Puffer type design makes operation of SF_6 CB much easier. In *Puffer* type design, the arc energy is utilized to develop pressure in the arcing chamber for arc quenching.

Here the breaker is filled with SF_6 gas at rated pressure. There are two fixed contact fitted with a specific contact gap. A sliding cylinder bridges these to fixed contacts. The cylinder can axially slide upward and downward along the contacts. There is one stationary piston inside the cylinder which is fixed with other stationary parts of the SF_6 circuit breaker, in such a way that it cannot change its position during the movement of the cylinder. As the piston is fixed and cylinder is movable or sliding, the internal volume of the cylinder changes when the cylinder slides.

During opening of the breaker the cylinder moves downwards against position of the fixed piston hence the volume inside the cylinder is reduced which produces compressed SF_6 gas inside the cylinder. The cylinder has numbers of side vents which were blocked by upper fixed contact body during closed position. As the cylinder move further downwards, these vent openings cross the upper fixed contact, and become unblocked and then compressed SF_6 gas inside the cylinder will come out through this vents in high speed towards the arc and passes through the axial hole of the both fixed contacts. The arc is quenched during this flow of SF_6 gas.

During closing of the circuit breaker, the sliding cylinder moves upwards and as the position of piston remains at fixed height, the volume of the cylinder increases which introduces low pressure inside the cylinder compared to the surrounding. Due to this pressure difference SF_6 gas from surrounding will try to enter in the cylinder. The higher pressure gas will come through the axial hole of both fixed contact and enters into cylinder via vent and during this flow; the gas will quench the arc.

3.9 D.C circuit breakers

It is well known that DC has no natural current zero. Therefore, the current either needs to reduced, by lengthening of the arc or cooling or by forced reduction of the current to zero. For lower voltage cases, a simple resistance and inductive coil connected across a switch forces the current to reduce to zero. Such a scheme is particularly being successful when the current magnitude is small. For higher voltage and current cases, a method that combines forced current reduction and grid control mechanism is applied.

Forced reduction of current zero: In this method an oscillatory LC network is utilized to let an oscillatory current flow in opposite direction to that of the direct current (DC). The moment the oscillatory current magnitude exceeds the DC value, the breaker current falls to zero temporarily. This helps in quenching the arc. The peak oscillatory current of the LC circuit should be more than the DC value through the breaker. The scheme operation can be understood from the figure given below. A normally open (NO) and a Normally Closed (NC) auxiliary breakers are utilized to discharge and charge the capacitor of the LC unit. The capacitor first is charged to line voltage through the L and R through the NC breaker. At the desired instant of main C.B opening, the capacitor discharges through the L when, the NO breaker becomes closed and NC becoming open.

In this scheme, the value of C is so chosen that, the rise time constant of the line voltage is smaller than the charging time constant of C, which ensures that the voltage across the C is maintained for longer time. Similarly the value of L is so chosen that, the rise time constant of the line current should be more than the changing time constant of the oscillatory current, which ensures that the oscillatory current reaches the load current quickly.

Method of Grid Control: All transient faults which die out immediately, can be controlled by method of grid control. In this method the faults can be switched out gradually in an artificial manner by forcing the whole system voltage to reduce to zero temporarily, with the help of converter grid control. Fast acting isolating switches are then used to isolate the faults. With this method also the short circuit current magnitude can be reduced considerably to levels much below the full, load levels so that severity of the fault can be reduced. This partial current reduction method is sufficient in the case of unsustained faults.

3.9.1 *Miniature circuit breaker* ***or*** *MCB*

Nowadays we use more commonly miniature circuit breaker or *MCB* in low voltage electrical network instead of fuse. The MCB has some advantages compared to the fuse.

1. It automatically switches off the electrical circuit during abnormal condition of the network means in over load condition as well as faulty condition. The fuse does not sense but miniature circuit breaker does it in more reliable way. MCB is much more sensitive to over current than fuse.

2. Another advantage is, as the switch operating knob comes at its off position during tripping, the faulty zone of the electrical circuit can easily be identified. But in case of fuse, fuse wire should be checked by opening fuse grip or cutout from fuse base, for confirming the blow of fuse wire.

3. Quick restoration of supply cannot be possible in case of fuse as because fuses have to be rewired or replaced for restoring the supply. But in the case of MCB, quick restoration is possible by just switching on operation.

4. Handling MCB is more electrically safe than fuse.

Because of many advantages of MCB over fuse units, in modern low voltage electrical network, miniature circuit breaker is mostly used instead of backdated fuse unit.

Only one disadvantage of MCB over fuse is that this system is more costlier than fuse unit system.

Miniature Circuit Breaker

Working principle MCB

There are two arrangement of operation of miniature circuit breaker. One due to thermal effect of over current and other due to electromagnetic effect of over current. The thermal operation of miniature circuit breaker is achieved with a bimetallic strip whenever continuous over current flows through MCB, the bimetallic strip is heated and deflects by bending. This deflection of bimetallic strip releases mechanical latch. As this mechanical latch is attached with operating mechanism, it causes to open the miniature circuit breaker contacts. But during short circuit condition, sudden rising of current, causes electromechanical displacement of plunger associated with tripping coil or solenoid of MCB. The plunger strikes the trip lever causing immediate release of latch mechanism consequently open the circuit breaker contacts. This was a simple explanation of miniature circuit breaker working principle**.**

Miniature circuit breaker construction

Miniature circuit breaker construction is very simple, robust and maintenance free. Generally a MCB is not repaired or maintained, it just replaced by new one when required. A miniature circuit breaker has normally three main constructional parts. The primary one is its frame and the other two parts are as follows

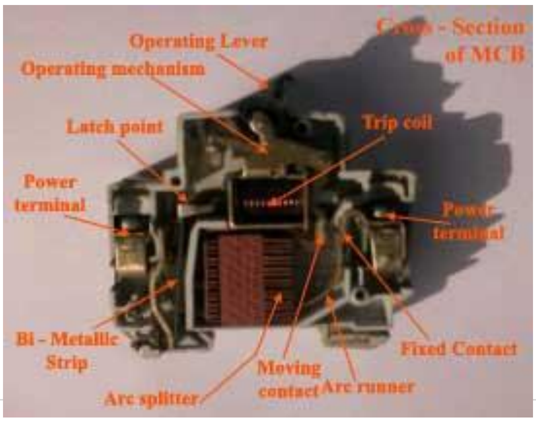
Operating mechanism of miniature circuit breaker

The operating mechanism of miniature circuit breaker provides the means of manual opening and closing operation of miniature circuit breaker. It has three-positions “ON,” “OFF,” and “TRIPPED”. The external switching latch can be in the “TRIPPED” position, if the MCB is tripped due to over-current. When manually switch off the MCB, the switching latch will be in “OFF” position. In close condition of MCB, the switch is positioned at “ON”. By observing the positions of the switching latch one can determine the condition of MCB whether it is closed, tripped or manually switched off.

The TRIP Unit of the MCB

The trip unit is the main part, responsible for proper working of miniature circuit breaker**.** Two main types of trip mechanism are provided in MCB. A bimetal provides protection against over load current and an electromagnet provides protection against short-circuit current.

OPERATION OF MINIATURE CIRCUIT BREAKER



There are three mechanisms provided in a single miniature circuit breaker to make it switched off. If we carefully observe the picture beside, we will find there are mainly one bi – metallic strip, one trip coil and one hand operated on – off lever. Electric current carrying path of a miniature circuit breaker shown in the picture is like follows. First left hand side power terminal – then bimetallic strip – then current coil or trip coil – then moving contact – then fixed contact and – lastly right had side power terminal. All are arranged in series. Miniature Circuit Breaker

If circuit is overloaded for long time, the bi – metallic strip becomes over heated and deformed. This deformation of bi metallic strip causes, displacement of latch point. The moving contact of the MCB is so arranged by means of spring pressure, with this latch point, that a little displacement of latch causes, release of spring and makes the moving contact to move for opening the MCB. The current coil or trip coil is placed such a manner that during short circuit fault the *mmf* of that coil causes its plunger to hit the same latch point and make the latch to be displaced. Hence the MCB will open in same manner. Again when operating lever of the miniature circuit breaker is operated by hand, that means when we make the MCB at off position manually, the same latch point is displaced as a result moving contact separated from fixed contact in same manner. So, whatever may be the operating mechanism from either of the three possibilities, such as deformation of bi – metallic strip, increased *mmf* of trip coil and/or manual operation, the same latch point is displaced and the deformed spring is released, which ultimately responsible for movement of the moving contact. When the moving contact separated from fixed contact, there may be a high chance of arc. This arc then goes up through the arc runner and enters into arc splitters and is finally quenched. When we switch on an MCB, we actually reset the displaced operating latch to its previous on position and make the MCB ready for another switch off or trip operation.

3.10 HRC Fuse or High Rupturing Capacity Fuse

HRC fuse or high rupturing capacity fuse is a type of fuse whose wire or element can carry short circuit heavy current for a known time period. During this time if the fault is removed, then it does not blow off otherwise it blows off or melts.

The enclosure of HRC fuse is either of glass or some other chemical compound. This enclosure is fully air tight to avoid the effect of atmosphere on the fuse materials. The ceramic enclosure having metal end cap at both heads, to which fusible silver wire is welded. The space within the enclosure, surrounding the fuse wire or fuse element is completely packed with a filling powder. This type of fuse is reliable and has inverse time characteristic, that means if the fault current is high then rupture time is less and if fault current is not so high then rupture time is long.

3.10.1 Operation of HRC fuse

When the over rated current flows through the fuse element of high rupturing capacity fuse the element is melted and vaporized. The filling powder is of such a quantity that the chemical reaction between the silver vapour and the filling powder forms a high electrical resistance substance which very much help in quenching the arc.