Testing & Maintenance of Electrical Machine

CP-1 (Installation, commissioning & Testing of Machine)

Inspection on Arrival of Machine:-

* Inspection is the examination of certain machines (i.e. motor or generator) & their parts to inspect for their damage.
* The main aim of the inspection is to check that machine which is received in good condition & also as per our requirments.
* So it is very much essential to inspect the machines carefully before the installation.
* This inspection work should be carried out by some competent person (knowledge regarding the inspection of a particular machine i.e. what to inspect & how to inspect.
* During the inspection of electrical machine, the necessary instructions given by the manufacturer must be followed.

→ Procedure to followed on the arrival of electric machine

* The wooden crates containing motors should be unloaded by using cranes.
* Sliding the motor down on an inclined plank should be avoided.
* If we used the inclined plank, then properly tied the wooden crates by the help of ropes & bring down in a steady manner to avoid injury to the machine & the personnels.

Handling of Electrical Machine (Motors)

* Motor should be handled very carefully to increase life & service of the motors.

Precautions:-

a) Always use lifting hook to lift the motor, if no hook is provided on the machine then cranes, Chain, Pulley block, ropes etc. should be used according to their lifting capacity.

b) Do not use any other part of the motor for lifting purposes.
c) Do not use shaft projection for dragging the motor
d) Do not roll or drag the motor on floor.
e) Avoid jerks to the motor in order to increase the life of the bearings.

Unpacking & checking the motor -:

* The packing box should be checked properly on the arrival of motor at the site.
* If any damage (:) occured during the transpotation, then immediately contact to the manufacturer or Supplier and insurance company.
* The packing box contains a part of list & bills. So collect though things, when the box was open.
* The packing box bears some marking indicator of the sender & the receiver address. So check it properly.
* Do not turn over the box & handle it carefully & Strictly followed the warning instruction.
* After that open the box by using proper tools for removing nails, screws & steel strip etc.

Inspect All parts -:

* After unpacking & checking, the machine should be brushed down to remove all small pieces of wood wool, packing paper dust etc.
* Then again properly checked all parts of the machine before proceeding to the installation.
* Also check that the motor name-plate details agree with supply order.

Storage of Electrical Motors -:

* prior to installation, the motors should be stored in a clean and dry place.

* The motor parts have a protective coat of anti-rust preservative which should not be taken off during normal storage periods.
* In case of long storage, periodic examination should be carried out & fresh preservative be applied after removed any rust & moisture.
* Motor should be protected from moisture, acid, alkali oil, gas, dust & injurious substances during the whole storage & installation period.
* Special precautions should be taken when the motor is idle for considerable period to avoid corrosion ବ୍ଲକାର & loss of grease.
* It is advisable to rotate the shaft periodically as the grease tends to settle down at the bottom.
* Before the motor is started after a long time period, check the condition of grease, if any deterioration of grease is apparent, then replaced it by new grease.

Procedure for storing a machine at site -:

a) The machine should be stored in clean, dry, store house having uniform temperature.
b) Large variation of temp. should be avoided.
c) Heaters should be provided to avoid dampness.
d) The humidity of air in the store room should not more than 68% & the temp. should not be below +15°C.
e) Direct sunlight, rain water, dust, gases, water, smoke should not be present in the store room.
f) Chemicals, batteries, gas cylinders, explosives should not be kept in the same store room.
g) There should be proper pest control to avoid rats, mosquitoes & other troublesome pests.

h) Machine should not be kept on mud floor.
i) The floor of store should not be subjected to vibrations. In case of vibration, the machine should be placed on rubber blocks.
j) There should be 'No smoking' sign in the store-room.

Procedure for inspection of an electrical motor before its installation -:

* The inspection of the motor should be carried out as follows -:

1. External inspection of motors should be properly done.
2. Inspection of terminals by opening the terminal lid.
3. Blowing of the motor with clean, dry air to remove dust.
4. Checking of the rotor for easy rotation when turned by hand.
5. Rectification of defects observed during inspection
6. Particular attention should be given towards antifriction bearings of the motor.
7. Insulation resistance between winding & frame tested by means of a "Megger" & compared it by the manufacturer data.

Note -: It should always be above 0.5 mega ohm.

Drying-out of an electric Rotating Machines & its Necessity -:

* All the motors should be dried out before the full voltage is applied to terminals.
* To decide whether drying out is necessary, the insulation resistance should be measured.
* If it is found that the insulation resistance (measured in Megger) between any terminal & frame is less, then the motor should be moved

to warm & dry place where the air is free from dust & the temp. does not exceed 90°C.

* The insulation of machines have a tendency to absorb moisture when not carrying currents & kept idle.
* This moisture reduces the insulation resistance.
* Thus, before commissioning a machine, the drying out is essential, particularly for high voltage machines (above 1000V rating)

Step in Drying-out of a Motor or a Generator -:

* preliminary preparation of the machine, source of heat, measurements etc. are checked properly.
* Arrange the set-up.
* Apply heat by one of the suitable means gradually
* Take periodic reading of

a) clock-time

b) Temperatures of windings, body and air

c) Insulation Resistance values of 15 second Megger Reading and 60 second Megger Reading.

d) winding Resistance (At the beginning & at the end) and during decreasing temp.

Note -: Megger is used for measuring Insulation Resistance & thermometer or thermocouples used for measuring temp.

e) Measure periodically of the insulation Resistance values.

f) Initially, during the 1st few hours, the value of insulation resistance reduces even though the heat is being applied for Drying-out. This is happend because the moisture trapped in different parts of machine. Hence the insulation resistance value starts reducing.

g) Intermediate Stage :- After a span of a few hours or a few days, the insulation resistance reaches to a steady value. This indicates that the moisture has spread all over the insulation (Different parts of m/c)

h) Rising stage :- After a few hours of steady value, the insulation resistance starts rising.

i) If we achived the desired insulation resistance value, then drying-out process is stopped.

j) The winding resistances are measured for various temperatures as the temp. start falling.

Measurements are taken during drying-out of electrical machines :-

a) 1. Insulation Resistance between phase & ground
2. Insulation Resistance between phases.

* The Insulation Resistance is measured by means of Megger.
* 1000 V Megger is recommened for testing High voltage motor.
* 500 V Megger is recommened for testing loco voltage motor.

Measurement Condition :-

* 15 sec reading (after continuous application of d.c voltage for 15 sec)
* 60 sec. Reading.

b) Temp. of winding & outlet Air.

* The reading are taken at an interval of 15min or 30mins initially & at an interval of 1 hours or 2 hours for the remaining drying out period.

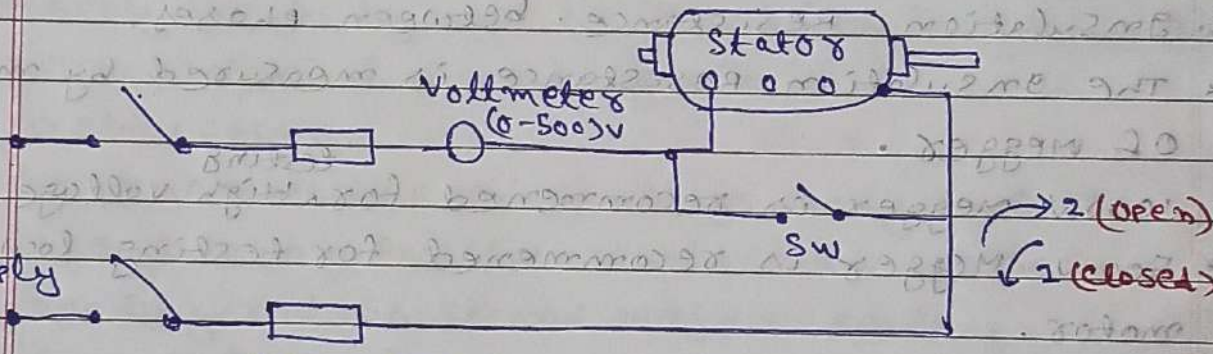
Voltmeter method of measurement of insulation Resistance :-

* This is used only when a megger is not available.
* A high resistance d.c. voltmeter with a range of 500 volts is used to measure the insulation resistance.

* Its sensitivity should be of the above of 100 Ω per volt.
* voltmeter indications are recorded when the single-pole switch closed (1) and again with it open (2)
* To determine insulation resistance, formula is

$$R_1 = R_2 \frac{(V_1 - V_2)}{V_2}$$

R_1 = Insulation resistance to be determined.
R_2 = Resistance of voltmeter.
V_1 = voltmeter indication with switch closed (1).
V_2 = voltmeter indication with switch open (2).



5 Amp, HRC (High Rupturing Capacity Fuses fuse)

(Voltmeter method for measuring insulation resistance)

Precaution while Drying out

1. Chamber should have thermal insulation to prevent heat loss.
2. The machine body should be covered with canvas to prevent heat loss.
3. Temp. of air shall be controlled by turning off the heater from time-to-time.
4. Local temperature should not exceed 75°C. There should be proper circulation of air in the chamber.

5. The temp. should be raised gradully. Not faster than 10°C per hour. Higher rate of heating results in damage due to differential expansion of metals & insulation.

6. Heating should be continuous & steady temperature shall be maintained continuously during the entire drying period.

Methods of drying out an electrical machine:-

* The machine to be dried is placed in a drying chamber.
* The drying chamber should be of volume about 4 times the volume of motor or machine.
* The air is circulated by means of fans & air circulation system.
* The air temp. is periodically measured by means of thermometers.
* After removed the moisture from the machine, it should be ready for installation.

Maintenance

→ Maintenance is the process for maintaining any equipment or machinery in a proper & efficient condition.
→ For getting satisfactory & trouble free service from any electrical equipment or apparatus or any other electric machines, it requires careful planed programme of checking and inspecting and also for preventing Maintenance.
→ It is necessary to keep the proper record of inspection, insulation resistance and all maintenance & repair operation etc. After that, it will be possible to find out the specific troubles.
→ A machine should never be allowed to run without lubrication. (Lubrication :- the action of applying a substance such as oil or grease to an engine or component so as to minimize friction & allow smooth movement).
→ Proper care should be taken for its cooling and over-loading.
→ The machines must be kept free from the moisture humidity, dirt, oil etc. as these factors affect the insulation of windings and may result in rusting the various parts of the machines.
(dirt :- Mud + dust)
→ The periodic inspection & maintenance details may vary with the type of machine & its working conditions.
→ Some Spare parts, Sub-assemblies, lubricants depending upon the need & importance of the machine & some spare coils, brushes, brush holders, starting gears & bearings etc. should be kept ready in stock.
(Spare parts :- a duplicate part to replace a lost or damaged part of a machine)
(Sub-assemblies :- a unit assembled separately but designed to be incorporated with other units into a larger manufactured product.

Fundamental of Maintenance-:

* Maintenance can be defined as those activities required to keep the equipment in operating condition so that it continues to meet specification.
* Thus, maintenance ensures that the production plant or equipment is available for use at minimum cost, for scheduled hours.
* When an electrical equipment fails or its performance degrades, it is required to restore its operation with minimum of down time.
(down time -: time during which a machine is unavailable for use.
* Thus maintenance restores the equipment operation economically & efficiently.
* Maintenance increases the availability of equipment by reducing down time. It assures the equipment availability for instant operation.
* Since a large no. of equipments are used in an organisation, it involves a sound policy for maintenance of the equipments used.
* Most of manufacturers of the equipments offer after-sales service to their customers.
* The maintence schedule is usually in the form of long sheets on which weeks, months of the year are tabulated.
* Each equipment in the plant or in big factory provided with a column in the maintenance sheet along with the periodic maintenance time.
* Further each major equipment is provided with a history card. The details about inspection, operation and remarks are written in these cards.
* The "spares" are important for maintenance duty The spares are kept in store with proper inventory control.

* In case of difficult jobs the manufacturer is consulted. The manufacturer provides trained personnel on request with necessary payment.

Classification of Maintenance :-

a) Corrective Maintenance :-

→ Corrective maintenance is carried out when an equipment fails or does not work satisfactory.

b) Preventive Maintenance :-

→ The preventive Maintenance is carried out to reduce the failure of equipment to minimum.

c) Contracted Maintenance :-

→ In contracted Maintenance, contract terms are agreed upon by the Supplier of the equipment and user, and may include both preventive and corrective maintenance.

Preventive Maintenance introduction :-

→ We know that all electrical machines & equipments may suffer partial or complete breakdown.

→ whenever the parts in any piece of equipment show signs of damage, they must be timely repaired.

→ If the electrical equipment is to give trouble-free and continuous service, and if its life span is to be prolonged then it is necessary to implement an effective system of preventive maintenance.

→ An effective system will include routine servicing and inspection, periodic repair of equipment according to a fixed schedule & routine, testing at specific intervals of time depending upon the operating condition.

→ With proper operation and an effective maintenance system, it is possible to ensure that electrical

equipment will be kept in a fit operating condition & breakdown or premature failure will be reduced to a minimum.

→ The term routine servicing & inspection includes the visual inspection or seeing that electric machine, transformers, starting and control devices operate at normal loads.

→ Regular visual inspection of all parts of equipments checking of bearings, winding, temperature etc. should be done.

→ Servicing work include like rectifying minor defects, tightening loose fastenings and such other operations which do not required any dismantling should also be done.

→ Routine testing should include the periodic measurement of insulation resistance, insulation testing, testing of transformer oil, measurement of air gap between stator & rotor of motors and all others tests as required by operating instructions.

Preventive Maintenance Essence :-

→ Basically the functions of this section are :-

1. Periodic visual inspection of various equipments to locate condition leading to breakdown.
2. UP KEEP of equipment and plant and repair defects at their initial stage.
3. To attend major breakdown and repairs.

→ preventive maintenance programme will have the following basic aspects :-

1. Inspection :- what to inspect and how to inspect?
2. Frequencies :- How often to inspect ?
3. Schedules :- when to inspect ?
4. Organisation :- who to inspect ?
5. Records :- what to record and how to record ?

Advantages of preventive Maintenance :-

1. It prevents unscheduled interruption to various machines and equipments & premature failures.
2. It makes an effective use of systematic maintenance & inspection to determine the need for minor and major repairs.
3. It reduces breakdown to a minimum and increase the efficiency of equipments & machinery.
4. Satisfactory maintenance of machines and other equipments at low cost.
5. It helps to plan flexibility in operation due to accurate knowledge of machinery conditions.
6. It makes working condition better.
7. It increase the life of the machine.
8. Less standby equipment is needed.
9. It lowers wear and tear (damage) of machine and other equipments.
10. provide greater safety and protection to the workers.

Classification of preventive Maintenance :-

1. Routine Maintenance :-

→ It should be carried out daily, if possible.

→ It includes visual inspection, minor repairs such as replacement of small parts and adjustment of equipment so that it remains in operation.

→ It includes all work required in cleaning of electrical equipment from dust or mud, cleaning of the fitting, cleaning the fixed and moving contacts of starters replacement of burnt contacts.

→ Routine maintenance of electric motors involves washing & lubrication of bearings, checking of control equipment & replacement of carbon brush etc.

→ This maintenance is carried out without dismantling the equipment, but it must always be disconnected from supply before any repairs are undertaken.
→ The routine maintenance work is carried out by the maintenance staff.

2. Periodic Maintenance -:
→ It should be carried out weekly, fortnightly (2 week) monthly, quarterly & half yearly depending upon the requirements and condition of the machine.
→ It includes inspection of loose parts, ventilation, replacement of worn parts, change in oil, checking of insulation etc.

3. Overhaul -: (a parts of machine examine & replace if necessary)
→ It should be carried out half-yearly or yearly.
→ It consists of replacement or renewal of the main units, assemblies and parts of electrical equipment.
→ It involves such work as rewinding of motor stator and rotor, replacement of bushing of high voltage circuit breakers and involves partial or complete dismantling of equipment.

4. Maintenance on Fault -:
→ It is carried out immediately as and when a fault occurs. Ex-: Blowing of fuse, short circuit or overloading etc.
→ The following factors should be taken into consideration at the time of preparing the schedule for maintenance.

a) checking of stationary parts.
b) checking of movable parts.
c) checking of working condition of equipment or machinery.

d) checking of surroundings in which the machinery or equipment has to work (i.e. atmospheric conditions)
e) checking of safety measures.
f) checking of protective devices.
g) checking of facilities available.
h) List of consumable and non consumable items to be used in the equipments and machinery.
i) checking of stores and spared inventory. (list of item)
j) checking of tools, trackles, jacks and fixtures etc.
(Online service)

Planning -:

→ It is an important & commonly used feature in the maintenance department.
→ The maintence engineer should inspect the plant periodically under working conditions and also in rest time with good planning & preparation.
→ Many tests can be made during lunch time recess.
* The planning of Maintenance should be categorized in the following ways -:

1. Routine maintenance.
2. Periodical maintenance. (weekly, fortnightly, monthly, (quarterly or half yearly)
3. Maintence of fault as & when the fault occurs.

Breakdown -:

→ when industrial plants or electrical machines are running and stop incidently, it is known as breakdown.

Causes of Breakdown -:

a) Faulty design construction.
b) Incorrect installation or use.
c) overload condition.
d) Negligence.
e) wear and tear (deterioration & minor damage)
f) Accident.

Breakdown Maintenance -:

→ Breakdown maintenance is carried out as and when necessary.

1. Engineering Records -:

→ The timely fulfillment of breakdown maintenance depends on the work record, in which repaired work of the electrical equipment is recorded.

→ This is recorded in a card form which tell us the overall condition of the equipment and kind of repairs work required in future.

→ The proper keeping of records promotes better planning of work.

2. Inspection -:

→ The maintenance work mainly depends upon the inspection.

→ There fore, inspection must be carried out by senior and experience person who has got thorough knowledge of maintenance work.

→ The inspection can be divided into two types.
a) External inspection b) Internal inspection.

External inspection -:

→ The external inspection is carried out when the equipments are in operation.

→ condition like vibration, abnormal sound, wear and slackness, lubrication etc. can be observed (not tight) & corrective action can be taken.

Internal inspection -:

→ Internal inspection is to be carried out during pre-planned Shut down which can be done monthly or quarterly or half yearly depending upon the operating conditions.

3. servicing -:
→ This refers to cleaning, adjustment, lubrication and maintenance functions without dismantling the equipment.
4. Testing -:
→ The testing of the electrical equipments must be done very carefully.
→ Because the performance of the equipments specially protective device, such as relays etc. depends upon the testing and proper setting.
→ Testing work should be done by responsible person who has thorough knowledge of use and proper handling of testing equipments.
→ Test entry should be made in the forms available.
5. Engineering Analysis -:
→ It is observed that a few equipments require more frequent repairs as compared to others
→ The following reasons are
a) Defective design.
b) faulty material
c) Unhealthy operating conditions
d) Misuse of equipment.
e) Poor maintenance.
f) Low quality material used in the equipment.
→ It is very easy to rectify those reasons, when detected.
6. Tools and Tackles -: (Tackles -: the equipment required for a task or sport)
→ Proper tools and tackles are more essential for the continuously operating unit.
→ Proper tools also reduce the amount of manual labour requried for handling heavy equipments.

→ Heavy and time consuming manual work can be reduced by -:

1. Mechanising the lifting and handling operation.
2. Employing infrared heating and induction heat loss method for drying out motors, transformers etc.
3. Jointing wires and rods by welding instead of Soldering.

7. Inventory control of stores and spares -:

→ It is also very much necessary for maintenance section to make the inventory of all the spares required & should be made readily available for use whenever required.

(Inventory -: a complete list of items)

2.3.2. List of commonly used Instruments for Maintenance

The instruments required in electrical maintenance department will largely depend upon the repair work to be done. In most of industries sufficient instruments are available to enable the staff to carryout maintenance and minor repairs. The testing generally determine the condition of plant and help in early detection of any fault. The following instruments are generally used for maintenance in industry.

(*a*) *Voltmeter with Switch :* Voltmeter with switch is used to find out voltage between main phases and between phase and neutral at the supply point.

(*b*) A small switch board fitted with various sizes of lamp holders and socket outlets including fluorescent lighting fittings, into which other components such as choke coil, starter, switch may be connected, for testing two flexible leads with two insulated test lamps. These may be used for continuity and insulation test.

(*c*) An oven provided with a ventilated fan and preferably heated electrically underhand or thermostatically control for drying out machine and other apparatus.

(*d*) Infra-red lamps may be used for heating in place of resistance heaters or stream pipe heating.

(*e*) Prawler can be used for testing the armature of the motor, repulsion type motor, series AC and universal motors.

(*f*) A low voltage supply from a car battery can be used through a switch and variable resistance for making voltage drop test on armature.

(*g*) A meggar for measuing earth resistance upto 100 Ω.

(*h*) An earth fault loop tester for impedance tests of earthing circuits.

(*i*) A clip-on multirange ammeter, a double range ac voltmeter, dc voltmeter and multirange dc ammeter are also used for maintenance work.

(*j*) A strong torch is used specially fitted with a terminal or socket output for simple continuity test and testing fuses etc. Other essential items are : Neon tester, speed counter, stop watch, tachometer, small magnifying glass & mirror, portable vacuum cleaner and blower, electrical soldering iron of 300 W and 60 W rating, glow lamp and light measuring meter, lifting apparatus and pulley drawing system should be available as required together with normal workshop facilities.

List of Commonly Used Tools For Maintenance

Installation and maintenance work necessitates the use of a large variety of measuring tools and gauges etc. Without the aid of proper tools it is difficult to carry repair work. The total maintenance time and efficiency of the service personnel depend upon the availability of tools. Sometimes, it may be difficult to carry out job for want of the particular tools. Proper selection and use of hand tools reduces fatigue, reduces damage due to use of wrong tool and improves the maintenance quality. It is preferred to purchase better grade tools. The following electrical tools are commonly required for servicing and maintenance of electrical machines.

1. Screw Drivers

It is a common hand tool for maintenance and assembly work. The shank is made of steel set into a wooden or plastic handle. The blade is shaped to fit recesses in the heads of screws. Screw drivers are made in many sizes but commonly used of 25 cms screw driver with 15 cms blade in order to meet different types of jobs.

Various types of screw drivers are available today :

(*a*) Standard screw drivers for in ordinary work.

(*b*) Offset screw driver is used when ordinary screw drivers cannot be used due to the square hole of the screw.

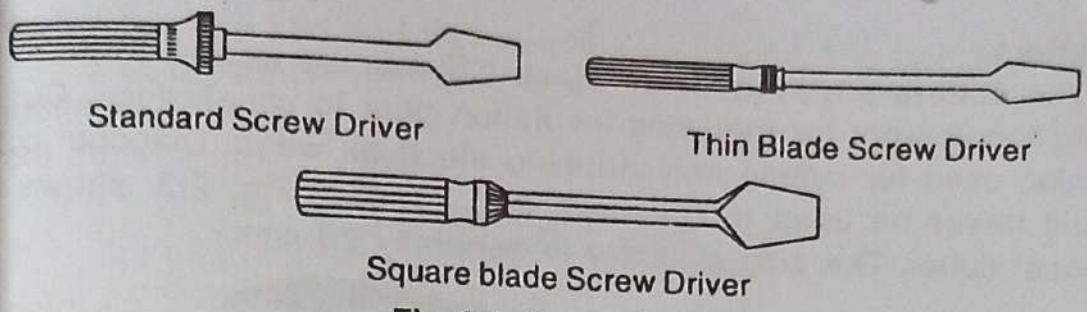


Fig. 2.1. Screw drivers

Precautions : Avoid greasy or oily handle. Do not use in place of Firmer Chisel. Use proper size for particular Screws.

2. Combination Pliers

This is one of most commonly used tools for maintenance work. It is used for holding and gripping small articles in situations where it may be unsafe to use hands. The different types of pliers are :

(*a*) *Long nose plier.* It is useful for forming eyes of wires which are to be used where they are held fast under screw long nose plier is shown in Fig.2.2 (*a*).

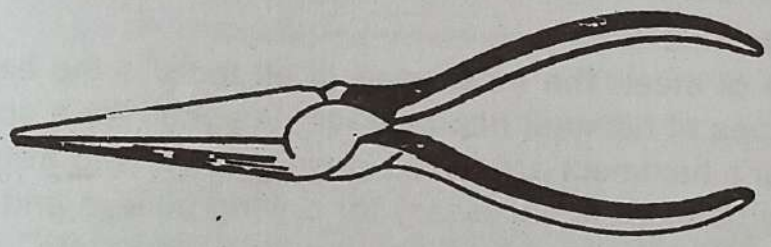


Fig. 2.2. (*a*) Long nose plier

The size of long nose plier is 10 cm. Do not cut steel substance with nose plier.

(*b*) *Side Cutting Pliers.* The material used for this cutter is steel. Such a plier is used for cutting wires, gripping operation by hand, twisting wires and a number of other operations required in electrical work. It is usually provided with snub-nosed jaws and have a cutting edge only on one side as shown in Fig. 2.2 (b). Usually 15 cms. or 22.5 cms. plier is used. An insulated plier is always preferred.

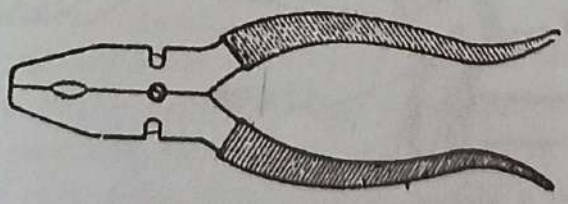


Fig. 2.2. (*b*) Side cutting plier

3. Cutters

The cutters are made from steel. Cutters are frequently required during repair work for removing insulation prior to connections. Cutters are also used for cutting and stripping electrical wires. Diagonal cutter should never be used to cut steel wire or rods. Fig. 2.3. shows the diagonal cutter. The size of cutter is generally 20 cms.

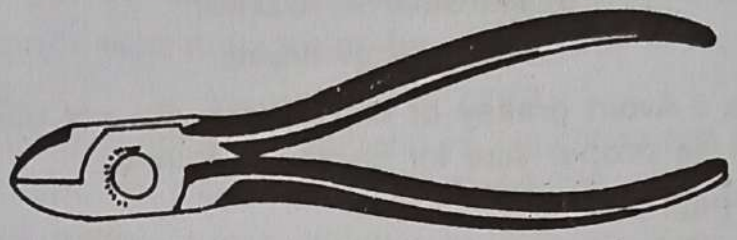


Fig. 2.3. Diagonal cutter

Precautions :

1. Do not use steel wires.
2. Protect from rust.
3. Do not cut hot substances.

4. The Hand Hammers

It is made of steel. The most used of all tools is the hammer. There are many shapes of hammer heads, each designed for a specific type of work. Engineer's hammers are made in weights varying from 100 gms to 1/2 Kg. Heavy hammer is necessary for driving pulleys and collars on to the shaft. Hammer shafts should be free from knots etc.

Types of Hammers. For electrical work generally following types of hammers are used :

(*a*) *Ball Peen Hammer.* It is required for driving nails into wooden batten and for cutting wall plaster and bricks when it is necessery to take wire from one room to another. It also used for rivetting purposes. The size of ball-peen hammer is varies from 1/4 kg to 2 kg. The hammer should never be used with loose handle.

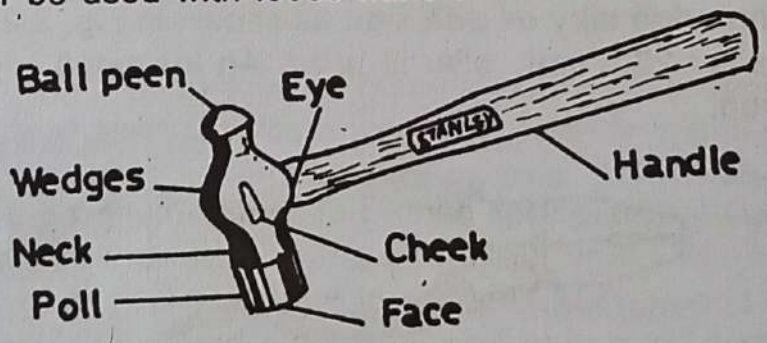


Fig. 2.4. Ball-peen hammer

(*b*) *Cross-Peen Hammer.* It is made of steel and available in different size. Generally weight of this hammer varies from 1/4 kg to 2 kg. It is

used for fixing clip and making straight hole in wall. The handle of hammer while using should not be greasy.

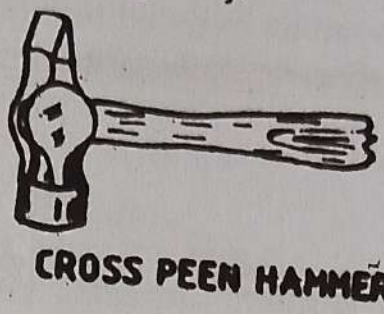


Fig. 2.5. Cross peen hammer

(*c*) Straight Claw Hammer. A straight claw hammer is preferred by electricians because the straight claw can be inserted behind, beneath or between wooden boards to be removed. It is shown in Fig. 2.6.

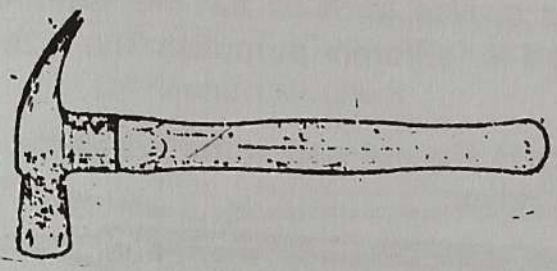
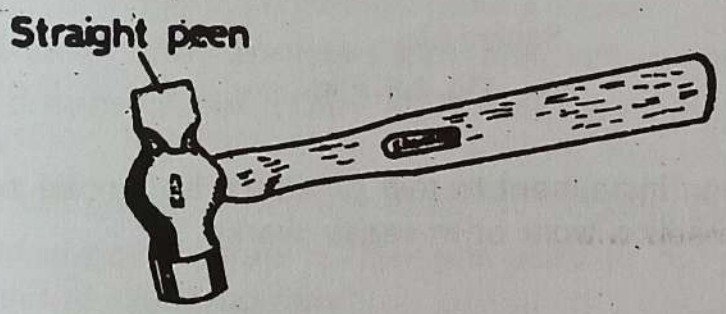


Fig. 2.6. Straight claw hammer

(*d*) *Straight peen Hammer.* This is similar to ball-peen hammer with the difference that the one end of straight peen instead of ball peen and face is similar in shape.



Use -:
Metal Shape

Fig. 2.7. Straight-peen hammer

5. The Hack-Saw

This is main tool used for cutting of metals such as conduits, cables etc. There are many types of sizes of hack-saw. Blades may be carbon or high speed steel. The size of the blade for hand work is about 250 mm long by 12 mm wide. The teeth on a hack-saw blade have a set to the sides. The best all-round blade for hand use in the 16-18 teeth per 2.5 cm. The hack-saw frame is adjustable. The blade is usually gripped

with the frame by means of wing nuts keep the hexa-saw straight while cutting.

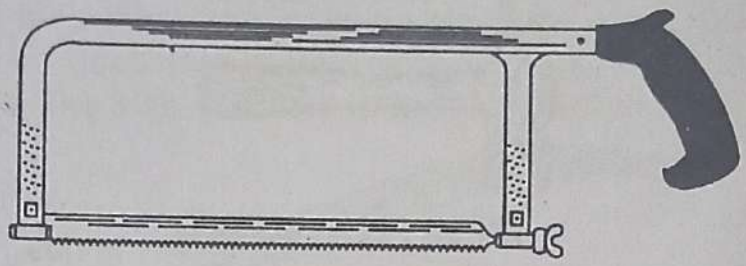


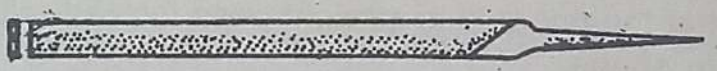
Fig. 2.8. Hack-Saw

6. The File

This is a cutting tool generally have X-cut teeth. The file is parallel for about two-thirds of its length and tapers in width and thickness. There are different types of files such as flat file, square file, round file, half round file etc. used for different purposes.The size of file is 8 cm to 35 cm.

Precautions : (1) Do not use without handle (2) Do not use it as hammer or screw driver.

Flat file



Square file

Fig. 2.9. File

7. Spirit Level

It is a common instrument to test or adjust horizontal surfaces. It is essential in all erection work or in repair works.

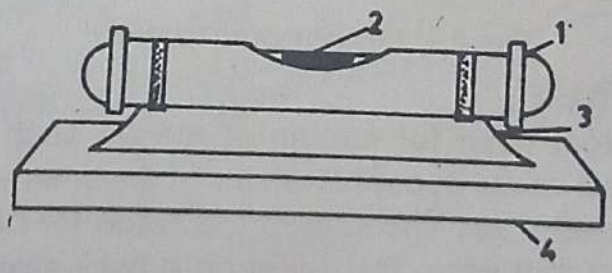


Fig. 2.10. Spirit level

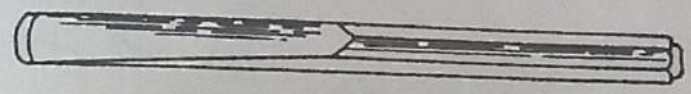
It is simply a glass tube, 200 to 300 mm long (1) almost filled with liquid. An air bubble, (2) remain at the top-most position of the tube. The

glass tube is placed within a large radius (3) having a flat base (4).

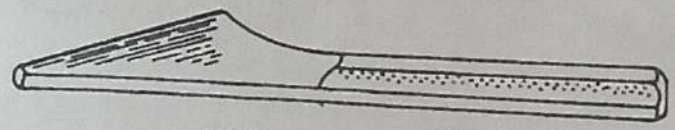
When spirit level is moved, the air bubble will move left or right depending upon the amount of tilting of its base. The angle of tilting can be quantified from calibrated graduations. The work will be taken as levelled when the air bubble is exactly centered on the centre mark. The level may be moved in both horizontal or vertical directions.

8. Chisel

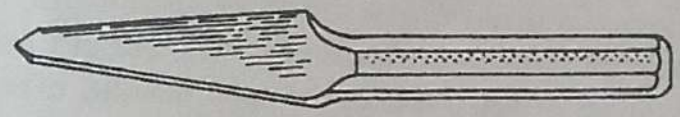
Chisels are the most common metal cutting tool used in the shop floor. They may be broadly classified into four categories :



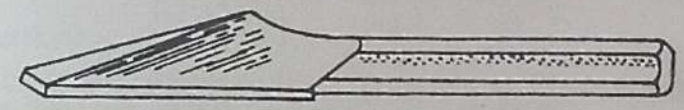
(a) Flat chisel



(b) Round nose chisel



(c) Cross cut chisel



(d) Diamond point chisel

Fig. 2.11. Different types of chisels

(a) *Flat chisel :* They are used for cutting off and surfacing.

(b) *Round nose chisel :* They are mainly used for cutting grooves and channels.

(c) *Cross cut chisel :* They are used for roughing purpose.

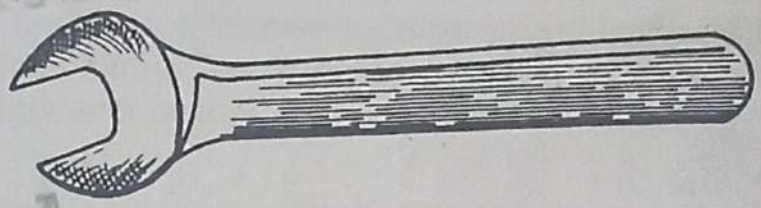
(d) *Diamond point chisel :* They are used to cut grooves square small holes and to clean corners.

It is flattened and tapered about one-third of its length. On no account should the head of a chisel be hard where it is struck by hammer. The chisel should not be oily.

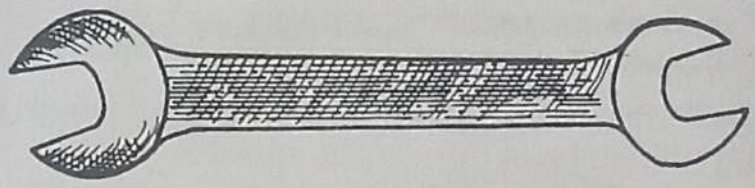
9. Spanners

These are used to grip and turn nuts and is helpful when an equipment is being disassembled. These are also known as 'Wrenches'. It is usually made of steel. Use of wrong size spanner may lead to rounding off the corners of the nut.

Spanner sizes are determined by the width across flats. They are available in inches and millimeter size to suit each nut size.



Single-ended wrench



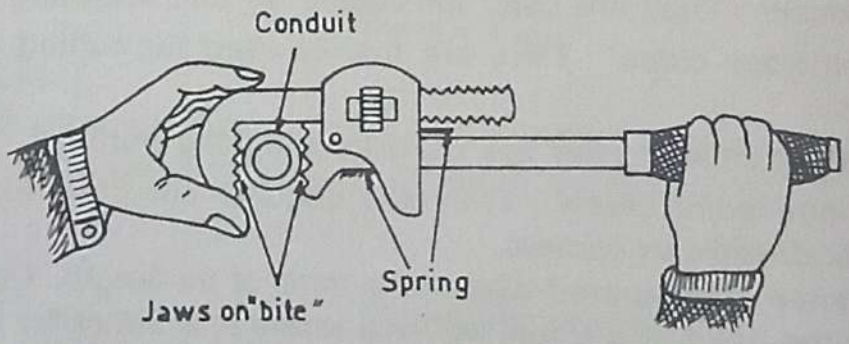
Double-ended wrench

Fig. 2.12

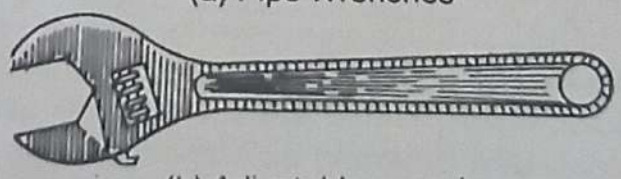
As the wrenches are generally made of cast steel, they are having less shock resistance capacity, therefore, they should never be used as hammers. Application of too much pressure should always be avoided. In case of adjustable wrenches, proper grease should be applied on jaw-spindles.

10. Pipe Wrenches

For connecting or disconnecting the rigid conduits pipe wrenches are required. A pipe wrench which can handle a conduit upto dia of 35 mm is sufficient.



(a) Pipe Wrenches



(b) Adjustable wrench

Fig. 2.13

In addition to this an adjustable wrench is also used for handling square or octagonal head bolts. Such a wrench is shown in fig. 2.13.

11. Bench Vice

It is used to clamp the material in its vice for cutting or threading operations. For electrical work generally bench vice is used. The machine vice is used holding the item while they are being drilled.

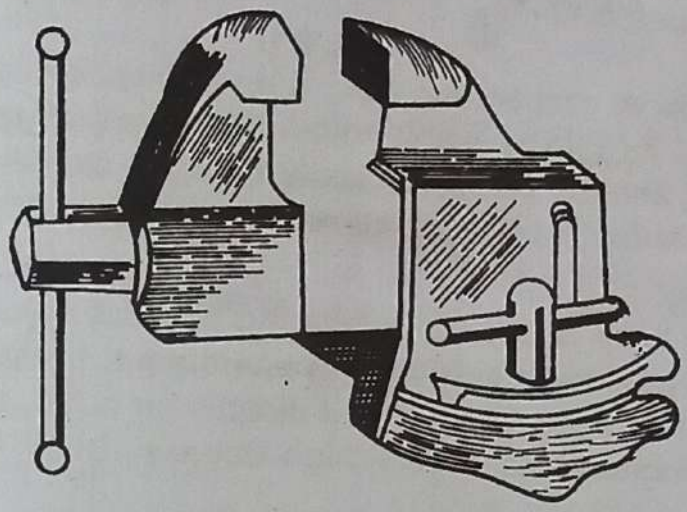


Fig. 2.14. Bench vice

It should not be used as base for hammering.

12. Centre Punch

When a hole is to be drilled in metals, the centre punch is usually used for making a starting hole. It is usually made of high grade tool steel hardened at both ends as shown in fig. 2.15.

Fig. 2.15. Centre Punch

13. Pocket Knife

The pocket knife is also one of the most important tools in the worker's tool kit. It is generally used for removing insulation from the wires. The knife must be made from high grade cutlery steel. The closing type of knife should always be preferred, although a knife made from a broken hacksaw blade can serve the purpose well.

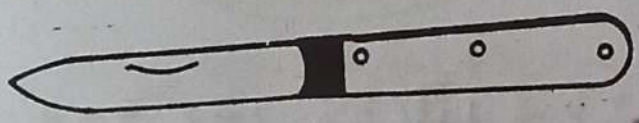
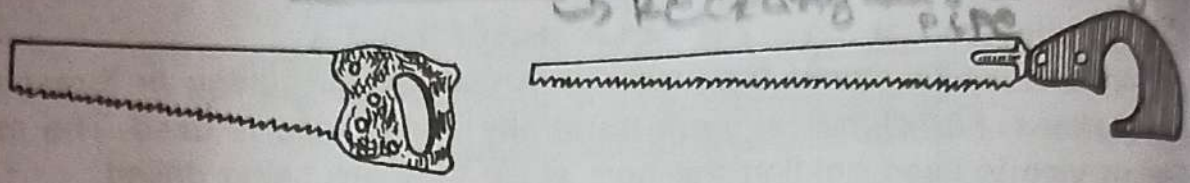


Fig. 2.16. Pocket Knife

14. Wooden Saw

The house wiring is also done with wooden casing capping or batten

and it is necessary to make use of a carpenter's saw for making joints or for cutting the casing or capping.



(a) Wood Saw (b) Key-hole Saw

Fig. 2.17

In addition to carpenter's saw, a small keyhole saw is also useful which is used for cutting small holes. Such type of saw has a thin and narrow blade, and the blade is usually attached with a fly wing nut to the handle, so that the blade may be replaced when it breaks.

15. Blow Lamp

The blow lamp is used for soldering and cable jointing purposes. It is capable of producing very high temperatures. Usually kerosene oil is burnt into it. If its flame is projected directly on a job, the temperature of the job will increase to a very high degree. Blow lamp is shown in Fig. 2.18.

Precautions : while burning put the mouth of blow lamp toward walls.

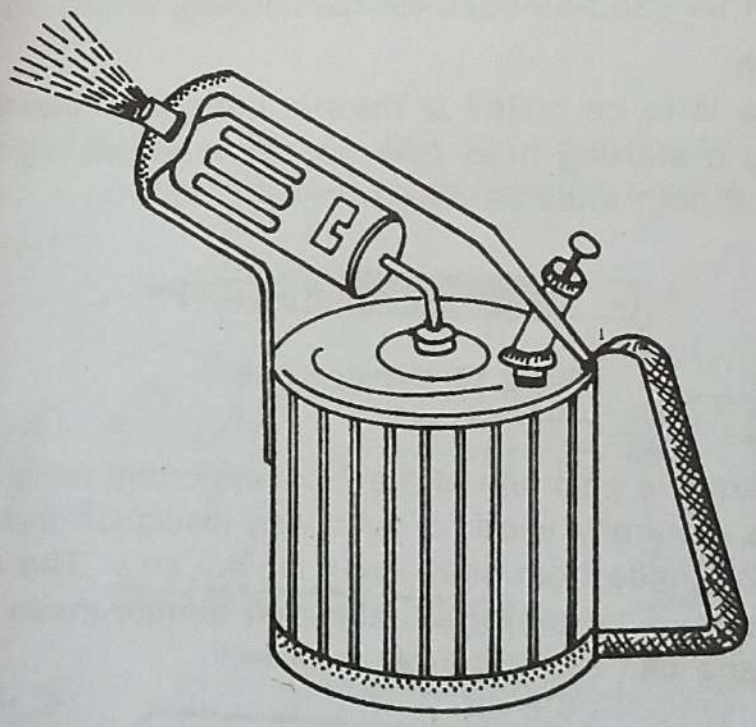


Fig. 2.18. Blow Lamp

16. Hand Drill

In house wiring, it is often required to drill a hole in wooden blocks and wooden boards to facilitate the passage of insulated V.I.R. wires which terminate into switches or other fittings. For such purposes, a

hand drill is much useful. It consists of a chuck with hardened steel jaws into which is placed the twist drill. A crank and gear is used for increasing the speed of drill. For opening the jaws, hold the chuck in left hand and turn the handle in an anti-clockwise direction with chuck pointing downward, and for tightening the twist drill, place the drill into the jaws, hold the chuck firmly and turn the handle in a clockwise direction with the drill pointing down, *i.e.*, in the direction of operation of the drill, and the drill will be firmly secured. Fig. 2.19. shows the hand drill.

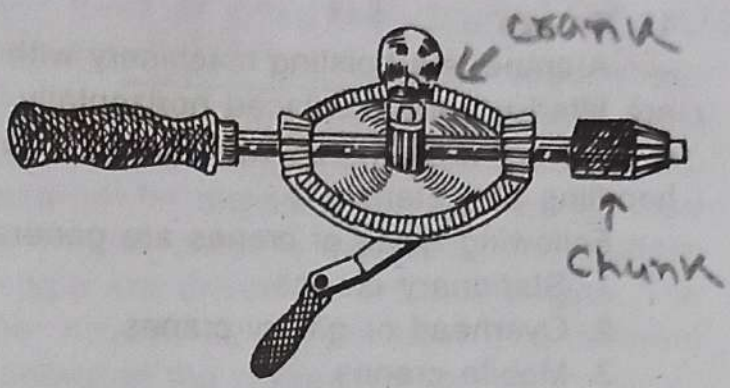


Fig. 2.19. Hand drill

Precautions : It should be kept clean and without greasy handle should be used.

17. Pulley Puller/Bearing Puller

It is used for removing pulley from the shaft of the Motor, Generator etc. It consists of three adjusting legs, a tightening screw and a screwed plate made of mild steel. Small pulley pullers with only two legs are used for pulling bearings. Hence called Bearing Puller.

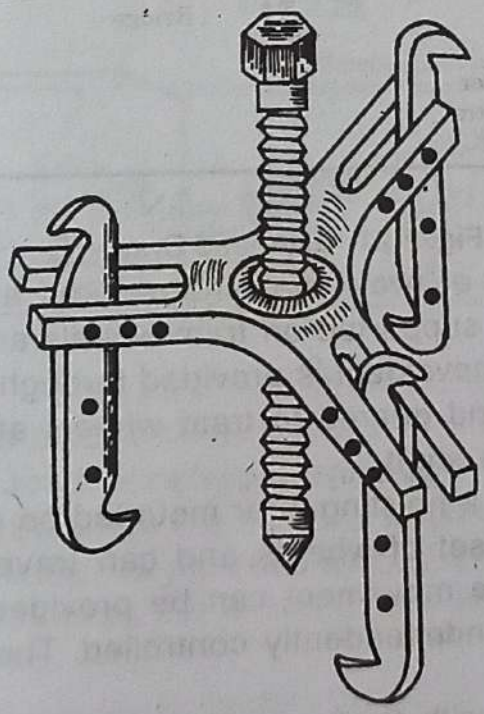


Fig. 2.20. Pulley Puller

Precautions : Avoid from rusting. Lubricate the joints from time to time.

18. Cranes

A crane is a hoisting machinery with the help of which heavy loads are lifted up and displaced horizontally. Today, almost every workshop, every plant is equipped with cranes. Cranes play very important role in handling of materials.

Following types of cranes are generally used :—

1. Stationary cranes.
2. Overhead or gantry cranes.
3. Mobile cranes.

Overhead or Gantry Cranes : These cranes due to its large service area, freedom from floor obstructions and three-way motion with electric drive is most widely used in erection work, steel plants, ice factories, foundry, storage yards, power houses and big machine ships.

It consists of two main parts :

(i) The Bridge

(ii) The trolley on the crab

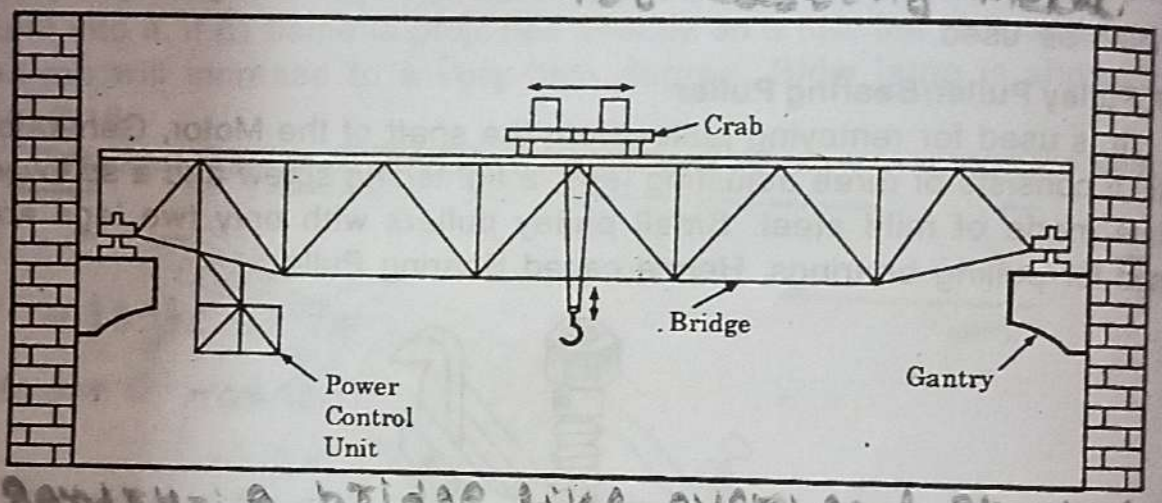


Fig. 2.21. Overhead Crane

The bridge consists of two main girders fixed at their ends to the end carriages which are supported on tram wheels and capable of moving on gantry rails. The movement is provided through a long shaft spanning the whole bridge and geared to tram wheels at the two ends. An electric motor drives the shaft.

The crab consists of a hoisting gear mounted on a frame. The frame is mounted on another set of wheels and can travel across the main girders. In this way three movement can be provided to the load hook and each movement is independently controlled. The movements are:

(i) Hoisting

(ii) Cross traversing with Crab

(iii) Longitudinal traversing with the bridge.

The control cabin is fitted usually under the bridge at one end.

Mobile Cranes

Fig 2.22 shows a *truck mounted crane* The former is used where mobility is of great importance and can move quickly over smooth, hard and even ground, while the latter is used for slushy soils or union ground. Track mounted or crawler should not be moved on road otherwise road surface will be damaged. The crawler crane is mounted upon endless crawler belts. Cranes of this type are driven by a diesel engine. The travel speed is from 16 km per hour to 32 km per hour. The different parts of both the cranes are shown in the respective figures.

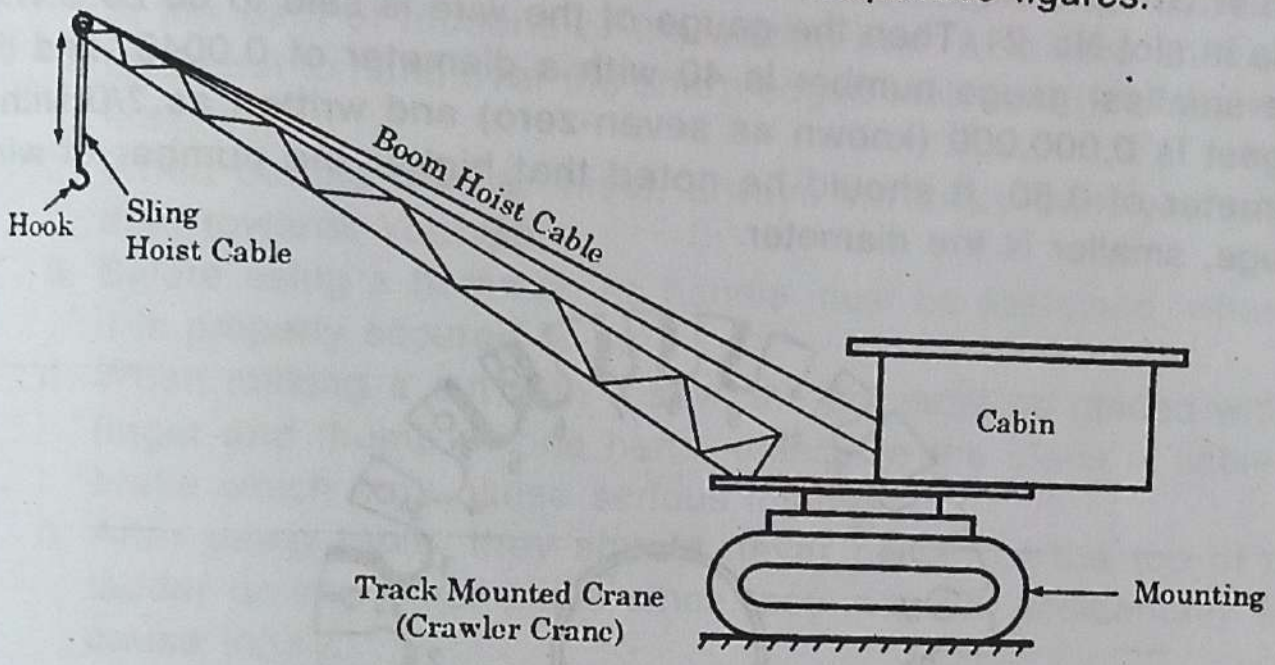


Fig. 2.22

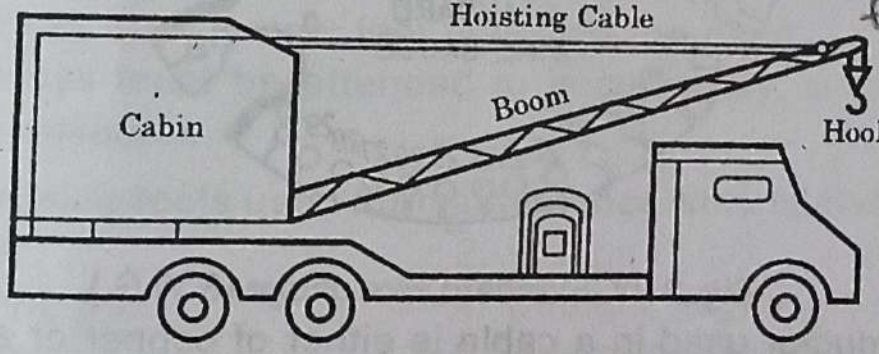


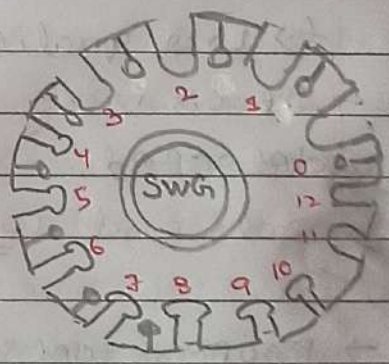
Fig. 2.23. Truck Mounted Crane

Another type of mobile crane is the steam crane. It can have wheels (simple) to run on road or railway wagon type wheels so that it can run on railway gauge. Steam is the medium of power and the steam is produced in a boiler which is provided opposite to the boom to serve as counterweight. It balances the moments of the jib and the load lifted in the hook for hoisting.

19. Standard wire gauge :- (S.W.G)

→ It is also called as British standard wire gauge.

→ The S.W.G is an instrument which is used for determining the size of a cable.



→ It consists of a thin circular plate of steel with a no.s of slots on its circumference.

→ Each slot is marked with different numbers.

→ Holes are provided at the end of each slot for removing the wires easily.

→ The smallest gauge number is 40 with a diameter of 0.0048" and the largest is 0,000,000 (known as seven-zero) and written as 7/0 with a diameter of 0.50".

→ It should be noted that higher the number of wire gauge, smaller is the diameter.

Precautions in Handling the tools

→ Great caution & care are acquired in handling tools.

→ A worker may injure himself or damage the tools, if he carelessly handle the tools.

→ The following safety precautions for handing the tools are - ① The sharp edged tools such as pocket knife, chisels etc. Should never be put in pocket without shield and while working with such tool, care should be taken not to place hand or finger in the path of motions of the cutting tool.

→ Also care should be taken, not to hand over the sharp-edged tools.

② When cutting with a chisel, always cut away from you rather than towards yourself.

③ Before using a hammer, its handle must be examined, whether it is properly secured or not.

④ When marking a cut with a saw, the cut must be guided with a finger and thumb of one hand, otherwise the blade is liable (likely to) to brake which may cause serious injuries.

⑤ After using tools, they should never be left at the top of the ladder or any other place, since they may fall accidentally and cause injury.

⑥ Only a suitable tool should be used for the proper purpose and if a particular tool does not suit the purpose, do not abuse (misuse) the tool, try to have a new tool matching the need.

⑦ All injuries must be attended to immediately, since delay may cause infection.

Maintenance Schedule of Electric Motors

Sl. No.	Daily	Maintenance & check programme of motor
1	Earthing of power connections	→ Inspect & tighten if necessary.
2	Control Gear	→ Inspect fuses and Relay settings.
3.	Temp. of winding	→ Look out for over heating.
4.	Bearing	→ Look out for over heating.
5.	Lubricants	→ Check lubricating system.
6.	Vibrations	→ watchout for excessive vibrations
Sl. No.	Weekly	Maintenance & Check programme of Motor
1.	Surrounding	→ Care should be taken that amount of unusual dust, dripping water, acids, fumes may not enter into the motor. → dangerous gas
2.	Sleeve Bearings Motor lubrication etc.	→ The level of oil should be checked with oil gauge and if the level is down, complete it to the guage line level. Check the bearing housings, if dry, then oil them.
3.	Ball Bearings	→ The bearings should be checked for noise, oil them little, add grease in the housings or replace them.
4.	Brushes and commutator or rings	→ when there is sparking note the Colour and condition of the commutor & brushes. The pigtail of the brushes for loose connection should be checked. The surface of commutator should be smoothened with the help of sand paper. Clean the segments of commutator with the help of cleaning stick.

SL.NO	Weekly	Maintenance & Check Programme of motor.
5.	Rotor & Armature	→ The uniformity of air gap in the motor should be checked in which the sleeve bearings are used.
6.	windings	→ If the dust particles are observed in the winding, blow it with blower. clean the dust with dry cloth. Note for the moisture contents in the winding. If noticed, dry them up.
7.	Mechanical Condition	→ Sometimes there is unusual noise is heard from motor due to metal to metal contact. Stop the motor & check it and remove the defects.
8.	Mechanical Inspection	→ Check the belt for suitable slackness and good surface condition. The controlling devices (like gear) should be checked thoroughly.

SL. NO.	Monthly / Quarterly	Maintenance & Check Programme of motor
1.	windings	→ Check the windings for their proper insulation. It should be tested for insulation resistance, short circuit and earth & leakage. Moisture contents should also be checked.
2.	Brushes	→ Check the brushes for their proper fittings and free play in the brush holders. Worn out brushes should be replaced.
3.	Commutator	→ Commutator surface should be examined for their smoothness. This surface should be smoothened with the help of emery paper. (Sand paper)

Sl No.	Monthly/Quarterly	Maintenance & Check Programme of motors
4.	Ball or roller bearings	→ The leakage of grease or oil from the bearing should be observed. If the leakage is noticed, clean it.
5.	Couplings and other Drives	→ Sometimes the belt becomes loose, adjust it.
6.	Enclosed gears	→ oil in the gear box should be checked properly. If the oil is not found in good conditions, drain it out and refill it by new oil.
7.	Loads	→ changing load conditions should be observed i.e. controlling devices troubles, poor headings or wrong adjustments.

Sl No.	Half yearly/Yearly	Maintenance & Check Programme of motors
1.	windings	→ Check the windings for insulation resistance. If needed, dry out the winding, clean it, varnish it.
2.	Squirrel cage Rotor	→ Broken or loose bars of rotor should be observed thoroughly. Set them properly or get it Soldered/welded if needed.
3.	Wound Rotor	→ collector, washers and connections should be checked.
4.	Air gap	→ Uniformity of air gap should be observed.
5.	Mechanical Parts	→ The inside & outside of frames and belts should be checked. The rotor should be observed for its misalignment.

Maintenance schedule of Synchronous Motor :-

→ For trouble free performance of the equipment and for maintenance work, we must have adopted an insurance policy.

→ Maintenance is also essential for the longer life of electrical machinery.

→ The following points are required for the maintenance schedule of Synchronous machines.

1. General :- The machines should be stopped and isolated from all supplies before any maintenance work is done.

→ The frequency of maintenance depends upon the site condition.

→ Frequent maintenance (say one a week) should be practical at first and the period extended as experience is gained.

2. Cleaning :- The unit should be periodically cleaned internally by blowing out with dry air and by wiping away any deposits of grease and carbon dust with a clean dry cloth.

→ At less frequent intervals all nuts and screws should be checked to ensure that they are tight.

3. Bearings :- The bearings are used with grease at works & the bearing should be grease again after every 3000 hours of running.

→ Do not mix different grades of grease, or over fill the Bearings.

→ Periodically cleaning process is also necessary for Bearing.

4. Oil leakage :- → It may be noted for lubricating the Synchronous machine.

→ It should be neither be excessive oiling or insufficient lubrication.

→ The lubrication should be appropriate and periodic.
→ Special care must be taken that there should not be any type of leakage of oil on the stator.
→ This results into breakdown of the stator winding insulation.

5. Temperature :→ The insulation temperature and body temperature must be recorded frequently.
→ It should be within permissible limits. So that machine can run smoothly.

6. Brushes :→ The brushes should be examined initially after every 100 hrs. of running.
→ care must be taken to see that the brush holders are not allowed to touch the surfaces of slipring.
→ The brushes should be replaced when they wear down to within 3 mm of their support arms.

CP-3

Installation, Commission & Testing of Sub-station

Substation:-

→ A substation is a part of an electrical power generation, transmission and distribution system. (parts of power system)

→ Their main function is to receive energy, transmitted at high voltage from generating stations, reduce the voltage to suitable value for local distribution and provide facilities to the customer.

→ Voltage on the outgoing distribution feeders can be regulated at the substation.

* Feeder -: Feeders are those power lines through which electricity is transmitted in power systems.

Design and planning of indoor Substations

Indoor Substations -: A substation in which the apparatus is equipped inside the substation building is called as indoor substation.

Design and planning of indoor substations -:

1. The type of supply required (3-ϕ, 4 wire or 3-ϕ, 3 wire) load and earthing arrangement.
2. Atmospheric conditions such as air temperature and moisture.
3. Atmospheric pollution.
4. Reliability of substation equipment so that there is minimum power intruption.
5. Continuity of service through alternative supply if the source of supply is interrupted.
6. Possibility for modification or future extention.
7. Noise Reduction.
8. Radio and telecommunication interference due to switching.

General Requirements of lay out of indoor Substation:-

1. Building construction -: when constructing the building provisions should be made for adequate (extra) space which is required for placing transformers, H.T and L.T

switch gear and cable trenches for incoming and outgoing cables.

(L.T -: Low tension, H.T -: High tension, Cable trenches - It is a method of laying cable into the ground by digging trenches)

→ The building of transformer room should be Spacious (extra space) and have the necessary clearances.

→ Sufficient passage and doorways should be provided so that large transformers can be moved in or out for repairs.

2. Ventilation -: There must be free circulation of air on all sides of the transformers.

→ For heavily loaded transformers exhaust fan should be provided.

→ By providing appropriate protection from water, birds etc., Ventilation process should be carried out.

3. Earthing -:

→ The equipment installed in a medium voltage (1KV - 52KV) distribution substation should be solidly earthed.

→ The transformer Neutral should also be earthed.

4. Cable trenches -:

→ cable trenches are provided for laying the cable.

→ The cable trenches should be protected against entry of water by blocking all the opening of the Trenches.

→ This process is carried out by filling gravel with sand and covered with Mild steel or R.C.C Slabs.

(gravel -: small piece of Rocks)

(R.C.C -: Reinforced cement concrete)

(Mild steel -: Iron + carbon (0.05% to 3.8%))

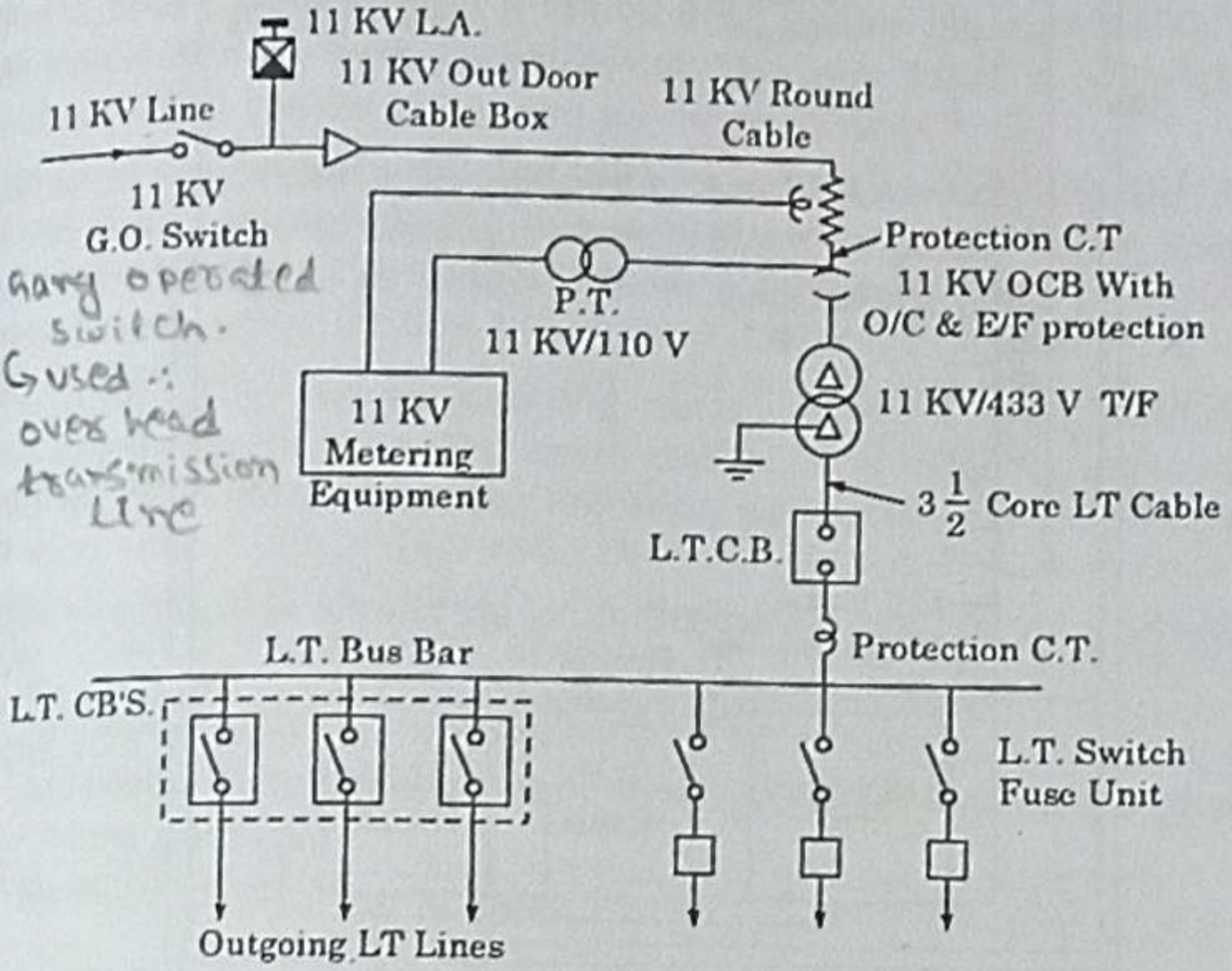
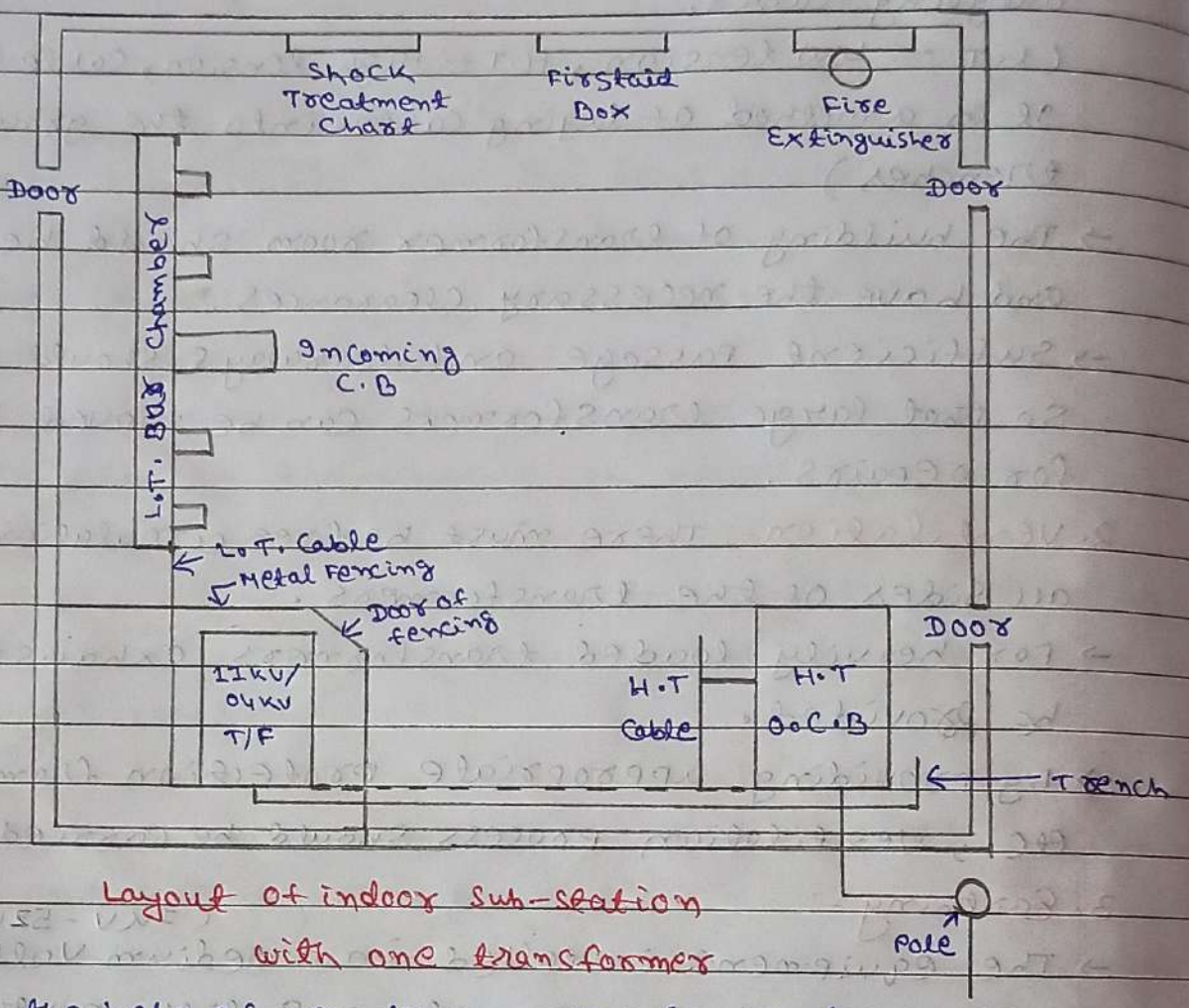


Fig. 5.21. Layout of Indoor Substation

Key diagram showing various Equipments and their connections.



Layout of indoor sub-station with one transformer

→ With the help of key diagram, the layout drawing and protective gear schemes can be evolved.

→ Layout of indoor substation depends upon the space available, number and size of transformers and the number & type of H.T and L.T switch gear required.

Layout of indoor substation :-

1. The transformer should be installed in a separate room. If this is not possible, then the transformer should be installed in one corner and protected by metal fencing.
2. The position of 11 KV O.C.B and transformer should be such that minimum possible 11KV cable is used.
3. L.T Switch gear should be located in such a position, so that the operation of circuit breakers and switches is easy.

Considerations for safe operation of Substation :-

1. Fencing and gate for transformer Enclosure :-

→ Expanded metal fencing supported by channel iron supports is provided to enclose the transformer.

→ A small gate is provided with locking arrangement for safety.

→ The fencing should be earthed at two different points.

2. Fire protection :-

→ CCl_4 (tetrachloromethane) and foam fire extinguishers and buckets filled with sand should be located in easily accessible positions in switch room or Substation.

3. Precautions against dust and insects :-

→ Indoor Substation should be made inaccessible to birds, reptiles, rats, insects and dust

→ All cable and openings should be sealed as far as possible.

4. Effect of atmosphere conditions :-

→ All steel and iron parts should be given an anti corrosive coating before final painting.

5. Earthing :-

→ Non current carrying parts with conducting surface should be effectively earthed. The earth connections of all equipments should be properly arranged.

→ The following point should be consider during earthing :-

i) Earth conductor should be of sufficient current carrying capacity.

ii) Lightning arrester should be earthed separately.

iii) Earth connection for equipments should be protected against mechanical damage.

iv) The leads of earth conductors should not be embedded in concrete.

v) The resistance of earth system should not exceed 2 Ω.

vi) All metal fencing should be earthed at two points.

vii) Pipe and plate earthing should be provided for indoor Sub-Station.

Function of Substation :-

a) To perform switching operation i.e. to switch on or off the power line.

b) To perform voltage transformation operation i.e. to step-up or step-down the voltage.

c) To perform power factor correction operation.
(Power factor correction is a technique of increasing the power factor of a power supply)

Classification of Substation :-

* The substation may be classified according to service, mounting function and type of apparatus used.

* According to service, the sub-station may be classified as :-

(1) Transformer Substations :- The substations transform power from on voltage to another.

→ This can be subdivided into 3 types.

a) Transmission or Primary Substation :-

→ Such substation receive power from a local generating station and step up its voltage for primary transmission

b) Sub-transmission or Secondary Substation :-

→ These receive power from primary sub-station through primary transmission lines at extra-high voltage (E.H.V) (above 66 kV) and step down its voltage for secondary transmission or primary distribution.

c) Distribution Sub-Station :-

→ They receive power from sub-transmission sub-station or directly from the power stations and step down its voltage for secondary distribution.

(2) Industrial Sub-station :-

→ The industrial sub-stations meant for large industries on individual basis are called industrial sub-station.

(3) Switching Sub-Station :-

→ The switching sub-station meant for perming switching

operation of power line without transmission of voltage are known as switching sub-station.

(4) Power factor Correcting or synchronous Sub-station :-

→ These are installed at the end of the line for improving the power factor and therefore relieve the transmission line and power stations from carrying or handing excessive current due to low power factor.

(5) Frequency changer Sub-station :-

→ These are used for converting normal supply frequency to other frequency for industrial utilization.

(6) Converting Sub-station :-

→ These are used for converting A.C into D.C or vice versa.

→ For some purpose such as battery charging, electric traction etc. D.C supply is required.

→ Thus, these Sub-stations are required.

According to Design :-

1. Indoor Type Sub-stations :-

→ In such sub-stations the apparatus is installed within the substation building.

→ Such substations are generally used for voltage up to 11KV but can also be constructed for 33KV or 66KV, if the surrounding atmosphere is free from impurities.

2. Outdoor Sub-stations :-

→ It is a distribution sub-station placed over head on a pole.

→ In such type of substation the equipment is installed in open. These substations are designed for handling extra high, high and low voltages.

→ Outdoor Sub-stations are of two types.

a) pole-mounted Substations b) Foundation mounted substations

a) Pole mounted Substations :-

→ Such substations are constructed for distribution of power in localities.

→ Single pole, H-pole and 4-pole structures with suitable platform are used for placing transformers of capacity up to 15KVA, 100KVA and above 1000KVA respectively.

b) Foundation Mounted Substation :-

→ For transformers of capacity above 300KVA, the transformers become too heavy to be installed on poles.

→ Therefore, the transformers are placed on a foundation prepared on the ground, in open.

Location of Substation :-

→ The following points should be kept in mind while choosing the location of a substation.

1. The substation should be as close to the load centres as possible.
2. The substation should be located at such point where all the prospective loads may be easily reached without any need for voltage regulation.
3. It allows the acess to the incoming transmission lines and outgoing distribution lines.
4. Allow for reasonable amount of expansion of the substations.
5. Choose the site where the substation building can be easily constructed without any restriction.
6. Cost of land should be as low as possible.
7. Keep load on the substation within such limits, so that in case of a shut down only a small number of consumers are affected.

Factors considered while selecting the site for a substation

a) Type of substation :-

→ The category of substation is important for its location.

→ Ex :- A step-up substation (primary substation), which is generally a point where power from various sources (generating machines or generating stations) is stepped up for long distance transmission.

→ It should be located as close to the generating station as possible to minimise the transmission losses.

→ Similarly a step-down substation (secondary substation) should be located for reliability of supply.

b) Availability of suitable and sufficient land :-

→ The land proposed for a substation should be normally level and open from all sides.

→ It should not be water logged, particularly in rainy season.

→ The site selected for a substation should be such that approach of transmission lines and distribution lines can be easily connected without any obstruction.

→ The places nearer to aerodrome, shooting practice grounds etc. should be avoided.

→ Types of substation Area Required :-

a) 400 KV substation — 50 ACRES.

b) 220 KV substation — 25 ACRES.

c) 132 KV substation — 10 ACRES.

c) Communication facility :-

→ Suitable communication facility is necessary for substation, during and after its construction.

→ Therefore, it is better to select a road site location for substation to easier & cheaper transportation facilitate.

d) Atmospheric Pollution -:

→ Atmosphere around factories, which may produce air fumes, dust, dirty water etc. and nearer to sea coasts, where air may be more humind & salty.

→ Therefore, substations should not be located near factories or sea coast.

e) Availability of Essential Amenities to the staff -:

→ The side should be such where staff can be provided essential amenities like School, hospital, drinking water, housing etc.

f) Drainage facility -:

→ The site selected for the proposed substation should have proper drainage arrangement or effective drainage arrange -ment to avoid pollution of air & water.

Civil Activities -:

→ The civil activities consume max^m time in a substation installation.

→ The civil planning includes the following major activities -:

i) Soil investigations at the allocated site.

ii) Design of Drawing of the site.

iii) Civil foundation work (concreting, building construction etc)

iv) civil work for earthing system.

v) Roads & Railway line.

vi) Construction of Fencing.

vii) Drainage, water supply facilities.

viii) civil work for cable system etc.

Note -: The arrangements of adequate quantities of cement, construction steel, construction water, construction power are made in advance.

→ The following buildings & provisions are made during initial stage of the project.

a) Site offices b) Storage buildings (iii) Residence facilities

d) Supply system for construction water & power (v) Road site

Drawing -:

→ These include the following -:

* Plot plans indicating area allocated to the substation approach roads, railway line etc.
* Layouts -: These include electrical layout, civil layout & complete substations layouts of important buildings.
* Drawing of stores -: These include indoor store, outdoor fenced stores, semi-enclosed sheds.
* Foundation plan for the complete substation including control building, transformers foundation, workshop building etc.
* Drawing for earthing layout.
* Drawing for cable layout.
* ventilation and air conditioning layouts.
* outline general arrangement drawings of equipments.
* Protection and control schematic drawings.

Despatch to Site -:

→ The following modes of transport are used :-

a) By ship b) By air c) By railway d) By road.

→ The equipment may be transported by either of the above mediums, depending upon the size, weight of the consignment and the transportations route.

→ The transport of these consignments should be planned before starting the detail design of such equipment.

→ The arrangements of special wagons, road trailers, Cranes etc. should be made in advance. (vehicle used for transporting)

→ The necessary permits from railway authorities and road authorities should also be obtained for transport.

Inspection on Arrival at Site -:

→ The packing cases are inspected for transit damage.

→ In case of any damage, the matter is reported to the Supplier and insurance company for insurance claim.

→ After that, the surveyors of the insurance company conduct survey and take the necessary action.

Storage:-

→ Three categories of stores are necessary for substation equipment. a) Indoor closed store b) outdoor fenced store c) Semi-enclosed fenced store.

→ Storage room for instruments and special equipment should also be planned.

→ Fire fighting arrangements are also planned.

→ Requirements of insurance policy should be considered while designing site stores.

Indoor Store:-

→ Indoor storage building should have sufficiently large storage area & sufficiently large doors on road side.

→ It should be well ventilated and well lighted.

→ Fire fighting arrangements must be their.

→ Transformer oil tankers should be stored in specially built room.

→ The oil drumps should be stored as per recommendations of the supplier.

Outdoor Store:-

→ The storage area should be above Max^m flood level and free from damp, mud etc.

→ The approach roads from the main road and to the substation should be well connected.

→ The necessary handling equipment should be available.

Foundation:-

→ The foundations plan of the complete substations indicates the building foundations, transformer foundation etc.

→ The depth of foundations is upto about two meters below compact soil.

→ The substation equipment needs firm and level foundations.

→ The foundation plan for an individual equipment is recommended by the manufacturer.

→ The provision of cable trenches, earthing mat, auxillary supplies, drainage etc. should not be ignored.

Civil works of control Room and other building :-

→ The plan includes to build ground floor, first floor, other floors, roof, finishing etc.

→ A separate building is usually required for maintenance workshop. A part from that conference room, toilets, storage rooms and extra rooms should be made for future used.

Erection of structures :-

→ The structures are provided with identification marks to enable proper and speedily assembly at site.

Erection of Yard Equipment :-

① Installation of Transformers :-

→ The smaller transformers are packed and despatched in assemble condition with oil.

→ Large transformers tanks are despatched nitrogen filled by road trailer / rail wagon and other accessories are transported by road on trucks.

→ The commissioning tests are carried out before commission

② SF_6 circuit Breaker :- (SF_6 :- Sulfur hexafluoride)

→ This type of circuit breaker is assembled by trained personnel or the manufacturer.

→ The breaker is dried out by hot air circulation. So we filled SF_6 gas on it.

→ Leakage free performance should be ensured before commissioning.

③ Porcelains, CTS, VTS :-

→ These are installed on respective structures.

→ The porcelain are closely observed for cracks & commissioning tests are carried out.

④ Earthing System :-
→ Earth resistance is measured during dry season and wet season.
→ These values shall be within permitted limits.

⑤ Busbars :-
→ Special facility for Aluminium welding is necessary
→ The welded joints are checked by x-ray equipment for good weld.
→ Bolted joints are tested by means of micro-ohm meter.
→ The resistance of the joint should be below 15 micro-ohm

⑥ Control Cables :-
→ The control cables are laid in the trenches in accordance with the cable layout drawings.

Main Equipment used in Substation :-

① Transformer :-
→ It is a static device which transfers a.c. electric power from one circuit to the other without any change in frequency level.
→ It is used to step up or step down the voltage.

② Incoming lines :-
→ These will supply power to the substation from the generating station or from transmission line at high voltage.

③ Isolating Switches :-
→ These can disconnect the lines and allow the equipment for repair or maintenance whenever required.
→ Isolators are inter locked with circuit breaker to prevent operation on load.
→ These are operated manually from the ground level.
→ The isolators may be single-pole or three-pole isolator.

(4) Bus bar -:

→ Bus bar term is used for a main bar of conductor carrying an electric current to which many connections may be made.

→ In some arrangement two buses are provided to which the incoming or outgoing feeders and the principle equipment may be connected.

→ one of these buses is called the main bus and secondary is called auxillary or transfer bus.

→ The switches used for connecting feeders and other equipment are called selector or transfer switches.

→ The bus bars used in substation are generally having rectangular cross-section.

→ Some other shapes of bus bar also used, such as round tube round solid bars or square tubes.

→ The bus bars are usually made of aluminium, copper or brass (copper + zinc).

→ For proper electrical connection, aluminium buses are coated with silver.

→ The bus bars are 5 to 6 meter in length. (Generally)

→ The most common sizes of bus bars are 40×4 mm, 50×5 mm, 50×6 mm, 60×8 mm, 80×8 mm and 100×10 mm depending upon the maximum current to be carried.

(5) Circuit Breakers -: (Used)

1. To carry full load current continuously.
2. To open and close the circuit on on load condition.
3. To make and break the normal operating current.
4. To make or break the short circuit in faulty section.

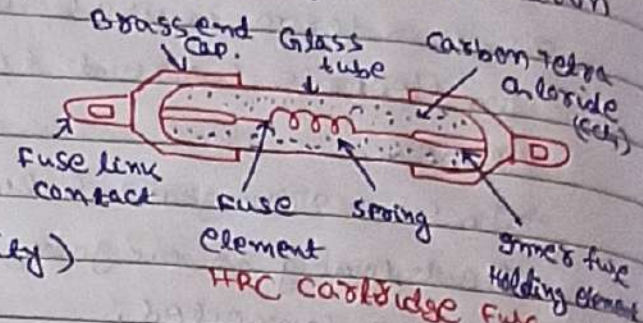
(6) Fuses -:

→ Fuse is a wire of short length or thin strip of material having low melting point.

→ It is installed on the panel board as a protective device during over current condition.

→ The fuses are mainly used on low voltage distribution circuits.

→ Generally HRC cartridge fuse is used as a protective device. (HRC :- High rupturing capacity)



⑦ Power Transformers :-

→ These are for stepping up the voltage for transmission at generating station and for stepping down the voltage for further distribution at the main step down transformer substation.

→ 2 windings, 3-ϕ transformers are used up to rating 10 MVA.

→ For transformers above 10 MVA generally air blast cooling is provided.

→ These are generally naturally cooled oil immersed known as O.N type (Oil Natural type).

→ For higher ratings forced oil, water cooling and air blast cooling are used.

→ For voltage regulation the transformers are provides with on load tap changer.

→ The transformers are generally installed on concrete slabs having a foundation of 1 meter to one and half meter deep.

⑧ Indicating and metering instruments :-

→ Ammeter, voltmeter, wattmeter, KWH meter, KVAR meters are installed in the substation to control and maintain a watch over the currents flowing in the circuits and over the power leads.

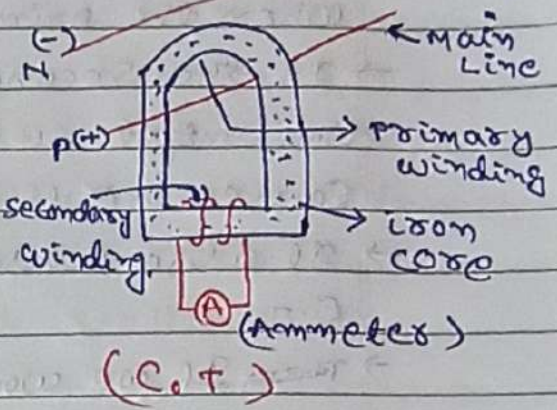
⑨ Load interrupter switches :-

→ These switches are used to close and open heavy voltage circuits under normal working conditions.

→ Lever arm manually operating system is used for closing and opening these switches.

(10) Instrument transformers :-

→ The instrument transformers are used with AC measuring instruments when the main voltage and current is very high.



→ It is of two types.

a) Current transformer (C.T) b) Potential transformer (P.T)

Current transformer :- (C.T)

→ It is very difficult to measure an A.C current above 100A in ammeters & also very dangerous to connect directly an instruments on these type of supply.

→ So we used current transformer which are used for reducing / stepping down A.C current from higher value to lower value for measurement / protection control.

→ The C.T is basically consist of an iron core on which a primary & one or two secondary windings are placed.

→ The primary winding is directly inserted in the power circuit and the secondary windings are connected to a measuring device.

→ When the rated current of C.T flows through primary winding, a current of 5 Amp. will appear in its secondary winding.

→ The primary winding is generally single turn winding and the no. of turns on the secondary winding depend upon the power circuit current to be measured.

→ The ratio of primary and secondary current is known as transformation ratio of the current transformer.

→ The secondary circuit of a C.T should never be kept open when the primary winding is carrying a current.
→ If the secondary windings of C.T is kept open, high emf might be induced in the secondary winding which causes heating of core and windings.
→ It also causes accident to human life & damage to C.T.
→ If we want to replace the ammeter from the secondary winding, then the secondary winding must be first short-circuited.

Applications of C.T :-

a) To measure large amount of load currents, as in case of transmission lines.
b) To increase the current range of instruments such as wattmeter, energymeter etc.
c) Used as protective relays.

b) Potential Transformers :- (P.T)

→ Potential transformer is a step-down transformer with the same principle.
→ It measure voltage above 500 V. (Generally)
→ The primary side of a potential transformer is connected to the system whose voltage is to be measured & the secondary side of P.T is connected to the voltmeter.

Applications of (P.T)

a) To measure high voltage in this type (P.T) of instruments.
b) It increases the voltage of instruments like wattmeter, energymeter etc.

(12) Surge Arrester :-

→ It is used in substation for diverting the high voltage surge to earth and protect insulation.

(13) Series Reactor -:

→ To limit the short circuit current level, series reactors are used.

(14) Shut Reactor -:

→ It is used for long EHV (Extra high voltage) transmi-ssion line to control voltage during load period.

(15) Shunt Capacitor -:

→ It is used for power factor improvement.

(16) Series Capacitor -:

→ It is used with EHV transmission lines to increase the power transferability.

Earthing System -:

→ The basic purpose of earthing system is to protect the human body from electric shock and stop the current to flow in the circuit.

→ Earthing is done to make the line dead.

Functions -:

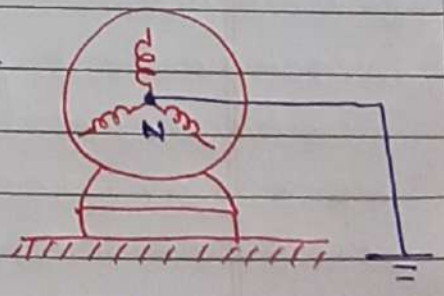
1. To maintain the potential of any part of the system at definite value w.r.t earth.
2. To allow current to flow to earth in case of a fault so that the protective gear will operate to isolate the fault circuit.
3. In fault condition, this system ensure that the apparatus never reach a dangerous potential w.r.t earth.

→ This system can be divided into 2 types.

a) Neutral or system Earthing b) Equipment earthing.

Neutral Earthing

→ Neutral earthing refers to the connect of the neutral point of a star connected winding (generators, transformers & other rotating machines) to ground.

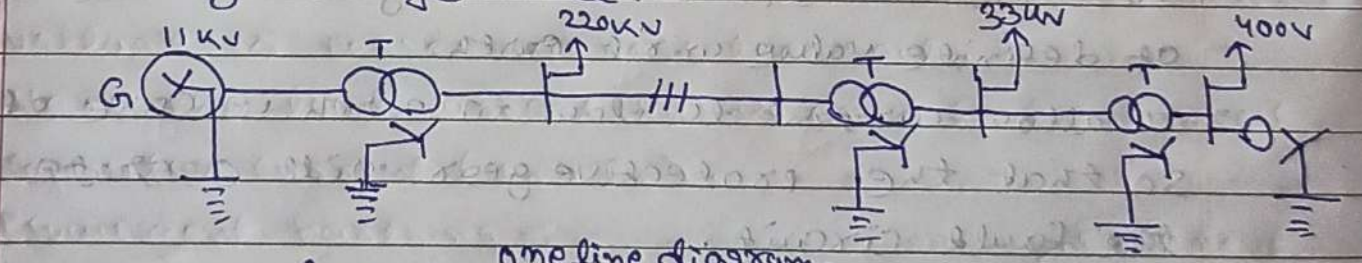


Neutral earthing

→ If the system is delta connected then an artificial neutral has to be provided.
→ Grounded Neutral System has following advantages.
a) Easy for earth fault protection.
b) Transient over voltages are easily dissipated to earth. These include lightning and switching over voltage condition.

Arrangement of Neutral Earthing -:

→ The neutral of star connected 3 phase winding of transformer can be earthed. The neutral of generator can be earthed.
→ If neutral point is not available, a separate star-delta transformer is arranged. Star point can be earth.
→ Sometimes special earthing transformer having zig-zag winding & neutral point is provided.
→ A rule to be followed - Provide neutral earthing at every voltage level.



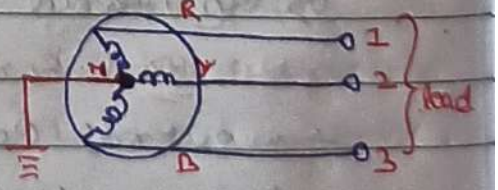
One line diagram.
(Earthing at each voltage)

Types of Neutral or System Earthing -:

a) Solid Earthing b) Resistance Earthing c) Reactance Earthing
d) Arc Suppression coil Earthing.

a) Solid Earthing -:

→ A direct metallic connection is made from the system neutral to an electrode or series of electrodes in contact with the general mass of the earth.



Solid earthing of generator neutral

→ This method is used when the maximum earth fault current is not heavy enough to cause serious damage.

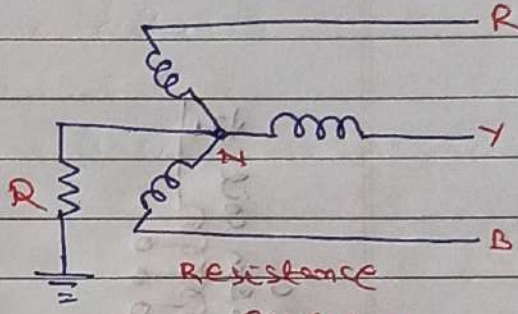
Advantages-:

1. The neutral is effectively kept at earth potential.
2. When neutral is earthed, then less insulation is required, therefore size and cost of machine is reduced.

b) Resistance Earthing-:

→ It is used when an earth fault current may cause damage if it is not restricted.

→ The resistors may either be metallic resistance units supports on insulator in a metal frame or liquid containing weak aqueous solution of zinc chloride ($ZnCl_2$) or Sodium carbonate (Na_2CO_3).



Resistance Earthing.

Advantages-:

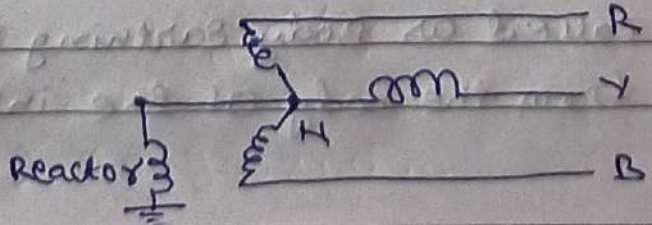
1. It minimizes the hazards of arcing ground.
(Hazard -: Any source of potential damage, harm or health effect on something or someone).
2. It reduces the interference with communication circuit.

c) Reactance earthing-:

→ Reactor-: It is a coil that has several turns and having high resistance values.

→ A reactor may be used instead of a resistor to limit the earth fault current.

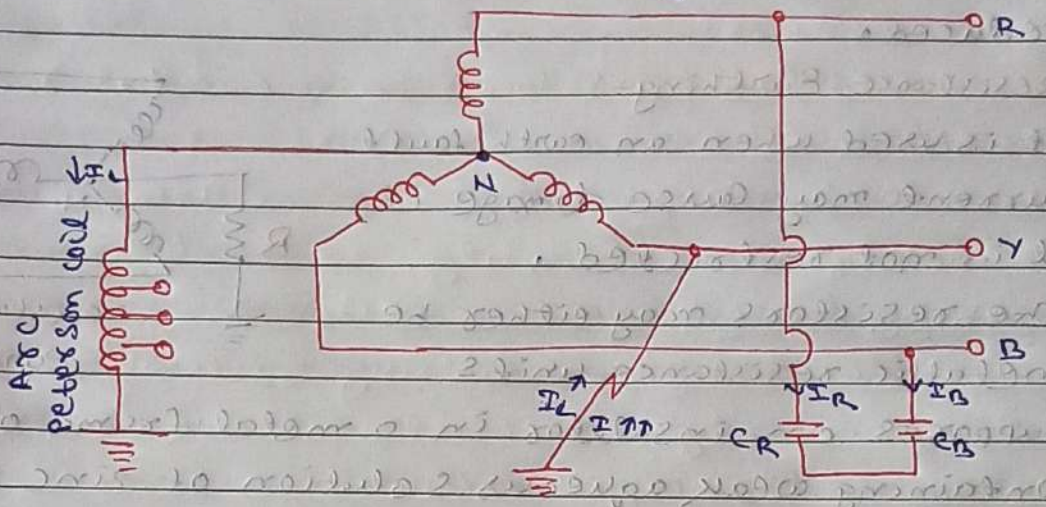
→ For a given earth-fault current, the reactor is smaller as compared to resistance, because the energy to be dissipated is less.



Arc Suppression coil :-

→ It is also called as peterson coil or ground fault neutralizer earthing.

→ In this method of neutral earthing, an iron-cored reactor called peterson coil is connected between the neutral of the power system and earth.



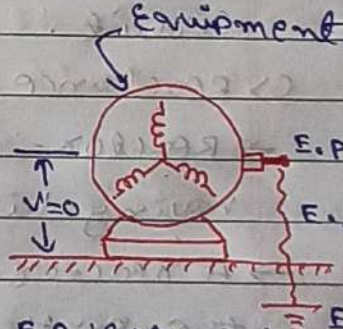
→ It is a special form of neutral point earthing reactor.

→ Under normal conditions there is no voltage across the coil but in case of earth fault, the phase or neutral voltage is passes across the coil.

→ Here the load current (I_L) is equal to the sum of capacitor current ($I_R + I_B$).

Equipment Earthing :-

→ Equipment Earthing connecting to the non-current carrying metal parts of equipments such as body, frame, structure of the equipment tower or any metallic parts of the instrument.



E.P :- Earth point.
E.S :- Earthing strip.
E.M :- Earthing mat.

→ Equipment earthing ensure safety from shock.

→ It is also called as Body Earthing because the earthing is connected from the body of the instrument.

E.S. = Earthing Strip
E.M. = Earthing mat.

Fig. 5.59. Equipment Earthing

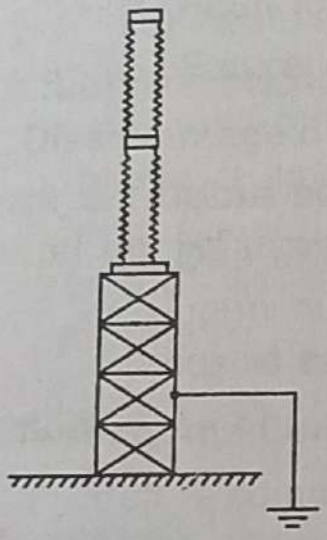


Fig. 5.60. Frame Earthing

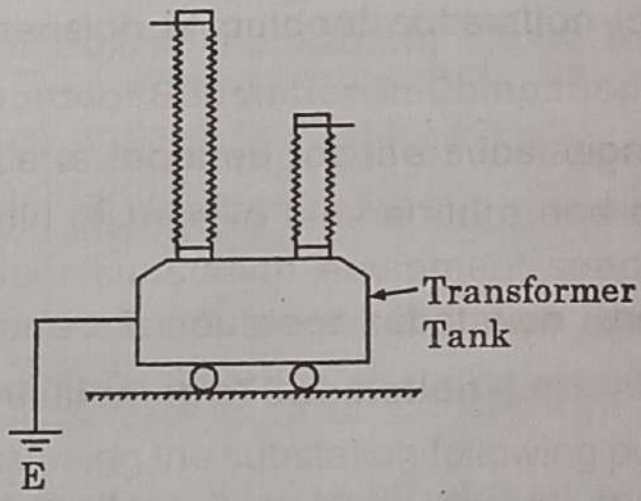


Fig. 5.61. Body Earthing

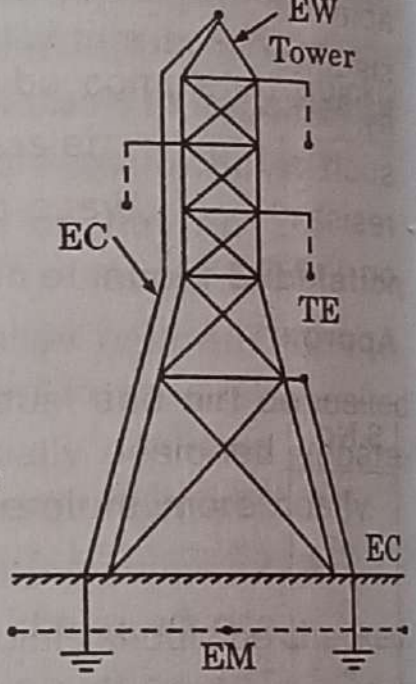


Fig. 5.62 Tower Earthing
TE = Tower earth;
EC = Earth conductor;
EW = Earth wire.

Grid Substation -:

→ Several generating stations are connected to each other to form an inter connected grid system.

→ The operation of such a grid is controlled from a load control centre or load dispatch centre.

→ There are several advantages of interconnecting the large generating stations such as -:

(1) By interconnecting the large generating station the amount of reserve plant capacity (extra supply of power) in the system is reduced. Thus the load factor and efficiency of operation are improved.

(2) The reliability of supply is increased.

(3) As the load curves (power vs time) for different stations are different, therefore diversity factor of the whole system is improved which increases the effective capacity of the whole system.

(4) With interconnected stations generator of large size can be used which reduce the capital cost/kw. In interconnected grid system large generators can be used so that in case of failure of any one of them, the power could be supplied from other stations.

Load Shedding -:

→ When all the generators get overloaded beyond the maximum mechanical power input, it becomes necessary to interrupt some load to save the system from breakdown. This process is called load shedding.

Responsibilities of individual regional grids in the grid system -:

1. Each regional grid should plan its generation to meet its demand.
2. It should control its own load frequency control. (Frequency control -: maintain balance bet^n production & consumption of power)

3. It should generate as per instructions of load control centre.
4. It should co-operate with other regional grids.

Regional Grids in India:-

① Northern Region ② western region ③ Southern region
④ Eastern Region ⑤ North Eastern Region.

→ National load dispatch centre is in Delhi.

Advantages of outdoor substations over indoor substation

1. Civil construction work required for outdoor substation is much less as compared to indoor. Hence the capital cost of outdoor substation is less.
2. Erection work of outdoor sub-station can be completed quiculy.
3. Fault location in outdoor sub-stations is easier.
4. Future extension of outdoor substation is easy.

Disadvantages of outdoor substation in comparision of indoor substation:-

1. More space is required for the outdoor substation.
2. Due to rapid change in temperature and dust or dirt deposited upon outdoor substation equipment specially designed apparatus is required for outdoor substation, therefore maintenance cost is high.

Maintenance of substation:-

→ The maintenance work should be carried in systemetic way so that there is not any interruption in supply.
→ The maintenance schedule are divided into two catagories.
→ Firstly the maintenance of substation is done in case of emergency (i.e. in case of failure)
→ secondly, the repair of the substation is carried out during operation.
→ The team for the maintenance work should be skilled personnel.

→ The maintenance includes-:

a) Daily, weekly, monthly, half yearly maintenance.

b) yearly maintenance.

c) Maintenance once in two years.

d) Maintenance once in five years.

Maintenance Schedule for different Substation Equipments-:

(1) visually inspection for
→ cleaniness. → for checking leakage.
→ for cracks in porcelain. → Sign for breakdown.

(2) checking of various switching devices.
→ for burning → for corrosion.

(3) To provide necessary lubrication to various joints.

(4) check level of oil in different equipment.

(5) check operating mechanisms
→ circuit breaker → isolators.

(6) Check gas pressure.

(7) check as per manufacturer instruction for connectors

(8) Inspection of surge arrester.

Testing and Commission of Substation-:

→ Before commissioning the substation following points should be checked.

(1) The earth resistance of substation should not be more than 5Ω.

(2) It should be insured that the H.T and L.T fuses are of appropriate sizes.

(3) It should be ensured that the air path of the silica gel breather of the transformer is clean. If it is chocked it should be cleared.

(4) Before commissioning the substation the operation of tap-changing switch should be checked.

(5) The oil level in transformer should be upto the mark indicated on the transformer.

5. Horn gaps are provided as a back up protection across HT bushing terminals and body of the transformer.

Control and Relay panels -:

Control Room and control panels -:

→ The protective relays are automatic devices which can sense the fault and send instructions to the associated circuit-breaker to open.

→ The relay and control panels are located mainly in the control room of the substation building from where it is possible to supervise and monitor the substation.

→ The substation can also be provided with equipment allowing remote control of another sub-station or load-despatching centre.

Location of control Room -:

→ There are no rules regarding the location and layout of control rooms. The substation control room is located at one end of the substation area.

→ The control room should be near the management office and instrument test room.

→ There should be good communication between the control room and management office.

→ The remote location of the control room results in costly cable runs.

→ The control room should be relatively away from noise, disturbances.

Layout of control Room -:

→ The layout of a control room depends on the size of the substation, operational requirement and type of installation.

→ The control room should be designed for routine operations, by one or two operators at a time.

→ The various equipments should be approximately equally spaced and separate area should be available

for movement of personnel.

→ If the substation is too large, it will have a large number of protective relay panels, control panels and metering panels.

Types of panel

i) Relay panel -: The relays are generally mounted on a separate panel. The type and number of relays depend on requirements.

ii) Instrumental Panel -: It indicates ammeter, voltmeters, energy meters, their selector switches, recording instru-ments, if any, fitted on instrument panel.

iii) Synchronising panel -: The panel for synchronising, can be conveniently arranged on the upper portion of the cubicle. (A small room that is made by separating off part of a larger room)

→ The indicating instrument show "incoming volts", "Bus-bar volts" and "Slow or fast"

iv) Cubicle panel -: The cubicles are arranged in a line, side by side. Sometimes, the relay cubicles are arranged back to back with their respective control cubicles, with a corridor in-between.

→ The corridor are provided for wiring which run between the control and relay panels.

v) Carrier Communication Panel -: Carrier Communication panel is connected to power line through coupling capacitor.

→ Communication can be carried out between the substati-ons by carrier channels.

vi) Automatic Voltage Regulator panel -:

→ It is used for regulating the voltage automatically.

(vii) Process control pannel -:

→ It is used for controlling different processes. (meters, switches, recorders, cctv camera etc)

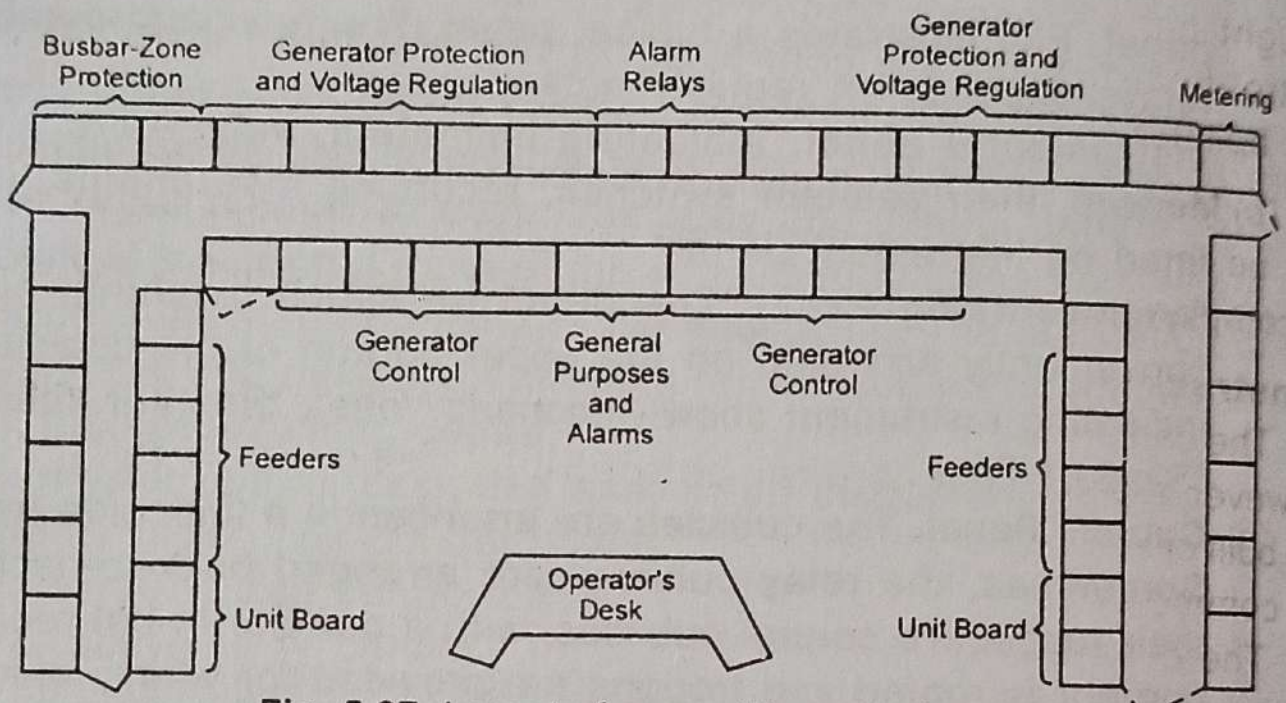


Fig. 5.37. Layout of a panel in control room

Types of installation for control and relay panel -:

a) Large installation -:

→ When a large no. of control circuit is used, then the arrangement should be such that, the indicating apparatus should be clearly visible from the central place.

→ The equipment should be compact.

→ The terminals should have good accessibility.

→ Separate panels should be provided for

i) Control & indication equipment

ii) Relay and indication equipment, voltage regular equipment.

b) Medium Size installation -:

→ In medium size installations, panel width can be increased to accommodate relay and other equipment.

→ In case of complex protective schemes, a separate relay panel is necessary.

Installation of control panels -:

→ After separate panels of a control board have been received at the site, they must be checked for any damage or missing parts.

→ These control panels must be compared with the installation drawing to ensure that they are complete in all respect.

→ The apparatus dismantled for transportation & received in separate packing should also be checked for damage or missing parts.

→ The insulation of panel wiring should be intact. (Completed)

→ The insulation resistance of all the control wiring should not be less than 1 MΩ.

→ The panel surfaces should be smooth and free from dents.

→ The front surface of the panels should line up in a common plane and should be given a priming coat followed by a finishing coat.

→ The panels should be moved into the control room by a crane and inside the control room, they must be moved into their respective place over channel with a winch or block or other necessary equipment.
→ They can also be moved on rollers, then the control board panels are mounted on a supporting frame planced in advance in the control room.
→ The middle panel should be set up first and then moving on both the sides.
→ Then the panels are joined together by welding the frame.
→ The supporting frame is earthed at not less than two points.
→ Then the instruments and other devices can be mounted in the panels according to the drawing.

Installation of control wiring :-

→ There are two methods of installation of control wiring
1. Panel wiring 2. General control wiring.
→ The wiring is suitable for 250v and are generally of grade 7/0.029 Cable.
→ Terminal blocks are used for connecting the wires.

Reactors

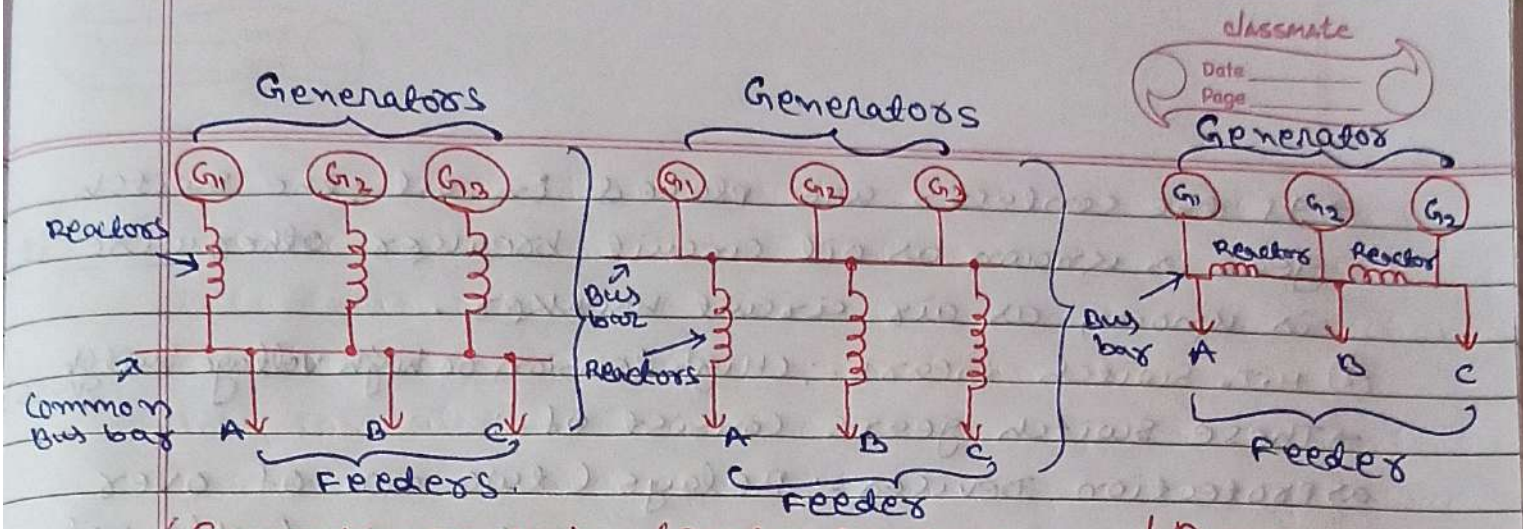
→ A Reactor is a coil which has a large inductive reactance in comparison with its ohmic resistance.
→ It is connected in the circuit to limit the short circuit currents to a safe value & protect the installation.
→ The reactors are also incorporated to protect the inadequate current of circuit breakers.
→ In industries and substation, two types of reactors are used.
a) Air cooled or dry type reactors.
b) oil cooled or oil immersed reactors.

a) Air cooled Reactors:
→ These reactors are used only upto 33 KV and generally cooled by natural air.
→ The reactors are mounted on porcelain foot step insulators.
→ These types of reactors have some following disadvantages
① These are not useful for outdoor service.
② They can only be used up to the voltage of 33 KV.
③ It requires large space.
④ Due to large size of coil used in this reactor, it is difficult to cool them by using fans.

b) Oil cooled Reactors:
→ These reactors are used at the voltage above 33 KV.
→ Oil cooled reactors are immersed in transformer oil.
→ The oil acts as an insulator and cooling agent.
→ The size of oil cooled reactor is small as compared to air cooled reactor and has high factor of safety against flash over. (an unintended high voltage electric discharge over or around an insulator)

Advantages of Oil cooled Reactors:
① They have small in size as compared to Air cooled reactors.
② They have better cooling efficiency.
③ The have higher factor of safety against flash over voltage. (factor of safety = puncher voltage / flash over voltage)

Installation of Reactors:
→ Reactors are connected as in series with generators known as generator reactors.
b) In series with feeders known as feeders reactors.
c) in series with bus-bars known as bus-bar reactors. (Ring system or tie-bar system)



(Generator Reactor) (Feeder Reactors) (Bus-bar Reactors)

Switch Gears :-

→ Switch gears are mechanical devices designed to close or open the contact members in a electrical circuit under normal or abnormal condition.

Selection of Switch Gears :-

→ The selection of switch gears depends upon the following points :-

a) Loading current
b) Working voltage
c) Fault current level
d) Atmospheric conditions
e) Types of operation i.e. manually operated, remote controlled, kinetic controlled etc.

Types of Switch Gears :-

→ There are two main types of switch gears.

1. L.T Switch gears → Air circuit breaker, Oil circuit breaker
2. H.T Switch gears

1. L.T Switch gears :- (low tension or low voltage switchgear)

→ These consist of earth fault protection and overload protection & no relay is connected in the circuit.

→ The maximum capacity of L.T switch gears is 1600A.

→ Capacity of these switch gears is selected according to the load requirments.

→ The capacity of incoming & outgoing cable in the panel board is also selected according to the capacity of switch gears installed on the panel board.

→ If the contacts are placed in oil, the switch gear is known as oil circuit breaker otherwise it is known as air circuit breaker.

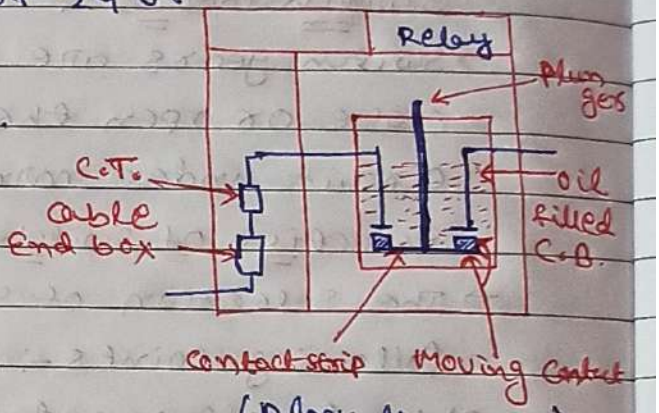
(2) H.T. Switch Gears :- (High tension or high voltage switch gears)

→ These switch gears consist of :-

a) Protection Devices :- Relays (two no. of over current relays and one no. of earth fault relay fed with battery circuit of 24 V.

b) Circuit breakers :-

c) Instrument transformers.



(Block diagram)

Installation of Switchgears :-

(1) Preliminary preparations :-

→ The preliminary preparation include study of drawings, acceptance, report checking certificates and test reports of the equipment, completion of civil engineering work, arranging the tools, lifting gears etc., organising the labour, prepare the schedule of installation, preparing sequence cards for erection etc.

→ Such cards indicate the sequence of operation, items involved, procedure in brief etc.

a) Sequence card for Erection of Switchgear Equipment :-

Sl. No.	Operation	Tools, lifting gear etc.	Drawing No.	Technique & procedure

→ The drawing include

1) circuit diagrams of the plant.
2) civil engineering plans, foundation plans etc.
3) Dimension drawing of equipment.

b) Location of switchgear :- i) indoor ii) outdoor

→ Generally upto 11KV, indoor switchgear is popular.

→ Indoor switchgear should be located in a clean dry room & free from snakes, rats, moisture, dust etc.

→ Floor should be dry & levelled. The floor should withstand load of about 1000 kg/m².

→ Enough space should be left in front and in the back of the switchgear as recommended by the manufacturer (About 1.7 meters in front & 0.7m in the back of 11KV drawout switchgear)

→ During ~~set~~ set up the switchgear, the following points should be consider. 1) Fire proof doors, roof, ceiling etc.

2) Sealing of cable ducts.

3) Sub-division of switchgear.

4) Installation of fire fighting apparatus.

c) Unpacking :- → The equipment is packed in crates & is brought to the site by railway and motor-truck.

→ Packings are lowered on the site by means of rope, hoist or crane carefully.

→ Care is taken that they are always maintained in upright position throughout.

→ On unpacking, the items are checked against the list.

→ Further the items are carefully inspected visually.

→ If any damage is found, the matter should be informed to the manufacturer & insurance company immediately & the damaged equipment should be returned.

d) Foundation :- The foundation is prepared according to the foundation plan.

→ Holes are provided of foundation bolt.

→ Trenches and passages are provided for cables & other pipes.

→ The floor should be correctly levelled and marked according to the drawing.

e) Erection :- The equipment is installed according to the procedure mentioned in the instruction manual.
→ Some types of lifting devices, special tools etc. may be necessary.
→ The assembly is erected vertically & is checked by spirit level.
→ If necessary, packing pieces are added in the base plate for obtained proper level.
→ After doing necessary adjustments & checking the level, the concrete mixture is poured into holes around foundation bolts & the nuts are tightened.
→ During erection, they should not be lifted under assembled state.
→ The assembled is carried out on site & the assembled units are not shifted.

f) Bus-bar earthing connection :-
→ The bus-bar contacts & surface of connectors should be cleaned with emery paper (sand paper) or smooth file.
→ The bus-bars are assembled as soon as they are cleaned.
→ Special grease is also applied.

g) Relays :- It is advisable not to adjust the relay-mechanism.
→ The faulty relay should be sent to the manufacturer since relay repair is a specialized job.
→ contacts of relay should be inspected for any sign of burning & sand paper should be used for cleaning.
→ All the terminals of the relay should be checked for tightness & for security.

h) Connection of Main Cable :-
→ The cable terminal box should be clean and moisture should be removed by blow-lamps.
→ The cable filling compound should be warmed to about 157°C to 168°C & allowed to cool to pouring temp.

of about 135°c - 140°c.
→ The buckets used for filling should be pre-heated to about 80° before use.
→ The compound is poured slowly down in the cable box to avoid air bubbles.
→ The level of the compound should be about 45 mm. below the top cover to allow expansion during service conditions.
→ The cable cover is bolted when the compound gets cold.
→ No moisture or dirt should enter while filling the compound.
→ The terminal lug is soldered to the cable conductor.

ii) Earthing :-

→ The earthing bar of the switchgear, the metallic non-current carrying parts are connected to station earthing system.
→ The earthing bar is run through various units and the frames of each unit are connected to earthing bar.
→ Earthing bar is connected to station earth by two GI flats. (GI - Galvanized iron)

HT / LT circuit Breaker :-

→ A circuit breaker is a device which makes or breaks a circuit either manually or by remote control under normal conditions.
→ It breaks a circuit automatically under fault cond^n.
→ Thus circuit breaker is just like a switch which can be operated under normal and abnormal cond^n conditions both manually or automatically.
→ To perform the above operation, a circuit breaker consists of fixed and moving contacts called electrodes.
→ When a fault occurs on the power system, the

trip coil of the circuit breaker is energised which pulls apart the moving contacts from the fixed contacts & open the circuit.

Types of circuit breaker -:

→ on the basis of the medium used for arc extinction the circuit breakers are classified as -:

a) Oil circuit breakers -: in which transformer oil is used for arc extinction.

b) Air blast circuit breaker -: in which blast of air is utilized for arc extinguishtion.

c) Sulphur Hexa-fluoride circuit breaker -: in which SF_6 gas is used for arc extinction.

Main parts of a circuit-Breaker -:

→ Parts of a circuit-breaker include

1. Poles with interrupter, support porcelain, arc quenching medium etc. (quenching (Arc) -: Stoppage of arc)
2. Operating Mechanism.
3. Support Structure.
4. Control Cabinet.

→ The part of the circuit breakers connected in one phase called the pole.

→ A circuit breaker suitable for three phase system is called a triple pole circuit breaker.

→ Each pole of the circuit-breaker comprises one or more interrupts or arc-extinguishing chambers.

→ The interrupters are mounted on support insulators.

→ The interrupter encloses a pair of fixed and moving contact.

→ The operating mechanism of the circuit-breaker gives the necessary energy for opening and closing of contacts of the circuit-breakers.

H.T Circuit Breaker :-

→ circuit breaker above 1000V are called high tension circuit breaker.

→ The circuit breaker cannot be used on DC circuit unless approved by the manufacturer.

Classification of H.T Circuit Breaker :-

→ It is based on the medium of arc extinction.

a> Bulk oil circuit breaker b> Air blast circuit breaker c> Sulpher Hexa fluoride circuit breaker (SF_6)

Bulk oil circuit breaker :-

→ These switches are suitable for a max^m voltage of 66 KV and have maximum breaking capacities ranging from 75000 to 250000 KVA.

→ The contacts of these switches which break high tension circuits are immersed in oil to ensure rapid & effective rupture of the circuit.

→ It is employed on 132KV service with maximum rating and three such breakers are employed to form a three phase unit.

Air-blast circuit breaker :-

→ In these circuit breakers, compressed air of pressure 18 to 20 kg/cm2 is employed for arc extinction.

→ These circuit breakers are suitable for the operating systems of 132KV or above and with breaking capacity of 6000 MVA and above.

→ However, this type of circuit breakers have also been designed to cover the voltage range 11KV to 132KV.

→ It is of two types.

i> Axial-blast air circuit Breakers :-

→ Here the air-blast acts along the arc.

ii> Cross-blast air circuit Breakers :-

→ Here the air-blast cuts across the arc.

Inspection & Maintenance of HT oil circuit breaker:-

→ The high voltage oil circuit breakers are used in large industries for power distribution at transformer substations for load switching & also connecting, disconnecting & protecting entire installation.

→ During operation, heavy current flows through its current carrying parts & the contacts are heated to high temp. by the arc between them at the time of closing or opening the circuit.

→ Thus the arcs can burn the contacts & the oil.

→ It causes serious damaged due to inadequate maintenance. So the preventive maintenance is essential for high voltage oil breaker.

i) cleaning of bushing as and when necessary. (Bushing :- Hollow electrical insulator)

ii) Checking the oil level in the circuit breaker monthly. Add more oil if oil level is low.

iii) Taking Sample of oil for testing from the tank of circuit breaker quarterly or after every six tripping.

iv) check the contacts as per the manufacturer instruction.

v) Replacement of the oil of the tank of circuit breaker when test result is not satisfactory.

vi) operating Mechanism :- Tightning of all nut and bolts if found loose, lubrication of parts subject to friction and correct operation of spring.

Inspection and Maintenance of LT circuit Breaker:-

→ These are the following inspection and maintenance is required.

i) General cleaning ii) checking the oil level.

iii) visual inspection of moving and fixed contacts.

→ It should be done after clearance of faults.

a) Enclosures - i) Check it for its condition and leakage.

ii) cleanliness iii) Damage to internal parts.

Inspection and Maintenance of LT circuit Breaker

To prevent the LT circuit breaker from excessive wear and tear and break down following inspection and maintenance is required.

(*i*) General Cleaning

(*ii*) Checking the oil level

(*iii*) Visual inspection of moving and fixed contacts.

It should be done after clearance of three faults.

(*a*) Enclosures

(*i*) Check it for its condition and leakage

(*ii*) Cleanliness

(*iii*) Damage to internal parts.

(*b*) Contactor

(*i*) Proper contact pressure, breakage of contact springs.

(*ii*) Loose connections.

(*c*) Oil : Condition of oil. Conduct dielectric test if oil is carbonized and contains other foreign materials.

(*d*) Relays : Testing and setting for correct operation of thermal, over current and no volt coils at the set values.

(*e*) Joint : Insulation test of cell connecting cables and inspect all cable joints.

carry its rated normal current continuously and to perform the operating duty corresponding to the rated making and breaking capacity assigned to it.

Installation of Outdoor Circuit-Breakers

Outdoor circuit-breakers are mounted on pre-fabricated galvanised steel structures.

The important steps in the installation include the following :

1. Receipt and storage

The packing cases are inspected and stored in indoor/covered stored in a planned location. Indoor equipment are stored indoor, outdoor equipment are stored outdoor.

Civil Works. These are carried out as a part of civil works. The foundation plan is decided on the basis of requirements of the clearness and the base of the equipment/structure. Pockets are provided for grouting the foundations bolts. Cables are laid on trays located in the cable trenches.

Earthing mat is made welded with iron rod mesh and is buried in the yard of depth of upto 1 metre. The risers are brought up upto earthing point on the structure, equipment base.

Foundations. The installations work is started after completions of foundations.

1. Check the readiness of foundations and their dimensions as per the drawings. Check the locations of holes for grouting with reference to foundation plan.
2. Check the level of foundation surface.
3. Place the based frame/structure of the circuit-breaker in position. Place foundation nuts spring washers and tighten. Make connection of earthing riser to the structure.
4. Assemble operating mechanism in its position.
5. Assemble support porcelains and interrupting heads.
6. Join the links in the mechanism with the links in the pole units as explained in manufacturer's Instruction Book.
7. Give auxiliary supplies to mechanism for motor, for trip circuit and closing circuit.
8. Tighten all the bolts and other hardwares. Remove packings.
9. If provision available, operate slow opening and slow closing.
10. Measure insulation Resistance.
11. Fill quenching medium after drying out operation. Check leakage and ensure leakage free assembly.
12. Measure insulation Resistance and resistance between terminals of poles.

13. Make terminal connection, earthing connections.
14. Operate breaker from local control panel.
15. Operate the breaker from control-room by operators instructions and then by operating the relevent relays

The breaker is ready for putting into service.

Precommissioning Checks/Tests

These are performed in accordance with the agreed field quality plan and include :

— Leakage tests
— Time/contact travel characteristics
— Time tests
— Insulation resistance test on main and auxiliary circuits
— Measurement of low resistance between terminals of pole.
— Checking of earthing connection
— Operation of breaker from local control cabinet
— Operation of breaker from control room by manual command; by relay command.

...carried out by the trained staff.

Commissioning Checks on Outdoor Circuit Breakers

After installation of outdoor breaker following tests/checks are made :

- Mechanical operation tests
- Measurement of insulation resistance, resistance between terminals of the pole.
- Pre-commissioning checks.
- Operation open and close.
- Checking of operation by energising the manual operating command.
- Checking the operation by energising of relays etc.
- Leakage tests, settings of pressure-switches.
- Simultaneous opening and closing of three poles.
- Timing tests.
- Interlocking, sequential operations of breakers, isolators and earthing switches.