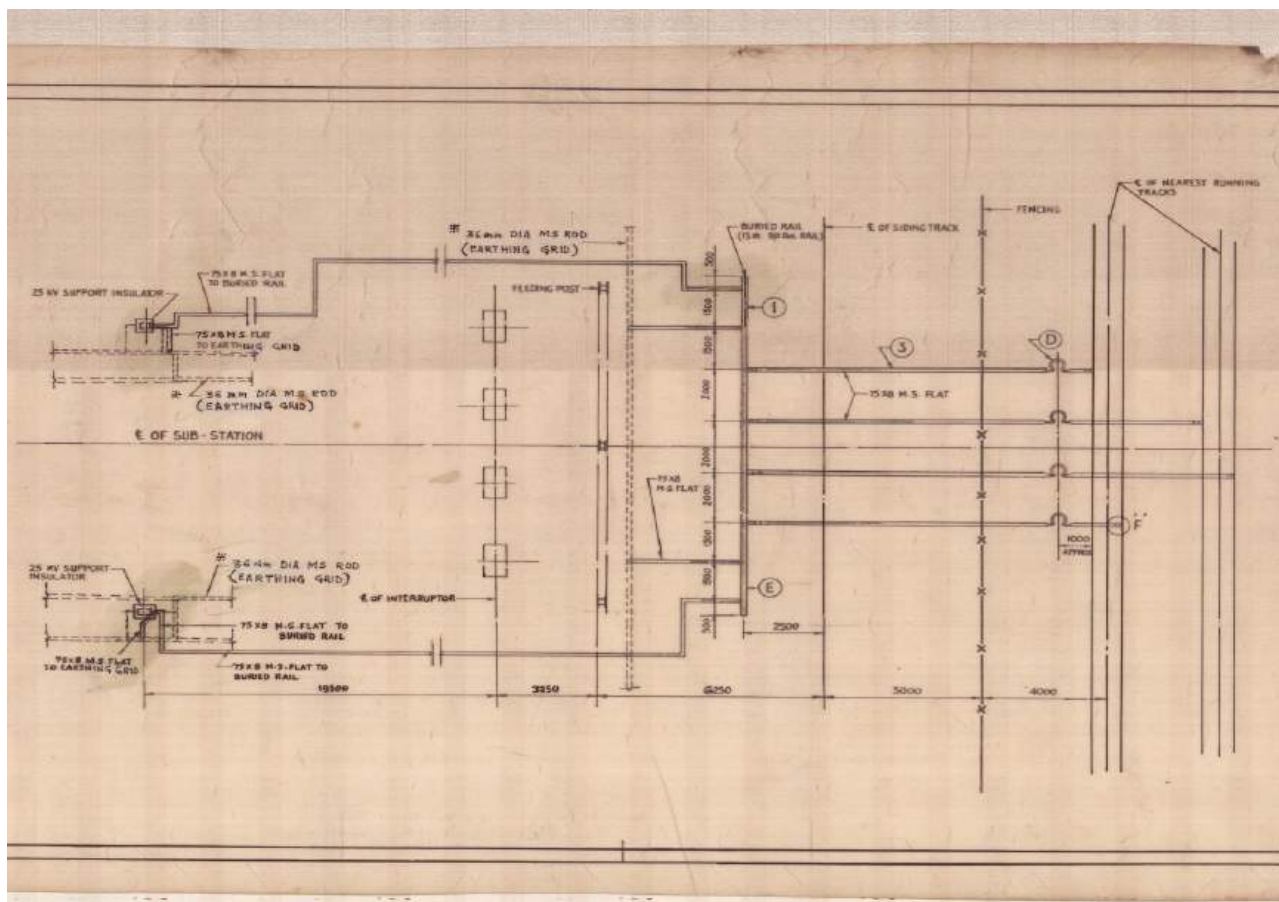
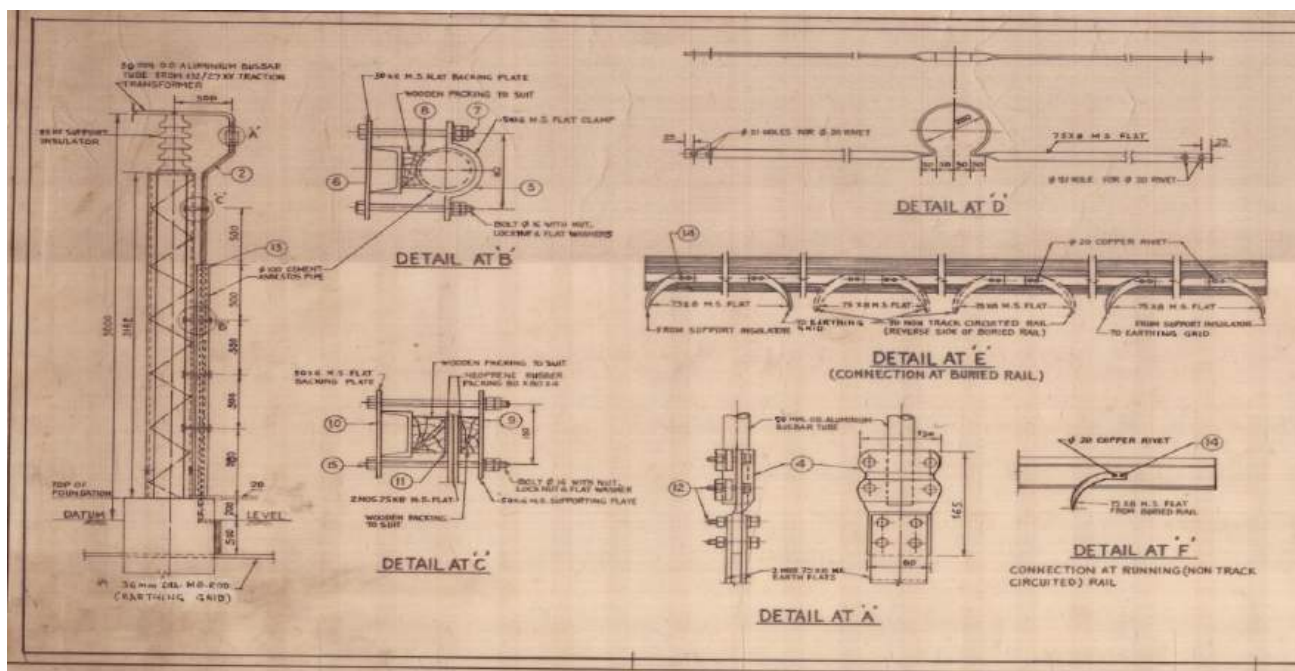
TYPICAL EARTHING GRID (MS ROD)



TYPICAL EARTHING GRID (MS ROD)

Annexure- III

Typical return current connection of buried rail at traction substation, drawing no. ETI/PSI/0212-1



SCHEDULE OF QUANTITIES				
REF NO	DESCRIPTION	DWG NO / PART / INDENT NO.	NO. OFF	REMARKS
1	50 kg RAIL 13000 MM LONG	-	1	
2	75 X 8 M.S. PLAT (FROM SUPPORT INSULATOR TO BURIED RAIL & EARTH BUS)		AS REQUIRED	
3	75 X 8 M.S. PLAT (FROM BURIED RAIL TO RUNNING RAIL)		AS REQUIRED	
4	50 MM ALUMINIUM BUS TERMINAL CONNECTOR	ETI/PSI/0210	2	
5	50 X 6 M.S. / PLAT CLAMP		6	
6	BACKING PLATE (BIG)		6	
7	M16 X 40 BOLT WITH 120/45 COMPLETE WITH ONE NUT ONE LOCKWASHER & ONE PLAT WASHER		12	
8	WOODEN PACKING		AS REQUIRED	
9	SUPPORTING PLATE		2	
10	BACKING PLATE (SMALL)		2	
11	NEOPRENE RUBBER PACKING		4	
12	M12 X 40/50 MMS. STAINLESS STEEL BOLT WITH ONE NUT & PLAT WASHER AND ONE SPRING WASHER		16	
13	100 DUCTMENT ASBESTOS PIPE (210 LONG)		2	
14	2000A COPPER RING		24	
15	M16 BOLT WITH 120/45 COMPLETE WITH ONE NUT ONE LOCKWASHER & ONE PLAT WASHER		4	

NOTE:

- ALL DIMENSIONS ARE IN MM.
- THE M.S. PLATS SHALL BE PAINTED WITH TWO COATS OF RED OXIDE ZINC CHROMATE PAINTER TO IS: 2074, CHS LABORED AND FINISHED WITH TWO COATS OF BITUMEN 80/20 BLOWN GRADE FOR LAYING DIRECTLY IN GROUND AT A DEPTH OF 600 MM BELOW GROUND LEVEL FOR PROTECTION AGAINST CORROSION. ALL THE EXPOSED SURFACES OF EARTHING CONNECTION (M.S. PLATS, ABOVE GROUND) LEVEL SHALL BE GIVEN ALL AROUND TWO COATS OF PAINTING TO COLOUR GRASS GREEN GRADE: 218 OF IS: 1555.
- A VERTICAL CLEARANCE OF 280 MM SHALL BE MAINTAINED BETWEEN THE TWO EARTH STRIPS, WHICHEVER THEY CROSS EACH OTHER.
- FOR TYPICAL EARTHING LAYOUT OF THE STATION REFER TO ETI/PSI/234-1
- WHEREVER THE EARTH PLAT CROSSES THE TRACK OR CIRCUT RAILS IT SHOULD BE INSULATED FROM RAIL WITH SUITABLE WOODEN PACKINGS.
- FOR LOCATION OF BURIED RAIL REFER THE RESPECTIVE EARTHING LAYOUT PLAN OF EACH SUBSTATION.
- THE LENGTH OF BURIED RAIL IS 13000 MM.
- DEPTH OF BURIED RAIL FROM GROUND LEVEL SHOULD BE AROUND 500 MM.
- CONNECTIONS FROM ONE SECONDARY TERMINAL OF THE TRANSFORMER TO EARTH IS MADE WITH TWO (75 X 8 MM) M.S. PLATS CLAMPED TO 25 KV BUSBAR (56/28 MM AL TUBE) SUPPORTED ON 25 KV PEDESTAL INSULATOR, WHICH IN TURN ARE CONNECTED TO H.T. EARTH CIRCUIT / EARTHING GRID AND BURIED RAIL.
- FOR SIZE OF THE M.S. ROD FOR EARTHING GRID REFER CLAUSE 7.1.2 OF CODE OF PRACTICE FOR EARTHING AND ETI/PSI/120 (2/11).

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TYPICAL RETURN CURRENT CONNECTION TO BURIED RAIL AT 132 KV/ 25 KV TRACTION SUB-STATION

DTI-1 *Ranveer* 26/10/18

ADE/TI *Pragati*

REF.

DATE	MOD	NATURE OF MOD.	INITIALS	DATE	NAME

R. D. S. O.

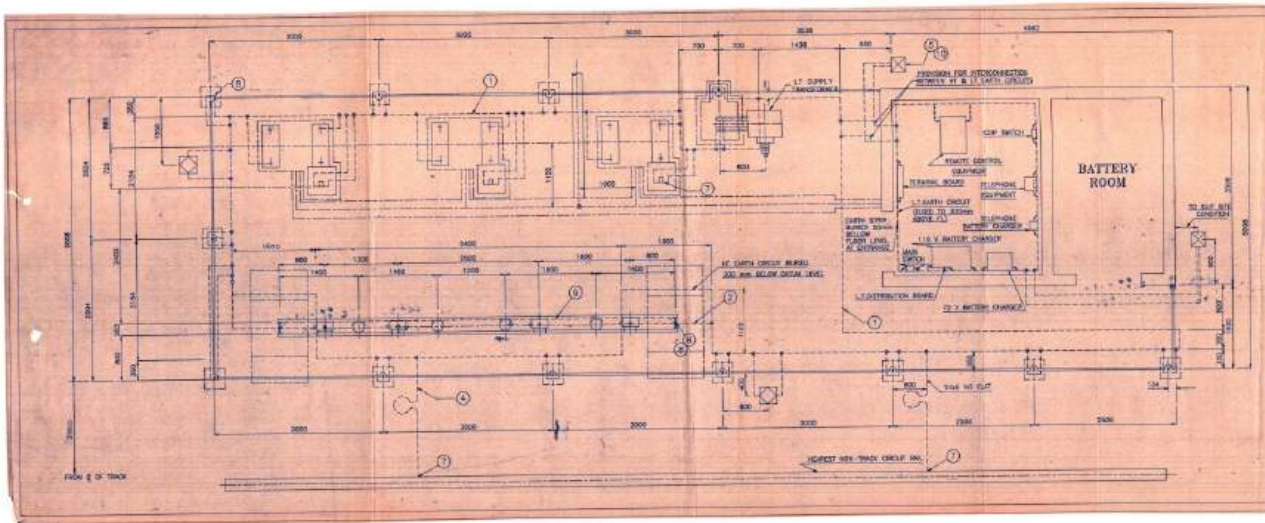
ETI/PSI/0212-1

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CK 26/10/18 *Pragati*

Typical return current connection of buried rail at traction substation, drawing no. ETI/PSI/0212-1

Annexure-IV

Typical Earthing layout of sub sectioning and paralleling station Drawing No. ETI/PSI/201-1

SCHEDULE OF MATERIALS					
REF.	DESCRIPTION	DRG./CODE NO.	QUANTITY	LENGTH IN M.	REMARKS
				EACH	TOTAL
1	50x6 MS FLAT FOR HT & LT EARTH CIRCUIT & EACH CONNECTION		139m APPX.		
2	50x6 MS STRUCTURE TO EARTH CIRCUIT BOND		4	1.25	5
3	NO. 8 SWG. GI. WIRE		5m		
4	50x6 MS EARTH CIRCUIT TO RAIL BOND		2	5.5	11
5	EARTH STATION	FIG. 1 OF CODE NO. ETI/PSI/120(2/91)	4		
6	16 Ø HRH BOLT 75/40, COMPLETE WITH NUT, LOCKNUT & WASHER		2		
7	16 Ø HRH BOLT 50/37, COMPLETE WITH NUT, LOCKNUT & WASHER		10		
8	12 Ø BOLT 50/37, COMPLETE WITH NUT, LOCKNUT & WASHER FOR FIXING MS FLAT TO MAST BEAM		32		
9	8 Ø GI. BOLT 40/30, COMPLETE WITH NUT, LOCKNUT & WASHER FOR FIXING MS FLAT TO STEEL WORK		13		
10	12 Ø BOLT WITH NUT, LOCKNUT & WASHER		9		

LEGEND :-

----- 50x6 MS FLAT FOR EARTH CIRCUITS AND EARTH CONNECTIONS

---X--- NO. 8 SWG GI WIRE FOR EARTHING OF LT EQUIPMENT

⊕ 25 KV LIGHTNING ARRESTER

---|--- CONNECTIONS OF 50x6 MS FLATS BY WELDING

⊕ POTENTIAL TRANSFORMER TYPE-I

---S2--- CONNECTION TO THE NEAREST NON-TRACK CIRCUIT RAIL

⊕ BONDING OF FENCING PANELS BY 6 SWG GI WIRE

--- STRUCTURE TO RAIL BOND FOR RSJ MAST

⊕ LT EARTHING STATION

⊕ HT EARTHING STATION

⊕ LT SUPPLY TRANSFORMER

NOTES:

- ALL DIMENSIONS ARE IN mm.
- WHEREVER 50x6 EARTHING FLATS ARE WELDED, THE MS SURFACES OF JUNCTIONS SHALL BE SCRAPPED OUT BEFORE WELDING & SHALL BE TREATED FOR ANTICORROSION AS PER STANDARD PRACTICE.
- RESISTANCE OF HT EARTH CIRCUIT SHALL BE LESS THAN 2 OHMS.
- THE MS FLATS FORMING THE HT EARTH BUS SHALL BE BURIED AT A DEPTH OF 300mm BELOW GROUND LEVEL AND LT EARTH BUS SHALL BE FIXED TO WALL INSIDE THE CUBICLE AT THE HEIGHT OF 300mm FROM FLOOR LEVEL.
- RESISTANCE OF LT EARTH CIRCUIT SHALL BE LESS THAN 2 OHMS.
- FOR ARRANGEMENT OF EARTHING STATION REFER FIG. 1 OF THE CODE OF PRACTICE FOR EARTHING OF POWER SUPPLY INSTALLATIONS FOR 25 kv AC, 50 Hz, SINGLE PHASE TRACTION SYSTEM CODE NO. ETI/PSI/120 (2/91).
- FENCING PANEL TO FENCING UPRIGHT BONDING SHALL BE DONE BY RAILWAYS.
- IF NECESSARY EARTHING STATIONS SHALL BE ADDED IN PARALLEL TO BRING DOWN THE TOTAL EARTH RESISTANCE LESS THAN 2 OHMS.
- THE MS FLATS SHALL BE PAINTED WITH TWO COATS OF RED OXIDE ZINC CHROMATE PRIMER AND FINISHED WITH TWO COATS OF BITUMEN.
- PAINTED MS FLAT AND 8 SWG GI WIRE SHALL BE USED IN PLACE OF GALV-ANISED MS FLAT AND 8 SWG COPPER WIRE.
- THE EARTHING ARRANGEMENT SHALL BE IN LINE WITH THE CODE OF PRACTICE FOR EARTHING OF POWER SUPPLY INSTALLATIONS FOR 25 kv AC, 50 Hz, SINGLE PHASE TRACTION SYSTEM CODE NO. ETI/PSI/120 (2/91) WITH ADDENDUM AND CORRIGENDUM SUP NO. 1 (10/93).

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TYPICAL EARTHING LAYOUT OF 25 kv AC SUB-SECTIONING AND PARALLELING STATION

DTI-1 *Roule* 26/10/98

ADE/TI *Hy. Shree*

REF:- CROSS REF:-

R.D.S.O.

DATE MOD. NATURE OF MOD. INITIAL

DATE NAME

DR

CH 26/10/98

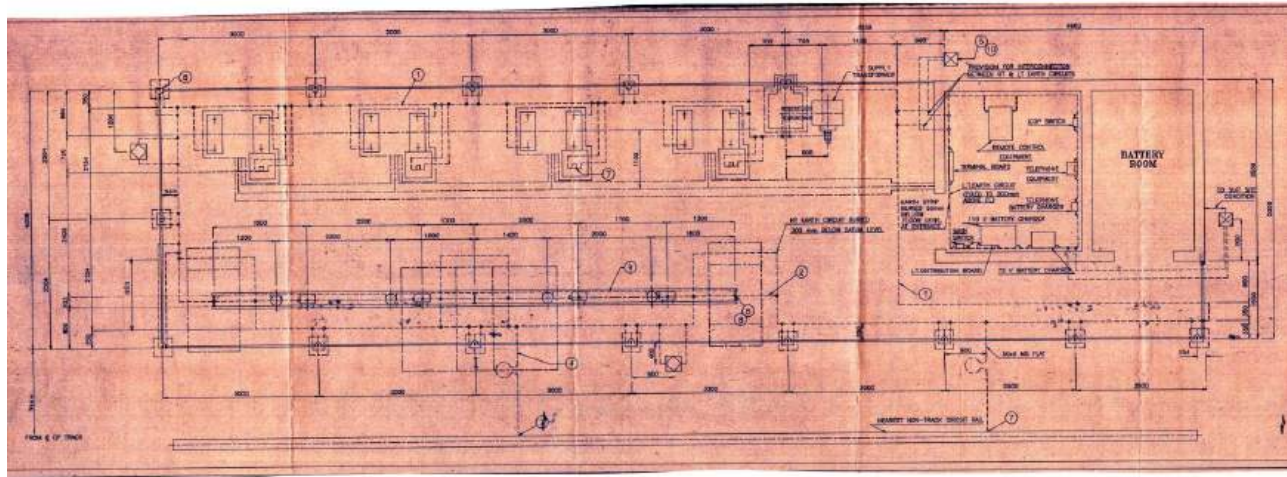
ETI/PSI/201-1

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Typical Earthing layout of sub sectioning and paralleling station Drawing No. ETI/PSI/201-1

Annexure-V

Typical Earthing layout of sectioning and paralleling station, drawing No. ETI/PSI/202-1

SCHEDULE OF MATERIALS						
REF.	DESCRIPTION	DRG./CODE NO.	QUANTITY	LENGTH IN M.		REMARKS
				EACH	TOTAL	
1	50x6 MS FLAT FOR HT & LT EARTH CIRCUIT & EACH CONNECTION		185m APPX.			
2	50x6 MS STRUCTURE TO EARTH CIRCUIT BOND		6	1.25	7.5	
3	NO. 8 SVG GI WIRE		5m			
4	50x6 MS EARTH CIRCUIT TO RAIL BOND		2	5.5	11	
5	EARTH STATION	FIG. 1 OF CODE NO. ETI/PSI/120(2/91)	4			
6	16 Ø HRH BOLT 75/45, COMPLETE WITH NUT, LOCKNUT & WASHER		2			
7	16 Ø HRH BOLT 50/37, COMPLETE WITH NUT, LOCKNUT & WASHER		10			
8	12 Ø BOLT 50/37, COMPLETE WITH NUT, LOCKNUT & WASHER FOR FIXING MS FLAT TO MAST BEAM		32			
9	8 Ø GI BOLT 40/30, COMPLETE WITH NUT, LOCKNUT & WASHER FOR FIXING MS FLAT TO STEEL WORK		13			
10	12 Ø BOLT WITH NUT, LOCKNUT & WASHER		8			

LEGEND :-

----- 50x6 MS FLAT FOR EARTH CIRCUITS AND EARTH CONNECTIONS	— BONDING OF FENCING PANELS BY 6 SVG GI WIRE
-X- NO. 8 SVG GI WIRE FOR EARTHING OF LT EQUIPMENT	— STRUCTURE TO RAIL BOND FOR RSJ MAST
⊕ 25 KV LIGHTNING ARRESTER	⊗ LT EARTHING STATION
— CONNECTIONS OF 50x6 MS FLATS BY WELDING	⊗ HT EARTHING STATION
⊕ POTENTIAL TRANSFORMER TYPE-1	⊕ LT SUPPLY TRANSFORMER
— CONNECTION TO THE NEAREST NON-TRACK CIRCUIT RAIL	

NOTES:

- ALL DIMENSIONS ARE IN mm.
- WHEREVER 50x6 EARTHING FLATS ARE WELDED, THE MS SURFACES OF JUNCTIONS SHALL BE SCRAPPED OUT BEFORE WELDING & SHALL BE TREATED FOR ANTICORROSION AS PER STANDARD PRACTICE.
- RESISTANCE OF HT EARTH CIRCUIT SHALL BE LESS THAN 2 OHMS.
- THE MS FLATS FORMING THE HT EARTH BUS SHALL BE BURIED AT A DEPTH OF 300mm BELOW GROUND LEVEL AND LT EARTH BUS SHALL BE FIXED TO WALL INSIDE THE CUBICLE AT THE HEIGHT OF 300mm FROM FLOOR LEVEL.
- RESISTANCE OF LT EARTH CIRCUIT SHALL BE LESS THAN 2 OHMS.
- FOR ARRANGEMENT OF EARTHING STATION REFER FIG.1 OF THE CODE OF PRACTICE FOR EARTHING OF POWER SUPPLY INSTALLATIONS FOR 25 KV AC, 50 Hz, SINGLE PHASE TRACTION SYSTEM CODE NO. ETI/PSI/120 (2/91).
- FENCING PANEL TO FENCING UPRIGHT BONDING SHALL BE DONE BY RAILWAYS.
- IF NECESSARY, EARTHING STATIONS SHALL BE ADDED IN PARALLEL TO BRING DOWN THE TOTAL EARTH RESISTANCE LESS THAN 2 OHMS.
- THE MS FLATS SHALL BE PAINTED WITH TWO COATS OF RED OXIDE ZINC CHROMATE PRIMER AND FINISHED WITH TWO COATS OF BITUMEN.
- PAINTED MS FLAT AND NO. 8 SVG GI WIRE SHALL BE USED IN PLACE OF GALVANISED MS FLAT AND NO. 8 SVG COPPER WIRE.
- THE EARTHING ARRANGEMENT SHALL BE IN LINE WITH THE CODE OF PRACTICE FOR EARTHING OF POWER SUPPLY INSTALLATIONS FOR 25 KV AC, 50 Hz, SINGLE PHASE TRACTION SYSTEM CODE NO. ETI/PSI/120 (2/91) WITH ADDENDUM AND CORRIGENDUM SLIP NO. 1 (10/93).

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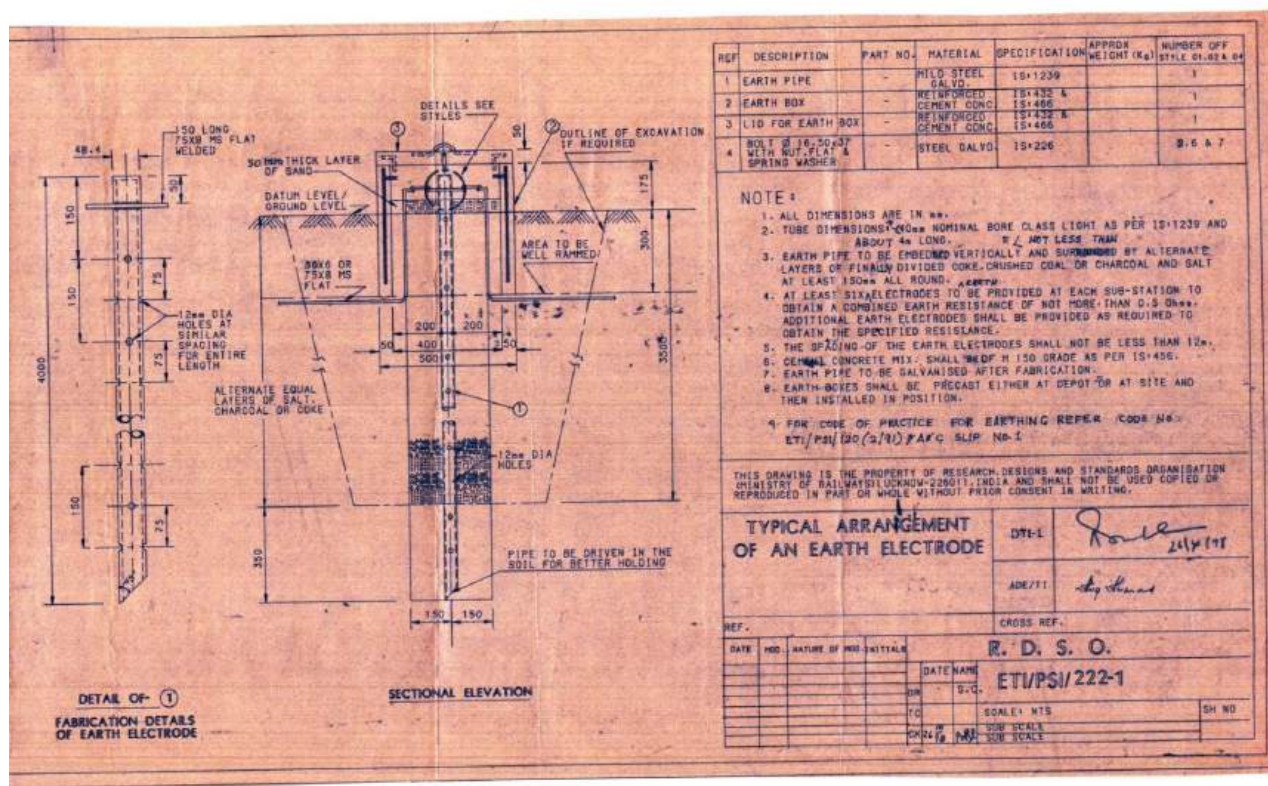
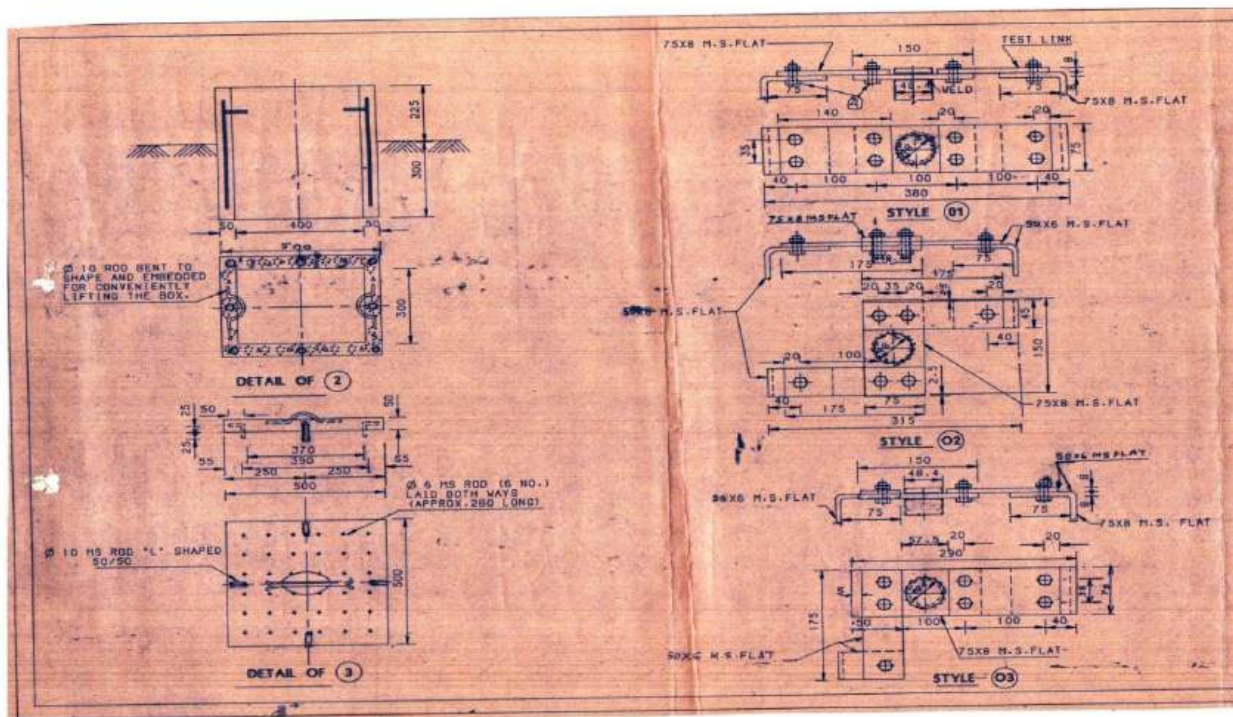
TYPICAL EARTHING LAYOUT OF A 25KV AC SECTIONING AND PARALLELING STATION

DTI-1
ADE/TI
CROSS REF:-
R.D.S.O.
ETI/PSI/202-1
SCALE: 1:30
SHND.

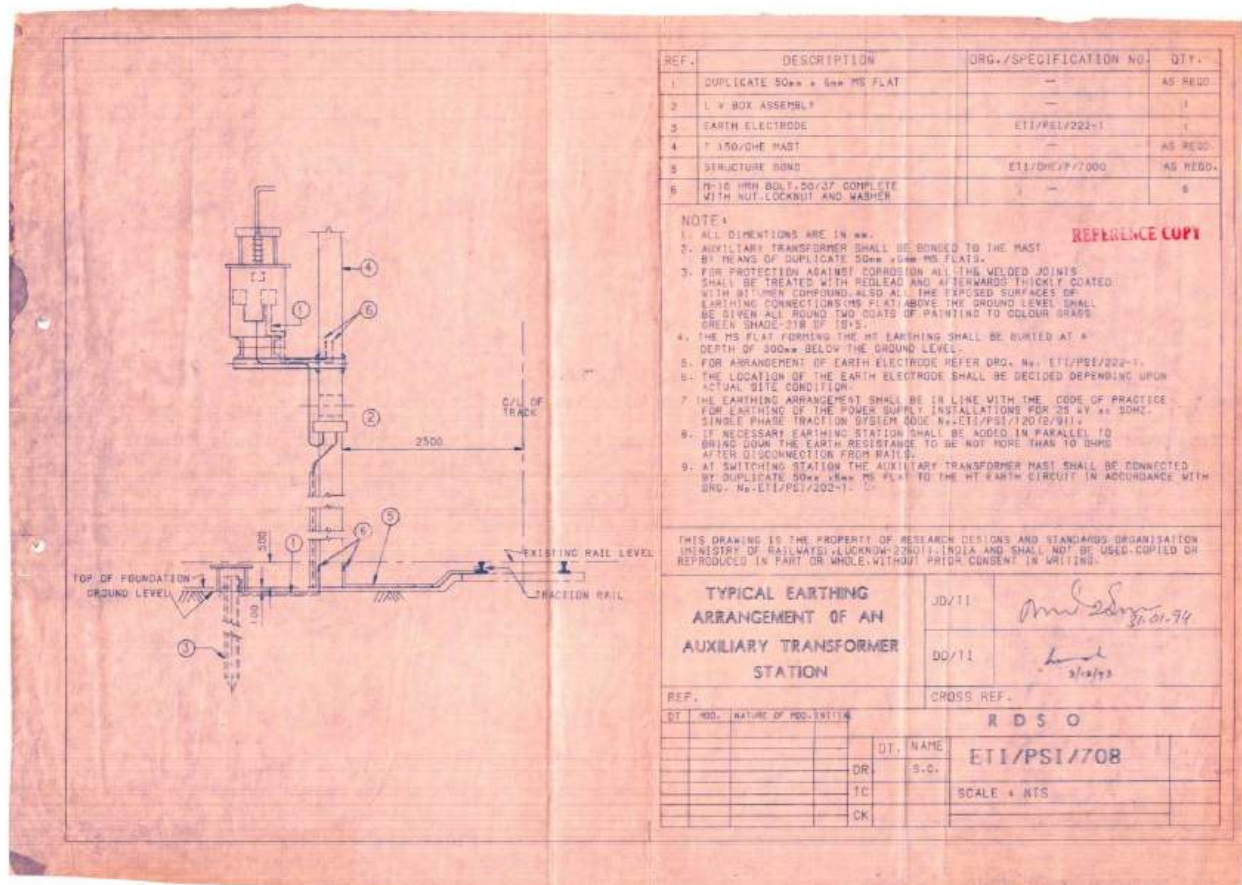
Typical Earthing layout of sectioning and paralleling station, drawing No. ETI/PSI/202-1

Annexure-VI

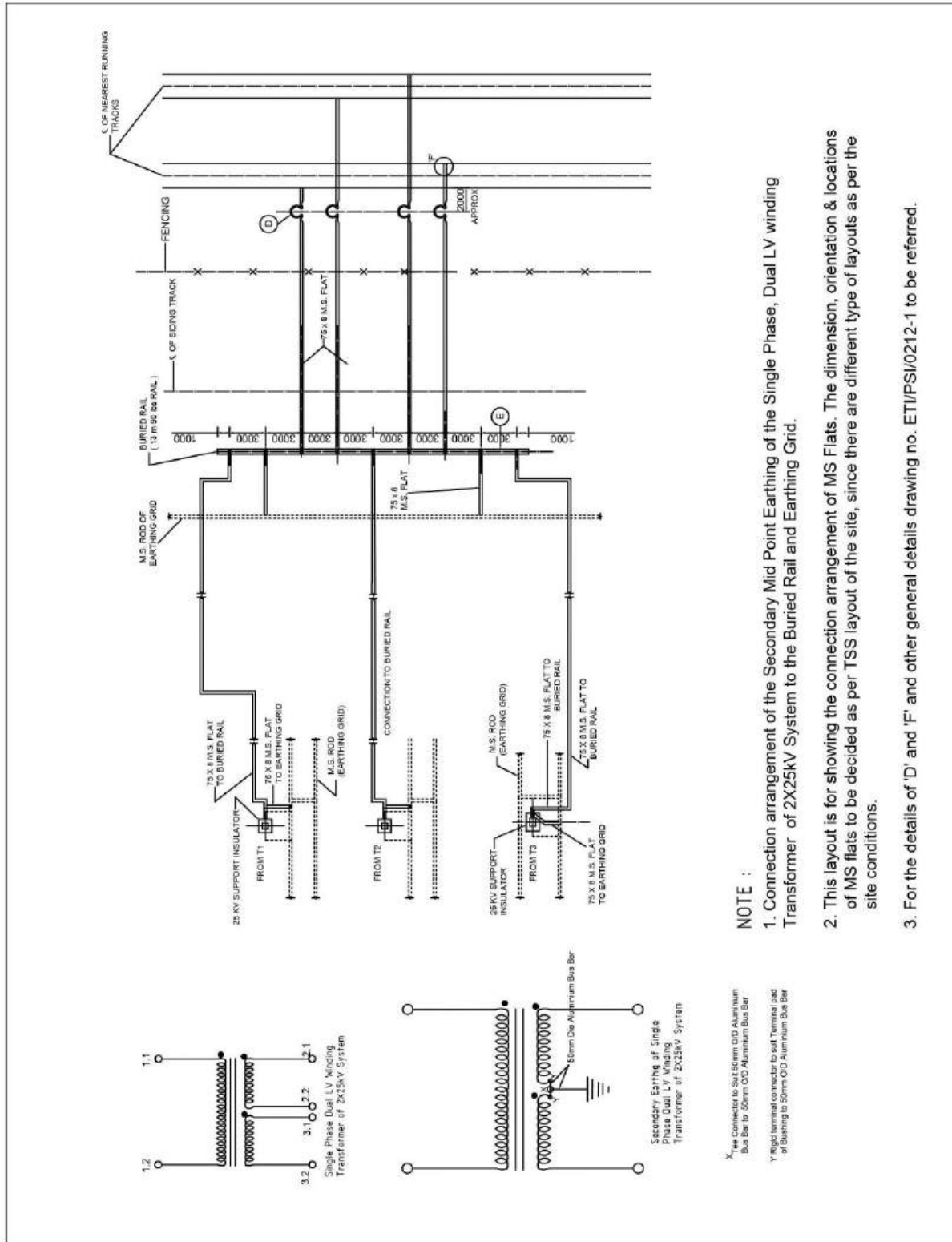
Typical arrangement of an earth electrode Drawing No. ETI/PSI/222-1



Typical arrangement of an earth electrode Drawing No. ETI/PSI/222-1

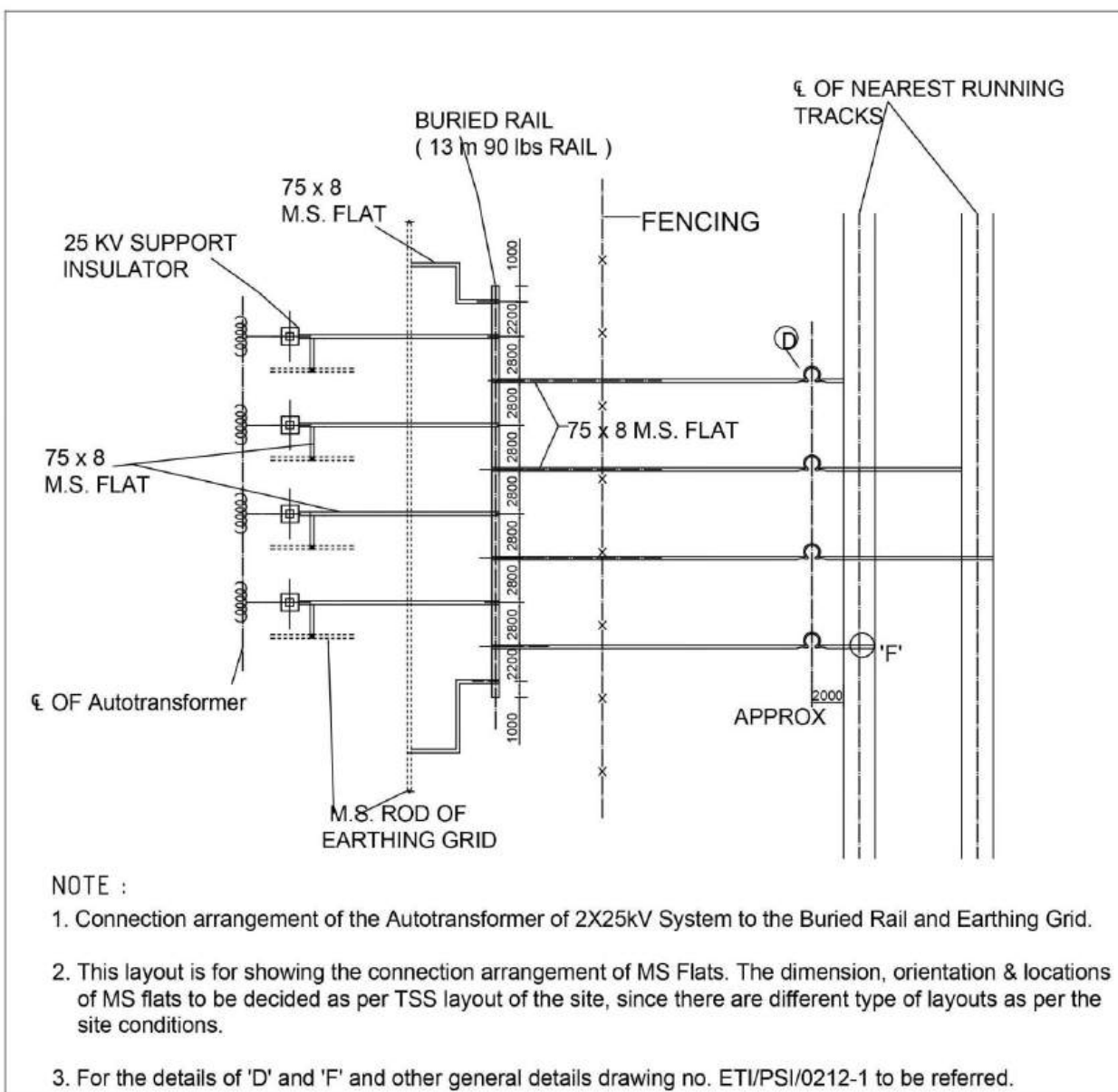
Typical Earthing arrangement of an Auxiliary Transformer station, Drawing No. ETI/PSI/708**Typical Earthing arrangement of an Auxiliary Transformer station, Drawing No. ETI/PSI/708**

Annexure-VIII

Connection arrangement to Buried Rail in TSS of V Connected Transformer

Annexure-IX

Connection arrangement to Buried Rail of Autotransformer at Scott Connected TSS and at SP/SSP of 2X25kV system



Annexure-X



Government of India,
Ministry of Railways
Research Designs & Standards Organisation,
Manak Nagar, Lucknow- 226 011

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42805(Off.)
Fax : 91-0522-2465763
E-mail: dti.rdso@gmail.com



पत्रांक: टीआई/पीएसआई/अर्थिंग/पॉलिसी/14

दिनांक: 26.02.2020

To,

The Principal Chief Electrical Engineer,

- (i) Central Railway, Station Building, Mumbai CST – 400 001.
- (ii) Eastern Railway, Fairlie Place, Kolkata-700 001.
- (iii) East Central Railway, Hajipur-844 101.
- (iv) East Coast Railway, Bhubaneswar-751 023.
- (v) Northern Railway, Baroda House, New Delhi - 110 001.
- (vi) North Central Railway, Allahabad-211 015.
- (vii) North Eastern Railway, Gorakhpur-273 012.
- (viii) North Frontier Railway, Mailgaon - 781 011.
- (ix) North Western Railway, Jaipur – 302 017.
- (x) Southern Railway, Park Town, Chennai- 600 003.
- (xi) South Central Railway, Railnilayam, Secunderabad-500 371.
- (xii) South Eastern Railway, Garden Reach, Kolkata-700 043.
- (xiii) South East Central, Railway, Bilaspur-495 004.
- (xiv) South West Railway, DRM's Office, Hubli-580 028.
- (xv) Western Railway, Churchgate, Mumbai-400 020.
- (xvi) West Central Railway, Jabalpur- 482 001.
- (xvii) Konkan Railway, Belapur Bhavan, Sector-11, CBD Belapur, Navi Mumbai 400614.
- (xviii) CAO, CORE Allahabad-211001.

विषय: विशेष रखरखाव निर्देश (SMI) सं. TI / SMI / 0032 Rev.02.

(Special Maintenance Instruction (SMI) no. TI/SMI/0032 Rev.02)

संदर्भ: (i) This office letter no. TI/PSI/EARTHING/POLICY/14 dated 26.11.2019.

(ii) Railway Board letter no. 2013/RE/161/122 dated 30.09.2019.

The draft the SMI No. TI/SMI/0032 Rev.02 was circulated to Zonal Railways vide this office letter referred (i) above. Based on the comments received, Special Maintenance Instruction (SMI) no. TI/SMI/0032 Rev.02 (Provision of Buried Rail at Switching Posts with Conventional Earthing System) has been finalised by this office and same is enclosed herewith for necessary action please.

This is issued with approval of the competent authority.

आशीष अंगवाल
26.02.2020
(डा. आशीष अंगवाल)
निदेशक टी आई - 3
क्रते महानिदेशक (टी आई)

संलग्नक: SMI No. TI/SMI/0032 Rev.02

प्रतिलिपि: ED/RE, Railway Board, Rail Bhavan, New Delhi – 110 001

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TI/SMI/0032 Rev.02	Effective from 19.02.2020.	Special Maintenance Instruction for Setting up Earthing station at switching Post	Page 1 of 5
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Government of India
Ministry of Railways

SPECIAL MAINTENANCE INSTRUCTION No.

TI/SMI/0032 Rev- 02

For

SETTING UP EARTHING STATION AT SWITCHING

POSTS (SSP & SP)

WITH CONVENTIONAL EARTHING SYSTEM

Issued By
Traction Installation Directorate
Research Designs & Standards Organisation
Lucknow – 226011.

February, 2020

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1.0 INTRODUCTION

- 1.1 This SMI supersedes the SMI No. TI/SMI/0032 Rev.01 issued by RDSO vide letter no. TI/PSI/Earthing/Policy/14 dated 01.04.2014.
- 1.2 With advances in track technology the Rail is no longer at ground potential which has been the assumption of existing Earthing Code ETI/PSI/120 & ETI/OHE/71. The structures have been conventionally bonded to the Rail with belief that the structure would be grounded through the Rail. Whereas, now Rail sees earth through the structures many-a-times with increasing rail-formation insulation.
- 1.3 The immediate concerns which arise are the rising of Rail potentials, affect on the efficacy of existing protection scheme and safety of Rail vehicles. Thus, it is decided to create Earthing stations at a place near the Switching Posts (SP/SSP). Idea is to create a positive, strong and deliberate earth connection to improve system resilience.
- 1.4 The SMI No. TI/SMI/0031 Rev.01 was discussed in the 30th MSG (TRD) held at Mount Abu on 13th & 14th April 2018 and 31st MSG (TRD) held at Somnath on 08th & 09th November 2019. The group deliberated for the revision of SMI.

2.0 REFERRED DOCUMENTS

SN	Document	Description	Number
1.	Specification	Code for Bonding and Earthing for 25 kV, a.c., 50 Hz Single Phase Traction System.	ETI/OHE/71
2.	Specification	Code of Practice for Earthing of Power Supply Installations for 25 kv, ac, 50Hz, Single Phase traction System.	ETI/PSI/120
3.	Specification	Specification for Exothermic Welding (Connection for Bonding, Earthing /Grounding)	TI/SPC/OHE/EXOTHR MBOND/0100 (04/10)
4.	Specification	Specification for Stainless Steel fasteners for 25kV AC Traction Overhead equipment	TI/SPC/OHE/FASTNE RS/0120 rev.01
5.	Drawing	Earthing Station	ETI/OHE/P/7020
6.	Drawing	Typical Earthing Layout at Feeding Station	ETI/PSI/203
7.	Drawing	Typical return Current connection to Buried Rail at 132/25 kV Traction Sub Station	ETI/PSI/0212-1
8.	Drawing	Return Current Connection to the Sub Sectioning and Paralleling Post.	ETI/PSI/0201-1
9.	Drawing	Return Current Connection to the Sectioning and Paralleling Post.	ETI/PSI/0202-1

- 3.0 It may be noted that in conventional electrification which uses a running Rail for return circuit, one end of Transformer's secondary is connected to this Earthing system, thereby making full traction current flow through this system. It may be further noted that full load current would not necessarily take: Running Rail>Buried Rail>Transformer. Some current can as well get to the transformer from Earth Electrode>Earth Grid>Transformer.

4.0 Existing Arrangement for Earthing the Tracks

There are no direct earth connections except at the Feeding posts. The design philosophy assumes that the Rails are naturally at ground potential and the structures get earthed by connection to the Rails.

Present connection at Feeding Post has been described in RDSO Drawing No. ETI/PSI/203. The following are main components of the present Feeding Post Earthing Station:-

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- 4.1 BURIED RAIL: Acts as maintenance free Earth Bus.
- 4.2 EARTHGRID: Connects various ground Electrodes and reduces the possibility of higher Step Potential.
- 4.3 EARTH ELECTRODES: Couples the Buried Rail to parent earth and hence bringing down the Earth potential.

5.0 DESIGN OF THE EARTHING STATION

Two Earthing Stations near the Switching Station, one on either side of the UP and DN track, shall be provided. For multi track system [i.e. Block Sections having more than two tracks (UP & DN track)], separate Earthing Station for each track shall be provided.

5.1 GENERAL ARRANGEMENT

Preferably Rail or TRD mast (all type) of length more than 9 m shall be used to create an Earth station. The released Rails/TRD Masts should always be preferred. Two Earth Electrodes shall be provided at each end of the Buried Rail as per RDSO Drawing No. ETI/OHE/P/7020. Thus the Buried Rail would be configured as Earth Bus.

5.2 DESIGN

A trench, of size about 0.6 m x 'X' m, with a depth of about 1 m from the ground level shall be dug on the track side. ('X' should be more than 2 m of the length of the Rail/TRD mast used)

- 5.2.1 At a distance of about $1.5\text{m} \pm 0.5\text{m}$, from either ends of the Buried Rail, two 19 mm Φ holes are drilled for connection to earth pits. 02 more holes at $1.5\text{m} \pm 0.5\text{m}$ from the above holes to be drilled for connection to track.
- 5.2.2 Two electrodes shall be provided as per RDSO Drawing No. ETI/OHE/P/7020 at a distance of $1.5\text{m} \pm 1.0\text{m}$ on both ends. Earthing shall be provided as described in RDSO Drawing No. ETI/PSI/0212-1 and mentioned at page no. 4 & 5 of this SMI. GI flats are preferably to be used for earthing, in view of longer life, but in case of non-availability of GI Flats, standard MS Flats can be used after painting them with two coats of Aluminium paint. Subsequently the word GI Flat will mean both the above methods.

5.2.3 Preparation of Earth Bus (Buried Rail)

- 5.2.3.1 The Rail (this nomenclature includes masts as mentioned in Para 5.1), duly prepared, shall be lowered in to the trench.
- 5.2.3.2 The connection between the Buried Rail and Earth Electrodes of respective Earth Pits on both sides shall be done through 75 x 8 mm GI Flats, by using 20 mm Φ Stainless Steel bolts as mentioned at page no. 4&5 of this SMI.

5.2.4 Preparation of Running Rail

Holes are drilled on the web of running Rail and connection to be made as mentioned on page no. 4&5 of this SMI.

5.2.5 Connection between the Running Rail and Buried Rail

Connections between the Running Rail and the Buried Rail are made with two GI Flats of size 75 x 8 mm, connected with Buried Rail with 20 mm Stainless steel bolts, as per RDSO Drawing No. ETI/PSI/0212-1 and to the Running Rail with M-12 Bolt, as mentioned at page no. 4&5 of this SMI.

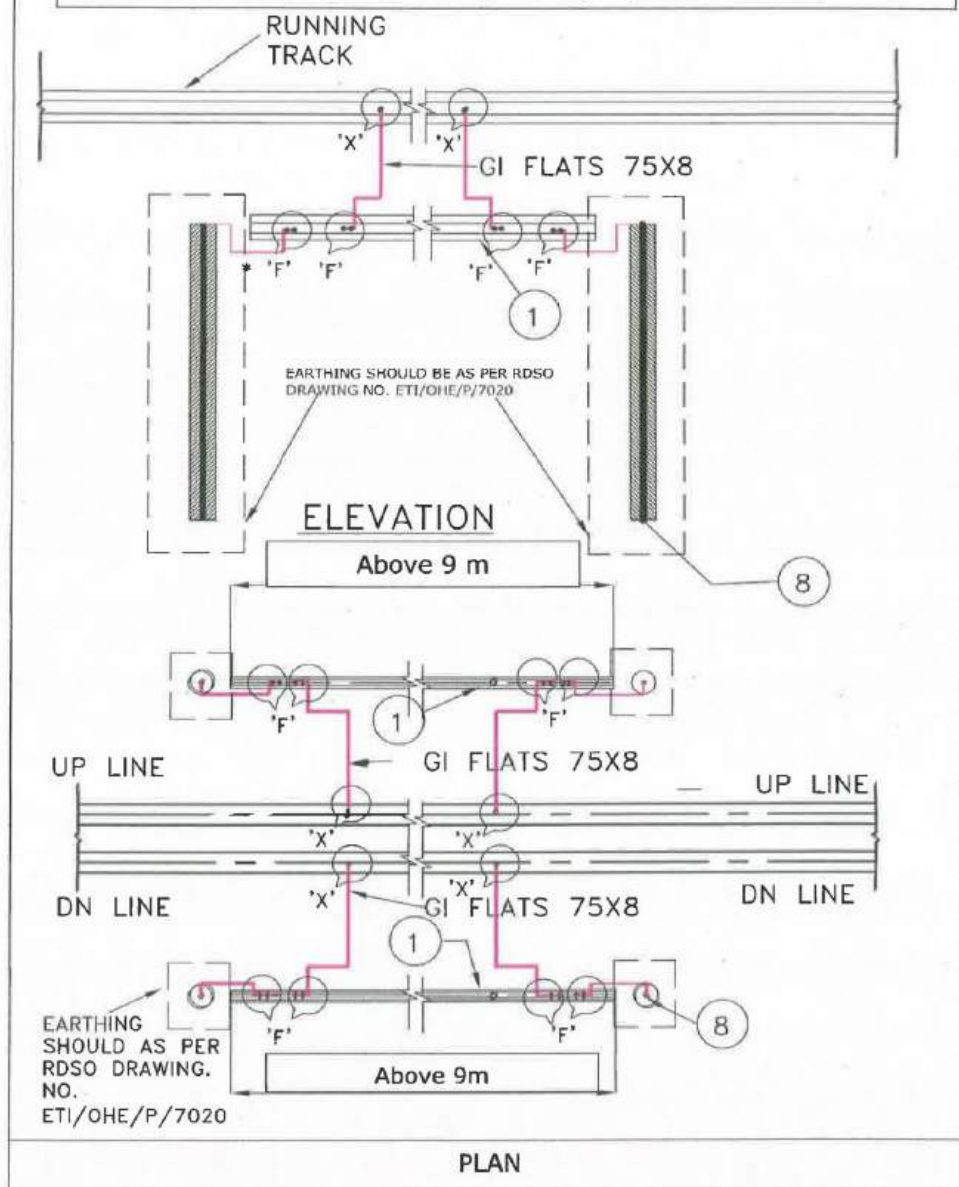
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Earthing station at switching Post

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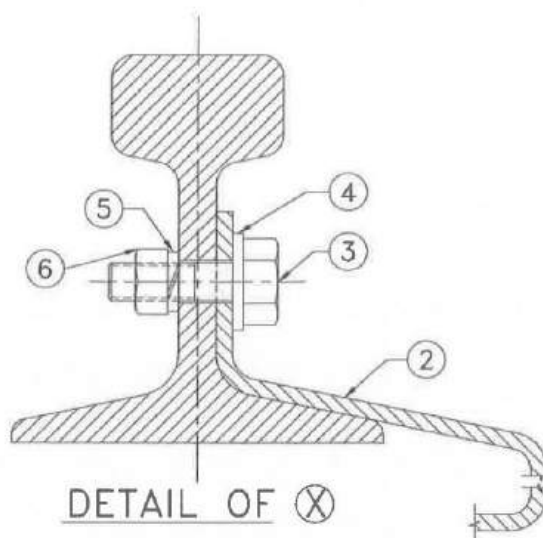
6.0 Connection arrangement of the Running Rail – Buried Rail – Earth Electrodes

- * For detail of 'X' refer page no. 05 of this SMI.
- * For detail of 'F' refer RDSO Drawing no. ETI/PSI/0212-1



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7.0 The Earth electrode shall be made as per Drawing No. ETI/OHE/P/7020.

8.0 For Buried Rail Drawing No. ETI/PSI/0212-1 to be referred.

9.0 Schedule of materials:

Ref:	Description	Quantity
1.	Above 9 m long rails or TRD masts.	02 Nos.
2.	Galvanised Iron Flats of 75mm X8 mm	as required
3.	M-12 Bolts (Stainless steel)	04 Nos
4.	Plain washer	04 Nos
5.	Lock washer (Spring steel)	04 Nos
6.	Nuts	04 Nos
7.	M-20 Bolts (Stainless steel) (for connection of GI flat to buried rail)	16 Nos
8.	Earth electrode as per RDSO Drawing no. ETI/OHE/P/7020	04 Nos

Sample Calculation for the Design of Earthing Mat for a TSS

(Note: This calculations is for example with assumed values, actual site values are to be taken for the actual calculations)

Data assumed for calculations:

a.	Resistivity of earth (Soil) in (ρ)	40 Ω -m
b.	Incoming Voltage	132kV
c.	Fault Level at incoming side (i.e. 132kV side)	7000 MVA
d.	Fault Current on primary side, I_g	$(7000)/(\sqrt{3} \times 132) = 30618A$
e.	Grid Dimensions	100m X 50m, Area = 5000m ²
f.	Resistivity of surface material (crushed rock), ρ_s	3000 Ω -m
g.	Thickness of the crushed rock surface layer, h_s	0.1 m
h.	Depth of Earth mat, h	0.6 m
i.	Reference depth of grid, h_o	1.0m

Standard Values to be taken:

a.	Duration of Fault current, t	<ul style="list-style-type: none"> To be taken as 01 second for the calculation of grid conductor size on the basis of HV side fault current. To be taken as 03 second for the calculation of grid conductor size on the basis of LV side fault current.
		0.5 second for determining the Tolerable touch and step potential
b.	Resistance of the Main Earthing Mat	0.5 Ω (maximum) for TSS

Step 1: Diameter of the grid MS rod size calculation (d):

(i) On the basis of HV side fault current i.e. 30618A for 01 second,

$$A = \frac{I\sqrt{t}}{80} = (30618 \times \sqrt{1}) / 80 = 382.724 \text{ mm}^2$$

By taking 100% margin factor due to corrosion, required area = 2 x 382.724 = 765.44 mm²
So, required conductor dia= $\sqrt{(765.44/3.14) \times 2} = 31.22\text{mm}$

(ii) On the basis of LV side fault current i.e. 6kA for 3 seconds,

$$A = \frac{I\sqrt{t}}{80} = (6000 \times \sqrt{3}) / 80 = 129.9 \text{ mm}^2$$

By taking 100% margin factor due to corrosion, required area = 2 x 129.9 = 259.8 mm²
So, required conductor dia= $\sqrt{(259.8/3.14) \times 2} = 18.19\text{mm}$

Higher between (i) & (ii) above is 31.22 mm. Now, considering the Para 7.1.2 of the specification, 32mm Diameter grid conductor is to be used.

Step 2: Tolerable Step & Touch Potential

$$E_{touch} = (1000 + 1.5C_s\rho_s) \frac{0.116}{\sqrt{t_s}}$$

$$\text{Where, } C_s = \frac{0.09 \times \left(1 - \frac{\rho}{\rho_s}\right)}{1 - \frac{0.09}{2 \times h_s + 0.09}} = 0.694$$

$$E_{touch} = \{(1000 + 1.5 \times 0.694 \times 3000)\} \times \{(0.116) / (\sqrt{0.5})\}$$

$$= 676.220V$$

$$E_{step} = (1000 + 6C_s\rho_s) \frac{0.116}{\sqrt{t_s}}$$

$$E_{step} = \{(1000 + 6 \times 0.694 \times 3000)\} \times \{(0.116) / (\sqrt{0.5})\}$$

$$= 2212.735V$$

Step 3: Design of Grid

Grid layout = 100m X 50m

Assumed spacing between earth grid conductors (D) = 5m

So, No. of Vertical rods in earth mat $N_x = (100/5) =$ taken as 20 and No. of Horizontal rods in earth mat $N_y = (50/5) =$ Taken as 10

Total length of earthing system conductor (L)

= $L_c + 1.15 L_r$ for grids with earth electrodes along the perimeter

$$L_c = 100 \times 10 + 50 \times 20 = 2000m$$

Assuming no. of earth electrodes = 70

So, $L_r = 4 \times 70 = 280m$ (4m length of earth electrode)

Total length of Earth conductor = $2000 + 1.15 \times 280 = 2320m$

Step 4: Grid resistance:

$$R_g = 0.443 \frac{\rho}{\sqrt{A}} + \frac{\rho}{L}$$

$$R_g = \{0.443 \times (40/\sqrt{5000})\} + (40/2320)$$

$$= 0.268 \Omega$$

Step 5: Maximum Grid Current (I_G)

$$I_G = C_p \times D_f \times I_g$$

$$= 1 \times 1 \times 30618 = 30618A$$

Step 6: Earth Potential rise

$$= R_g \times I_G$$

$$= 0.268 \times 30618 = 8200V$$

Step 7: Estimated mesh and step voltage

Estimated mesh voltage

$$E_{\text{mesh}} = \frac{\rho \cdot K_m \cdot K_i \cdot I_G}{L}$$

$$K_i = 0.644 + (0.148 \times n)$$

$$n = n_a \times n_b \times n_c \times n_d$$

$$= 13.33 \times 1.02 \times 1 \times 1 = 13.73$$

$$K_i = 0.644 + (0.148 \times 13.73)$$

$$K_i = 2.676$$

$$K_m = \frac{1}{2\pi} \left[\ln \left(\frac{D^2}{16hd} + \frac{(D+2h)^2}{8Dd} - \frac{h}{4d} \right) + \frac{K_{ii}}{Kh} \ln \frac{8}{\pi(2n-1)} \right]$$

$$Kh = \sqrt{1 + \frac{h}{ho}} = 1.2649, K_{ii} = 1, n = 13.73, D = 5m, d = .032m, h = 0.6m$$

$$\text{Thus, } K_m = 0.409607$$

$$\text{Now, } E_{\text{mesh}} = (40 \times 0.409607 \times 2.676 \times 30618) / (2320)$$

$$= 578 \text{ V (Which is less than 676.22 V, tolerable mesh voltage)}$$

Estimated step voltage

$$E_{\text{step}} = \frac{\rho \cdot K_s \cdot K_i \cdot I_G}{L} \text{ V}$$

$$K_s = \frac{1}{\pi} \left[\frac{1}{2h} + \frac{1}{D+h} + \frac{1}{D} (1 - 0.5^{n-2}) \right] = 0.385938$$

$$E_{\text{step}} = (40 \times 0.3859 \times 2.676 \times 30618) / (2320)$$

$$= 545V \text{ (Which is less than 2212.735 V, tolerable step voltage)}$$

Estimated Touch Voltage is less than Tolerable Touch Voltage and Estimated Step Potential is less than Tolerable Step Potential, Thus design is safe.

Annexure-XII

Sample Calculation for the Design of Earthing Mat for TSS, SP & SSP of 2X25kV System

(Note: This calculations is for example with assumed values, actual site values are to be taken for the actual calculations)

Data assumed for calculations for TSS:

a.	Resistivity of earth (Soil) in (ρ)	40 Ω -m
b.	Incoming Voltage	132kV
c.	Fault Level at incoming side (i.e. 132kV side)	7000 MVA
d.	Fault Current on primary side, I_g	$(7000)/(\sqrt{3} \times 132) = 30618A$
e.	Grid Dimensions	100m X 50m, Area = 5000m ²
f.	Resistivity of surface material (crushed rock), ρ_s	3000 Ω -m
g.	Thickness of the crushed rock surface layer, h_s	0.1 m
h.	Depth of Earth mat, h	0.6 m
i.	Reference depth of grid, h_o	1.0m

Data assumed for calculations for SP & SSP:

a.	Resistivity of earth (Soil) in (ρ)	40 Ω -m
b.	Fault Current to be taken	12000A
c.	Grid Dimensions	50m X 30m, Area = 1500m ²
d.	Resistivity of surface material (crushed rock), ρ_s	3000 Ω -m
e.	Thickness of the crushed rock surface layer, h_s	0.1 m
f.	Depth of Earth mat, h	0.6 m
g.	Reference depth of grid, h_o	1.0m

Standard Values to be taken:

a.	Duration of Fault current, t	<ul style="list-style-type: none"> To be taken as 01 second for the calculation of grid conductor size on the basis of HV side fault current. To be taken as 03 second for the calculation of grid conductor size on the basis of LV side fault current.
		0.5 second for determining the Tolerable touch and step potential
b.	Resistance of the Main Earthing Mat	0.5 Ω (maximum) for TSS 2.0 Ω (maximum) for SP & SSP

Step 1 : Diameter of the grid MS rod size calculation (d):

- (i) On the basis of HV side fault current i.e. 30618A for 01 second, (by assuming Fault MVA 7000MVA at primary side)

$$A = \frac{I\sqrt{t}}{80} = (30618 \times \sqrt{1}) / 80 = 382.72 \text{ mm}^2$$

By taking 100% margin factor due to corrosion, required area = 2 x 382.72 = 765.44 mm²
So, required conductor dia= $\sqrt{(765.44/3.14) \times 2} = 31.22\text{mm}$

- (ii) On the basis of LV side fault current i.e. 12kA for 3 seconds,

Diameter of the grid MS rod size calculation (d):

$$A = \frac{I\sqrt{t}}{80} = (12000 \times \sqrt{3})/80 = 259.8 \text{ mm}^2$$

By taking 100% margin factor due to corrosion, required area = 2 x 259.8 = 519.6 mm²

So, required conductor Dia= $\sqrt{(903.68/3.14) \times 2} = 25.73\text{mm}$

Higher between (i) & (ii) above is 31.22 mm. Now, considering the Para 7.1.2 of the specification, 32mm Diameter grid conductor is to be used at the TSS. Considering the uniformity in the size of the buried grid conductor, at the SP & SSP of 2X25kV system also 32mm Diameter grid conductor is to be used.

A Sample calculation for the TSS is already given at Annexure-XII. Therefore, for the SP & SSP the calculation is mentioned below:

Sample calculation for SP & SSP of 2X25kV is given as below:

Step 2: Tolerable Step & Touch Potential

$$E_{touch} = (1000 + 1.5C_s \rho_s) \frac{0.116}{\sqrt{t_s}}$$

$$\text{Where, } C_s = 1 - \frac{0.09 \times \left(1 - \frac{\rho}{\rho_s}\right)}{2 \times h_s + 0.09} = 0.694$$

$$E_{touch} = \{(1000 + 1.5 \times 0.694 \times 3000)\} \times \{(0.116) / (\sqrt{0.5})\}$$

$$= 676.220\text{V}$$

$$E_{step} = (1000 + 6C_s \rho_s) \frac{0.116}{\sqrt{t_s}}$$

$$E_{step} = \{(1000 + 6 \times 0.694 \times 3000)\} \times \{(0.116) / (\sqrt{0.5})\}$$

$$= 2212.735\text{V}$$

Step 3: Design of Earthing Grid

Grid layout = 50m X 30m

Assumed spacing between earth grid conductors (D) = 5m

So, No. of Vertical rods in earth mat $N_x = (50/5) = 10$ and No. of Horizontal rods in earth mat $N_y = (30/5) = 6$

Total length of earthing system conductor (L)

= $L_c + 1.15 L_r$ for grids with earth electrodes along the perimeter

Now, $L_c = 50 \times 6 + 30 \times 10 = 600\text{m}$

Assuming no. of earth electrodes = 10

So, $L_r = 4 \times 10 = 40\text{m}$ (4m length of earth electrode)

Total length of Earth conductor = $600 + 1.15 \times 40 = 646\text{m}$

Step 4: Grid resistance

$$R_g = 0.443 \frac{\rho}{\sqrt{A}} + \frac{\rho}{L}$$

$$R_g = \{0.443 \times (40/\sqrt{1500})\} + (40/637)$$

$$= 0.52\Omega$$

Step 5: Maximum Grid Current (I_G)

$$I_G = C_p \times D_f \times I_g$$

$$= 1 \times 1 \times 12000 = 12000\text{A}$$

Step 6: Earth Potential rise

$$= R_g \times I_G$$

$$= 0.52 \times 12000 = 6240 \text{ V}$$

Step 7: Estimated mesh and step voltage

Estimated mesh voltage

$$E_{\text{mesh}} = \frac{\rho \cdot K_m \cdot K_i \cdot I_G}{L}$$

$$K_i = 0.644 + (0.148 \times n)$$

$$n = n_a \times n_b \times n_c \times n_d$$

$$= 7.5 \times 1.01 \times 1 \times 1 = 7.6$$

$$K_i = 0.644 + (0.148 \times 7.6) = 1.77$$

$$K_m = \frac{1}{2\pi} \left[\ln \left(\frac{D^2}{16hd} + \frac{(D+2h)^2}{8Dd} - \frac{h}{4d} \right) + \frac{K_{ii}}{Kh} \ln \frac{8}{\pi(2n-1)} \right]$$

$$K_h = \sqrt{1 + \frac{h}{D}} = 1.2649, \quad K_{ii} = 1, \quad n = 7.6, \quad D = 5\text{m}, \quad d = .032\text{m}, \quad h = 0.6\text{m}$$

Thus, $K_m = 0.49$

$$\text{Now, } E_{\text{mesh}} = (40 \times 0.49 \times 1.77 \times 12000)/(646)$$

$$= 644\text{V (Which is less than 676.22 V, tolerable mesh voltage)}$$

Estimated step voltage

$$E_{\text{step}} = \frac{\rho \cdot K_s \cdot K_i \cdot I_G}{L} \text{ V}$$

$$K_s = \frac{1}{\pi} \left[\frac{1}{2h} + \frac{1}{D+h} + \frac{1}{D} (1 - 0.5^{n-2}) \right] = 0.38$$

$$\text{Now } E_{\text{step}} = (40 \times 0.38 \times 1.77 \times 12000) / (646)$$

$$= 500\text{V (Which is less than 2212.735 V, tolerable step voltage)}$$

Estimated Touch Voltage is less than Tolerable Touch Voltage and Estimated Step Potential is less than Tolerable Step Potential, Thus design is safe.

INDUSTRY PVT LTD.-VADODARA
(ID- 35315)

E-76, GIDC Manjusar, Taluka Savli
Vadodara,Gujarat - 391770, India
Current status since - 13/02/2020

Regd Add. : E-76, GIDC Industrial
Area, Manjusar Vadodara,Gujarat -
390001, India

M/s JAINCO TRANSMISSION
LIMITED-KOLKATA
(ID- 1028544)

JAINCO
Jalan Complex, Gate No-1,
LaneNo.-7, Jangalpur, Bombay
Road(NH-6) Howrah,West Bengal -
711411, India

Regd Add. : Dhanshree Tower, 70,
Diamond Harbour Road, Room No.
3B & 3C, 3rd Floor Kolkata,West
Bengal - 700023, India

Current status since - 21/01/2022

M/s JHR Overseas
(ID- 1051914)

JHR
Back Side New Era Machines, New
Model Town, Sahnewal
Ludhiana,Punjab - 141120, India

Regd Add. : Back Side New Era
Machines, New Model Town,
Sahnewal Ludhiana,Punjab -
141120, India

Current status since - before
01/01/2020

M/s MOSDORFER INDIA PVT. LTD.-
MUMBAI
(ID- 125222)

MIPL
Plot No. 196/1 and 2 Village -
Gonde Dhumla MIDC Gonde, Taluka
- Igatpuri Nashik,Maharashtra -
422403, India

Regd Add. : 403C, Wing B1,
Marathon Innova, Opp. Peninsula
Corporate Park, Lower Parel,
Mumbai Mumbai,Maharashtra -
400013, India

Current status since - before
01/01/2020

M/s NSS STORES SUPPLY AGENCY
PRIVATE LIMITED-HOWRAH
(ID- 35966)

NSSA
P-280, Banaras Road, Belgachia,
P.O. Netajigarh Howrah,West
Bengal - 711108, India

Regd Add. : P-280, Banaras Road,
Belgachia,PO-Netajigarh undefined
Howrah,West Bengal - 711108, India

Current status since - before
01/01/2020

M/s SHRI ASHUTOSH
ENGINEERING INDUSTRIES UNIT II-
RAIPUR
(ID- 97354)

SAEI/II
(Unit-II), Plot No. 156/1, 157/1, 160
& 161, New Patharidih, Urla
Raipur,Chhattisgarh - 492001, India

Regd Add. : Plot No. 156/1,
157/1,160 and 161, PH- 101, New
Patharidih, Urla, Raipur
Raipur,Chhattisgarh - 492001, India

Current status since - before
01/01/2020

Sub Item ID: 4200025048, Earth Electrode (7021)
Spec: 11 SPC OHF Fittings 0130 with A.C Slip No. I, FTE-OHF-13 (4-84)
may 2018/ Drw: ETE OHF P 7021, STR: CORE STR-20, (Total Vendor
Count: 16) Lokesh

Approved Vendor: (Vendor Count: 16)

M/s AUMNI TRANSMISSION
INDUSTRY PVT LTD.-VADODARA
(ID- 35315)

AUMNI
E-76, GIDC Manjusar, Taluka Savli
Vadodara,Gujarat - 391770, India
Current status since - 13/02/2020

Regd Add. : E-76, GIDC Industrial

For buildings,
machines, C.I.S panels,
H.Mant, Poles, water
cookers, Lift, Relaxation
Control Panels, (1)
Di Sets and other L.T.
equipment & earthings.

Area, Manjusar Vadodara,Gujarat -
390001, India

2 M/s CHATTERJEE ENGINEERING CEC
CO-KOLKATA
(ID- 17708) 3/1, Chanditolla Branch Road
Kolkata West Bengal - 700053, India

Regd Add. : 216 A J C ROSE ROAD Current status since - before
FLAT 2A KOLKATA,West Bengal - 01/01/2020
700017, India

3 M/s Chatterjee & Co. (Construction) CCC
Pvt Ltd 142/143/2, Madhusudan Paul
(ID- 1051029) Chowdhury Lane Howrah West
Bengal - 711101, India

Regd Add. : 216, A.J.C. Bose Road, Current status since - before
Flat-2A Kolkata,West Bengal - 01/01/2020
700017, India

4 M/s DYNAMIC STEEL FORGE DSE
RAJKOT Plot No. G-2521, Near Bhumi
(ID- 91949) Cement Almighty Gate GIDC
Metoda Taluka-Lodhika, Rajkot
Rajkot,Gujarat - 360021, India

Regd Add. : PLOT NO.G-2521, Current status since - 26/11/2020
ALMIGHTY GATE NEAR BHUMI
CEMENT GIDC METODA RAJKOT
RAJKOT,Gujarat - 360021, India

5 M/s JAINCO TRANSMISSION JAINCO
LIMITED-KOLKATA Jalan Complex, Gate No.-1,
(ID- 1028544) LaneNo.-7, Jangalpur, Bombay
Road(NH-6) Howrah,West Bengal -
711411, India

Regd Add. : Dhanshree Tower, 70, Current status since - before
Diamond Harbour Road, Room No. 01/01/2020
3B & 3C, 3rd Floor Kolkata,West
Bengal - 700023, India

6 M/s JHR Overseas JHR/IL
(ID- 1051914) Village- Chhandra, chd Road
Ludhiana,Punjab - 141113, India

Regd Add. : Back Side New Era Current status since - before
Machines, New Model Town, 01/01/2020
Sahnewal Ludhiana,Punjab -

141120, India
JHR
Back Side New Era Machines, New
Model Town, Sahnewal
Ludhiana,Punjab - 141120, India
Current status since - before
01/01/2020

7 M/s KHATRI CASTINGS PRIVATE KHATRI
LIMITED-MUMBAI At Valvada, Near Karambele Railway
(ID- 3601) Station, NH-8, Taluka-Umargaon,
Opp. Maruti Depot Valsad,Gujarat -
396001, India

Regd Add. : 144 Naman Plaza Current status since - before
Shoppers Stop Bldg S V Road 01/01/2020
Kandivali (West), Mumbai
MUMBAI,Maharashtra - 400067,
India

8 M/s KSE ELECTRICALS PVT LTD KSE
KOLKATA Jalan Industrial Complex 3rd Main
(ID- 6285) Road, 4th Left Lane, NH-6, P.O.-
Begri Howrah,West Bengal -
711411, India

Regd Add. : Chatterjee Internation

Centre, 33A, Chowringhee Road, 7th Floor Kolkata, West Bengal - 700071, India

Current status since - before 01/01/2020

M/s KUMAR FASTENERS-
MATHURA
(ID- 3905)

KF Mathura

S-15, Building Material Complex Site-A, Industrial Area Mathura, Uttar Pradesh - 281004, India

Regd Add. : S-15, Building Material Complex, Industrial Area, Site-A, Mathura, Uttar Pradesh - 281004, India

Current status since - before 01/01/2020

M/s MOSDORFER INDIA PVT. LTD.-
MUMBAI
(ID- 125222)

MIPL

Plot No. 196/1 and 2 Village - Gonde Dhumla MIDC Gonde, Taluka - Igatpuri Nashik, Maharashtra - 422403, India

Regd Add. : 403C, Wing B1, Marathon Innova, Opp. Peninsula Corporate Park, Lower Parel, Mumbai Mumbai, Maharashtra - 400013, India

Current status since - before 01/01/2020

M/s NIKE ENERGY
MANUFACTURING PRIVATE
LIMITED-VARANASI
(ID- 23941)

NIKE

Plot No. 279/2 Ganeshpur Tarna Varanasi, Uttar Pradesh - 221003, India

Regd Add. : 279/2 GANESHPUR, TARNA SHIVPUR VARANASI, Uttar Pradesh - 221003, India

Current status since - 18/11/2021

M/s NSS STORES SUPPLY AGENCY
PRIVATE LIMITED-HOWRAH
(ID- 35966)

NSSA

P-280, Banaras Road, Belgachia, P.O. Netajigarh Howrah, West Bengal - 711108, India

Regd Add. : P-280, Banaras Road, Belgachia, PO-Netajigarh undefined Howrah, West Bengal - 711108, India

Current status since - before 01/01/2020

M/s ROYAL BALAJI ENGINEERING
PVT LTD-KOLKATA
(ID- 23501)

Royal

NH-6, Bombay Road, Dhulagari, Sankrail Howrah, West Bengal - 711302, India

Regd Add. : 153/2B, Sumukh Apartment, APC Road KOLKATA, West Bengal - 700006, India

Current status since - before 01/01/2020

M/s SHRI ASHUTOSH
ENGINEERING INDUSTRIES UNIT II-
RAIPUR
(ID- 97354)

SAEI/II

(Unit-II), Plot No. 156/1, 157/1, 160 & 161, New Patharidih, Urla Raipur, Chhattisgarh - 492001, India

Regd Add. : Plot No. 156/1, 157/1, 160 and 161, PH- 101, New Patharidih, Urla, Raipur Raipur, Chhattisgarh - 492001, India

Current status since - before 01/01/2020

M/s TAG CORPORATION-CHENNAI
(ID- 1033964)

TAG

Shed No. 4 & 5, SIDCO Industrial Estate, Thirumudivakkam Chennai, Tamil Nadu - 600044, India

Regd Add. : No: 91, Thiruneermalai



Road, Chromepet undefined
Chennai,Tamil Nadu - 600044, India **Current status since** - 01/02/2022

M/s TRANSMISSION LINE **TLP-H**
PRODUCTS-KOLKATA
(ID- 5692) NH-6, Sankrail Industrial Park P.O.
Dhulagarh, PS- Sankrail
Howrah,West Bengal - 711302, India

Regd Add. : 102 Central Plaza 2/6
Sarat Bose Road Kolkata,West Bengal - 700020, India **Current status since** - 23/09/2020

Sub Item ID: 4200025049, **Earth Electrode**
Spec: TI,SPC_OHE_Fittings_0130_with A_C_Slip_No_1, ETI-OHE-13 (4-84)
may 2018, **Drw:** ETI PSI 222, **STR:** CORE-STR-20, (Total Vendor Count:
8)

Approved Vendors (Vendor Count: 8)

M/s AUMNI TRANSMISSION **AUMNI**
INDUSTRY PVT. LTD.-VADODARA E-76, GIDC Manjusar, Taluka Savli
(ID- 35315) Vadodara,Gujarat - 391770, India
Current status since - 18/11/2021

Regd Add. : E-76, GIDC Industrial
Area, Manjusar Vadodara,Gujarat -
390001, India

M/s Chatterjee& Co, (Construction) **CCC**
Pvt. Ltd. 142/143/2, Madhusudan Paul
(ID- 1051029) Chowdhury Lane Howrah,West
Bengal - 711101, India

Regd Add. : 216, A.J.C. Bose Road,
Flat-2A Kolkata,West Bengal - **Current status since** - before
700017, India 01/01/2020

M/s JAINCO TRANSMISSION **JAINCO**
LIMITED-KOLKATA Jalan Complex, Gate No.-1,
(ID- 1028544) LaneNo.-7, Jangalpur, Bombay
Road(NH-6) Howrah,West Bengal -
711411, India

Regd Add. : Dhanshree Tower, 70,
Diamond Harbour Road, Room No.
3B & 3C, 3rd Floor Kolkata,West Bengal - 700023, India **Current status since** - before
01/01/2020

M/s KUMAR FASTENERS- **KF Mathura**
MATHURA S-15, Building Material Complex
(ID- 3905) Site-A, Industrial Area
Mathura,Uttar Pradesh - 281004,
India

Regd Add. : S-15, Building
Material Complex, Industrial Area, **Current status since** - before
Site-A, Mathura,Uttar Pradesh - 01/01/2020
281004, India

M/s NSS STORES SUPPLY AGENCY **NSSA**
PRIVATE LIMITED-HOWRAH P-280, Banaras Road, Belgachia,
(ID- 35966) P.O. Netajigarh Howrah,West
Bengal - 711108, India

Regd Add. : P-280, Banaras Road,
Belgachia,PO-Netajigarh undefined **Current status since** - before
Howrah,West Bengal - 711108, India 01/01/2020

M/s ROYAL BALAJI ENGINEERING **Royal**
PVT LTD-KOLKATA NH-6, Bombay Road, Dhulagari,
(ID- 23501) Sankrail Howrah,West Bengal -
711302, India

for F.S.S.
Substation
0.250 kVA &
subap

5

Regd Add. : 153/2B, Sumukh Apartment, APC Road KOLKATA, West Bengal - 700006, India **Current status since** - before 01/01/2020

M/s SHRI ASHUTOSH ENGINEERING INDUSTRIES UNIT II- RAIPUR (ID- 97354) **SAEI/II** (Unit-II), Plot No. 156/1, 157/1, 160 & 161, New Patharidih, Urla Raipur, Chhattisgarh - 492001, India

Regd Add. : Plot No. 156/1, 157/1, 160 and 161, PH- 101, New Patharidih, Urla, Raipur Raipur, Chhattisgarh - 492001, India **Current status since** - before 01/01/2020

M/s TRANSMISSION LINE PRODUCTS-KOLKATA (ID- 5692) **TLP-H** NH-6, Sankrail Industrial Park P.O. Dhulagarh, PS- Sankrail Howrah, West Bengal - 711302, India

Regd Add. : 102 Central Plaza 2/6 Sarat Bose Road Kolkata, West Bengal - 700020, India **Current status since** - 23/09/2020

Sub Item ID: 4200025051, Strain Clamp suitable for ACSR Zebra Conductor (with Minimum Ultimate Tensile Strength of 7000 kg and Slip strength of 4000 kg) **Spec:** TI_SPC_OHE_Fittings_0130_with A_C_Slip_No_1, ETI-OHE-13 (4-84) may 2018, **STR:** CORE-STR-20., (Total Vendor Count: 1)

Approved Vendors (Vendor Count: 1)

M/s TRANSMISSION LINE PRODUCTS-KOLKATA (ID- 5692) **TLP-H** NH-6, Sankrail Industrial Park P.O. Dhulagarh, PS- Sankrail Howrah, West Bengal - 711302, India

Regd Add. : 102 Central Plaza 2/6 Sarat Bose Road Kolkata, West Bengal - 700020, India **Current status since** - 23/09/2020

Sub Item ID: 4200025052, Arcing Rings **Spec:** TI_SPC_OHE_Fittings_0130_with A_C_Slip_No_1, ETI-OHE-13 (4-84) may 2018, **STR:** CORE-STR-20., (Total Vendor Count: 1)

Approved Vendors (Vendor Count: 1)

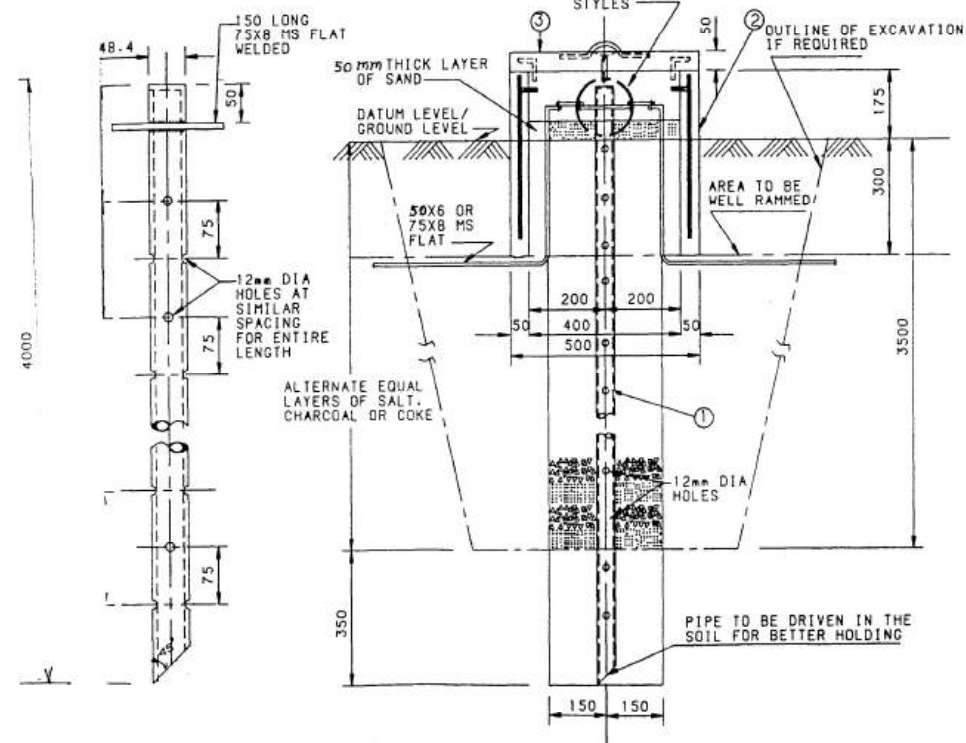
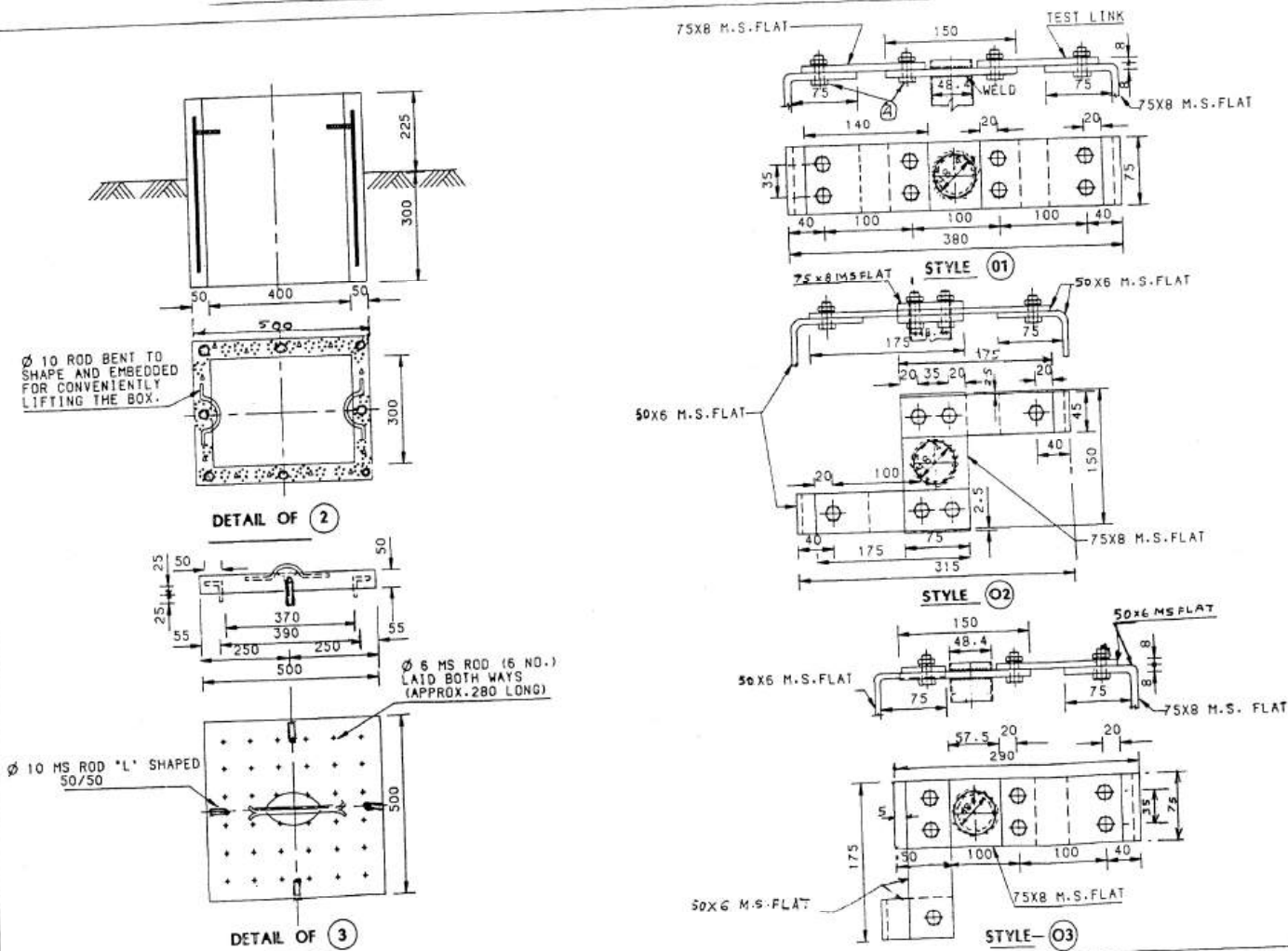
M/s TRANSMISSION LINE PRODUCTS-KOLKATA (ID- 5692) **TLP-H** NH-6, Sankrail Industrial Park P.O. Dhulagarh, PS- Sankrail Howrah, West Bengal - 711302, India

Regd Add. : 102 Central Plaza 2/6 Sarat Bose Road Kolkata, West Bengal - 700020, India **Current status since** - 23/09/2020

Sub Item ID: 4200025053, Socket Eye (20 mm) **Spec:** TI_SPC_OHE_Fittings_0130_with A_C_Slip_No_1, ETI-OHE-13 (4-84) may 2018, **STR:** CORE-STR-20., (Total Vendor Count: 1)

Approved Vendors (Vendor Count: 1)

M/s TRANSMISSION LINE PRODUCTS-KOLKATA (ID- 5692) **TLP-H** NH-6, Sankrail Industrial Park P.O. Dhulagarh, PS- Sankrail Howrah, West Bengal - 711302, India



DETAIL OF- (1)
ICATION DETAILS
ARTH ELECTRODE

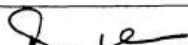
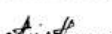
SECTIONAL ELEVATION

REF	DESCRIPTION	PART NO.	MATERIAL	SPECIFICATION	APPROX WEIGHT (Kg)	NUMBER OFF STYLE 01-02 & 04
1	EARTH PIPE	-	MILD STEEL GALVD.	IS:1239		1
2	EARTH BOX	-	REINFORCED CEMENT CONC.	IS:432 & IS:466		1
3	LID FOR EARTH BOX	-	REINFORCED CEMENT CONC.	IS:432 & IS:466		1
4	BOLT Ø 16.50x37 WITH NUT, FLAT & SPRING WASHER	-	STEEL GALVD.	IS:226		3.6 & 7

NOTE :

1. ALL DIMENSIONS ARE IN mm.
 2. TUBE DIMENSIONS: $\phi 40$ mm NOMINAL BORE CLASS LIGHT AS PER IS:1239 AND ABOUT 4m LONG. $\frac{\pi}{2}$ NOT LESS THAN
 3. EARTH PIPE TO BE EMBEDDED VERTICALLY AND SURROUNDED BY ALTERNATE LAYERS OF FINALLY DUSTED COKE, CRUSHED COAL OR CHARCOAL AND SALT AT LEAST 150mm ALL ROUND. $\frac{\pi}{2}$ EARTH
 4. AT LEAST SIX ELECTRODES TO BE PROVIDED AT EACH SUB-STATION TO OBTAIN A COMBINED EARTH RESISTANCE OF NOT MORE THAN 0.5 Ohms. ADDITIONAL EARTH ELECTRODES SHALL BE PROVIDED AS REQUIRED TO OBTAIN THE SPECIFIED RESISTANCE.
 5. THE SPACING OF THE EARTH ELECTRODES SHALL NOT BE LESS THAN 12m.
 6. CEMENT CONCRETE MIX. SHALL BE OF M 150 GRADE AS PER IS:456.
 7. EARTH PIPE TO BE GALVANISED AFTER FABRICATION.
 8. EARTH BOXES SHALL BE PRECAST EITHER AT DEPOT OR AT SITE AND THEN INSTALLED IN POSITION.
9. FOR CODE OF PRACTICE FOR EARTHING REFER CODE No. ET/PSI/120(2/19) & AKC SLIP No.1

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(MINISTRY OF RAILWAYS)LUCKNOW-226011,INDIA AND SHALL NOT BE USED COPIED OR
REPRODUCED IN PART OR WHOLE WITHOUT PRIOR CONSENT IN WRITING.

TYPICAL ARRANGEMENT OF AN EARTH ELECTRODE				DTI-1		 24/1/77	
				ADE/TI			
REF.				CROSS REF.			
DATE	MOD.	NATURE OF MOD.	INITIALS	R. D. S. O.			
				DATE	NAME		
					S.O.		
				DR			
				TC			
				CK	15 24/1/77		
					SCALE: NTS		SH NO
					SUB SCALE		
					SUB SCALE		



भारत सरकार GOVERNMENT OF INDIA
रेल मंत्रालय MINISTRY OF RAILWAYS

MAINTENANCE FREE EARTH & RING EARTH

CAMTECH/ S/PROJ/13-14/Rg & MFeth/1.0
September, 2013



महाराजपुर, ग्वालियर — 474 005
Maharajpur, GWALIOR - 474 005



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7	Equi-potential earth busbars	14
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12	Limits of Earth Resistance	21
13	Checklist for earthing and bonding system	22
14	Material and dimensions of bonding components	27
15	Inspection and Testing	29
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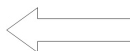
MAINTENANCE-FREE EARTH & RING EARTH

1. Introduction

This type of earthing and bonding system is adopted for S&T equipments with solid state components which are more susceptible to damage due to surges, transients and over-voltages being encountered in the system due to lightning, sub-station switching etc. these equipments include Electronic Interlocking, Integrated Power Supply equipment, Digital Axle Counter, Data Logger etc.

This type of earthing arrangement requires no maintenance so called as “Maintenance free earthing or “Effective Earthing”. Effective earthing electrode eliminates problems of conventional earthing:

1. By providing highly corrosion resistant Earthing Electrode.
2. By eliminating the corrosion causing elements in the salt.
3. By providing uniform non corrosive, low soil resistivity material around the electrode.



1.1 Importance of Earthing

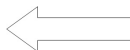
- Efficiently dissipate electric surge to protect equipments thus minimize downtime, service interruption & replacement cost.
- Provide a stable reference for electrical and RF circuits to minimize noise during normal operation.
- Protect staff from dangerous electric shock.

1.2 Characteristics of good Earthing System

- Low resistance and electrical impedance
- Conductors of sufficient dimensions capable of withstanding high fault current.
- Lower earth resistance ensures that energy is dissipated into the ground in the safest possible manner
- Lower the earth circuit impedance
- High corrosion resistance
- Mechanically robust and reliable.

1.3 Location for earth

- Low lying areas close to building or equipment
- Close to existing water points but not naturally well drained
- Avoid Dry sand, lime stone, granite, stony ground and high bank.

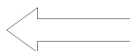


2. Applications

- House-hold earthing.
- Transmission & distribution systems.
- Substation & Power Generators Transformer.
- Telecomm Towers & Microwave Antennas.
- Lightning protection earths in difficult conditions for home as well as industries.
- Manufacturing Facilities & Refineries.
- Computers & Data processing Centers.
- Railway Signalling equipments / installations consisting of solid state components.

3. Features

- Low resistance and electrical impedance ensures dissipation of energy into the ground in the safest possible manner.
- Adequate current carrying capacity
- Durable and reliable.
- Specially developed anti-corrosive Packing Material having less resistivity, and high moisture retaining capacity is used surrounding the electrode.
- This complete arrangement eliminates any possibilities of corrosion of the electrode unlike conventional system.



- Mechanically robust and reliable.
- Maintenance Free
- Reliable life : 10 -12 years.
- The packing material helps in maintaining uniformity at different strata and offers less resistance to current dissipation, with good moisture retaining property. The acceptable Earth resistance shall not be more than 1 Ohm.

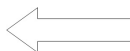
4. Components

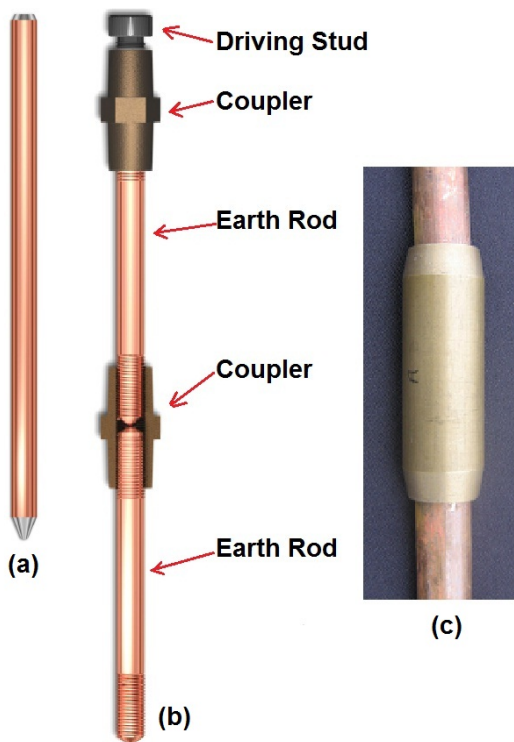
Following are the components of earthing and bonding system:

- Earth Electrode
- Earth enhancement material
- Earth pit
- Equi-potential earth-busbar
- Tape/strip and associated accessories

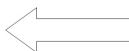
4.1 Earth Electrode

Earth electrode is made up of high tensile low carbon steel circular rods bonded with copper on outer surface. The earth electrode shall be of minimum 17.0 mm diameter and 3 meter length as shown in figure :1.





**Figure:1(a) Copper bonded steel earth electrode
(b) Electrode with coupler (c) Enlarged view of coupler**

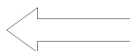


4.2. Earth enhancement material

Earth enhancement material is a superior conductive material that improves earthing effectiveness by improving conductivity of the earth electrode and ground contact area. It mainly consists of Graphite and Portland cement. It is supplied in sealed moisture proof bags.

It has following characteristics:

- Highly conductive, improves earth's absorbing power and humidity retention capability.
- Non-corrosive in nature having low water solubility but highly hygroscopic.
- Resistivity of less than 0.2 Ohms-meter.
- Suitable for installation in dry form or in a slurry form.
- Does not depend on the continuous presence of water to maintain its continuity.
- Permanent and maintenance free and in its "set form", maintains constant earth resistance with time.
- Does not dissolve decompose or leach out with time.
- Does not require periodic charging treatment nor replacement and maintenance.



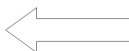
- Suitable for any kind of electrode and all kind of soils of different resistivity.
- Does not pollute the soil or local water table and meets environmental friendly requirements for landfill.



(a) Before setting

(b) After setting

Figure 2:Earth enhancement material



4.3 Backfill material

- The excavated soil is suitable as a backfill but should be sieved (screened) to remove large stones and place around the electrode taking care to ensure that it is wet and compact.
- Material like sand, salt, coke breeze, cinders and ash shall not be used because of its acidic and corrosive nature.

4.4 Earth pit

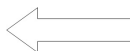
Construction of unit earth pit

(Ref: Typical installation drawing no. SDO/RDSO/E&B/001)

- Prepare a hole of 100 mm to 125 mm dia manually or with the help of 'Earth auger' to a depth of about 2.8 meters.
- Place the earth electrode into the centre this hole.
- Gently drive on the top of the rod to penetrate it into the soil so that minimum 150 mm of the electrode shall be inserted in the natural soil.
- Now fill the Earth enhancement material (min. approx.30-35 kg) into the augured/dug hole in slurry form and allow it to set. After setting, the diameter of composite structure (earth electrode



- +earth enhancement material) shall be of minimum 100 mm dia. covering entire length of the hole.
- Cover the remaining portion of the hole by backfill soil, which is taken out during auguring/digging.
 - A copper strip of 150 mm X 25 mm X 6mm shall be exothermically welded to main earth electrode for taking the connection to the main equi-potential earth bus bar in the equipment room and to other earth pits, if any.
 - The main earth pit shall be located as near to the main equi-potential earth busbar in the equipment room as possible.
 - Figure 3 shows the installation of maintenance free earth for S&T installations with reference to typical installation drawing no. SDO/RDSO/E&B/001 dated 19.09.2008.



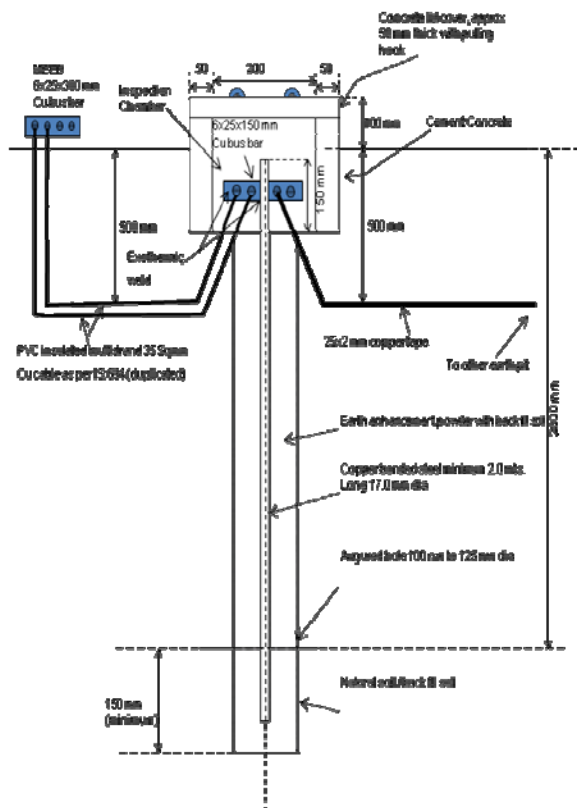
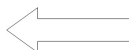


Figure 3: Installation of maintenance-free earth



5. Construction of Ring/ loop Earth

At certain locations, it may not be possible to achieve earth resistance of ≤ 1 Ohm with one earth electrode/pit due to higher soil resistivity. In such cases, provision of loop earth consisting of more than one earth pit shall be done.

The number of pits required shall be decided based on the resistance achieved for the earth pits already installed. The procedure mentioned above for one earth pit shall be repeated for other earth pits.

The distance between two successive earth electrodes shall be min. 3 mtrs. and max. upto twice the length of the earth electrode i.e. 6 mtrs. approx.

These earth pits shall then be inter-linked using 25X2 mm. copper tape to form a loop using exothermic welding technique.

The interconnecting tape shall be buried at depth not less than 500 mm below the ground level. This interconnecting tape shall also be covered with earth enhancing compound.

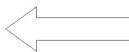
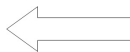




Figure 4 : Interlinking of earth pits using copper tape

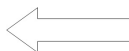


6. Inspection Chamber

- The inspection chamber is a concrete box of 300mmX300mmX300 mm (inside dimension) with smooth cement plaster finish provided on top of the pit.
- A concrete lid, painted black, approx. 50 mm. thick with pulling hooks, shall be provided to cover the earth pit.
- Care shall be taken regarding level of the floor surrounding the earth so that the connector is not too deep in the masonry or projecting out of it.
- On back side of the cover, date of the testing and average resistance value shall be written with yellow paint on black background.



Figure 5: Inspection chamber

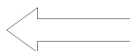


7. Equi-potential earth busbars

- Each equipment room i.e. IPS/Battery Charger room and EI/Relay room is provided with one equi-potential earth bus bar. Such bus bars are termed as Sub equi-potential busbars (SEEB).
- The equi-potential earth busbar provided in the IPS/Battery Charger room and directly connected to Class 'B' SPDs and the main earth pit is termed as Main equi-potential earth busbar (MEEB).
- The EEBs have pre-drilled holes of suitable size for termination of bonding conductors.
- The EEBs shall be insulated from the building walls by providing low voltage insulator spacers of height 60 mm between EEB and the wall.
- For ease of inspection and maintenance, EEBs shall be installed at the height of 0.5 mm from the room floor surface.
- Copper lugs with spring washers are used for all terminations on EEBs.

Bonding Connections

- To minimize the effect of circulating earth loops and to provide equi-potential bonding, "star type" bonding connection is required.



- Each of the SEEBs installed in the rooms shall be directly connected to MEEB using bonding conductors. Also, equipment/racks in the room shall be directly connected to its SEEB.

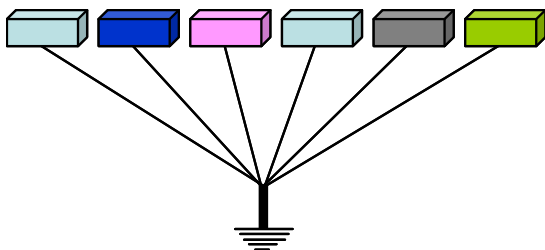


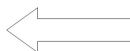
Figure 6: Star type bonding connection

- The bonding conductors shall be bonded to their respective lugs by exothermic welding.
- All connections i.e. routing of bonding conductors from equipments to SEEB and from SEEBs to MEEB shall be as short and as direct as possible with minimum bends and separated from other wiring. However, connection from SPD to MEEB shall be as short as possible and preferably without any bend.



8. Materials and Dimensions

Component /Bonding	Material [as per IS:694]	Size
Main equi-potential earth busbar (MEEB)	Copper	300X25X6 mm (min.)
Sub equi-potential earth busbar (SEEB)	Copper	150X25X6 mm (min.)
Individual equipments to SEEB using copper lugs with stainless steel nut and bolts	Multi-strand single core PVC insulated copper cable	10 Sq.mm.
SEEB to MEEB using copper lugs with stainless steel nut and bolts.	Multi-strand single core PVC insulated copper cable	16 Sq.mm.
Surge protection devices (SPDs) to MEEB using copper lugs with stainless steel nut and bolts.	Multi-strand single core PVC insulated copper cable	16 Sq.mm.
MEEB to main earth electrode	Multi-strand single core PVC insulated copper cable	35 Sq.mm.
Main earth pit to other earth pit in case of loop earth.	Copper tape	25X2 mm.



9. Single earth system

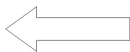
- The Telecom installations shall use single earth system in which the different earth connections from equipments, towers, D.C. power supply, metallic structures etc. shall be interconnected to each other through low resistance earthing conductors.
- This method is recommended to keep all the points to be earthed at approximately same potential level.

10. Earthing of IPS system [An example]

The IPS systems and its individual modules have earth terminals and these should be properly earthed to the IPS cabinet.

Zonal Railways shall provide earthing arrangement as per IS:S 3043. The earth resistance shall not be more than 2 ohm. Earth provided shall preferably be maintenance free using earth resistance improvement material.

No earth shall be connected to the system. The system earth shall be connected to Class B protection module and Class B module only shall be connected to earth. (Class B protection is dealt in Section IV – Lightning & Surge Protection)



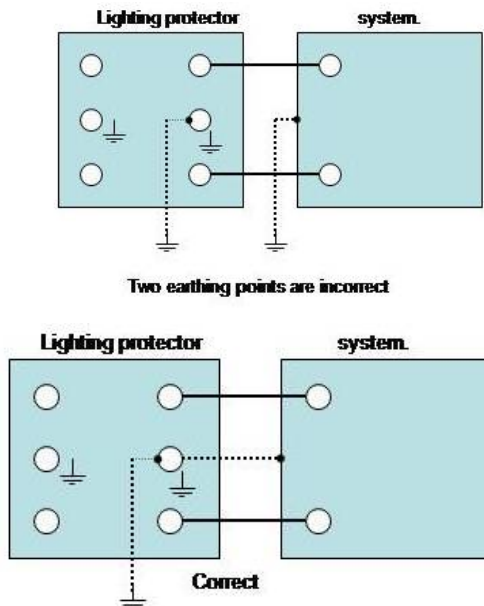
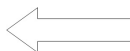


Figure 7(a): connected to earth directly - Incorrect
(b): connected to earth through Class B – Correct

Care must be taken so that the distance between earth pit connection and IPS is always higher than that of the distance between earth pit connection and Class B module.



Separate routing and combining of all earths at one point is correct as shown in the Fig. below.

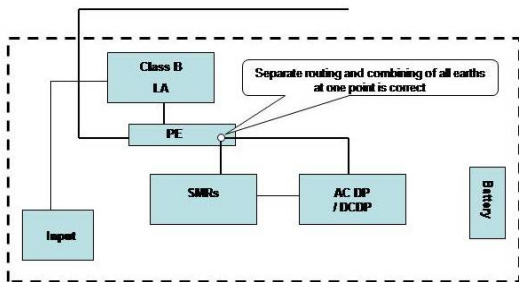


Figure 8 : Separate routing and combining of all earths at one point

11. Precautions

- Pour sufficient water so that mixture is in paste / mud form.
- Allow the pit to absorb the water and become compact.
- Test the earth pit before connecting to the electrical circuit.
- Avoid excess watering.
- Do not hammer the earth electrode.
- The surroundings of the earth electrode should be kept moist by periodically pouring water through



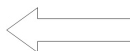
the pipe in order to keep the resistance below specified value.

- Coke treated electrodes shall not be situated within 6 meters of other metal structure.
- The protective earth of Telecom system shall not be connected to the earth of mains power supply system. A minimum distance of 10 Meters is desirable.

12. Limits of Earth Resistance

Maximum values of earth resistances specified for earthing of S&T equipments are as under:

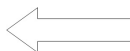
Sr.	Description	Max. Earth resistance
1.	Telegraph and Block Instrument using earth return circuit	10 Ω
2.	Earths for surge arrestors/ lightening dischargers	10 Ω
3.	Earthing of Signalling equipment	10 Ω
4.	Earthing of signalling cable screen in AC electrified areas	10 Ω
5.	Earthing of Telephone Exchange	5 Ω
6.	Earthing of AL sheathed telecom cable in AC electrified area.	1 Ω
7.	Earthing repeater and cable huts.	5 Ω
8.	Axle counter cable screened in AC RE area	1 Ω



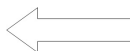
Sr.	Description	Max. Earth resistance
9.	Electronic Interlocking installation	1 Ω
10	Integrated Power Supply System & its individual modules	2 Ω
11	Digital Axle Counter EJB and its apparatus case connected to same earth. All cable armours connected to same earth.	1 Ω
12	Reset box of Digital Axle Counter connected to earth (indoor) near SM's Room.	1 Ω

13. Checklist for earthing and bonding system [As per RDSO/SPN/197/2008]

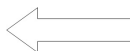
Sr.	Description of the activity	Remarks
1.	Location of the earth pit: it Should be located as near to the main Equi-potential earth busbar in the equipment room as possible.	
2.	Earth electrode: Earthing electrode should not be installed on high bank or made up soil.	
3.	The earth electrode (copper bonded steel cored rod) shall be of minimum 17 mm diameter and minimum 3 meters long.	



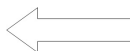
Sr.	Description of the activity	Remarks
4.	Measure the thickness of the copper bonding with micron gauge. The minimum copper bonding thickness shall be 250 microns.	
5.	Should have UL making, manufacturer's name or trade name, length, diameter, catalogue number punched on every earth electrode	
6.	Earth enhancement material: Shall be supplied in sealed, moisture proof bags. These bags shall be marked with manufacturer's name or trade name, quantity etc.	
7.	The excavated soil can be used as backfill but should be sieved to remove any large stores and placed around the electrode taking care to ensure that it is well compacted.	
8.a	Constructions of unit earth pit: A hole of 100 mm to 125 mm dia shall be augured/dug to a depth of about 2.8 meters.	



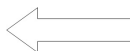
Sr.	Description of the activity	Remarks
8.b	Earth enhancement material minimum approx. 30-35 kg shall be filled into the augured /dug hole in slurry form and allowed to set.	
8.c	A copper strip of 150mmx25mm x 6mm shall be exothermically welded to main earth electrode for taking connection to the main equi-potential earth bus bar in the equipment room and to other earth pits, If any.	
8.d	The other end connection inside the equipment room shall also be of exothermic type.	
8.e	Exothermic weld material shall be UL listed and tested as pr provisions if IEEE 837 by NABL/ ILAC member labs.	
9.	Measure the earth resistance value. (the earth resistance shall be measured at the main equi-potential earth bus bar (MEEB) with all the earth pits interconnected using fall of potential method), it shall be less than 1 ohm.	



Sr.	Description of the activity	Remarks
10.	If more than one earth pit is being prepared ensure that	
a.	The distance between two successive earth electrodes shall be min. 3 meters and max. up to twice the length of the earth electrode i.e. 6 meters approx.	
b.	The earth pits shall then be interlocked using 25x2 mm. copper tape to form a loop using exothermic welding techniques.	
c.	The interconnecting tape shall be buried at depth not less than 500mm below the ground level.	
d.	The interconnecting tape shall also be covered with earth enhancing compound.	
11.	Inspection chamber: A 300x300x300 mm inside dimension concrete box with smooth cement plaster finish shall be provided on the top of the pit. A concrete lid, painted black, approx. 50 mm thick shall be provided with pulling hooks, shall be provided to cover earth pit. Date of the testing and resistance value shall be written with yellow paint on black background.	



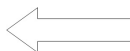
Sr.	Description of the activity	Remarks
12.	Equi-potential earth bus bar and its connection to equipments and surge protection devices in the equipment room. Refer typical bonding connections drawing no. SDO/RDSO/ E&B /002	
13.	Equi-potential earth bus bar: the equip-potential earth bus bar for each of the equipment room i.e. IPS/Battery charger room and EE relay room to be provided. Connection from main earth pit shall be terminated in IPS/Charger room where B&C class SPD is provided.	
14.	The equi-potential earth bus bar located in the IPS /battery charger room and directly connected to class SPDs and the main earth pit shall be termed as main equi-potential earth bus bar (MEEB). The equi-potential earth bus bars located in individual rooms shall be termed as sub equi-potential bus bars (SEEB).	
15.	Each EEB shall be installed on the wall with insulators spares of height 60 mm and shall be installed at a height of 50 cms from floor level.	



Sr.	Description of the activity	Remarks
16.	All termination on the EEBs shall be done using copper lugs with spring washers.	
17.	Each of the SEEBs installed in the rooms shall be firmly connected to MEEB using copper bonding.	
18.	Equipment racks in the room shall be directly connected to SEEB	
19.	The warranty of such system shall be 60 months from the date of commissioning (Date of commissioning shall be jointed to main earth pit and near MEEB).	

14. Material and dimensions of bonding components for connection of individual equipments with equi-potential bus bar and earth electrode shall be summarized below:

Component/ bonding	Material	Size
Main equi-potential earth bus bar MEEB	Copper	300x25x6 mm (min)
Sub equi-potential earth bus bar SEEB	Copper	150x25x6 mm (min)
Individual equipment to SEEB using copper lug with stainless steel nut and bolts	Multi strand single core PVC insulated copper cable as per IS:694	10 sq.mm

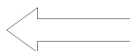


Component/ bonding	Material	Size
SEEB to MEEB using copper lugs with stainless steel nut and bolts	Multi strand single core PVC insulated copper cable as per IS:694	16 sq.mm
Single protection device (SPD) to MEEB using copper lugs with stainless steel nuts and bolts	Multi strand single core PVC insulated copper cable as per IS:694	16 sq.mm
MEEB to main earth electrode	Multi strand single core PVC insulated copper cable as per IS:694 (duplicated)	35 sq.mm
Main earth pit to other earth pit in case of loop earth	Copper tape	25x2 mm

15. INSPECTION & TESTING

[As per telecom manual chapter XXIII para 33, 34 & 35]

- The complete protection arrangement should be inspected and tested by ASTE/DSTE/Sr.DSTE to ensure that the work has been completed in a satisfactory manner and the material and components used conform to the standard.
- Routine inspection of the installation, particularly the earth resistance shall be taken twice a year by



the SE/SSE incharge of the station and Earth connections of all installation should be checked thoroughly two months in advance of every monsoon season and remedial measures should be taken well in advance of monsoon.

- A log book shall be kept in which details of the measurement and inspection should be recorded for scrutiny by higher officials.

16. Source of Suppliers

- JMV LPS LIMITED
W-50, Sector-11, Noida, Ghaziabad, Uttar Pradesh,
www.copperbondedrods.com, www.jmv.co.in
- True Power Earth Solution
D-10, Vibhuti Khand, 2nd Floor, Gomti Nagar,
LUCKNOW - 226002 Call: (0522) 4071125, 9838352487
- Arcon Power System
32, 5th Floor, Room No. 512, South Block, Tea
Board, Ezra Street, Kolkata 700001, (033) 66342138
- Signet Engineers
65 Navi Peth, Near Patrakar Bhavan, Sadashiv peth Pune -
411030 , **(020) 66827332**, www.signetengineers.com
- ERICO
705, 7th Floor, Padma Tower-I, Rajendra Place
New Delhi, Phone: +91 11 4153 9164
- Globetel Technologies, No. 52, Bhavani Towers, 1st
Floor, Opp. Indane Gas Agency, Anand Bagh X Roads,



Safilguda, Ecil X Croads, , Hyderabad, Andhra Pradesh -
500047, <http://www.globeteltechnologies.com/>

vii. A. N. Electricals, Delhi

2107, 2nd Floor, Chah Indira, Behind Jubilee Cinema,
Bhagirath Palace, , Delhi, 110006, India
www.anelectricals.com

viii. Sor Enterprise, Ahmedabad

4910/4911, Gidc, Phase-Iv, Opposite Water Tank,
Vatva, , Ahmedabad, Gujarat -382445
sor.tradeindia.com/ Sba Power & Earthing Equipments

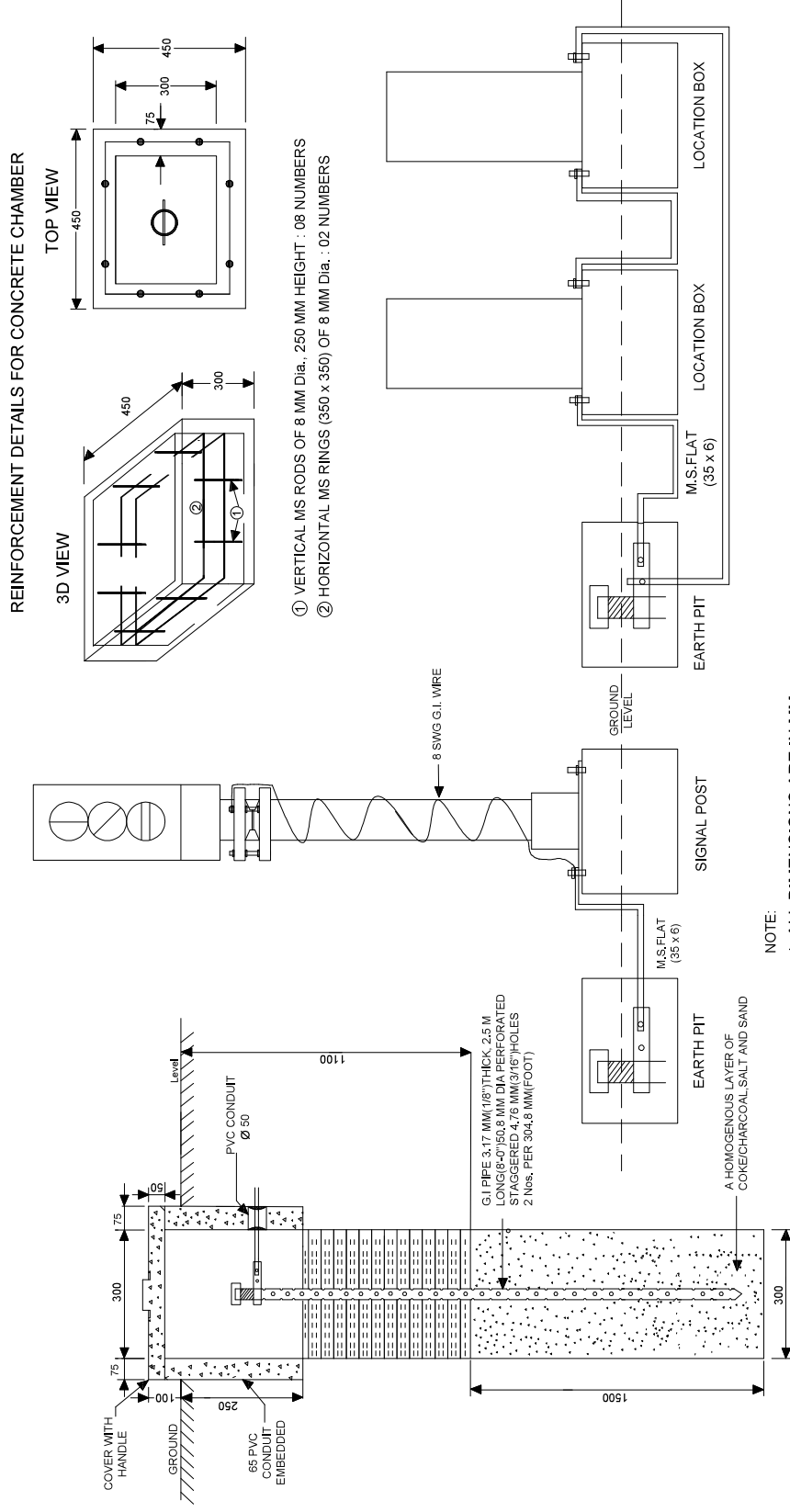
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Exit



EARTHING ARRANGEMENT FOR SIGNALS, LOCATION BOXES



NOTE:

1. ALL DIMENSIONS ARE IN MM.
2. ALL MULTIPLE UNITS CALLING-ON, SHUNT ROUTE & SCREENS SHALL BE LOOPED TOGETHER.
3. CODE OF PRACTICE FOR EARTHING AS PER IS:3043
4. CONCRETE OF M25 GRADE 1:2:4 WITH MAXIMUM SIZE OF STONE CHIPS OF 10 MM.