Earthing of Power Station/EHV Sub Station

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- Introduction to electrical Earthing
- Soil Resistivity and Interpretation

Introduction to electrical Earthing/Grounding

Electricity being the driving force of our very civilization in the last hundreds years, the extent of its use is considered as an index of development. Like all good things it brings with it a degree of danger to life and property due to defects in the electrical apparatus or their usage. Taking into account the number of lives or property lost/damaged, due to electrical shocks and fire accidents caused by electricity, it is necessary and inevitable to think of measures of safety. Providing suitable protective equipment can ensure safety from electrical shocks and fires, apart from proper design of the electrical apparatus.

One of the important aspects in the operation of the protective equipment is proper Earthing. By Earthing, it means making a connection to the general mass of the earth. Earthing also increases the reliability of the supply service as it helps to provide stability of voltage conditions, prevent excessive voltage peaks during disturbances and also as a means of providing a measure of protection against lightning.

Earthing is making an electrical connection to the general mass of earth. Its use is wide spread in the supply network right from the generation to the apparatus on the consumer's premises. The requirements of earthing varies at different points based on the fault level, soil resistivity and the safety considerations

Objectives of Earthing:-

1. To ensure that no part of equipment, other than live parts, should assume a potential which is dangerously different from that of surroundings.
2. To allow fault current dissipate safely to earth and also to assure proper operation of protective devices.
3. To suppress dangerous potential gradients on the earth surface which may cause incorrect operation of control and protective devices and also may cause shock or injury to personnel.
4. It plays a very important part in increasing the reliability of the supply service and it helps to provide stability

of voltage conditions, preventing excessive voltage peaks during disturbances and also in providing protection against lightning surges.

Types of Earthing:-

Earthing can be divided into neutral earthing and equipment earthing. Neutral earthing deals with the earthing of system neutral to ensure system security and protection, whereas equipment earthing deals with earthing of non-current carrying parts of equipment to ensure safety to personnel and protection against lightning.

Depending on the type of installation i.e., generating station, H.V. substation, transformer center, pole/tower and consumer installations, suitable earthing system has to be designed duly taking into consideration, the various requirements such as fault current, limiting of earth potential rise, safety of nearby communication circuits and safe body currents etc.

For a H.V. station earthing the two important factors to be considered are Earth potential rise and safe Touch and Step potentials.

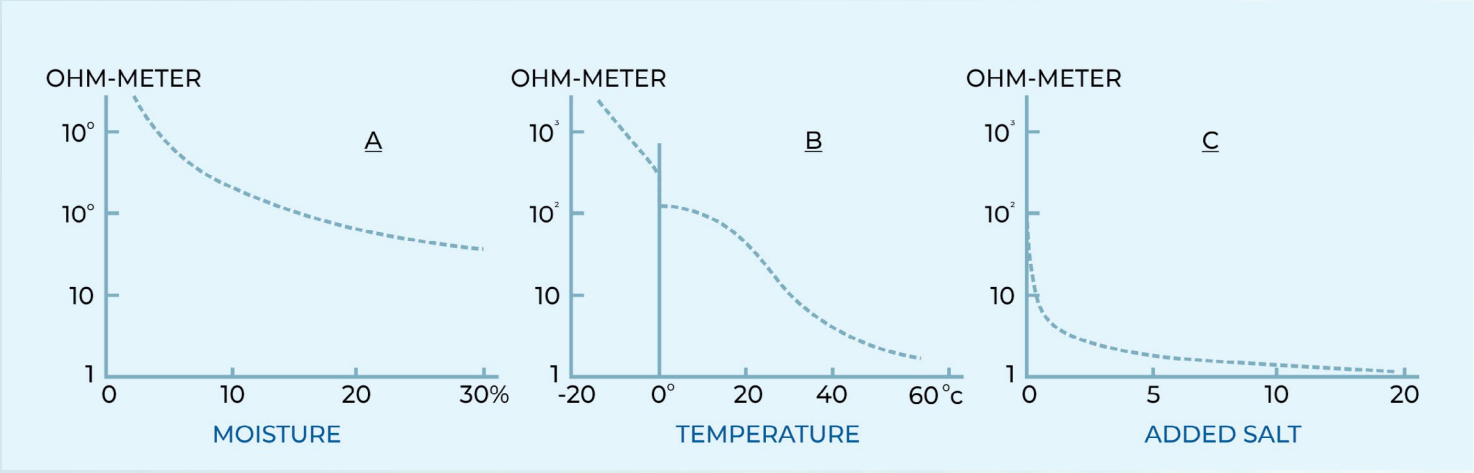
It is to be noted that limiting the Step and Touch potentials to safe value is more important than attaining a low value of the resistance. However the earth resistance of the sub-station has to be brought down to the lowest possible level. The safe value of earth resistance for any sub-station depends upon not only the level of fault current and the resistance but also on the vicinity to communication stations.

Factors to be considered for design of earth mat for an EHV Sub-station are:

1. Soil Resistivity.
2. Tolerable limits of body current.
3. Fault current.
4. Area available for earth grid.

Soil Resistivity

The resistance of earth electrode, earth electrode potential rise, and earth surface potentials that affect the magnitude of dangerous voltages, are directly proportional to electrical resistivity of soil. Therefore, it is important that the electrical resistivity of soil is measured and analyzed to decide on the soil model to be adopted for design of earth grid. Soil resistivity in an area is not constant but varies with weather conditions as well as with type and nature of soil. It can also vary with depth below earth surface. Since an earthing system shall perform for many years under varying weather conditions, proper soil resistivity measurement must be made to design an effective Earthing system.



Effect of moisture, temperature and salt on soil resistivity

Before designing Earth mat, it is necessary to determine the soil resistivity of the area in which H.V. sub-station is to be located. The resistivity of the earth varies considerably from 10 to 10,000 - meter depending on the types of soil.

Further, the resistivity may also vary at different depth depending upon the type of soil, moisture content and temperature etc., at various depths which affects the flow of current due to the fact that the earth fault current is likely to take its path through various layers.

Method of measuring the soil Resistivity

The most common method employed in the measurement of soil Resistivity is Wenner's four Electrode method. In this method, four probes are driven into earth along a straight line at equal intervals, say 'S' m. apart. The current terminals C1 and C2 of an earth tester are connected to outer electrodes and the potential terminals P1 and P2 are connected to inner electrodes. The readings of the earth tester 'R' are recorded while turning the crank at about 135 rpm. The resistivity is calculated from the following formula:

$$\rho = \frac{4\pi S R}{1 + \frac{2S}{\sqrt{S^2+4e^2}} - \frac{2S}{\sqrt{4S^2+4e^2}}}$$

Where e = depth of burial of the probe in m. and is > S/20

If 'e' is << than S the above formula reduces to $\rho = 2\pi SR$ Ω -meter.

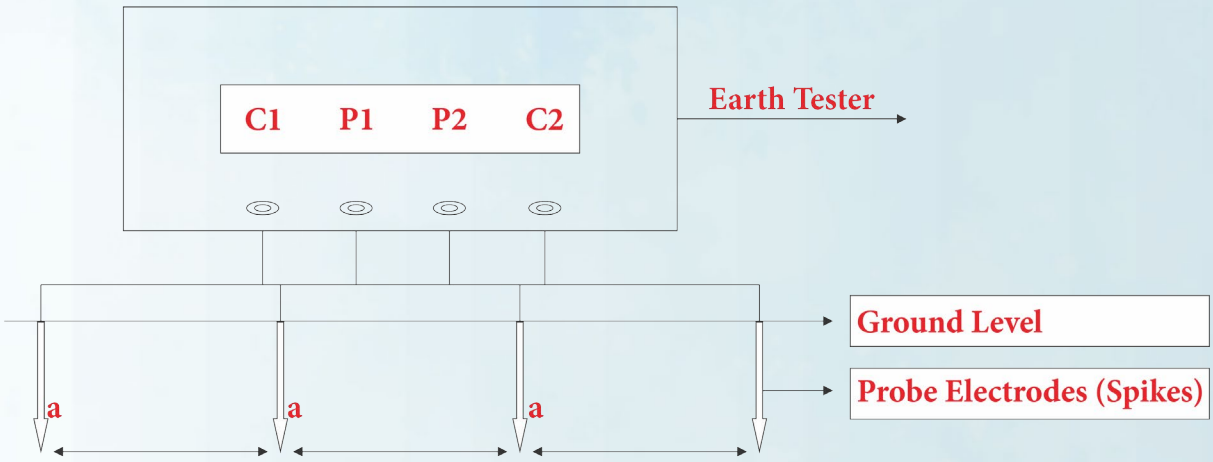
To account for the seasonal variations, the average Soil resistivity is multiplied by the factor as shown below, which is termed as the apparent resistivity.

Sl. No.	Season of measurement	Multiplication factor
1	Summer	1
2	Winter	1.5
3	Rainy	2

Method of measuring the soil Resistivity

The most accurate method in practice, of measuring the average resistivity of large volumes of undisturbed earth, is the four point method. In this method, four electrodes are driven into the earth along a straight line at equal intervals.

The most frequently used earth tester is the four terminal earth tester shown in the figure;



Test set up for earth resistivity measurement

When using such an earth tester, the resistivity may be evaluated from the equation as given below;

$$P = 2*\pi*a*R$$

Where,

P = resistivity of soil in ohm-metre,

a = distance (spacing) between successive electrodes in metre, and

R = resistance reading shown by the earth tester in ohm.