CHAPTER-9&10

TYPES OF TARIFF & SUBSTATION

Tariff

Definition -The rate at which electrical energy is supplied to a consumer is known as to a consumer is known as Tariff

- Although tariffs should include the total cost of producing and supplying electrical energy plus the profit,
- yet it cannot be the same for all types of consumers. It is because the cost of producing electrical energy depends to a considerable extent upon the magnitude of electrical energy consumed by the user and his load conditions.
- Therefore, in all fairness, due consideration has to be given to different types of consumers (e.g., industrial, domestic and commercial) while fixing the tariff. This makes the problem of suitable rate making highly complicated.

Objectives of Tariffs: Like other commodities, electrical energy is also sold at such a rate so that it not only returns the cost but also earns reasonable profit. Therefore, a tariff should include the following items :

- ✓ Recovery of cost of producing electrical energy at the power station.
- ✓ Recovery of cost on the capital investment in transmission and distribution systems.
- ✓ Recovery of cost of operation and maintenance of supply of electrical energy,e.g., metering equipment,billing etc.
- ✓ A suitable profit on the capital investment.

Desirable Characteristics of a Tariffs

A tariff must have the following desirable charaeteristics:

Proper return : The tariff should be such that it ensures the proper return from each consumer.

- ✓ In other words, the total receipts from the consumers must be equal to the cost of producing and supplying electrical energy plus reasonable profit.
- ✓ This will enable the electric supply company to ensure continuous and reliable service to the consumers.

Fairness: The tariffs must be fair so that different types of consumers are satisfied with the rife of of electrical energy.

- ✓ Thus a big consumer should be charged at a lower rate than a small consumer.
- ✓ It is because increased energy consumption spreads the fixed charges over a greater number of units, thus reducing the overall cost of producing electrical energy.

- ✓ Similarly, a consumer whose load conditions do not deviate much from the ideal (i.e., non-variable) should be charged at a lower* rate than the one whose load conditions change appreciably from the ideal.

Simplicity: The tariff should be simple so that an ordinary consumer can easily understand it ACOMpliCated tariff may cause an opposition from the public which is generally distrust-ful of supply companies.

Reasonable profit: The profit element in the tariff should be reasonable. An electric supply company is a’ public utility company and generally enjoys the benefits of monopoly.

- ✓ There-fore, the investment is relatively safe due to non-competition in the market. This calls for the profit to be restricted to 8% or so per annum.

Attractive: The tariff should be attractive so that a large number of consumers are encour-aged to use electrical energy. Efforts should be made to fix the tariffs in such a way so that consumers can pay easily.

Types of Tariff

There are several types of tariff. However, the following are the commonly used types of tariff :

1. Simple tariff: When there is a fixed rate per unit of energy consumed, it is called a simple tariff or uniform rate tariff.

- In this type of tariff, the price charged per unit is constant i.e., it does not vary with increase or decrease in number of units consumed.
- The consumption of electrical energy at the consumer's terminals is recorded by means of an energy meter.
- This is the simplest of all tariffs and is readily understood by the consumers.

Disadvantages

- There is no discrimination between different types of consumers since every consumer has to pay equitably for the fixed charges.
- The cost per unit delivered is high.
- It does not encourage the use of electricity.

2. Flat rate tariff: When different types of consumers are charged at different uniform per unit rates, it is called a flat rate tariff.

- In this type of tariff, the consumers are grouped into different classes and each class of consum-ers is charged at a different uniform rate.
- For instance, the flat rate per kWh for lighting load may be 60 paise, whereas it may be slightly less (say 55 paise per kWh) for power load.
- The different classes of consumers are made taking into account their diversity and load factors.

- The advantage of such a tariff is that it is more fair to different types of consumers and is quite simple in calculations.

Disadvantages

- Since the flat rate tariff varies according to the way the supply is used, separate meters are required for lighting load, power load etc. This makes the application of such a tariff expen-sive and complicated.
- A particular class of consumers is charged at the same rate irrespective of the magnitude of energy consumed. However, a big consumer should be charged at a lower rate as in his case the fixed charges per unit are reduced.

3. Block rate tariff: When a given block of energy is charged at a specified rate and the succeeding blocks of energy are charged at progressively reduced rates, it is called a block rate tariff.

- In block rate tariff, the energy consumption is divided into blocks and the price per unit is fixed in each block.
- The price per unit in the first block is the highest and it is progressively reduced for the succeeding blocks of energy.
- For example, the first 30 units may be charged at the rate of 60 paise per unit ; the next 25 units at the rate of 55 paise per unit and the remaining additional units may be charged at the rate of 30 paise per unit.

- The advantage of such a tariff is that the consumer gets an incentive to consume more electrical energy.
- This increases the load factor of the system and hence the cost of generation is reduced. However, its principal defect is that it lacks a measure of the consumer's demand.
- This type of tariff is being used for majority of residential and small commercial consumers.

4. Two-part tariff: When the rate of electrical energy is charged on the basis of maximum demand of the consumer and the units consumed, it is called a two-part tariff.

- In two-part tariff, the total charge to be made from the consumer is split into two components viz., fixed charges and running charges.
- The fixed charges depend upon the maximum demand of the consumer while the running charges depend upon the number of units consumed by the consumer.
- Thus, the consumer is charged at a certain amount per kW of maximumtt demand plus a certain amount per kWh of energy consumed i.e.,

$$\text{Total charges} = \text{Rs}\,(b \times \text{kW} + c \times \text{kWh})$$

$$b = \text{charge per kW of maximum demand}$$

$$c = \text{charge per kWh of energy consumed}$$

- This type of tariff is mostly applicable to industrial consumers who have appreciable maximum demand.

Advantages

- It is easily understood by the consumers.
- It recovers the fixed charges which depend upon the maximum demand of the consumer but are independent of the units consumed.

Disadvantages

- The consumer has to pay the fixed charges irrespective of the fact whether he has consumed or not consumed the electrical energy.
- There is always error in assessing the maximum demand of the consumer.

5. Three-part tariff: When the total charge to be made front the consumer is split into three parts viz., fixed charge, semi-fixed charge and running charge, it is known as a three-part tariff. i.e.,

$$\text{Total charge} = \text{Rs}\,(a + b \times \text{kW} + c \times \text{kWh})$$

a = fixed charge made during each billing period. It includes interest and depreciation on the cost of secondary distribution and labour cost of collecting revenues,

b = charge per kW of maximum demand,

c = charge per kWh of energy consumed.

SUBSTATION

Key Diagram of Substation 66/11KV:

Fig. 25.10 shows the key diagram of a typical 66/11 kV sub-station. The Key Diagram of Substation can be explained as under:

1. There are two 66 kV incoming lines marked 'incoming 1' and 'incoming 2' connected to the bus-bars. Such an arrangement of two incoming lines is called a double circuit. Each incoming line is capable of supplying the rated sub-station load. Both these lines can be loaded simultaneously to share the sub-station load or any one line can be called upon to meet the entire load. The double circuit arrangement increases the reliability of the system. In case there is a breakdown of one incoming line, the continuity of supply can be main-tained by the other line.

2. The sub-station has duplicate bus-bar system; one 'main bus-bar' and the other spare bus- The incoming lines can be connected to either bus-bar with the help of a bus-coupler which consists of a circuit breaker and isolators. The advantage of double bus-bar system is that if repair is to be carried on one bus-bar, the supply need not be interrupted as the entire load can be transferred to the other bus.

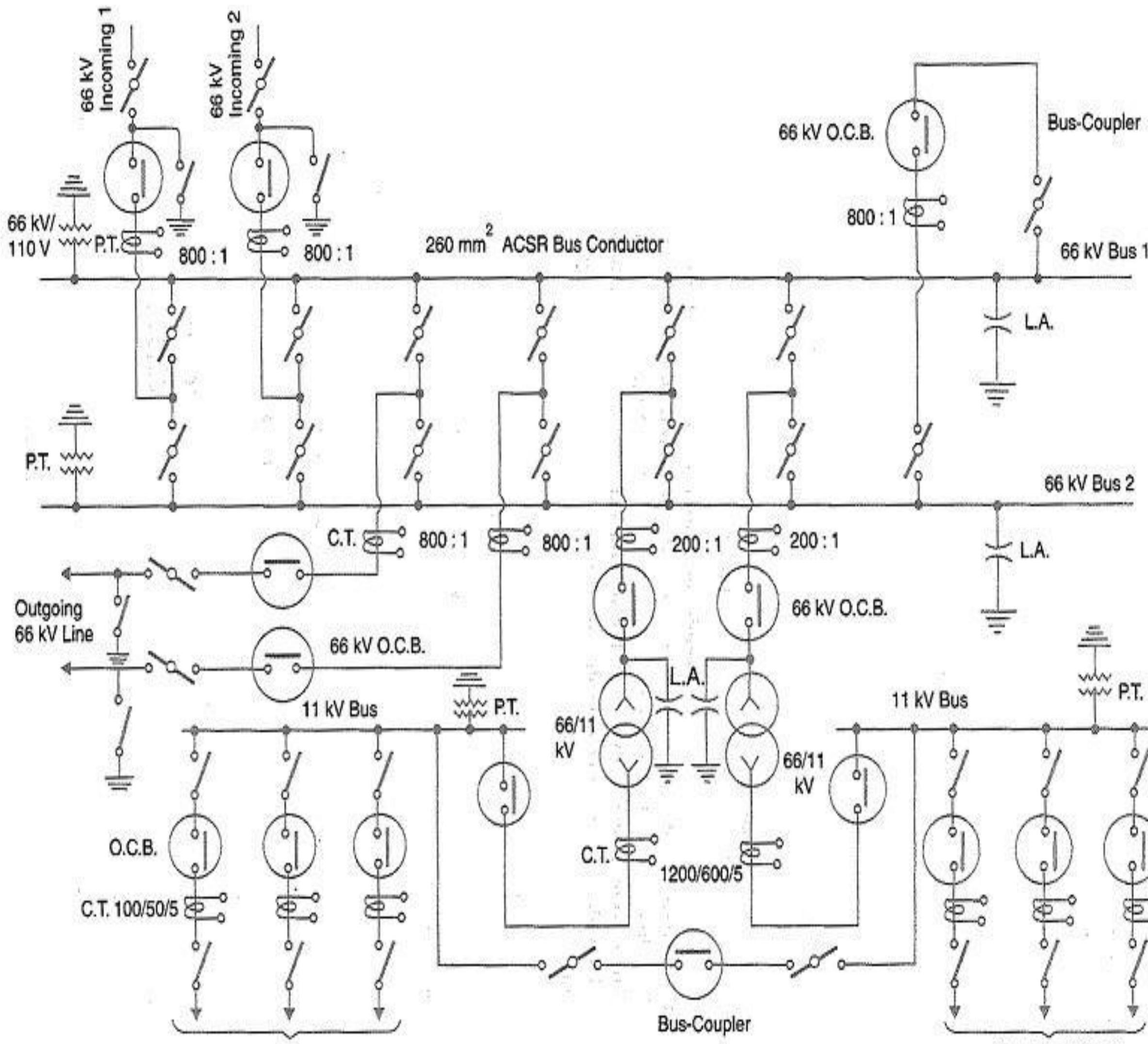


Fig. 25.10

3. There is an arrangement in the sub-station by which the same 66 kV double circuit supply is going out i.e. 66 kV double circuit supply is passing through the sub-station. The outgoing 66 kV double circuit line can be made to act as incoming line.

4. There is also an arrangement to step down the incoming 66 kV supply to 11 kV by two units of 3-phase transformers; each transformer supplying to a separate bus-bar. Generally, one transformer supplies the entire sub-station load while the other

transformer acts as a standby If need arises, both the transformers can be called upon to share the sub-station load. The 11 kV outgoing lines feed to the distribution sub-stations located near consumers localities.

5. Both incoming and outgoing lines are connected through circuit breakers having isolators on their either end. Whenever repair is to be carried over the line towers, the line is first switched off and then earthed.

6. The potential transformers (P.T.) and current transformers (C.T.) and suitably located for supply to metering and indicating instruments and relay circuits (not shown in the figure). The P.T. is connected right on the point where the line is terminated. The CTs are connected at the terminals of each circuit breaker.

7. The lightning arresters are connected near the transformer terminals (on H.T. side) to pro-tect them from lightning strokes.

8. There are other auxiliary components in the sub-station such as capacitor bank for power factor improvement, earth connections, local supply connections, d.c. supply connections However, these have been omitted in the Key Diagram of Substation for the sake of simplicity.

Key Diagram of 11kv/400v Indoor Substation:

Fig. 25.11 shows the Key Diagram of Substation of a typical 11 kV/400 V indoor sub-station. The key diagram of this sub-station can be explained as under:

1. The 3-phase, 3-wire 11 kV line is tapped and brought to the gang operating switch installed near the sub-station. The G.O. switch consists of isolators connected in each phase of the 3-phase line.

2. From the G.O. switch, the 11 kV line is brought to the indoor sub-station as underground cable. It is fed to the H.T. side of the transformer (11 kV/400 V) via the 11 kV O.C.B. The transformer steps down the voltage to 400 V, 3-phase, 4-wire.

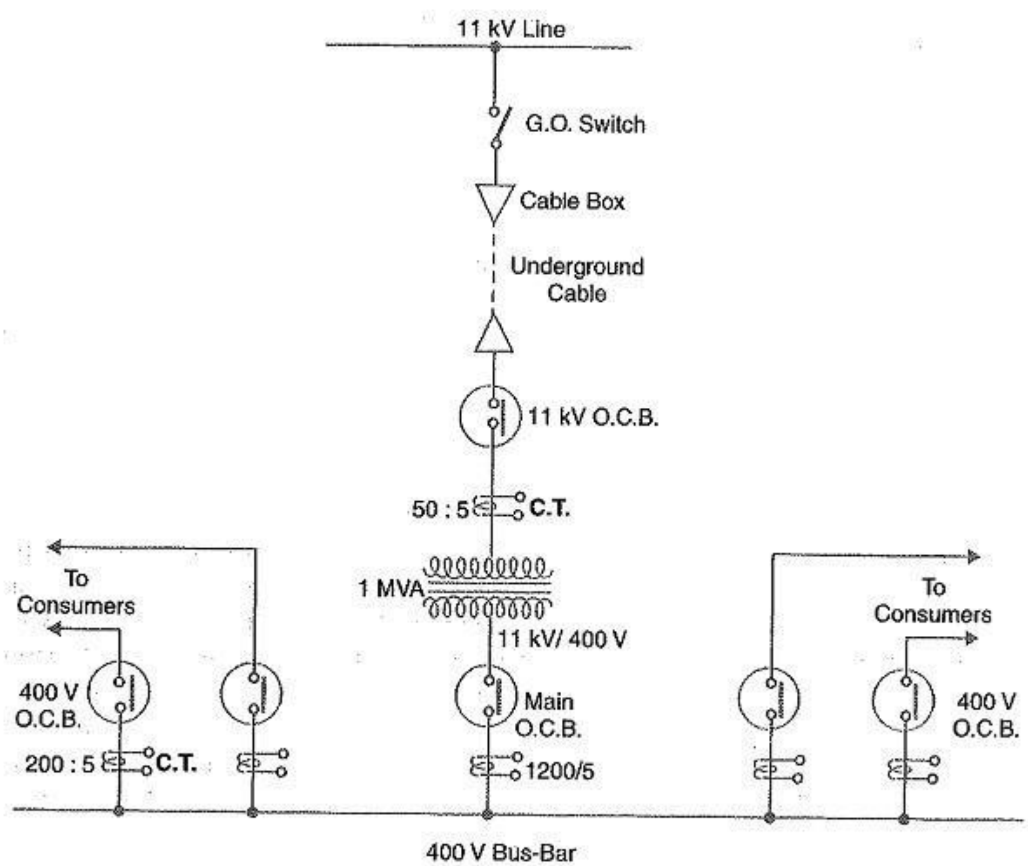


Fig. 25.11

3. The secondary of transformer supplies to the bus-bars via the main O.C.B. From the bus-bars, 400 V, 3-phase, 4-wire supply is given to the various consumers via 400 V O.C.B. The voltage between any two phases is 400 V and between any phase and neutral it is 230 V. The single phase residential load is connected between any one phase and neutral whereas 3-phase, 400 V motor load is connected across 3-phase lines directly.

4. The CTs are located at suitable places in the sub-station circuit and supply for the metering and indicating instruments and relay circuits.

Design of substation earthing system

The substation earthing system comprises of a grid (earth mat) formed by a horizontal buried conductors.

- ✓ The grounding system in substation is very important. The functions of grounding systems or earth mat in include:
- ✓ Ensure safety to personnel in substations against electrical shocks.
- ✓ Provide the ground connection for connecting the neutrals of stat connected transformer winding to earth (neutral earthing).
- ✓ Discharge the overvoltages from overhead ground wires or the lightning masts to earth. To provide ground path for surge arresters.
- ✓ Provide a path for discharging the charge between phase and ground by means of earthing switches.

- ✓ To provide earth connections to structures and other non-current carrying metallic objects in the sub-station (equipment earthing).
- ✓ In addition to such a grid below ground level, earthing spikes (electrodes) are driven into the ground.
- ✓ They are connected electrically to the earth grid, equipment bodies, structures, neutrals, etc. All these are connected to the station earthing system by earthing strips.
- ✓ If the switchyards have a soil of low resistivity, earth resistance of the earthing system would be low. If the soil resistivity is high, the mesh rods are laid at closer spacing. More electrodes are inserted in the ground.
- ✓ The fence, equipment body, tanks, support, structures, towers, structural steelworks, water pipes, etc. should be earthed.

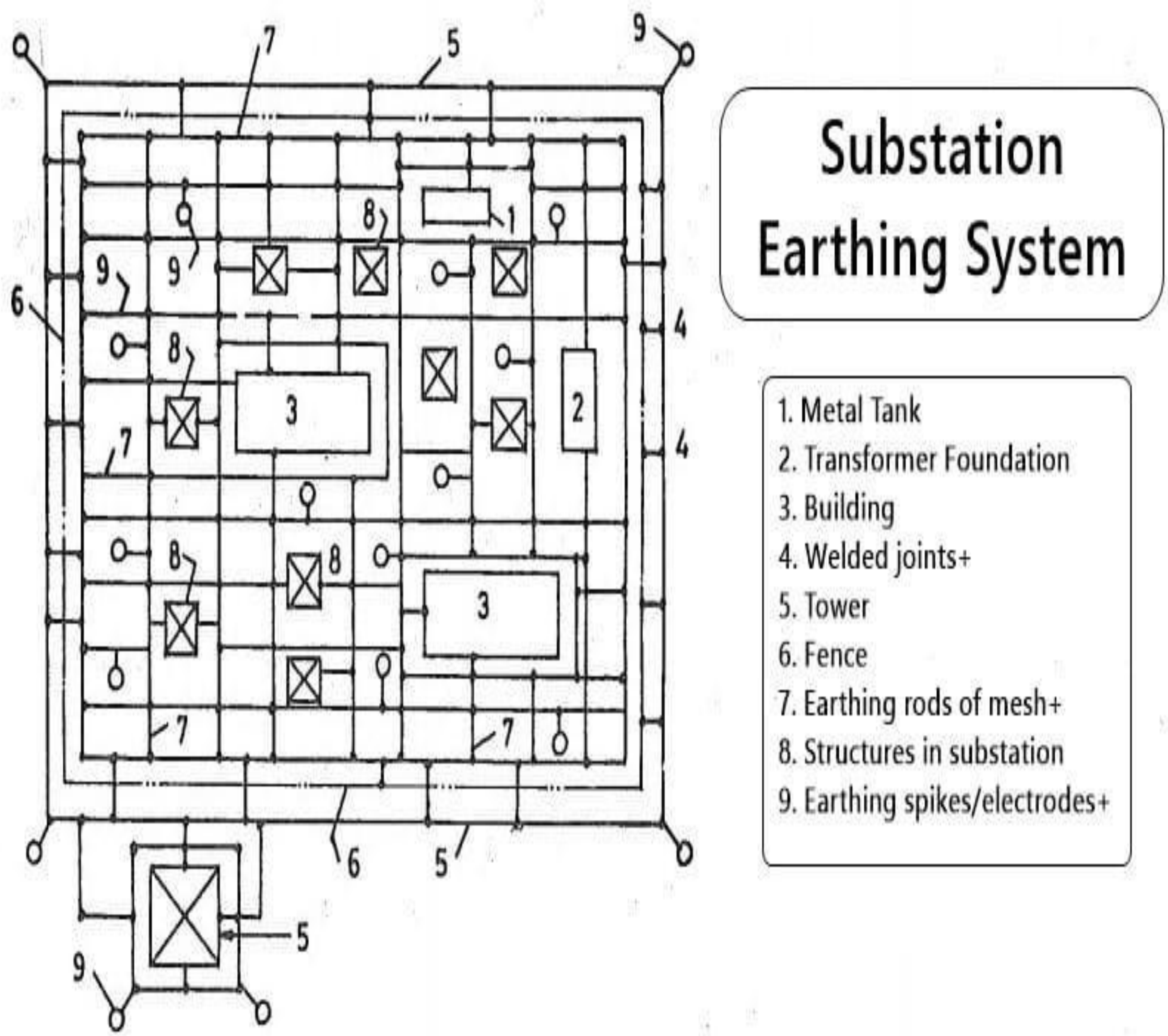
Earth Resistance Value

- ✓ The value of earth resistance of the ground system determines the voltage rise of the various earthed points during the earth fault.
- ✓ If earth fault current is I, earth resistance is R, the voltage rise under short circuit condition would be V= IR.
- ✓ The permissible potential rise and the maximum possible earth fault current set a limit on the maximum value of earth resistance.
- ✓ To achieve earth resistance within specified limits, enough number of earth spikes and sufficient surface area of the earth grid and closer ground mesh rods are necessary.

- ✓ The touch potential and earth potential in the switchyard under any earth fault condition should be within safe limits.
- ✓ The conventional “Low earth resistance criterion” and Low Current Earth Resistance Measurement continues to be in practice for Substations and Power Station up to and including 220 kV.
- ✓ The parts of the Earthing System include the entire solid metallic conductor system between various earthed points and the underground earth-mat.
- ✓ The earthed points are held near-earth potential by low resistance conductor connections with earth-mat.

Underground Horizontal Earth Mesh (Mat/Grid)

- ➢ The mesh is formed by placing mild steel bars placed in X and Y directions in mesh formation in the soil at a depth of about 0.5 m below the surface of substation floor in the entire substation area except for the foundations.
- ➢ The crossings of the horizontal bars in X and Y directions are welded.
- ➢ The earthing rods have also placed the border of the fence, surrounding building foundations, surrounding the transformer foundations, inside fenced areas, etc.
- ➢ The mesh ensures uniform and zero potential distribution on the horizontal surface of the floor of the substation hence low “step potential” in the event of flow of earth fault current.



Substation Earthing System

Earthing Electrodes (Spikes)

- Several identical earth electrode is driven vertically into the soil and are welded to the earthing rods of the underground Mesh. Larger number of earth electrodes gives lower earth resistance.

- The number of Earth-Electrodes (Spikes) Ns for soil resistivity 500-ohm meter and earth fault current Is is :
- Ns = Is / 250 Amperes
- i.e., approximately 250 Amp per spike, for soil resistivity of 500 ohm-meter.
- The number of Earth-Electrodes (Spikes) Ns for soil resistivity 5000-ohm meter is
- Ns = Is / 500 Amperes
- i.e., approximately 500 Amp per spike, for soil resistivity of < 5000 ohm-meter.
- Is = Short Circuit level of the substation, A

Example:

33 kV substations: 25000 to 31000 A

400 kV Substations: 40000 A

Earthing Risers

These are generally mild steel rods bent in vertical and horizontal shapes and welded to the earthing mesh at one end and brought directly up to equipment/structure foundation.

Earthing Connection

- Galvanized Steel Strips or Electrolytic Copper Flats or Strips/Stranded Wires (Cables) /Flexibles: These are used for final connection (bolted/welded/clamped) between the Earthing Riser and the points to be earthed.
- For Transformer Neutral/High Current Discharge paths copper strips/stranded wires are preferred.

- Galvanised Iron Strips/stranded wires are more common for all other earthing connections.
- The earthing strips are finally welded or bolted or clamped to the Earthed Point.

THANK YOU

Prepared by :- Suchismita Barik