STANDARD GUIDELINES FOR EARTHING SYSTEM FOR EHV SUB-STATION

1.0 General:

Earthing system in the Sub-Station plays very vital role in power system performance and that's why it requires special attention. Here general philosophy for earhing system for GETCO is framed based on various standards and references.

IS 3043- 1987 gives overall guidelines for earthing of equipments.

In IE Rules 1956, rule 67 gives the guidelines for the earthing in the sub-station.

IEEE-Standard 80 – gives detailed guidelines for providing Earthing Mat in Sub-Station.

CBIP Manual for earthing system (# 302) – gives various papers on earthing practices and case studies.

2.0 Methodology

As per the various standards, we design the complete earthing system for our EHV sub-stations. Earth mat is designed as per IEEE STD 80 - 2000.Equipments are provided the earthing as per IS 3043-1987.The drawing for earthing the equipments are compiled in Drg No GETCO/E/STD/P-012 sheet 1 to 24

- The complete design of earthing system depends on the data input. Soil Resistivity is the key input that's why its measurement plays major role in correct and optimum design.
- Soil Resistivity should be measured with reliable and accurate instrument.
- The process of measurement of Soil resistivity: Refer Drg no GETCO/E/STD/P-012 sheet 23 & 24.
  Method of Measurement of Earth Resistivity:
  Typical Switchyard Area: 70 Mtrs x 56 Mtrs
  Lx = 70 Mtrs
  Ly = 56 Mtrs
  Diagonal Dm = 90 Mtrs
  At a distance of 10-12 Mtrs along the diagonal point no. 1 to 7 & 8 to 14 are selected. Measurement with reliable (preferably electronic earth tester) meggar using Wenner's method is carried out. Select Loc. no.1, spacing between the spikes should be varied from 1.0 Mtr to 10.0 Mtrs (1, 2, 5 and 10).
  Take the readings of resistance (R) considering distance between two spikes 1, 2, 5 & 10.
  Similarly take the set of readings for all 14 locations.
  Calculate Soil Resistivity (rho) = 2 Π S R
  Where, S = Distance between two spikes in Mtrs
  R = Earth Resistance in Ohms
  Derive the average value of resistivity for all the locations of equal distance.

RESISTANCE MEASURED					RESISTIVITY CALCULATED			
Loc. No.	With S=1 Mtr	With S=2 Mtr	With S=5 Mtr	With S=10 Mtr	With S=1 Mtr	With S=2 Mtr	With S=5 Mtr	With S=10 Mtr
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
				Average				

The distance between two spikes - S should be 1, 2, 4, 8 &16 Mtr. or 1, 2, 5, 10, 20 Mtr. for a particular locations of measurement and for each value of S, Resistivity (rho) is calculated and average is calculated for such readings. This will give the average resistivity of the switchyard. If variation between max. and minimum values is < =30 % then uniform Soil Resistivity Model can be considered other wise two/multi layer model should be selected and design in this case becomes complicated and requires special care.

- Resistivity measured with distance between two spike S will actually represents the resistivity at the depth of S mtr. So one should take the readings for more distance between two spike (as the availability of land permits) to get the real model of soil resistivity.

2.1 The entire switch yard is laid with one or more Earth Mat (also called MESH) as per design. The typical drawing of mesh is given in Drg No GETCO/E/STD/P-010 .Mesh is made up of conductors (either MS round bar or MS Flat or GI strip).Conductors are laid along X and Y direction of yard with separation of D mtr. (as per design) at a depth of min.0.6 mtr.and joined together with the help of welding joints at all junctions.

2.2 Mesh should also be extended one/two meter beyond the fencing of switch yard. The poles of fencing should be connected to the mesh. The switch yard area should be such defined that fencing and 1-2 mtr beyond fencing area may fall in the area purchased by GETCO.When it is not possible to lay the mesh outside the fencing area,chainlink fencing should be replaced by compound wall of two meter height with poles (1.5mtr ht).of chain link fencing and these poles should be connected to main mesh.

2.3 Below the mesh level, vertical ground rods (MS round bars) normally having length of 3.0 mtr, are driven along the periphery and at the junction

points of mesh. These rods help fault current to spread over the vicinity of land and thus discharge it in an earth rapidly.

2.4 Crushed metal (or gravel) of 20mm size with a layer of 0.10 mtr or 0.15 mtr as per design should be spread above the soil. Normally surface resistivity of metal /gravel, we use, is considered as 3000 Ω-Mtr.
0.1 mtr layer may contain 0.05 mtr layer of crushed fine powder of metal or sand and 0.05 mtr layer of 20 mm dia metal/gravel.

3.0 Treated Earth Electrodes

The typical drawing for pipe type earth electrode is given in Drg No. GETCO/E/STD/P-011 sheet 02. (please refer recommendation 4 xvii)

3.1 Each Neutral of power transformers is to be connected with two separate treated earth electrode (with 50/100 mm dia pipe). Both of them should be connected in parallel and finally connected with main earth mat. Similarly following earth electrodes (pipe type) should be provided in a sub-station for equipments and connected with mesh.

- Each Lightning Arrestor
- Each Coupling Capacitor/CVT
- Each neutral of distribution transformer.
- Each class of CR panels combined together with one electrode
- All PLCC panels combined together with one electrode
- All the auxiliaries like Battery Chargers, LTPB and Lighting in control room together with one electrode
- All VHF set & computer sets together with one electrode.

4.0 Recommendations (**Important Aspect to keep in mind.)**

i. Spacing between the conductors may be reduced as far as possible near the periphery of the grid.
ii. Check pits in reasonable no of quantities (2 Nos for 66kV,2/3 nos for 132kV ,4-6 nos for 220kV and 6-8 for 400kV Sub-station) should be provided as per drawing attached.(GETCO/E/STD/P-011 sheet 01)
iii. Electrode for LA should be as near as possible so as to shorten the length of earth connection and preferably it should be of copper.
iv. Use of bentonite powder (clay) under and around the complete mat and also around vertical ground rods and selected portion of the yard may be advised if reisitivity is high. Other earth re-activating compound may be used for old electrodes or at the time of installation where resistivity is very high.
v. Each Street light pole outside the switch yard should be provided with a earthing as per our standard practice (charcoal + Sault +earth with round wire coil) and circumference of the pole at the foundation should be provided with a surface layer (metal gravel) for app one mtr dia area.
vi. If pipe line is passing through both the Zones of within switchyard and outside the switchyard then it should be buried below earth and connected to mesh with a conductor via clamp. If such pipe is required to be kept over

the ground it should be painted with green color and one danger board should be provided stating caution of risk of high potential during fault.

vii. No control cable should be drawn from live switch yard to out side switchyard.

viii. Power cable if required to be run from inside to outside switchyard, separate earthing with another mesh at the end outside the yard should be provided.

ix. All the reinforcement bars of RCC foundations should be firmly connected to the grid. It will increase the safety.

x. Main Gate of the switchyard should be provided with a flexible bond (usually of copper) at least at two places of each doorframe and should be connected with main mesh through suitable risers.

xi. Tower with peak should be provided with 3 mtr (or more length if requires as per design) vertical rod with 4 to 5 nos star shape horizontal conductor (round bar or strip) having 3 to 5 mtr length .The riser should be with minimum length & minimum bends and finally connected with main mesh. Similar is the case with LA (but provision of treated earth electrode may be continued if soil resistivity is high and hygroscopic nature of soil is required to be maintained.)

xii. No pipe electrode/rod electrode should be kept Isolated. In many cases pipe electrode of neutral of transformer and that for LAs are not connected with the grid .It is very dangerous in case of fault; high resistance is offered by earth and detection of fault by relay setting may not be done in time causing failure of equipment ,fire or other accidents.

xiii. For the entire switchyard there should be only one ground.

xiv. Single core cable with sheath should be earthed at one end only and not at the both ends as sheath will face circulating current for which is not designed and will get heated.

xv. Gate opening should be inside the switchyard instead of outside to safeguard against the dangerous voltage during opening the gate.

xvi. DG set doesn't require to be grounded as its operation is temporary and fault does not leave such bad effect on the system. Still for the sake of safety considering DG set as equipment it should be provided with body earthing at two places.

xvii. No treated earth electrode is required if resistivity is less (say < 50 ohm-mtr). For the purpose of mandatory electrode of neutrals and LAs etc ,simple pipe can serve the purpose. It is preferable to use 100 dia 13 mm thick CI pipe (with required 3/5 mtr length) electrodes but simple (not treated) for longer life.

5.0 Standard Design and calculations:

5.1 Earth Mat sizes and calculations for various conditions are given in Ann-1

5.2 Calculation of resistance of pipe electrodes of various types for ready reference are given in Ann -2