PRINCIPLES OF DIFFERENT METHODS OF EARTHING

Q. 9.1. What precautions to be observed to prevent electric shock ?

Ans.

1. Care in handling all electrical apparatus and equipments in the only effective safeguard against injury and death.
2. Never use appliances, etc., that have damaged or frayed leads
3. Replace immediately broken switches ands plugs, etc.
4. Check that all metallic parts of electrical equipment are effectively earthed.
5. Never place bare wires of leads in plug, fit a plug top.
6. Check for proper working of safety devices.
7. Proper condition of electical hand tools.
8. Correct rating of fuses, etc.
9. Never tamper unnecessarily with any live apparatus.

Q. 9.2. What is an earthing ? What is the necessity of earthing the electrical appliances and machines ?

(Foreman, Delhi, 1976, 89, 2002, 2003)

Ans. Earthing : A wire coming from the ground 2.5 to 3 metres deep from an electrode (plate or so) is called **earthing.**

The earth's potential is always taken as zero for all practical purposes.

The electrical appliances or machines when connected with earth attain zero potential and are said to be earthed.

IMPORTANCE OF EARTHING

Q. 9.3. Why earthing is done ?

Or

What is the object of earthing ?

(N.C.V.T., 1980, 1985, 86)

Ans. 1. To save human life from danger or shock or death by blowing fuse of any apparatus which become leaky.

2. To protect large buildings from atmospheric lighting.

3. To protect all machines fed from O.H. lines from lighting arresters.

4. To maintain the line voltage constant (∵ neutral of every alternator, transformer is earthed).

Good Earthing is that Earthing

Which gives very low resistance to the flow of heavy current (Short Circuit Current) of a circuit.

Q 9.4. Why Double earth is necessary for a 3 Phase machine and equipment ? How is it done ?

Ans. Double earth is used to give minimum resistance to the flow of whole current of the apparatus in case short circuit or leakage or any other such fault happens.

Second reason is, if one earth is out of order, second will do the work.

For *double earthing* : Two earthings are done at a distance of about 5 metres, and the two earth wires should be fixed with the help of thimbles (lugs) of proper sizes with the apparatus at two different places. Precaution should be taken that the two wires should not touch each other.

Earths required for each of the following (according to I.E. Rules, 1956)

1. Single-phase 1 H.P. Motor – One earth
2. Three-phase 5 H.P. Motor – Two earths
3. Three-phase 100 H.P. Motor – Two earths
4. Conduit pipe in a wall – One earth
5. A wall bracket – One earth
6. Fan Regulator – One earth
7. Portable Heater – One earth
8. Metallic supports of O.H. line one mile long – after every 3 poles

9. 11,000/440 volt transformer – Two earths.
10. Earth pin of 3 pin lighting plug sockets and 3 pin power plug sockets should be permanently and efficiently earthed.
11. All metal casing or metallic coverings containing or protecting and electric supply line or apparatus, such as iron clad switches, iron clad distribution fuse boards, G.I. Pipes and conduit enclosing V.I.R. or P.V.C. cables, the down rods of electric fans, should be connected to earth.
12. The metal casing of portable apparatus, such as heaters, refrigerators, hand lamps, soldering irons, electric drills etc., should be connected to earth. If any one of them is installed in a fixed position, a separate direct connection to the earth should be provided in addition to earth wire in the connecting cable.
13. The frame of every generator, stationary motor and so far as is possible, portable motor and the metallic parts.
14. Stay wires provided for overhead lines should be connected to earth by connecting at least one strand to the earth wire.

PLATE EARTHING

Q 9.5. Describe one method of providing good earth for an electric sub-station.

(App. 1979, Foreman, Delhi 1969, N.C.V.T., 1974, 83, 89 W/m)

Ans. For good earth in electric substation, plate earthing is used.

Plate earthing : In plate earthing, the looping earth wire is bolted effectively with the earth plate made up of copper size 60 cm × 60 cm × 3.18 mm (2′ × 2′ × 1/4″) and embedded 3 meters in ground. Copper plates are found to be most effective earth electrodes and are not affected by the soil moisture *i.e.*, these do not get rusted. But on account of its high material cost, galvanized iron plates are preferred and usually used for normal work.

In case the soil resistivity is high, the plate should be placed vertically in ground at a higher depth. A line diagram showing the plate earthing system is shown in Fig.[I]:9.1.

The plate is kept with its face vertical and is so arranged that it is embedded in an alternate layer of coke and salt for a minimum thickness of about 15 cm. The coke salt decreases the earth resistance. It should be remembered that the nuts and bolts must be of copper for copper plate and should be of G.I. for G.I. plates. Usually, the earth wire is drawn through a G.I. pipe fitted with a tunnel on the top through which salty water is poured in the pit of earth plate from time to time in summer season when the moisture of the soil will decrease to a larger extent which will increase the earth resistance.

The conductivity, *i.e.*, earthing efficiency, increases with the increase of plate area and depth of embedding. Its only disadvantage is that discontinuity of earth wire and plate below the earth cannot be observed physically; hence is misleading and sometimes results in heavy loss in case of any fault.

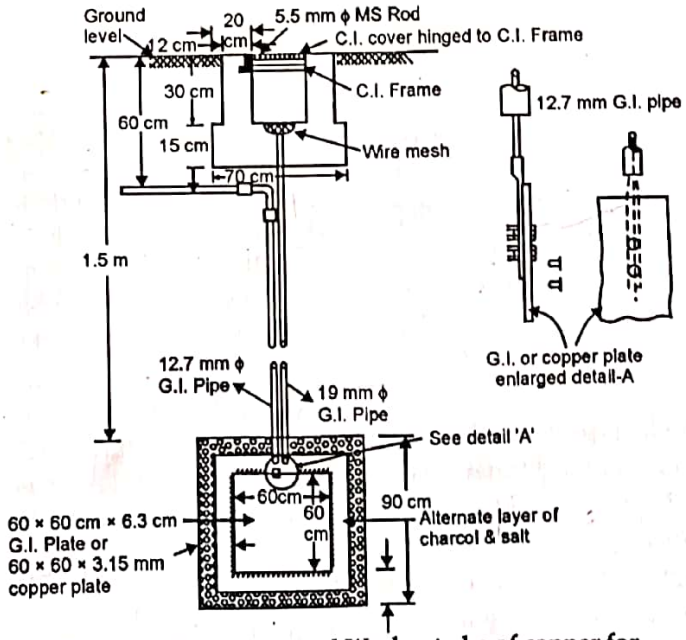

Fig.[I]:9.1. Plate earthing

PIPE EARTHING

Q 9.6. Describe pipe earthing with full specifications as per Indian Standard.

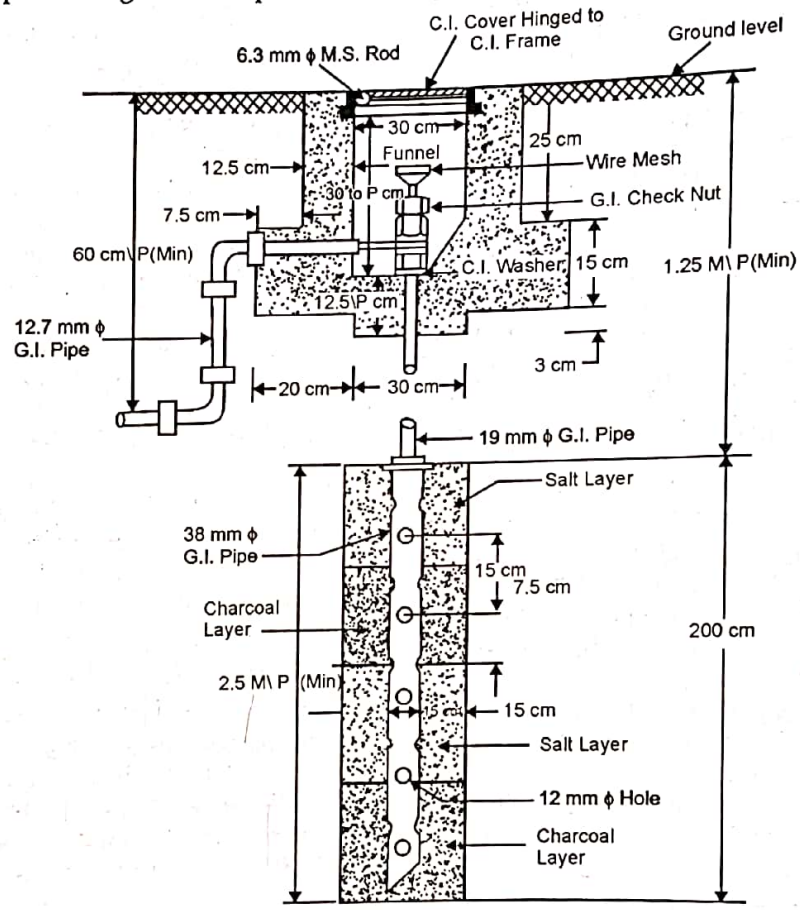

Fig.[I]:9.2. Pipe earthing

Ans. Pipe earthing : In this system of earthing a G.I. pipe of 38 mm dia and 2 metres (7 feet) length is embedded vertically in ground to work as earth electrode but the depth depends upon the soil conditions; there is no hard and fast rule for this. The earth wires are fastened to the top section of the pipe with nut bolts. The pit area around the G.I. pipes is filled with salt and coal mixture for improving the soil condition and efficiency of the earthing system.

The contact surface area of G.I. pipe with soil is more in comparison to the plate because of its circular section and hence can take up heavy leakage current for the same electrode size. The earth wire connection with the G.I. pipe being above the ground level can be checked for carrying out continuity tests as and when desired while in plate-earthing it is difficult – *It is an advantage over the plate-earthing.*

IMPROVING OF EARTH RESISTANCE

Q 9.7. What should be the resistance of a good earth ? If it increases, what steps should be taken to reduce it ? How the earth resistance is measured ? ***(N.C.V.T. 1979)***

Ans. The earth resistance for copper wire is 1 Ω and for G.I. wire it should not be more than 3 Ω.

Earth resistance is measured by earth tester which is explained in chapter Electrical Instruments. As the total current is to pass through the earth wire, the earth resistance should be kept as low as possible. The resistance increases in hot days (summer days).

To Reduce Earth Resistance

1. By pouring water : The dampness of the soil and coal salt paste depends upon the atmospheric conditions. In summer season fresh salt water should be poured through the pipe over the coal bed.

The soil resistance can be lowered only to a certain limit by the above method, and in order to lower it further following are the additional steps to be taken :

(*a*) **Increase in plate area :** In case of increase in plate area, the decrease of resistance value is not in direct proportion to the area. It is found that to reduce the resistance value by one-sixth, the increase in area is 36 times more for the same soil condition and depth of electrode. So this method is not used.

(*b*) **Increase in depth :** The increase of depth below the ground level of the same plate reduces the resistivity of the earthing system. It is found that plate area reduces to fifty percent when the depth is doubled for the soil resistance. With this method also the soil resistance value cannot be lowered as much as desired on account of excavation work; however, it helps to a great extent.

2. Electrodes in parallel : In this system of lowering earth resistance, the soil resistance falls considerably as the number of electrodes interconnected in parallel are increased for same depth. This method is suitable only where greater area of a free oil is available for earthing. The plant should be so placed in parallel as not to overlap the earthing region covered by the individual electrode.

R_1 and R_2 etc., are the earth resistance of each electrode and are the total earth resistance of the system,

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} +$$

I.S.I. GUIDELINES FOR EARTHNG

Q 9.8. What are the specifications required for Earthing as per I.S.I. ? *(N.C.V.T. 1979)*

Ans. Following are recommended specifications as per I.S.I. for providing good earthing :

1. The earthing electrode should be situated at a place atleast $1\frac{1}{2}$ metres away from the building (outside) whose installation system is being earthed.
2. The earth wire should be of same material as that of earth electrode used.
3. The minimum sectional area of earth lead wire should not be less than 0.02 sq. inch (No. 8 S.W.G.) and not more than 0.1 sq. inch.
4. The size of earth conductor as a general rule should not be less than half of the section of the line conductor.
5. The earth wire should be taken through G.I. pipe of 12 mm (1/2") dia. for at least 32 cm $\left(1\frac{1''}{4}\right)$ length above and below ground surface to the earth electrode to safeguard against mechanical wear and tear.
6. Loose earth and coal salt mixture should be filled around the earth electrode for effective earthing (see plate earthing and pipe earthing figure for more specifications).
7. The earth wire connected to the earth electrode *shall not be* necessarily run along the whole wiring system. All the earth wire run along the sub-circuits should be terminate and hooked firmly at the main board and from where the main earth wires should be run to the earth electrode. The loop earth wires should be of 14 S.W.G. copper wire.
8. All the joints in the earth wire should be firmly done with nut bolts of the same material as of earth wire.

Bonding

The connections of all the metal casings of live equipment to the earth electrode system is termed *bonding*.

Bonding provides a low resistance path for leakage current. All conduits of a wiring system are bounded together at the service switch. The service switch is connected to the local earth electrode of equipment earthing. Earthing conductors of metal conduits wiring reaching from different directions are bonded at the joint box or junction box. Bonding is done by copper wire, copper strip, GI wire or GI sheet. Equipment of a substation are generally connected to a common bonding bar.

The common bonding bar embedded in the soil works as the earth electrode.

A copper strip 4 cm by 5 mm is used for the bonding of major sub-stations of 33 kV and above : HV cable of size 120 mm^2 or more tanks of transformers of 500 kVA or more; etc.

A copper strip 2.5 cm by 3 mm is used for the bonding of small sub-stations; transformer tank below 500 kVA; HV and LV cables of 70 mm^2 or below; LV sub-stations equipment, etc.

Earth Continuity Conductor

Bonding conductors running from individual equipment to the common earth electrode are called Earth Continuity Conductors (ECC).

The size of earth continuity conductor required is determined by consideration of voltage drop and temperature rise. It is recommended that under fault conditions, the voltage drop between two normally earthed parts with which