Diploma Wallah.in

Electrical Engineering

Third Semester

Switchgear :- The device that is used to switching, controlling and protecting the electrical circuit is known as switchgear.

Features of switchgear :-

i) Complete Reliability
ii) Certain discrimination
iii) Quick operation.
iv) Provision for manual control and instruments.

Types :-

(1) Indoor switchgear :-

Typically used in residential, commercial, and industrial buildings, indoor switchgear is generally safer and more reliable than outdoor switchgear. It also tends to take up less space.

(2) Outdoor switchgear :-

Usually found in substations, power plants, or along power distribution lines. outdoor switchgear is often used for - distance

power transmission, large power plants and ultra-high voltage transmission.

Most commonly used switchgear equipment and protective devices for switching and interruption of current.

⇒ 1. Switches
2. Fuses
3. Circuit Breaker
4. Relays

(1) **Switches :-**

Basic devices for controlling the flow of current.

types :-

(i) Isolators (Disconnectors) :-

Used for disconnecting parts of a circuit for safety.

(ii) Air Break switches :- Operated manually or automatically, used for switching high current at normal circuit conditions.

(iii) Load Break switches :- Capable of switching off a circuit under load.

(2) Fuses :-
Designed to interrupt the circuit by melting under excessive current conditions. ~~types~~

(3) Circuit Breakers :- Automatically interrupt fault currents and are used for overload and short circuit protection.

(4) Relays :- Act as protective switches and trip circuit breakers when a fault is detected.

Importance of power system protection :-

⇒ Power system protection is important because it prevents damage to power system components and keeps the power system stable :-

(1) Protects components :- Power system protection protects components like generators, transformer, transmission lines, and distribution bus bars from damage caused by short circuits

and other abnormal conditions.

② Keeps system stable :- Power system protection keeps the power system stable by isolating only the faulty components while keeping the rest of the network operational.

③ Limits damage :- Power system protection limits damage at the fault location and prevents the effects of the fault from spreading into the system.

Necessity of Protective devices :-

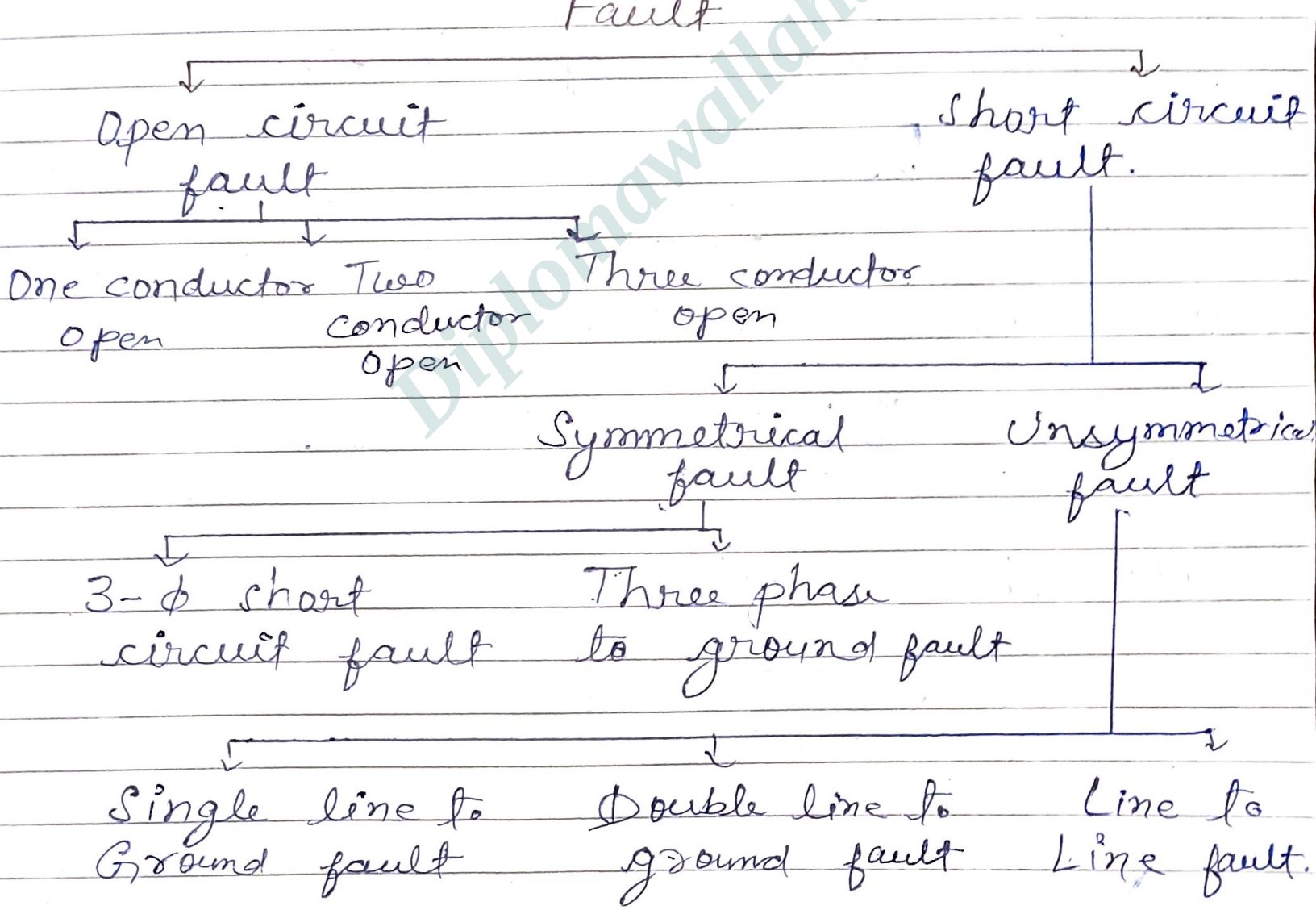
=> ① Protect people :- Prevent injury or death from electrical faults.

② Protect equipment :- Prevent damage to electrical equipment and control panels.

③ Maintain system reliability :- Ensure that the system operates safely and reliably.

④ Restore power :- Restore power supply as quickly as possible after a fault.

Fault :- Fault is the abnormal condition of the electrical system which damages the electrical equipment and disturbs the normal flow of the electric current and voltage levels.

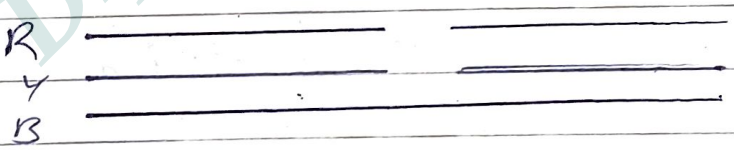


(i) Open circuit fault :-

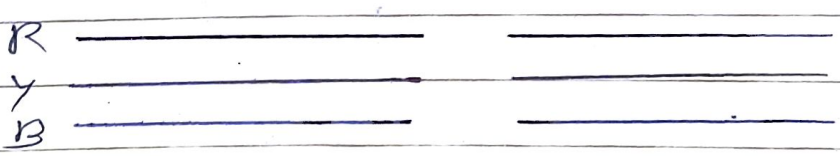
The open circuit fault mainly occurs because of the failure of one or two conductors. The open circuit fault takes place in series with the line, and because of this. It is also called the series fault.
The types of open circuit fault :-

(i) One conductor open fault :-

(ii) Two conductors Open fault :-

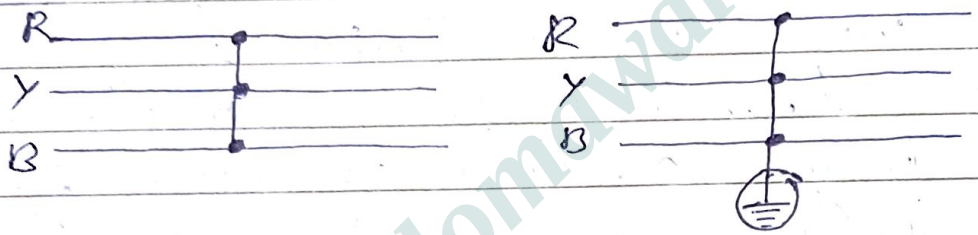


(iii) Three conductors Open fault :-



② Short circuit fault :—

In this fault, the conductors of the different phases come into contact with each other with a power line. power transformer or any other circuit element due to which large current flow in one or two phases of the system. The short - circuit fault is divided into the symmetrical and unsymmetrical fault.

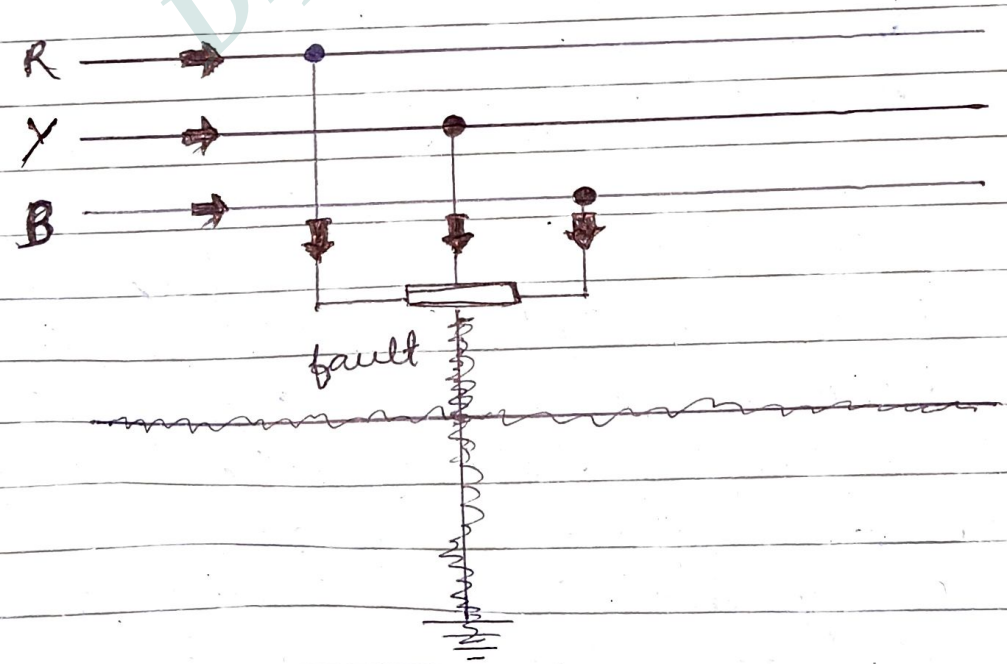


(i) Symmetrical fault :— The faults which involve all three phases is known as the symmetrical fault. Such types of faults remain balanced even after the fault. The symmetrical faults mainly occur at the terminal of the

generators. The fault on the system may arise on account of the resistance of the arc between the conductors or due to the lower footing resistance.

(a) Line-to-line-to-line fault :-

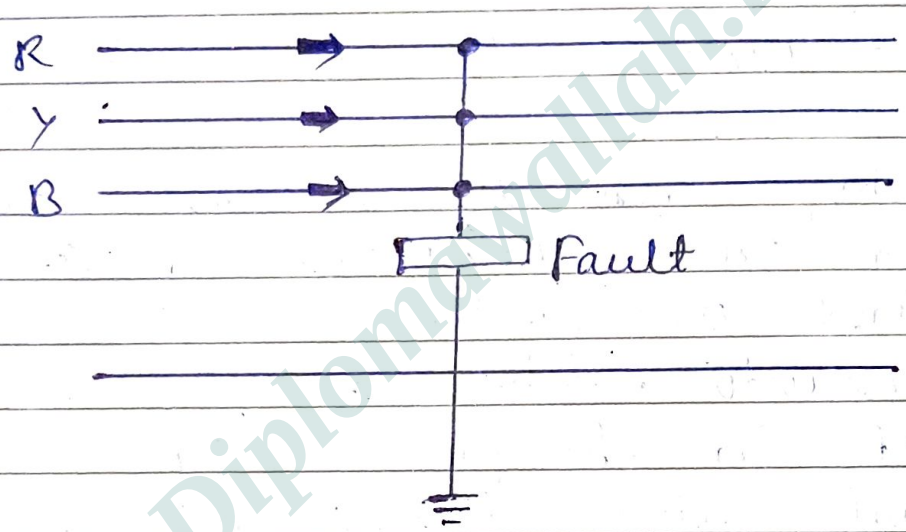
Such types of faults are balanced. i.e. the system remains symmetrical even after the fault. The L-L-L fault occurs rarely. but it is the most severe type of fault which involves the largest current. This large current is used for determining the rating of the circuit breaker.



Three line ~~to Ground~~

(b) L-L-L-G (Three phase line to the ground fault) :-

The three-phase line to ground fault includes all the three phase of the system. The L-L-L-G fault occurs between the three phases and the ground of the system. The probability of accurence of such type of fault is nearly 2 to 3 percent.



LLL-G fault.

(ii) Unsymmetrical Fault :-

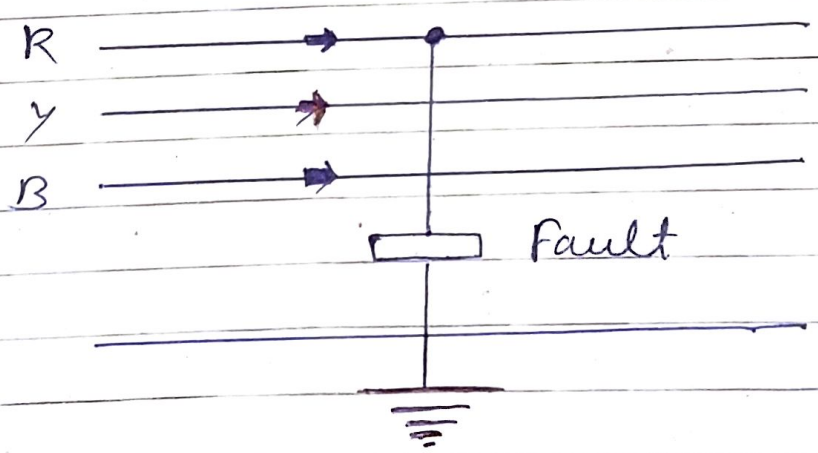
The fault gives rise to unsymmetrical current. i.e., current differing in magnitude and phases in the three phases of the power system are known as the unsymmetrical fault. It is also defined as the fault which involves the

one or two phases such as L-G, L-L, L-L-G fault. The unsymmetrical makes the system embalanced. It is mainly classified into three types. They are -

(a) Single Line-to-ground (L-G) fault
(b) Line-to-line fault (L-L)
(c) Double Line-to-ground (L-L-G)

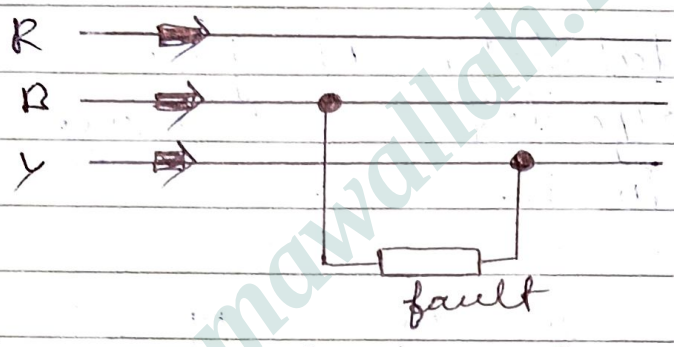
(a) Single Line-to-Line Ground :-

The single line of ground fault occurs when one conductor falls to the ground or contact the neutral conductor. The 70-80 percent of the fault in the power system is the single line-to-ground fault.



Single line to Ground fault.

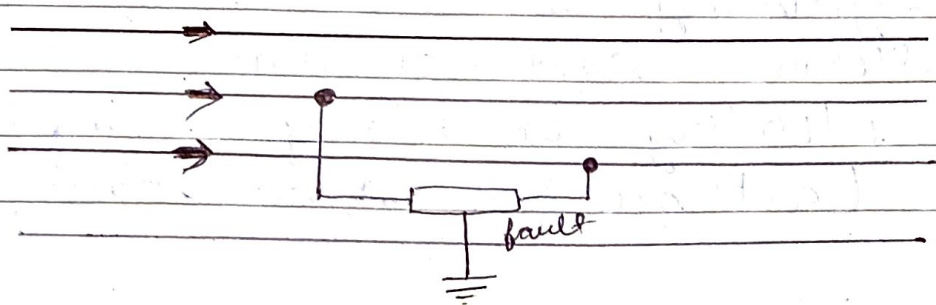
(b) Line - to - Line Fault :- A Line - to - Line fault occurs when two conductors are short circuited. The major cause of this type of fault is the heavy wind. The heavy wind swinging the line conductors which may touch together and hence cause short circuit. The percentage of such type of faults is approximately 15 - 20 %.



Line - to - Line fault.

(c) Double Line - to - line Ground Fault :-

In double line - to - ground fault. the two lines comes in contact with each other along with the ground. The probability of such types of faults is nearly 10 %.



Harmful effect of short circuit current :-

- The heavy current due to fault causes excessive heating which may results in fire explosion.
- Some time the short circuit current takes the form of arc that may cause considerable damage.
- The stability of power system may be affected and may be completely shutdown.
- Damage to other apparatus in the system may be caused due to overheating.

Sources of faults :-

Faults in electrical systems can arise from various sources :-

a) Natural causes :-
- Lightning strikes
- Storms and cyclones
- Flooding or heavy rainfall
- Earthquakes and landslides.

b) Equipment Failures :-
- Overloading and overheating
- Insulation breakdown

c) Human Errors :-
- Operational mistakes (e.g., wrong switching operations)
- Accidental damage during construction or maintenance
- Improper installation or poor maintenance.

d) External Factors
- Three Trees, animals, or birds contacting overhead lines.
- Vehicular collisions with poles or transformers
- Fire incidents or explosions.

Fuse :- Fuse is a electrical safety device that is designed to protect electrical components from over currents.

- It is a short piece of wire
- low melting point
- Inverse time characteristics
- Zinc, copper, Aluminium, silver
- Cheapest form of protection.

Types of fuse :-

(1) Low voltage fuse (2) High voltage fuse

(i) Rewireable fuse (ii) Catridge fuse
(Semi enclosed) (Total enclosed)

(1) Low voltage fuse

(i) Rewireable fuse :-

The most commonly used fuse in 'house wiring' and small current circuits is the semi-enclosed or rewireable fuse (also sometimes known as kit-kat type fuse). It consists of a porcelain base carrying the fixed contacts to which the incoming and outgoing line or phase wires are connected and a porcelain

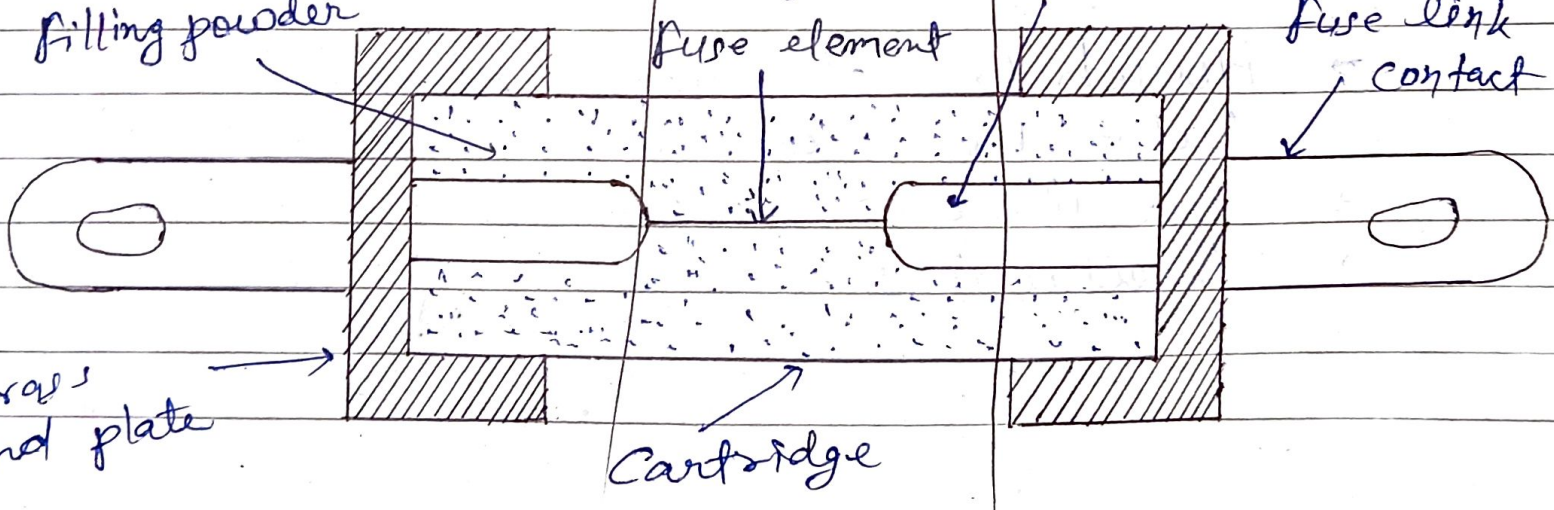
fuse carrier holding the fuse elements. The fuse wire may be lead, tinned copper, aluminium or an alloy of tin - lead.

Advantages :-
→ Easy removal or replacement.
→ Slow speed of operation.
→ 500A rated current.

Disadvantages :-

(i) cartridge fuse :- Cylindrical design with metal caps on both ends. Enclosed in a glass, ceramic, or fiber body protection.

(ii) HRC fuses :- Where large concentrations of power are concerned, as in the modern distribution systems, it is essential that fuses should have a definite known breaking capacity and also this breaking capacity should have a high value. High rupturing capacity catridge fuse, commonly called HRC cartridge fuses.



② High voltage type :-

(i) Cartridge type :-

Construction of low voltage HRC fuse is similar to L-V designs are used upto 33 kV with short circuit capacities of about 8760 amp. at voltage (500 KVA 3-phase).

(ii) Liquid type :- This has wide range of the applications to h-v systems. they may be used for voltage transformer protection or for circuit upto 400 A rated current on system upto 132 kV or highest & may have breaking capacity of 6,100 A at 33 kV.

4 Applications of fuse wire :-

→ Household electrical circuit
→ Automotive circuit.
→ Industrial equipment
→ Electronics.

Fuse element materials :-
Tin, Copper, Lead, Zinc, Silver

Features of Fuse elements :-

1. Low melting point for quick operation.
2. High conductivity to minimize the power losses.
3. Low oxidation tendency to ensure long life.
4. Consistent melting characteristics for reliable performance.

Characteristics of fuse :-

1. Current - voltage Rating :- Operates within specified voltage and current ranges.
2. Breaking Capacity :- Ability to interrupt maximum fault current safely.
3. Time - current characteristics :-
Defines the time it takes to blow for a given current.

Important terms :-

① Current Rating :-

The rating is specified by the manufacturer. It is defined as the rms value of the current which the fuse wire can carry continuously without deterioration, and with temperature rise within specified limits.

② Fusing current :-

It is defined as the minimum value of current at which the fuse element or fuse wire melts. Obviously, its value will be more than the current rating of the fuse element.

$$I = kd^{3/2}$$

k = Constant.

d = diameter.

③ Fusing factor :-

The ratio of minimum fusing current and the current rating

of fuse element is known as fusing factor and it is always greater than unity.

$$\text{Fusing Factor} = \frac{\text{Minimum Fusing current}}{\text{current rating of fusing elements}}$$

$$FF > 1$$

For a semi-enclosed or rewirable fuse which employs copper wire as the fuse element, fusing factor is equal to 1.9 to 2.0. for the standard duty catridge fuses fusing factor is equal to 1.45.

④ Prospective current :-

The rms value of the first loop of the fault current is called the prospective current.

Prospective current may be defined as the current that would flow in the circuit under fault conditions when the fuse were replaced by a link of negligible impedance.

⑤# Cut-off current :-

- The melting of fuse element before the current reaches the prospective peak is called the cut off.
- Cut off current is off instantaneous value.

⑥# Pre-arcing or melting Time :-

On occurrence of a fault, the fault current rises rapidly and heat is generated in the fuse element. As the fault current attains it cut-off value, the fuse melts and an arc is initialed.
Pre-arcing time is the time between the commencement of the current which tends to cause a break in a fuse element and the instant that the arc is initiated.

⑦# Arcing time :- This is the time accounted from the instant of arc initiation (end of the pre-arcing time) to the instand of arc being extinguished or

the arc current becomes zero.

⑧ Total operating Time :-

This is the sum of pre-arcing time and arcing time.

⑨ Breaking Capacity :-

Breaking capacity of a fuse is the rating corresponding to the rms value of the arc component of the maximum prospective current and the system voltage.

HRC fuse :-

The HRC fuse whose full name is the High Rupturing capacity fuse is similar to a normal fuse in which the fuse wire carries a short circuit current up to a certain limit. if the flow exceeds this, it burns. HRC fuses are made from glass or some other type of chemical compound.

The fuse is tightly closed to prevent atmospheric air from entering it. The ends of the fuse are made ciramic metal caps which are attached with flexible silver wire. There is a large amount a space on inside of this which is around the wire otherwise the element of the fuse.
The HRC fuse is uniform, has the feature that it has very low tripping time if it has a high-pressure current. Similarly, if the fault current is not high, the break time is long.

Construction of HRC fuse :-

(1) Outer body :- A heat resistant material like ceramic or fiberglass that withstand high temperatures

(2) Internal filler :- A powder like silica sand, quartz or chalk that absorbs heat during an overload.

③ Fuse element :- A silver-based element that melts at a predetermined temperature when there's an overload.

④ End caps :- Metallic caps that are sealed to make the fuse airtight and prevent energy dissipation.

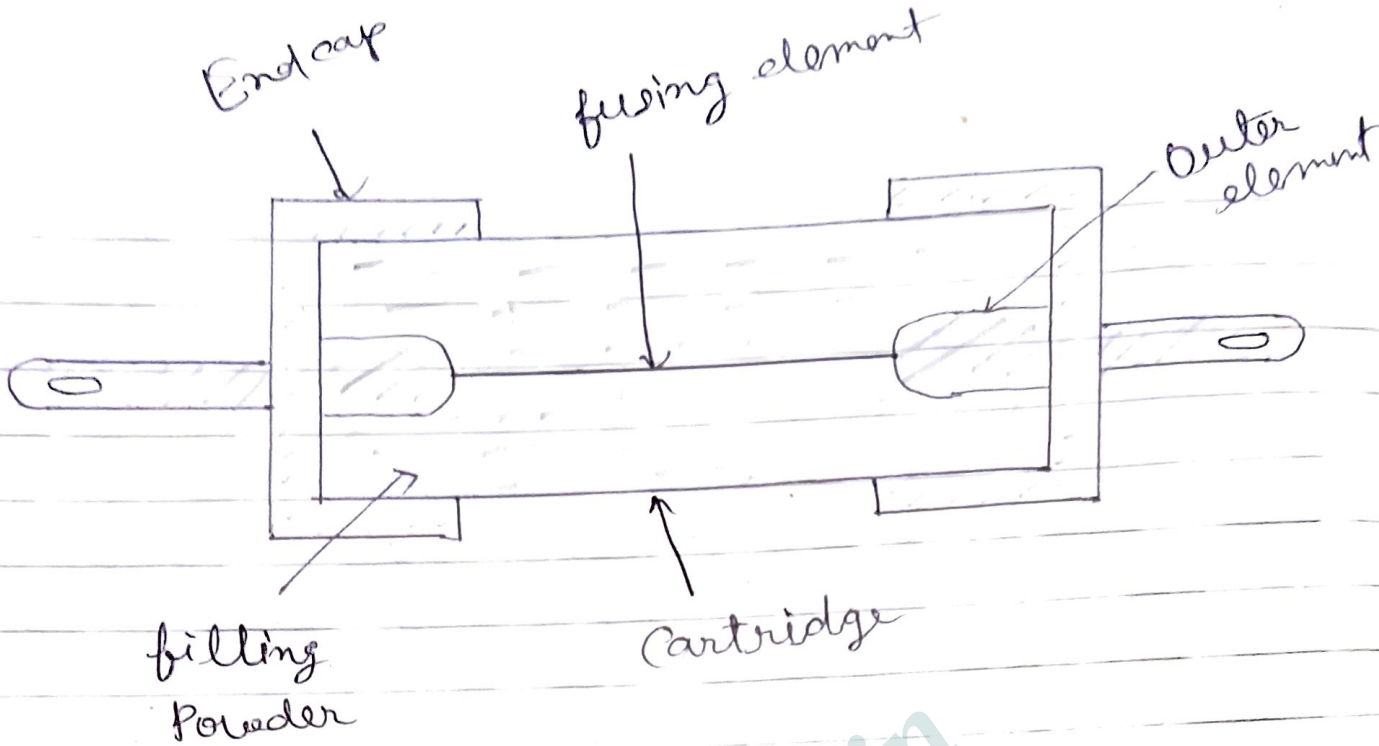
⑤ Sealant :- An epoxy resin or other sealant that strengthens the joints and protect against moisture, oxidation and pressure.

⑥ Insulating covers :- Some fuses have organic polymer casings or insulation sleeves for operator safety.

⑦ Blade contacts :- Copper alloy or copper alloy contacts that connect the fuse link to the fuse base.

⑧ Cover plates :- Plates with gripping legs that allow you to insert and remove the fuse link.

⑨ Indicate device :- A device lets you quickly identify fuses that have operated.



Working principle of HRC fuse :-

Under normal conditions, the current does not generate enough heat to dissolve it. If more current passes than its limit the fault current melt the element of the fuse before it reaches its climax. When the fuse is in an overload condition the fuse ingredient does not melt but if such a condition lasts for a long time then a material like eutectic will melt and break the fuse element.

The thinner parts of the fuse element melt faster in a smaller area when the fuse is in a short circuit.

condition. And it will break before the eutectic material. HRC, therefore, has reason to provide limitations within the element of the fuse.

Advantages of HRC fuse:-

- Cheaper compared to other fuses.
- The design is straight forward and simple.
- Maintenance of any kind is not required.
- Easy working
- This program is ongoing
- High breaking capacity.

Disadvantages of HRC fuse:-

- This cannot be reused once exited.
- It causes overheating for close contacts.
- After each action, they will change
- The probability of interlocking is high.

Applications of HRC fuse :-

- HRC fuses are used to protect high voltage switch gears from short circuits.
- Used for backup security.
- This type of fuse is also used in motor stator.

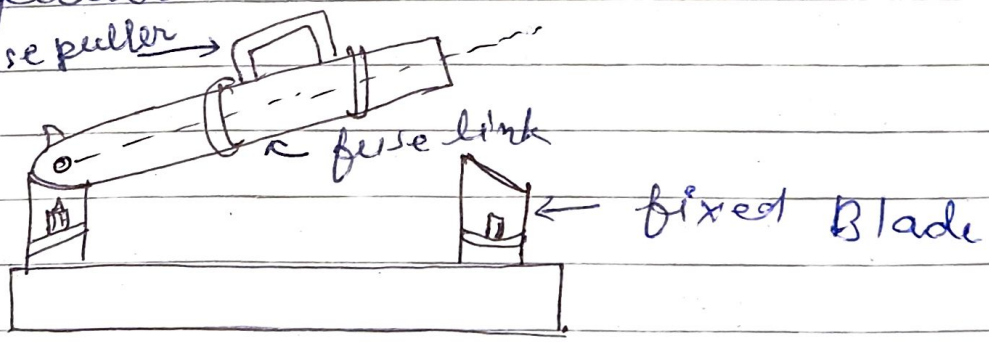
Types of HRC fuse :-

1. Low voltage HRC fuse
2. High voltage HRC fuse.

(1) Low voltage HRC fuse :-

(i) Knife blade type HRC link fuses :-

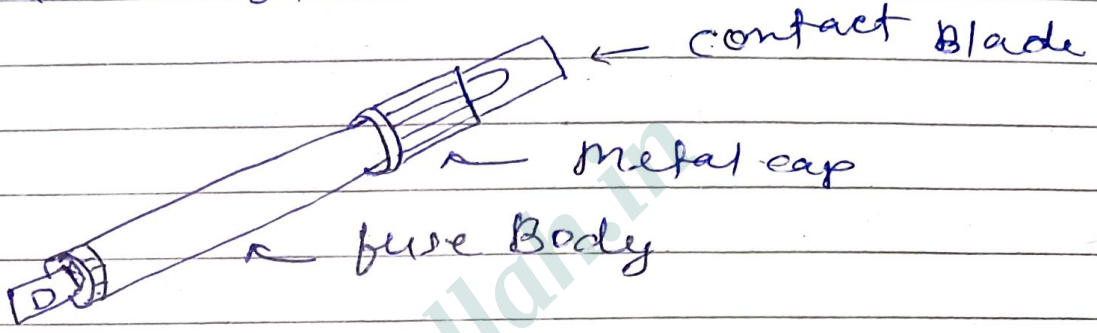
⇒ Replaced on live ckt at no load with the help of special insulated fuse puller.



(ii) Bolted type HRC link fuses :-

⇒ It has 2 conducting plates on either side.

⇒ Such a fuse needs an additional switch so that fuse can be taken out without a shock.



(2) High voltage HRC fuse :-

(i) Cartridge type HV HRC fuse :-

⇒ Similar construction similar to L.V type except that some special design features are incoparated.

⇒ Wound in the shape of helix so as to avoid corona effect at higher voltage.

⇒ In some design, two fuse element in parallel are employed.

(ii) Liquid type HV HRC fuse :-

⇒ Killed with carbon tetra chloride

⇒ Used for voltage transformer protection.