

## PRACTICAL IN POWER DISTRIBUTION

Electrical power is essential for economic development and for improving the quality of life. The three major parts of electrical power system are generation, transmission and distribution. You are primarily dealing with the distribution part of the electrical system, i.e. the part that brings electrical power to the consumer.

This course provides you with the requisite knowledge to enable you to be well informed and capable of working with the electrical system with complete understanding. However, we realize that only theory subject is not sufficient to make you confident in your day-to-day working life. This practical workbook is to help you on this count. We recognize that practice work is required to give you that hands-on experience, which will make you confident and also make you aware of the problems, which you may face in your day-to-day work-life. This practical workbook is to aid fulfillment of this aim.

This course is laid out in 'activities', whereby each activity takes up one task connected with the act of providing electrical power to the retail customer. These tasks have been chosen, as these are the activities most likely to be faced by you, in your working life.

Each 'activity' describes the task taken up therein, and provides some background or theoretical information for proper understanding and appreciation of the activity. The required tool and tackle are described, and only then is the task started. The practical course is designed to be a guide to the practical activity, to be carried out in the presence of, and under the guidance of an experience trainer.

In these activities we introduce technical dimension of the power distribution system and discuss its operation and maintenance aspects also. It is our belief that significant improvement can be brought about in the power sector just by toning up the operational and maintenance practices, sharpening of work culture and training.

We hope that the activities presented here related to power distribution, would provide you an insight into the working of the sector and help you in carrying out your responsibilities better.

At the end of the practical workbook, you are expected to be reasonably proficient in practically handling the stated activities.

**Happy learning & Wish you all the very best.**



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## PRACTICE FOR DIGGING HOLES AND ERECTION OF POLES

### Structure

- 1.1 Objectives of Activity
- 1.2 Equipment/Materials/Facilities Required
- 1.3 Brief Theory
- 1.4 Procedure
- 1.5 Tabular Record of Observations
- 1.6 Precautions
- 1.7 Self Test

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### 1.1 Objectives of Activity

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After performing this activity, you should be able to

- **practice the technique for the erection of poles for overhead lines.**
- **describe the safety measures to be taken during erection of poles.**
- **understand economical and accident-free utilization of labour during erection.**

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### 1.2 Equipment/Materials/Facilities Required

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- Drilling Machine.
- Earth auger (i.e. to drill a hole in earth), digging bars, shovels or pick axes.
- Three ropes of  $\frac{3}{4}$  " diameter each and one rope of  $1\frac{1}{4}$  " diameter, and nearly 40 ft. to 50 ft. long.
- X-shape wooden frame for supporting the pole while erecting,
- Hoisting rig, a trunk or a skid winch, or a derrick pole.
- Standard tools.

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## 1.3 Brief Theory

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After a route survey of the transmission line, the poles have to be erected, so that further action of stringing and sagging of the conductors may be undertaken.

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## 1.4 Procedure

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### (1) Transportation of Poles

All other material can be transported easily either in a truck or a bullock cart. For poles, (though this can also be done by the above mentioned methods) it is recommended that a special trolley be made and which may be pulled either by bullocks or a tractor or by manual labour. After the poles are transported, erection work starts.

### (2) Preparation of the Poles for Erection

After the poles have reached the site, the following operations should be completed.

- Drill the Holes
- Paint the pole, if not already done. (Not needed in the case of concrete poles.)
- Fit the cross-arm and knee bracing
- Fix up pins and clamps for insulators
- If muffs are provided, they should be grouted on the poles. If not, grouting should be done later on.

### (3) Digging of Holes

After fixing the point where the pole is to be erected, a hole is to be excavated in the ground. The depth to which the pole is to be planted is a matter, which can only be determined in the light of past experience. Roughly  $1/6^{\text{th}}$  of the length of the pole is planted. In the case of planting in solid rocks, the depth is less.

The following table shall be a useful reference in digging holes in the ground.

Length of Pole (Ft.)	Depth in Ground in Solid Earth (Ft.)	Depth in Ground in Solid Rock (Ft.)
25' – 0"	5' – 0"	3' – 6"
30' – 0"	5' – 0"	3' – 6"
36' – 0"	6' – 0"	4' – 0"
42' – 0"	7' – 0"	4' – 6"
65' – 70'	8' – 0"	6' – 0"

### ➤ Size at the Top and at the Bottom

It should be sufficiently larger than the pole (or pole base, if used) to allow the use of tempering bars for tamping. In ordinary firm soil, pole holes are excavated by :

- Hand, using digging bars, shovels or pickaxes,
- Earth augers, and
- Drilling machine.

If the hole is dug manually it should be 3' × 1½' in size and should be tapered. If it is dug by an earth auger or drilling rig, it should be 9 or 10 inch diameter, depending on the size of the pole.

The hole should be in the same position as the intended position of the pole at the bottom.

A concrete pad of 3' thickness may be prepared at the bottom to provide a firm base.

### (4) Raising of Poles

Three ropes of 3/4" diameter and one of 1¼ " diameter, 40 to 50 feet long are tied near the top of the pole, with pole in the horizontal position.

Then the pole is raised by about 5 to 6 feet on a wooden X-shaped frame. One or two men, depending upon the weight of the pole, should hold the 3/4" ropes in three different directions and 3 to 4 men should hold the 1¼ " rope in the fourth direction. Then the pole may be pulled by these men till it gets into the pit. A hoisting rig, a trunk or a skid winch can be used with advantage. A derrick pole can also be used with advantage. This pole being lighter, is first

erected, and then, by pulling the pole which is to be erected, the derrick pole is lowered.

It becomes easy to lift the pole.

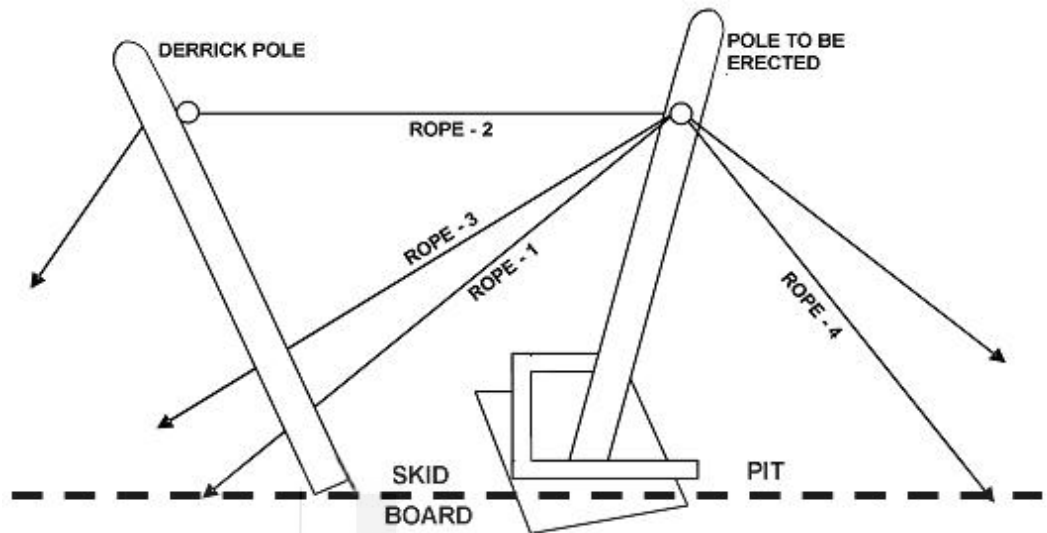


Figure 1.1 : Derrick Pole Method

#### (5) Checking of Pole Alignment

As soon as the pole is erected, it should also be checked for verticality by a plumb – bob.

#### (6) Concreting the Pole

Poles should have a strong foundation, because the failure of the pole may not necessarily be due to a crack or fracture, but due to wrong foundation. If the muff is pre-cast, this is to be fitted before the erection of the pole. Then only the earth is to be tamped. It is better to tamp in more soil than comes out of the original hole to provide greater firmness. If the pole has not been fitted by a pre-cast muff, then it should be grouted by cement concrete mixture in the ratio of 1 : 2 : 4.

If the hole is drilled by means of an earth auger or drilling rig then it should be grouted without the aid of a steel muff but if a larger hole has been dug, then a steel plate muff of 10" diameter, or another suitable size, depending upon the size of the pole may be used.

This steel muff may be removed the after one day of the installation. The baulk should be one foot above grounded level. It is essential that this casing should be beveled at the top to prevent lodgment of water between the concrete and the pole surface.

## 1.5 Tabular Record of Observations

After erection of poles, record observations in the following tabular form (the data pre-filled in the 'Data' column is to serve as an example, and should be replaced with the actual values).

Sl. No.	Details	Data	Pole No. 1	Pole No. 2	Pole No. 3
1.	Length of pole	30 ft.			
2.	Type of pole, whether PCC/steel	Steel			
3.	Height above ground	25 ft			
4.	Depth in ground	5 ft.			
5.	Whether muff is provided or not	Yes			
6.	Type of X-arm	Horizontal			
7.	Whether angle pole or not	No			
8.	Nos. of holes drilled	5 Nos.			
9.	Paint done or not	Done			

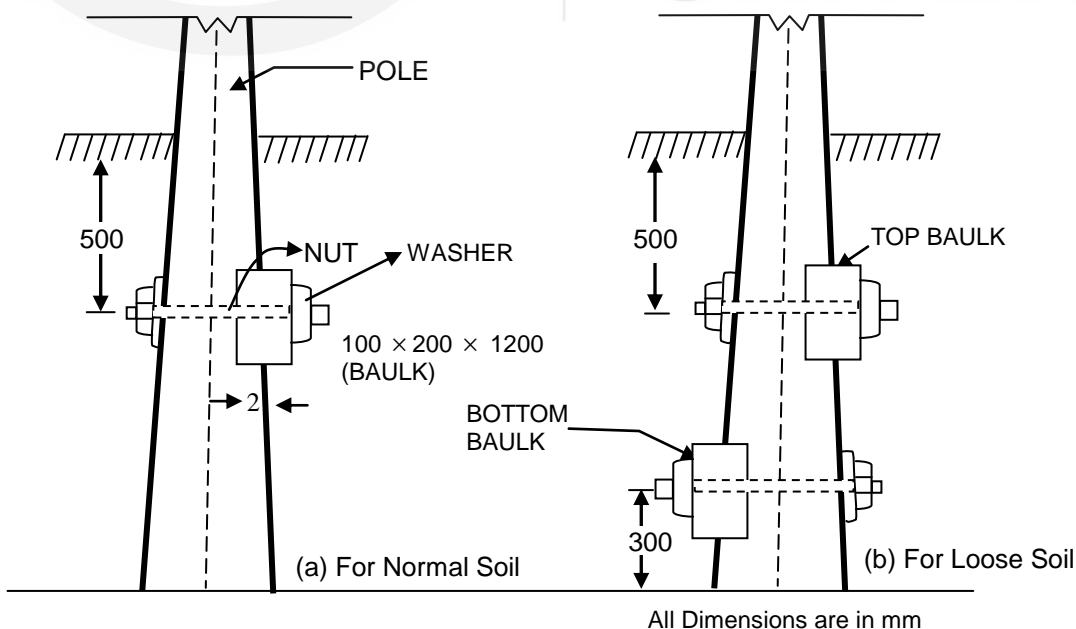


Figure 1.2 : Fitting Baulk in Foundation of Pole

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## 1.6 Precautions

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- Ropes should be of the proper size.
- Muffing should be provided as necessary.
- One coat of paint, together with anti-rust treatment, must be done on steel poles.
- Proper numbering must be put on the poles
- Record of data regarding each pole must be prepared carefully.
- Holes must be dig to the proper depth
- Take safety measures to avoid accidents.
- To have proper coordination and economical utilization of manpower, one person from the gang of erectors must be made leader, so that others work under his command.

**Self Test**

**Answer the following questions :**

Q.1 What procedure is used for erection of overhead line pole? Also draw a diagram for showing the erection of the pole.

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Q.2 Why muffling is necessary?

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Q.3 Give the necessity of paint on steel poles.

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Q.4 Why alignment of the pole is necessary?

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Q.5 Why proper coordination is required in the gang of erectors?

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# PRACTICE OF FIXING DIFFERENT FITTINGS ON POLES SUCH AS CROSS-ARMS, INSULATORS, STAY-WIRE, GUY RODS/WIRES

## Structure

- 2.1 Objectives of Activity
- 2.2 Equipment/Materials/Facilities Required
- 2.3 Brief Theory
- 2.4 Procedure
- 2.5 Tabular Record of Observations
- 2.6 Precautions
- 2.7 Self Test

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## 2.1 Objectives of Activity

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After performing this activity, you should be able to

- **get familiar with different kinds of fixtures/fittings are in use for overhead lines.**
- **know about the fixing of these fittings on poles.**
- **make economical utilization of manpower and materials.**

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## 2.2 Equipment/Materials/Facilities Required

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- Cross-arms
- Insulators with fittings
- Anchor rods
- Stay wires
- Guy rods/wires
- Stay insulators
- Overhead conductors
- Conductor clamps
- Line construction tool kit.

## 2.3 Brief Theory

The main function of a pole is to support conductors at a safe distance above the ground. Multiple conductors must also be kept a safe distance apart from each other. This is the function of the cross-arm. Several designs are in use. They vary from a steel channel to V, U and zig-zag shape or teak wood or sheesham wood cross-arm. In order to prevent arcing, the construction should be such that under the worst conditions, the distance between wires, when swinging, will never be less than the following figures, anywhere along the length :

Line Voltage	Separation
3.3 kV	7.5 cm
6.6 kV	7.5 cm
11 kV	10 cm
33 kV	10 cm

**A guy is a brace or stranded wire fastened to the pole to strengthen the pole and to keep it in position.** Guys provide 'pull' support. Guys are used wherever the wires tend to pull the pole out of its normal position and to sustain the line during the abnormal loads caused by sleet, wind and cold. Guys may be classified as braces; wire guys; anchor or down guy and stub guy.

**Braces are used wherever wire guying is not convenient such as along lines** paralleling a highway or in marshes where anchors cannot be firmly embedded. A span guy is a wire guy running from the top of a pole to the top of an adjacent pole. It is used at important crossing.

**A head guy is a wire running from one side of a cross-man to the next pole. An anchor or down guy is a wire guy running from the top of a pole to an anchor in the ground.** Line guys are installed in straight pole lines to reinforce the line against stresses due to broken conductors, etc. Side guys are used to reinforce a pole line against an unbalanced side pull of the conductors. Such pulls are developed at curves, angles, wherever there is a turn in the line.

A storms guy is a combination of line and side guys. A stub guy is a means of obtaining clearance for a wire guy. A sidewalk guy is an anchor guy with a horizontal strut at a height above a sidewalk to clear the walk.

A wire guy consists of a cable, cable clamps, strain insulator and anchor.

**The function of an insulator and anchor :** The function of an insulator pin is to hold the insulator mounted on it in a vertical position. Insulator

pins holds the insulator mounted on it in a vertical position. Insulator pins in use in the field are made of metal e.g. iron or steel. The function of an insulator is to insulate the line conductors from each other and from the pole or tower.

**Three classes of insulators are used on overhead lines, namely, pin type, suspension type and strain type.**

The **pin insulator** gets its name from the fact that it is supported on a pin. The pin holds the insulator, and the insulator has the conductor tied to it. Pin insulator commonly in use these days, are made of porcelain.

The **suspension insulator** as its name implies, is supported from the cross-arm and has the line conductor fastened to its lower end. It is made up of a number of sections stringed together. These are mainly used for high voltages above 33 kV. At this voltage, the pin insulator becomes quite heavy and it is difficult to obtain sufficient mechanical strength in the pin to support the insulator.

The use of a suspension insulator eliminates the use of the pin and makes it possible to obtain any distance between the conductors and the pole or tower by merely increasing the number of insulators in the string.

A **strain insulator** is used where a pull must be carried as well as insulation provided. Such places occur where a line is dead ended, at corners, at sharp curves, at extra long spans, as at river crossings or mountainous country, etc. in such places the insulator insulates electrically, but must also have sufficient mechanical strength to counterbalance the forces due to tension in the line conductors.

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## 2.4 Procedure

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- (i) Complete drilling of holes for the cross-arm and guy support, before shifting the poles to the site for erection.
- (ii) Decide the length of cross-arm to be used and use a template for boring holes. For 11 kV lines, the length of the cross-arm is nearly 5'-0" but for special requirements a length of 7'-0" and 10'-0" may also be used. For a 33 kV line a 7'-0" long cross-arm and knee bracings should be at right angles to each other.
- (iii) Use H-pole where unusual loads have to be withstood – at angles or at line terminal corners, or at branch lines, etc.

alternatively, single poles supported by wire guys or pole struts can be employed.

- (iv) Installation of a guy involves the following operations : digging-in the anchor, inserting the strain insulator in the guy wire, fastening the guy wire to the pole; tightening the guy wire and fastening to the anchor, and mounting the guy wire guard. Guy wires should be placed on the poled and stay rod fixed before the line conductors are stretched on the poles. If line conductor are placed first, the poles would be pulled out of position. The guy-wire tightening may need to be re-done after the line conductors are stretched.
- (v) Insert an egg type strain insulator for safety. The two ends of guys should be threaded through the insulator in such a way that the porcelain of the insulator is under compression, making it possible to withstand a larger pull. In case the porcelain breaks, the guy will still be effective because of the linking of the two ends.
- (vi) Draw the guy up until the pole is pulled over slightly towards the guy to keep proper tension.

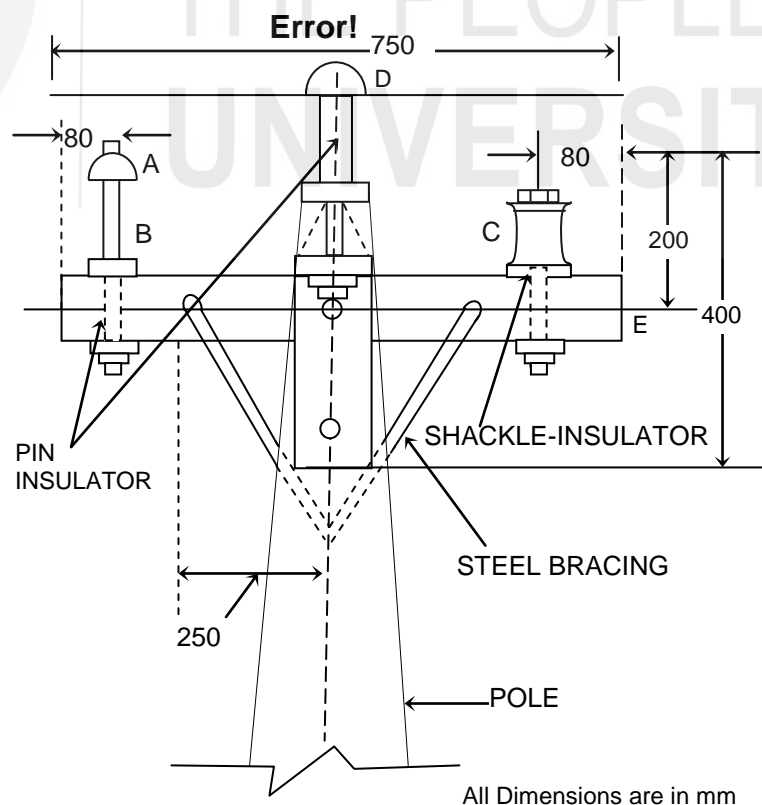


Figure 2.1 : Different Fittings on Poles

## 2.5 Tabular Record of Observations

The trainer should ask the technicians to do on the spot erection and then tell them to prepare a diary report. They should prepare pole-wise details of the fittings provided.

If some fixture is not provided, then 'no' should be mentioned in the table.

**Tabular Record of Observations**

Sl. No.	Fittings	Pole No. 1	Pole No. 2	Pole No. 3	Pole No. 4
1.	Cross-arm	Yes			
2.	Guy wire	Yes			
3.	Knee bracing	Yes			
4.	Pole clamps	Yes			
5.	Guy insulator	Yes			
6.	Thimble	Yes			
7.	Stay rod	Yes			
8.	Lock nut	Yes			
9.	Stay bow	Yes			

## 2.6 Precautions

- Holes of cross-arms and knee bracings should be at right angles to each other
- Guy wires should be placed on the poles and the stay rod must be fixed before the line conductors are stretched on the poles
- Thimbles should be used at both ends of the guy to avoid damage to strands
- Use strain insulators for safety.

**Self Test**

**Answer the following questions :**

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Q.1 Write short note on the following :

- (a) Guy
- (b) Anchor
- (c) Cross-arms

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Q.2 Why thimbles are used at the ends of guy wire?

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Q.3 What is the use of egg types strain insulator?

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Q.4 Define insulator and give classification of overhead line insulators?

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# PRACTICE OF STRINGING AND SAGGING IN OVERHEAD LINE CONDUCTORS

## Structure

- 3.1 Objectives of Activity
- 3.2 Equipment/Materials/Facilities Required
- 3.3 Brief Theory
- 3.4 Procedure
- 3.5 Tabular Record of Observations
- 3.6 Precautions
- 3.7 Self Test

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### 3.1 Objectives of Activity

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After performing this activity, you should be able to

- **get familiar with the techniques to reel out the conductor, and string it for sagging in overhead line construction.**
- **know sagging and tying of the line conductor.**
- **acquaint the technicians with a systematic procedure for overhead line erection.**

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### 3.2 Equipment/Materials/Facilities Required

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- Erected poles with fittings
- Line conductor
- Pulling blocks
- Snatch block
- Ropes
- Tie Wires
- Vehicle for carriage
- Light strips of wood to serve as targets
- Come-along or pulling grips
- Block and tackle or chain block
- Lineman hand tools
- Safety belt

### 3.3 Brief Theory

After the poles have been erected and fixtures set on the poles, the most important phase of line construction starts, which is stringing and sagging the line conductor, stringing it so that the overhead line is erected as per specifications. The final phase of tying-in is also needed before the line is ready.

#### ➤ Reeling Out of the Conductors

Reeling out of the conductors may be accomplished by either of the two methods :

##### Methods for reeling out of conductors

1. Moving reels with the conductor stationary.
2. Pulling conductors from stationary reels.

The first method involves the following steps :

- (1) Mount the reels of wire (as many reels as the number of conductors to be strung) on a truck or carriage in such a manner that the reels are free to rotate.
- (2) Fasten the ends of the conductors to a pole, tower footing or some other fixed object.
- (3) Drive the truck slowly along the route of the line, allowing the conductors to unwind as the reels are moved forward. Care should be taken to avoid inter-twining of the conductors while unreeling.

By this method the conductors are not dragged over the ground, avoiding scratching or damage. They are simply laid out on the ground without being pulled over it.

The second method involves the following steps :

- (1) As the reels on which conductors are wound remain in a fixed position, these are raised off the ground or supported in their carriages in such a way that they are free to rotate.
- (2) Pull out conductors, thereby, rotating the reels and unwinding the conductors.

- (3) Either simply draw the conductors forward, sliding or dragging them over the ground or keep these suspended in the air in tension so that they will not touch the ground. Take care that the conductors do not get scratches, as it will not only damage the conductor, but later lead to corona loss. For aluminum conductors in use these days, 'suspension in the air' method is better.

### ➤ **Stringing and Hoisting Line – Conductors**

It is a common practice to use the tension stringing method for overhead lines. Tension stringing is the process in which conductors are kept off the ground throughout the entire stringing operation.

To keep the conductors in tension, a puller is required on the leading end of the conductor and a brake or tension on the trailing end of the conductor.

Before the stringing operation is begun a pulling line of wire rope for transmission lines or manila rope for distribution lines is attached to the leading end of the conductor and is run through stringing sheaves hung from each tower or pole cross-arm for the full distance from the tensioner to the puller. It is the function of the pulling line to pull the conductor into the stringing sheaves, as it is pulled forward by the puller.

As the conductors are reeled out, they are hoisted up to the cross-arm. Each time a pole or tower is reached, the truck or tractor pulling the conductor, pulls a little ahead and halts to permit each wire or cable to be hoisted. This is generally done by means of a hand line.

Hoisting of the conductor to the cross-arm is called **Laying up**. The common practice is to use snatch blocks for 'Laying up', or rope baskets in city areas, where it is not possible to switch off supply all the time. In this way, instead of placing conductors directly on the cross-arm which may damage the conductors due to scratches, conductors are hung in so called snatch blocks.

A **snatch block** is a single sheave block so arranged that it opens in one side, thereby, permitting the conductor to be inserted or removed without threading it through.

**A snatch block serves two purposes :**

- It is a support for the line conductor.
- The pulley on the block runs so easily that it aids the conductor in taking on a uniform tension throughout, attaching to the suspension insulator. Rope baskets consist of two parallel ropes support from the ends of the cross-arms in the crossing span with numerous cross ropes to cater or support the unstrung conductors.

➤ **Pulling up of Conductor**

After the conductors are hoisted, they are ready to be pulled up. To carry out this operation a come-along, or pulling grip is fastened to the end of the line conductor. There are several makes of come-along in general use. All are designed with parallel jaws that will grip the wire firmly without injuring it. The conductors may be pulled from the top of the pole in the case of short line extension.

The pole used to pull from, must be properly guyed to withstand the strain. If there is quite a bit of pulling to be done, however, as in new construction, it is better, easier and faster to pull from the ground than on the pole.

After the conductors are pulled to the proper tension or sag, the conductors can be snubbed to the bottom of the pole to which the block and tackle is attached. Care should be taken in pulling up, so that splices and sleeves do not catch on the cross-arm or in the sleeves of snatch blocks. Any catch of this sort may prevent the conductor from coming up as it should.

After the conductors are pulled, they should have  $\frac{1}{2}$  to 4 hours or more depending upon the length of the pull, to allow them to creep. This creep will make the tension and sag in each span uniform.

When possible, an equalizer may be used in pulling up conductors in order to produce the same tension on each conductor. A simple form of equalizer for two conductors consists of a rope with a come-along on each end to grip the two line wires. The rope runs over a snatch block to which the pulling tackle is attached. Since the rope is free to move through the snatch block, the conductors will pull up to the same tension.

## ➤ **Sagging the Conductor**

Conductors are sagged uniformly when the tension is the same in each span throughout the entire length. New conductors must be pre-stretched so as to remove the non-elastic stretch.

**Several different methods are used : Sighting, use of transit, timing waves and use of a dynamometer.**

In usual practice, only sighting and use of transit is followed.

In sighting for sag, it is better to select a span near the middle of the length pulled up. The length of wire pulled at one time may vary from a few hundred feet to a half-mile (around 800 m) or more.

Preferably, a span near the middle of the length pulled should, therefore, be selected in sighting for sag. If the section includes a number of curves, it is desirable to sag at more than one point.

**A simple and accurate method of measuring the sag is by the use of targets placed on the poles below the cross-arm.** The targets may be a light strip of wood like a lath nailed to the pole, at a distance below the conductor when resting on the insulator equal to the desired sag. The lineman sights from one lath to the next. The tension on the conductor is then reduced or increased until the lowest part of the conductor in the span coincides with the lineman's line of sight. Sagging T's can also be used in the same way as the targets, except that T's are hung on the line conductor.

In the case of an H-frame line, where the line conductors are on one or the other sides of the poles, a lineman stationed on one pole and looking at a corresponding pole span-length away, cannot include the lowest point of the conductor in his line of sight.

To get around this difficulty, a transit is securely fastened to the pole at distance equal to the desired sag, below the conductor support. Then the transit is leveled.

To observe the sag, the transit is sighted at the conductor at mid-span and then is swung around until it is in line with the pole a span length away. The conductor is drawn up farther if the sag is too large or relaxed if the sag is too small.

## ➤ **Releasing Pulling Blocks**

After the conductors are pulled up, provide a temporary dead end to hold the conductor until the next stretch of wire is pulled up and held.

A temporary dead end can be arranged by running a head guy from the top of the last pole 'a' to the butt of next pole 'b'.

A lineman then climbs pole 'a' and hitches a come-along to the cross-arm by means of a rope sling and then reaches out and slides the come-along along the wire as far as possible so that the grip will hold the wire when the pulling blocks are released. After dead-ending or snubbing is completed, the pulling blocks should be gradually released. Avoid releasing with a jerk, or an abnormal stress may be placed on the conductor and their supports, which might result in failure such as the snapping of a pin, cross-arm guy, or even a pole, in extreme cases.

### **Tying in**

Conductors should occupy such a position on the insulator as will produce minimum strain on the tie wire. The function of the tie wire is only to hold the conductor in place on the insulator, leaving the insulator and pin to take the strain of the conductor.

The common practice is to use wire ties throughout in the distribution system and almost entirely on the transmission lines, when pin insulators are employed. For suspension insulators, clamps are used. Different kinds of ties are in use.

The point is that it should be easy to apply and relatively simple to make, keeping in mind its function, that it should bind the line conductor securely to the insulator and, in addition, should reinforce the conductor on the both sides of the insulator.

However, the tie wire should be of the same kind of wire as the line wire. Never use a tie wire a second time.

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## **3.4 Procedure**

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- (i) After the poles have been erected and fixtures have been set on the poles, reel out and stretch the conductor along the line using any method described earlier, depending upon the availability of equipment. If a truck or carriage is available, then use the method of moving the reels with the conductor stationary. In our countryside, for small rural area lines, the practice adopted is to take conductors in bundles to the site of work after reeling them out manually in the stores and then to stretch them manually.

- (ii) Use tension stringing and hoist the line conductors on the cross-arm. Use snatch blocks instead of laying up directly on cross-arms.
- (iii) Perform pulling-up operation for line conductors using come-along or pulling grip, block and tackle or chain block as per availability. To produce the same tension in line conductors, use an equalizer.
- (iv) Perform the sagging operation, using sighting method in general and transit method, wherever an H-pole frame is used.
- (v) After sagging is done, release pulling blocks.
- (vi) Perform tying-in operation at every pole using tie wires nearly 3 ft. long.

### 3.5 Tabular Record of Observations

The following measurement should be recorded for all material used as per example below :

Sl. No.	Item	Quantity
1.	Poles	10 Nos.
2.	Aluminium conductor	3000 m.
3.	Cross-arms	10 Nos.

### 3.6 Precautions

- Avoid scratching of the conductor by its coming in touch with the ground as it may damage or injure the line conductors.
- Sagging should be done with equal tension in all the line conductors.
- The tie wire should be for the same material as the line wire.
- Release the pulling blocks slowly and not with a jerk as that will put abnormal stresses on the conductors and supports which may lead to failure, such as snapping of pins.
- The measurement record of the material used on the line must be completed.
- Conductors must not be allowed to lay up on steel cross-arm as there may be damage to the conductors.

**Self Test**

**Answer the following questions :**

Q.1 Write the importance of stringing and sagging?

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Q.2 Explain the methods for reeling out of the conductors.

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Q.3 Why damage on the surface of conductor is avoided?

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Q.4 What is the result of unequal tension in the line conductors?

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Q.5 Draw a diagram showing the sagging of conductors of any line.

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.....

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# PRACTICE OF JOINTING OVERHEAD LINE CONDUCTORS

## Structure

- 4.1 Objectives of Activity
- 4.2 Brief Theory
- 4.3 Equipment/Materials/Facilities Required
- 4.4 Procedure
- 4.5 Precautions
- 4.6 Self Test

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### 4.1 Objectives of Activity

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After performing this activity, you should be able to

- **get familiar with different types of line joints and practice of joining line conductors, and**
- **acquire knowledge regarding, which type of joint is to be used under which situation.**

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### 4.2 Brief Theory

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Joining conductors is a practical requirement. It may be required while laying a new power line, because the conductor length on a reel may be insufficient to span the total length of the line. Even for an existing line, a break in the conductor may have to be repaired by joining.

Line joints can be divided into three classes : splices, sleeve joints and compression joints. Splicing is suitable for small-sized copper conductors. But, larger sizes of hard drawn copper and aluminum conductors are usually joined by means of splicing sleeves or compression joints. There is another class of splicing, called Automatic Splice. This class is not included here.

In the field, the common practice is to use sleeve joints and compression joints to join overhead line conductors.

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### 4.3 Equipment/Facilities /Materials Required

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- Line conductors
- Splicing clamps (connectors)

- Cleaning material
- Pliers
- Sleeves twisters
- Compression die
- Sleeves
- Friction tape

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## **4.4 Procedure**

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### **➤ Making a Splice**

- (i) Scrape the two end sections of the conductors to be spliced and clean with cleanser. The conductors should be cleaned until bright. Remove all rough or high spots.
- (ii) Place the cleaned conductors together until approximately 20 to 30 cm (for smaller sizes)/30 to 40 cm (for larger sizes) of the ends overlap each other.
- (iii) Place splicing clamps (known as connectors) on the two conductors about 10 cm from the end of the conductor. See that the connectors grip both the conductor firmly. The conductors should not be allowed to slip or turn in the connectors, otherwise a 'burned' conductor will result and one of the conductors will eventually break at that point.
- (iv) Twist conductors from both ends i.e. wrap each conductor about the other conductor. The usual number of turns to be made is four. More turns may burn the conductor while less may give away and the conductors will crawl apart.
- (v) Shift both connectors on to the twisted portion of the conductors. The shift required will be equal to the width of the connector.
- (vi) With a pair of pliers, finish the splice by serving up the ends. Finishing is done by wrapping the loose ends of the wire about the conductors. Three or four turns are the usual number. These turns are known as 'buttons'.
- (vii) After the buttons are on, the ends should be cut close to the splice.
- (viii) Solder the Splice.
- (ix) Wrap the open section with four layers of friction tape and paint with compound if covered wires are used.

## ➤ **Marking a Sleeve Joint**

Medium-size line conductors are best joined by a splicing sleeve, which is a special connection to ensure good electrical and mechanical joints. The sleeve itself is a piece of single or double tubing. To make a sleeve joint, the procedure is as follows :

- (i) Scrape both end sections of the wires clean and bright.
- (ii) Run wires through sleeves, allowing the ends to protrude, i.e. the ends of the wires should project about 10-5 cm beyond the ends of the sleeve.
- (iii) Bend these wires with pliers. This bending keeps them from slipping out of the sleeve.
- (iv) Make three and a half turns with sleeve twisters, one on either end. Twist lightly.
- (v) Cut off the excess conductor beyond the joint on either side and the joint is completed.
- (vi) Sleeves should be made of the same kind of material as the line conductor.

## ➤ **Making a Compression Joint**

Compression joint also makes use of a sleeve. Instead of twisting the sleeve, however, the sleeve is compressed with great force onto the conductor. The use of a die in compression makes the sleeve grip the conductors firmly.

**The orders of steps for making a compression joint are as below :**

- (i) Clean conductor end sections thoroughly. All dirt and grease should be removed with gasoline or similar cleaning solvent. When a conductor that has been in series, is being spliced, special care should be taken to remove oxidation on that portion which is inserted in the sleeve.
- (ii) Match the size of splicing sleeve to the size of the conductor.
- (iii) The die number must be matched to the sleeve number.
- (iv) The conductor ends must be properly centered in the sleeve.

- (v) The specified number of indents must be made.
- (vi) The joint is ready.

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## **4.5 Precautions**

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- The ends of the wires must be cleaned until they are bright. Any rough or high spots must be removed.
- Connectors should grip the ends of the conductors properly.
- Only the require number of turns should be used in twisting.
- Shift of connectors should be equal to the width of the connector.
- Finishing should be done carefully using pliers.



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**Self Test**

**Answer the following questions :**

Q.1 Describe the process of joining line conductors.

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Q.2 Describe the specific safety precautions taken during jointing overhead line conductors.

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Q.3 Discuss the common practices used for joining overhead line conductors.

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Q.4 Write various steps for making a compression joint.

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Q.5 Excessive twisting of the conductors is not good, why?

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## PRACTICE OF INSTALLATION OF OVERHEAD SERVICE LINE

### Structure

- 5.1 Objectives of Activity
- 5.2 Equipment/Materials/Facilities Required
- 5.3 Brief Theory
- 5.4 Procedure
- 5.5 Log Book
- 5.6 Self Test

### 5.1 Objectives of Activity

 After performing this activity, you should be able to

- **install the over head service line for a single storey building.**

### 5.2 Equipment/Facilities/Material Required

#### ➤ **Equipment/Tools**

Lineman's Tool Kit, Lineman's Personal Protective Equipments.

#### ➤ **Facilities**

LT Overhead line, Single storey structure where service line is required to be installed.

#### ➤ **Material Required**

Sl. No.	Material	Quantity	Remarks
1.	GI Wire	Length from pole to house + 10% extra	
2.	I Thimble	1 No.	
3.	Pole Clamp	1 No.	
4.	Pipe Clamp	2 Nos.	
5.	50 mm G I Pipe	3 m	
6.	Ring Insulators	4 Nos. per meter	
7.	Stay Wire 7/10	3 m	
8.	Stay bows	2 Nos.	
9.	Stay rod with bolts	1 No.	

10.	Stay Insulator	1 No.	
11.	IC 30 cm x 25 cm main board	1 No.	
12.	I C Kit Kat 10 Amps	1 No.	
13.	Neutral link	1 No.	
14.	Single core weather proof wire	Length x 2 plus 10% extra length up to main board	
15.	Cement and River Sand	Lot	
16.	GI Wire No.14	½ kg	
17.	Shackle Insulators	4 Nos. (250 V)	

### 5.3 Brief Theory

In case the consumer's premise is less than 45 metres away from the nearest distribution line, the service connection may be provided by means of overhead weather proof or PVC cable.

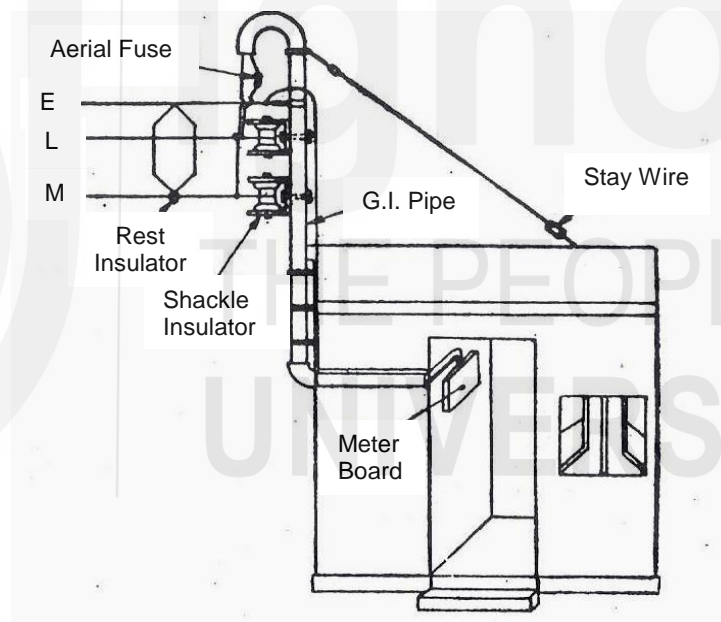


Figure 5.1 : Overhead Service Line for Single Storey Building

### 5.4 Procedure

- (i) Tie the ring insulator with GI Wire No 14.
- (ii) Fix the pole clamp on pole with the Shackle insulators and I-hook.
- (iii) Fix the G.I. pipe of 50 mm size with bend on the house wall near the main board.
- (iv) Fix the stay wire.

- (v) Fix the pipe clamp with I-hook and shackle insulators as shown in Figure 5.1.
- (vi) Insert the wires (G.I. + weather proof) in the ring insulators. The ring insulators must be equally spaced along the length of the GI wire.
- (vii) Tie the G.I. wire with I-hooks at the pole and pipe.
- (viii) Take tapping from the weather-proof wires for main board.
- (ix) Insert the tapped wire in the G. I. pipe.
- (x) Make connections on the main board by fixing neutral link, fuse Kit Kat.
- (xi) Fix the energy meter and give connection.
- (xii) Give connection at the pole to the main overhead line subject to safety precautions, in case of live main line.

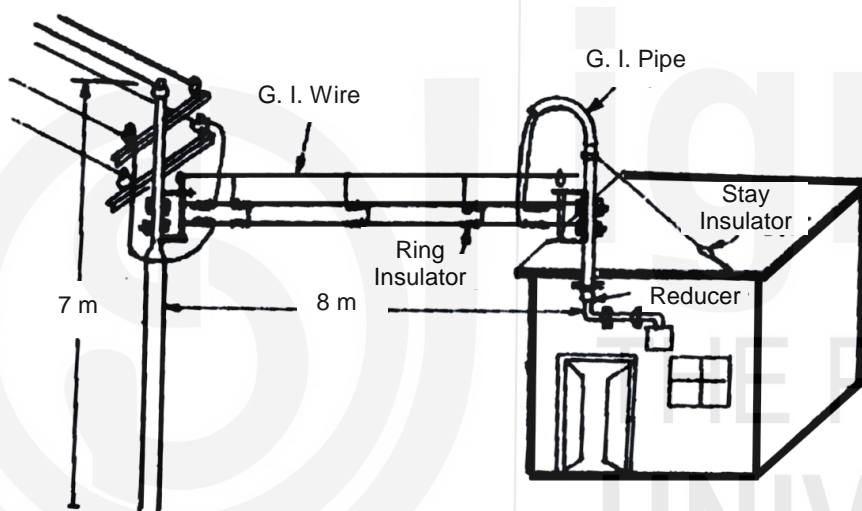


Figure 5.2 : Overhead Service Line for Single Storey Building

## 5.5 Log-book Record

The trainer should ask the trainees to connect an Overhead service line for a low rise building and tell them to prepare a report. The trainees should record the actions taken and the equipment/parts used. The record should be in the form of a work-log, or an action-taken report. The length of the service line and the voltages at either end should also be recorded.

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**Self Test**

**Answer the following questions :**

Q.1 Write the procedure to install overhead service line for single storey building.

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Q.2 Name the material which is used for stay wire and why stay wire is needed?

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Q.3 What are the main functions of rest insulator, aerial fuse, ring insulator and stay insulator.

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Q.4 Identify the various equipment used for protection of line personnel performing a live line operation.

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# PRACTICE OF IDENTIFICATION OF CABLE JOINTING KITS AND TERMINATIONS

## Structure

- 6.1 Objectives of Activity
- 6.2 Equipment/Materials/Facilities Required
- 6.3 Theory
- 6.4 Procedure
- 6.5 Safety Instructions
- 6.6 Self Test

---

### 6.1 Objectives of Activity

---



After performing this activity, you should be able to

- **make the technicians familiar with the different type of cable jointing kits and terminations and make them familiar with the jointing process.**
- **explain the safety measures to be taken.**

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### 6.2 Equipment/Materials/Facilities Required

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- Cable
- Cable Jointing Kit
- Cable Lugs
- Jointing Sleeves
- Single Compression Brass Glands
- Impregnated Paper Tapes
- Tropoline Casting Resin System
- Tropoline Resin Based Sealing Putty
- Non-Magnetic Trefoil Clamps Type
- Composite Tool Box
- Compression Jointing Tools
- Scrapper Tool

## 6.3 Theory

A power cable is an assembly of two or more electrical conductors, usually held together with an overall sheath. The assembly is used for transmission of electrical power. Power cables may be installed as permanent wiring within buildings, buried in the ground, run overhead, or exposed. Flexible power cables are used for portable and mobile tools and machinery.

Power cables of adequate current carrying capacity and voltage rating are provided at the substation. Power cables are used for 33 kV, 11 kV or LT system, to carry load current.

### ➤ Advantage of using Cables

**As compared to overhead lines, cables have the following advantages :**

- The cable transmission is not subjected to supply interruption caused by lightning or thunderstorms, birds and severe weather conditions.
- It reduces accident caused by the breaking of the conductors.

### ➤ Types of Cable :

- XLPE (Cross Linked Polyethylene Insulated Power Cable)
- PILC (Paper Insulated Lead Covered)
- PVC (Polyvinyl-chloride Cable)
- Oil-filled Cables

### • XLPE (Cross Linked Polyethylene Insulated Power Cable)

Because of Excellent Thermal, Mechanical and Electrical Properties XLPE Cables are being used extensively throughout the world in all Power Stations, Industrial Plants, Chemical, Fertilizer and Heavy duty Industries.



### Advantages of XLPE Insulation

- Higher current carrying capacity.
  - Higher emergency and short circuit rating.
  - XLPE is not prone to fatigue damage due to vibration or heating cycles.
  - XLPE are light in weight thus easy in handling during manufacturing and Installation.
  - Lower Dielectric losses.
  - Better resistance to most chemicals, such as ordinary acid, bases, oils.
  - Jointing and termination are very easy.
  - Better flexibility down up to  $-40^{\circ}\text{C}$ .
- **PILC (Paper Insulated Lead Covered)**

The paper insulation in power cable has been almost superseded. It is quite cheap and has low capacitance and high dielectric strength. It's hygroscopic and its specific resistance is of the order of 109 Ohm per cm. cube, but its use depends upon its dryness; even a small amount of moisture lowers its insulation resistance. So before use, the paper insulation in it is impregnated in insulating oil. The maximum safe temperature of paper insulated cable is  $950^{\circ}\text{C}$  approx. The paper insulated cable should never be left unsealed. In case of need, its end should temporarily be covered with wax or tar.



Figure 6.2 : PILC (Paper Insulated Lead-Covered)

- **PVC (Polyvinyl-Chloride)**

It is a thermoplastic synthetic resin and is being widely used as insulation. It has high electric resistivity, good dielectric strength and mechanical toughness over a wide range of temperature. Moisture, acids and alkalis do not affect PVC.

PVC insulated cables are usually employed for medium and low voltage applications. A major use is for Domestic industrial lights and power installations.

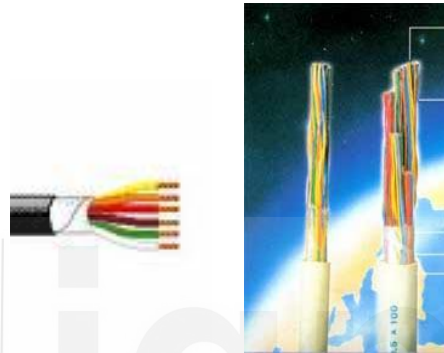


Figure 6.3 : PVC Insulated Cables

- **Oil Filled Cables**

In such cables the conductor are stranded around a hollow cylindrical spiral of plain narrow metal strip.

**The oil filled cables are of three types :**

- (i) Single core with an oil channel within conductor
- (ii) Single core with sheath channel
- (iii) Three core filler space channel.

<b>Advantages of the Oil Filled Cables</b>
<ul style="list-style-type: none"><li>• The requirement on thickness of the dielectric decreases, which reduces the overall size and weight of the cable.</li><li>• The thermal resistance of the cable decreases due to decrease in dielectric thickness, which increases the current rating of the cable.</li><li>• Perfect impregnation can be used.</li><li>• Cables can be impregnated after sheathing</li></ul>

## ➤ Jointing Kits

Types of Kits	Cable Type
Heat Shrinkable	XLPE and PILC
Push on Type	XLPE
Resin Cast Type	PILC
Tapex Type	XLPE

## ➤ The Cable Constructional Details (as Per Lable)

- **Conductor** : Aluminum or Copper.
- **Screen** : Screened or Unscreened (for upto 3.3 KV).
- **Inner sheath** : Taped or Extruded, Normal or FR/FRLS PVC.
- **Armour** : Armoured or Unarmoured. If armoured then flat strips or round wires.
- **Outer sheath** : Normal ST-PVC or FR/FRLS FVC. Any specific drum length with tolerance.
- **Drum size** : Any limitation on dimension/weight of drum.
- Any other special constructions.

## ➤ Joining Cables

In case of a cable breakage or in the event of a localized cable fault, the two sections of the cable have to be joined, to restore continuity.

### Type of Jointing Method

Type of Jointing Method	Name of Power Cables
Heat Shrinkable Straight through Joint	11 KV, PILC
Heat Shrinkable Straight Through Joint	11 KV, XLPE Aluminum Cable
Heat Shrinkable Straight through	XLPE/PVC Size of Cable
Heat Shrinkable	Outdoor XLPE
Heat Shrinkable Transition Joint	11 KV Aluminum Cable
Heat Shrinkable Outdoors	PILC Voltage 11 kV (Ue)
Heat Shrinkable	Indoor XLPE

## Material Requirement

- H.S Outer Jacketing Sleeve
  - Main Sleeve
  - Side Sleeve
- G.I. Wire Mesh
- H.S. Insulating Sleeve
- Earthing Material
- H.S. Adhesive Lined Breakout
- H.S. Oil Barrier Sleeve
- Glass Bedding Tape
- H.S. Stress Control Tubing
- H.S. Belting Oil barrier Sleeve
- Insulating Mastic
- Stress Control Mastic for Ferrule Region
- Crimping Type Inline Connector
- Mastic Sealing Tape
- Cable/Core Tie Wraps
- Mopping Cloth For Cleaning
- Core Cleaning Solvent
- Emery Sheet

### ➤ Types of Terminations

A joint is considered to be the weakest link in the system but the overall reliability of a distribution system depends on it. Therefore, jointing accessories and techniques have an important and critical role; despite their comparative low value in the overall investment.

- Cast Iron Mould
- Epoxy Resin Type
- Heat Shrinkable
- Cold Shrinkable
- 'Push On' Type

## 6.4 Procedure

### ➤ Detection of Fault

#### Cable Faults

The fault that is most likely to occur is :

- A breakdown of the cable insulation, which allows current to flow from the core to the earth, or to the cable sheath, is called a **ground fault**.
- A **cross or short circuit fault**, in which case the insulation between two cables or between two cores of a multi core cable, is faulty.
- An **open circuit fault** where the conductor breaks or a joint pulls out. The method for locating an open circuit fault differs from those used in other two cases.

In the case of multi-core cables, the insulation resistance of each core to ground, and between cores should be measured. If the fault is to ground, this will enable the faulty core to be identified; and in case of a short circuit, the cores, which are involved can be determined.

The fault may be of the type :

- Phase to ground fault
- Phase to phase fault.

### ➤ Cable Jointing

A joint is a connection between two lengths of cable, in which the continuity of the conductor, the insulation and the protective covering is maintained.

or

The making of a cable joint is to rebuilt the continuity of the conductor and insulation system.

#### Assembly of the Joint

Degrease paper inner sheath next to the lead sheath and then wrap glass bedding tape for a distance of 10 mm.

Put the Heat shrinkable belting oil barrier on the glass bedding tape already applied and shrink with help of blow lamp/torch.

Avoid extra heating.

Put the Heat shrinkable stress control tube into position ensuring that 15 mm of the sleeve comes on the lead sheath and balance on belting oil barrier sleeve. Shrink with the help of blowlamp/torch.

Slide the heat shrinkable oil barrier sleeve from the end of the cores and places them at position ensuring that they go down into the crutch of the cable as much as possible. Carefully shrink down barrier sleeve from bottom to top ensuring that heat is uniformly applied around each tube. Allow to cool down.

Slide the breakout over the cores and pull well down into the Crutch of the Cables. Hold down out with a plier to avoid upward slippage. Commence shrinking the boot at the centre working along them to the top and shrink completely.

Insert the heat shrinkable insulating tubing's (say Q.1 and Q.2) from the each end of the core and slides up to where the jointing works will not be disturbed.

### **Connection Conductor**

Insert the cable conductor into the ferrule after cleaning and polishing the conductor.

After ensuring that two conductors meet end to end at the centre of ferrule, compress the ferrule with compression die.

Compress in order from the centre of the ferrule to both ends of the ferrule.

During the process of crimping, take care not to damage the insulation.

Smoothen the surface of inline connector (ferrule) with the help of smooth file or a sand paper.

Clean the surface of Insulation and ferrule with the help of clean cloth soaked with cleaning fluid supplied with the kit.

Apply stress control tape on conductor sleeves and on bare conductor on both sides of conductor sleeves.

Bring Insulation tube Q1 in position so that it equally covers the core on both sides of the cable and shrink it with the help of torch/blow lamp. Avoid extra heating.

Put the insulating tube Q 2 on the Insulating tube Q 1 and shrink it with the help of blow lamp/torch.

Fix the main earthing connection with the help of copper braided strip from lead to lead. Use plumbing metal for sealing gap between the steel strip armour and lead sheath.

The continuity between armour and lead sheath shall also be achieved.

Relay the core as far as possible. Wrap two layers of G.I. mesh around the cores with a 50% overlap. Cover the joint area upto exposed armour. Bind the end of G.I. mesh with the help of cotton tape and PVC tape provided in the kit. Fold back the excess earth braid/s over the applied G.I. mesh and tighten it with armour clamp on both sides. Cover armour clamps and all sharp edges with the help of cotton tape or PVC tape.

Wrap mastic-sealing tape over the worm drive clamp. Slide the heat shrinkable adhesive lined side sleeve on one side of the G.I. wire mesh ensuring that about 200 mm of G.I. wire mesh is covered under this and shrink completely. Slide the second sleeve to the other side of the G.I. wire mesh and position it at the prescribed position and shrunk completely.

### ➤ **Cable Ends are Terminated by Providing**

- Stress control screens
- Earthing clamp lead
- Insulation
- Lug rain sheds

#### **Remember**

While making joints and terminations, it is essential to know the size and type of the cable in order to select appropriate kits for joints and terminations. The kits contain the accessories required along with instruction sheets for step-by-step procedure for making joints and terminations. The cable and end terminations should be prepared as per the dimensional drawing and procedure given in the instruction sheet.

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## **6.5 Safety Instructions**

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- To avoid accidents due to use, or fatal injuries-necessary instruction given in the manual of the kit are to be followed.
- To avoid risk of accidental fire or explosion when using gas torches, always check all connection for leaks before igniting the torch, and follow manufacturer's safety instructions.
- To minimize any effect of fumes produced during installations, always provide for good ventilation of the confined workspace.

**Self Test**

**Answer the following questions :**

Q.1 In which conditions cables are used for transmission of electrical power? Compare the advantages of using cables over overhead lines.

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Q.2 Write short note on various types of cable with their advantages.

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Q.3 Describe construction details of a cable.

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Q.4 During the crimping process, what care should be taken?

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Q.5 Discuss various types of jointing kits and terminations. Write the importance of cable ends terminations.

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# PRACTICE OF MEASURING THE EARTH RESISTANCE

## Structure

- 7.1 Objectives of Activity
- 7.2 Equipment/Materials/Facilities Required
- 7.3 Theory
- 7.4 Procedure
- 7.5 Conclusion
- 7.6 Treatment for Minimizing the Earth Resistance Values
- 7.7 Self Test

---

### 7.1 Objectives of Activity

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After performing this activity, you should be able to

- **explain the method of measuring earth resistance of an earthing installation and its importance of being low.**

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### 7.2 Equipment/Facilities/Materials Required

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- Earth tester – 1
- Earthing installation under test – 1
- Spike – 2
- Connecting wires of negligible resistance.

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### 7.3 Brief Theory

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We already know that the value of short circuit current depends upon the magnitude of earth fault loop resistance. In order that fuse should afford sufficient protection, it is necessary that it should blow off quickly.

This is just possible only when the magnitude of fault current is sufficiently high. In other words, for a given system voltage, it is important to keep the magnitude of earth fault loop resistance of earth at consumer and earth resistance at the substation or generating station as small as possible.

High earth resistance would also show up as higher voltage in the rest of the circuit, posing danger to humans and equipment. Proper maintenance

of electrical installation, therefore, requires periodic measurement of earth resistance.

### ➤ Methods of Earth Resistance Measurement

#### Three Terminal

In this method we use an Earth Tester (Figure 7.1), which has four terminals, P1, P2, C1 and C2. The tester has a built-in generator, operated by a rotating handle, and a meter to read the resistance value.

To conduct this test, the earth tester terminals C1 and P1 are shorted to each other and connected to the earth electrode (pipe) under test. Terminals P2 and C2 are connected to the two separate spikes driven in earth. These two spikes are kept in same line at the distance of 25 meters and 50 meters due to which there will not be mutual interference in the field of individual spikes. If we rotate generator handle with specific speed we get directly earth resistance on scale.

**Note :** Spike length in the earth should not be more than 1/20th distance between two spikes.

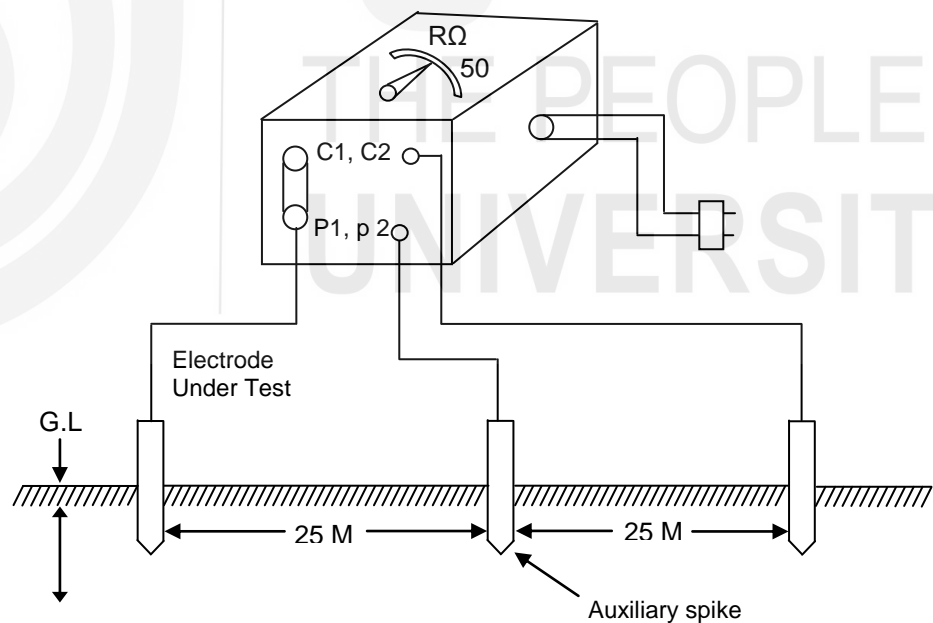


Figure 7.1 : Earth Tester for Measuring Earth Resistance

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## 7.4 Procedure

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Measurement of earth resistance is usually carried out by earth tester as shown in Figure 7.1. Earth tester has D.C. generator and Ohm meter current and voltage coils just similar to those in a Megger.

However, to avoid the effects of back e.m.f. due to polarization, as soil resistance is electrolytic in nature, A.C. is used in the test. For this purpose current reverser is used which is mounted on the armature extension of the D.C. generator. A.C. output taken from the reverser brushes 3 and 4 is brought to current terminals  $C_1$  and  $C_2$  of the earth tester – terminal  $C_1$  connected to earth electrode EE whose earth resistance is to be found out.  $C_2$  is connected to an auxiliary earth electrode  $AE_2$  spiked in earth at a distance of about 25 m. from EE.

When the Generator is driven, A.C. will flow from electrode EE to the good earth, which has zero resistance and then will reach auxiliary electrode.

Corresponding to A.C. flowing between brushes 3 and 4, D.C. will flow through brushes 1 and 2 and current coil of the tester. As a result of voltage drop taking place in the earth around the electrode, there are formed equipotential shells around the main electrode EE and auxiliary electrode  $AE_2$ . The circular surface area on the ground bound by the last equipotential shell which touches the good earth is called resistance area, Figure 7.1.

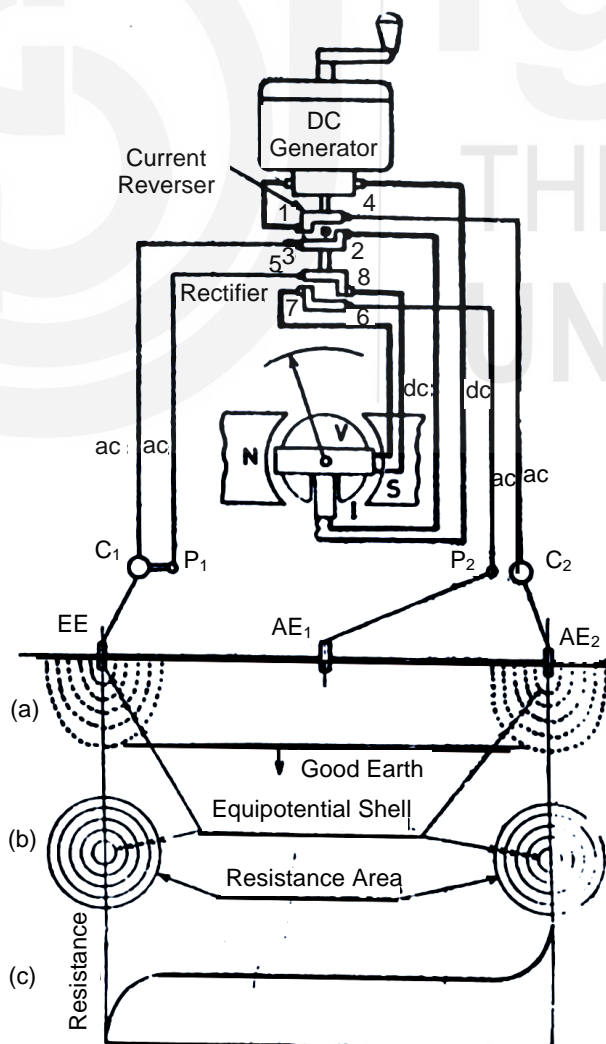


Figure 7.2

Outside the resistance area no voltage drop takes place. Electrodes EE and AE<sub>2</sub> are taken so much apart that their resistance areas do not overlap. If another auxiliary electrode AE<sub>1</sub> is spiked in earth in between the electrodes EE and AE<sub>2</sub> then there should be no voltage drop between AE<sub>1</sub> and AE<sub>2</sub>. This A.C. voltage is picked up at terminals p<sub>1</sub> and p<sub>2</sub>, which is then rectified. D.C. output of rectifier at brushes 7 and 8 is applied to voltage coil. If we move AE<sub>1</sub> a few meters on a perpendicular line on either side of the line joining EE and AE<sub>2</sub>, then the readings of resistances so obtained should be same. This will be clear from Figure 7.2, which shows how resistance varies between two electrode EE and AE<sub>2</sub>.

If the three readings taken after moving AE<sub>1</sub> are not the same, it means that the resistance areas of EE and AE<sub>2</sub> overlap and we must take AE<sub>2</sub> further away.

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## 7.5 Conclusion

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If the earth resistance is near about unity, it is normal. Too high value is dangerous as it means low value of short circuit current, which may not allow the fuse to operate.

Standard Earth Resistance Value	
Major power station	0.5 Ω
Major sub-stations	0 Ω
Minor sub-station	2.0 Ω
Neutral Bushing	2.0 Ω
Service connection	4.0 Ω
L.T. Lightning Arrestor	4.0 Ω
L.T. Pole	5.0 Ω
H.T. Pole	10.0 Ω
Tower	20-30 Ω

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## 7.6 Treatment for Minimizing the Earth Resistance Values

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If earth resistance is more than the allowed values, following Treatment can be used for minimizing resistance:

- Oxidation on joints should be removed and joints be tightened.

- Sufficient water should be poured in and around the earth electrode.
- Earth Electrode of bigger size, as far as possible, should be used.
- Electrodes should be connected in parallel.
- Deeper and wider Earth Pit can be made.
- Soil Treatment may be carried out around the Earth Electrode.

**Self Test**

**Answer the following questions :**

Q.1 Why power station has very low value of earth resistance as compared to the service connection of the house?

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Q.2 Write the treatment for minimizing the earth resistance values.

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Q.3 What is the importance of measurement of earth resistance?

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Q.4 Describe the method of earth resistance measurement.

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# PRACTICE OF INSPECTION AND ROUTINE MAINTENANCE ACTIVITY OF A TRANSFORMER

## Structure

- 8.1 Objectives of Activity
- 8.2 Equipment/Materials/Facilities Required
- 8.3 Brief Theory
- 8.4 Procedure
- 8.5 Self Test

---

### 8.1 Objectives of Activity

---



After performing this activity, you should be able to

- **make the technicians familiar with the method of inspection and routine maintenance activity of a transformer up to 1000 kVA.**

---

### 8.2 Equipment /Materials/Facilities Required

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- A Transformer (for inspection) up to or below 1000 kVA.
- Clamp/Clip-on meter.
- Transformer Oil Testing Set.
- Standard Tool Kit.

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### 8.3 Brief Theory

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With proper operation and maintenance, the expected life of a transformer is 15 to 20 years, without need of any major repair work. As compared to most other electrical equipment, transformer requires relatively less maintenance. However in order to obtain a long and trouble free service, it must be properly maintained.

**The maintenance work can be divided into three categories :**

- Routine Inspection or Routine Preventive Maintenance and Minor Repairs.
- Medium Repairs.
- Major Repairs.

The objective of maintenance of transformer is to obtain trouble free long life and ensure high reliability of supply.

➤ **Routine Preventive Maintenance and Minor Repairs**

This includes preventive maintenance work, which does not call for opening the transformer cover.

- **It includes visual inspection** : Checking of filaments, checking of the level of oil, cooling system fastening, control circuit, oil level leakage, etc.
- The insulation resistance values are measured.
- The BDV (Break Down Voltage) of oil sample is measured.
- The gas sample obtained from Buchholtz relay is analysed.
- The nut bolts are tightened, the porcelain surfaces are cleaned.
- Silica gel (de-humidifier) in the breather is replaced.
- The external fitments are repaired whenever necessary.
- The oil level is brought to desired value.
- The oil is filtered.
- Minor repair work is carried out by the operating personnel in the substations.

➤ **Medium Repair Work**

This includes dismantling the transformer for inspection/repairs if the core-coil assembly is to be accessible.

The sub-assemblies are inspected and repaired as necessary (e.g. repair conservator tank, tap-changer, cooling system, sealing gaskets, etc.).

The gaskets are replaced, if necessary.

The defects revealed in routine maintenance are removed during the minor repair work.

The other minor repairs and maintenance mentioned earlier is also carried out.

## ➤ Major Repair Work

Major repair work is carried out after a serious internal fault or after prolonged service-life (8 to 10 years).

This involves opening-up of the transformer, replacement of windings and insulation, tightening of the core laminations, replacement of bushings, etc. Such repair work requires complete dismantling of the transformer.

Major repair work is carried out by trained personnel, in a planned manner preferably in a well-equipped repair-workshop, perhaps the vendor's factory.

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## Procedure

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Typically, the supplier specifies the transformer maintenance schedule and the procedure. The following is a general guideline.

### ➤ Typical Maintenance Schedule for Transformers up to 1000 kVA

Frequency of Inspection	Inspection	Inspection Details	Action Required if Conditions are Unsatisfactory
1. Hourly*	Load (amperes) Temperatures, Voltage	Check against rated figures	Start fans if necessary
2. Daily	Dehydrating breather	Check that air passages are clear. Check the colour of the active agent	If silica gel is pink, change; may be reactivated for use again
3. Monthly	Oil level in transformer	Check transformer oil level	If low, top up with dry oil. Examine transformer for leaks.
4. Quarterly	Bushings	Examine for cracks and dirt deposits	Clean or replace
5. Half-yearly	No conservator	Check for moisture cover	Improve ventilation, check oil
6. Yearly	Oil in transformer	Check for dielectric strength and water content.	Take suitable action to restore quality of oil

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”	Earth resistance	Check for acidity and sludge.	Take suitable action if earth resistance is high
“	Relays, alarms, their circuits etc.	Examine relay and alarm contacts, their operation, fuses etc. check relay accuracy etc.	Clean the components and replace contacts and fuses if necessary. Change the setting if necessary.
7. Two Yearly	Non-conservator transformer	Internal inspection above core.	Filter oil regardless of condition
8. Five Yearly or after internal fault	–	Overall inspection, lifting of core and coils.	Wash by hosing down with clean dry oil.

**It may be considered :**

From 1 to 6 as minor repairs

7 as medium repair

8 as major repairs

A rigid system of preventive maintenance will ensure long life.

Log books and history – records should be maintained for each transformer.

No work should be done on the transformer unless it is disconnected from supply, and the terminals, tank and the cover are solidly earthed.

➤ **Typical Maintenance Schedule for Transformers above 1000 kVA (For Information)**

Sl. No.	Frequency of Inspection	Inspection	Inspection Details	Action Required if Conditions are Unsatisfactory
1.	Hourly	Ambient temperature	Check that temperature is reasonable	If abnormal heating, shut down the transformer and investigate if heating is persistently higher than normal
	“	Winding temperature		
	“	Oil Temperature Load (amperes) Voltage	Check against rated figures	

2.	<p>Daily</p> <p>“</p> <p>“</p> <p>“</p> <p>“</p> <p>Quarterly</p>	<p>Oil level in transformer</p> <p>Oil level in bushing</p> <p>Leakage of water into cooler</p> <p>Relief diaphragm</p> <p>Silica-gel breather</p> <p>Bushing</p>	<p>Check against transformer oil level</p> <p>Check that air passages are free. Check colour of active agent</p>	<p>If low, top up with dry oil, examine transformer for leaks</p> <p>Replace if cracked or broken</p> <p>If silica-gel is pink change by spare charge. The old charge may be reactivated for use again</p> <p>Clean or replace</p>
3.	<p>“</p> <p>“</p>	<p>Oil in transformer</p> <p>Cooler fan bearings, motors and operating mechanisms</p>	<p>Examine for cracks and direct deposits</p> <p>Check for dielectric strength and water content</p> <p>Lubricate bearings. Check gearbox. Examine contacts check manual control and interlocks</p>	<p>Take suitable action to restore quality of oil</p> <p>Replace burnt or worn contacts or other parts</p>
4.	Half yearly	Oil cooler	Test for pressure	
5.	<p>Yearly or earlier if the transformer can conveniently be taken out for checking</p> <p>“</p> <p>“</p> <p>“</p> <p>“</p>	<p>Oil transformer</p> <p>Oil filled bushings</p> <p>Gasket joints</p> <p>Cable boxes</p> <p>Surge diverter and gaps</p>	<p>Check for acidity and sludge.</p> <p>Test oil</p> <p>Examine compounds for leaks</p> <p>Check for sealing arrangements for filling holes</p> <p>Examine for crack and dirt deposits</p>	<p>Filter or replace</p> <p>Filter or replace</p> <p>Replace gaskets, if leaking</p> <p>Tighten the bolts evenly to avoid uneven pressure</p> <p>Clean or replace</p>

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6.	5 yearly	Relays, alarms, their circuits, etc.  Earth Resistance  1000 to 3000 kVA	Examine relay and alarm contacts, their operation, fuses, etc. Check relay accuracy, etc.  Overall inspection including lifting of core and coils.	Clean the components and replace contacts and fuses, if necessary. Change the setting if necessary  Take suitable action; if earth resistance is high.  Wash by housing down with clean dry coil.
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**Self Test**

**Answer the following questions :**

Q.1 Write the importance of maintenance of transformer.

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Q.2 Give short notes on minor, medium and major repairs for a transformer.

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Q.3 Give various inspection details and the action required if conditions are not satisfactory during routine maintenance for transformers upto 1000 kVA? Consider frequency of inspection : daily, quarterly and yearly.

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# PRACTICE OF TROUBLE SHOOTING AND MAINTENANCE ACTIVITY OF SWITCH GEARS

## Structure

- 9.1 Objectives of Activity
- 9.2 Equipment/Materials/Facilities Required
- 9.3 Theory
- 9.4 Procedure
- 9.5 Log Book Record
- 9.6 Self Test

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### 9.1 Objectives of Activity

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After performing this activity, you should be able to

- **make the technicians familiar with the method of inspection and routine maintenance activity of switch gears.**

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### 9.2 Equipment/Materials/Facilities Required

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- LT/HT Switchgear
- Clamp-on Meter
- Multi Meter
- Standard Tool Kit
- HT Neon Testor (For HT)
- Discharge Rod
- Earthing Rod.

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### 9.3 Theory

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Switchgears are mechanical devices designed to close or open the contact members in an electrical circuit under normal or abnormal conditions.

**The selection of switchgears depends upon the following points :**

- Working voltage.
- Loading current.

- Fault current level.
- Atmospheric conditions.
- Types of operation, i.e. manually operated, remote controlled, pneumatically controlled, etc.

### Types of Switchgears

Two main types of switchgears are :

- **L. T. switchgears**, which can further be divided into two types.
  - Air circuit breaker and
  - Oil circuit breaker
- **H. T. switchgears.**

#### ➤ L. T. Switchgears

These consist of earth fault protection and over load protection and no relay is connected in the circuit.

The maximum capacity of L. T. switchgears is 1600 amps. Capacity of these switchgears is selected according to the load requirements. The capacity of incoming and outgoing cable in the panel board is also selected according to the capacity of switchgears installed on the panel board.

Sometimes couplers are also used in the panel boards with bus-bars to connect the supply alternatively according to the load demand and to increase the life of the switchgear.

If the contacts are placed in oil, the switchgear is known as **oil circuit breaker**, otherwise it is known as **air circuit breaker**.

#### **Air Circuit Breakers**

Such circuit breaker consists of two fixed contacts mounted one above the other in a vertical plane. When the breaker is closed, these contacts are stuck together under heavy pressure by a sticking member operated by a system of linkages.

Parallel arcing contacts are made of carbon alloy or copper-tungsten alloy to save the contact points from getting damaged due to repeated arcing. The arcing and auxiliary contacts close before and open after the main contacts come in operation.

A **latch** is used to hold in position the breaker, which may be operated electrically or mechanically. Such type of breaker is mostly used on d.c. circuits and low voltage a.c. circuits, upto 600 V, for the protection of the general lighting, power and motor circuits.

### Oil Circuit Breaker

In such circuit breakers, the current carrying contacts are immersed in transformer oil. The oil help in quenching the arc faster and also works as a cooling medium.

When the current is passed through the contact of the circuit breaker is interrupted by opening the contacts, the current continues as an arc, which is maintained due to the ionization of the molecules between the contacts.

The energy produced by the arc between the contact points is absorbed by the oil and the arc space is kept cool. When the current is zero, the pressure of hot oil above the contacts forces the cool oil into the contacts space which works as an insulating agent between the contact space and avoids the re-striking of the arc.

### ➤ H. T. Switch Gears

These switchgears consist of :

- **Protection Devices** – Relays (one numbers earth fault relay and two numbers over current relays fed by a battery circuit of 24 V, or a rectifier)
- **Operating mechanism**
- **Circuit breakers**
- **Instrument** – Current Transformer (CT) and Potential Transformer (PT).

### Protection Devices

**Earth Fault Protection** : When any one of the phases is earthed, the current in the different phases is unbalanced. In a normal system in which the neutral is earthed, the current equal to vector sum of currents in the three different phases will flow through the neutral conductor. In a balanced circuit, this current is zero. In the case of earth fault, the relay connected to the neutral will be energized due to the net current and will close the trip circuit.

The earth protection can also be obtained by inserting three current transformers in the three different phases by connecting their secondary's across the relay operating coil to energise it. When the earth fault occurs, unbalancing of currents is produced in the phases, which energise the relay operating coil due to their vector sum thereby closing the trip circuit.

**Over Current Protection :** In this system, three star connected current transformers are installed in the three phases (one in each phase) and three star connected relays are connected in series with secondary's of these. When excess current flows through any of the phases or through all phases, the relay is operated, closing the tripping coil circuit. The tripping coil after getting energized trip the circuit breaker.

### Operating Mechanism

The H. T. switchgears consist of closing, tripping and interlocking mechanism of circuit breakers, usually connected to a common bus bar. The isolators are provided on both sides of the circuit breakers to disconnect them or to make them dead from live parts to keep them ready for repairs and maintenance without any danger. The electrical or mechanical interlocking helps the circuit breaker to open before opening the isolators and isolators are opened before opening or removal of any cover or barrier.

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## 9.4 Procedure

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### Maintenance of Air Circuit Breakers

Sl. No	Parts to be Inspected	Maintenance Action	Time Period
1.	Main Contacts and moving contacts	Using a fine file, file the pitted contacts, clean the surface with petrol or recommended chemical and lubricate with suitable lubricant like Vaseline, if necessary	Half yearly
2.	Arcing contacts	Clean the contact surface with fine cloth and petrol, but do not lubricate them	Quarterly
3.	Bus bars	Tighten the joints, if there is any loose joint.	Half yearly

4.	Earthing	Check the earth connections, its continuity and tighten the connections, if found loose.	Yearly
5.	Bearings and joints	Clean the rusted bearings and joints with petrol and re-grease the bearings with proper grade grease.	Yearly
6.	Visible break blades	Clean with petrol and lubricate with Vaseline.	Half yearly
7.	Insulated parts	Cleaning of dust and dirt	Half yearly

### Maintenance of Oil Circuit Breakers

Sl. No.	Parts to be Inspected	Maintenance Programme	Time Period
1.	Main contacts and moving contacts	File the contacts with smooth file if badly pitted and clean them with emery cloth and then with fine cloth. If the contacts are burnt, replace them.	(a) Quarterly in case of heavy duty (b) Yearly in case of normal duty
2.	Arc control device	Check the control device for carbon deposits. Remove it with blunt edged tool and wash the surface with Kerosene oil. Replace the burnt plates or replace the whole assembly for better performance.	(a) Quarterly in case of heavy duty (b) Yearly in case of normal duty (c) Quarterly in heavy duty (d) Yearly in normal duty
3.	Connecting rods and levers	Inspect all the pins, screws and nuts and tighten them properly, if found loose. Lubricate them with proper grade heavy machine oil.	Half yearly
4.	Closing and tripping mechanism	Operate the circuit breaker by hand to see its proper and correct mechanism operations. Lubricate the closing mechanism with recommended grade machine oil. Use firm and smooth fabric for cleaning purpose replace worn out parts.	Yearly

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5.	Oil level guage	Inspect the level of the oil in the gauges. Top it with dehydrated oil, if level is found low.	Quarterly
6.	Insulating oil	Check the condition of the oil and take the sample oil to test it for its correct dielectric strength in the oil testing set. Drain out the dirty oil and refill it with fresh, having proper dielectric strength oil. The dielectric strength should be checked after each 12 medium fault interruptions.	(a) Quarterly in case of heavy duty (b) Yearly in case of normal duty
7.	Contact resistance	Check the contact resistance and record them	Yearly
8.	Insulators	Inspect the porcelain and bushings for cracks and breakage and replace the broken units. The cracked porcelain causes leakage and cracked bushings allow the leaking oil. Clean also the dust and carbon, because it lowers the insulation resistance causing flash-overs.	Half yearly
9.	Relay setting	Check all relay for correct operation with a relay testing set.	Half yearly
10.	Indicating Devices	Check the indicating devices and lamps. If found defective, correct them or replace them.	Yearly

### Troubleshooting of Circuit Breakers

Sl. No.	Main Faults	Causes	Remedies
1.	Overheating	This is due to (1) Burnt contact or when carbon is collected on the contact surface (2) Over loading (3) Misalignment of contacts	(1) Replace the burnt contacts or clean the carbon deposits with fine cloth (2) Check and reduce the load to within limits

		<p>(4) Improper surface of contacts</p> <p>(5) Improper ventilation of substation</p> <p>(6) Improper condition of oil</p>	<p>(3) Set the contacts in the proper order</p> <p>(4) Smooth them with emery paper or smooth file and clean them</p> <p>(5) Maintain the proper ventilation</p> <p>(6) Replace the old oil with fresh oil</p>
2.	No tripping	<p>This is due to</p> <p>(1) Shorted trip coil</p> <p>(2) Shorted operating coil</p> <p>(3) Slipping of plunger from the latches</p> <p>(4) Loose connections of battery</p> <p>(5) Discharged battery</p> <p>(6) Low tension of spring</p> <p>(7) Relay contacts do not make contact</p>	<p>(1) Replace the trip coil</p> <p>(2) Replace the relay</p> <p>(3) Replace the latches</p> <p>(4) Tighten the connections</p> <p>(5) Get the battery charged</p> <p>(6) Replace the spring</p> <p>(7) Set the contacts correctly</p>
3.	Magnetic switch	<p>(1) Switch may be defective</p> <p>(2) Relay contact may be welded together</p> <p>(3) Plunger may remain stuck onto the lever or latches</p>	<p>(1) Replace the switch</p> <p>(2) File the surface of the contacts and clean them</p> <p>(3) Correct the lever or replace it</p>

### ➤ Maintenance of Metal Clad Switches

For the maintenance of metal clad switches inspect the different parts of the switches from time to time for its easy and efficient operation and to increase its life to operate smoothly.

### Maintenance of Metal Clad Switches

- Check the handle for its easy operation, if lever is not working properly, set it or oil it.
- Check the tension of the spring, if it has low tension replace it.
- Check the pins of the cover and handle, if loose, tighten them and if broken, replace them.
- Check the contact strips, if not making contacts with the terminals strips, bend them little to make the contacts properly.
- Check the insulating fibre rod, if found cracked, replace it.
- Check the terminals screws if missing or loose, replace it.
- Check the fuse grips and base, if found cracked or broken replace them.
- Check the connections, if found loose, tighten them.

### 9.5 Log-book Record

Open a switchgear, preferably one not in use, else totally isolated from the live circuit, and identify all the parts. Disassemble and then re-assemble the switchgear fully. Maintain a log of every action taken and the condition of each part. This exercise must be undertaken under proper supervision?

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**Self Test**

**Answer the following questions :**

Q.1 List the troubleshooting of circuit breakers in terms of main faults, causes of faults and their remedies.

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Q.2 Fill the blanks given below :

<b>Maintenance of Air Circuit Breakers</b>		
<b>to be</b>	<b>Maintenance Action</b>	<b>Time Period</b>
ected	-----	Half yearly
ts	--	
ts	-----	Quarterly
g	--	
ts		
<b>Maintenance of Oil Circuit Breakers</b>		
<b>to be</b>	<b>Maintenance Action</b>	<b>Time Period</b>
ected	-----	Yearly
g	-	
g		
nis		
el	-----	Quarterly
	-	y



**Activity No. 10**

## Structure

- 10.1 Objectives of Activity
- 10.2 Equipment/Materials/Facilities Required
- 10.3 Brief Theory
- 10.4 Procedure
- 10.5 Precautions
- 10.6 The Points to be Remembered
- 10.7 Self Test

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### 10.1 Objectives of Activity

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After performing this activity, you should be able to

- **make the technicians familiar with the techniques and methods of installation and sealing of energy meters.**

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### 10.2 Equipment/Materials/Facilities Required

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- Different types of Energy Meter
- Service Cables of different size
- Meter Boxes
- Meter Seals
- Clamp/Clip-on meter.
- Electric/Hand Drill
- Drill bits
- Ball peen hammer
- Standard Tool Kit.

## 10.3 Brief Theory

The distribution company charge a customer for the power consumed. As this is the basic source of revenue for the company, and also as per the law, it has to install an accurate electric/energy meter at the customer's premises.

An electric meter or energy meter is a device that measures the amount of electrical energy supplied to customer. Utilities record the values measured by these meters to generate an invoice for the electricity.

At present, energy meters based on electromagnetic technology and static meters are being used in the Indian Distribution Network.

**Single-phase meters are being used for most of the domestic and some commercial consumers, whereas 3-phase meters are being used for industrial, agricultural and large commercial consumers.**

### Energy meters typically consist of :

An energy measurement apparatus for measuring the energy consumption and a gauge that is visible outside the meter, showing the amount of electrical quantities including the energy consumed. Electricity meters track among other things, the amount of energy consumed, typically **measured in kilowatt-hours (kWh)**, at each customer's facility.

The available technology options for metering are given as follows :

Available Technology Options for Metering	
(i)	Electromechanical meters;
(ii)	Hybrid meters;
(iii)	Static (electronic) meters;
(iv)	Demand meters;
(v)	Multiple tariff (variable rate) meters/Time of Usage (TOU) meters;
(vi)	Prepaid meters;
(vii)	Automatic Meter Reading (AMR) and Remote Meter Reading (RMR).



(a)



(b)

Figure 10.1: (a) Electromechanical Energy Meter, and (b) Electronic Meter

### ➤ Electromechanical Meters

Electromechanical energy meters (Figure 10.1(a)) are based on the rotating disc Principle. The working of these meters is explained in the Box below.

#### Working of Electromechanical Meters

The meters have a revolving metallic disc mounted on jewel bearings/magnetic suspension bearings. The display is cyclometer or mechanical counters and accuracy is typically 1% or 2% (class 1.0 or 2.0).

They cater to limited tariffs applicable mainly to 1-phase 3-phase direct connected segment (whole current meters). The electromechanical induction meter operates by counting the revolutions of the disc, which rotates at a speed proportional to the power consumed. The number of revolutions is, thus, proportional to the energy usage. The metallic disc is acted upon by three magnetic fields, one proportional to the voltage, another to the current and a third constant field supplied by a permanent magnet. One of the varying fields induces currents in the metallic disc, which are then acted upon by the other varying field to produce a torque. This results in the torque being proportional to the product of the current and voltage, i.e. power.

As the metallic disc rotates through the permanent magnetic field, eddy currents are again produced which dissipate energy (since the disc has some resistance) and act to slow the rotation. This drag is proportional to the rotation speed. The equilibrium between the applied torque and the drag results in a speed proportional to the power. The rotating disc in this type of meter is, in fact, an electric motor of a type called a reluctance motor or eddy current motor. It consumes a small amount of power, typically around 2 W.

## ➤ **Static (Electronic) Energy Meters**

Electronic energy meters (Figure 10.1(b)) are replacing traditional electromechanical meters in many residential, commercial and industrial applications because of the **versatility and low-cost** afforded by electronic meter designs.

The measurement circuits are electronic with LED (Light Emitting Diode)/LCD (Liquid Crystal Display) display and their accuracy is typically class 0.2, 0.5, 1.0.

They cater to multiple tariffs for all segments CT-VT (Current Transformer-Voltage Transformer) operated, CT operated, 1-phase or 3-phase Direct connected segment.

**These meters measure and record active, reactive and apparent demand/energy.** The static energy meters are microprocessor based and have non-volatile memory to record and store data.

**The electronic meter, in its basic form has :** A power supply, a metering engine, a processing and communication engine, i.e. a microcontroller, other add-on modules such as Real Time Clock (RTC), LCD display, communication ports/modules, etc.

These meters are extremely **difficult to tamper** with, and if somebody does attempt to tamper with it, it will send alarm signals and record the information. The programmability of microprocessor has become a useful tool for incorporating different features like tamper data, import-export, time-of day metering, load pattern analysis, etc.

They can be made SCADA (Supervisory Control and Data Acquisition) systems compatible. They can have communication ports to support AMR/RMR on various communication platforms, as well as, for downloading of data on external storage devices.

## ➤ **Prepaid Meters**

**Prepaid metering is a system whereby consumers purchase electricity through a smart card.** The amount paid, together with other information, is encoded on a smart card (fitted with a microprocessor).

In order to transfer the credit, the consumer inserts the card in a compatible meter. The meter reads the data and when the pre-paid amount of energy has been used up, power to the consumer is disconnected.

The consumer gets the card reloaded/reprogrammed. The system has the capability of programming with multiple rates, time of use tariffs, etc. The consumer can read, among other data, the remaining money, on the display of the meter.

The use of prepaid meters results in almost total elimination of non-payment and delayed payment and enables transfer of reliable, accurate and up to date consumption and billing data according to tariff policy in use. This information can be utilized by the utility for demand forecasting and for controlling peak demands. It also means substantial reduction in staff for meter reading, bill serving, bill complaints and bad debts, etc.



Figure 10.2 : Prepaid Meter

Full meter programmability allows maximum flexibility in changing tariffs. Consumer can also decide in advance the affordable level of expenditure, which may help him and the utility in elimination of disputes regarding inaccurate bills.

**Automatic Meter Reading (AMR) and Remote Meter Reading (RMR)** describe various systems that allow meters to be checked without the need to send a meter reader out. This can be effectively achieved using off-site metering, that is an electronic meter is placed at the junction point where all the connections originate, inaccessible to the end-user and it relays the readings via the AMR technology to the utility.

Remote metering enables online metering of energy consumption. It is particularly useful for high value consumers where accuracy of billing and delays in time taken for meter reading are important. Monitoring of consumption patterns to detect theft/tampering of meters is possible with these types of meters.

The remote metering unit may be the RTU (Remote Terminal Unit), which receives the pulses generated by the electronic meters and is connected to the Central PC (Personal Computer) Station through a communication system, which could be PLCC (Power Line Carrier Communication), public switched telephone network, radio, etc.

### ➤ **Single-phase Meters**

Single-phase meters are generally **rated for 240 V AC supply**; the current ratings are 5/10, 10/20, 2.5/10 or 5/20 A and are for direct connection to the mains. They start registration with small load of about 6 W and record up to 4800 W.

The main feature of a single-phase meter (electromechanical induction type) is its simplicity, compactness and robust design. It comprises a potential coil and a current coil. The potential coil is fitted on the middle limb of an E-shaped electro-magnet and connected across the supply mains.

Similarly, the current coil consisting of a few turns of heavy gauge copper wire is wound on two limbs of a U-shaped electro-magnet. The two fluxes, produced by the voltage (pressure or potential) coil and current coil, create a mechanical torque on the non-magnetic aluminum disc (which is located between the 2 coils) causing it to rotate.

A brake magnet of C-shaped alloy steel is provided to control the movement or rotation of the disc set up by two fluxes. The disc rotates through the narrow air gap of the C-shaped magnet and eddy currents are set up, which interact with the field and exert braking effect.

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## **10.4 Procedure**

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### ➤ **Energy Meters – Installation and Commissioning**

The meters are connected before the consumer's isolating device (Main Switch), which may be a molded case circuit breaker, miniature circuit breaker or an ironclad switch fuse unit. At the time of commissioning, each meter is tested at site by the owner. A reference standard meter of 0.2 class or better is used for testing.

### ➤ **Supply Side Wiring**

The supply side wiring is the responsibility of the utility and the following must be ensured while carrying it out.

- The supply wires provided are of suitable rating.
- In case of more than one meter on one service line, it is preferable to use bus-bars. When a number of meters are connected to a single distribution mains, for registering electricity supplied to different consumer loads, separate service lines – phase(s) and neutral, are used for each meter. Each independently metered consumer load is directly connected to the distribution mains through its meter connected in specified phase sequence so as to meet accuracy requirements of relevant standard.
- The supply wire is properly terminated.
- The connection is as per connection diagram mentioned on meter.
- Utility should use its own earthing for its devices. Utility provides **phase and neutral (Single Phase) supply** to the consumers. The **neutral** is used for carrying return current only. The neutral of one consumer should not be connected to other consumers who have independent and separate supply connection.

Utility provides separate neutral to each consumer up the metering point and same is used by the consumer. The consumer ensures that all the correct wiring practices are followed and neutral is not looped with other consumers or meters in the same premises. Consumer should not earth the neutral after the metering point. Wherever there is multiple meter installations, bus bar arrangement is used for neutral, so that looping is avoided.

### ➤ **Installation of Meters and Verification of Connections**

Apart from testing and calibrating the meters they must be properly installed as per the connection diagram.

The points that must be kept in view while meters are installed are given in the Box below.

## Installation of Meters

- (a) Position of meter should be such that reading is easily visible.
- (b) Mounting of meter should be on solid wall or DP structure or on panel board.
- (c) Vertical mounting of meters should be ensured. The utility engineer should use a plumb bob and mark a vertical line prior to installation. He could also use a spirit level and put on the top of the meter after hanging on the screw hole. Alternatively, he should put spirit level on the edge of the terminal block to ensure vertical mounting.
- (d) For HT metering equipment, CTs should be right on the incoming side before the point of isolation.
- (e) The meter box should be sealed.
- (f) The meter recording should be checked at site.

### 10.5 Precautions

The following should also be ensured :

- Appropriate crimping device should be used for crimping the lugs. Thimbles should be of appropriate configuration (pin type, fork type, etc.) to match with the terminal block, for low current connection. For high current terminations, crimping should be used with cable crimping tools and multiple point crimping should be done for the lugs used for higher current ratings.
- If the terminal block is of MS cage clamp type, there is no need to use any lugs and the copper cables can be directly terminated at the clamp.
- The recommended tightening torque must be exerted on the screw to ensure proper tightening of the terminations. It is recommended to use proper tools, equipments for this purpose.
- Usage of lugs as per the recommendation of manufacturer and ensuring proper crimping will protect the joints from failures.
- For high current terminations, tensile test and shock test should be performed after crimping the lugs.

- Where aluminum cable termination is to be done on copper bus bars or brass studs, bimetallic type of lugs should be used.
- Some meters have lower terminal pitch. Because of this, cables foul with each other while installation. Proper cable size according to the meter rating should be defined.
- Aluminum conductor cables should be replaced by copper cables for the whole current meters.

For indoor meters, the wiring should be done such that the cables enter the meter box from the bottom or rear side. This is not only aesthetic, but also prevents the service cable from tampering, etc.

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## 10.6 The Points to be Remembered

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The points that should be verified after installation of the metering system are given in Box.

Points of Verification
(i) Phase association
(ii) CT polarity
(iii) VT polarity
(iv) Phase angles
(v) Phase sequence
(vi) System conditions – unbalanced capacitors
(vii) Actual CT/VT ratio

### ➤ Sealing Points

The meter seal should be tamper proof. The consumer should be briefed about seals. The sealing of all metering systems should be done at various points (as applicable) to avoid tampering. **There should be at least one seal at all points mentioned below (wherever applicable) :**

- CT Secondary Boxes (in addition to locking arrangement).
- PT Secondary Box (in addition to the locking arrangement).
- Meter Cabinet.

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- Meter Test Block.
- Meter Terminal Cover.
- Meter Cover.
- Panel doors where CT and PT secondary circuits are terminated or where possibility for shorting or breaking exists and fuses/links are provided.
- PT selector relay box where automatic change-over of potential supply to meter from one PT to another is provided.
- CT Primary Links and Top Covers.
- MD Reset Push Button.
- Boxes/Cabinets containing terminals for remote transmission of metered data via communication channels, junction boxes in the system and boxes wherein interface devices are mounted.
- Meter reading port.

Seals are necessary to guard against tampering with the connections and internal parts of a meter. Tampering of seals will give consumers access to the relevant part of a meter installation where s/he can manipulate the unit to record less energy leading to commercial loss. A seal is placed to detect unauthorized entry to the meter internals.

The effectiveness of the seal depends on the type of seal (whether it is tamper proof or not, whether a duplicate can be obtained or not, etc.), and the procedures used in tracking the seals.

**Self Test**

**Answer the following questions :**

Q.1 List the different types of energy meters.

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Q.2 What are the advantages of electronic meter over electromagnetic meter?

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Q.3 Highlight the salient features of electronic meter.

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Q.4 Discuss the various available technology options for metering.

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Q.5 Describe the important points that must be kept in view while meters are installed.

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# PRACTICE OF TESTING OF DOMESTIC WIRING INSTALLATIONS

## Structure

- 11.1 Objectives of Activity
- 11.2 Equipment/Materials/Facilities Required
- 11.3 Brief Theory
- 11.4 Circuit Diagram
- 11.5 Procedure
- 11.6 Observations
- 11.7 Precautions
- 11.8 Self Test

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### 11.1 Objectives of Activity

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After performing this activity, you should be able to

- **ensure safe and satisfactory, trouble free long working life, the testing of domestic installation is considered essential on the following occasions :**
  - **Before putting a new installation in service and connection and re-connection of supply mains.**
  - **Whenever a change, addition or modification in the existing wiring is done.**

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### 11.2 Equipment/Facilities/Materials Required

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- A continuity tester or a low voltage source with suitable indicating system.
- Ohm-meter.
- Megger/insulation resistance tester.
- Pliers combination
- Screw drivers
- Standard Tool Kit.

## 11.3 Brief Theory

The following tests are carried out on the installations initially and at regular intervals, and a record is maintained or a certificate is given.

- Continuity test of the electrical circuits.
- Polarity checking of all single pole switches and 3-pin sockets.
- Insulation test.
- Earth continuity test.

## 11.4 Circuit Diagram

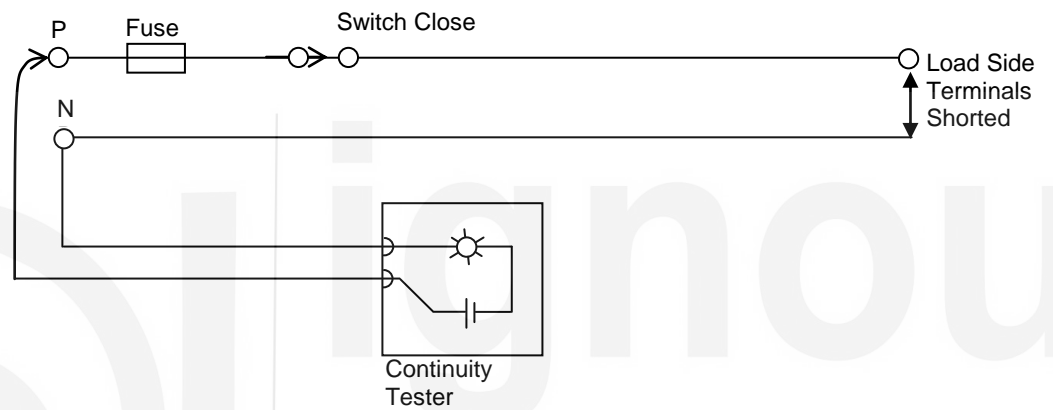


Figure 11.1 Continuity Test

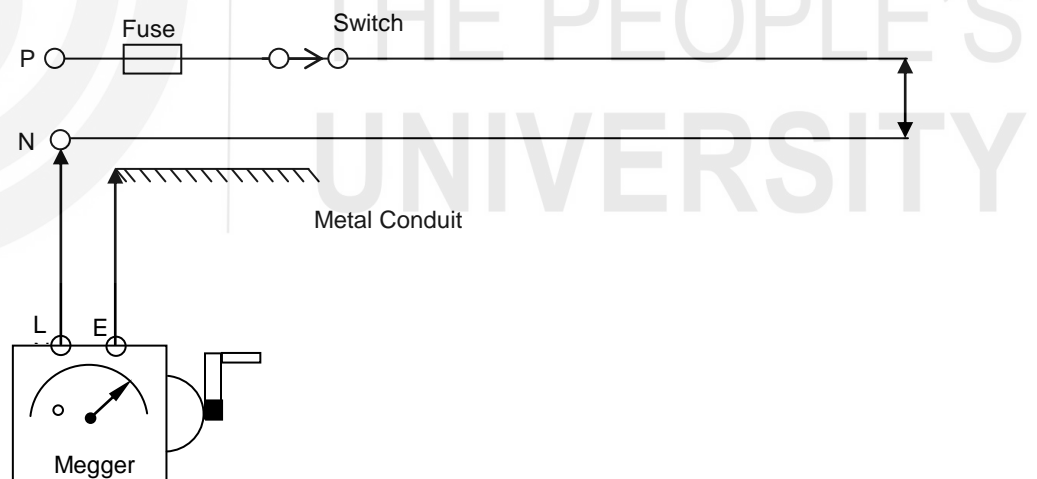


Figure 11.2 : Insulation Test on Circuit to Earth (Conduit)

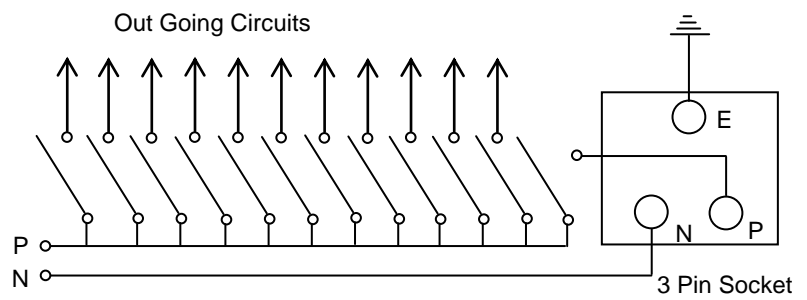


Figure 11.3 : Testing of Polarity of Switches and Three Pin Socket

## 11.5 Procedure

- (i) Disconnection the supply from the existing installation and remove the main switch fuses.
- (ii) Disconnect all loads like fans, lamps, tube lights, stabilizers, electric bell, buzzer, heaters, ovens, geyser etc. if already connected.

Let us discuss some important tests which are carried out on the installations :

### ➤ Continuity Test

Check one circuit at a time from the output of the respective fuse to the neutral strip with a continuity tester; after removing the fuse, note the indication. A lighted lamp or deflection on the instrument shows “continuity”, and no indication shows, open circuit or high resistance joint. Record the result of each circuit. Replace each fuse after the test.

### ➤ Testing for Polarity of Single Pole Switches and Sockets

- (i) Open all the switchboards and check that all switches control the phase line.
- (ii) Check that all 3 – pin sockets have the phase on the right hand side pin at the base facing the socket and is controlled by a switch. Close all the switchboards.

### ➤ Insulation Resistance Test

Insulation resistance is carried out by using a 500 V megger or insulation resistance tester.

Before checking, test the instrument for correct indication :

- (i) Short the output leads and rotate the handle. The pointer should deflect to zero on the scale.
- (ii) Keep the leads open, and rotate the handle. The pointer must stay at infinity point on the scale.
- (iii) Connect the tester’s ‘line’ terminal to the output of the main switch and the earth terminal to the earth of the switch casing. Rotate handle and note the reading.

- (iv) Pointer showing infinity or close to this point on the scale shows good insulation.
- (v) Pointer showing away from infinity but not close to zero shows bad or poor insulation.
- (vi) Pointer showing zero or close to it indicates a short circuit to earth.
- (vii) Record each reading.
- (viii) Check phase line to earth and record the reading.

➤ **Earthing**

To ensure continuity in earthing, all the metallic conduits, iron boxes, iron clad switchboards, earthing points on various light and power sockets must be connected electrically to the main earth and must not have a resistance value of more than 1 Ohm (to earth) when checked with an ohmmeter.

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### **11.6 Observations**

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The result of all the tests must be recorded in the following format :

Sl. No.	Test	Reading	Observation	Result
1	2	3	4	5
1	Continuity Test			
2.	Insulation Test (i) Conductors to earth with load terminals shorted (ii) Phase to neutral – Lead (iii) Phase to earth – Terminals (iv) Neutral to earth – Open			
3.	Polarity Test			
4.	Earth Continuity Test			

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## 11.7 Precautions

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- Always disconnect the supply before attempting any test.
- Always check the megger, the ohm-meter and the continuity tester before use.
- Bring the circuit to normal working conditions after testing and reconnect the supply.
- Always record the results.



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**Self Test**

**Answer the following questions :**

Q.1 What is megger? What do you understand if pointer of megger shows infinity or zero?

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Q.2 Discuss various necessary tests which are carried out on the domestic wiring installations?

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Q.3 What do you mean by Ohm-meter?

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Q.4 Draw the circuit diagram for continuity test.

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Q.5 What precautions should be taken while testing of domestic wiring installations?

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# PRACTICE OF IDENTIFICATION AND LOCATION OF VARIOUS FAULTS IN HOUSE WIRING AND THEIR RECTIFICATION

## Structure

- 12.1 Objectives of Activity
- 12.2 Equipment/Materials/Facilities Required
- 12.3 Brief Theory
- 12.4 Procedure
- 12.5 Some Common Wiring Faults in Tabular Form
- 12.6 Observation Table
- 12.7 Precautions
- 12.8 Self Test

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### 12.1 Objectives of Activity

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After performing this activity, you should be able to

- **understand the functioning of an electric circuit.**
- **establish a clear concept of three essentials of the circuit, i.e. source, circuit elements, and the connected load.**
- **analyze the faults with reasoning, locate them and to carry out rectification.**

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### 12.2 Equipment/Facilities/Materials Required

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- Insulated combination pliers
- Set of common screwdrivers
- test lamp
- neon tester
- fuse wires 5 amp and 10 amp
- insulation tape – PVC self adhesive, or black cotton self adhesive
- knife
- multimeter
- megger
- continuity tester

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## 12.2 Brief Theory

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Every electrical circuit needs four essential elements for proper functioning, i.e.

- (i) **Energy source**
- (ii) **Control components like switches, fuses, circuits breaker, etc.**
- (iii) **Wiring**
- (iv) **Equipment or connected load, i.e. lamp, fan, iron, cooler, heater, etc.**

Most of the common faults occur as a result of supply failure, defective switches, sockets and plugs, faults in the wires, or defective equipment, and an electrician must understand clearly the reported fault, reason it out and try to locate it from the simplest possibility.

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## 12.3 Procedure

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- (i) Note down, the details of the building, flat, house and room number, if applicable and write down the fault with its associated circuit such as “Light is not working in room No. 114” or “There is no power in the basement” or “Cooler pump motor in physics lab. Cooler unserviceable” or “Complete blackout in the projection room”, etc.
- (ii) Take one fault at a time and start the work; try to complete it before attempting the second one. But if more than one faults occurs at a time, then attend to them in order of priority, i.e. the most important first and the least important last. Try to collect other information related to the faults, which may be helpful in localizing and rectifying the defect quickly.

For easy understanding, let us **take a few typical cases**.

➤ **No Electrical Power in a Particular Building**

Check if other buildings in the adjoining area have power. If other building also do not have light, then possibly the mainline (or the phase) feeding all the affected buildings is off, or a pole fuse or feeder pillar fuse is blown. Report to the nearest supply agency and do not attempt any repair.

If all other buildings have power, then check the main fuse in the main switch, after switching it off.

- (i) Replace the blown fuse with a proper fuse wire of the specified rating.
- (ii) Check the supply at the mains switch with a neon tester and test lamp. If it is all right, fix the rewired fuse in position.
- (iii) Switch on all loads in the building.

➤ **If the fuse blows out again after switching on the main switch and other circuits, then proceed as under**

- (i) Do not attempt to replace the fuse with a thick wire, but locate and rectify the defective circuit.
- (ii) Remove all the fuses from the distribution board, switch off the circuit switches, and check across each fuse with a series lamp, i.e. test lamp.
- (iii) If the lamp lights on a particular fuse, it shows fault in that circuit before the switch, i.e. the conductor is earthed to the conduit or shorted with neutral wire or both. If rectification is not easily possible, then isolate that circuit, replace the fuses in the other circuits and switch on. This fault can be grouped under major rectification.

➤ **In a room, only one light is defective and others are glowing bright**

Sl. No.	Possible Faults	Rectification
1.	Fused lamp	Check lamp and replace
2.	Lamp loose in the holder	Check and replace defective lamp holder
3.	Loose connection at switch terminals	Tighten the connection at the switch terminals
4.	Improper switch toggling action	Replace the toggle switch with a new one of same size and rating
5.	Loose fuse in holder, blown out fuse	Check fuse, tighten contacts and/or replace the fuse
6.	Loose connection at fuse holder	Check and tighten the fuse holder connections

➤ **Lights are working but desert cooler/air conditioner does not work**

Sl. No.	Possible Faults	Rectification
1	Blown out fuse	Check and replace the fuse
2	Loose connection at the rear of the 3-pin socket	Check and tighten connection
3	Loose connection at the plug pins	Open and check the connections in the plug and tighten the connections, if required
4	Over heated socket, Oxidized and burnt out pins	Replace with a serviceable socket
5	Low voltage	If the lights also glow dim, measure the voltage, switch off and wait till voltage improves or use a voltage regulator
6	Low voltage or repeated fuse blow-outs on switching on the load	Faulty load equipment. Remove the power connection and declare fault.

➤ **In a particular room, no light works, but when checked, all switches show phase available**

When checked with a test lamp, the lamp doesn't light from the switches to the neutral wire, but lights to earth.

**Possible Fault :** Open neutral.

**Rectification :** check and ensure continuity of neutral return.

**12.4 Some common wiring faults in tabular form**

Sl. No.	Fault	Possible Causes	Rectification
1	2	3	4
1.	No Light	(1) Fused filament lamp (2) Blown out fuse (3) Defective switch/loose connections (4) Fractured aluminium wire at the connection points in holder or switch (5) Loose lamp holder (6) No power	(1) Check and replace with a serviceable lamp (2) Check the fuse and replace after re-wiring (3) Check and replace or tighten connections (4) Renew connection if fractured (5) Replace with a serviceable holder (6) Check for power of mains fuse, if blown, and replace

2.	Fuse blows out after replacement	<ul style="list-style-type: none"> <li>(1) Excess load than planned or low capacity fuse</li> <li>(2) Short circuit in the equipment</li> <li>(3) Short circuit exists even after disconnection of the equipment</li> <li>(4) Short circuit exists even with all the switches in the off position</li> <li>(5) Short circuit is due to phase wire short to neutral inside the conduit</li> </ul>	<ul style="list-style-type: none"> <li>(1) Check up the connected load and remove extra load, if connected, or put the proper fuse</li> <li>(2) Switch off and check each item for earthing and rectify the fault</li> <li>(3) Switch off all load switches and check</li> <li>(4) Fault exists before the switches, locate and isolate the defective circuit</li> <li>(5) Pull out the defective wire and drew through new wires and connect after checking</li> </ul>
3.	Lights flicker when heater is switched on	<ul style="list-style-type: none"> <li>(1) Loose fuse grip in holder in main fuse</li> <li>(2) Loose contacts in the main switch knife contacts</li> <li>(3) Loose connection of aluminium conductors in the main circuit before distribution</li> </ul>	<ul style="list-style-type: none"> <li>(1) Check and replace heating up fuse grip or main switch, tighten points in the holder</li> <li>(2) Check for sparking, heating up of fuse grip or main switch, tighten contact points, clean burn our surface and ensure the tightness of connections</li> </ul>
4.	Water pipes give shock	<ul style="list-style-type: none"> <li>(1) Leakage in wiring</li> <li>(2) Open neutral</li> <li>(3) Leaking, geyser, oven, refrigerator and improper or broken earth return</li> </ul>	<ul style="list-style-type: none"> <li>(1) Check insulation of wiring using a megger; if weak, replace the defective wire</li> <li>(2) Check continuity of neutral wire</li> <li>(3) Check all appliances for insulation and proper earth return and rectify the fault</li> </ul>

## 12.5 Observation Table

Record the observations and actions in a table as given below :

Sl. No.	Location/ Fault	Test	Reading	Observation	Result
1	2	3	4	5	6
1.	Physics Lab. No Supply	Continuity Test			
2.	Director's room AC not working	Insulation Test			
3.					
4.					

### Note

Only the required tests need be carried out, as relevant to the reported fault.

## 12.6 Precautions

- Always switch off mains before testing a circuit or attempting any repair on the installation.
- Use rubber soled shoes and rubber gloves as far as possible, while working on electrical installations.
- Use tools with insulated handles.
- While checking with a test lamp, connect one lead first to earth or neutral and then only connect the second lead to the live terminal to prevent accidental shock.

**Self Test**

**Answer the following questions :**

Q.1 Describe some common wiring faults with their possible causes and rectifications.

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Q.2 Mention the possible faults and their rectifications in the case of :

- (a) No electrical power in a particular building.
- (b) In a room only one light is defective and others are glowing bright.

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Q.3 Write the short note on fuse, electrical load, rating of fuse wire and multimeter.

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