# Substation Engineering

## Earthing Systems (IS 3043) (Part 1 of 3)

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# Earthing Systems (IS 3043) (Part 1)

- Substation Earthing System
- Introduction to Earthing
- Guidelines as per IS 3043 Code of Practice

# Lecture Agenda

- What is Earthing?
- Purpose and Need for Earthing
- Introduction to IS 3043 Standard
- System Earthing vs Equipment Earthing
- Types of Earth Electrodes
- Pipe Earthing Specifications
- Plate Earthing Specifications

# Introduction to Earthing

- Earthing (Grounding) is the connection of the non-current carrying parts of electrical equipment or the neutral point of a supply system to the general mass of earth.
- It provides an intentional, low-impedance path for fault currents to flow into the earth.
- Earth acts as a massive sink with zero potential, ensuring equipment frames stay at zero volts.
- The connection is made via an 'Earth Electrode' buried in the ground.

# Purpose and Need for Earthing

- Human Safety: Protects operating personnel from fatal electric shock in case of insulation failure.
- Equipment Protection: Provides a return path for fault currents, allowing protective relays to operate and isolate the faulty section.
- Voltage Stabilization: Maintains the voltage of healthy phases at a stable level during single line-to-ground faults.
- Lightning Protection: Discharges lightning surges and overvoltages safely to the ground.

# Introduction to IS 3043

- IS 3043 is the Indian Standard Code of Practice for Earthing.
- Provides guidelines on design, installation, and maintenance of earthing systems.
- Covers definitions, soil resistivity measurement, calculation of earth fault currents, and selection of earthing conductors.
- Specifies the dimensions and materials for earth electrodes (pipe, plate, strip).
- Harmonizes with international standards while addressing specific Indian soil and environmental conditions.

# Key Terminology in Earthing

- Earth Electrode: A metal plate, pipe, or rod driven into the ground to make electrical contact with the earth.
- Earth Continuity Conductor (ECC): The wire that connects equipment enclosures to the main earthing terminal.
- Earthing Lead: The conductor connecting the main earthing terminal to the earth electrode.
- Earth Resistance: The total resistance offered by the earth electrode and the surrounding soil to the flow of fault current.

# Categories of Earthing

- Earthing systems in substations are broadly classified into two categories:
- 1. System Earthing (or Neutral Earthing)
- 2. Equipment Earthing (or Safety Earthing)
- Both are physically interconnected in a substation via the earth grid, but they serve different distinct purposes.

# System Earthing (Neutral Earthing)

- Connecting the neutral point of a star-connected transformer or generator to earth.
- Purpose: Protects the system against arcing grounds and high overvoltages.
- Ensures relay operation by providing a closed loop for zero-sequence fault currents.
- Types: Solid earthing, Resistance earthing, Reactance earthing, Peterson coil earthing.
- Vital for stabilizing phase voltages during asymmetric faults.

# Equipment Earthing (Safety Earthing)

- Connecting non-current carrying metallic parts (frames, enclosures, structures) to earth.
- Purpose: Ensures these parts remain at or near zero potential even if live parts accidentally touch them.
- Prevents electrocution of personnel.
- Requires very low resistance so fault current prefers the earth path over a human body.
- In substations, all transformer tanks, breaker bodies, isolator bases, and fences must be grounded.

# Types of Earth Electrodes

- IS 3043 specifies several types of electrodes depending on soil conditions and fault current magnitude:
- 1. Pipe Electrode
- 2. Plate Electrode
- 3. Strip or Conductor Electrode
- 4. Rod Electrode
- For bulk installations like substations, Pipe and Plate earthing are historically common, while modern substations rely heavily on a buried grid (mesh) of strips.

# Pipe Earthing Configuration

- A galvanized iron (GI) pipe is buried vertically in the earth.
- Surrounded by alternating layers of charcoal and salt to retain moisture and improve conductivity.
- A funnel is provided at the top for pouring water to maintain soil dampness.
- The earthing lead is bolted to the top of the pipe.

*Diagram/Visual: Detailed cross-sectional diagram of pipe earthing showing GI pipe, perforations, charcoal/salt layers, and funnel assembly.*

# Pipe Earthing: IS 3043 Specifications

- Pipe Material: Galvanized Iron (GI) or Cast Iron.
- Pipe Internal Diameter: Minimum 38 mm for GI, 100 mm for Cast Iron.
- Pipe Length: Minimum 2.5 meters (for normal soil), up to 2.75m for dry soil.
- Depth of burial: The top of the pipe should not be less than 1.25 meters below ground level.
- Perforations: 12 mm diameter holes drilled at intervals for moisture diffusion.

# Plate Earthing Configuration

- A copper or GI plate is buried vertically in a deep pit.
- Like pipe earthing, the plate is surrounded by 15 cm thick layers of charcoal and salt.
- Earthing lead is securely bolted to the plate using a GI or copper pipe.
- Offers a larger surface area in contact with the soil compared to a pipe.

*Diagram/Visual: Cross-sectional diagram of plate earthing showing the vertical plate, bolted connection, and charcoal/salt fill.*

# Plate Earthing: IS 3043 Specifications

- Plate Dimensions: Minimum 60 cm x 60 cm (0.6m x 0.6m).
- Thickness: Minimum 3.15 mm for Copper, 6.3 mm for Galvanized Iron (GI).
- Depth of burial: Minimum 3.0 meters below ground level.
- Orientation: The plate must be placed vertically in the earth pit.
- Watering arrangement: A 19 mm dia pipe is provided to pour water and keep the pit moist.

# Comparison: Pipe vs Plate Earthing

| Feature | Pipe Earthing | Plate Earthing |
|---|---|---|
| Electrode | GI Pipe | Copper or GI Plate |
| Surface Area | Less | More (for a given depth) |
| Fault Current Capacity | Moderate | High |
| Cost | More Economical | Higher Cost (especially Copper) |
| Application | General purpose, domestic, small sub-stations | Heavy duty, power stations, large substations |

# Factors Influencing Earth Resistance

- Condition of the soil (moisture content).
- Temperature of the soil.
- Depth of the electrode.
- Spacing between multiple electrodes.
- Material and dimensions of the electrode.
- Presence of salts and chemical composition of the earth.

# Summary of Lecture 26

- Earthing connects equipment to the general mass of earth for safety and protection.
- System earthing handles neutral points; Equipment earthing handles metallic enclosures.
- IS 3043 is the guiding Indian standard for earthing practices.
- Pipe and Plate earthing are two traditional methods, each with specific dimensional requirements.
- Charcoal and salt are used to artificially lower soil resistivity around the electrode.

# Next Lecture Preview

- In the next lecture, we will discuss:
- Soil Resistivity and its measurement.
- Factors affecting Soil Resistivity.
- Measurement of Earth Resistance using the Fall of Potential method.
- Wenner 4-pin method for soil resistivity testing.