

Technical Specifications for Equipment

All materials required to complete the work as per given specifications & drawings etc. must be manufactured and supplied using fresh raw material. Re-moulded, re-circulated materials are not acceptable. The procurement of materials must be made by the contractor directly from manufacturer or through authorized dealer/distributors. Documentary evidence to this effect is to be made available to Employer for necessary checks/verification of source of supply of materials. Second hand materials/ partial used materials/ used materials would not acceptable.

Climatic condition details are given with various materials specifications however, bidder shall note that materials covered under project specific RDSS works shall be utilized in that particular project only. Hence, the geographical location of that particular project site and its associated climatic condition shall be applicable for all the materials of that particular project.

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1. Pipe in Cage Earthing

Sr.No	Technical Specification No./Revision	Date of revision
1.	GUVNL/GPRD/TS/PiC Earthing/RP-041/R0	14/06/2018
2.	GUVNL/GPRD/TS/PiC Earthing/RP-041/R1	09/03/2021
3.	GUVNL/GPRD/TS/PiC Earthing/RP-041/R2	12/08/2021

This specification is divided into two parts. The first part (Part-A) covers the scope of supply of maintenance-free, Ready Capsule, Pipe-in-cage, special type earthing system to be provided for the distribution network. The other part (Part-B) covers the scope of installation, testing, and commissioning of maintenance-free, Ready Capsule, Pipe-in-cage, special type earthing system in the distribution network.

The part-C is for the turnkey-based tender (Part-C) i.e. scope covering Supply, carting of PiC capsules, GI Strip, etc. from RSO/division/subdivision store to the destination, installation, testing, and commissioning of maintenance-free, Ready Capsule, Pipe-in-cage, special type earthing system and other relevant accessories (Like GI Strip, PVC Pipe, Nut-Bolts, Nameplate, etc.), both Part-A and Part-B shall be considered.

(PART-A)

TECHNICAL SPECIFICATIONS FOR SUPPLY OF MAINTENANCE FREE, ECO-FRIENDLY, READY CAPSULE, PIPE-in-CAGE (PiC) TYPE EARTHING

1.0 SCOPE:

This specification covers the supply of maintenance-free, Ready Capsule, Pipe-in-cage, special type earthing system, and other relevant accessories (Like GI Strip, PVC Pipe, Nut-Bolts, Nameplate, etc.) to be supplied at the designated locations provided **by the DISCOMs** The technical specification is designed keeping in view the following advantages,

- a) In this type of Earthing Electrode, the electrode, the surrounding enhancing material bonding with the electrode, and the cage are in pre-fabricated, ready-to-use form so that on-field mal-practice in form of less digging of earth pit, less Earth enhancement filling, improper watering at the site, can be overcome. This makes the quality check very convenient.
- b) Due to the pre-fabricated, ready-to-use methodology, no on-field wastage of Earth enhancement material is done.
- c) Installation procedure is effective, convenient, less time-consuming, and cheaper.
- d) Transportation and storing of material, compared to separate components (i.e. electrode, Earth Enhancement compound, etc.) on the field is convenient, cheaper, and too easy to do.
- e) Quality assurance of this type of earthing can be carried out very effectively with minimum effort.

2.0 APPLICABLE STANDARDS:

This earthing system shall be conformed to the relevant standard specification unless otherwise specified, in line with the requirement of any of the latest applicable standards. The applicable amendments as and when imposed shall be applicable.

Sr. No.	Standard	Title of Standard
1.	IS: 3043/1987	Code of practice for Earthing
2.	IEC 62561-7	The requirement of Earthing Enhancement Compound
3.	IEEE-80- 2000	IEEE Guide for Safety in AC Sub Station Grounding
4.	ASTM G57-06	Test Method for Field Measurement of Soil Resistivity, Using the Wenner, Four-Electrode Method
5.	IS: 2629 & IS: 4736	For hot-dip galvanizing for Iron and Steel
6.	IS:1161 Or IS: 1239 (Part-1 & Part-2)	Steel Tubes for Structural Purposes: Specification Or Steel Tubes, Tubulars, And Other Wrought Steel Fittings — Specification
7.	IS:13229-1991	Zinc for Galvanizing
8.	IS:9537:1983	Conduits for electrical installations
9.	IS:13592:1992	UPVC pipes for soil and waste discharge systems

10.	IEEE Std. 142-2007	IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
11.	IS:5216-1982	Recommendations on Safety Procedures and Practices in Electrical Work
12.	CEA	Measures relating to Safety and Electric Supply Regulations, 2010
13.	EN-12547-2	Characterization of Waste – Leaching – Compliance Test for Leaching of Granular Waste Materials and Sludges – Part 2
14.	EN 12506	Characterization of Waste – Analysis of Eluates – Determination of pH, As, Ba, Cd, Cl-, Co, Cr, Cr VI, Cu, Mo, Ni, NO2-, Pb, total S, SO42-, V and Zn.
15.	IS 2720-26	Method of test for soils, Part 26: Determination of pH value

3.0 GENERAL REQUIREMENTS:

- a) This maintenance-free earthing system shall be based on ready capsule type, Pipe-in-Cage technology concept in which, One Galvanized hollow pipe (Electrode) is kept inside the Galvanized Perforated cage as per drawing. The space between the electrode and cage shall be filled with a specially developed earth enhancement material(EEM) made up of Conductive Cement, Graphite carbon powder, Sodium montmorillonite/ Sodium Bentonite Powder, Hydrous aluminum silicate, etc. to reduce earth resistivity.
- b) The system shall be almost maintenance-free and require no periodic or scheduled maintenance for an expected period of 15 years.
- c) There shall be no requirement to add any other chemical or water at any time after initial installation because of the hygroscopic characteristic of Earth Enhancement Material (EEM).
- d) The material offered shall conform to relevant standards with high quality and good workmanship capable to perform continuous and satisfactory operations in the actual service conditions at the site.

4.0 EARTH ELECTRODE:

The earth electrode is the main component of the earthing system which is meant for collecting, releasing, and discharging earth leakage and fault currents. The earth electrode should be ready capsule type made with Pipe-in-Cage (PiC) technology concept. It includes the hollow MS pipe, as a primary electrode which should have IS marking as per IS: 1161 **or** IS: 1239. For the effective life of the earthing system, the whole unit shall be provided a zinc coating of not less than 80 microns through a hot-dip process. The zinc used for galvanizing should follow Zn 98.0 Grade as per IS: 13229-1991 and the process and measurement of hot-dip galvanizing should be as per IS: 2629.

The outer cage of the GI pipe shall be provided with a **3.5 mm dia. (±10% Tolerance) holes** and shall be hot-dip galvanized with a minimum of 80 microns.

- a) **Dimensions:** Here, two different size electrodes are proposed, i.e. 2000 mm and 3000 mm length electrodes. Generally, an electrode having a 3000 mm length is preferable, but where digging of 3000 mm pit is not possible, two parallel earthing of electrodes having a 2000 mm length are to be used.

Primary Electrode: Dimensions of the electrode are as under, however, detailed dimensions are shown in the attached drawing No. GPRD-16 (Rev.2) & GPRD-17 (Rev.2). All the tolerances and other specifications to the same should be as per IS: 1161 or IS:1239.

Length (L):

- a) 1900 mm (pipe) +100mm (terminal) =2000 mm
- b) 2900 mm (pipe) +100mm (terminal) =3000 mm

The whole primary electrode should be made from a single piece i.e. without any joint or welding

- I. Nominal Bore Diameter: 40 mm (Medium duty)
- II. **Outer Diameter (Ø):** 48.3 mm (hollow) (With tolerance: 47.9 mm – 48.8 mm)
- III. **Thickness (t):** 3.2 mm (tolerance : -10%, + not limited) with hot-dip galvanized of minimum 80 microns
- IV. **Weight of electrode:** To be followed according to limit specified in IS (3.56 Kg/meter, Tolerance: ± 10%)

Perforated Cage: The perforated cage is to be prepared from a minimum 150 mm outer dia. MS pipe having a minimum thickness of 1.5 mm and 80 microns Galvanized coating with a welded GI plate on the top and bottom portion of the cage such that earth enhancement material can be accommodated in between the primary electrode and perforated cage. The welded portion shall be applied with a zinc spray to maintain the uniform galvanizing across the whole design.

I. Dimensions:-

- a) 1880 mm (L) X 150 mm (Ø) for 2000 mm Electrode
- b) 2880 mm (L) X 150 mm (Ø) for 3000 mm Electrode

Tolerances in length: (-1%, + not limited)

II. Circular Hole for Cage: 3.50 mm Dia. (Tolerance: ±10%)

The Center to center distance between two consecutive holes in any direction shall be in the range of 45 mm to 70 mm.

III. The thickness of Perforated Cage: 1.5 mm (min.) with minimum hot-dip galvanized of 80 microns

b) **Terminal:** Primary electrode must be provided with a connection terminal facility as shown in the drawing by pressing 100 mm at the top side of the pipe to form a strip having dimensions as mentioned in the drawing **without joint or welding. The pipe shall be pressed by hydraulic press only. No hammered pressed/ welding shall be acceptable.** Two numbers of holes of diameter as mentioned in the drawing shall be provided in the pressed portion of the top side of the pipe for connecting the strip with the earth electrode.

c) Electrically Insulated Enamelled Paint Coating and PVC Cap:

As shown in drawing No. GPRD- 16(Rev. 2) & GPRD-17(Rev. 2) following insulation needs to be provided on the top 250 mm length of PiC Electrode (150 mm Cage + 100 mm terminal) to prevent the flow of current in the top portion, for the same the supplier has to supply PiC earthing with

- The electrically insulated enamelled/bituminous paint coating of minimum 40-micron thickness and of 20 Kv/mm dielectric strength should be provided on the top 150 mm portion of the cage
- Additionally, An insulated PVC cap of appropriate die-electric strength with a minimum thickness of 2 mm should also be provided

This is done to prevent the danger to the living being from Step potential.

d) **Zinc coating:** The earth electrode consists of one mild steel pipe with the provision of connections at the top end as shown in the attached drawings No. **GPRD- 16(Rev.2) & GPRD-17(Rev.2)**. The entire electrode shall be hot-dip galvanized **with at least 80 microns** over all the surfaces **without leaving any point of the electrode un-galvanized and the cage shall be hot-dip galvanized with at least 80 microns in accordance with IS 4736: 1986**. The process of hot-dip galvanizing shall be followed as per IS 2629. For uniform distribution of fault currents, an earth electrode must be cylindrical in shape.

e) **Short Time Current Rating:** The earth electrode shall be capable to withstand a minimum of 20 KA (rms) short time current for 1 sec.

f) **Embossing/punching of Unique Serial No. and manufacturing details:-**

Following things are to be permanently embossed/punched with the clearly visible stamping on the connecting terminal and/or top flat plate of Cage for each PiC Earthing capsule which should be non-removable.

1. Small Logo/Name of manufacturers of PiC earthing capsule
2. DISCOM wise unique serial no. (for eg. PG0000001) in coordination with the concerned tender publishing authority such that DISCOMs can maintain and track the inventory of the same
3. The manufacturing month and year.

g) **Tender sample submission :- (Deleted)**

h) **Packaging And Material Handling:-**

The cage should be designed with high durability such that in the worst transport condition also, the particles of Earth Enhancement Material should not leach out. The packing of the Earth capsule should be done in such a manner that no material leakages should happen even in the worst transportation & handling condition For the same the PiC should be wrapped with a PVC packing tap.

5.0 EARTH CONDUCTIVITY ENHANCEMENT MATERIAL:

a) **Placement of Earth Enhancement Material:-**

It shall be placed between the primary earth electrode and perforated cage to improve the conductivity of the earth electrode & ground contact area. Earth enhancement material (Backfill compound) shall be according to **IEC 62561-7**, and superior conductive material that improves earthing effectiveness, especially in areas of poor conductivity such as rocky ground, sandy soil & areas of moisture variation with different soil strata.

b) **Material composition:-**

The suggested composition of the compound is as under.

Sr. No.	Component	% by mass	Remarks
1	Conductive Cement	15 %	Earth enhancement Back Filling Compound Composition with
2	Graphite carbon powder	45%	

3	Sodium montmorillonite/ Sodium Bentonite Powder	30 %	maximum permissible tolerance of ± 10 % in each content
4	Hydrous aluminum silicate	10 %	

Note:

- The maximum permissible limit of Salt content is below 2 %.
- The Sulphur content in the back-fill compound shall not be more than 2 % in any case.
- All the components used in the mixture shall be having a mesh size of at least 150-200 mesh.
- The verification of the quality of the earth enhancement compound shall be done by measuring the resistivity of the compound by performing a soil box test as mentioned in Cl. 5.0(J)
- The graphite carbon powder should have a minimum 95% of carbon content. The usage of coal powder is restricted due to its high fly ash content which is resistive in nature.
- The conductive cement should have bonding capability as well as high conductivity. The use of normal cement will increase the resistivity of the compound. Hence the usage of normal cement content is restricted.

c) Maintenance-Free:-

The Earth Enhancement Material/ Backfill compound shall be a Highly Conductive Compound and maintenance-free. The watering shall be required at the time of its installation only. No re-charging with water, salts, or any other chemical shall be required and it shall maintain almost constant earth resistance during its life cycle without manual watering. It must set firmly and should not dissolve or decompose or otherwise pollute the soil or the local water table.

d) Hygroscopic:-

It should have the capacity to retain more than 10% moisture at 105°C. It should have better hygroscopic properties to absorb moisture. It should absorb & release the moisture in the dry weather condition and help in maintaining the moisture around the earth electrode. It should expand & swell considerably & remove entrapped air to create a strong connection and bond between the earth electrode & soil. It should diffuse into the soil pores & create conductive roots enlarging the conductive zone of the earth pit.

e) Non-toxic:-

Material shall **be non-toxic, non-reactive, non-explosive & non-corrosive**. It shall not cause burns, irritation to the eye, skin, etc. It shall not pollute the soil or local water table & shall meet environmentally friendly requirements for landfills.

f) Leachability Test:-

The requirement for earthing enhancement materials is that they must be chemically and physically stable. Specifically, they must be chemically inert to the surrounding soil and must not decompose or leach over time. Resistance to leaching is a quality of proper EEM because leaching compromises the material's lifetime value. Regardless of the material used, EEM that is washed away cannot uphold the superior conductivity it was intended to provide. **The leach test shall be tested as per IEC 62561-7 Clause 5.2** at NABL accredited Government/ government-supported laboratory. Conformance is verified by testing in accordance with EN 12457-2 and EN 12506.

g) Sulphur Content:-

A significant amount of sulfur cannot exist in the EEM for the system to be effective. If an earthing enhancement material contains a significant amount of sulfur, it can corrode the ground rod electrode. Sulfur causes corrosion to zinc, copper, lead, and iron—all of which are commonly used metals in ground rods. Sulphur Determination test As per IEC 62561-7 clause 5.3. IEC 62561-7 requires that any earthing enhancement material should contain less than 2% sulfur. The test certificate complying with the above requirements should be submitted.

h) Corrosion Test:-

The significance of the test is that the earth enhancement materials have to be physically and chemically inert with the earth electrodes in order to avoid corrosion damage to the earthing electrode. This test is to be followed as per clause no. 5.5 of IEC 62561-7. The corrosion rate is determined by using potentiodynamic polarization resistance methods as outlined in ASTM G59-97 and ASTM G102-89.

i) Soil Box Test – EEM Conductivity test:-

The Earth enhancement material should diffuse. It should expand & swell considerably & remove entrapped air to create a strong connection and bond between earth electrode & soil into the soil pores & create conductive roots enlarging the conductive zone of the earth pit.

It is required that the resistivity of the Earth enhancement material shall not be higher than 0.20 Ω-m (i.e. 20 ohm-cm), when it is tested with 4 electrode method using a soil box having cross-section area of 4 cm x 3.2 cm=12.8 Cm² and keeping the electrodes at a distance of 12.8 Cm. in a soil box.

The soil boxes are designed such that the cross-sectional area of the soil (or liquid) sample (A), with the box filled level, divided by the separation between the pins (L) is equal to 1 cm.

For example

A = Cross-sectional area (Inner side conducting plate) = 4 cm x 3.2 cm = 12.8 cm²

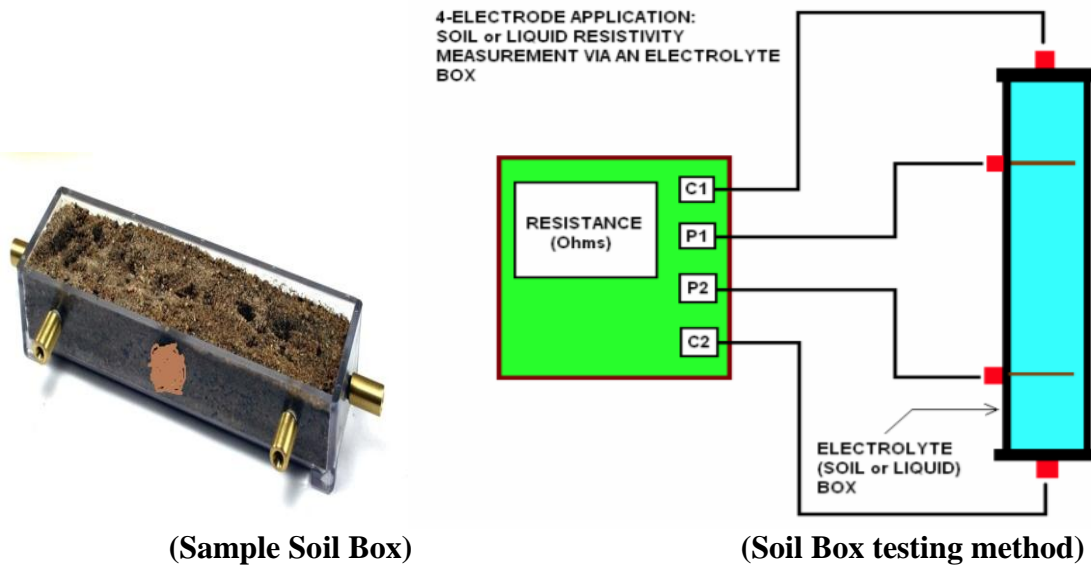
L = Pin separation (P1-P2) = 12.8 cm

A / L = 1 cm

Soil Box Example:

Measured Resistance (4 Point method with Earth tester) = 19.7 Ω
Resistivity Value = 19.7 Ω x 1cm
= 19.70 Ω-cm
= 0.197 Ω-meter

The supplier shall produce the facility of the soil box for testing. One destructive sample should be randomly selected from the presented lot to test for the soil box test. It is required that the test instrument of standard make such as Megger, Chauvin Arnoux or Fluke should only be used for the testing of the soil box. Further, the meter should be able to measure the resistance with the 4 Pole method and should have a high accuracy of ± 2% or less with a professional testing kit.



j) PH Value test:-

It should be **alkaline in nature with a pH value of > 7 & < 9**. Test certificate as per IS 2720-26 from NABL approved Government/government-supported laboratory to be provided for the compound so designed.

k) Weight of EEM :-

The weight of EEM **should be measured while performing destructive testing**. The weighing scale having stated accuracy and valid calibration certificate as mentioned in Annexure-1 should only be used. The weight requirement of EEM per kg of Cage is as below

Weight of EEM Per meter of perforated Cage length: - 15 KG/meter (±5%)

- Weight of EEM in 2880 mm Perforated cage dimensions: - 43 Kg (-5%, +not limited)
- Weight of EEM in 1880 mm Perforated cage dimensions: - 28 Kg (-5%, +not limited)

It is mandatory that above measurement should be carried out while EEM is in dry condition.

6.0 QUALITY CHECK AND INSPECTION:-

The quality check of the sample is to be carried out as per the following list.

A) TYPE TEST:-

The bidder is required to submit the type test certificates as listed below, **within the commencement period.** All these test certificates shall be carried out at any NABL accredited Government/ Government supported laboratory. These tests should not be older than **7(Seven)** years as on the scheduled date of opening of the Technical bid.

1. Toxic Content test on Conductive materials (RoHS Certification of non-hazardous material)
2. Leachability Test as per clause no. 5.2 of IEC 62561-7
3. Short Circuit Withstand Test on Earth electrodes (20 KA rms for 1 sec)
4. PH Value Test (pH value of > 7 & < 9 as per IS 2720-26)
5. Sulphur determination Test as per clause no. 5.3 of IEC 62561-7

6. Granular Size of Material (Mesh Size of material at least 150-200 mesh)
7. Corrosion Test (as per clause no. 5.5 of IEC 62561-7)
8. PVC Pipe tests for the effect of sunlight (Clause no. 8.5 of IS: 13592)

Note:- The contractor shall require to submit the valid type test report of the Material within the commencement period. No separate time period will be granted for submission of the valid Type test report. The Type tests should have been carried out within 7 (seven) years prior to the date of opening of this tender.

B) ROUTINE TEST:-

The supplier has to submit the following routine test certificate. The routine test certificate is to be provided for each and every sample and is to be submitted at the time of lot inspection to the inspector of DISCOM.

1. Serial No. :
2. Dimensions and weight of the electrode (Length, OD, thickness, weight, coating thickness of galvanizing)
3. Dimensions and weight of the outer cage (Length, OD, thickness, weight, coating thickness of galvanizing,)
4. Resistivity and weight of EEM
5. GI Strip Dimensions and coating thickness of galvanizing
6. PVC Pipe dimensions

C) Acceptance Test:-

The user acceptance test shall be carried out by the inspecting officer of the DISCOM on the following sampling basis. The test carried out will be the destructive test (**Destructive Testing definition:** Testing methods, the use of which destroy or impair the part or product insofar as its intended use is concerned, but which give proof or an indication of the strength or quality of similar or duplicate parts or products. Such tests involve the subjection of the test piece to various influences, of destructive magnitudes, such as impact, stress, pressure, cyclic movement, etc.)

In the process of acceptance testing, after taking the reading of dimensions, the bottom plate is required to be cut through the cutter, and then the whole main electrode is to be drawn out. The dimensions of the whole main electrode and its weight is to be verified according to the following table. After weighing the earth electrode; **the cage is to be cut as per the discretion of the DISCOM from any three parts of the whole PiC unit and Earth enhancement material is to be collected in three different samples. Readings of all three samples are to be checked with the soil box test as mentioned in the relevant standard and to confirm the acceptance of the lot, all three values should not be higher than 0.20 Ω-m (i.e. 20 ohm-cm).**

The Earth enhancement material is also to be drawn out for verification of resistivity test with soil box having dimensions as mentioned above. The other tests are to be carried out as per the following table.

Proposed Sampling criteria for destructive sample testing of a lot:-

1. Quantity less than 50 = 1 Sample
2. Quantity ≥ 50 & < 500 = 2 sample
3. Quantity ≥ 500 & < 1000 = 3 sample
4. Quantity ≥ 1000 and < 2000 = 4 sample
5. Quantity > 2000 (To be decided by Competent Authority)

Note:- The samples shall be selected randomly from the lot under testing

The purchaser or his authorized inspector shall have all rights for free access to the manufacturer's works. The manufacturer or his authorized representative shall remain present at all reasonable times and conduct all tests and measurements as per the technical specifications in presence of the purchaser representative shall give facilities to inspect the manufacturing process at any stage of manufacture. The purchaser shall have the right to reject the whole or part of any work or material that does not conform to the requirements of the specifications. All the reasonable/complete facilities considered necessary for the inspection by the inspector/s inspecting shall be provided by the manufacturer free of cost.

The acceptance test on the materials of PiC will be performed as per the detail mentioned in the following tables.

A. ACCEPTANCE TEST FOR PiC EARTHING :-

Sr. No.	Technical Particulars	Remarks	Confirm (Yes/No) or Measurement Reading				
			Samp.-1	Samp.-2	Samp.-3	Samp.-4	
1	PiC Earthing Sample details (Permanently embossed/punched with the clearly visible stamping) :-						
	Small Logo/Name of manufacturers of PiC earthing	All things should be permanently embossed with the clearly visible stamping on the connecting terminal and/or top flat plate of Cage for each sample					
	Unique serial no.						
	The manufacturing month and year						
2A	Electrode: (Confirming to IS: 1161-2014/IS 1239) Nominal Bore : 40 mm (Medium duty)						
	For 3000 mm Electrode						
	Length (L): 2900 mm (pipe) + 100 mm (terminal)=3000mm (Tolerance : $\pm 1\%$, + not limited)		The electrode should be ISI marked with the mini. Parameters of weight, thickness and dimensions as mentioned or better.				
	Outer Diameter (ϕ): 48.3 mm (hollow) (With tolerance : 47.9 mm – 48.8 mm)						
	Thickness (t): 3.2 mm (tolerance : -10%, + not limited)						
Weight of electrode : 10.6 (Kg.) At least ($\pm 10\%$)							
(all tolerance will be applicable as per IS:1161-2014/IS : 1239)							

2B	For 2000 mm Electrode	The electrode should be ISI marked with the mini. Parameters of weight, thickness and dimensions as mentioned or better.				
	Length (L): 1900 mm (pipe) + 100 mm (terminal)=3000mm (Tolerance : -±1%, + not limited)					
	Outer Diameter (Ø): 48.3 mm (hollow) (With tolerance : 47.9 mm - 48.8 mm)					
	Thickness (t): 3.2 mm (tolerance : -10%, + not limited)					
	Weight of electrode : 7.1 (Kg.) At least (± 10 %)					
3	I. Galvanized Perforated cage for Earthing :-	The cage should have thickness and holes as specified or better.				
	a) 2880 mm X 150 mm for 3000 mm electrode					
	b) 1880 mm X 150 mm for 2000 mm electrode					
	Circular Hole Size of Net: 3.5 mm Dia. (Tolerance: ±10%)					
	The thickness of Net: 1.5 mm (min.) with hot-dip galvanized					
	Center to center distance between two consecutive holes in any direction shall be in the range of 45 mm to 70 mm.					
	I. Design Versatility :-					
	The cage should be designed with high durability such that in worst transport condition also, the particles of Earth Enhancement Material should not leach out. For the same the PiC should be wrapped with PVC packing tap.					
II. Handling :-						
The cage with all content should be design kept in view handling condition at site.						
4	Zinc coating on electrode :-	The measurement should be taken by coating thickness tester. It should be $\geq 80 \mu$				
	Galvanizing on the main electrode (in micron):-					
	Galvanizing on the Perforated cage (in micron):-					
5	Resistivity Test of Earth enhancement Back Filling Compound Confirming to IEC: 62561-7	Soil box test to be carried out with calibrated earth tester - Destructive Testing				

Resistivity < 0.2 Ω-m				
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B. ACCEPTANCE TEST FOR OTHER ACCESSORIES OF PIC EARTHING:-

Sr. No.	Technical Particulars	Remarks	Confirm (Yes/No) or Measurement Reading			
			Samp.-1	Samp.-2	Samp.-3	Samp.-4
1	GI Strip :	The size of the GI Strip should be measured with calibrated digital vernier calipers & Galvanized coating with coating thickness tester				
	GI Strip dimensions (L x B x H) in mm					
	GI Strip coating (in μ)					
2	Earthing Display board made up of FRP material having a size of (L X B x H) in mm - minimum 200 mm x 150 mm x 3 mm with following bare minimum parameters	The size of the FRP board should be measured with the digital calibrated vernier calipers and display board should contain all the details as mentioned.				
	(1) Name of Manufacturer/ Trade Name / Supplier					
	(2) PO NO:					
	(3) Feeder Name					
	(4) PiC Earthing Serial No.					
	(5) Drawing No _____					
	(6) Length Of Electrode in mm					
	(7) Date of Installation					
	(8) Resistance value in Ohm on Installation date					
(9) Soil Resistivity in Ohm-Meter						
3	Dimensions of Rigid PVC Pipe (Sunlight protected):-	The size of the PVC Pipe should be measured with calibrated digital vernier calipers				
	a) Outside Diameter : 40 mm (tolerance:-0.4 mm)					
	b) Inside Diameter: 34.4 mm (Min.) (Heavy Duty)					
	The pipe should have BIS marking of IS:9537 on its body					
4	Verification of test instrument as per specification:-	The details of the test				

	The bidder has to submit a technical catalog of the earth resistivity measurement instrument to be used in the tender for measurement.	instrument should be as per specification and the calibration certification should be verified (Within 1 Year)				
	Make of instrument					
	4 Pole testing available					
	Professional earth testkit accessories (Company provided : Cable Reels, Spikes, etc.)					
5	uPVC Cable Tie Dimension :- Dimensions of uPVC Cable Tie (600 mm x 7 mm x 1.3 mm)	Dimensions to be verified				

All the measurements need to be taken with the calibrated Digital Vernier calipers, Digital micrometer screw gauge, Digital weighing machine, etc.

7.0 GUARANTEED TECHNICAL PARTICULARS (GTP) :

The bidder needs to fill up the details and conforms to the technical particulars of the products as per GTP.

A. GURANTEED TECHNICAL PARTICULARS FOR PiC EARTHING :-

Sr. No.	Technical Particulars	Remarks	Details
1	Electrode: (Confirming to IS: 1161 <u>or</u> IS: 1239) Nominal Bore: 40 mm (Medium duty)	The electrode should be ISI marked with the mini. Parameters of weight, thickness, and dimensions as mentioned or better.	
	(a) For 3000 mm Electrode		
	Length (L): 2900 mm (pipe) + 100 mm (terminal)=3000 mm (Tolerance : -1%, + not limited)		
	Outer Diameter (Ø): 48.3 mm (hollow) (With tolerance: 47.9 mm – 48.8 mm)		
	Thickness (t): 3.2 mm (tolerance : -10%, + not limited)		
	Weight of electrode : 10.6 (Kg.) (Tolerance : ± 10 %)		
	(b) For 2000 mm Electrode		
	Length(L): 1900mm(pipe)+100mm(terminal)=2000mm (Tolerance : -1%, + not limited)		
	Outer Diameter (Ø): 48.3 mm (hollow(With tolerance: 47.9 mm – 48.8 mm)		
	Thickness (t): 3.2 mm (tolerance : -10%, + not limited)		
Weight of electrode : 7.1 (Kg.) (Tolerance : ± 10 %)			
2	Galvanized Perforated cage for Earthing:-	The cage should have thickness and holes as specified or better.	Conforms/ Not Conforms
	a) 2880 mm (L) X 150 mm (Ø) (min.) for 3000 mm electrode		
	b) 1880 mm (L) X 150 mm mm (Ø) (min.) for 2000 mm electrode		
	<i>Tolerances in length: (-1%, + not limited)</i>		
	Circular Hole Size of Net: 3.5 mm Dia. (Tolerance: ±10%)		
3	Zinc coating:-	The zinc coating	Conforms/

	Galvanizing on the main electrode (in micron):-	should be a Minimum of 80 micron for electrode and cage	Not conforms
	Galvanizing on the Perforated cage (in micron):-		
4	Testing of Mixture proportion for Earth enhancement Back Filling Compound Confirming to IEC: 62561-7 with the soil box and standard earth resistance testing meter (during destructive testing of the selected sample as per proposed sampling criteria as mentioned in Cl.5.0(i). Resistivity $\leq 0.2 \Omega\text{-m}$		Conforms/ Not Conforms
	Weight of EEM Per meter of perforated Cage length (in dry condition) : - 15 KG/meter (Tol.: $\pm 5\%$) <ul style="list-style-type: none"> • Weight of EEM in 2880 mm Perforated cage dimensions: - 43 Kg (Tol.: -5%, +not limited) • Weight of EEM in 1880 mm Perforated cage dimensions: - 28 Kg (Tol.: -5%, +not limited) 		
5	Earth pit:-	No manual excavation shall be allowed	Conforms/ Not Conforms
	Method of digging Earth Pit:-Through Bore/auger machine, having a Diameter of 200-300 mm		
	Earth Pit: 200-300 mm dia.?		

B. GURANTEED TECHNICAL PARTICULARS FOR OTHER ACCESSORIES OF PiC EARTHING:-

Sr. No.	Technical Particulars	Remarks	Confirm (Yes/No)
1	GI Strip :	Dimension and coating of GI Strip shall be verified.	
	GI Strip of 25mm wide, 3mm thick, having hot-dip galvanized-zinc coating of min. 80 microns and joints or welding should be avoided as far as possible. (Joints in the earthing circuit are not desirable, however, if it is technically not possible to lay earthing strip without a joint, in that case only, joints should be provided with minimum 2 No.s of nut bolts		
2	Earthing Display board made up of FRP material having a size of 200 mm x 150 mm x 3 mm with the following details. It should be mounted with a suitable mounting stand or bind properly with 4 no.s PVC cable ties (Cable tie dimensions to be added).	Earthing display board as per specification should be provided.	
	1. Name of Manufacturer/ Trade Name / Supplier		
	2. PO NO: 3. Feeder Name		

	<p>4. PiC Earthing Serial No.</p> <p>5. Length Of Electrode in mm</p> <p>6. Date of Installation</p> <p>7. Resistance value in Ohm on Installation date</p> <p>8. Soil Resistivity in Ohm-Meter</p>		
3	<p>Dimensions of Rigid PVC Pipe (Sunlight protected):-</p> <p>a) Outside Diameter : 40 mm (tolerance:- -0.4 mm)</p> <p>b) Inside Diameter: 34.4 mm (Min.) (Heavy Duty)</p> <p>c) BIS marking of IS 9537 on pipe</p> <p>Additionally, the pipe should be conforming to the tests for the effect of sunlight as per Clause no. 8.5 of IS: 13592 with the latest amendments thereof. A valid test report of the NABL accredited lab should be provided for the same.</p>	PVC Pipe should conform to the requirement of dimensions and BIS marking as mentioned	
4	<p>Verification of test instrument as per specification:-</p> <p>The bidder has to submit a technical catalog of the earth resistivity measurement instrument to be used in the tender for measurement.</p>	Verification of test instrument catalog as per tender norms.	
5	<p>Minimum Dimensions of uPVC Cable Tie (600 mm x 7 mm x 1.3 mm)</p>		
6	<p>Verification of workmanship and material used as per specifications, instructions, and drawing; such as GI nut bolts, connections, etc.</p>		
7	<p>Valid calibration certificate of all the measuring instruments used in the inspection.</p>		

8.0 CHECKLIST OF TESTS CERTIFICATES TO BE SUBMITTED:

- 1) Toxic Content test on Conductive materials (RoHS Certification of non-hazardous material)
- 2) Leachability Test as per clause no. 5.2 of IEC 62561-7
- 3) Short Circuit Withstand Test on Earth electrodes (20 KA rms for 1 sec)
- 4) PH Value Test (pH value of > 7 & < 9 as per IS 2720-26)
- 5) Sulphur determination Test as per clause no. 5.3 of IEC 62561-7
- 6) Granular Size of Material (Mesh Size of material at least 150-200 mesh)
- 7) Corrosion Test (as per clause no. 5.5 of IEC 62561-7)
- 8) PVC Pipe tests for the effect of sunlight (Clause no. 8.5 of IS: 13592)
- 9) Test instrument brochure

9.0 GUARANTEE:

- a) The product offered shall have a guarantee for good design, Materials, and workmanship. The defective material or the materials which are not supplied as per the design and the specifications shall have to be repaired/replaced free of cost if reported within 66 months from the date of dispatch or 60 months from the date of commissioning whichever is earlier.
- b) Reported failed/defective units under the guarantee period as above shall be repaired/replaced as early as possible. In any case, it should be **repaired/replaced within 30 days**. The failed units are **to**

be collected by the supplier from our field offices within 15 days of reporting. If an immediate arrangement for the collection of the failed units are not done by the Supplier and if the units are not repaired/replaced and returned within two month's time, the DISCOM will deduct the full cost of the PiC unit from the bill.

(PART-B)

TECHNICAL SPECIFICATIONS FOR INSTALLATION, TESTING AND COMMISSIONING OF MAINTENANCE FREE, ECO-FRIENDLY, READY CAPSULE, PIPE-in-CAGE (PiC) TYPE EARTHING WITH ALL RELEVANT ACCESSORIES.

1.0 SCOPE:

This specification covers

- a) The carting of PiC capsules, GI Strip, etc. from RSO/division/subdivision store to the destination, Installation, Testing, and commissioning of maintenance-free, Ready Capsule, Pipe-in-cage type earthing system, and other relevant accessories (Like GI Strip, PVC Pipe, Nut-Bolts, Name-plate, etc.) with a good standard of workmanship and following guidelines mentioned in IS:3043 and relevant REC standard.
- b) To write the measurement reading of testing of earth pit resistance and soil resistivity and other parameters as mentioned on the FRP nameplate with non-removable, permanent paint/ UV protected permanent marker for each and every earth pit.
- c) It also covers supply, Installation, testing, and commissioning of the electrically insulated enameled/bituminous paint coating or heat shrinkable sleeves.

2.0 PROCEDURE FOR INSTALLATION OF PiC EARTHING :

- a) The PiC Earthing needs to be installed **at least 300 mm (30 cm-1ft.) below ground level**, above which the mother soil filling and dumping should be done such that ground level should be maintained as it was before. No parts of the earth electrode should be accessible or touchable to the ground level. The connections from the PiC Earth electrode to the parts to which earthing is to be provided should be erected **through the digging of the slot of 1 ft of depth through the soil till the pole/support structure such that the strip should not be easily exposed to the living beings.**
- b) Two different size electrodes are proposed, i.e. 2000 mm and 3000 mm length electrodes. Generally, the electrode having 3000 mm length is preferable. But, wherever digging of 3000 mm pit is not possible, two parallel earthings of electrodes having 2000 mm length are to be used. The earth pits **should be dug with the help of an auger/bore having a size from 200 mm-300 mm.** as per the length of the electrode. **The manual excavation of the pit shall not be entertained.** The ready-to-use electrode is inserted into the pit vertically and then the pit is filled with local soil and water.
- c) At the time of installation, a tight filling of mother soil with sufficient watering is required to make contacts of soil uniformly surrounding to the electrode to provide the low resistive path to dissipate the fault current in all directions from the circular surface of the electrode. The loose earth filling surrounding the newly installed earthing may not give low resistance to earthing.
- d) **The testing of soil resistivity should be carried out at each location with the Wenner-4 point method. The resistance of the earth pit should be measured before connecting the earth**

electrode to the network and a record of the same shall be preserved. Due care should be taken, as not to measure the earth electrode in live connected conditions, the results derived so may be misleading.

The measurement of soil resistivity and earth pit resistance should be carried out only through a professional earth testing kit (testing kit with their 30-meter reels, spikes, Test leads, etc.) of Megger, Chauvin Arnoux or fluke make. The accuracy of the 4 Pole earth testing kit should be $\pm 2\%$ or better. The brochure of the test equipment to be used is to be submitted with the bid.

- e) The connection from Earthing Electrode to various network equipment, Transformer body, Transformer Neutral, fabrication of pole and T/C structure, Lightning Arrestors **by way of using mandatorily by 25 x 3 mm GI strip, Nut-bolts, and rigid PVC pipe shall be done.** Due care shall be taken at the time of connection of GI Strip with earth electrode so that the insulated enameled paint/PVC cap should not be damaged or torn out.
- f) Supply, Installation, testing, and commissioning of the electrically insulated enameled/bituminous paint coating of minimum 40-micron thickness and of 20 Kv/mm dielectric strength **or** Supply, Installation, testing, and commissioning of the heat shrinkable insulated sleeves of appropriate dielectric strength **on to the top 100 mm connecting part including GI strip up to the PVC Pipe level should be insulated with either of the above-mentioned method.** It is also needed to install **the PVC cap provided by the manufacturer of PiC to the top 150 mm portion of the cage** such that the whole part is electrically insulated. This is done to prevent the danger to the living being from Step potential.
- g) To validate the quality of the workmanship, the engineer-in-charge may opt for inspection. If the workmanship quality or material used is found to have deviated from the technical specification, the DISCOM shall take strict action for the same.
- h) Earthing Display board is made up of FRP material having a size of 200 mm x 150 mm x 3 mm with the following details. It should be free-standing with a suitable mounting stand or bind properly with 4 no.s PVC cable ties.
 1. Name of Manufacturer/ Trade Name / Supplier
 2. PO NO:
 3. Feeder Name
 4. PiC Serial No.
 5. Length of Electrode in mm
 6. Date of Installation
 7. Resistance value in Ohm on Installation date
 8. Soil Resistivity in Ohm-Meter

All parameters are mandatory to be written with a Permanent Paint Marker not with an ordinary permanent marker as in the case of an ordinary permanent marker due to the Sunlight effect the written data gets vanished after some months.

- i) Before installation, the surface of the earth electrode shall be cleaned properly, and **all resistive materials including PVC packing tap shall be removed from the surface.** If the PVC packing

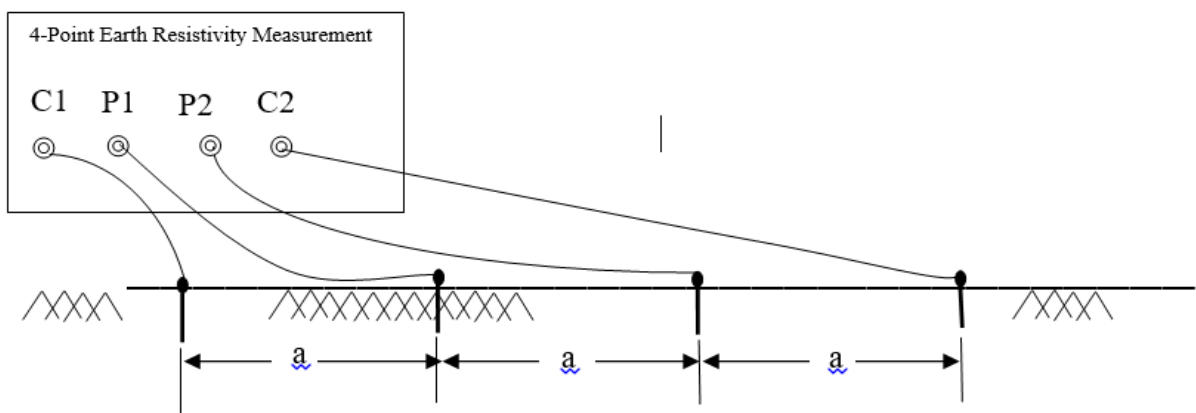
tap remains on the surface of the PiC earthing, it will prevent the smooth dissipation of current into the earth.

- j) The earth pits should be dug with the help of an auger (200 mm-300 mm dia.). The manual excavation of the pit shall not be entertained. The earthing electrode shall be installed at the proper depth and put vertically in the center of the pit and then the pit is filled with local soil and water. At the time of installation, sufficient watering is required to mix up the soil uniformly surrounding the electrode. The care shall be taken that there should be tight bonding between the electrode and mother soil. So proper dumping is required at the time of installation, otherwise the porous (gap) between electrode and mother earth will not allow quick dissipation of fault current.

Connections: The scope of work shall cover carting of PiC capsules, GI Strip, etc. from RSO/division/subdivision store to the destination, installation, and Connection of GI Strip of 25mm wide, 3mm thick, having hot-dip galvanized-zinc coating of **min. 80 microns** without any joints or welding. Joints in the earthing circuit are not desirable, however, **if it is technically not possible to lay earthing strip without a joint, in that case only, joints should be provided with minimum 2 No.s of nut bolts** . The connections from the PiC Earth electrode to the parts to which earthing is to be provided should be **erected through the digging of the slot of 1 ft of depth through the soil such that the strip should not be easily exposed to the living beings**. Also, in the soil, it should be inserted through the PVC pipe, and **additionally, up to the minimum height of 2.5 meters from the ground level, it should be erected through the cover of the PVC Pipe supported with a pole by 5 nos of standard make cable ties as per instructions of Engineer-In-Charge**. Thus, the whole arrangement should be such that no conducting part shall be exposed to the living being.

3.0 PROCEDURE OF MEASUREMENT/TESTING:-

- a) **MEASUREMENT OF EARTH RESISTIVITY :**



C1-C2 denotes the Current Terminal
P1-P2 denotes Potential Terminal
a = the distance between two spikes

For Ex. The calculation of soil resistivity according to Wenner Four electrode method is as below.

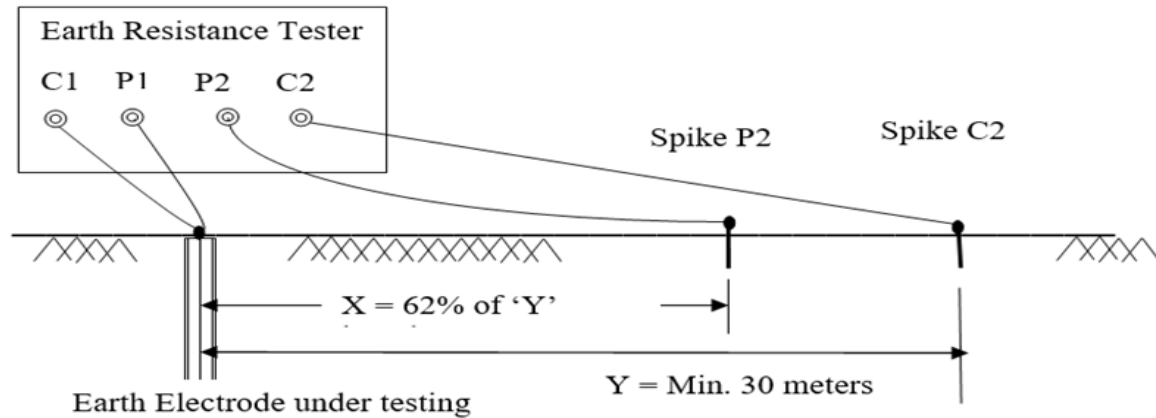
Considering distance between spikes (a) = 4 meter

$$\rho = 2 \times \pi \times a \times \text{Resistance value shown by earth resistance tester}$$

$$\rho = 2 \times 3.14 \times 4 \text{ m} \times 2 \Omega$$

$$\rho = 50.24 \Omega\text{-m}$$

- b) **MEASUREMENT OF EARTH PIT RESISTANCE:** The value of earthing resistance should be measure by the following method of measurement.



The meter will show the value in Ohm

The connecting wire length of the terminal connecting the earth electrode with C1-P1 of megger should not be more than 1 meter. All three electrodes should be in linear alignment to avoid the unnecessary addition of extra earth resistance during the measurement process.

4.0 GUARANTEED TECHNICAL PARTICULARS (GTP):-

Sr. No	Technical Particulars	Remarks	Details
1	Earth pit:-	No manual excavation shall be allowed	
	Method of digging Earth Pit:-through Bore/auger machine (which machine is available ?)		
	Diameter = 200 – 300 mm dia.		
2	Verification of test instrument as per specification:-	The details of the test instrument should be as per specification and the calibration certification should be verified (Within 1 Year)	
	The bidder has to submit a technical catalog of the earth resistivity measurement instrument to be used in the tender for measurement.		
	Make of instrument		
	4 Pole testing available		
	Professional earth test kit accessories (Company provided: Cable Reels, Spikes, etc.)		

5.0 GUARANTEE:-

- a)** The product/service offered shall have a guarantee for the material used or supplied for the carting, installation, testing, commissioning, and workmanship. If these are not done as per the design and the specifications; they shall have to be repaired/replaced free of cost if reported within 66 months from the date of dispatch or 60 months from the date of commissioning whichever is earlier.
- b)** Reported failed/defective units under the guarantee period as above shall be repaired/replaced as early as possible. In any case, it should be repaired/replaced within 30 days. If an immediate arrangement for the correction of the failed units as mentioned in the tech specifications are not done by the Supplier and if the units are not repaired/replaced within two months' time, the DISCOM will deduct the full cost of the services from the bill.

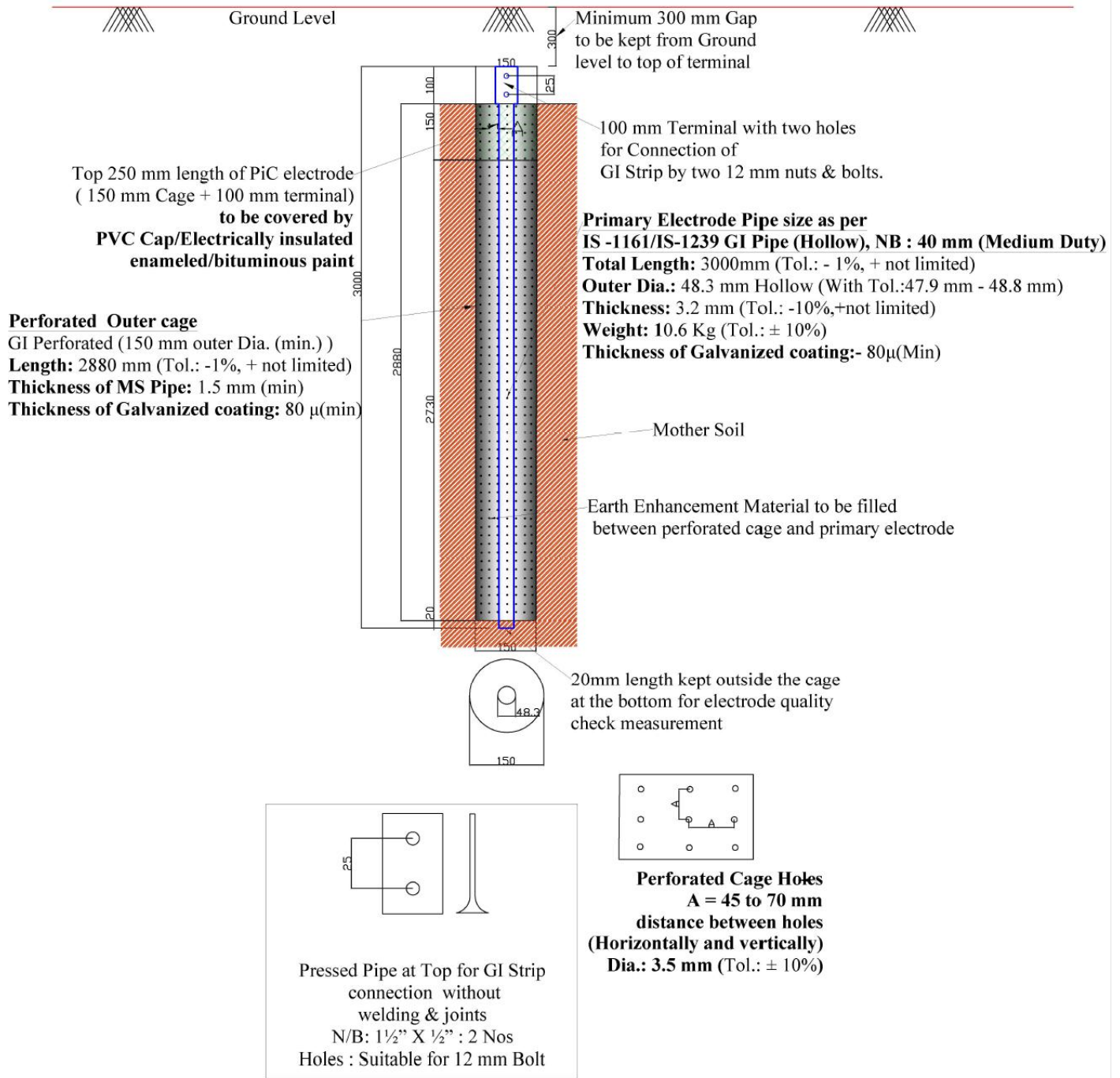
Annexure-1
(List of Testing Equipment/Machinery Required from the bidders)

Sr. No.	Name of Equipment	Technical Requirement	Deviation (Yes/No) (Mentioned detail, If any)
1	Soil Box	Designed in compliance with standard ASTM G57	
2	Digital Vernier Calipers*	Range : 0-200mm LCD Resolution : 01mm Accuracy : ±0.02mm	
3	Digital Micrometer Screw gauge*	Range : 0-25mm Accuracy : ±2µm Type : With ratchet stop	
4	Digital Weighing scale*	Range : 10 g to 100 kg Precision : 10gram Weighing platform : 300x300mm wide	
5	Steel Scale*/ Measuring Tape*	Range : 1 cm-1000cm Precision : 1 cm	
6	Coating thickness tester*	Measuring Ranges: Ferrous/Non-ferrous : 0 ~ 1000um; Guaranteed Tolerance: Ferrous: ±3% +1um; Non-ferrous: ±3% +1.5um Precision: Ferrous/Non-ferrous: 0.1um.	
7	Digital Professional Earth Test Kit*	4-Pole Professional Earth test kit Company provided 30-meter reels, spikes, Test leads, etc. of Megger, Chauvin Arnoux or fluke make. Accuracy : ±2% or better.	

* All instruments having valid Company provided calibration certificate (In case of newly purchased equipment) or NABL accredited calibration certificate of 1 year or later should only be considered valid. Brochure to be provided along with the bid.

Drawing No.: GPRD-17 (Revision:2)

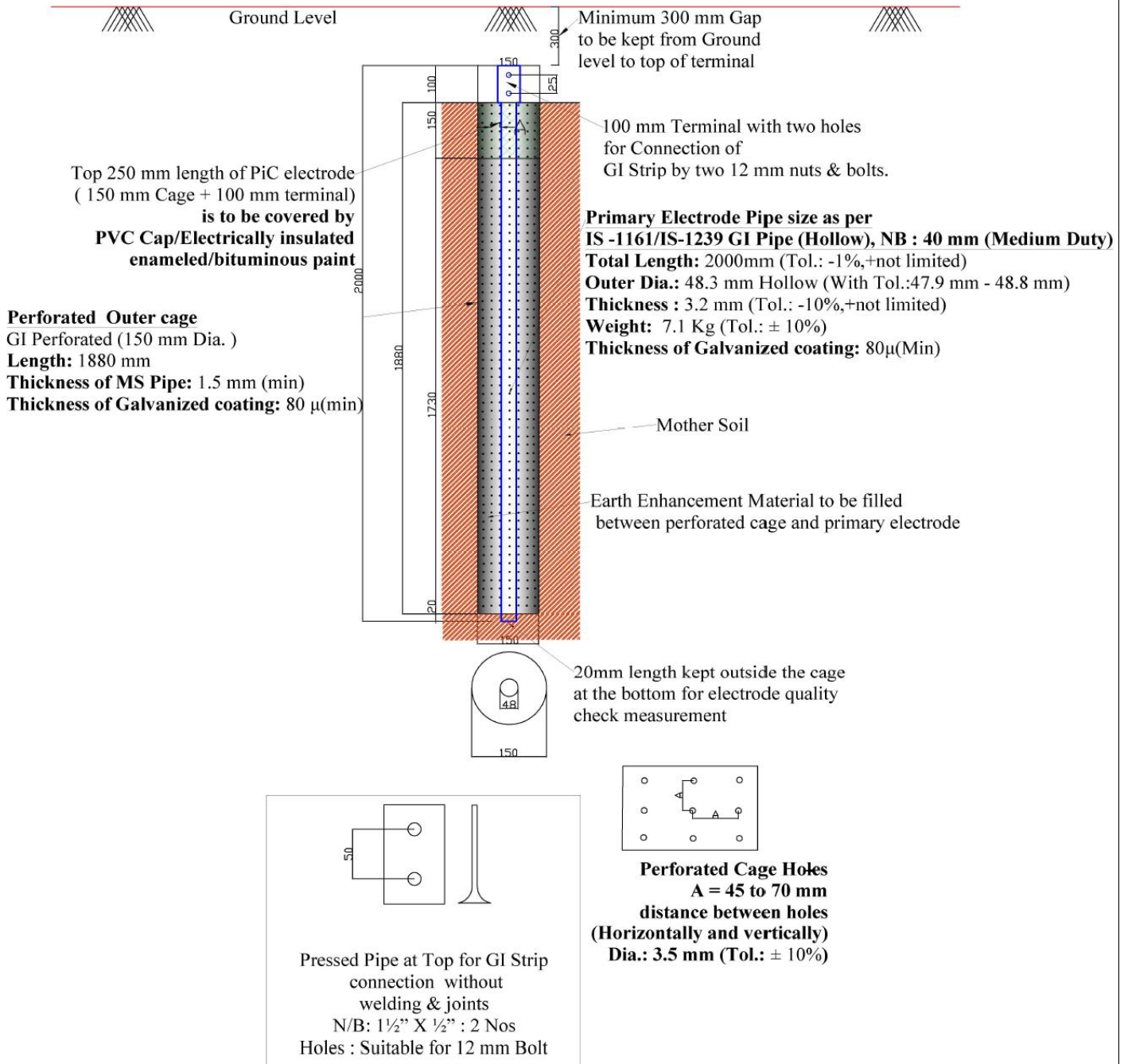
Maintenance Free, Eco-Friendly Ready Capsule - Pipe in Cage(PiC) type 3000 mm Earthing



Gujarat Power Research & Development Cell, GUVNL, Gandhinagar			
Project : Maintenance Free, Eco-Friendly Ready Capsule - Pipe in Cage (PiC) type 3000 mm Earthing			
Prepared By:	H.M.Sakariya, JE (R&D)		Date : 13/08/2021
Checked By :	D.R.Shah, DE (R&D)		Revision : 2
Approved By :	J.B.Upadhyay, i/C SE (R&D)		Scale: N.T.S.

Drawing No.: GPRD-16 (Revision:2)

Maintenance Free, Eco-Friendly Ready Capsule - Pipe in Cage (PiC) type 2000 mm Earthing



Gujarat Power Research & Development Cell, GUVNL, Gandhinagar			
Project : Maintenance Free, Eco-Friendly Ready Capsule - Pipe in Cage (PiC) type 2000 mm Earthing			
Prepared By:	H.M.Sakariya, JE (R&D)		Date : 13/08/2021
Checked By :	D.R.Shah, DE (R&D)		Revision : 2
Approved By :	J. B. Upadhyay, i/C SE (R&D)		Scale: N.T.S.

2. G.I. Earthing Bolts & Nuts with Washer & Spring Washer for Earthing of HT/LT Distribution System

SCOPE :-

This specification covers the details of G.I. Bolts and Nuts (With washer and spring washer) of size 40mmx16mm for Earthing purpose. The same are to be used to connect G.I. Wire.

APPLICABLE STANDARD :-

Except when it complies with specific requirement in this specification, the bolts and nuts shall comply with IS: 1363/1992 Part-I and Part-III & the zinc coating shall comply with IS: 2633/86 with latest amendments. Plain washer as per IS: 2016 /1967 suitable for M-16 Bolts and Spring Washers as per IS: 3063/1994 suitable for M-16 bolts.

Applicable Drg. : Drg. No. Tech - 321 Rev. 4.

TESTS :-

The bolts, nuts, washers and spring washers shall be hot dip galvanized and shall withstand following acceptance test:

- i) Visual Inspection.
- ii) Dimension check.
- iii) Galvanizing test (Uniformity) (Four dips)

SAMPLING :-

Sampling for each lot shall be 32 Nos. for the above acceptance tests.

PACKING :-

The bolts shall be packed in lots of 250 Nos. duly assembled in standard double gunny bags or double woven polythene bag, packing. Supplier should keep the material duly packed in double gunny bag or double polythene bags with lead seal provided for sealing of materials after inspection.

TENDER SAMPLES :- (Deleted)

SUBMISSION OF DRAWING :-

The successful bidders will have to submit the three Nos. of drawing within 7 days from the date of receipt of the order for our approval.

Name of Manufacturer

and Address:

GUARANTEED TECHNICAL PARTICULARS

PART 'A'

Technical Information and Guaranteed Technical Particulars for supply of G.I.Earthing Bolts & Nuts size 40X16 mm:

Sr. No.	Particulars	Confirmation
1	The G.I.Earthing Bolts & Nuts size 40X16 mm with plain Washer & Spring Washer shall confirm to- 1) IS:1363 (P.I & III), IS: 2633/86, IS: 2016/67 & IS: 3063/94 2) Company Specification & 3) Drawing No. Tech X 321 (Rev. 4)	Yes
2	Size 40X16 mm	Yes
3	Dimension of Bolts & Nuts shall be as per IS:1363/92 full thread M-16, except slot dimension, as per Drg. No. Tech - 321 (Rev. 4).	Yes
4	Dimension of Washer shall be as per IS: 2016/67	Yes
5	Dimension of Spring Washer shall be as per IS: 2016/67	Yes
6	Bolt, Nut, Washer, Spring Washer shall be hot dip galvanized.	Yes
7	Tolerance in dimension as per relevant IS and as mentioned in Drawing No. Tech X 321 (Rev. 4)	Yes
8	Galvanizing Test as per IS: 2633/86	Yes
9	Packing shall be in double gunny bags / polythene bags containing 250 Nos. per bag.	Yes

PART 'B' : (ENCLOSURES)

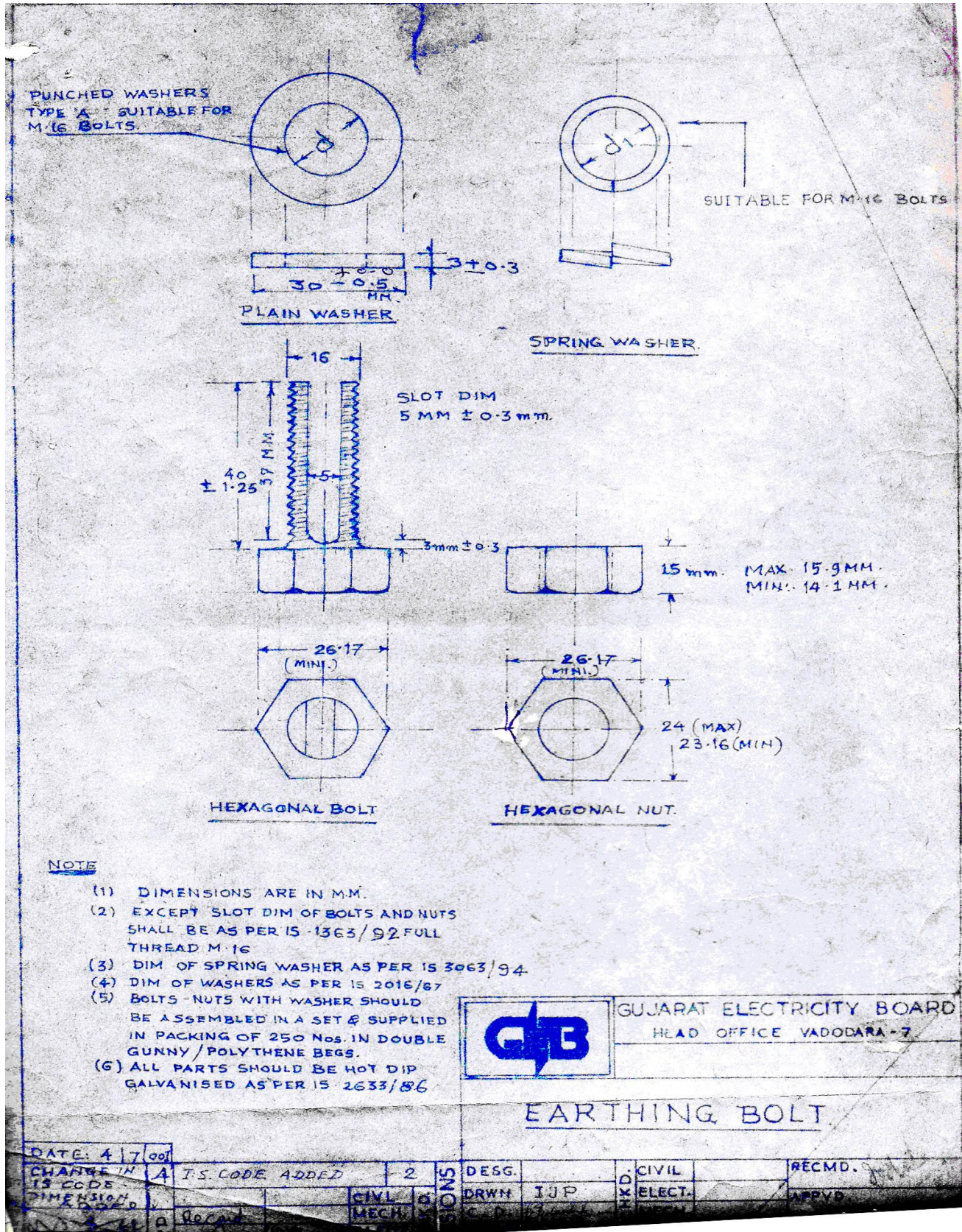
Bidders have to furnish below documents and have to confirm the requirements:

Sr. No.	Particulars	Confirmation
1	Submission of own drawing duly signed & seal in line with Drawing No. Tech X 321 (Rev. 4)	Yes
2	List of Plant & Machinery available.	Yes
3	List of testing facilities.	Yes
4	List of orders pending / executed: a) With GUVNL (Formerly GEB) and/or their subsidiary companies i.e. PGVCL/MGVCL/DGVCL/UGVCL b) With agencies other than GUVNL (Formerly GEB) and/or their subsidiary companies i.e. PGVCL/MGVCL/DGVCL/ UGVCL	Yes

PART 'C'

Bidder has to mention technical deviation if any, quoting relevant clause of specifications, in respective Annexure only. Any deviation given elsewhere will not be considered and will be ignored.

Drawing:



3. Earthing

(AS PER IS 3043-1987)

Earthing shall generally be carried out in accordance with the requirements of Indian Electricity Rules 2003 amended from time to time and relevant regulations under Electricity Supply Authority concerned.

In case of high and extra high voltages, the neutral points shall be earthed by not less than two separate distinct connections with earth, each having its own electrodes sub-station and will be earthed at any other point provided no interference is caused by such earthing. If necessary, the neutral may be earthed through suitable impedance.

As far as possible, all earth connections should be visible for inspection. Each earthing system shall be so designed, that, the testing of individual earth electrodes is possible. It is recommended that the value of any earth system resistance shall be such as to conform to the degree of shock protection desired.

It is recommended, that a drawing showing the main earth connections and earth electrodes be prepared for each installation and submitted to Employer.

No addition to the current carrying system, either temporary or permanent, shall be made which will increase the maximum available fault current on its duration until it has been ascertained that the existing arrangement of earth electrodes, earth bus-bar etc., are capable of carrying the new value of earth fault current which may be obtained by this addition.

All materials, fittings etc., used in earthing shall conform to Indian Standard Specifications, wherever they exist.

GENERAL REQUIREMENTS AND PROCEDURES FOR EARTHING AT SUB-STATIONS.

The ground resistance for sub-stations should not exceed a value 2(two) ohms. The joints/connections in the earthing, system shall be welded only, except the connections, which require opening for testing/maintenance. Such connections should be bolted tightly, using spring and ring washers for proper contact pressure. The G.S. flats to be provided for the horizontally laid earth grid should have overlap welded joints, with length of welding at least twice the width of the flat, e.g., 100 MM for 50x6 MM G.S. flats. There should not be any dirt, grease, oil, enamel, paint or any such non-conductive coatings on the surfaces being joined/ connected. Only the finished joints/connections above ground may be provided with red-oxide or any other protective coating. Underground earth electrodes and earth grid elements, when laid, should have a clean metallic surface, free from paint, enamel, grease or any such non-conductive coatings.

As far as possible, all earth connections should be accessible for visual inspection. No cut-outs, links or switches, other than linked switches arranged to operate simultaneously on the earthed or earthed neutral conductor and the live wire shall be inserted in the supply system. Earth electrodes or mate should not be installed in close proximity to metal fence to avoid possibility of fence becoming live. Separate earth electrodes, isolated from the earth grid, are to be provided for grounding the fence wires.

Pipes or rods used as electrodes should be in one piece, as far as possible, with a minimum allowable length of 3 mtrs. Except where rock or hard stratum is encountered, the pipe/rod electrodes should be

driven into the ground to a minimum depth of 3 mtrs. The strip electrodes, forming the horizontal grid, should be buried underground to a minimum depth of 0.5 mtrs. The path of earth wire should be out of normal reach of any person, as far as possible.

For high resistivity soils, above 100 Ohm-mtrs., attempts should be made to bring the soil resistivity in the range of 50 to 60 Ohm-mtrs. By digging and treating the soil mass around the earth grid/electrodes with a mixture of salt and charcoal.

In case of rocky top soil and sub-stratum, having very high resistivity, with no scope of improvement by other means, the procedure given below should be followed:

- 1.** At least two bores of diameter little less than 40 mm, with a minimum distance of 10 mtrs. between them, should be made in the ground at suitable locations inside the S/S yard. The boring should be done until soil sub-stratum rich in moisture and low in resistivity is encountered. G.I. pipes of 40 MM dia. should be descended in each bore, such that, the soil mass around the pipes grips them tightly, Back – filling of bores, if required, with wet soil/clay may be done to ensure this condition. The G.I. pipes in these deep bores should be interconnected with the main earthing grid of the S/S through 50x6 mm G.S. flat, with all the joints/connections and terminations being either fully welded, or clamped/bolted and welded simultaneously. The G.I. pipes in the bores should also be interconnected with each other. In extreme cases, the bores may have to be made at remote locations i.e. outside the S/S yard, with inter-connections, through 50x6 MM flats, as explained before.
- 2.** The procedures to be observed stringently for making connections and joints between various elements of the earthing system are as follows:
 - a.** G.S. flat to Structure/flat - The G.S. flat should be welded to the metallic portion (leg) of the structure after thoroughly cleaning the surfaces to be welded. The length of the welding should be at least twice the width of the G.S. flat, e.g.-minimum 100 mm for 50x6 mm G.S. flat. Exactly similar procedure is to be adopted for joints between two G.S. flats.
 - b.** G.I. wire to structure. The G.I. wire should be bolted to the structure after making an eye formation and kept tight with the help of spring and ring washer. Then, the entire arrangement should be welded.
 - c.** G.I. wire to G.S. flat- The G.I. wire should be bolted and then welded to G.S. flat, as explained above.
 - d.** G.I. rod to G.S. flat- The G.I. rod should be securely clamped to the G.S. flat with the help of bolts and washers and the entire arrangement should then be welded.
 - e.** G.I. wire to G.I. pipe – GI wire should be bolted to the G.I. pipe and then welded, keeping in view the relevant precautions, mentioned before.
 - f.** G.I. flat to G.I pipe – The GI flat should be bolted tightly to the G.I. pipe and then the connection should be welded.

Before making connections and joints, it should be ensured that, the elements to be joined have a clean metallic contact surface without any non-conductive coating.

EARTH GRID SYSTEM

Grid system of interconnected conductors forming a closed loop mesh is to be installed using 75x8 mm MS flat for peripheral and branch conductors. Interconnections are made by welding them. This earth grid will be laid at a depth of about 0.5 mtr. bonded to general mass of the earth by 3 mtrs. long earth electrode of solid MS rod (or pipe) of dia 25mm. The G.I. pipe 40 mm. dia 3 mtrs. long in the earthing pits, driven vertically.

It is to this earth grid that the transformer neutral, apparatus, frame work and other non-current carrying metal work associated like transformer tank, switchgear frame etc. are to be connected. All these connections should be made in such a way that reliable and good electrical connection is ensured. Aluminum/ other paint, enamel, grease and scale should be removed from the point of contact before connections are made. No part of the ground connection leads should be embedded in concrete.

Arrangement of connection of earth connection shall be as follow:

1. STRUCTURES:

Structures including frames, metal supports within the substation grid at least two legs, preferably diagonally opposite (where more than two legs are provided) on each metal structure shall be connected to earth grid with GI wire of 4mm dia or 6 mm dia.

2. ISOLATORS/ SWITCHES:

The operating handle shall be connected to earth grid independent of the structure earthing or through the steel mounting structure, through 4 mm dia G.I. wire.

3. LIGHTNING ARRESTOR:

The bases of lightning arrestors shall be directly connected to the earth electrodes by 4 or 6 SWG G.I. wires as short and as straight as practicable, to ensure minimum impedance. Separate earth leads should be used for L.A. in each phase. In addition there shall be as direct connections as practicable from the earthed side of the lightning arrestors to the frame of the apparatus being protected. Surge counters, could also be inserted in the circuit where lightning incidences are high, but in such cases, the lightning arrestor should be mounted on insulated base. Invariably, earth connections for lightning arrestors should be separate, and in no case should they be joined looped or meshed with other conductors. For lightning arrestors mounted near transformers, earthing connections shall be done with the earthing pits and earthing leads shall be laid clear of the tank and collars in order to avoid possible oil leakage caused by arcing. The earth connection should not pass through iron pipes, as it would increase the reactive impedance of the connection.

4. POWER TRANSFORMER:

- The tank of the transformer shall be directly connected to the main earth grid. In addition there shall be a separate and as direct a connection as practicable from the tank to the earth side of protecting LA using 4 or 6 SWG GI wire.

- The earthing of the neutral shall be by two separate, distinct and direct connections of 50x6 mm GS flat to earth pits, which form a part of the earth grid, and shall be run clear of the tank and collars.
- The transformer track rails shall be connected to earth

5. OUT DOOR VCB:

At least two legs, preferably diagonally opposite of the supporting structure frame work of each circuit breaker unit shall be connected to the earth grid, through 50x6 mm G.S. flats.

6. FENCING:

Fencing and gate should be earthed separately.

7. CURRENT TRANSFORMERS / POTENTIAL TRANSFORMERS:

The bases of the current transformers should be directly connected to the earth grid through 4 or 6 SWG G.I. wires. The base (neural side) of the P.Ts. should be directly connected to the earth grid through 4 or 6 SWG G.I. wires. Separate earth leads should be used for P.Ts. in each phase. The termination of leads on the P.T. neutral should be bolted/clamped and not welded, to facilitate opening of the earth connection for testing purposes. In addition, all bolted cover plates to which bushings are attached, should be connected to the earth grid, both in case of C.Ts. and P.Ts.

- 8.** Armoring of armored metal-sheathed cables within the station grid area shall be connected to the earth grid.

Substation L.T. Supply Transformer: Same as above except that the neutral earthing conductor used shall be 4 or 6 SWG G.I. wire.

4. Installation

1. Earthing

The earthing shall be done in accordance with requirements. Earthing of panels shall be done in line with the requirements given in respective equipment section of this specification.

2. Civil Works

The civil works shall be done in accordance with requirements stipulated under Section-17 of this specification.

3. Structural Steel Works

The structural steel works shall be done in accordance with requirements stipulated under Section-17 of this specification.

4. Bay Equipment

- 4.1 The disposition of equipment to be supplied is shown in enclosed single line diagrams and layout drawings.
- 4.2 The Bidder shall prepare layout drawings and submit the same for approval of the EMPLOYER. The approval of drg. shall not absolve Bidder from his responsibility regarding designing & engineering of Sub-Station and Bidder shall be fully responsible for all works covered in the scope of this specification.

5. Lightning Protection

Detailed drawings shall be submitted for approved locations on Sub-Station towers provision of lightning rod electrode at suitable Location.

- 5.1 Lightning protection System down conductors shall not be connected to other conductors above ground level. Also no intermediate earthing connection shall be made to Surge arrester, Voltage Transformer, earthing leads for which they shall be directly connected to rod electrode.
- 5.2 Every down conductor shall be provided with a test joint at about 150 mm above ground level. The test joint shall be directly connected to the earthing system.
- 5.3 The lightning protection system shall not be in direct contact with underground metallic service ducts and cables.

6. Equipment Erection Notes

- a. All support insulators, circuit breaker interrupters and other fragile equipment shall be handled with cranes with suitable booms and handling capacity.
- b. Where, assemblies are supplied in more than one section, Bidder shall make all necessary mechanical and electrical connections between sections including the connection between buses. Bidder shall also do necessary adjustments/alignments necessary for proper operation of circuit breakers, isolators and their operating mechanisms. All components shall be protected against damage during unloading,

transportation, storage, installation, testing and commissioning. Any equipment damaged due to negligence or carelessness or otherwise shall be replaced by the Bidder at his own expense. The Bidder shall strictly follow manufacturer's recommendations for handling and erection of equipment.

- c. The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc. Handling equipment, sling ropes etc. should be tested before erection and periodically thereafter for strength.
- d. Bending of piping should be done by a bending machine and through cold bending only. Bending shall be such that inner diameter of pipe is not reduced. The pipes shall be thoroughly cleaned before installation.
- e. Cutting of the pipes wherever required shall be such as to avoid flaring of the ends. Hence only a proper pipe cutting tool shall be used. Hack saw shall not be used.
- f. For cleaning the inside and outside of hollow insulators only Muslin or leather cloth shall be used.

7. Storage Of Equipment

Bidder is responsible for the proper storage and maintenance of all materials/equipment to be supplied by him for the work. The Bidder shall provide & construct adequate storage shed for proper storage of equipment. Sensitive equipment shall be stored indoors. All equipment during storage shall be protected against damage due to acts of nature or accidents. Bidder shall take all required steps to carryout subsequent inspection of materials/equipment stored as well as erected until the same is taken over by the EMPLOYER. The storage instruction of the equipment manufacturers/ Engineer-in-Charge shall be strictly adhered to.

8. Cabling

- 8.1 Cabling shall be in trenches, excavated trenches for direct burial, pulled through pipes and conduits run clamped on steel structures etc.
- 8.2 Cables inside the Sub-Station shall be laid on angle supports at 600mm spacing with separate tiers for control and power cables.
- 8.3 All interpole cables (both power & control circuit) for equipments shall be laid in cable trenches/G.I. Conduit Pipe of NB 50/100mm which shall be buried in the ground at a depth of 300mm.

9. Conduits, Pipes And Accessories

- 9.1 The bidder shall supply and install all rigid conduits, mild steel pipes, flexible conduits, hume pipes etc. including all necessary sundry materials, such as tees, elbows, check nuts, bushings, reducers, enlargers, wooden plugs, coupling caps, nipples, gland sealing fittings, pull boxes etc. The size of the conduit/pipe shall be selected on the basis of maximum 40% fill criterion. All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed in an approved manner, to prevent damage to threaded portion and entrance of moisture and foreign material.
- 9.2 Rigid conduits shall be flow-coat metal conduits of XXX (name) Coated Tubes or equivalent make. The outer surface of the conduits shall be coated with hot-dip zinc and chromate coatings. The inner

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

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

10. Cable Tags And Marker

- 10.1 Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.
- 10.2 The tag shall be of aluminium with the number punched on it and securely attached to the cable conduit by not less than two turns of 20 SWG GI wire conforming to IS:280. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables.
- 10.3 Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanised iron plate.
- 10.4 The marker shall project 150mm above ground and shall be spaced at an interval 30 meters and at every change in direction. They shall be located on both sides of road and drain crossings.
- 10.5 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry. Cable tags shall be provided inside the switchgear, motor control centres, control and relay panels etc., wherever required for cable identification, such as where a number of cables enter together through a gland plate.
- 10.6 Specific requirements for cabling, wiring ferrules as covered in respective equipment section shall also be complied with.

11. Storage And Handling Of Cable Drums

Cable drums shall be unloaded, handled and stored in an approved manner and rolling of drums shall be avoided as far as practicable. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum. In absence of any indication the drums may be rolled in the same direction it was rolled during taking up the cables.

12. Cable Supports And Cable Tray Mounting Arrangements

- 12.1 In cases where no embedded steel inserts are available, the Bidder shall have to secure the supports on wall or floors by suitable anchoring at no extra cost to the Employer. Details of fixing steel plates by anchor fasteners shall be decided during detailed engineering stage.
- 12.2 The cable supports shall conform to the requirements of this Specification.
- 12.3 Insert plates will be provided at an interval of 600mm wherever cables are to be supported without the use of cable trays, while at all other places these will be at an interval of 2000mm.

13. Cable Terminations And Connections

- 13.1 The termination and connection of cables shall be done strictly in accordance with cable and termination kit manufacturer's instructions, drawing and/or as directed by the Employer.

- 13.2 The work shall include all clamping, fittings, fixing, plumbing, soldering, drilling, cutting, taping, heat shrinking, (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job.
- 13.3 Cost of all consumable material shall be included in the erection rates quoted.
- 13.4 The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Bidder shall be responsible for drilling of gland plates, painting and touching up. Holes shall not be made by gas cutting.
- 13.5 The Bidder shall tag/ferrule the control cable cores at all terminations, as instructed by the Employer. In panels where a large number of cables are to be terminated and cable identification may be difficult, each core ferrule may include the complete cable number as well.
- 13.6 Spare cores shall be similarly tagged with cable numbers and coiled up.
- 13.7 Control cables shall have stranded copper conductor. Bare portion of the solid conductors shall be tinned after removing the insulation and shall be terminated directly without using cable lugs.
- 13.8 All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively closed.
- 13.9 If the cable end box or terminal enclosure provided on the equipment is found unsuitable and requires modification, the same shall be carried out by the Bidder as directed by the Employer.

14. Directly Buried Cables

The Bidder shall construct the cable trenches required for directly buried cables. The scope of work and unit rates for construction of cable trenches for cables shall include excavation, preparation of sand bedding, soil cover, supply and installation of brick or concrete protective covers, back filling and reaming, supply and installation of route markers and joint markers. The bidder shall ascertain the soil parameters prevailing at site, before quoting the unit rates. Laying the cable and providing protective covering shall be as per approved drawing.

15. Installation of Cables

- 15.1 Power and control cables shall be laid in separate tiers. The order of laying of various cables shall be as follows, for cables other than directly buried.
 - a) Power cables on top tiers.
 - b) Control, instrumentation and other service cables in bottom tiers.
- 15.2 Single core cables in trefoil formation shall be laid with a distance of three times the diameter of cable between trefoil centre lines. All power cables shall be laid with a minimum centre to centre distance equal to twice the diameter of the cable.

15.3 Power and control cables shall be securely fixed to the supports. Trefoil clamps for single core cables shall be pressure die-cast aluminium (LM-6), Nylon-6 or fibre glass and shall include necessary fixing GI nuts, bolts, washer, etc. these are required at every 2 metre of cable runs.

15.4 Cables shall not be bent below the minimum permissible limit. The permissible limits are as follows:

a)	Type of cable & voltage grade	Minimum bending radius
b)	Power cable	12 D
c)	Control cables	10 D

Where D is overall diameter of cable.

15.5 Where cables cross roads, drains and rail tracks, the cables shall be laid in reinforced spun concrete or steel pipes, buried at not less than one metre depth.

15.6 In each cable run some extra length shall be kept at a suitable point to enable one (for LT Cables) or two (for H.T cables) straight through joints to be made, should the cable develop fault at a later date.

15.7 Selection of cable drums for each run shall be so planned as to avoid using straight through joints. In case joints are necessary the same shall be supplied by the Bidder. Cable splices will not be permitted except where called for by the drawings, unavoidable or where permitted by the Employer.

15.8 Control cable terminations inside equipment enclosures shall have sufficient lengths so that switching of termination in terminal blocks can be done without requiring any splicing.

15.9 Metal screen and armour of the cable shall be bonded to the earthing system of the station, wherever required.

15.10 Rollers shall be used at intervals of about 2.0 metres, while pulling cables.

15.11 All due care shall be taken during unreeling, laying and termination of cable to avoid damage due to twist, kink, sharp bends etc.

15.12 Cable ends shall be kept sealed to prevent damage.

15.13 Inspection on receipt, unloading and handling of cables shall generally be in accordance with IS: 1255 and other Indian Standard Codes of practices.

15.14 Wherever cables pass through floor or through wall openings or other partitions, wall sleeves with bushes having a smooth curved internal surface so as not to damage the cables, shall be supplied, installed and properly sealed by the Bidder at no extra charges.

15.15 The erection work shall be carried out in a neat workmanlike manner and the areas of work shall be cleaned of all scrap materials, etc. after the completion of work in each area every day. Bidder shall remove the RCC/steel bench covers before taking up the work and shall replace all the trench covers after the erection work in that particular area is completed or when further work is not likely to be taken up for some time.

15.16 Bidder shall furnish three copies of the report on work carried out in a particular week, such as cable numbers and a date on which laid, actual length and route, testing carried out, along with the marked up copy of the cable schedule and interconnection drawing wherever any modifications are made.

- 15.17 In case the outer sheath of a cable is damaged during handling/installation, the Bidder shall repair it at his own cost, and to the satisfaction of the Engineer-in-Charge. In case any other part of a cable is damaged, the same shall be replaced by a healthy cable, at no extra cost i.e. the Bidder shall not be paid for installation and removal of the damaged cable.
- 15.18 All cable terminations shall be appropriately tightened to ensure secure and reliable connections. The Bidder shall cover the exposed part of all cable lugs whether supplied by him or not with insulating tape, sleeve or paint.

16. Conduits, Pipes Installation

- 16.1 Bidder shall supply all conduits, pipes and ducts as specified and to be shown in detailed engineering drawing. Flexible conduit should be used between fixed conduit and equipment terminal boxes. Where vibration is anticipated, the flexible conduit shall be as per the relevant IS.
- 16.2 Bidder shall have his own facility for bending, cutting and threading the conduits at site. Cold bending should be used. All cuts & threaded ends shall be made smooth without leaving any sharp edges. Anti corrosive paint shall be applied at all field threaded portions. The Bidder shall supply and apply this protective material.
- 16.3 All conduit/pipes shall be extended on both sides of wall/floor/openings. Exposed conduits/pipes shall be adequately clamped at an interval of about 2m. The fabrication and installation of supports and the clamping shall be included in the scope of work by Bidder.
- 16.4 When two lengths of conduits are joined together through a coupling, running threads equal to twice the length of coupling shall be provided on any length to facilitate easy dismantling of two conduits.
- 16.5 Conduit installation shall be permanently connected to earth by means of special approved type of earthing clamps. G.I. Pull wire of adequate size shall be laid in all conduits before installation.
- 16.6 Each conduit run shall be painted with its designation as indicated on the drawings, such that it can be identified at each end.
- 16.7 Embedded conduits shall have a minimum concrete cover of 50mm. Positioning and ensuring proper alignment during concrete by other agencies shall be the responsibility of the Bidder.
- 16.8 Conduit runs sleeves shall be provided with the bushings at each end.
- 16.9 Metallic conduit runs at termination shall have two locknuts and a bushing for connection. Flexible conduits shall also be suitably clamped at each end. Bushings shall have rounded edges so as not to damage the cables.
- 16.10 Where embedded conduits turn upwards from a slab or fill, the termination dimensions shown on the drawings, if any, shall be taken to represent the position of the straight extension of the conduit external to and immediately following the bend. At least one half the arc length of the bend shall be embedded.
- 16.11 For underground runs, Bidder shall excavate and back fill as necessary.

ANNEXURE-I : Earthing Notes

1. General

- 1.1 Neutral points of systems of different voltages, metallic enclosures and frame works associated with all current carrying equipments and extraneous metal works associated with electric system shall be connected to a single earthing system unless stipulated otherwise.
- 1.2 Earthing system installation shall be in strict accordance with the latest editions of Indian Electricity Rules/CEA Regulations, relevant Indian Standards and Codes of practice and Regulations existing in the locality where the system is installed.
- 1.3 Bolts and nuts required for earthing all main equipment structures and for connecting with earthing system shall be in the scope of the Bidder.

2. Details Of Earthing System

Item	Size	Material
Main Earthing conductor	Suitable for a system	Mild Steel
	current of 31.5 KA/1s as	
	per IS	
Conductor above ground & earthing leads (for equipment)	To be submitted by the vendor as per above	Galvanized Steel
Rod Electrode	Suitable for a system	Mild steel
	current of 31.5 kA/ 1s as	
	per IS	
G.I. Earthwire	7/8 SWG	GI

3. Earthing Conductor Layout

- 3.1 Earthing conductors in outdoor areas shall be buried at least 600mm below finished grade level unless stated otherwise.
- 3.2 Minimum 3000 mm spacing between rod electrodes shall be provided unless stipulated otherwise.
- 3.3 Wherever earthing conductors cross cable trenches, underground service ducts, pipes, tunnels, railway tracks etc., it shall be laid at least 300 mm below them and shall be re-routed in case it fouls with equipment/structure foundations.
- 3.4 Tap connections from the earthing grid to the equipment/structure to be earthed, shall be terminated on the earthing terminals of the equipment/structure, if the equipment is available at the time of laying the grid. Otherwise, “earth insert” with temporary wooden cover or “earth riser” shall be provided near the equipment foundation / pedestal for future connections to the equipment earthing terminals.
- 3.5 Earthing conductor along their run on cable trench ladder columns, beams, walls, etc. shall be supported by suitable welding/cleating at intervals of 750 mm. Earthing conductors along cable trenches shall be on the wall nearer to the equipment. Wherever it passes through walls, floors etc. galvanized iron sleeves shall be provided for the passage of the conductor. Both ends of the sleeves shall be sealed to prevent the passage of water through the sleeves.
- 3.6 Earthing conductor around the building shall be buried in earth at a minimum distance of 1500mm from the outer boundary of the building. In case high temperature is encountered at some location, the earthing conductor shall be laid minimum 1500mm away from such location.

- 3.7 In outdoor areas, tap connections shall be brought 300mm above ground level for making connections in future, in case equipment is not available at the time of grid installations.
- 3.8 Earthing conductors crossing the road shall be either installed in hume pipes or laid at greater depth to suit the site conditions.
- 3.9 Earthing conductors embedded in the concrete fibre shall have approximately 50mm concrete cover.

4. Equipment And Structure Earthing

- 4.1 The connection between earthing pads and the earthing grid shall be made by short and direct earthing leads free from kinks and splices. In case earthing pads are not provided on the item to be earthed, same shall be provided in consultation with engineer. The equipments shall be earthed at two distinctive points on panels.
- 4.2 Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular interval. Apart from intermediate connections, beginning points shall also be connected to earthing system.
- 4.3 Metallic conduits shall not be used as earth continuity conductor.
- 4.4 A separate earthing conductor shall be provided for earthing lighting fixtures, lighting poles, receptacles, switches, junction boxes, lighting conduits, etc.
- 4.5 Wherever earthing conductor crosses or runs along metallic structures such as gas, water, steam, conduits, etc. and steel reinforcement in concrete it shall be bonded to the same.
- 4.6 Cable and cable boxes/glands, lockout switches etc. shall be connected to the earthing conductor running along with the supply cable which, in turn, shall be connected to earthing grid conductor at minimum two points, whether specifically shown or not.
- 4.7 Railway tracks within Sub-Station area shall be bonded across fish plates and connected to earthing grid at several locations.
- 4.8 Earthing conductor shall be burried 2000mm outside the Sub-Station fence. Every post of the fence and gates shall be connected to earthing loop by one lead.
- 4.9 Flexible earthing connectors shall be provided where flexible conduits are connected to rigid conduits to ensure continuity.

5. Jointing

- 5.1 Earthing connections with equipment earthing pads shall be of bolted type. Contact surfaces shall be free from scales, paint, enamel, grease, rust or dirt. Two bolts shall be provided for making each connection. Equipment bolted connections, after being checked and tested, shall be painted with anti-corrosive paint/compound.
- 5.2 Connection between equipment earthing lead and between main earthing conductors shall be welded/brazed type. For rust protections, the welds should be treated with red lead and afterwards thickly coated with bitumen compound to prevent corrosion.
- 5.3 Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingression.
- 5.4 Resistance of the joint shall not be more than the resistance of the equivalent length of the conductor.
- 5.5 All ground connections shall be made by electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it. Artificial cooling shall not be allowed.

- 5.6 Bending of large diameter rod/thick conductor shall be done preferably by gas heating.
- 5.7 All arc welding with large diameter conductors shall be done with low hydrogen content electrodes.

6. Power Cable Earthing

Metallic sheaths and armour of all multi core power cables shall be earthed at both equipment and switchgear end. Sheath and armour of single core power cables shall be earthed at switchgear end only.

7. Specific Requirement For Earthing Systems

- 7.1 Earthing terminal of each surge arrester, capacitor voltage transformer and lightning down conductors shall be directly connected to rod electrode which in turn, shall be connected to station earthing grid.
- 7.2 Earthing mat comprising of closely spaced (300mm x 300mm) conductors shall be provided below the operating handles of the isolators.
- 7.3 For specific requirements for earthing at panel refer to Section-Control and Relay Panel of this specification.

8. Specific Requirements For Lightning Protection System

- 8.1 Conductors of the lightning protection system shall not be connected with the conductors of the safety earthing system above ground level.
- 8.2 Down conductors shall be cleated on the structures at 2000mm interval.
- 8.3 Connection between each down conductor and rod electrodes shall be made via test joint located approximately 150mm above ground level.
- 8.4 Lightning conductors shall not pass through or run inside G.I. conduits.
- 8.5 Lightning protection system installation shall be in strict accordance with the latest editions of Indian Electricity Rules/CEA regulations, Indian Standards and Codes of practice and Regulations existing in the locality where the system is installed.

9. Procedure For Non Destructive Testing

- A) LIQUID PENETRANT EXAMINATION OF WELDED JOINTS
 - a) Evaluation of indications – As per standard Test Procedure.
- B) RADIOGRAPHIC EXAMINATION OF WELDED JOINTS to be carried out as per standard test procedure on 10% welded joint.

5. Minimum Guarantee/Warranty Required for supplied Materials

Notwithstanding any of the specifications above, the minimum Guarantee/Warranty requirement for major materials shall be as per below table:

Sr. No.	Material	Gurantee / Warranty
1	Pipe in Cage Earthing	60 months from Commissioning

6. Letters for Amendment in Technical Specification

The bidder shall ensure that due attention has been given in supply of materials and erection works as per latest amendments issued by REC/GUVNL/PGVCL from time to time. Some amendment letters are attached herewith for reference of the bidder.