UNIT III: Energy Resources, Electricity Bill & Safety Measures

ENERGY RESOURCES

Conventional & Non-Conventional Energy Resources

Conventional Energy Resources	Non-Conventional Energy Resources
Fossil fuel, CNG, coal, oil, natural gas are the examples of the conventional sources of energy.	Solar Energy, Wind Energy, Bio Energy, Hydro Energy, Tidal Energy, Ocean Energy are the examples of non-conventional energy resources.
The conventional sources of energy are non - renewable by any natural process.	Non-conventional energy resources are renewable.
These resources are available in a limited quantity.	Non-conventional energy sources are eco-friendly in nature.
These sources are used by business.	These sources are used by households.
High carbon emissions	Low or zero carbon emissions
Established technology	Evolving technology
Relatively cheaper	Initially higher costs
Environmental impact	Minimal environmental impact

Introduction:

Hydroelectric power plant (Hydel plant) utilizes the potential energy of water stored in a dam built across the river. The potential energy of the stored water is converted into kinetic energy by first passing it through the penstock pipe. The kinetic energy of the water is then converted into mechanical energy in a water turbine. The turbine is coupled to the electric generator. The mechanical energy available at the shaft of the turbine is converted into electrical energy by means of the generator.

Layout of Hydroelectric power plant:

The schematic representation of a hydroelectric power plant is shown below.

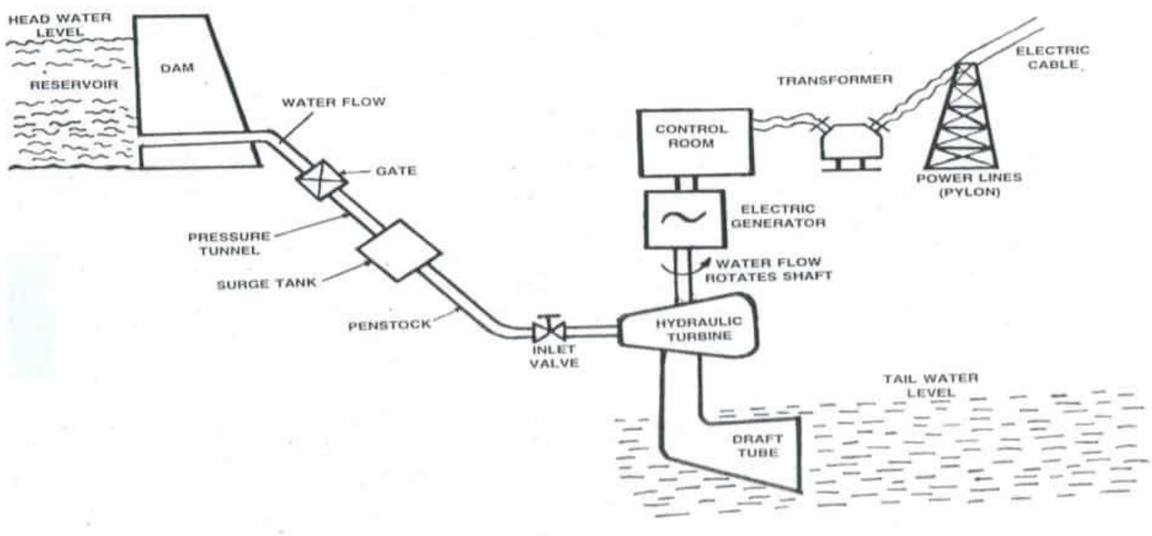


Fig.Layout of Hydro electric Power plant

The Hydroelectric Power Plant consists of following sections:

- Reservoir and Dam
- Control Gate
- Penstock
- Surge Tank
- Water Turbine
- Generator

Reservoir and Dam:

The dam is constructed on a large river to ensure sufficient water storage and the dam forms a large reservoir behind it. The height of the water level (called a water head) in the reservoir determines the potential energy stored in it.

Control Gate:

The amount of water released in the penstock can be controlled by a control gate.

Surge Tank:

A surge tank is a small reservoir or tank which is open at the top and is fitted between the reservoir and the powerhouse. The water level in the surge tank rises or falls to reduce the pressure swings in the penstock.

Penstock:

A penstock is a steel pipe which carries water from the reservoir to the turbine. The potential energy of the water is converted into kinetic energy as it flows down through the penstock due to gravity.

Water Turbine:

Water from the penstock is to be travelled to the water turbine and the turbine is coupled to an electric generator. Kinetic energy (K.E.) of the water drives the turbine and consequently, the generator gets driven.

Generator:

A generator is placed or mounted in the powerhouse which is coupled to the shaft of the turbine. The passage of water from the nozzle hits the turbine blades which makes the shaft of the turbine to rotate. It drives the generator and electricity are produced.

The produced electricity will be Step up or Stepdown through a transformer and later on it will supply to the domestic and industrial applications.The water passing through the turbine is discharged to the tailrace which carries water away from the powerhouse after it has been passed through the turbine.

Working of Hydroelectric Power Plant:

The dam is constructed on a large river to ensure sufficient water storage and the dam forms a reservoir behind it. The height of the water level (called a water head) in the reservoir determines the potential energy stored in it.

The water is travelled from the reservoir passing through the gates. Water initially with some potential energy is converted to high-pressure energy during the passage.

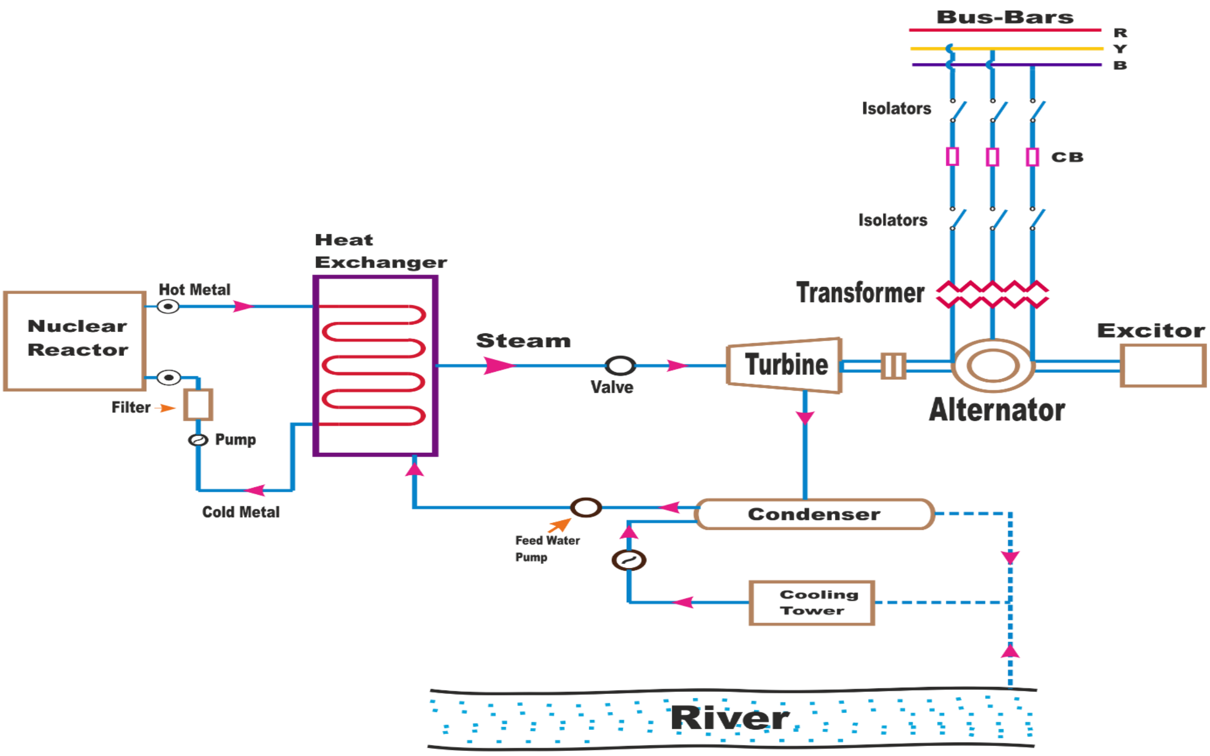
A surge tank is placed at the top and is fitted between the reservoir and the powerhouse. This water level rises or falls to reduce the pressure in the penstock.

The maximum amount of water is released through the penstock when the control gate is fully opened.This kinetic energy is converted to electrical energy, as the turbine is coupled to an electric generator.

The passage of water from the nozzle hits the turbine blades which makes the shaft of the turbine to rotate. It drives the generator and electricity are produced. The water which moves away from the turbine enters into the after bay via Tailrace.

Layout of Nuclear Power Plant:

The layout of Nuclear Power Plant is shown below.



The main components of nuclear power plant are,
1. Nuclear Reactor
2. Steam Generator
3. Turbine
4. Coolant pump & Feed pump
5. Generator.

Nuclear reactor:

It consists of the following components.

(a) Core: This contains the nuclear fuel and space for coolant. The fuels used are U^{233}, U^{235},Pu^{239}.
To have uniform release of heat, the fuel is shaped and located in the core.

(b) Moderator: The moderator is used to reduce the speed of the fast moving neutrons. For natural uranium, the following are used as moderators-graphite, heavy water or beryllium. For enriched uranium, the ordinary water is used as moderator.

(c) Control rods: The control rods are used to start the chain reaction, maintain the chain reaction at required level and to shut down during emergency. The control rods are made of cadmium, boron and hafnium.

(d) Coolant: Coolant is used to transfer the heat which is produced in the reactor to steam generator for rising the steam. The generally used coolants are ordinary & heavy water, air, carbon dioxide, helium and hydrogen and liquid metals like sodium and potassium.
(e) Reflector: Reflector is used to reflect the escaping neutrons back into the core. This improves the neutron economy of the reactor. The generally used reflectors are heavy water, graphite and beryllium.
(f) Radiation shield: Radiation shield is a concrete shield to absorb dangerous radiations like alpha, beta, Gama rays tend to escape to the atmosphere.
(g) Reactor vessel: This is a housing for all the equipment's and it is designed in such a way that it can withstand high pressures safely. The reactor is positioned at the bottom of the vessel.

Steam generator:

In this, the steam is generated from the feed water by absorbing heat from the hot coolant from the reactor.

Turbine:

The generated steam is made to expand in the turbine to produce work. This work is converted into electricity by generator which is coupled with turbines.

Coolant pump & Feed pump:

The coolant pump is used to maintain the flow of coolant and the feed pump is to pump the feed water to the steam generator.

Generator:

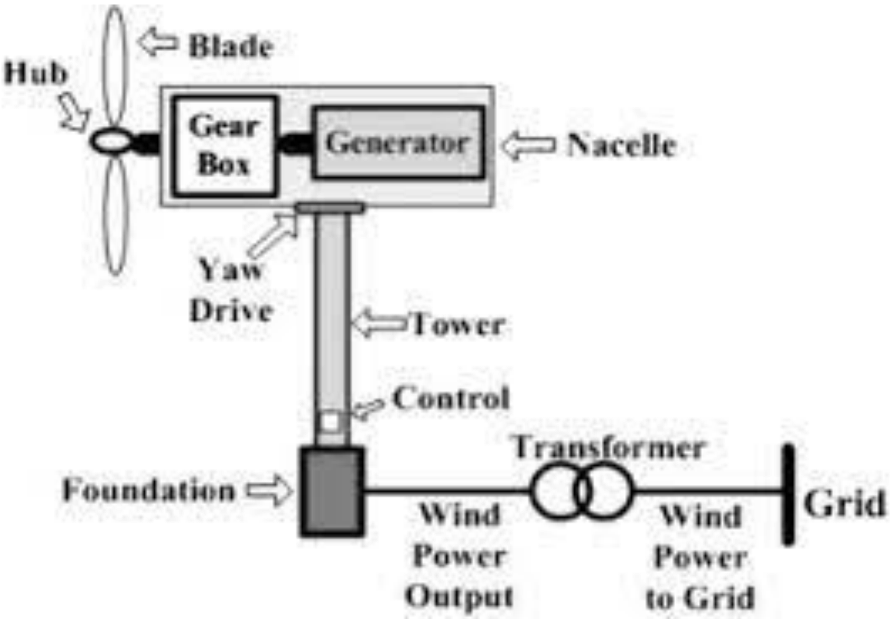
The generator is used to convert the mechanical energy into electrical energy. The generator is directly coupled to the turbine.

Working of Nuclear Power Plant:

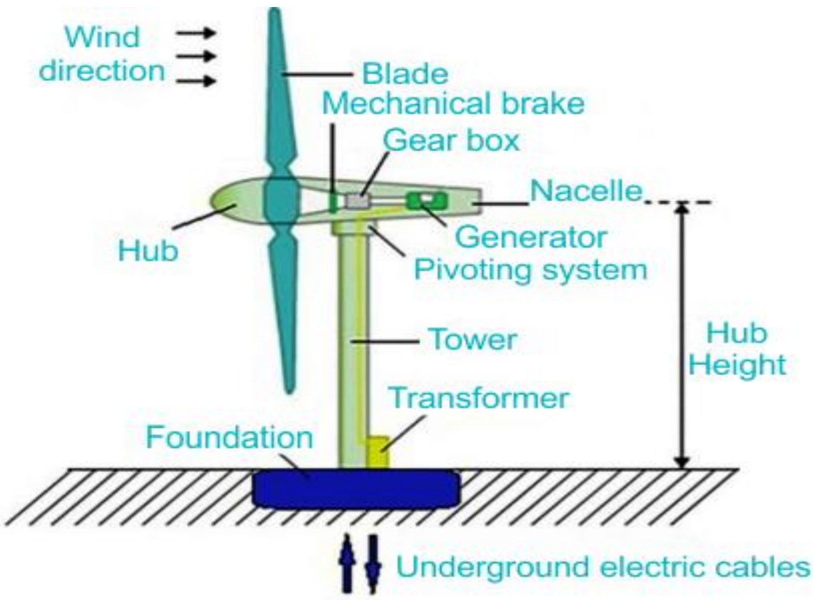
Basically, nuclear power plants work in the same way as coal and gas fired plants converting heat to electricity.Nuclear fission inside the reactor pressure vessel generates heat, which heats water until it evaporates, turning thermal energy into latent energy in steam. This team which is under high pressure then drives the turbines, which turn the generators connected to them generating electrical energy like a bicycle dynamo. Condensing the steam required to drive the turbines is done either by direct flow or seawater cooling or via a cooling system using a cooling tower.

Layout of Wind power plant:

Wind power is a sustainable and renewable energy source that efficiently converts wind energy into electricity. Wind turbines, resembling airplane wings or helicopter rotor blades, utilize the aerodynamic force from the rotor blades to generate electricity. Clustered in wind farms across large areas, these turbines harness the kinetic energy of moving air and convert it into rotational energy through the spinning of the blades. This rotational energy is then transferred to a generator via a shaft, producing electrical energy. Wind plants can be situated on land or offshore, and they can also be hybrid plants incorporating other sources like solar energy. With minimal environmental impact compared to fossil fuel burning, wind power offers clean and valuable investment for a sustainable future.



The wind turbine works on the principle of conversion of kinetic energy of wind to mechanical energy used to rotate the blades of a fan connected to an electric generator. When the wind or air touches the blades (or) vanes of the windmill it the air pressure can be uneven, higher on one side of the blade and lower on the other. Hence, uneven pressure causes the blades to spin around the center of the turbine. The turbine does not operate at wind speeds above **55 mph** with the use of the controller.

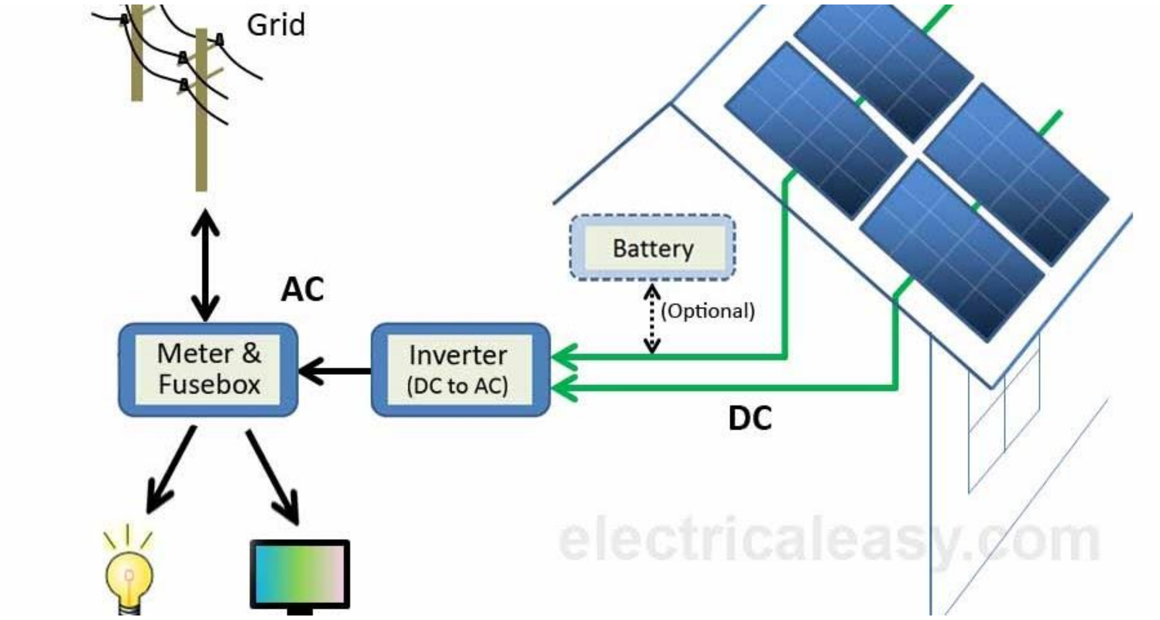


The rotor shaft of the turbine (low speed and high speed) is interlinked with the gearbox which converts the speed from **30 to 60 rpm into 1000 to 1800 rpm**. As the gearbox consists of gears, to transmit mechanical energy. These speeds are most suitable to the generator for the generation of electricity. When the rotor of the turbine rotates it drives a generator through a setup gearbox causing the generator to produce electrical energy. Windmills are available in size from **100 KW to 36 MW** mainly used off-shore.

Layout ofSolar power plant:

A solar power plant creates the energy from the sun to produce electricity in an environmentally friendly way. It uses various technologies to capture solar radiation and convert it into usable energy, making it a clean and sustainable alternative to traditional fossil fuels.
The electricity generated by solar power plants can be fed into the power grid to supply homes, businesses, and industries with clean energy. One of the significant advantages of solar power is its eco-friendliness, as it does not release harmful pollutants or greenhouse gases, reducing the impact on climate change and the environment.

The block diagram of Solar Power Plant is shown below.



1. **Solar Panels:** The solar power plant comprises thousands of solar panels, which are made up of semiconductor materials like silicon. When sunlight hits the solar panels, it excites electrons in the semiconductor, creating a flow of direct current (DC) electricity.
2. **Inverters:** The DC electricity generated by the solar panels is then sent to inverters, which convert it into alternating current (AC) electricity. AC electricity is the standard form of electricity used in homes and businesses.
3. **Transformer and Grid Connection:** The AC electricity is then passed through a transformer to increase its voltage to the appropriate level for grid transmission. Afterward, the electricity is fed into the electrical grid through power lines, supplying renewable energy to homes and businesses.

ECTRICITY BILL

Power rating of Household Appliances:

The Rating of an electrical appliance indicates the voltage at which the appliance is designed to work and the current consumption at that voltage. The Power rating of the appliance is related the power it consumes. Every electrical appliance has a power rating which indicates the amount of electricity required to do work. . This is usually given in watts (W) **or kilowatts(kW).**

The Energy consumption of a device is calculated by multiplying the wattage of a device and operational hours.

Energy consumption = Wattage X operational hours

UNIT: The unit of electrical energy consumed is kWh. One kilowatt-hour is the electrical energy consumed by an electrical appliance of power 1 kW when it is used for one hour. Therefore 1kwh =1 unit.

<u>Calculation of Power consumption of electrical home appliances.</u>

Let us consider different home appliances to calculate approximate total energy consumption of house per month.

Sl NO	Appliances	Watts	NO	Total no of watts	No of operational hours per day	Total Energy consumed= No of watts x No of operation hours	Energy consumed in kwh(units) per day= energy consumed / 1000
1	Tube light	60 W	10	600	5	3000	3
2	Fan	75 W	4	300	8	2400	2.4
3	Refrigerator	200W	1	200	24	4800	4.8
4	AC	1000W	1	1000	5	5000	5
5	Laptop	50W	1	50	2	100	0.1
6	Television	50W	1	50	3	150	0.15
7	Grinders	1000W	1	1000	½	500	0.5
8	Printers	50W	1	50	½	25	0.025
9	Washing machine	2000W	1	2000	1	2000	2
10	Micro wave	1000W	1	1000	1	1000	1
			Total no of units consumed per day				**18.9=19units**

Therefore per day 19 units of energy is consumed

For 1 month = 19 x 30 = **570 units permonth**

Tariff

The electrical energy generated in generating station is delivered to a large number of consumers at reasonable rates.

Definition of tariff: The rate at which the electrical energy is supplied to a consumer is known as tariff.

The tariff should include:

1. Recovery of cost of generating electrical energy in power stations
2. Recovery of cost of capital investment in transmission and distribution.
3. Recovery of operation and maintenance of supply of electrical energy.
4. A suitable profit on capital investment.

There different types tariff. The consumers who have appreciable maximum demand for them two part tariff method is employed.

Two Part Tariff

When the rate of electricity energy is charged on the maximum demand of the consumer and the units consumed is called two part tariff.

In this tariff scheme, the total costs charged to the consumers consist of two components: fixed charges and variable charges (running charges). It can be expressed as:

Total Cost = [A (kW) + B (kWh)] Rs

Where, Fixed charges - A = charge per kW of max demand

Variable charges - B = charge per kWh of energy consumed .It is obtained by multiplying no of units consumed and rate per unit.

The fixed charges will depend upon maximum demand of the consumer and the running charge will depend upon the energy (units) consumed. The fixed charges are due to generation, transmission and maintenance.

Advantages

If a consumer does not consume any energy in a particular month, the supplier will get the return equal to the fixed charges.

Disadvantages

If a consumer does not use any electricity, he has to pay the fixed charges regularly.
The maximum demand of the consumer is not determined. Hence, there is error of assessment of max demand.

Electricity Bill

Calculation of electricity bill for low tension domestic consumer is as follows.
The electricity bill consists of two components: fixed charges and variable charges (running charges). It can be expressed as:

Total Electricity Bill = [A (kW) + B (kWh)] + Tax

Where, Fixed charges - A = charge per kW of max demand

A= Total kW X charge per kW

Example: If the sanctioned load is 3KW then A= [1x85 + 2x95] = 275rs

(Note: For 1kw it is 85 rs and above 1kw it 95 rs per kw)

Where Variable charges - B = charge per kwh of energy consumed.

B = No of units consumed x rate per unit

Example: If the no of units consumed is 120 units

then**B = [50 x4.1 + 50 x 5.55+ 20 x 7.1] = 624rs**

(Note: For 0- 50 units – 4.1 rs per unit, 50- 100 units – 5.55 rs , 100- 200 units – 7.1rs) Therefore Total Electricity bill for given example is

= 275 +624+ Tax.

ELECTRICAL SAFETY MEASURES

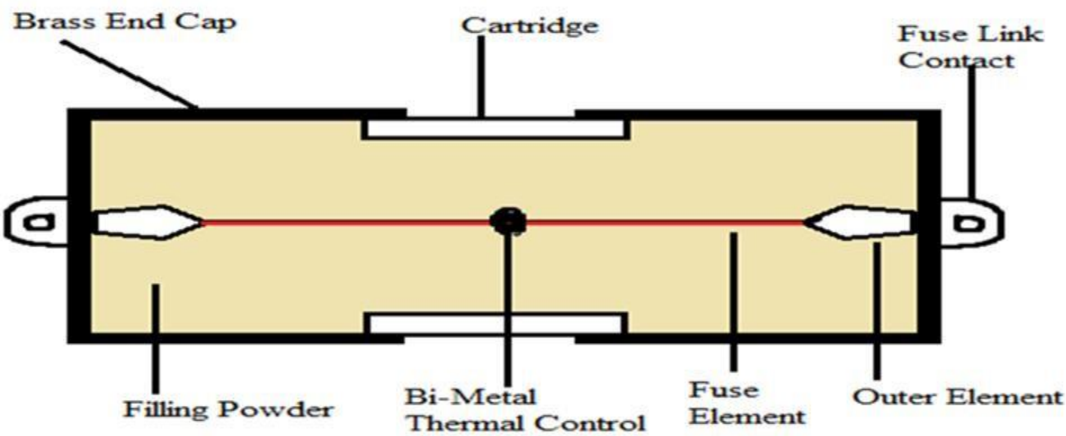
Protective Devices

Protection for electrical installation must be provided in the event of faults such as short circuit, overload and earth faults. The protective device must be fast acting and isolate the faulty part of the circuit immediately. It also helps in isolating only required part of the circuit without affecting the remaining circuit during maintenance. The following devices are usually used to provide the necessaryprotection:

- Fuses
- Relays
- Miniature circuit breakers(MCB)
- Earth leakage circuit breakers(ELCB)

Fuse

An Electric Fuse is a protective device which interrupts the flow of excessive current in an Electric circuit. This works on the principle of heating effect of the Electric Current



A Fuse consists of conducting wire, which has high resistivity and low melting point. The thickness of the Fuse wire is determined based on the amount of current flow in the circuit. If a fault causes a flow of excess Current then a Conductor break the Circuit by melting or separating it, the thin Conductor used is known as an Electric Fuse. The wire inside the Fuse melts if there is an occurrence of high Current due to a short Circuit or an overloaded Circuit. As a result of which the Current stops flowing since the wire has broken. In order to stop the flow of Electricity. Once a Fuse melts, it can be changed or replaced with a new Fuse. A Fuse is normally made up of elements like zinc, copper, aluminum and silver.

Miniature circuit breaker (MCB):

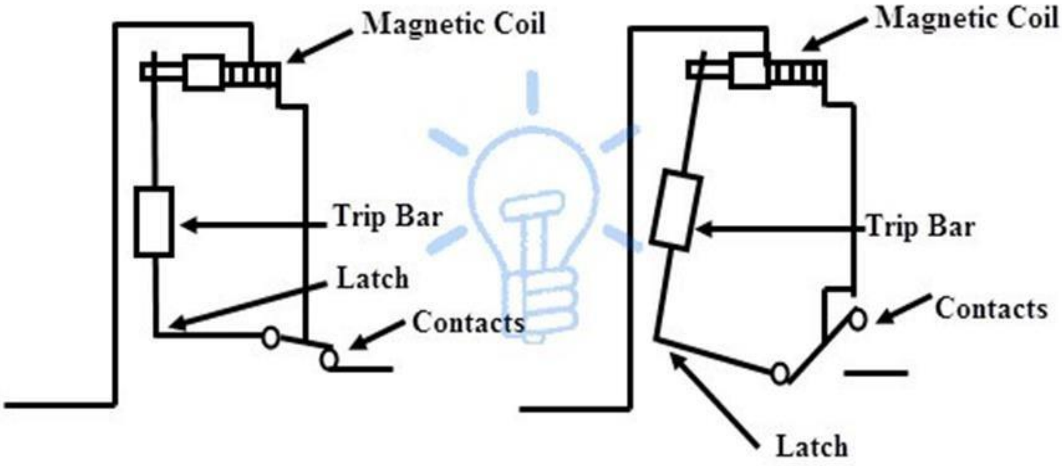
An MCB - miniature circuit breaker is an electromagnetic device that embodies complete enclosure in a molded insulating material.

The main function of an MCB is to open the circuit automatically when the current passing through MCB exceeds the value for which it is set. It can be manually switched ON and OFF as similar to normal switch if necessary. An MCB is a simple, easily operable device and is maintenance-free too. It can be easilyreplaced. The trip unit is the key part of the MCB on which the unit operates. The bi-metal present in the MCB circuit protects against overload current and the electromagnet in the circuit protects against short-circuitcurrent.

Working

When the overflow of current takes place through MCB, the bimetallic strip gets heated and it deflects by bending. The deflection of the bi-metallic strip or trip bar releases a latch. The latch causes the MCB to turn off by stopping the flow of the current in the circuit. This process helps to safeguard the appliances or devices from the hazards happening due to overload or overcurrent. To restart the flow of current, MCB must be turned ON manually.

In the case of short circuit conditions, the current rises suddenly in an unpredictable way, leading to the electromechanical displacement of the plunger associated with a solenoid. The plunger hits the trip lever, it causes the automatic release of the latch mechanism by opening the circuit breaker contacts.



Comparison between Electric Fuse and MCB:

ELECTRIC FUSE	MINIATURE CIRCUIT BREAKER – MCB
Whenever excessive current flows through the fuse, the conducting material inside it melts down thereby interrupting the current flow.	An electromagnetic mechanism present inside the MCB helps it to instantaneously interrupt the current flow during faults.
Fuses other than rewireable fuses cannot be reused.	Miniature circuit breakers can be reused after the clearance of faults.
Fuses acts faster than MCB. Typical tripping time 2ms.	Tripping time for MCB is 20ms.
Can protect against short circuit and overloads.	Can protect against short circuit and overloads.
Cheaper than MCB.	MCB costlier than fuses.

Fuse cannot be used as as an ON/OFF switch.	The MCB is used as an ON/OFF switches.

Personal safety measures:

Electric shock andprecautions

An electric shock is the sudden discharge of electricity through a part of the body when a person comes in contact with electrical equipment.
The factors affecting the severity of shock are

1. Magnitude of the current through thebody
2. Path of the current through thebody
3. Time for which current is passed through thebody
4. Frequency of thecurrent
5. Physical and physiological condition of theperson

Precautions against Electric shock

- Avoid water at all times when working with electricity. Never touch or try repairing any electrical equipment or circuits with wet hands. It increases the conductivity of the electric current.
- Never use equipment with damaged insulation. The insulation of conductors must be proper and in goodcondition.
- Earth connection should be maintained in propercondition
- Use of the fuses and cables of properrating.
- Use the rubber soled shoes whileworking.
- Megger tests should be done to check theinsulation.
- Never touch two different terminals at the sametime.
- Never remove the plug by pullingwire.
- The sockets should be placed at a properheight
- Switch off supply and remove the fuses before starting the work with anyinstallation.
- Always use insulated screw drivers, and line testers.

Earthing:

Connection of the body of electric equipment to the general mass of the earth by wire of negligible resistance is called **Earthing**. It brings the body of the equipment to the zero potential during electric shock.

Necessity of Earthing

1. To protect the human beings from danger of shock in case they come in contact with the charged frame due to defectiveinsulation.
2. It guarantees the safety of electrical appliances and devices from the excessive amount of electric current.
3. It protects the appliances from high voltage surges and lightningdischarge.
4. It provides an alternative path for leakage of current hence protects theequipment.
5. It keeps the voltage constant in the healthyphase
6. It protects the Electric system and buildings fromlightning.

7. It avoids the risk of fire in the electrical installationsystem.
8. To maintain the line voltage constant under unbalanced loadcondition.

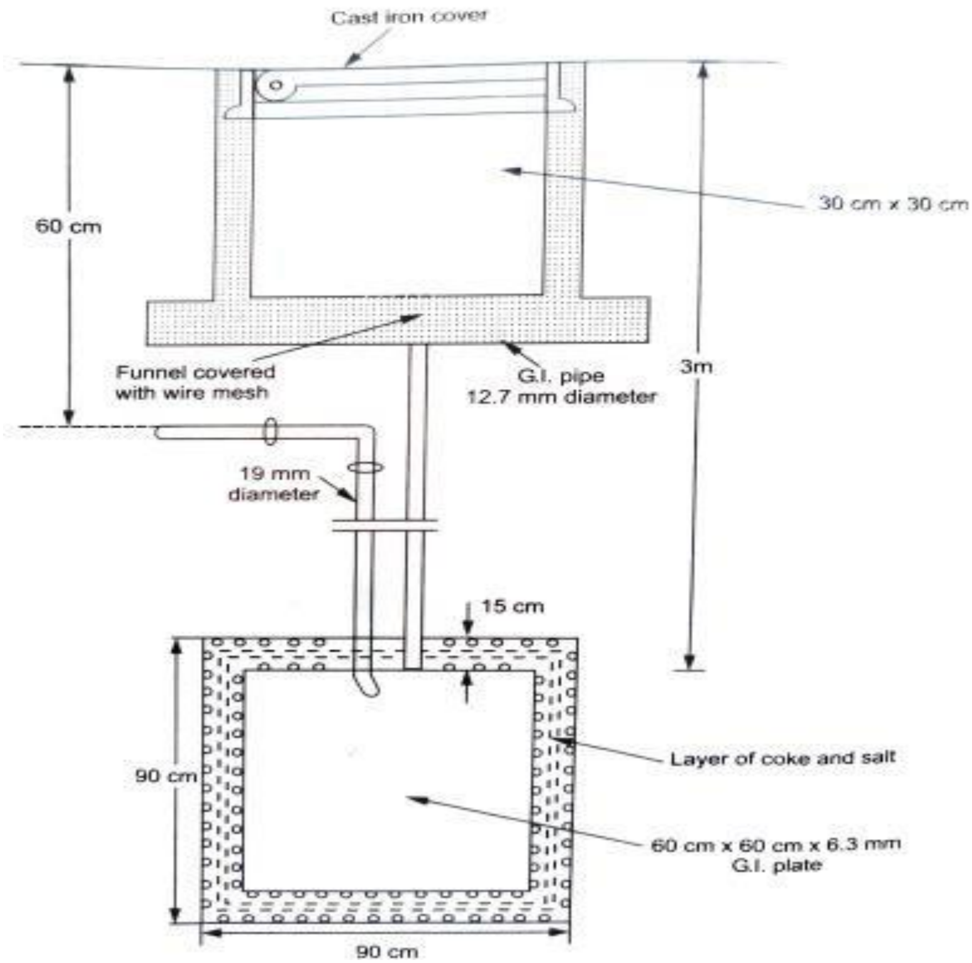
Types of Earthing

They are two types of earthing

1. PlateEarthing
2. PipeEarthing

Plate Earthing :

In this method a copper plate or GI plate of 60cmX60cmX3.18cm is placed vertically down inside the ground at a depth of 3m. The plate is surrounded by the alternate layers of salt andcoal with a minimum thickness of about 15cm. The earth wires drawn through the GI pipe are bolted through the earth plate. The GI pipe is fitted with the funnel on a top in order to have an effective earthing by pouring the salt water periodically. The schematic arrangement is as shown below.

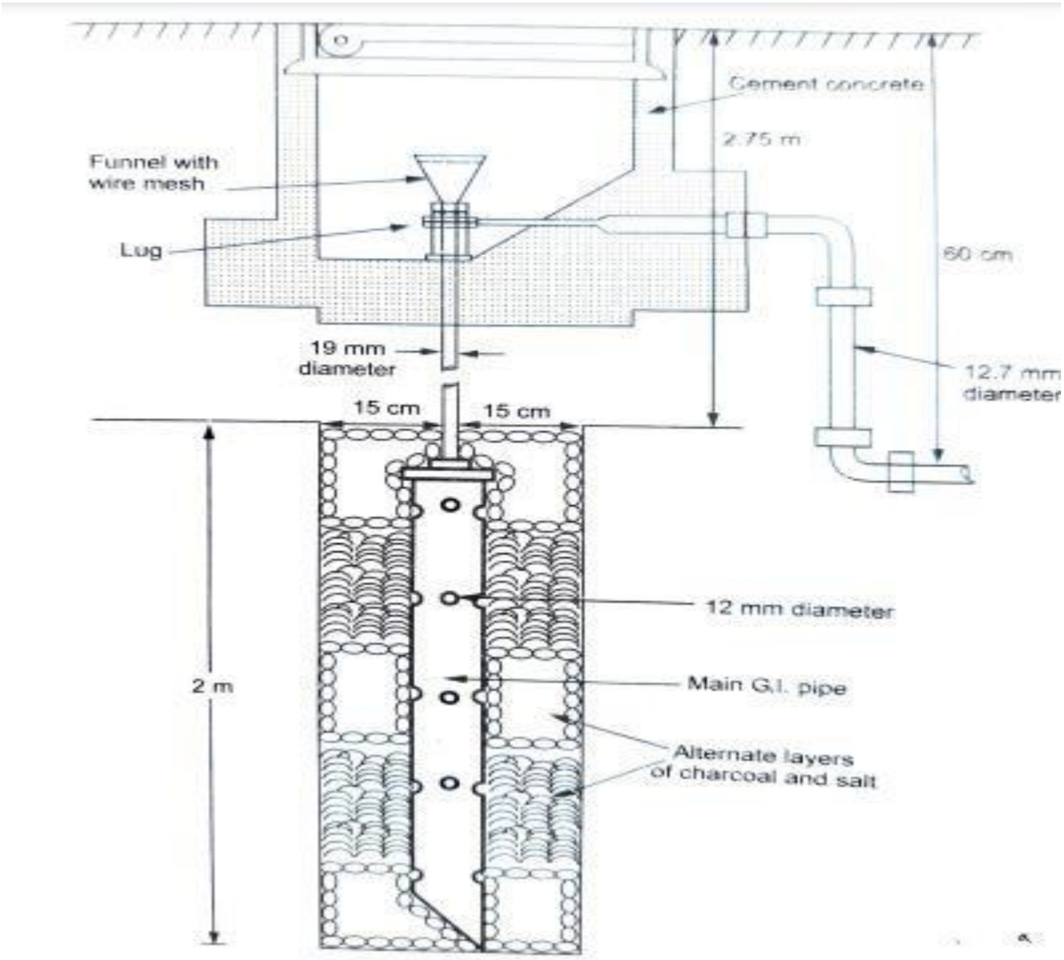


The earthing efficiency increases with the increase of the plate area and depth of the pit. The depth of the pit depends upon the resistivity of the soil.
The only disadvantage of this method is that discontinuity of earth wires from the earthing plate which is placed below the ground as it cannot be observed physically this may cause miss leading and result into heavy losses under fault condition

Pipe Earthing :

In this method a Galvanized iron pipe of 38 mm diameter and length of 2 meters with 12 mm holes is placed vertically into the ground at a depth of 4.75m.This pipe acts as an earth electrode. The depth depends upon the condition of thesoil
The pit area around the pipe is filled with the alternate layers of salt and coal for

improving the condition of the soil and earthing efficiency. The earth wires are connected to the top section of the pipe above the ground level with nut and bolts. The funnel is provided to pour the salt water. The schematic arrangement is as shown below.



The contact surface of GI pipe with the soil is more as compare to the plate. Hence it can handle large leakage current for the same electrode size. The earth wires connected to the GI pipe above the ground level can be physically inspected time to time.

The only disadvantage of pipe earthing is that, the pipe length has to be increased sufficiently in case of soil of high specific resistivity. This increases excavation work and hence increased in cost.