BEE201:

Fundamentals of Electrical Engineering

Unit-5: - Electrical Installations

Content

- Types of Wires, Cables, and Bus-bars
- Introduction of Switch Fuse Unit (SFU), MCB, ELCB, MCCB, ACB
- Fundamentals of Earthing and Lightning protection
- Types of Batteries

Types of Wires and Cables

The Wires employed for internal wiring of buildings may be divided into different groups according to

1) Conductor used
2) Number of cores used
3) Voltage grating
4) Types of insulation used

According to the conductor material used, the cables can divide into two classes

1) Copper Conductor cables
2) Aluminum conductor's cables

According to the numbers of cores, the cables consist of, the cables may be divided into following classes

1) Single core cables
2) Twin core cables
3) Three core cables
4) Two cores with ECC (earth continuity conductor) cables

According to the voltage grating the cables may be divided into two classes

1) 250/440-volt cables
2) 650/1,100-volt cables

According to the type of insulation the cables are of following types

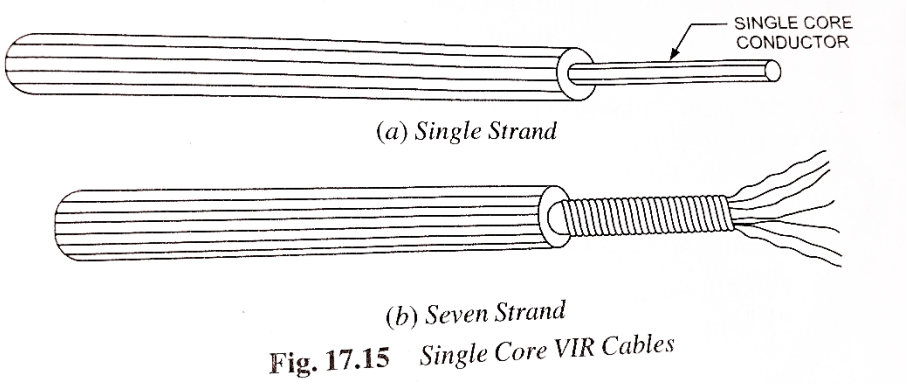
1) Vulcanized Indian rubber (VIR) insulated cables
2) Tough rubber Sheathed (TRS) or cab tyre sheathed (CTS) cables
3) Lead Sheathed Cables
4) Polyvinyl chloride (PVC) cables
5) Weatherproof cables
6) Flexible cords and cables

7) XLPE cables
8) Multi-strand Cables

Vulcanized Indian Rubber (VIR) cables

VIR cables are available in 240/415 volt as well as in 650/1,100-volt grades.

VIR cables consist of either tinned copper conductor covered with a layer of vulcanized Indian rubber insulation. Over the rubber insulation cotton tape sheathed covering is provided with moisture resistant compound bitumen wax or some other insulating material for making the cables moisture proof.



(*a*) *Single Strand*

(*b*) *Seven Strand*

Fig. 17.15 *Single Core VIR Cables*

The thickness of rubber insulation depends upon the voltage grade for which the cable is required.

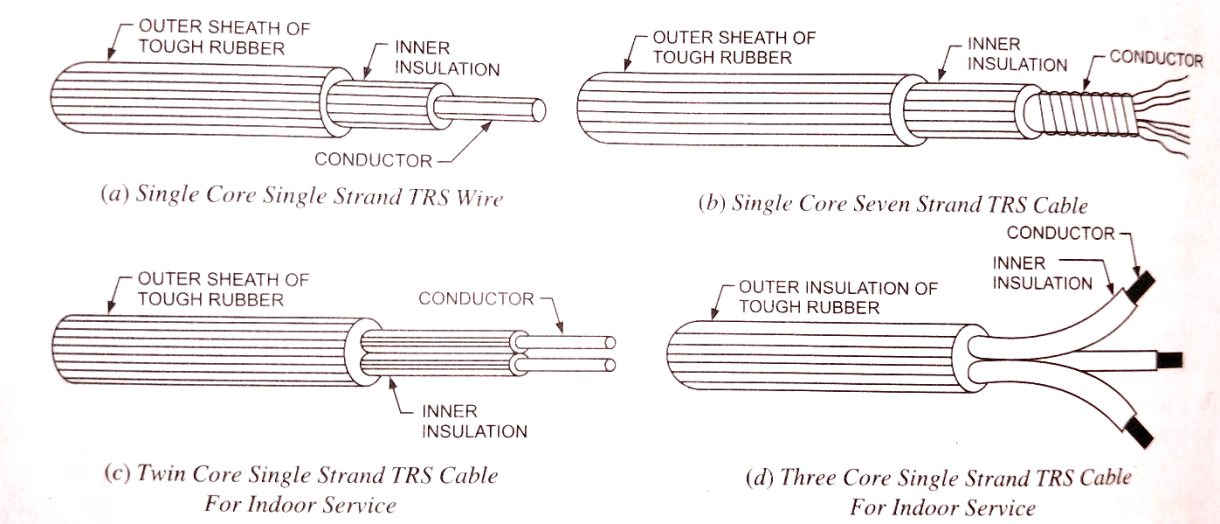
The copper conductor is tinned to provide protection against corrosion due to the presence of traces of Sulphur, zinc oxide, and other mineral ingredients in the VIR.

A single core single strand VIR wire may be employed but larger cables must be stranded.

Tough Rubber Sheathed (TRS) or Cab Tyre Sheathed (CTS) Cables

These cables are available in 250/440 volt and 650/1,100-volt grades and used in CTS or TRS wiring.

TRS cable is nothing but a vulcanized rubber insulated conductor with an outer protective covering of tough rubber, which provide additional insulation and protection against wear and tear.



These cables are waterproof, hence can be used in wet conditions. These cables are available as single core, circular twin core, circular three core, flat three core, twin and three core with earth continuity conductor (ECC).

The core is insulated from each other and covered with a common sheathing.

In wiring of 3 pin plugs separate earth wire may be used as it is cheaper in cost and easier in installation These cables are cheaper in cost and lighter in weight than lead alloy sheathed cables and have the properties like those of lead sheathed cables and thus provide cheaper substitute to lead sheathed cables

Lead Sheathed Cables.

These cables are available in 240/415-volt grade. The lead sheathed cable in a vulcanized rubber insulated conductor covered with a continuous sheath of lead.

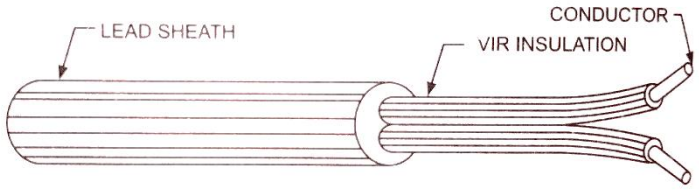


Fig. 17.17 *2-Core Lead Sheathed Cable*

The lead sheath provides very good protection against the absorption of moisture and sufficient protection against mechanical injury and so can be used without casing or conduit system. It is available as a single core, flat twin core, flat three core and flat twin or three core with an earth continuity conductor.

Polyvinyl Chloride (PVC) Insulated Cables

These cables are available in 250/440 volt and 650 1,100-volt grades and are used in casing-capping, batten, and conduit wiring system. In this type of cable conductor is insulated with PVC insulation. Since PVC is harder than rubber, PVC cable does not require cotton taping and braiding over it for mechanical and moisture protection.

PVC insulation is preferred over VIR insulation because of the following reasons:

i. PVC insulation has better insulating qualities.
ii. PVC insulation provides better flexibility.
iii. PVC insulation has no chemical effect on metal of the wire.
iv. Thin layer of PVC insulation will provide the desired insulation level.

v. PVC coated wire gives smaller diameter of cable and, therefore, a greater number of wires can be accommodated in the conduit of a given size in comparison to VIR or CTS wires.

PVC cables are most widely used for internal wiring these days. Though the insulation resistance of PVC is lower than that of VIR but its effect is negligible for low and medium voltages, below 600 V.

Weather Proof Cables

These cables are used for outdoor wiring and for power supply or industrial supply. These cables are either PVC insulated or vulcanized rubber insulated conductors being suitably taped (only in case of vulcanized rubber insulated cable braided and then compounded with weather resisting material. These cables are available in 240/415 volt and 650/1,100-volt grades mese cables are not affected by heat or sun or rain.

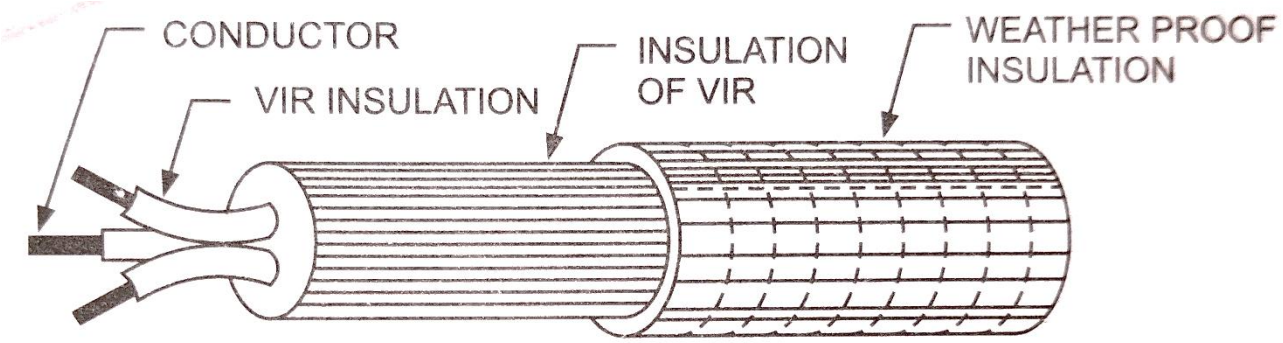


Fig. 17.18 *3-Core Weather Proof Cable*

Although TRS cables can be used for outdoor purposes but due to their higher cost, weatherproof cables are generally used for outdoor services.

Flexible Cords and cables

The flexible cords consist of wires silk/cotton/plastic covered. Plastic cover is popular as it is available in different pleasing colors. Flexible cords have tinned copper conductors.

Flexibility and strength are obtained by using conductors having larger number of stands. These wires or cables are used as connecting wires for such purposes as from ceiling rose to lamp holder, socket outlet to portable apparatus such as radio, fans lamps. The flexibility of such wires facilitates in handling the appliances and prevents the wire from breakage. These must not use in fixed wiring.

These are available in various sizes and with various thickness of coating.

XLPE Cables

PVC and XLPE cables are built of insulation made of polymer. Polymers are substances consisting of long macromolecules built of small molecules or groups of molecules as repeated units. These are divided into homopolymers and copolymers.

Homopolymers are built by reactions of identical monomers. Copolymers are built up of at least two different kinds of monomers.

The mechanical properties of polymers are tensile strength, elongation elasticity and resistance against cold depend upon chemical structure.

Their resistance against external chemical influences, acids, bases, and oils together with their thermal and electrical characteristics are the decisive factors for the usefulness of cables insulated and sheathed with these materials.

Advantages of PVC cables over other types of Cables

1) Non-hygroscopic insulation almost unaffected by moisture.
2) Non-migration of compound allowing vertical installation.
3) Complete protection against most forms of electrolytic/chemical corrosion.
4) Tough/resilient sheath with excellent fire resisting qualities.
5) Good ageing characteristics.
6) Not affected by vibrations.

Advantages of XLPE cables over Both PVC and all other types of Cables

1) Higher current rating.
2) Higher short-circuit current rating.
3) Longer service life.
4) Can withstand 130 degrees centigrade (maximum) for short time and is favorable to endure short circuit stresses.
5) It is less sensitive to the setting of network protection.
6) Because of thermosetting process taking place through cross-linking, crack resistance is increased.
7) Due to chemical cross-linking internal stresses are reduced. Consequently, material is less sensitive during manufacture, to the setting of the cooling gradient.
8) The thermal resistivity of cross-linked material is favorably low, compared to thermoplastic material.
9) Low dielectric loss (a significant advantage)
10) Excellent mechanical features of the insulation improves the protection against external effects.
11) The resistance of XLPE to acids, alkalis are outstanding and often compensates adverse environmental influences.

Presently XLPE cables are used extensively for high tension and low-tension work. Even for distribution work at 3-phase 415 V industry is using XLPE cables.

Fuses

Fuse is perhaps the simplest and cheapest device used in intercepting an electrical circuit under short circuit, or excessive overload, current magnitudes. As such, it is used for overload and/or short-circuit protection in high voltage (up to 66kv) and low voltages (up to 400 v) installations/circuits.

The action of fuse is based on the heating effect of the electric current. In normal operating conditions when the current flowing through the circuit is within safe limits, the heat developed in the fuse element carrying the current is readily dissipated into the surrounding air, and therefore the fuse element remains at the temperature below its melting point.

However, when some fault, such as short circuit occurs or when load connected in the circuit exceeds its capacity, the heat generated due to the excess current causes the element to melt thus breaking the circuit.

Larger the current, the more rapidly the fuse will blow (Fuse has inverse time current characteristics.).

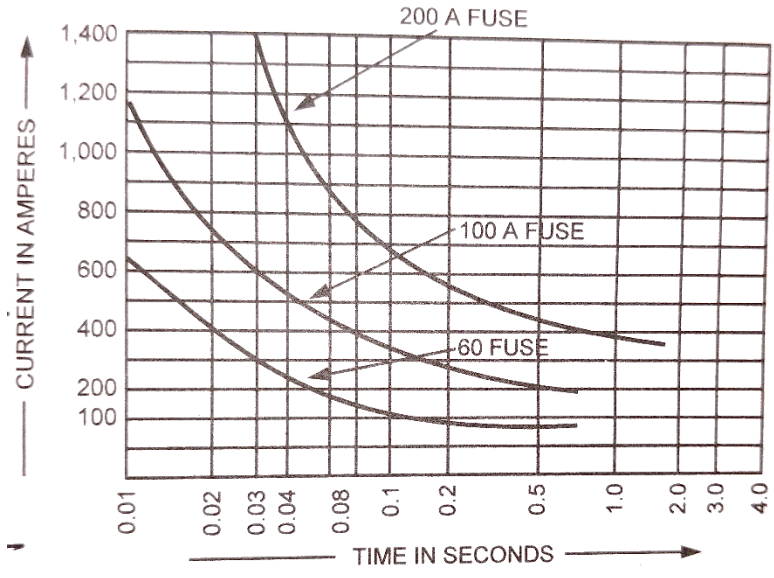


Fig. 17.19 *Time-Current Characteristic*

Advantages

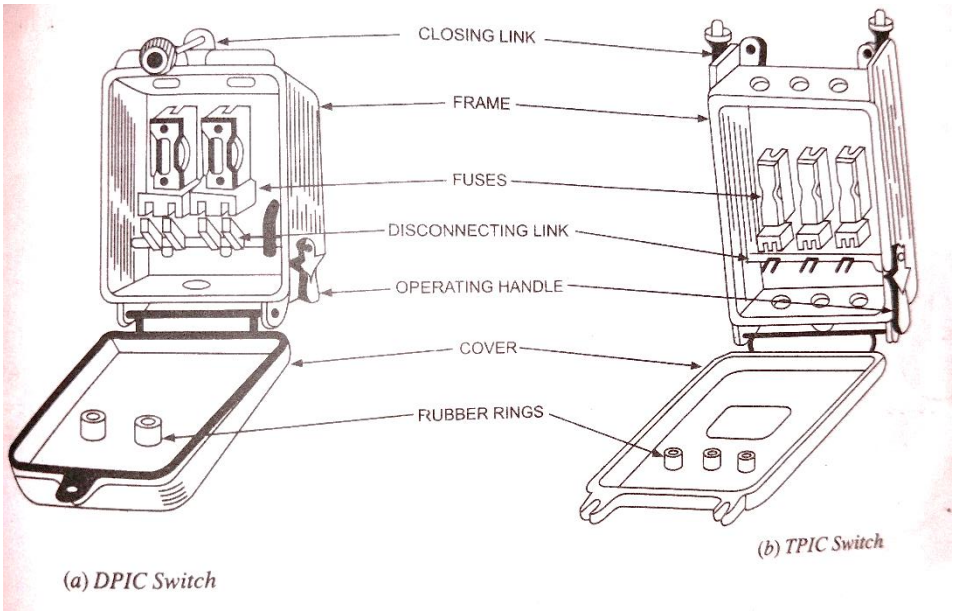
1) It is cheapest form of protection available.
2) It needs no maintenance.
3) Its operation is inherently completely automatic unlike a circuit breaker which require an elaborate equipment's for automatic action

Disadvantages

1) Considerable time is lost in rewiring or replacing a fuse after operation.
2) On heavy short circuits, discrimination between fuses in series cannot be obtained unless there are considerable differences in the relative size of the fuses concerned.

Switch Fuse Units

As per Indian Electricity rule 50. A suitable linked Switch (A switch operating simultaneously on phase or line and neutral wire) is to be provided immediately after the meter board. This rule also stipulates that a suitable cut out must be provided just after the linked switch to protect the circuit against excessive current. The linked main switch and fuse unit may be provided as one unit or as separate unit.



Switch fuse is a combined unit and is known as an iron clad switch. Being made of iron it may be double pole for controlling single phase two wire circuit or triple pole for controlling three phases. 3 wire circuit or triple pole with neutral link for controlling three phase four wire circuit. The respective switches are known as double pole ironclad DPIC.Triple Pole Iron clad TPIC and Triple Pole with Neutral Link Iron clad TPNIC switches. Since no fuse is to be provided in neutral.IR rule 32 in DPIC switch fuses

where provision is made for fuses in both the wires. One fuse carrier is furnished with fuse Element and other with a thick copper wire.

Miniature Circuit Breaker (MCB)

It is a device that provides Definite protection to the wiring, installations and sophisticated equipment's against overcurrent and short circuit faults. The outer and interior view of an MCB is shown in figure. Thermal operations (Overload protection) are achieved with a bimetallic strip which deflects when heated by an overcurrent flowing through it.

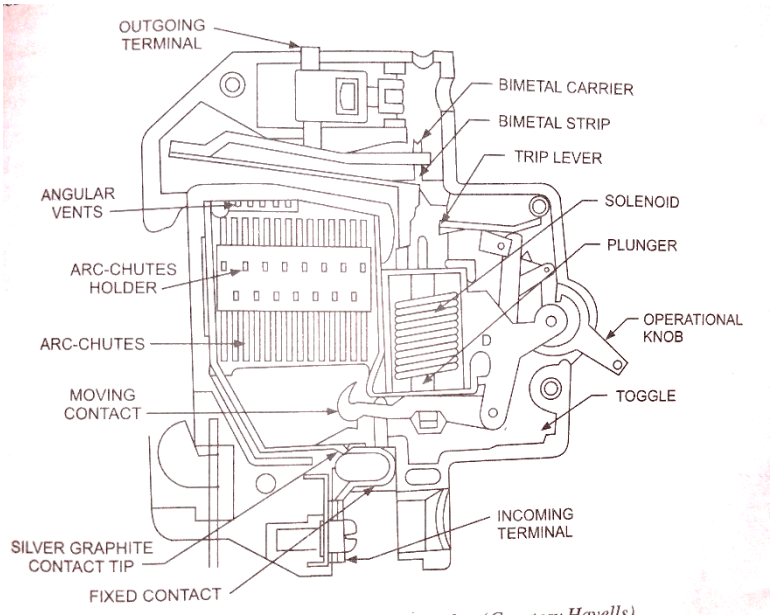
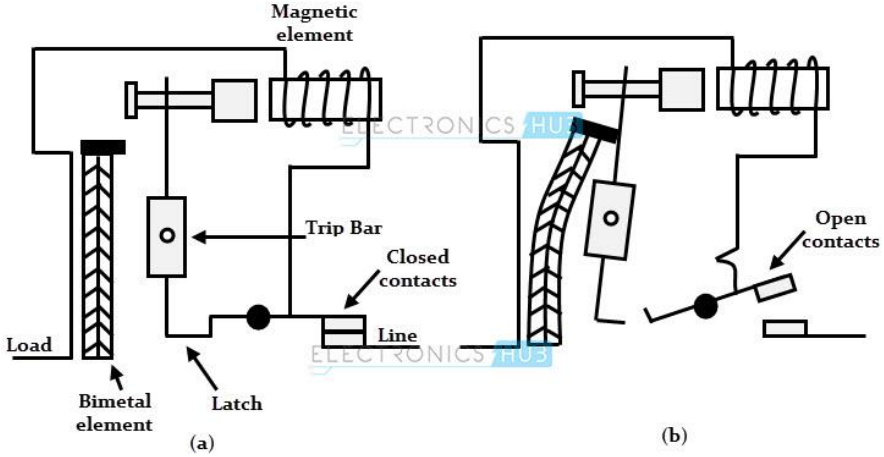


Fig. 17.25 *Miniature Circuit Breaker (Courtesy Havells)*

In doing so, releases the latch mechanism and causes the contacts to open. Inverse time current characteristics results, that is Greater the overload or excessive current sorter the time period to operate the MCB.On the occurrence of short circuit the rising current energizes the solenoid operating the plunger to strike the trip level, causing Immediate release of the latch mechanism. Rapidity of the magnetic solenoid operation causes instantaneous opening of contacts.

Miniature circuit breaker is available with different current rating of



0.5,1,2,2.5,3,4,5,6,7.5,10,16,20,25,32,35,40,63 100,125 ,160 A. And voltage rating of.240 / 415 Volt AC And up to 220 Volt DC. Operating time is very short, less than 5 milliseconds. So, they are very suitable for the protection of important and sophisticated equipment's such as air conditioner, refrigerator, computers etc.

Earth Leakage Circuit Breaker (ELCB)

It is a device that provides protection against earth leakage. these are of two types first the current operated type and second the voltage operated type.

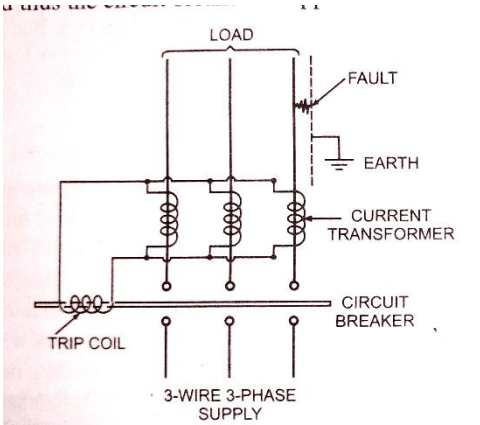


Fig. 17.26 *Current-Operated Earth-Leakage Trip*

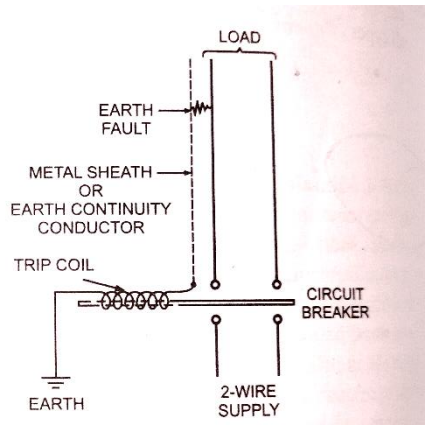


Fig. 17.27 *Voltage-Operated Earth-Leakage Trip*

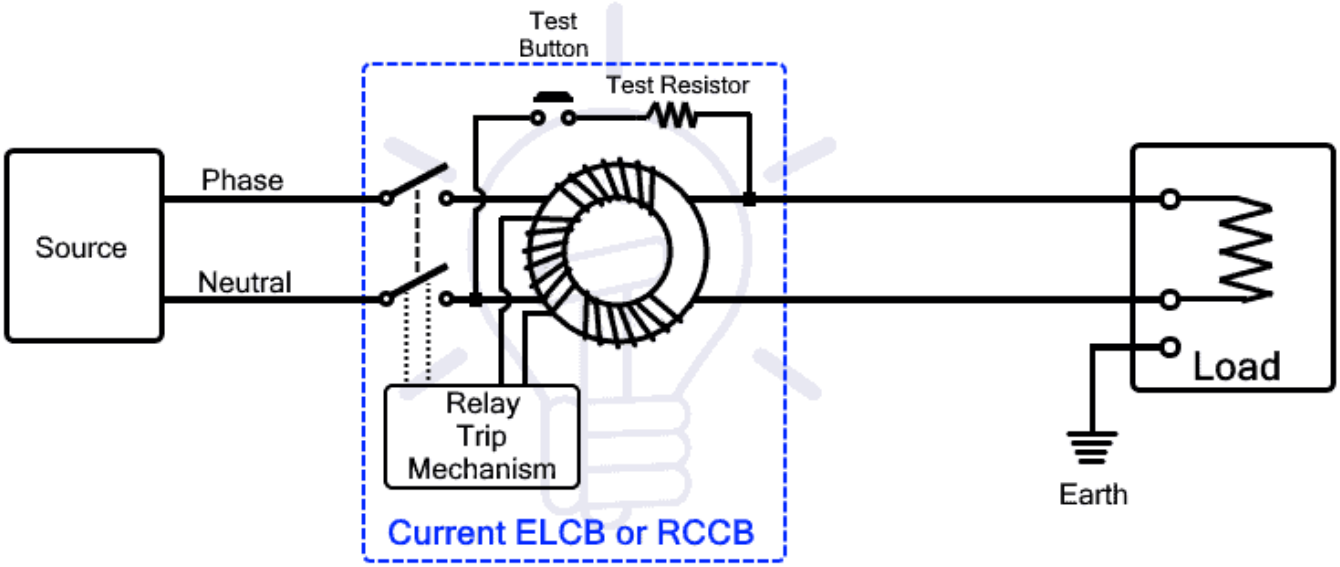
Current operated earth leakage circuit breaker

It used when the product of the operating current in amp and the earth loop impedance in ohms does not exceed 40. Where such as circuit breaker is used the consumer's earthing terminal is connected to a suitable earth electrode. a current operated earth leakage applied to a three phase three wire circuit is shown in figure. In normal conditions when there is no earth leakage the algebraic sum of the currents in the three coil of the current transformer is zero and no current flow through that trip coil in case of any earth leakage the currents are unbalanced and the trip coil it is energized and thus the circuit breaker is tripped.

Voltage Operated Earth Leakage Circuit Breaker

It is suitable for use when the earth loop impedance exceeds the values applicable to fuses or excess current circuit breaker or to current operated earth leakage circuit breaker. Such an earth leakage trip in a

two-wire circuit is shown in figure. when the voltage between the earth continuity conductor and earth electrode rises to a sufficient value the trip coil will carry the required current to trip the circuit breaker. With such a circuit breaker the earthing lead between the trip coil and the earth electrode must be insulated in addition the earth electrode must be placed outside the resistance area of any other parallel earths which may exist. In both the above types of ELCB the tripping operation may be tested by means of a finger operated test button which passes a predetermined current from the line wire through our high resistance to trip the coil and thus to earth. Their operation should be performed regularly both types of earth leakage circuit breaker are arranged to work manually and may take the place of the linked switch or fuses or the excess-current circuit breaker.



Molded Case Circuit Breaker (MCCB)

A molded case circuit breaker MCCB is a type of electrical protection and device that can be used for a wide range of voltages and frequencies of above 50 Hertz and 60 Hertz the main distinctions between molded case and miniature circuit breaker are that the MCCB can have current rating of up to 2,500 ampere and its trip settings are normally adjustable .an additional difference is that MCCB tend to be

much larger than MCB as with most type of circuit breaker and MCCB has three main functions.

Protection against overload

Currents above the rated value that lasts longer than what is normal for the application

Protection against electrical faults

During a fault such as short circuit or line fault they are extremely high currents that must be interrupted immediately.

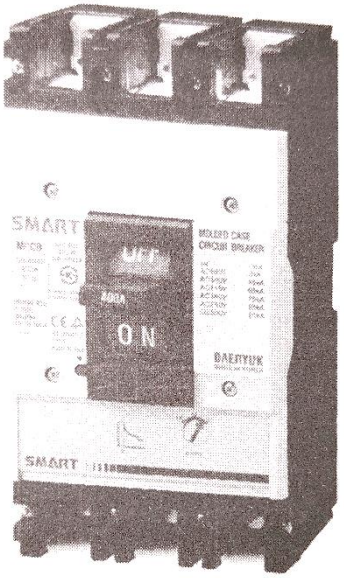


Fig. 17.28 *Molded Case Circuit Breaker (MCCB)*

Switching a circuit on and off

This is a less common function of circuit breaker but they can be used for that purpose if there is not an adequate manual switch.

The wide range of current ratings available for molded case circuit breaker allow them to be used in a wide variety of applications MCCB are available with current rating from low values such as 15 amperes to industrial rating such as 2,500 amp. This them to be used in both low power and high-power application.

Operating mechanism

At its core the protection mechanism employed by MCCB is based on same physical principles used by all type of thermal magnetic circuit breaker.

Overload protection it is accomplished by means of a thermal mechanism. MCCB have a bimetallic contact which expands and contracts in response to change in temperature. under normal operating conditions the contact allows electric current through the MCCB. however as soon as the current exceeds the adjustive trip value the contact will start to heat and expand until the circuit is interrupted.

The thermal protection against overload is designed with the time delay to allow short duration over current which is a normal part of operation for many devices. however, any overcurrent condition that last more than what is normally expected we present an overload and the overcurrent condition that lasts more than what is normally expected represent an overload and the MCCB is tripped to protect equipment and personnel.

On the other hand, fault protection is accomplished with electromagnetic induction and the response is instant fault current should be interrupted immediately no matter if they are the duration is sort or long. Whenever a fault occur the extremely high current induce magnetic field in a solenoid coil located inside the breaker this magnetic induction trips a contact and current is interrupted. As a complement to the magnetic protection mechanism MCCB have internal arc dissipation measures to facilitate interruption

As with all the type of circuit Breakers the MCB includes a disconnection switch which is used to trip the breaker manually it is used whenever the electric supply must be disconnected to carry out field work such as maintenance of equipment upgrades.

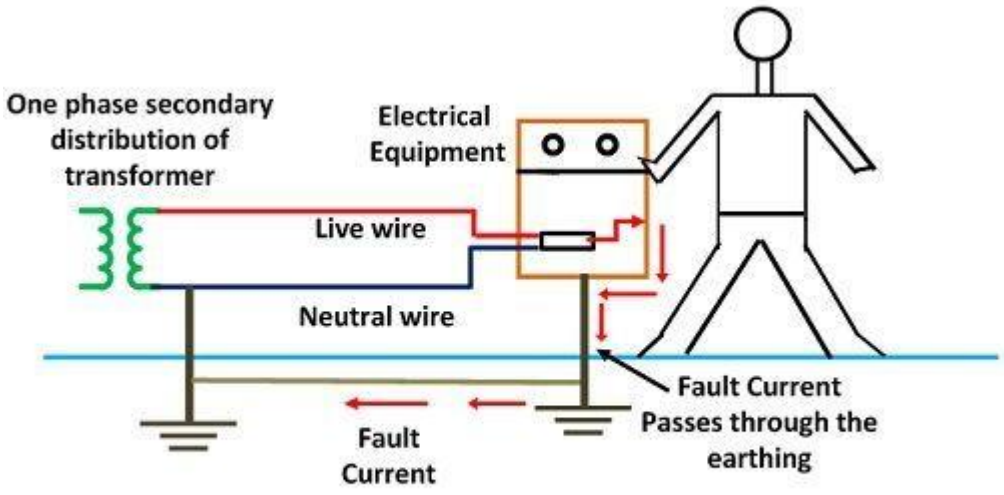
Earthing and Its Importance

Earthing means connections of the neutral point of a supply system or the non-current carrying parts of electrical apparatus, such as metallic framework, metallic covering of cables, earth terminal of socket outlet, stay wires etc., to the general mass of earth in such a manner that always an immediate discharge of electrical energy takes place without danger.

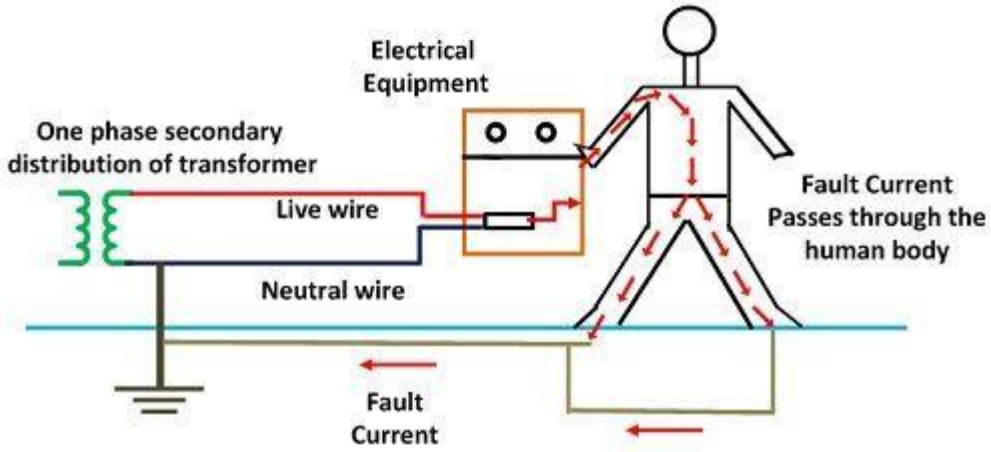
Earthing is provided because:

a) To ensure that no current carrying conductor rises to a potential with respect to general mass of earth than its designed insulation.
b) To avoid electric shock to the human beings
c) To avoid risk of fire due to earth leakage current through unwanted path.

In an electric installation, if a metallic part of an electric appliance comes in direct contact with a bare or live wire (that may be due to failure of insulation or otherwise) the metal being a good conductor of electricity is charged and static charge on it will accumulate. Now if any person comes in contact with this charged metallic part, he will get a severe shock. But if the metallic parts of the appliances are earthed, the charge will be transferred to the earth immediately, as the metallic part comes in direct contact with a bare or live wire or breakdown occurs. And as the discharge takes place to earth, the impedance of path of the current is low, a large amount of current flows to earth, the instant, the current exceeds the limiting value, the fuse provided in the circuit will blow off and cut off the appliance from supply. Thus, earthing of metallic parts of electrical equipment and appliances provides safety.



Electrical System With Earthing



METHODS OF EARTHING

Strip or Wire Earthing:

In this system of earthing, strip electrodes of cross section not less than 25 mm x 1.6 mm if of copper and 25 mm x 4 mm if of galvanized iron or steel are buried in horizontal trenches of minimum depth 0.5 meter. If round conductors are used, their cross-sectional area shall not be smaller than 3.0 mm if of copper and 6 mm^2 if of galvanized iron or steel. The length of buried conductor shall be sufficient to give the required earth resistance. It shall, however, be not less than 15 meters. The electrodes shall be as widely distributed as possible, preferably in a single straight or circular trench or in a number of trenches radiating from a point. If conditions require use of more than one strip, they shall be laid either in parallel trenches or in radial trenches.

This type of earthing is used at places which have rocky soil earth bed because at such places excavation work of plate earthing is difficult.

Rod Earthing

In this system of earthing, 12.5 mm diameter solid rods of copper or 16 mm diameter solid rods of galvanized iron or steel or hollow section 25 mm GI pipes of length not less than 2.5 meters are driven vertically into

the earth either manually or by pneumatic hammer. In order to increase the embedded length of electrodes under the ground, which is sometimes necessary to reduce the earth resistance to desired value, more than one rod sections are hammered one above the other.

Suitability: Areas which are sandy in character.

This system of earthing is very cheap as no excavation work is involved.

Pipe Earthing

This is the most common and best system of earthing as compared to other systems suitable for the same earth and moisture conditions.

In this method of earthing, a galvanized steel and perforated pipe of approved length and diameter is placed upright in a permanently wet soil.

The size of the pipe depends upon the current to be carried and type of soil. Usually, the pipe used for this purpose is of diameter 40 mm and 2.5 meters in length for ordinary soil or of greater length in case of dry and rocky soil. The depth at which the pipe must be buried depends upon the moisture of the ground. The pipe is placed at a depth of 3.75 meters (minimum). The pipe is provided with a tapered casting at the lower end in order to facilitate the driving. The pipe at the bottom is surrounded by broken pieces of coke or charcoal for a distance of about 15 cm around the pipe. Generally alternate layers of coke and salt are used to increase the effective area of the earth and to decrease the earth resistance respectively. Another pipe of 19 mm diameter and minimum length 1.25 meters is connected at the top of GI pipe through reducing socket.

In our country in summer season the moisture in the soil decreases which causes increase in earth resistance. So, a cement concrete work, is done in order to keep the water arrangement accessible, and in

summer to have an effective earth, 3 or 4 buckets of water are put through the funnel connected to 19 mm diameter pipe, which is further connected to GI pipe.

The earth wire (either GI wire or GI strip of sufficient cross section to carry faulty current safely) is carried in a GI pipe of diameter 12 mm at a depth of about 60 cm from the ground.

Care should be taken that earth wire is well protected from mechanical injury, when it is carried over from one machine to another.

Plate Earthing

This is another common system of earthing. In plate earthing an earthing plate either of copper of dimensions 60 cm x 60 cm x 3 mm or of galvanized iron of dimensions 60 cm x 60 cm x 6mm is buried into the ground with its face vertical at a depth of not less than 3 meters from ground level. The earth late is embedded in alternate layers of coke and salt for a minimum thickness of 15 cm. The earth wire (GI wire for GI plate earthing and copper wire for copper plate earthing) is securely bolted to an earth plate with the help of a bolt, nut and washer made of material of that of earth plate (made of copper in case of copper plate earthing and of galvanized iron in case of GI plate earthing).

Batteries

A Battery is a source of electric power consisting of one or more electrochemical cells with external connections for powering electrical devices.

Primary Battery

Batteries that can not be recharged, once they are fully discharged.

Low Cost and Simple to use.

Carbon-Zinc dry cells and alkaline cells dominate portable consumer battery applications.

Mercury and Lithium based chemistries are implemented for energy density and small size.

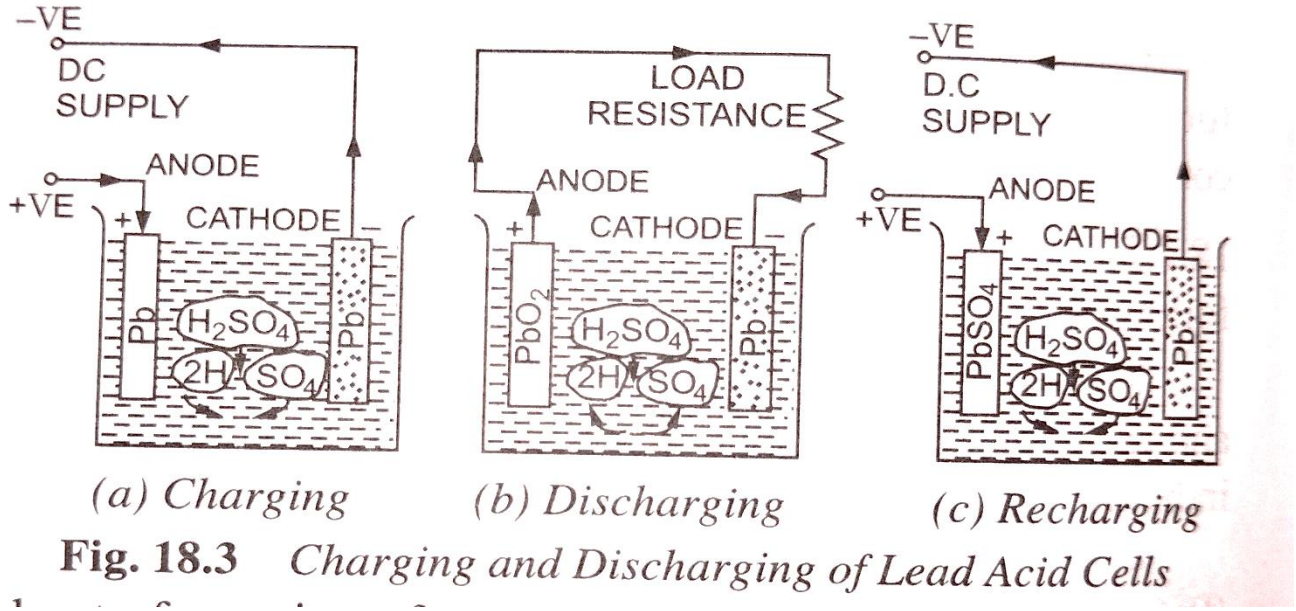
Secondary Battery/Storage Battery/Accumulators

Batteries that can be recharged again and again after used.

High initial cost and need maintenance.

Lead-acid and Nickel-cadmium are commercial success.

Lead-Acid Batteries



(a) Charging *(b) Discharging* *(c) Recharging*

Fig. 18.3 *Charging and Discharging of Lead Acid Cells*

Classification

According to service rendered by them, are classified into automotive, motive-power, and stationary batteries.

Lead-Acid Automotive Batteries

Are used to supply power for starting, lighting and ignition of IC engines employed to propel auto-vehicles. Normally these batteries consist of 6 cells, connected in series, with capacity of the order of 100 ampere-hours and provide power at 12 V.

Nowadays maintenance free (MF) batteries are available for these purpose that has no gassing charging. The electrolyte is either absorbed within the microporous separators and the plates or immobilized within suitable gelling agents.

Charged from AC supply through full wave bridge rectifier employing semiconductor diodes. Output voltage is controlled by the transistorized voltage controller.

Lead-acid motive-power Batteries

Are of better quality in comparison to automotive batteries and provide constant output voltage, high volumetric capacity, good resistance to vibration and long service life (1000-1500) cycles. These batteries are capable of withstanding prolong and deep discharges and deep recharges on the daily bases.

Battery supply power at voltage ranging from 12 to 240 V.

Used in industrial trucks, commercial vehicles, mining, airport, tractors, robotics etc.

Lead-Acid Stationary Batteries

In the standby applications, are used to supply power to essential services or to provide alarms or emergency lighting, in case of breakdown of main power supply. Tremendous increase in demand due to increase in demand of Uninterruptable power system (UPS).

Advanced lead-acid battery (100 mwh) has been developed for use in power generating stations to store energy during off-hours and during peak load.

Active Materials

The materials, in a cell taking active participation in chemical reaction during charging and discharging are called the active materials of the cell.

The active materials of a lead-acid battery are

Lead peroxide (pbo_2) dark chocolate brown in color. It forms the positive active material.

Sponge lead (Pb) grey in color . It forms the negative active material.

Dilute Sulphuric Acid(H_2SO_4) is used as electrolyte. Electrolyte of fully charged battery contains about 31% sulphuric acid by weight and 21% by volume for specific gravity of 1.23 at 70 degree centigrade .

Chemical Reactions

During Charging

$$PbO_2 + 2H = PbO + H_2O$$
$$PbO + H_2SO_4 = PbSO_4 + H_2O$$
$$PbO_2 + H_2SO_4 + 2H = PbSO_4 + 2H_2O$$

During Discharging

$$PbSO_4 + 2H = H_2SO_4 + Pb$$

$$PbSO_4 + 2H_2O + SO_4 = PbO_2 + 2H_2SO_4$$

Cell Reaction

$$\underset{\text{Positive plate}}{PbO_2} + 2H_2SO_4 + \underset{\text{Negative plate}}{Pb} \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} \underset{\text{Positive plate}}{PbSO_4} + 2H_2O + \underset{\text{Negative plate}}{PbSO_4} + \text{Electrical energy}$$

...he charging and ... from right to left for recharge.

Charging and Discharging Curves

When the cell is charged, the voltage of the cell increases from 1.8V to 2.2V and then increase very slowly, rather remains almost constant for sufficient time, and finally rises to 2.5 to 2.7V.

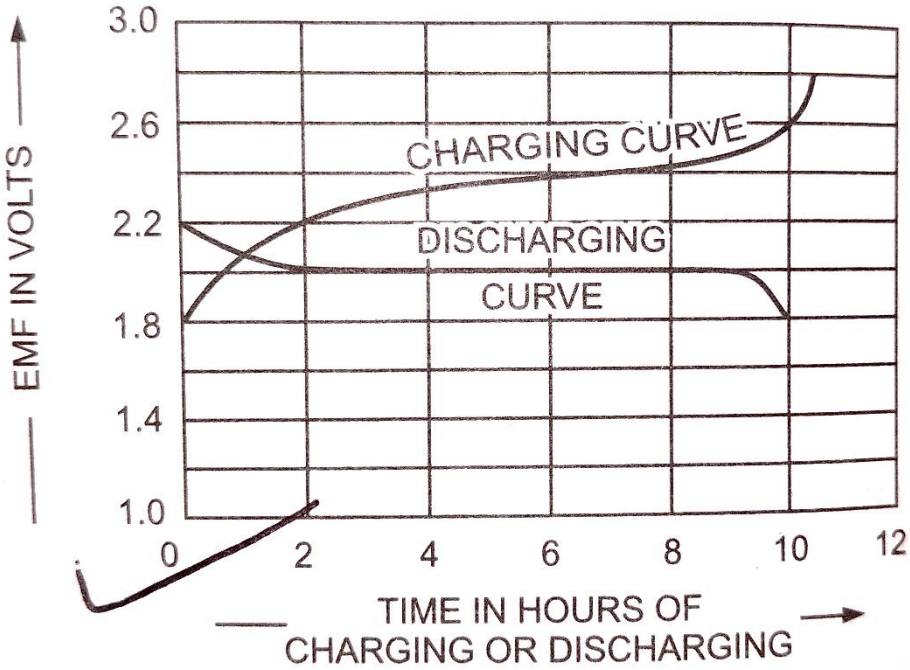


Fig. 18.4 *Typical Charge and Discharge Curves For Lead-Acid Accumulator*

When a charged storage cell has just been disconnected from the charging source, its terminal voltage falls rapidly to 2.2V . On discharging the voltage of cell drops to 2.0V in beginning and them remain constant for sufficient time and then falls to 1.8V.

Electrical Characteristics

There are three important characteristics often accumulator namely

1. Voltage
2. Capacity
3. Efficiency

Voltage

Average EMF of cell is approximately 2.0 Volt. The value of EMF of a cell does not remain constant but varies with the change in specific gravity

of electrolyte, temperature, and the length of time since it was last charged.

The emf of the cell Increases with the increase in specific gravity of the electrolyte and vice versa but increase in specific gravity of the electrolyte also causes increase in internal resistance of the cell therefore its values will to not go beyond 1.22 .

Best results are obtained with the electrolyte of specific gravity 1.21

Capacity

The ability of an accumulator to last and provide current is called the rated output or the capacity /backup while the voltage of the cell it is determined by its chemistry the capacity of the cell is infinitely variable the capacity of cell is essentially the number of electrons that can be obtained from it.

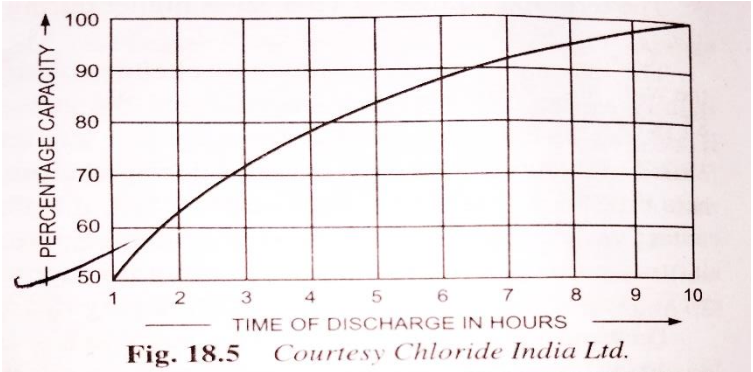


Fig. 18.5 *Courtesy Chloride India Ltd.*

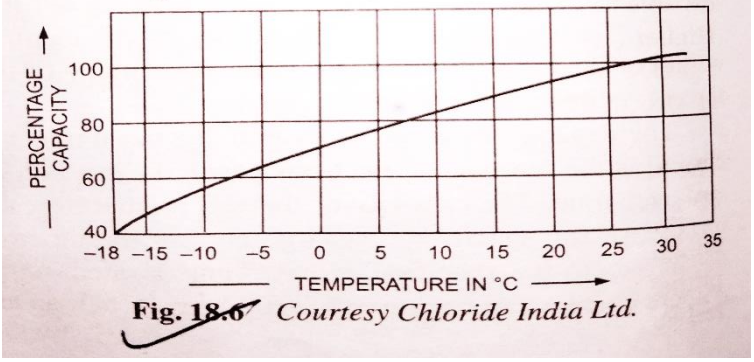


Fig. 18.6 *Courtesy Chloride India Ltd.*

Since the current is the number of electrons per unit time, cell capacity is the integration of current supplied by the cell over time the capacity of the cell is therefore expressed in ampere-hours and is equal to the product of the specific discharge current in ampere multiplied by the number of hours before the cell discharges to the specific extent .thus a rated output of 10 ampere hours means that one ampere current can be drawn for 10 hours or half an ampere current for 20 hours.

At a particular temperature the capacity of the cell depends on its rate of discharging for instance 100 ampere hours battery capable of giving

a continuous discharge of 10 A for 10 hours . But in reality, capacity decrease with the increase in discharging rate.

Efficiency

Efficiency of cell can be given in two ways

1) The quantity or Ampere-Hour (A-H) Efficiency

Efficiency is defined as the ratio of output to the input, similarly quantity efficiency or ampere-hour efficiency.

The quantity efficiency of lead acid battery cell varies from 90 to 95%.

efficiency is

$$\textit{i.e. Ampere-hour efficiency, } \eta_{AH} = \frac{\text{Ampere-hours of discharge}}{\text{Ampere-hours of charge}} \times 100 = \frac{I_d \times T_d}{I_c \times T_c} \times 100$$

2) Energy or Watt-hour efficiency

Defined as ratio of energy delivered in watt-hour by the cell during discharge and the energy drawn in watt-hour during charge.

y the cell during discharge

$$\textit{i.e. Energy or watt-hour efficiency, } \eta_{W-H} = \frac{\text{Output in watt-hours}}{\text{Input in watt-hours}} \times 100$$

$$= \frac{\text{Current delivered} \times \text{time of discharge} \times \text{average pd during discharge}}{\text{Current drawn} \times \text{time of charge} \times \text{average pd during charge}} \times 100$$

$$= \frac{I_d \times T_d \times V_d}{I_c \times T_c \times V_c} \times 100 = \frac{I_d\, T_d}{I_c\, T_c} \times 100 \times \frac{V_d}{V_c} = \eta_{A-H} \times \frac{V_d}{V_c}$$

ampere-hour capacity both tend to raise

Battery Rating

Ampere-hour or capacity rating

The ampere-hour rating of a battery is usually determined from its ability to deliver current continuously for 20 hours at 27 degrees centigrade. A battery that can deliver 5 ampere steadily for 20 hours then its rating will be 100 Ah.

Reserve capacity

That is of capacity of a battery is indicated in terms of minutes a battery is capable of tolerating a drain of 25 A without dropping terminal voltage below 10.5 Volt (1.75 Volt per cell).

Use of Lead-Acid Batteries

The storage batteries are employed for a great variety and range of purposes

1. The storage batteries are employed in central power stations for supplying the whole load during high load period.
2. Supplying peak load during peak load hours
3. Local lighting for odd time of breakdown
4. regulation of load and voltage
5. compensating feeder drop and as a preventive against shutdown