



Repair and Maintenance of Power Distribution Lines

INTRODUCTION

Repair and maintenance of lines is very important for uninterrupted supply of electricity. Maintenance is done primarily twice a year, once before monsoon and the next is done after monsoon to see if any breakdown has occurred in the line. Line patrolling, maintaining ground clearance, replacement of insulators, restringing of lines, replacement of burnt jumpers, replacement of damaged conductor, replacement of damaged pole, etc. are some of the checks performed during maintenance. Proper maintenance of line improves its life drastically.



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SESSION 1: PREPARATION FOR REPAIR AND MAINTENANCE OF POWER DISTRIBUTION LINES

Materials and Accessories used in Power Distribution

In this section, we will discuss some materials and accessories used in power distribution.

Poles (Supports)

The poles or supports are classified according to the material used for it:

- Steel
- Cement
- Wood



Fig. 4.1 Tubular Poles



Fig. 4.2 RCC Poles

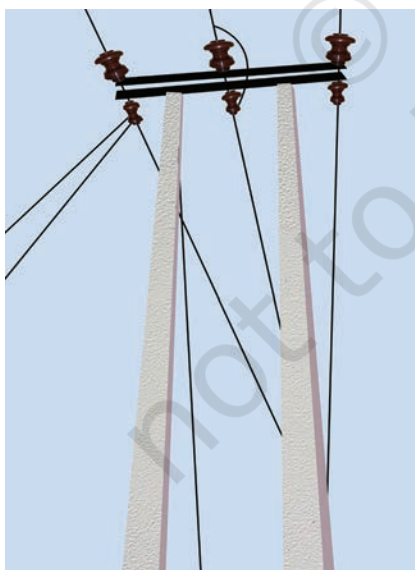


Fig. 4.3 PSC Poles

Steel poles are further classified as follows

Rail Poles: These can be of L shape, rail type and tubular shape. They are better than R.C.C. poles, light in weight and cheaper in cost. The poles are affected by atmospheric moisture, rains, etc. Hence they are always painted or coated with chemicals to avoid rusting. These are normally used for 33kV lines.

Tubular Poles: Tubular poles are either of swaged section (built up sections) or stripped single unit type (jointless one casting). The action of wind pressure is very low because of their circular section as compared to plain section R.C.C. poles and can be erected easily by digging pits of diameter or section slightly greater than the pole's diameter. These are normally used in hilly areas (Fig. 4.1).

Cement poles are further classified as follows

R.C.C. poles: These poles are made by reinforcing (i.e. embedding) steel rods into concrete slabs of pole shaped cylinders. These poles are of permanent nature, have a long life, remain unaffected by rain, sunlight, etc. and are heavy in weight due to the presence of concrete and steel (Fig. 4.2).

P.S.C. poles: Pre-stressed cement concrete poles are essentially made of concrete. A frame of high tensile steel wire is inserted into a mould and stretched to a certain level. Galvanised wire is used as earth wire inside the mould. A right proportion of concrete mix is poured in the mould and a vibrator is used to compress the concrete to produce high strength PSC poles (Fig. 4.3).

Wooden poles

Wooden poles are light in weight and cheap in comparison to all other types of poles, made up of wooden beams. These are easily affected and spoiled by atmosphere, rain water, white



ants, soil moisture, etc. Therefore, they are used for temporary work and are coated with special chemical for permanent installations. The common impregnating material (coating) used is Creosote. These poles are normally used in hilly areas.

As per the CEA (Central Electricity Authority) Regulations 2010, Relating to Safety and Electric Supply, Clause 57(2), the supports should have the following minimum factor of safety as given in Table 4.1.

Table 4.1

S. No.	Types of Supports	Factor of Safety
1	Metal Supports	1.5
2	Mechanically processed concrete supports	2.0
3.	Hand moulded concrete supports	2.5
4.	Wooden supports	3.0

An Earthing arrangement is provided with a projected length of 50 mm at both ends of the pole, using 8 S.W.G G.I. wire embedded in concrete. In actual practice, it is convenient to use 8m poles for all purposes (instead of having different sizes) with minor adjustments in spans, if required. This avoids future replacement costs, omission or errors by workmen in transportation and selecting different poles for different locations. The selection of poles for erection of lines depends on a number of factors such as:

- Pole strength
- Type and size of conductor
- Maximum wind pressure
- Maximum line tension
- Snowfall
- Presence of fruit farms
- Guarding
- Different crossings like river, road, railway, telephone lines, etc.

The erection of power distribution lines involves only erection of different types of poles, such as steel, PSC, wooden poles, etc.





Fig. 4.4 All Aluminium Conductors



Fig. 4.5 Aluminium Conductor Steel Reinforced



Fig. 4.6 All Aluminium Alloy Conductors

Conductors

Aluminium conductors of different types and sizes are used for drawing overhead lines, whether they are LT or HT lines. These include:

AAC – All Aluminium Conductors: This type of conductor is made up of one or more strands of hard drawn 1350 aluminium alloy. The AAC conductors are used in low and high voltage overhead lines. AAC is used extensively in urban areas where spans are usually short but high conductivity is required (Fig. 4.4).

ACSR – Aluminium Conductor Steel Reinforced: It is a type of high-capacity, high-strength stranded conductor typically used in overhead power lines. The outer strands are high-purity aluminium, chosen for its excellent conductivity, low weight and low cost. The centre strand is of steel for additional strength to help support the weight of the conductor (Fig. 4.5).

Reinforced Conductors

AAAC – All Aluminium Alloy Conductors: These conductors are made out of high strength Aluminium-Magnesium-Silicon Alloy. These conductors are designed to get better strength to weight ratio and offer improved electrical properties, excellent sag-tension characteristics and superior corrosion resistance when compared with ACSR (Fig. 4.6).

Table 4.2 lists various specifications of different types of conductors used:

Table 4.2 Specifications of Different Types of Conductors

S. No.	Code Name	Nominal Aluminium Area (mm ²)	Equivalent nominal copper area (mm ²)	Stranding & wire diameter in mm of Aluminium (mm)	Stranding & wire diameter in mm of steel (mm)	Breaking load kg.	Weight of Cond. kg./km	Calculated Resistance at 20°C in ohms/ km	Current carrying capacity at 40°C above 30°C ambient temp.
1.	Gnat	25	16	7/2.21		485	73	1.071	85
2.	Ant	50	30	7/3.10		852	144	0.544	135
3.	Squirrel	20	13	6/2.211	1/2.11	771	85	1.394	75



4.	Weasel	30	20	6/2.59	1/2.59	1136	128	0.9289	102
5.	Rabbit	50	30	6/3.35	1/3.35	1850	214	0.5524	150
6.	Racoon	80	48	6/4.09	1/4.09	2746	318	0.3712	202
7.	Dog	100	65	6/4.72	1/4.72	3299	394	0.2792	250

The Gnat and Ant conductors (mentioned in S. No. 1 and 2) are generally used for LT Lines. The other types of conductors (mentioned from S. No. 3 to 7 are all ACSR Conductors and are commonly used on 11kv lines, except Dog conductors. As per CEA Regulations 2010 relating to Safety and Electric Supply, Clause 7, the minimum factor of safety for conductors have to be based on their ultimate tensile strength.

Insulators

Pin Type Insulators: These are commonly used on 11 kV Lines. The pins for pin insulators shall have a stalk length of 135 mm, shank-length of 125 mm and minimum failing load of 2kN. They should be forged. The pin type insulator is secured to the cross-arm on the distribution pole. There is a groove on the upper end of the insulator for resting the conductor. The conductor passes through this groove and is bound by the annealed wire made of the same material as the conductor. Pin type insulators can be of one part, two parts or three parts type, depending upon the application voltage. For example, in 11kV system, one part type insulators are used where the whole pin insulator is one single piece of properly shaped porcelain or glass (Fig. 4.7).



Fig. 4.7 Pin Type Insulators

Shackle Type Insulators: The shackle insulators are used in low voltage distribution lines (LT lines). They are also called spool insulators. These insulators are used to isolate the live conductor from pole and are mounted in every pole of electrical line. These insulators can be mounted either in vertical or horizontal positions (Fig. 4.8).



Fig. 4.8 Shackle Type Insulator

There are two types of shackle insulator fittings—strap type and u-clamp type fittings. Strap type fittings are for dead-end locations. On the other hand, u-clamp type fittings are for tangent locations or for service lines where the load is small. All fittings are to be galvanised.



Fig. 4.9 Disc Type Insulators



Fig. 4.10 Guy Strain Insulator

Disc Type Insulators: In higher voltage, such as beyond 33kV, it becomes uneconomical to use pin insulator as the size and weight of the insulator becomes more. Handling and replacing bigger sized single unit insulator is a difficult task. Suspension insulator was developed to overcome these difficulties. In suspension insulator, the number of insulators are connected in a series to form a string and the line conductor is carried by the bottom most insulator. Each insulator of a suspension string is called disc insulator because of its disc-like shape. Disc insulators are normally used in 11kV lines for dead-end locations (Fig. 4.9).

Guy Strain Insulators: These are only used for guy/stay wires. These are designed to work in mechanical tension or strain, as they are capable to withstand the pull of a suspended electrical wire or cable. The guy strain insulators are used in overhead electrical line. The strain insulator is inserted between stay wire to isolate the lower portion from electricity. It may also be used where a wire attaches to a pole or tower, to transmit the pull of the wire to the support while insulating it electrically (Fig. 4.10).

Pins for Insulators

Pins for pin insulators have to be of single-piece forged. All ferrous parts should be galvanized (Fig. 4.11).

Helically formed pin insulator ties used for holding the conductor on the pin insulator have been standardised and should conform to the requirements of IS: 12048-1987. Types and dimensions of pins are as follows:



Fig. 4.11 11 kV GI Forged Pins for Pin Insulators

Table 4.3 Types and Dimensions of Pins

Voltage (kV)	Type	Stalk Length	Shank Length (mm)	Failing load minimum kN
33	Large Steel Head type L 300 N	300	150	10
11	Small Steel Head type S 165P	165	150	5

Guy Assembly

Guy assembly is needed for dead-end and angular locations to counter balance the load on the supports



due to pulling of the conductors, so that supports remain straight in vertical position without bending in any direction. They are also provided at mid-span support as a protection against the wind load (Fig. 4.12).

G.I. Wire

G.I. wires are used for protective guarding at the crossing of lines with roads, railway tracks, telecommunication lines, etc. These have to be of 3.15, 4 and 5 mm sizes. The wires shall be galvanised with “heavy coating”. G.I. wires are used in reinforcement of aluminium conductors in distribution and transmission of electricity. ACSR wire is used for power fencing as this material is most suitable for electric conduction (Fig. 4.13).

GO Switches

Gang operated switches or GO switches, as they are commonly called, are switching devices used in overhead power lines. They are called Gang Operated as they are operated in a Gang, all three switches together, using a single mechanism. The gang operated switches are also called Air Break Switches because air is used as the breaking medium. These are normally installed at the pole mounted distribution substation to isolate the transformer from HT line, so that the HT fuse replacement could be carried out for the restoration of supply. The GO switches are used in electrical lines with voltage of 5 kV. They can be mounted vertically or horizontally, and can be motorised and operated from a remote location.

11kV Cross-arms

The following types of cross-arms are used for 11kV Lines:

- **V cross-arms** for tangent locations with clamps are widely used in many electrical transmission lines, for effective and efficient distribution of power. They have the capacity to bear heavy electrical fluctuations and voltages (Fig. 4.14).
- **Double-channel cross-arm** for tension or cut point locations where D.P.s. are used. The conductors



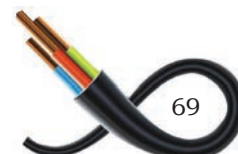
Fig. 4.12 Guy Assembly



Fig. 4.13 G.I. Wires



Fig. 4.14 V Type Cross-arms



for the double cross-arm configurations are suspended from an adjustable tie plate which connects the two timber cross-arm members together. The cross-arm can be used to support up to three conductors, one mounted at the centre and one mounted one foot from either end of the cross-arm (Fig. 4.15).



Fig. 4.15 Double-channel Cross-arms



Fig. 4.16 L.T. Cross-arms

- **L.T. cross-arms** have been standardised for horizontal as well as vertical formation of conductor. They have a strong structure and high sensitivity (Fig. 4.16).

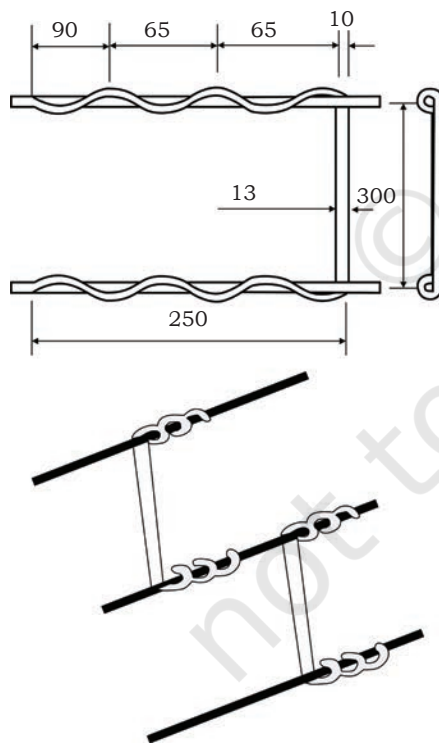


Fig. 4.17 Line Spacers

L.T. Line Spacers

Clashing of L.T. conductors in the mid-span very often takes place due to sag, wind and longer spans (Fig. 4.17). This results in faults and interruptions. In order to overcome this problem spacers are provided. As per REC Construction Standards two types of spacers are generally used:

- **Spiral** - made from high quality PVC. They should be circular with 13 mm diameter.
- **Composite** - made from poly-propylene in a single mould (except the clamping pieces). They should be rectangular strips of 25 mm × 12 mm dimensions.








Fig. 4.18 Vertical Line Spacers



Tools to be used for distribution line maintenance

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Name	Function	Image
Screwdriver	Used to turn, tighten or remove screws	 <p>Screwdriver</p>  <p>Slotted Phillips Robertson</p>
Wrenches	<p>Used to allow rotary motion in only one direction and preventing the motion in opposite direction,</p> <p>Used to tighten nuts of various sizes</p>	
Spanner	<p>Used to provide grip to apply torque for turning objects such as nut or a bolt.</p> <p>A spanner with variable diameter to tighten nuts and bolt of various sizes</p>	  <p>Spanner (Top) and wrench (Bottom)</p>

Survey and Right of Way (ROW)

Survey of the Proposed Route of Line

Initial survey should be carried out for construction of new lines. During line survey various type of crossings i.e. highway crossing, railway, river, telephone lines, E.H.V. lines etc. are to be taken into account. It should be seen that telephone line should not be parallel to power line for excessive length. The induction effect on telephone line will cause disturbance to telephone



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communication and even damage equipment. It is necessary to obtain the approval of P and T Department (B.S.N.L.) for route of lines with voltages of 33 KV and above.

Any crossing should be at right angle i.e. 90 degrees, which enables to keep a short span and safe clearance. If possible, highway and railway crossings should be avoided. Railway authority gives permission for overhead crossing only for E.H.V. Lines. Low and medium voltage lines are to be crossed with underground cables.

Before finalising the route, the following parameters should be kept in mind

1. The shortest route possible.
2. As close as possible to the road for easy maintenance and approach during the construction.
3. Route should be in the direction of possible future load.
4. Angle points should be less.

The areas to be avoided as far as possible are

- (a) Rough and difficult country side
- (b) Urban development area
- (c) Restricted access for transport vehicles
- (d) Abrupt changes in line routes
- (e) Difficult crossing — river, railway lines
- (f) Proximity to aerodromes
- (g) Natural hazards like steep valleys, hills, lakes, gardens, forests, playgrounds, etc.

The route selected for a distribution line shall be such that it will give the lowest cost considered over a period of years, consistent with accessibility for easy maintenance, etc. This includes many considerations such as original cost, tree trimming and compensation, freedom from vehicular damages, future development and availability for services. Transportation contributes to a major portion of construction cost. Hence while finalising the route alignment, it should be ensured that transportation cost should be as low as possible.

Transport of RCC/PSC poles pose greater problems as they are generally heavier than other types of



supports for the same purpose. The RCC/ PSC poles are generally stronger on the longer axis than on the shorter axis. Care should be taken on this aspect while handling, to prevent excessive stressing of the pole at the time of transporting. The unloading of poles from truck or trailer should also be done carefully. Suitable skid boards must be used and on no account, the poles should be dropped. Several utilities have special trucks made with side loading arrangements for pole transportation or trailers should be used. It is preferable to provide a chain pulley block with a beam arrangement in the middle of the truck body to facilitate unloading/ loading of poles. The poles should not be dragged on a rough surface, but transported in small hand-cart.

Detailed Survey

The survey of the overhead lines can be broadly divided into two heads:

- (a) Preliminary 'Walk Over' survey
- (b) Detailed survey

Having provisionally fixed the route, on the survey map, a preliminary 'Walk Over' survey is carried out, before conducting the survey with ranging rods. As far as possible, the line route is taken through areas with minimum tree growth. If there are alternative routes, all such routes are investigated for final evaluation of the most economic route.

Detailed survey can be carried out by the theodolite and angle points can be fixed and marked with survey stones. A route map to a scale of 1cm=0.5km can be prepared showing the various angles, approach roads, near the line, routes detail of railways, communication lines, EHT line crossing, river crossing, etc. But this is not necessary in case of small lines as the local staff usually is conversant with the topography and therefore marking of locations aligning the line with ranging rods is found to be satisfactory.

Right of Way

- (a) Once the route of the line is fixed approval has to be obtained,
 - (i) from the railway authorities for railway crossings,



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- (ii) from the competent forest authorities for routing of the line in forest areas, and
- (iii) from the state level Power Tele-communication Coordination Committee (PTCC).
- (b) In addition if urban development, airport and similar other areas fall in the route of the line, permission has to be obtained from those departments.
- (c) Sometimes private gardens/orchards may fall on the route and require tree cutting. The details of trees are to be marked. Compensation is fixed by revenue authorities and paid to the owner.

Pole Locations

While locating poles on lines, the following general principles are to be kept in mind:

1. Keep spans uniform in length as far as possible.
2. Locate to have horizontal grade.
3. By locating the poles on high places short poles can be used and will maintain proper ground clearance at the middle of the span. In extremely hilly or mountainous areas, poles are located on ridges thereby increasing the spans without greatly increasing the pull on the conductor. This is possible because the sag can be made very large by maintaining the required ground clearance.
4. Poles should not be placed along the edges of cuts or embankment or along the banks of creeks or streams.
5. Cut-point for a section could be at a length of 1.6 km (except in special cases), where double-pole structures should be provided to take tension of the conductors. It may have been already estimated that 10 supports (locations) are mostly required for one km length of H.T. line and 15 supports for L.T. line.

Work permit

Rules regarding work permit and important notices/information:



- Unless line-clear permit is issued by an authorised person, the worker should not climb on pole or apparatus. No one should go in the vicinity of bare conductor and work.
- Only shift engineer or operation in-charge is authorised to issue permit.
- The line-clear permit should only be issued to a person duly authorised for said work.
- The only competent authority to authorise a worker is the executive engineer of that division or superintending engineer. They should issue authorisation order in writing.
- The permit can only be issued or obtained by those authorised persons for the work and jurisdiction as prescribed in the written authorisation order by the competent authority.
- The written order by the competent authority should invariably be displayed on the notice board at the concerned sub-station, power house and distribution centres in a specific format.
- The consolidated authorisation should be kept at the office of the concerned superintending engineer.
- The superintending engineer (SE) or chief engineer (CE) of Circle/Zone can authorise persons other than stated above such as E.E. (Testing) or testing staff (or any other person who is competent to work in the views of concerned SE/CE).
- The area authority should include the names of such authorised persons in their list. The area officer should obtain the list of authorised persons of bulk consumers and area in the vicinity and also handover his list to them.
- Generally, the line inspector or persons of equivalent post are authorised for working on H.T. line/installations. However, division engineer may authorise the person/persons of lower rank, if he is confident about his skills.

Methods for issuing or obtaining and returning the permit:

- For obtaining line-clear permit, only an authorised person should apply. He should apply for line clear permit to the authorised person



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- only and such authority will issue the permit accordingly.
- Where it is not possible to obtain permit in writing then permit can be obtained on telephone. In such a case, the permit obtaining authority should confirm by repeating the matter with permit issuing authority over phone. The same should be noted in the permit book by both the persons. The duplicate copy of line clear permit after cancellation shall be sent to each other by post or in person as early as possible for record. This register should be inspected by area or divisional Officer from time to time.
- The permit book is an important record and should be preserved properly. The pages of permit book should be numbered serially. Pages from this book should not be taken out or torn or used for any other work. In case any page is torn or taken out by some person due to any reason, then the concerned person should sign on the same and make dated entry in the logbook of sub-station/ power house with signature.
- The person, who has taken the permit, should return it. In case where the permit issuing and obtaining authority is same, the self-permit should be taken in his name and cancelled after completion of work. This procedure should be followed strictly.
- In case the permit is taken in person, same can be returned on phone.
- While issuing or returning permit on phone, the code words should be used.

Precautions to be taken while issuing permit:

It is the duty of the shift engineer or person issuing the line clear permit to ensure that the sub-station/ feeder/equipment for which the permit is being issued, should be made dead, i.e., equipment/ feeder should be discharged and properly earthed. First, he should switch off the equipment/feeder as per the instructions laid down. Thereafter, he should adhere to the following instructions regarding grounding and locking of equipment:



- Power T/F should be opened (off position) and locked, at S/stn, respectively.
- Warning boards with following instructions should be tagged on handles of isolators/breakers:
 - Do not charge. Workers are working.
 - The line/equipment under permit - Don't charge.
 - Attention - work in progress - Do not charge the line/equipment.
- The same type of warning boards should be tagged on handles of control switchgear. The control circuit fuse of control panel should also be taken out and kept in the custody of the permit issuing authority.

Duties and Responsibilities of a Distribution Lineman

When the lineman is entrusted with the responsibility of construction (erection of lines, distribution substation, UG/AB cables):

- He shall be responsible for surveying HT lines and LT lines and report to his superiors any variation from the original estimates.
- He shall be responsible for executing the distribution lines and erecting transformers, underground and AB cables as per technical standards.
- He shall be responsible for all T and P issued for execution of work.
- He shall maintain the time rolls and mark the attendance regularly.
- He shall maintain a register showing the allocation of work every day and also write in the same register the progress of work against the allocation.
- He shall prepare pole schedules, after completing the work and handover the same to his superiors.

In case he is put in charge of contract work, he shall be responsible for proper supervision of work and see that the work is executed as per standards. Materials issued to the contractor shall properly be accounted:

- He shall maintain a dairy showing the day to day work done in detail and take the signatures of his next superiors once in a fortnight.



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- He shall be responsible to ensure that the code of safety rules is followed by him and the staff working under him. A copy of the said code is already supplied to him. Any instances where the staff fails to use safety appliances as per the code shall be brought to the notice of his superiors immediately for taking disciplinary action.
- He shall be responsible for upkeep of T and P and safety appliances supplied to him and keep them in working order.

The lineman is entrusted with O and M (operation and maintenance) activities (lines, distribution substation and UG/AB cables):

- To restore power supply in an area as quickly as possible or make arrangements for alternate power supply till power is restored.
- To maintain LT, HT (Low tension, High tension) lines and equipment under his charge as per the schedule fixed up, as well as continuity of supply.
- To report any interruption beyond one hour on LT lines and restoring supply.
- To rectify HT and LT lines by following instructions from superiors for such rectification.
- To maintain distribution transformers/substations in his area of jurisdiction covering oil testing, checking of condition of breather, GO Switch operation, HT Fuses and LT side protection, earthing of transformer body, neutral, etc.
- To attend breakdown of HT and LT Lines in a time bound manner as per performance standards set by the State Electricity Regulatory Commission.
- To replace damaged transformers in a time bound manner as per performance standards set by the State Electricity Regulatory Commission.
- To make proper gradation of fuse in services and all other places where fuses are used.
- To maintain a register showing the allocation of work every day and also record the progress of work against the allocation.
- To supervise work under contract and see that all maintenance work is carried out as per maintenance schedule and as per standards.
- To follow the code of safety rules and encourage the staff working under him to do the same.
- To ensure security of T and P and safety appliances supplied to him and keep them in working order.



Check Your Progress

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A. Fill in the blanks

1. Rail poles are _____ than RCC pole.
2. RCC poles are made by _____ steel rods into concrete slabs of pole-shaped cylinders.
3. Pin-type insulation are commonly used on _____ lines.
4. LT cross arms have been standardised for horizontal as well as _____ formation of conductors.

B. Multiple choice questions

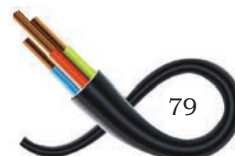
1. Identify which is not a cement pole:
(a) RCC pole
(b) PSC pole
(c) Wooden pole
(d) Rail pole
2. Pin-type insulators are commonly used on:
(a) 11 KV line
(b) 33 KV line
(c) 15 KV line
(d) None of these
3. GO switches are used as:
(a) Switching devices
(b) Cutout devices
(c) Controlling switches
(d) None of these
4. LT line spacers are provided:
(a) To keep distance between wires
(b) For holding wires
(c) For tying of wires
(d) None of these

C. Match the columns

Group A	Group B
1. Distribution Lineman	(a) recruitment of various roles
2. Electricity Act 2003	(b) concerned with grievances
3. DISCOM	(c) construct LT, HT lines
4. Escalation Matrix	(d) allows multiple licensing in distribution

D. Short answer questions

1. Why RCC poles are more preferred in erection of lines?
2. List the factors responsible for selection of poles.
3. Discuss the role of conductors and their types.
4. What is the role of Guy strain insulators?



SESSION 2: SPECIFIC TERMINOLOGY IN DISTRIBUTION LINE

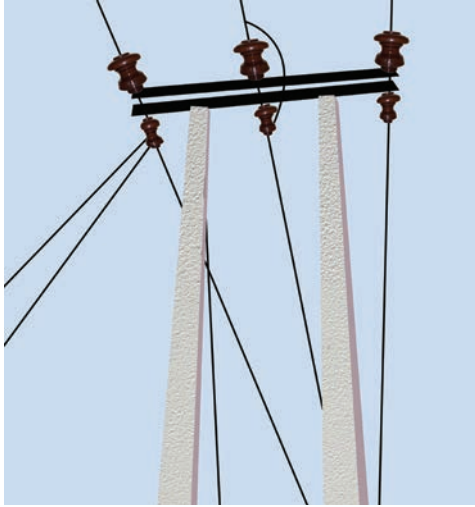


Fig. 4.19 Pole



Fig. 4.20 Tower

Low Tension (LT) Line and High Tension (HT) Line

A low-tension line is a low voltage line and a high-tension line is a high voltage line. In India LT supply is of 400 Volts for three-phase connection and of 230 Volts for single-phase connection. High tension or HT supply is applicable for bulk power purchasers who need 11 kilo-Volts or above.

Overhead Line

Overhead line means any electric supply line which is placed above ground and in the open air.

HT and LT lines upto 33 kV are erected on poles (Fig. 4.19). Extra High Volt i.e., EHV lines of 66,132, 220 and 440 kV are erected on towers (Fig. 4.20).

Peak Demand

It is the maximum load/demand which is recorded during the peak hours representing the simultaneous maximum demand of all the consumers at a particular point. It can be annual peak load, monthly peak load, weekly peak load and daily peak load etc. Peak load for a state is recorded by state load dispatch centre. For different categories of consumer peak/maximum demand will be recorded by the consumer energy installed at their premises.

Load Shedding

Load shedding is normally carried out when the power demand is more than the power availability at a given point of time to shed excess load on the generating stations. Load shedding is carried out on priority basis. Emergency services such as hospitals, fire services, important government office etc. are left out and load shedding is carried out phase by phase. Thus the switching 'OFF' of particular feeder (circuit breaker) to avoid total breakdown due to overload is called shedding.



Power system

The production of electricity and transmission and distribution in our houses, factory or piece of work involves a long process, which consists of operation of power machines and system network. The whole process is referred as the 'Power System' (Fig. 4.21).

Power system can be divided into three broad sections: generations, transmission and distribution and utilisation.

Power generation

Generation of power is done through various sources like thermal, hydro, non conventional as well as nuclear power station.

In thermal power station use of coal, gas and diesel is made for generation of power.

Similarly through hydro power station use of water as well as tidal energy is used for generation of power.

Non conventional energy uses solar, wind, bio fuel as well as agricultural waste.

Nuclear power station uses nuclear energy to generate power.

Transmission

Transmission system is used for transmitting the power for long distances and it consists of transmission lines and substation at extra high voltage and high voltage. In transmission system, two substations are connected at the same voltage.

In transmission, substation consists of transformers, bus bars, circuit breakers, isolators, protection and communication equipments and a control room.

Power Distribution System

Power distribution involves distribution of power received at HV substations to consumers through distribution system which operates at voltages at 33 KV and below. A distribution system consists of electrical sub stations, distribution transformers and distribution lines.

A distribution substation is located near or inside city/town/village/industrial area. It receives power



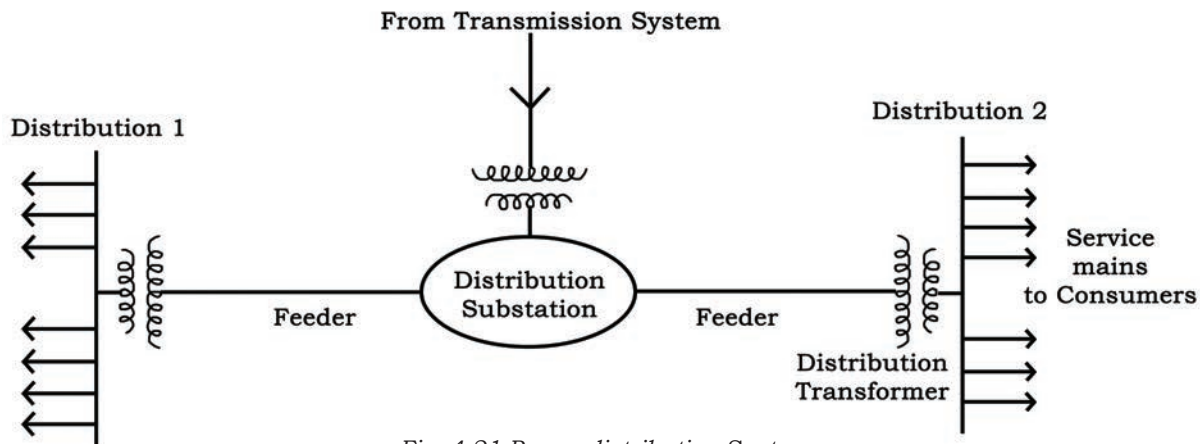


Fig. 4.21 Power distribution System

from a transmission network. The high voltage from the transmission line is then stepped down by a step-down transformer to the primary distribution level voltage.

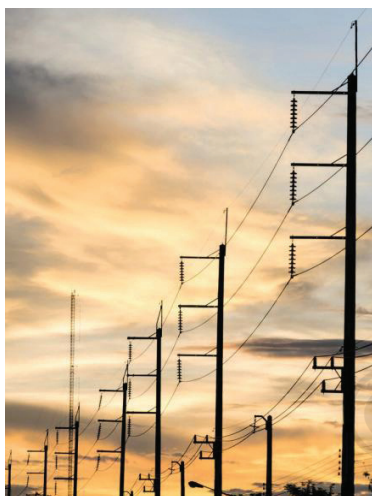


Fig. 4.22 HT Line

- Primary distribution system: It connects the transmission system with secondary distribution network, at 33 kV or 11 kV voltage levels and form the backbone of the distribution system.
- Secondary distribution system: Supplies power to consumers at voltages of 415 volts and/ or 240 volts and constitutes the first contact of utility authorities with the consumers.
- Distribution lines: These include overhead lines and/or cables. The lines in rural areas are mostly radial in nature. The lines in city areas are mostly mesh-like networks often called 'ring mains', which are used to increase the reliability of supply and to meet the high density of loads (Fig. 4.22).

Utilisation refers to the process through which the electricity is put to different uses such as:

- Power for industrial units
- Power for different kinds of household appliances and gadgets
- Power for communication and electrical traction
- Use in medical equipment, electrolysis, etc.

We can say that the voltage of a local transmission line is 13,800 volts. This voltage is then lowered even



further between 220 and 440 volts for industrial use and from 120 to 240 volts for commercial and residential customers.

Difference between Transmission and Distribution Line

Transmission line helps in the movement of electricity from a power plant or power station to the various substations whereas the distribution line carries electricity from the substation to the consumer's end.

In electric power distribution, a service drop is an overhead electrical line running from a utility pole, to a customer's building or other premises. It is the point where electric utilities provide power to their customers.

Common safety warnings

Power lines are not insulated and one should always avoid contact with them. It is quite possible for people to get electrocuted if you touch power lines.

The strongest magnetic fields are usually emitted from high voltage transmission lines — the power lines on the big, tall metal towers. To be sure that you are reducing the exposure levels to 0.5 milli gauss (mG) or less, a safety distance of 700 feet may be needed. It could be much less, but sometimes more.

Power lines produce low-to mid-frequency magnetic fields (EMFs). These types of EMFs are in the non-ionizing radiation part of the electromagnetic spectrum, and are not known to damage DNA or cells directly, according to the National Cancer Institute.

Is there a safe living distance from power lines? Hundreds of studies worldwide have shown that living next to high voltage power lines and other parts of the power transmission network increases your risk of cancer and other health problems. The closer you are the more you are bombarded with dangerous EMFs.

NOTES



A. Fill in the blanks

1. _____ means any electric supply line which is placed above ground line and in the open air.
2. HT and LT lines upto _____ 33 kV are erected on poles.
3. The voltage of a local transmission line is _____ volts.
4. Transmission system is used for _____ the power for long distances.

B. Multiple Choice Question

1. Generation of power is done through various sources
 - (a) Thermal,
 - (b) Hydro,
 - (c) Non conventional as well as nuclear power station
 - (d) All the above
2. Extra High Volt i.e., EHV lines of _____ kV are erected on towers.
 - (a) 66
 - (b) 32,
 - (c) 220 and 440
 - (d) All the above
3. The strongest magnetic fields are usually emitted from high voltage transmission lines are _____ milli gauss
 - (a) 02
 - (b) 03
 - (c) 04
 - (d) 05
4. It is the _____ load/demand which is recorded during the peak hours
 - (a) Minimum
 - (b) Maximum
 - (c) Average
 - (d) None of these

C. Short Answer questions

1. Differentiate between high and low tension line.
2. Define peak demand.
3. Discuss the importance of power distribution system.
4. Why house should not be made near high transmission line.
5. Differentiate between transmission and distribution line.



Construction

The construction activity of H.T. lines is divided into the following:

1. Pit marking, pit digging
2. Erection of supports and concreting
3. Providing of guys to supports
4. Mounting cross-arms, pin and insulators, and pin binding
5. Paying and stringing of the conductor
6. Jointing of conductors
7. Sagging and tensioning of conductors
8. Crossings
9. Guarding
10. Earthings
11. Testing and commissioning

Pit Marking and Digging Procedure

After surveying, the pole location should be marked with the peg. The pits should not be too large than necessary, as otherwise, after erection of the pole and filing there remains a possibility of tilting of the pole. For marking the pits, the dimensions of the pit and the distance from centre of the pits are required. Pits having a dimension of about 1.2m x 0.6m should be excavated with its longer axis in the direction of the line. The planting depth should be about 1/6 length of the support (1500 mm). Excavation is generally done by using pickaxe crow bars and shovel. Very hard or rocky soil may require blasting of rock by small charges of gun powder, etc.

Erection of Poles and Concreting

After excavation of pits is completed, the supports/poles to be erected are brought to the pit location by manual labour or by cart. Then the pole is erected inside the pit. Erection of poles can be done by using bipod/wooden horse made of 15 cm G.I. pipe and 6m long. The distance between the legs should be



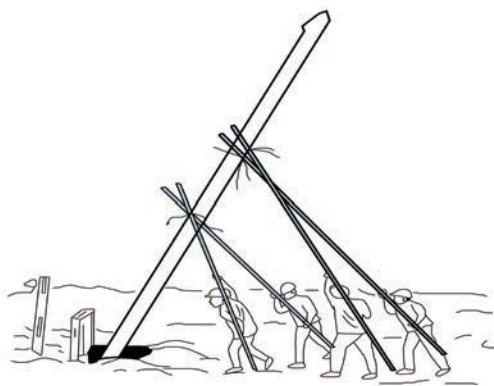
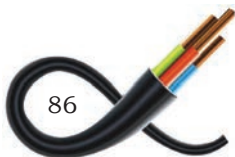


Fig. 4.23 Erection of pole

10 m. The tie wire for attachment of bipod to the pole is about 6 m long and is made of 7/10 SWG (3.15mm) stay wire and this wire should be attached to the pole at 8m. The pole is slid along the line route. The pole is tied with three ropes. The rope at the bottom prevents the pole from dragging in the direction of the pull. To prevent the support from the moving side from rising, two guy ropes are fixed on both sides and attached to a temporary anchor. For smooth sliding and perfect placement of pole in the pit, an inclined trench having 15.2 cm (6 in) width and 10.2 cm (4 in) length may be dug adjacent to the pit as shown in fig 4.23. A piece of M.S. channel is placed in an inclined position at the opposite end of the pit for enabling the pole to slip smoothly inside it. The trench would facilitate the pole to skid smoothly into the pit with jerks. The bipod is placed in position and attached to the pole by means of tie wire. The rope pulley is used to pull for lifting the poles. When the pole has reached at an angle of (35° to 40°) the derrick and bottom holding rope is slowly released. When the pole assumes the vertical position, the holding ropes should be tightened.

It should be ensured that during the time of erection, the two men shifting the bipod while raising the pole when it is free at a 40 degree angle, will also join the other two men who are holding the rope. The supervisor should be at a distance, guiding correct position so that in the event of breaking of rope, if the pole falls, it will not cause an accident.

Before the pole is put into RCC, padding or alternatively suitable base plate may be given below the pole to increase the surface contact between the pole and the soil. The padding will distribute the density of the pressure due to weight of the pole on the soil. After lifting the pole it should be kept in a vertical position with the help of manila rope of 20/25 diameter, using the rope as a temporary anchor. The alignment of the poles should be checked and set right by visual check. The verticality of the poles are to be checked with a spirit level. After the pole erection has been completed,



and confirming that the verticality and alignments are all right, earth filling and ramming should be done (Fig.4.23).

In swamp and special locations, before earth filling, the poles are to be concreted up to the ground level of the pit. After poles have been set, the temporary anchors should be removed.

Erection of Double pole (DP) Structure for Angle Locations

Double pole structures are required in all the angle locations as well as in the tangent locations. DP is erected at a distance of every one kilometre as line DP. For angles of deviations more than 10°, DP structure should be erected. The pit digging should be done along the bisection of angle of deviation.

After the poles are erected, the horizontal/cross bracing should be fitted and the supports should be held in a vertical position with the help of temporary guys of Manila rope 20/25 mm diameter. Ensuring that the poles are held in vertical position (by spirit level) the concreting of poles with 1:3:6 ratio may be done from bottom of the pole to the ground level. Before lifting the pole in the pit, concrete padding of not less than 75 mm thickness may be put up for the distribution of the loads of the support on the soil or anchor plate should be used.

Concreting

The concreting mixture 1:3:6 ratios would mean 13 bags of cement 100 cft of stone and 50 cft of sand. It may be noted that while preparing the concrete mixture large quantities of water should not be used as this would wash away cement and sand.

Table 4.4 General proportions of Concrete Mixer

	Material	Proportion 1:3:6	Proportion 1:2:4	Proportion 1:4:8
1.	1×1/4 Stone Metal	100 cft	100 cft	100 cft
2.	Sand	50 cft	50 cft	50 cft
3.	Cement	13 bags	20 bags	10 bags
4.	Water	484 ltr	484 ltr	484 ltr



NOTES

11 kV Line

Normally 10 poles are erected within 1 km distance (average span length 100-105m).

Stays

After the pole erection is over, guying or putting stays is carried out. The following are different types of stays used in distribution lines (Fig.4.24).

1. Ordinary Stay
2. 'A' Type
3. Self Stay ("B" type)
4. 'Y' stay
5. Flying stay
6. Strut
7. Storm guys

Ordinary Stay: This type of stay is generally used. The size of stay rod, turn buckle and stay wires are to be used as per the line tension. Generally, for H.T. lines of 19 mm (3/4") diameter stay rod, 20 mm (5/6") size eye bolt, and 7/8 size stay wire are used and for L.T. lines of 15 mm (5/6") stay rod, 12.5 mm (1/2") eyebolt and 7/10 size stay wire are used. Stay insulator shall be used at a vertical height of 3 meter (10") from the ground.

'A' Type Stay: When the line tension is less and there is no sufficient space for stay, this type of stay is used. In cities, many times, there is no sufficient space for stay. At such places, the stay pit is dug at a short distance from the pole and hence cannot take adequate tension. A support angle is fixed to the pole. Arrangement is available to affix the stay wire to the angle. This is called "Stay out trigger". This type of stay looks like English 'A'.

Self Stay or 'B' Type Stay: When there is no space for stay, the lower portion of the stay wire is clamped by stay clamp to the lower portion of the pole. Such type of stay is called Self stay or 'B' type stay.

'Y' Type Stay: It is used for supporting guarding cross arm. It is also used for side brackets.

Flying Stay: When the line is on the roadside and there is no space for stay, pole piece of sufficient height is erected at the other side of the road and a stay wire is



tied up between pole and pole piece. For giving tension to the pole piece, stay wire and stay rod are used.

Strut (Stud): When the pole is on the roadside and there is no space for stay, one pole is used as a support to the line pole from opposite side of the stay. The support pole is called “strut”. Strut is fixed to line pole by a suitable clamp.

Storm Guys: When the line is straight and the distance from one cut-point to another is more, this type of stay is used. At mid-pole of the line, two stays at an angle of 60° on both sides are tied up. Such type of stay is called “Storm Guys”. For angle location, stays are to be given in such a way that tilting of the pole due to conductor tension is avoided. Stay insulators are used to obstruct the leakage current.

Stay Binding: The stay should be linked with pole earthing and/or neutral wire using G.I. so that leakage current will pass through earthing or neutral to the ground. Such binding is called “Stay Binding”.

Remember

1. if stay insulator is not provided, 8 S.W.G. G.I. wire shall be used near the stay clamp and link it to neutral conductor. The length of G.I. wire should be sufficient to join the stay wire to neutral of L.T. line or in case of H.T. line, to the H.T. earthing. This G.I. wire should be well bound to the earthing or neutral.
2. stay insulator should not be less than 10 ft from the ground.

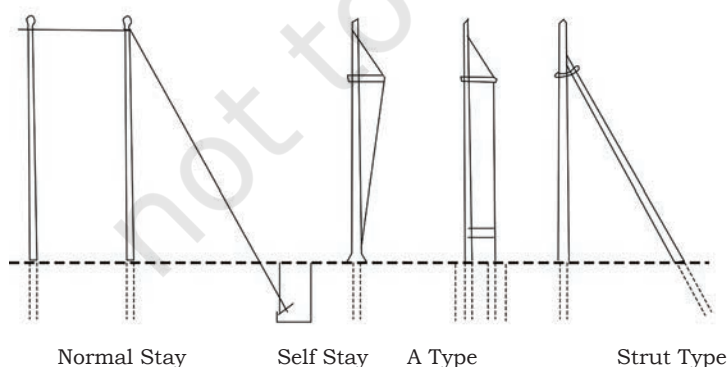


Fig. 4.24 Types of stay

3. While binding the stay, pole should not be tilted.
4. Thimble is necessary for stay binding. If the thimble is not available, the portion on stay wire on eye bolt should be binded properly.

REC construction G4 gives the details of various guys. The figure 4.25 gives the detail of stay set arrangement for 11kV/LT Line.

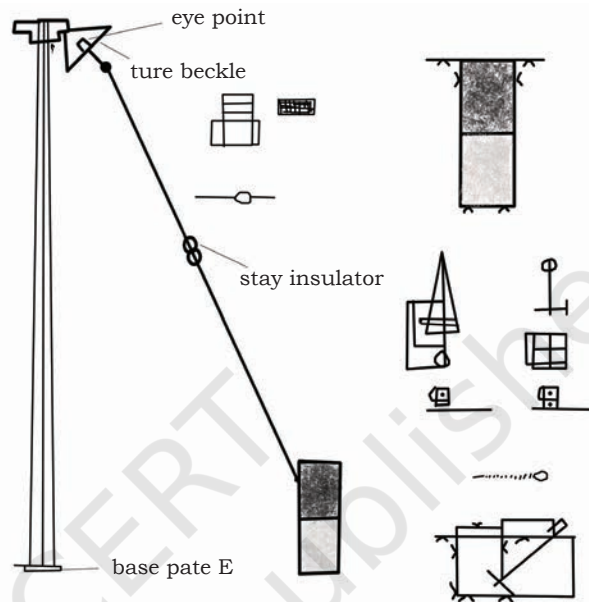


Fig. 4.25 Erection of stay

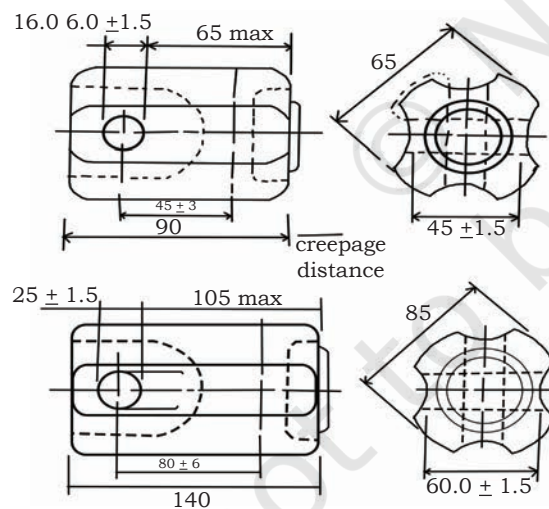


Fig. 4.26 Dimensions of stay

Fifteen locations are there within 1 km. Provision for 9 guy-sets is made with 7/3.15 stay-wire (5.5kg). The turn-buckle M.S. rod of 16 mm diameter concrete quantity at the rate of 0.2 cm per stay-set should be provided. Either base pad should be used or additional provision for base pad-concreting should be made (Figs. 4.26 and 4.27).

11 kV and LT Stay erection

Guy Strain Insulators

Guy strain insulators are placed to prevent the lower part of the guy from becoming electrically energised by a contact of the upper part of the guy when the conductor snaps and falls on them or due to leakage. No guy insulator shall be located less than 3.50 meter (vertical distance) from the ground.



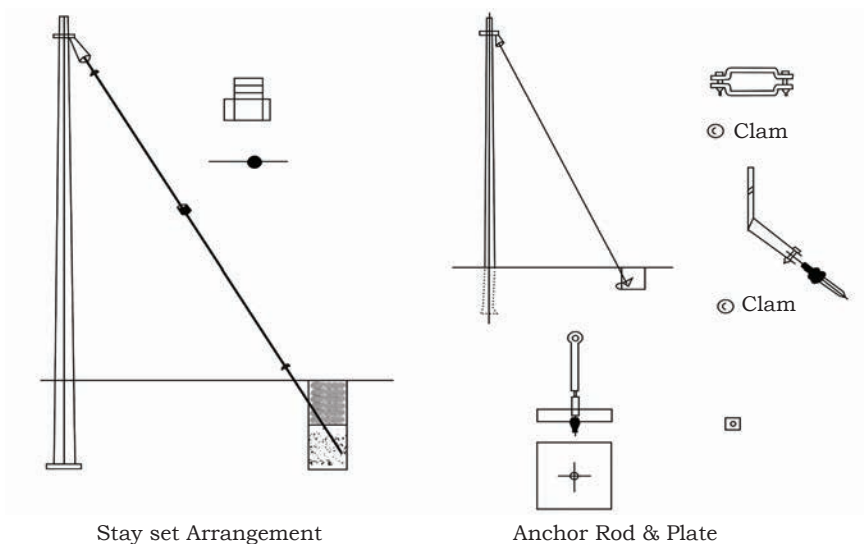


Fig. 4.27 Construction of various components of stay

Fixing of Cross-Arms and Top-brackets

After the erection of supports and providing guys, the cross-arms and top-brackets are to be mounted on the support with necessary clamps, bolts and nuts. The practice of fixing the cross-arms a bracket before the pole erection is also there. In case, these cross-arms are to be mounted after the pole is erected, the lineman should climb the pole with necessary tools. The cross-arm is then tied to a hand line and pulled up by the ground man through a pulley, till the cross-arm reaches the lineman. The ground man should station himself on one side, so that if any material drops from the top of the pole, it does not strike him. All the materials should be lifted or lowered through the hand line, and should not be dropped.

11 kV 'V' cross arm fixing

Insulators and Bindings

Line conductors are electrically insulated from each other as well as from the pole or tower by non-conductors, which we call 'insulators'.

There are 3 types of porcelain insulators

1. Pin type
2. Strain type
3. Shackle type

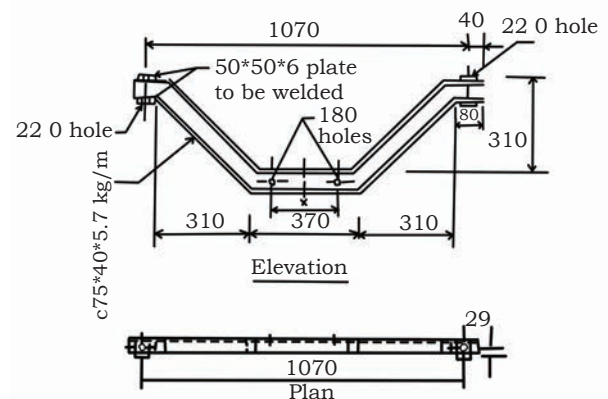


Fig. 4.28 11 kV 'V' cross arm specification



The pin type insulators are generally used for straight stretch of line. The insulator and its pin should be mechanically strong enough to withstand the resultant force due to combined effect of wind pressure and weight of the conductor in the span. The strain insulators are used at terminal locations or dead-end locations and at places where the angle of deviation of line is more than 10° . The shackle type of insulators are used for L.T Lines (Figs. 4.28 and 4.29).

The pins for insulators are fixed in the holes provided in the cross-arms and the pole top brackets. The insulators are mounted in their places over the pins and tightened. In case of strain or angle supports, where strain fittings are provided for this purpose, one strap of the strain fitting is placed over the cross-arm before placing the bolt in the hole of cross-arms. The nut of the straps is so tightened that the strap can move freely in horizontal direction (Fig. 4.30).

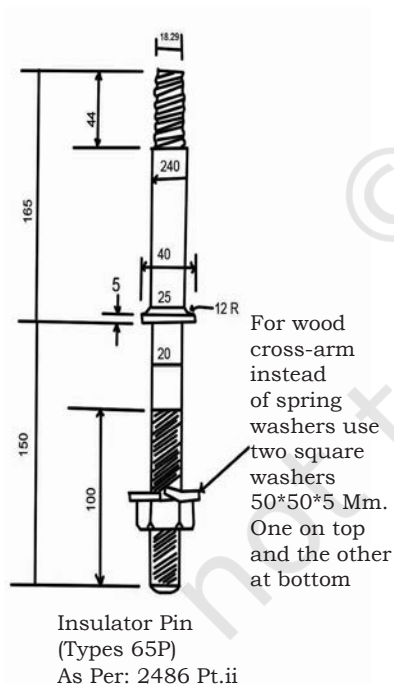


Fig. 4.30 Specification of GI pin

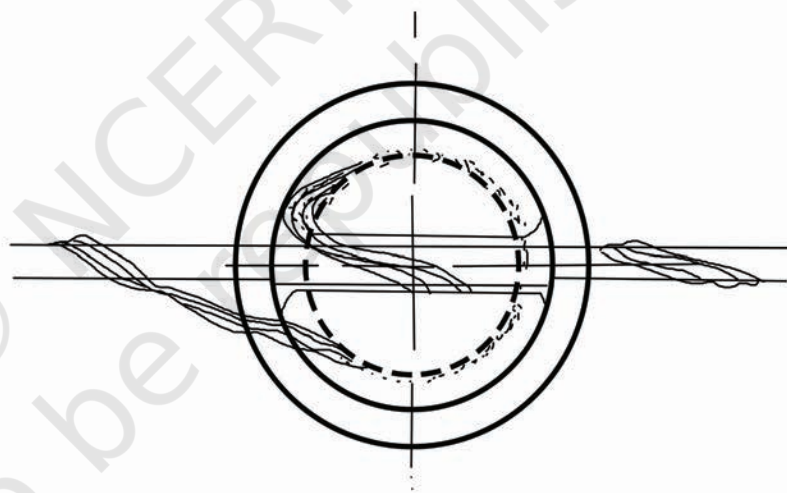


Fig. 4.29 Binding of pin insulator

Tying of Conductor on Pin Insulators

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

In straight line, the best practice is to use a top groove insulator. These insulators will carry grooves on



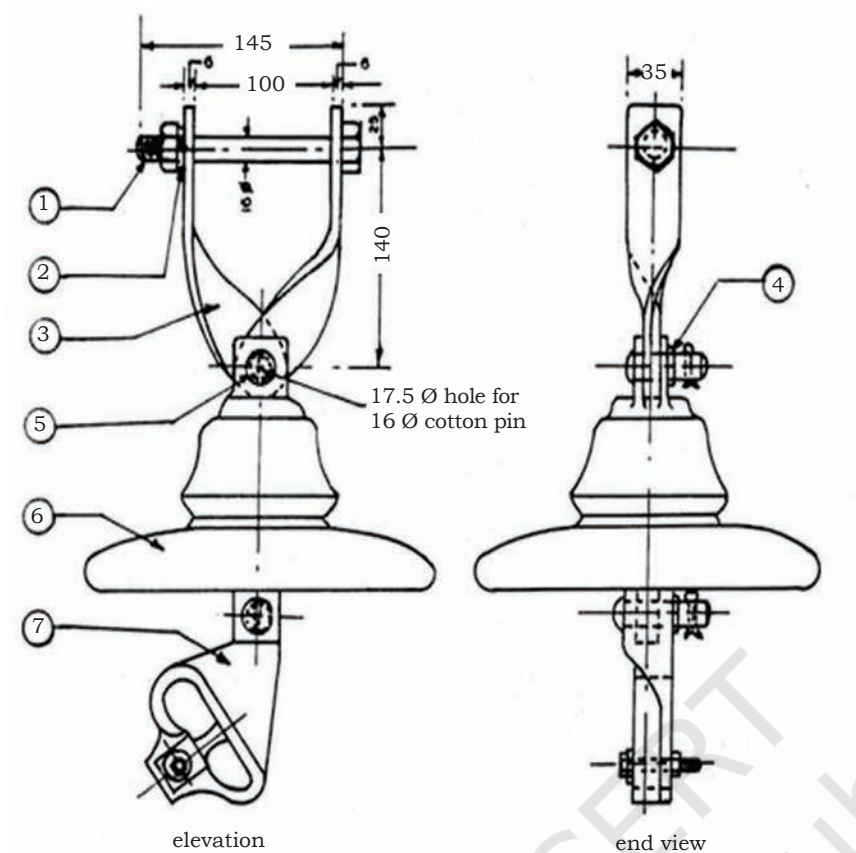


Fig. 4.31 Fixing of Disc Insulator

the side as well. When the conductor is placed on the top groove, the tie wire serves only to keep the conductor from slipping out (Fig. 4.31).

On corners and angles (below 5 deviations) the conductor should be placed on the outer side of the insulators. On the far side of the pole, this pulls the conductor against the insulator instead of away from the insulator.

Kind and Size of Tie Wire to be used

In general the tie wire should be the same kind of wire as the line wire i.e. aluminium tie wire should be used with aluminium line conductor. The tie should always be made of soft annealed wire so that it may not be brittle and injure the line conductor. A tie wire should never be used for second time. Good practice is to use number '6' tie wires for line conductor. The length of the



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wire varies from 1m for simple tie of small insulators (LT pin insulators) to 3 m (33 KV pin insulators).

Rule of Good Tying Practice

1. Use only fully annealed tie wire.
 - (i) Use that size of tie wire which can be readily handled, yet one which will provide adequate strength.
 - (ii) Use length of tie wire sufficient for making the complete tie, including an end allowance for gripping with the hands. The extra length should be cut from the end if the tie is completed.
 - (iii) A good tie should:
 - Provide a secure binding between line wire insulators and tie wire.
 - Have positive contacts between the line wire and the tie wire so as to avoid shifting contacts.
 - Reinforce line wire in the vicinity of insulator.
 - (iv) Avoid use of pliers.
 - (v) Do not use the wire which has been previously used.
 - (vi) Do not use hard drawn wires for tying.
2. Good helical accessories are available and can be used.

Conductor Sagging and Erection Stringing

Conductor erection is the most important phase in construction. The main operations are:

- Transportation of conductor to work site
- Paying and stringing of conductor
- Joining of conductor
- Tensioning and sagging of conductor

The conductor drums are transported to the location. While transporting, precautions are to be taken so that the conductor does not get damaged/ injured. The drum could be mounted on cable drum support, which generally is made from crow-bar and wooden slippers for small size conductor drums. The direction of rotation of the drum has to be according to the mark in the drum so that the conductor could be drawn. While drawing the conductor, it should not rub causing damage. The conductor could be passed over



poles on wooden or aluminum snatch block mounted on the poles for this purpose.

The mid-span jointing is done through compression crimping or if helical fittings are used the jointing could be done manually. After completing the jointing, tensioning operation can be started. The conductor is pulled through come-along clamps to string the conductor between the tension locations. Sagging of conductor has to be in accordance to the Sag Tension chart. In order to achieve it, it is preferred to pull the conductor to a tension a little above the theoretical value so that while transferring it from the snatch blocks to the pit insulators and to take care of temperature variation proper sag could be achieved. Sagging for 33/11 kV line is mostly done by 'sighting'. A horizontal strip of wood is fixed below the cross-arm on the pole at the required sag. The lineman sees from other end and the sag is adjusted by increasing or decreasing the tension. The tension clamps could then be finally fixed and conductor be fixed on pin-insulators. All fittings, accessories like guys, cross-arms, etc., could be checked as they

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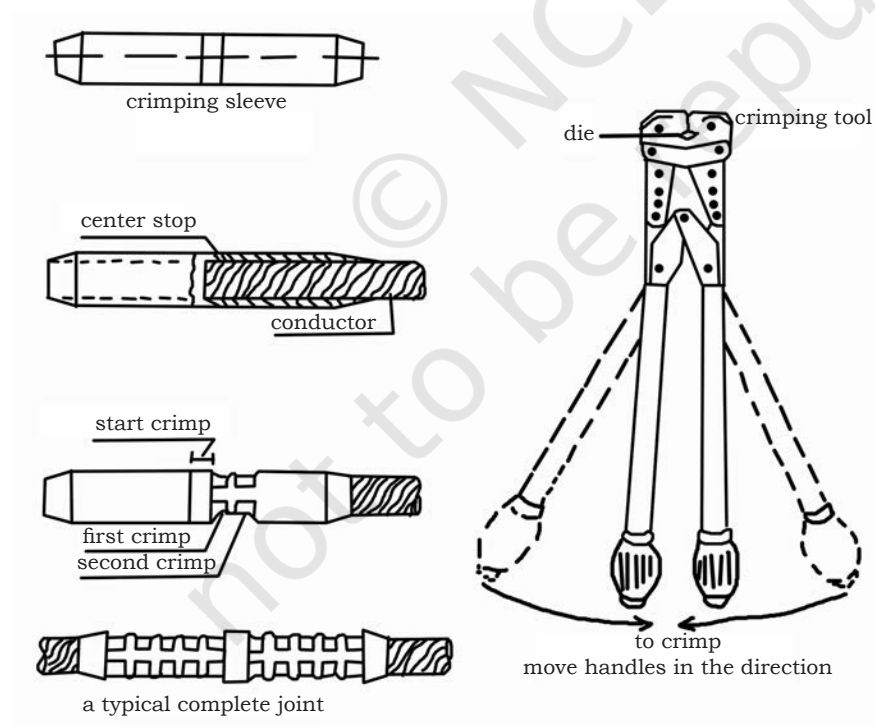


Fig. 4.32 Crimping of ACSR and AAC conductor

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should not have deformities. Along the overhead line where the conductor is to be strung, four number of wheel consisting of wooden circular base provided with vertical steel rod is placed, which is loaded with the conductor drums (as required). These conductors, say three in number are dragged using the 'come along' tool by either labourers, tractor or pulling machine along the line supports (Fig. 4.32).

This bunch of conductors is lifted up to the cross-arms by a man on the pole-top using a pulley and rope. And a handful of other labourers pull the other end of the rope. Thus, the conductor reaches the cross-arm. A similar procedure is followed for all the poles before sagging.

Ground Clearance

- Specified clearances are to be maintained at the lowest point of the span with maximum sag as per CEA Gazette Notification 2010
- Maximum sag is related to the temperature
- Tension of conductors is to be limited so that F.O.S. is 2

Keeping all these parameters in view, sag-tension charts are to be drawn for each conductor size, so that, while constructing the lines, these charts are referred for keeping proper sag and tension at the atmospheric temperature at that time. This will help in maintaining required clearance.

Maximum Clearance between Supports

The supports are designed to withstand certain working load. This governs the distance (span) between two supports. The load on the supports depends upon wind pressure on conductors, surface area of the support, fittings etc. The greater the wind pressure zone area the lesser the span. REC has issued Construction Standards for span for 11kV and LT Lines for various wind pressure zones i.e. 50 kg/m, 75 kg/m and 100 kg/m. The span for 11kV for 50 kg/m is 107meters and it gets reduced at higher wind pressure.



Table 4.5 11 kV Line—Triangular Configuration (Rec Construction Standards)

Conductor size (Normal AI area)	Working load of supports	Maximum permissible span in meters in a wind pressure zone of		
		50 kg/m	75 kg/m	100 kg/m
Rabbit ACSR (equivalent AAAC 7/3.15)	140 kg	107 (107)	67.5 (72)	NR
	200 kg	NR	104 (107)	73.5 (78.0)
Weasel ACSR (equivalent AAAC 7/2.5)	140 kg	107 (107)	87.5 (90)	NR
	200 kg	NR	107 (107)	95 (98)
Squirrel ACSR(equivalent AAAC 7/2)	140 kg	107	107	NR
	200 kg	NR	107	107

LT lines (3 phase 4 wire) 8 m supports (3 phase – 4 wire) line vertical formation

- (i) Above spans will suit for single phase lines also.
- (ii) 3 phase-5 wire lines are required to provide street lighting in the inhabited areas where spans have to be limited to get normal intensity of light hence the details are not given.

Table 4.6 Maximum permissible spans with ACSR, AAAC and AAC Conductor

Conductor Size (Normal AI area)	Working load of Supports	Maximum permissible span in meters in a wind pressure zone of		
		50kg/m	75kg/m	100kg/m
ACSR Rabbit (equivalent AAAC 7/3.15)	140 kg	99 (103)	62.5 (63)	NR (NR)
	200 kg	NR (NR)	93.5 (98)	66.5 (69)
ACSR Weasel (equivalent AAAC 7/2.5)	140 kg	99.5 (107)	77.5 (77)	NR (NR)
	200 kg	NR (NR)	99.5 (107)	82.5 (83)

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ACSR Squirrel (equivalent AAAC 7/2)	140 kg 200 kg	100.5 (107) NR (NR)	91 (91) 100.5 (107.0)	NR (NR) 97 (99)
AAC (Ant)	140 kg 200 kg	71.5 NR	66.5 67.5	NR 63
AAC (Gnat)	140 kg 200 kg	73 NR	66 66	NR 59.3

Overhead Conductor Stringing

Along the overhead line where the conductor is to be strung, four wheels consisting of wooden circular base provided with vertical steel rod are placed, which are loaded with the conductor drums (as required). These conductors, say, three in number are dragged using the 'come along' tool by either labourers, tractor or pulling machine along the line supports.

This bunch of conductors is lifted up to the cross-arms by a man on the pole-top using a pulley and rope. A handful of other labourers pull the other end of the rope. Thus, the conductor reaches the cross-arm. The details are shown in figure 4.33. A similar procedure is followed for all the poles before sagging.

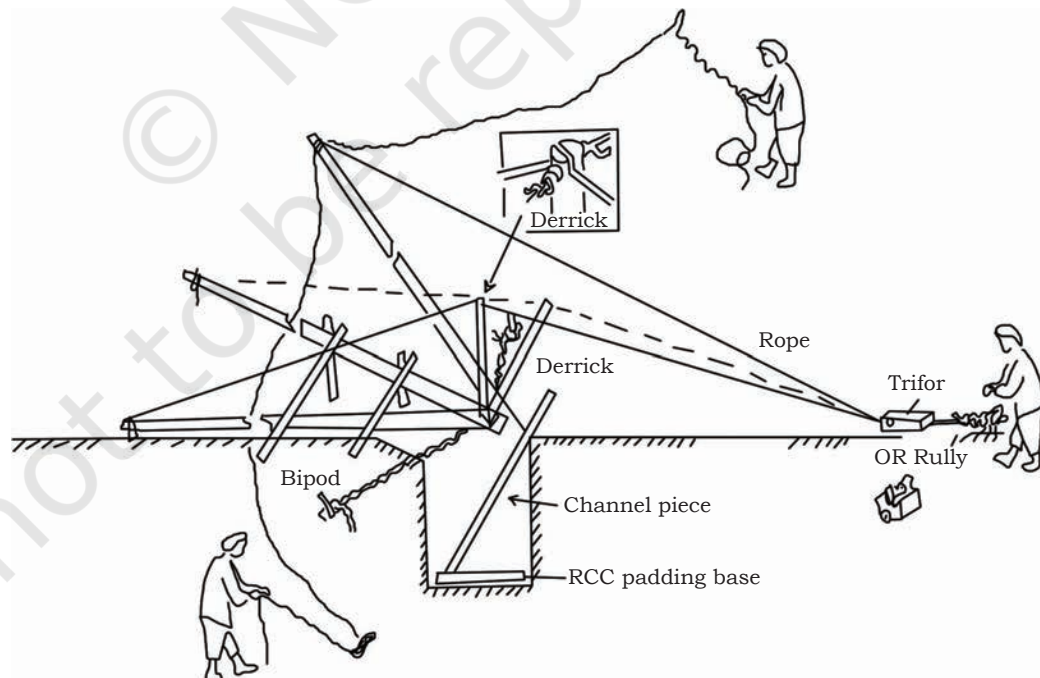


Fig. 4.33 Derrick Method



Sagging and Tensioning

The variation in the atmospheric temperature results in the increase or decrease of the length of the conductor of a section. In summer, when temperature is high, the length increases due to expansion and in winter, when the temperature is low the length decreases due to contraction. With increase in length, the conductor becomes loose, sag increases and tension reduces, while in winter the sag decreases, tension increases.

11 kV Fixing and binding of strain Insulator

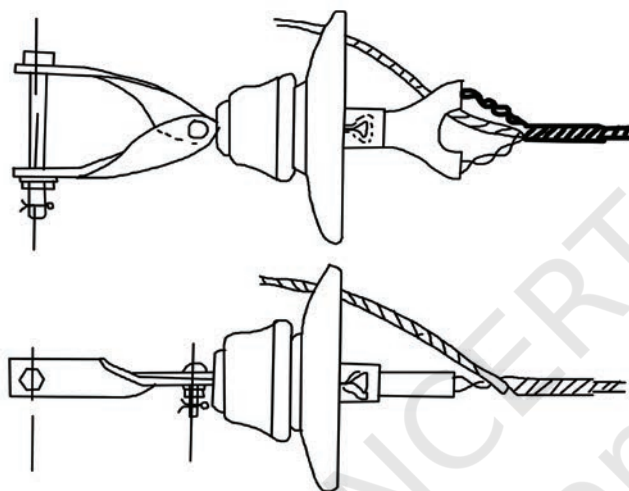


Fig. 4.34 Strain Insulator Assembly with Helically Formed Fittings

There are two important factors which affect the sag and tension:

- Elasticity of the conductor and
- Temperature

Sag is directly proportional to wind pressure load (W) and inversely proportional to temperature (T). If the length of the conductor increases due to temperature increase then sag will increase. This may be the case in summer, while it may be reverse in winter. The tension will accordingly decrease or increase.

In order to keep the sag and tension values under varied working conditions according to the regulations, Sag-Tension charts are prepared for different spans and temperatures for ACSR, AAAC and AAC conductor.



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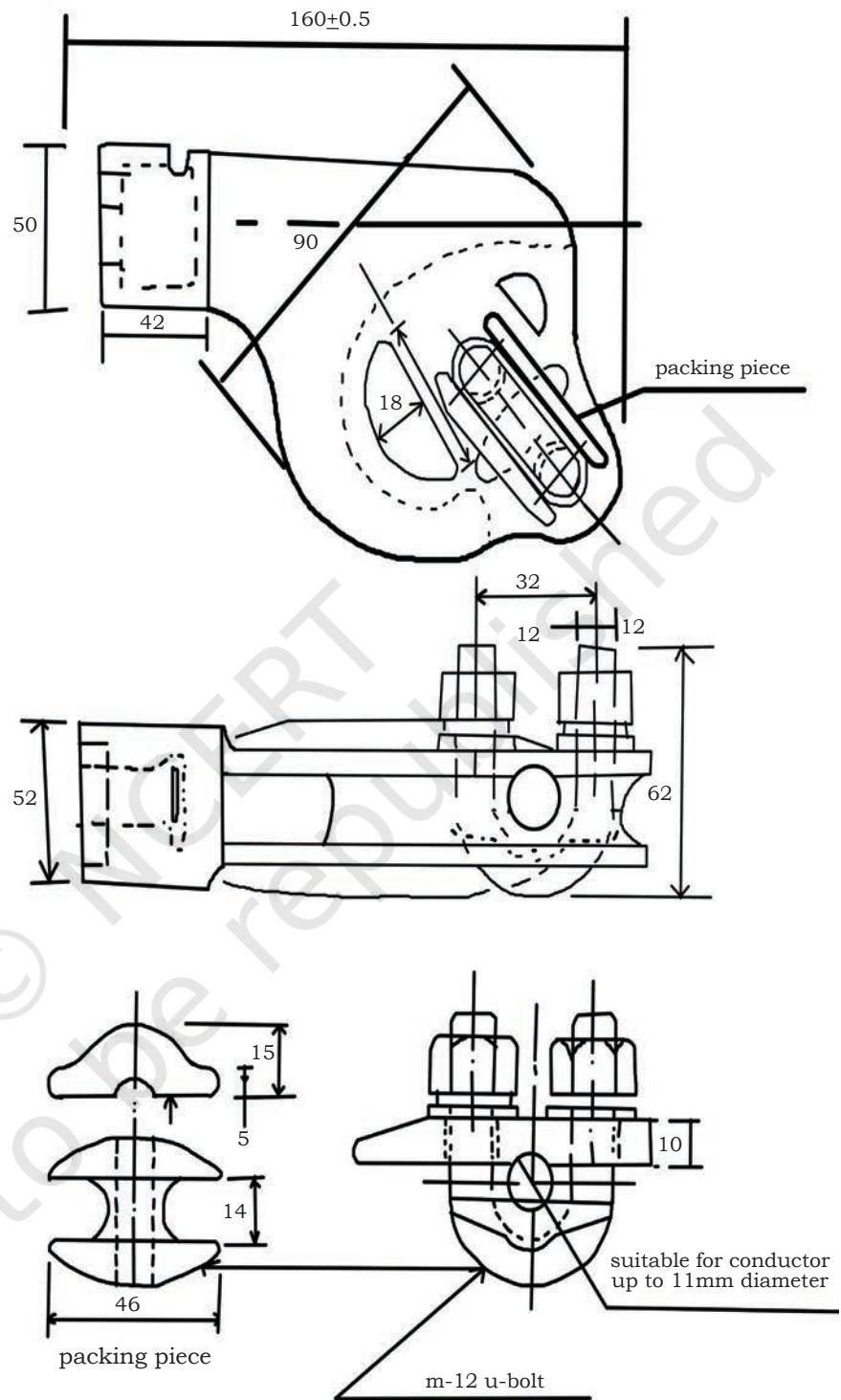


Fig. 4.35 11kV Strain Clamp for Ball and Socket type insulator



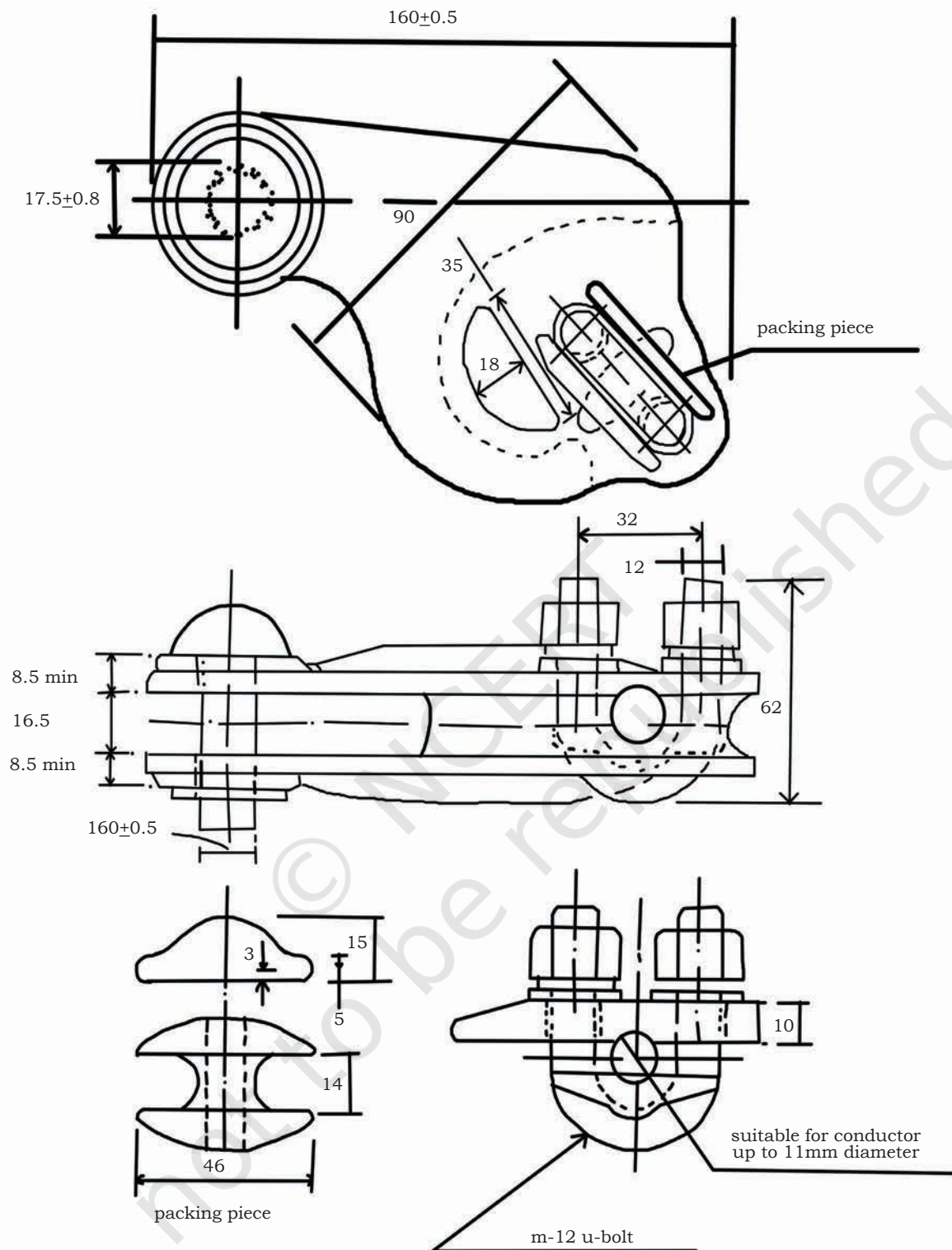


Fig. 4.36 Fixing of Disc insulator

Conductor Jointing

The length of distribution lines are in kilometers and one coil of conductor is not able to solve the length problem. Hence jointing the conductor is necessary.

Another necessity of jointing the conductor is breaking of the conductor for some reason.

Types of Joints

(1) Britannia, (2) Telephone, (3) Married Joint, (4) T" joint, (5) Sleeve joints, (6) Compression joint.

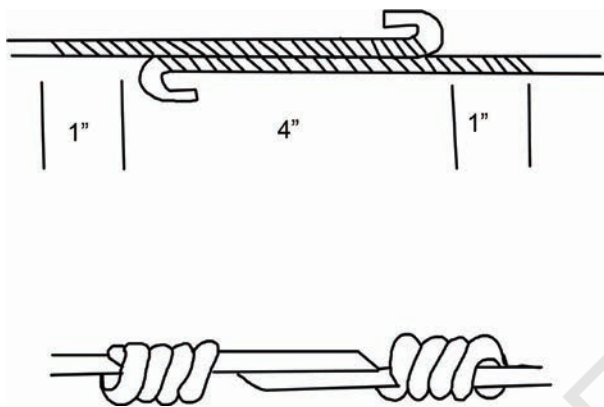


Fig. 4.37 Britannia Joint

Britannia Joint: This type of joint is made only on solid conductors and cannot be made on stranded conductor. Two conductors of length 6 inches (150 mm) are brought in front of each other to be joined. Then both conductors should be cleaned to make sure that they are rust free. If the conductor is of copper; it should make good electrical connection.

Then ends of both the conductors are bent through half centimetre and placed on each other. The length of the contact portion should be minimum 100 mm. This joint should be bound by 14 mm copper wire as shown in the figure (Fig. 4.37).

Telephone Joint (Western Union): This joint is used only for solid conductors. It is used for conductors of size 8 SWG or higher size. First, they are bent at 100 to 125 mm from the edges and are placed over each other. Then each one is twisted with another conductor.

Married Joints: This joint is made between copper conductors having central strand of G.I. wire. This joint should not be made between Al conductors. Approximately 175 to 200 mm of conductor strands are unwound. The G.I. strand of both conductors should be broken up to a length of 175 mm. Both conductors should be brought in front of each other and their strands should be woven with each other. The strand of one conductor is twisted on another conductor, and the strand of the other conductor is twisted on the first.



Likewise all the strands are twisted and then soldered. This is used only for small span length (Fig. 4.38).

‘T’ Joint: This joint is made with stranded conductor. This joint cannot take tension. It is used for jumper or tapping in sub-station. The conductor strands to be separated up to 100 mm. Then middle steel strands are cut. Then it shall be placed to horizontal conductor with three strands each on either side and shall be twisted over the horizontal conductor (Fig. 4.39).

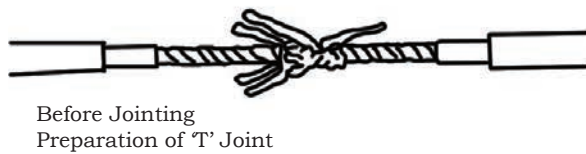


Fig. 4.38 Married Joint



Fig. 4.39 'T' Joint

Sleeve Joint: It can be made with any type of aluminium conductor. Graphite grease is applied over the conductor and as shown in figure 4.40 two Al sleeves should be taken. These sleeves should be placed on the conductor as shown. Sleeves should be twisted by twisting wrench. This joint is made for L.T., H.T., ACSR, AAC conductor up to 0.06 cm^2 (Fig. 4.40).



Fig. 4.40 Sleeve Joint

Compression Joint: This joint is used for conductors of more than 0.06 cm^2 sizes. For preparing these joints, two different sleeves are used. There are two holes in Al sleeve. Rebating is done through these holes. Slide aluminium sleeves are slid over one conductor. It is slid until only the working length protrudes. The next step will be cutting of the aluminium strands for installation of the steel sleeve. It is measured back from each end of the conductor and then a distance equal to half the length of the aluminium sleeve is marked. The cut

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line is then marked. The marked location for cutting should be taped. The outer strands are cut with a rotating tool until the layer becomes loose. To prevent nicking, the core inner layer should not be cut. The wire in the inner layer is removed by hand. It is extremely important to note that a small cut on the core should not be disturbed while cutting the aluminium strands. If this happens, the ultimate strength of the joint will be reduced. Repeat the above process with another conductor. Insert the conductor's core into the steel sleeve, making sure that the ends butt solidly against the center stop. Also, ensure the distance from the end of the barrel to the aluminium strand. Lubricate the sleeves with solid lubricating wax. Remove the tape from the ends of the aluminium strands. Set the steel sleeve into the compressing tool. Choose a proper size of the die for steel sleeve. Make initial die compression at the centre of the steel sleeve. Make compression on both sides of the centre compression. Overlap successive compressions by approximately 0.5 inches. Choose one side and compress it to the end. Repeat the same process to the other side also. The aluminium sleeve extrudes beyond the steel sleeve. Remove and clean the steel sleeve. Now change the die in compressing tool for the aluminium joint compression. Slide the aluminium sleeve over the steel sleeve until the end of the barrel aligns with the marks placed on the conductor. Inject the filler compound through holes. This filler compound protects the steel barrel from corrosion, cleans the strands by removing oxides while compressing. Now make the initial compression on either side of the splice beginning at the start mark. Continue making compressions on one side to the end. Complete the compression on the other side also. The centre portion of the splice is not compressed.

Jumpering

Connecting two conductors or wires is called Jumpering.

1. Jumper should not be connected to main conductor. The jumper should always be connected by P.G. clamps as shown in Fig 4.41.



2. When the jumpers are near metallic portion, all such jumpers are covered with alkathene pipe.



Fig. 4.41 Jumpering

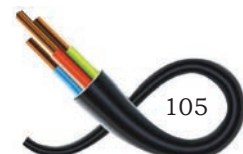
3. Conductor joints are marked on A.C.S.R. conductor when dispatched. Mid span joint should be made before stringing because the steel strand is not kept continuous. Hence it is necessary to replace the company joint.
4. Care should be taken that mid span joint will not be less than 40 feet from pole.
5. Every joint should be done carefully.
6. Where conductor strands are cut, repair sleeve is used.
7. Conductor joint strength should be 95% that of conductor, and resistance should be that of main conductor.

Guarding

Guarding is an arrangement provided for the lines, by which a live conductor, when accidentally broken, is prevented to come in contact with other electric lines, telephone or telegraph lines, railway lines, roads, and persons or animals and carriages moving along the railway line or road, by providing a sort of cradle below the main electric line. Immediately after a live conductor breaks, it first touches this cradle guard of G.I. wires before going down further. This, in turn, trips the circuit breakers or H.T./L.T. fuses provided for the H.T./LT. lines, and the electric power in the conductor or the line is cut off, and danger to any living object is averted.

Guarding is not required for crossings of 66 kV and higher voltage lines where the transmission line is protected by fast acting relay operated circuit breaker of modern design with a tripping time of even less than the order of 0.25 seconds from occurrence of fault to its clearance. For all other crossings, like railway tele-communication lines and major road crossing guarding is essential.

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The minimum height between any guard wire and live crossing conductor shall not be less than 1.5 m in case of a railway crossing (Fig. 4.41).

Types of Guarding

- (i) P.V.C. Guarding
- (ii) Levice Guarding

P.V.C. Guarding

This is mainly used for L.T. Lines passing through agriculture field. This is used where formation of line is vertical. The upper end is tied in shackle bolt and lower end is tied to the neutral. A G.I. wire frame is prepared so that there will be horizontal G.I. wire piece at equal distance below every conductor. The vertical wires of the frame are insulated with P.V.C. pipe. Even during conductor swings, it will not be earthed due to P.V.C. pipe. In case of snapping of conductor, it will make contact with the G.I. wire and get earthed, resulting blowing of the fuse (Fig. 4.42).

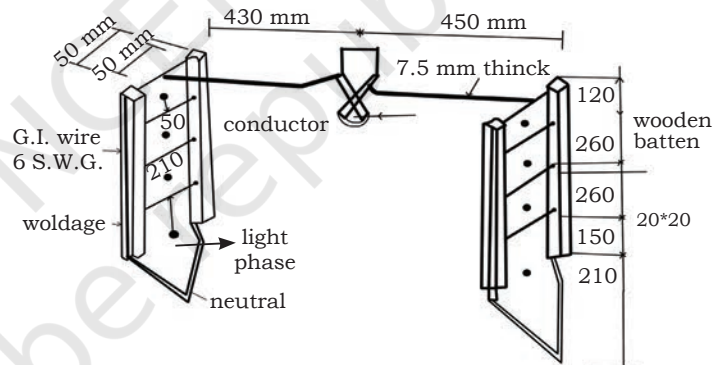


Fig. 4.42 Vertical Type Guarding

There are two types of guarding according to the formation. A). To use in case of 'D' clamps. (B) Direct shackle type.

Levice Guarding

This is of the following types:

- (i) Carpet guarding
- (ii) Cradle guarding
- (iii) Box type guarding

There are two, three or four guard wire for levice guarding. These are bound with cross arm. The horizontal laces at



a specific distance are tied up to the above wires. This guarding is used up to 33 KV lines.

(i) Carpet Guarding: The specific length cross arms are fixed on the poles. Four G.I. wires are used for guard wire. Lacings are tied up at specific distance. This type is used for power line crossing or power and telephone line crossing (Fig. 4.44).

(ii) Cradle Guarding: It consists of 6 guard wire. Four are on lower side and two on the upper side. Cross lacing is done from three sides. It is also called Tray guarding. Even though the conductor while snapping jumps up drastically, it will not go out of the cradle guarding. This is used for railway or L.T. to 33 KV guarding in residential area, for road crossing or along the road lines (Fig. 4.43).

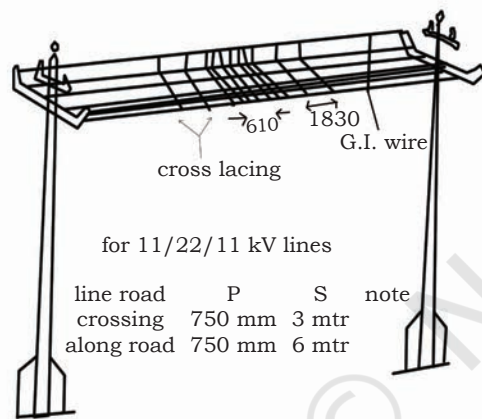


Fig. 4.43 Cradle Type Guarding

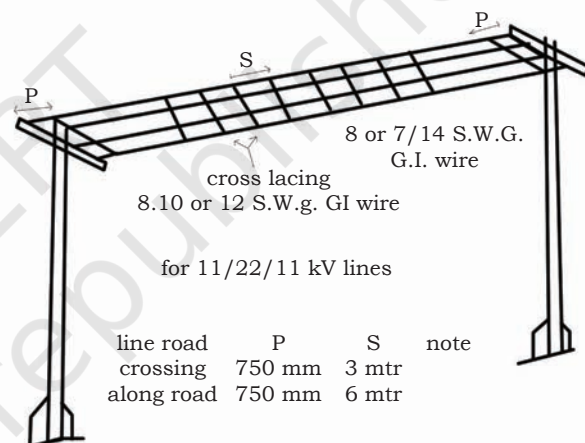
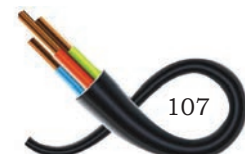


Fig. 4.44 Carpet Guarding

(iii) Box Type Guarding: This is used for composite lines. By fixing cross arms to the lower line, carpet guarding is done and also for the upper line, the upper guard wire is fixed to the lower by vertical lacing.

Road crossing and guarding

- As far as possible road crossing should be at right angle, but not less than an angle of 60 degrees.
- Cradle guarding is used for road crossing of power line or along the line.
- G.I. wire of 10 W.S.G. for L.T. line and 8 W.S.G for 11 KV to 33 KV lines is used for guarding.



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- (d) The first lacing should be at a distance of 750 mm from the pole. Other lacing is tied at a distance of 3 meter from each other.
- (e) The vertical distance between conductor and guarding in mid span should be minimum 610 mm for L.T. and 1220 mm for H.T line.
- (f) The vertical distance between L.T. line guarding cross arm and neutral should be 610 mm (2 ft.) and the length of cross arms should be 750 mm (2½')
- (g) The clearance between line and guarding cross arm for 11 KV, 22 KV and 33 KV line should be 650 mm (2¼'), 750 mm (2½') and 840 mm (2¾') respectively.
- (h) There is no need of guarding for lines above 66 KV, as their circuit breakers are sensitive. The breaker trips when conductor snaps thereby isolating the line.

Presently, due to electrification of railway-tracks, 11kV and L.T. crossings have to be done through underground cables.

Special Instructions

- (a) Power lines should always be guarded as above.
- (b) The distance between guard-wire and telephone line should be minimum 920 mm.
- (c) The telephone crossings for 66 KV and above are done by Telephone Department. The clearance between the power line and telephone line shall be as below :
 - 66 KV and 132 KV - - 2750 mm (9')
 - 220 KV and 400 KV -- 4575 mm (15')

Fitting Accessories on H.T./L.T. line

It is essential to fix accessories after pole erection. Line accessories are of two types.

- (a) Conductor accessories
- (b) Pole accessories

a. Conductor Accessories

1. Binding Tape: Binding tape is used for binding pin insulator, shackle or Line insulator to the conductor. The tape is wound on the conductor. The metal of binding tape should be same as that of conductor. The



first layer is wound along the wire in direction of twist of wire and second layer is in opposite the twist. The portion on which the binding wire is to be wound should be taped 25mm more from either side. This tape is used for avoiding conductor snapping due to friction.

2. Binding Wire: It is used for binding insulator to the conductor.

3. P.G. Clamp: It means parallel groove clamp. This is used for joining jump wire. Line tension cannot be given on P.G Clamps. Bi-metallic P.G. clamp is made out of two different metals and the conductor of the same metal is used in the same type of metal groove of P.G. Clamp

4. T Clamp: T clamps are used in substation to connect the jumps and cannot sustain tension.

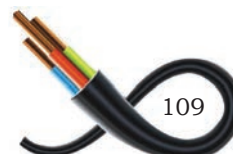
b. Pole accessories

The main pole accessories are cross arms, clamps, insulators, aluminum bobbins, nuts and bolts, stay clamp, etc.

Earthing

Earthing shall generally be carried out in accordance with the requirements of CEA regulations for measures relating to safety and electricity supply, dated 20th September 2010 and the relevant regulations of the Electricity Supply Authority concerned and as the following:

1. All metal supports, fittings etc. shall be permanently and efficiently earthed. Either a continuous wire may be run with earthing arrangements at 4 points in 1.609 km or each independent structure should be efficiently earthed.
2. Similarly at consumer's premises a suitable earthing point would be provided. Consumer has to make arrangement for independent earthing.
3. Sub-stations structures etc. should be provided with two independent earthing points. This should be interconnected or matting in the sub-station area could be laid-down for connecting to the earth points.



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4. For RCC/PCC poles the metal cross-arms and insulator pins shall be bonded and earthed at every pole for HT lines and at every 5th pole for LT lines.
5. All special structures on which switches, transformers, fuses, etc., are mounted should be earthed.
6. The supports on either side of the road, railway or river crossing should be earthed.
7. All supports (metal, RCC/PCC) of both HT and LT lines passing through inhabited areas, road crossings and along such other places, where earthing of all poles is considered desirable from safety considerations should be earthed.

In special locations, railway and telegraph line crossings, special structures, etc., pipe/rod earthing should be done. At other locations the coil earthing may be adopted. The coil earthing consist of 10m length of 8 SWG G.I. wire compressed into a coil 450 mm length and 50 mm diameter and buried 1500 mm deep.

Earthing and its types

It is very important to earth the line and electrical equipment. It will be electrically unsafe without earthing. The pole/ body of equipment connected solidly to earth are called earthing.

1. For Electrical supports and equipment

In case of short circuit or leakage, current will pass with minimum resistance to earth so that maximum current will flow through effected circuit so that fuse will blow or circuit breaker to trip. This will isolate the faulty line or equipment from live circuit.

2. Transformer neutral earthing

- (a) The leakage or unbalanced current will have path with minimum resistance.
- (b) Sensitive protecting equipment works properly. (Earth Fault Relay)
- (c) It prevents the lines being charged to excessive high voltage due to lightening or switching surges.



- (d) By connecting resistance in the neutral earthing, fault current is controlled.
- (e) It helps for keeping neutral voltage always zero.

3. For Lightning Arrestor

The lightning arrestor or earthing, discharges the lightning charge with very low resistance, which prevents possible damages to the infrastructure. For this, very low earth resistance is necessary. This quality can be achieved by piercing the earth electrode deep in the ground till the wet soil.

Earth tester measures earth's resistance and its unit is ohm.

It is very important to earth the line and electrical equipment. It will be electrically unsafe without earthing. The pole/body of the equipment connected solidly to earth is called earthing.

Methods of Earthing

As per REC Construction Standards there are two types of earthing:

1. REC Construction Standard J-1 Coil Earthing (Fig. 4.45)
2. REC Construction standard J-2 Pipe Earthing or Spike Earthing (Fig. 4.46)

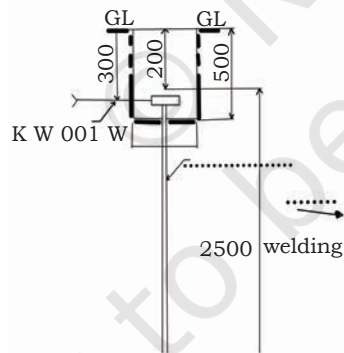


Fig. 4.46 Pipe Earthing

Notes:

1. All dimensions are in mm
2. Earth terminal should be made of G.I
3. Manufacturing tolerance
4. Clamp is to be welded to spike
5. The whole assembly is to be hot dip galvanised (BIS: 2629 and 4759)

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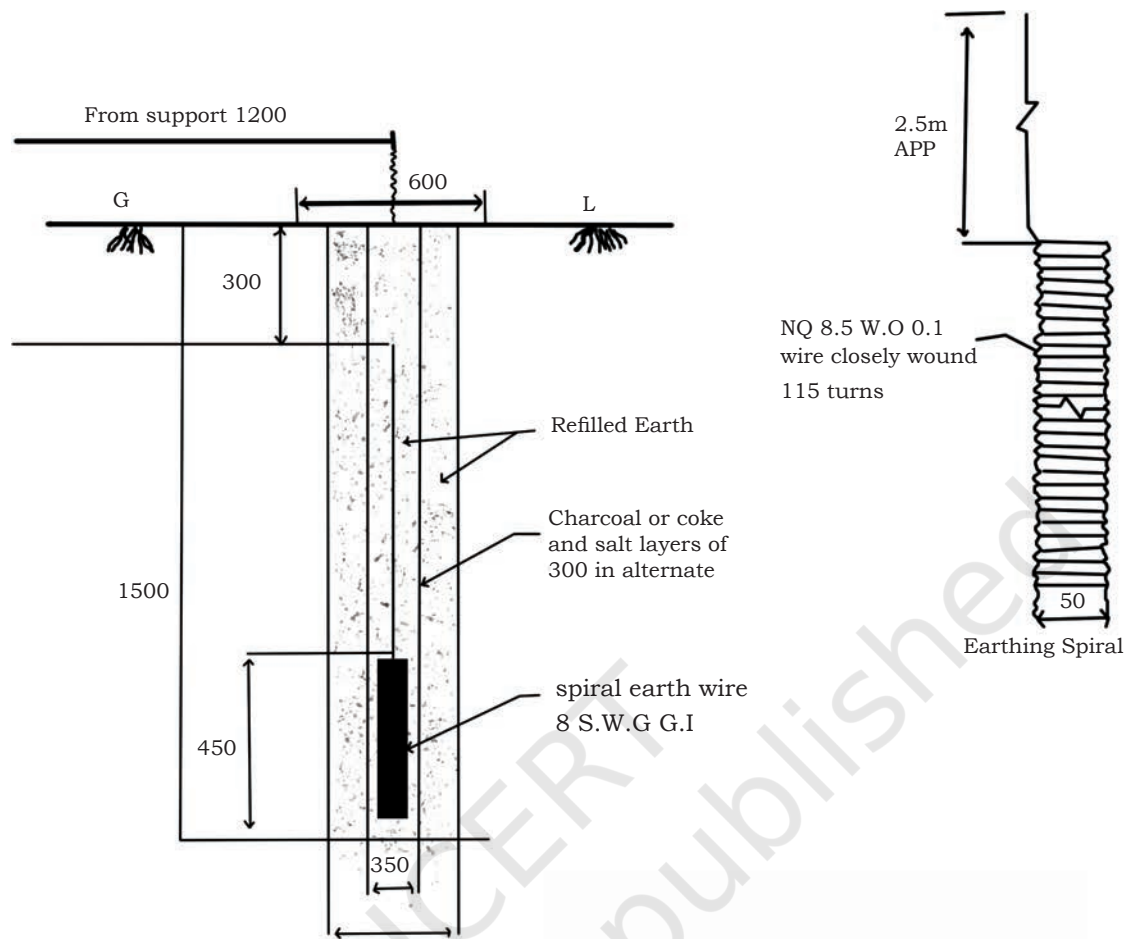


Fig. 4.45 Coil Earthing

6. All ms (mild steel) parts should be as per BIS: 2062
7. Weight mentioned is for packing and forwarding purpose only

Earth Resistance

- (a) Earth resistance is depended on following factors:
 - (i) Type of soil
 - (ii) Temperature of earth
 - (iii) Humidity in earth
 - (iv) Minerals in earth
 - (v) Length of electrode in the earth
 - (vi) Electrode shape and size
 - (vii) Distance between two electrodes
 - (viii) Number of electrodes



(b) Maximum earth resistance allowed is as below:

- (i) Major power station 0.5 ohms
- (ii) Major sub-stations 1.0 ohms
- (iii) Minor sub-station 2 ohms
- (iv) Neutral bushing 0.2 ohms
- (v) Service connection 4 ohms
- (vi) L.T lightning arrestor 4 ohms
- (vii) L.T. pole 5 ohms
- (viii) H.T. pole 10 ohms
- (ix) Tower 20-30 ohms

If earth's resistance is more than the above values, the following treatments can be made for minimising resistance.

- (i) Oxidation on joints should be removed and joints should be tightened.
- (ii) Sufficient water should be poured in earth electrode.
- (iii) Earth electrode of the biggest value should be used.
- (iv) Electrodes should be connected in parallel.
- (v) Earth pit of more depth and width-breadth should be made.

Anti-climbing Devices

In order to prevent unauthorised persons from climbing any of the supports of HT and LT lines without the aid of a ladder or special appliances, certain anti-climbing devices are provided to the supports. Two methods generally adopted are:

- (i) barbed wire binding, for a distance of 30 cm to 40 cm at a height of 3.5 m to 4 m from ground level,
- (ii) clamps with protruding spikes at a height of 3 m to 4 m.

Testing and Commissioning

When the line is ready to energise, it should be thoroughly inspected in respect of the following.

1. Poles — proper alignment, concerting and muffing.
2. Cross-arms — proper alignment.



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3. Binding, clamps and jumpers — To check whether these are in reach.
4. Conductor and ground wire — Proper sag and to check whether there are any cuts, etc.
5. Guy — To check whether the Guy wire is tight and whether the Guy insulators are intact.

Earthing System: In order to check whether the earthing connections support and the fittings are intact the following steps should be taken. Measure earth's resistance with a earth tester. After the visual inspection is over and satisfied, the conductor is tested for continuity/ground, by means of a Megohmmeter or megger. At the time of testing through the megger, a person should not climb on the pole or touch the guarding, conductor, guy wire etc.

1. Before charging any new line, it should be ensured that the required inspection fee for the new line is paid to the electrical inspector and approval obtained from him for charging the line.
2. The line should be energised before the authorised officer.
3. Before energising any new line, the officer-in-charge of the line shall notify to the workmen that the line is being energised and that it will no longer be safe to work on line. Acknowledgement of all the workmen in writing should be taken in token of having intimated them.
4. Wide publicity should be made in all the localities through which the line is to be energised will be passing. It is necessary to Intimate the time and date of energising and warning the public against the risk in meddling with the line.
5. The Officer-in-Charge of the line shall personally satisfy himself that the same is in a fit state to be energised.

Principle of Operation of Fuse

Heating effect of electric current is used in the operation of the fuse (Fig. 4.47). Any increase in an electric current in the circuit results in the increase in the rate of heat generation which will increase the temperature of the



fuse wire. If this temperature happens to be above the melting point of the material of fuse wire, fuse must have operated.

Regulators used in distribution system are voltage regulators which are used to adjust voltage at distribution end. The step type voltage regulator takes an incoming voltage that will vary with load conditions and maintains a constant output voltage. As the loading increases along the distribution feeder, the voltage will drop. This reduction in voltage reduces the amount of power used by the lighting portion of the load. There are two types of regulators: single phase regulator and three phase regulator (Fig. 4.48).



Fig. 4.47 Fuse



Fig. 4.48 Voltage Regulator

Auto Re-closer

- (a) A Re-closer is a protection device (Fig. 4.49):
 - For overhead power lines
 - It is a circuit breaker designed to handle fault currents
 - Designed to Re-close on to a fault

Sectionaliser

- (a) A Sectionaliser is a load break switch:
 - It is used in conjunction with a “re-closer” or “circuit breaker”.
 - It counts the interruption created by a re-closer during a fault sequence.



Fig. 4.49 Auto Re-closer

Check Your Progress

A. Fill in the blanks

1. Double poll (DP) strutures are required in all the angle_____
2. In 11 KV lines _____ poles are erected within 1 km distance.
3. Guy strain insulators are placed to _____ the lower part of the guy.
4. Connecting to conductors or wires is called _____.
5. Cross arms and _____ are mounted on the support with necessary clamps, bolts and nuts.

B. Multiple choice questions

1. Which type of joint is made with Aluminium conductors?

(a) Compression	(b) Meried
(c) Sleeve	(d) Britannia



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2. Which of these is not a type of porcelain insulator?
(a) Pin type (b) Strain type
(c) Britannia (d) Shackle type
3. While binding the stay, pole should not be tilted.
(a) False
(b) True
4. The diamond guarding is used for
(a) LT Line (b) HT Line
(c) Both HT and LT (d) None of the above
5. Average span of 11 KV line is
(a) 50 meter (b) 2. 60 meter
(c) 3. 75 meter (d) 4. 100 meter

B. Short answer questions

1. Discuss the importance of guarding. Explain the types of guarding.
2. List the factors on which earth's resistance is dependant
3. How do lightening arrestors help in earthing?
4. Explain the types of joints used in conductor jointing.

SESSION 4: DISTRIBUTION LINE MAINTENANCE

The lines and equipment should be inspected by the competent authority. Following points need to be taken care of during inspection:

1. For existing substation, the work should be done as per the layout approval.
2. Statutory clearances have to be ensured, while inspecting the following crossings:
 - (a) Railway crossings
 - (b) P and T crossings
 - (c) Junctions
 - (d) Road Crossings
3. Make sure that proper clearance is obtained for the lines with different voltages operating on the same support.
4. DPs and cut points should be inspected based on need and approvals.
5. Adequate safety and clearances should be ensured while running the lines at domestic colonies.



6. There should be appropriate earthing.
7. Any crossing should be at right angles, to the extent possible.
8. Proper cross arms, extension cross arms should be ensured as per the requirement.

Maintenance

When an overhead line trips on a sustained fault, it should be inspected to find out the nature of fault such as loose sag, snapping of conductor, tree branches touching the lines, conductor falling on cross arms (Fig. 4.50). An improvement with a view to avoid re-occurrence of such faults in future should be arranged and carried out soon (Fig. 4.51). Complaints regarding no current/failure of power supply, voltage fluctuation, and load shedding and scheduled outages shall be addressed by the senior lineman as per the provisions of the regulations. Problems related to current such as no current or failure of power supply in premises could occur due to various reasons such as:

- Fuse blown out/tripping of MCB
- Burnt meter
- Broken service line
- Service line snapped from pole
- Fault in distribution mains
- Distribution transformer failure
- Fault in HT system
- Problem in grid (33 kV or 66 kV) substation
- Planned/scheduled/emergency maintenance work
- Load shedding
- Street light complaint



Fig. 4.50 Power Distribution Lines

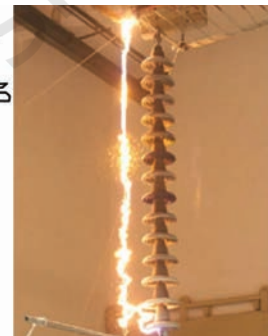
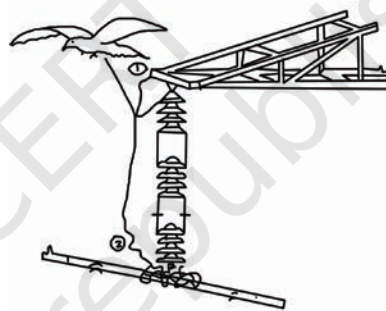


Fig. 4.51 Mitigating Bird Hazards to Overhead Lines

Pre-monsoon Inspection

The inspection carried out with the overhead lines without supply is called pre-monsoon inspection. It should be planned in advance with proper tools and equipment (Figs. 4.52 and 4.53).



Pre-monsoon inspection involves the following

1. Tree cutting should be properly executed.
2. Sagging of lines should be minimised.
3. Leaned poles should be rectified.
4. Lines should be properly aligned by tightening with proper bolts and nuts.
5. Earthing should be checked.
6. Torn insulators/flash over insulators should be replaced.
7. Jumpers at cut points should be checked up.
8. Stay wires should be properly aligned.

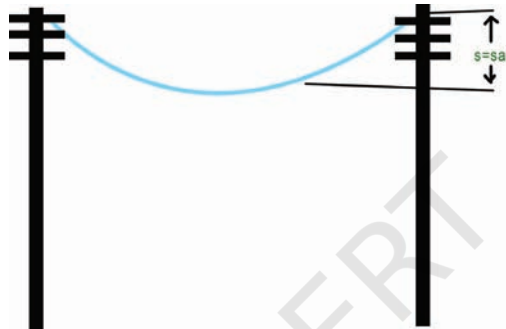


Fig. 4.52 Sag in Overhead Distribution Lines



Fig. 4.53 Inspection of Power Distribution Lines

11 kV Lines Maintenance

11 kV Lines maintenance is required to minimise interruptions and improve the efficiency of power supply. The overhead lines should be inspected periodically to detect any fault which may lead to break down of electric supply. When an overhead line trips, it should be inspected to find out the nature of fault.



Fig. 4.54 Low Tension Distribution Lines (LT)

Low Tension (LT) Line Maintenance

LT Line (Fig. 4.54) maintenance includes:

1. Alignment of poles
2. Replacement of damaged service wire
3. Removal of bird nests
4. Tree clearance
5. Checking of pole fittings and street light brackets
6. Careful examination of damages to L T conductor such as black spots on conductor



Ground Patrol

The periodic patrolling (not exceeding a month) of overhead lines at ground level, while, the line is live, is called **ground patrol** (pole to pole inspection) poles maintenance. The following should be checked:

- Leaning of pole (Fig. 4.55)
- Sinking of earth around the pole
- Corrosion of metal at ground level (RSJ Poles)
- Cracks in Pre stressed Cement Concrete Poles (PSCC).

Cross Arms

The following should be checked while maintaining cross arms:

- Tilting of cross arms
- Rusting of cross arms
- Bird nest or creeper on cross arm (Fig. 4.56)

Bindings

The looseness and cutting of bindings should be carefully observed while patrolling.

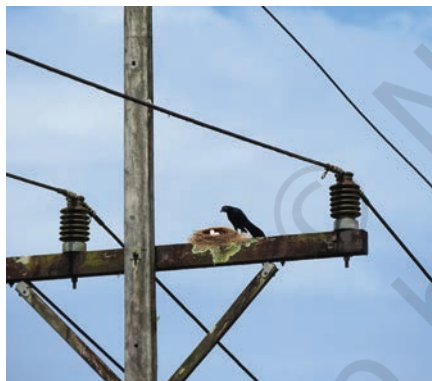


Fig. 4.56 Bird's Nest on Cross Arm

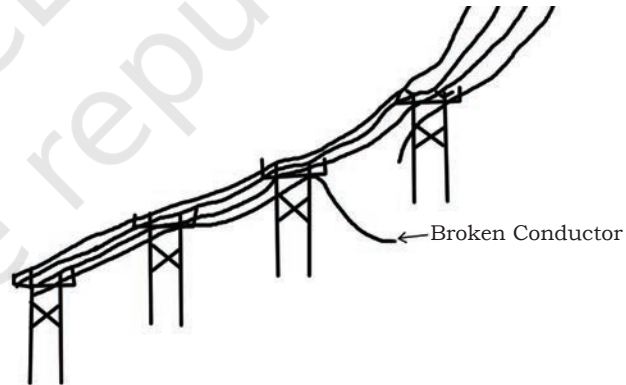


Fig. 4.57 Conductors Distribution System

Conductors

The following should be checked while maintaining conductors (Fig. 4.57):

- Cut strands, burnt marks and corrosion
- Breakage/Looseness of conductors
- Spotting kites, green creepers on the conductors



Fig. 4.58 Stay Wire



Stay Wire

The following should be checked while maintaining stay wire (Fig. 4.58):

- Corrosion of guy rod and stay wire
- Guy wire tightness
- Creeper on the stay wire

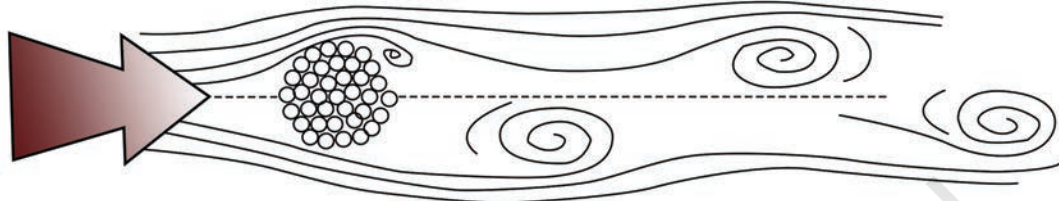


Fig. 4.59 Aeolian Vibration

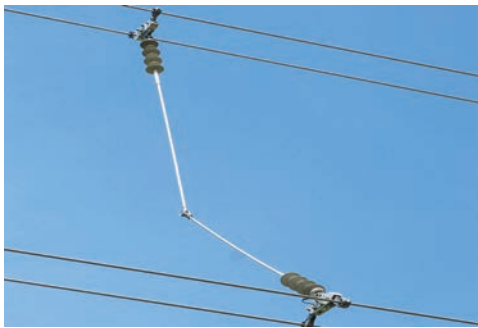


Fig. 4.60 Power Line Galloping

Causes of Conductor Damage

Aeolian vibration: It is one of the most important problems in power transmission lines because it represents the major cause of fatigue, failure of conductor strands or of items associated with the support, use and protection of the conductor during high wind pressures (Fig. 4.59).

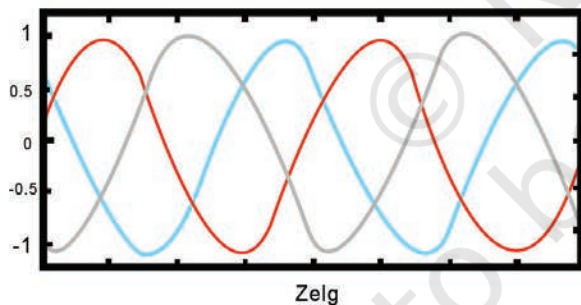


Fig. 4.61 Voltage Balance

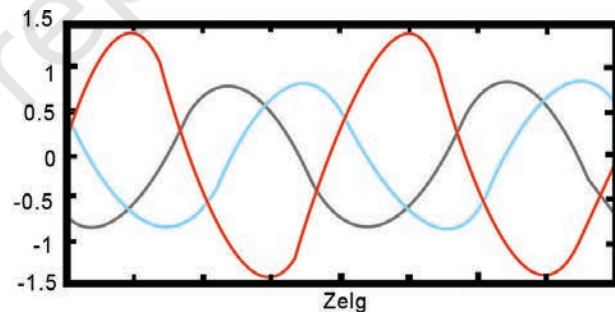


Fig. 4.62 Voltage Imbalance

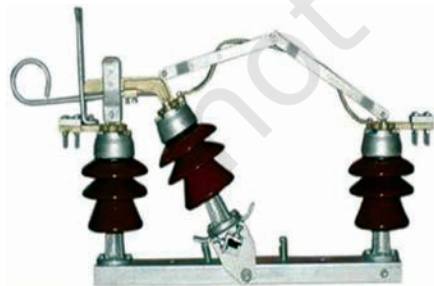


Fig. 4.63 Air Break Switches

Galloping: The high-amplitude, low-frequency oscillation of overhead power lines is due to wind. Sway oscillation and gallop tend to short circuit between lines thus damage is caused due to arcing. PG clamp maintains equal distance across the lines by maintaining the sag to protect from sway oscillation (Fig. 4.60).



Unbalance loading: Major line failures are due to unbalance load when one phase conductor gets overheated and snapped (melted down) due to excessive current (Figs. 4.61, 4.62 and 4.63).

Overloading: When a line is loaded beyond the maximum current carrying capacity the conductor gets overheated and snapped.

Air Break (AB) switches need maintenance to check:

- Defect in closing of the AB switch
- Missing of the lock
- Damage of earth wire
- Dust accumulation on the insulators
- Blades/contact burnings

11 kV Cable and Cable Boxes

- Proper supporting of cable and cable boxes
- Damage to insulator and compound leakage from the box
- Intactness of terminal connections with overhead lines and earthing

Insulator Discs

Due to moisture and dust particles on the surface of insulator the resistance is reduced. This leads to flash over marks in case of lightning (Fig. 4.64).

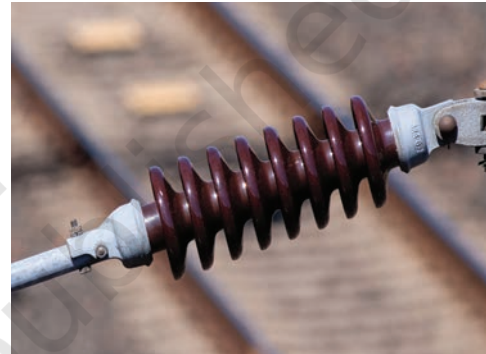


Fig. 4.64 Disc Insulators used in Power Lines

Causes of Insulator Damage

1. Due to difference in temperatures and hot and cold season, there is extra stress on both conductor and insulators of entire overhead network (Fig. 4.65).
2. During rainy season dust over the insulator becomes conductive and forms fine hair crack which further develops to fretting due to load and lightening.
3. Excessive tightening of PG clamps causes extra strain to disc insulator, pin insulator and conductor through-out up to end points and causes tensile breaks of conductor and abrasion, fatigue on pin insulators.



Fig. 4.65 Wire Insulation Damage



Fig. 4.66 Megger



Fig. 4.67 Earth



Fig. 4.68 Equipment Calibration

4. Though lightning arresters (LA) are the most effective means of protecting electrical lines against lightning and switching, failure of LA directly impacts the insulators damage due to spark.

Line conductors are electrically insulated from each other as well as from the pole ‘insulators’. The insulator and its binding should be mechanically strong enough to withstand the resultant force due to combined effect of wind pressure and weight of the conductor in the span.

Material Testing Equipment

Line conductors are electrically insulated from each other as well as from the pole ‘insulators’. The insulator and its binding should be mechanically strong enough to withstand the resultant force due to combined effect of wind pressure and weight of the conductor in the span.

Proper calibration and working of equipment should be double checked before using them for testing and repair activity (Figs. 4.66, 4.67 and 4.68). In case tools used in testing are not properly working and calibrated, then it will not lead to proper adjustment of equipment which in turn would result in malfunction of the total connected system. All the equipment which are meant for testing and repair activities should be kept separately from other equipment, and should be tested for their accuracy and workability according to defined standards.

Table 4.7: Line Patrol Log Sheet

Item No.	Points to be checked during inspection and defects noticed	Location Nos.			Action taken for Rectification	Inspection Officer's Remarks
	General					
1.	Adequate clearance to conductors and poles are available from trees, shrubs, bushes etc.		Yes	No		
2.	Vertical and horizontal clearance from the neighbouring structures under construction etc., are adequate		Yes	No		



3.	Any new road, channels, earth embankment are constructed near or below the lines reducing clearance		Yes	No		
	Poles					
4.	The pole is leaning and if so whether stay is required to make it plumb		Yes	No		
5.	Earth around the pole has sunk or eroded		Yes	No		
6.	The metal is corroded at ground level		Yes	No		
7.	Any cracks have been developed in PCC/RCC poles		Yes	No		
8.	The pole is intact and free from mechanical injury due to vehicles dashing against them		Yes	No		
	Cross Arms					
9.	Any bird nest, or creeper observed on cross arms		Yes	No		
10.	The cross arm is tilted		Yes	No		
11.	The cross arm is rusted		Yes	No		
	Binding/Clamps/Jumpers					
12.	The bindings/jumpers are cut,		Yes	No		
	Loose, Charred or Burnt		Yes	No		
13.	Visible indications for heating of the PG clamps are observed		Yes	No		
14.	Visible dangers like cut strands, and burn marks, corrosion etc. observed		Yes	No		
15.	The conductors are loose, increasing the sag		Yes	No		
16.	Kites or green creepers are observed on the conductors		Yes	No		
17.	The conductor/ground wire has sufficient clearance over roads, rivers, channels, railways and telecommunication circuits, haystacks etc.		Yes	No		
18.	The guarding and earth, provided for conductors are intact		Yes	No		
	Guys					
19.	Corrosion of guy rod and stay wire is observed		Yes	No		
20.	The guy wire is tight		Yes	No		



21.	The guy insulators provided are intact		Yes	No		
22.	Any green creepers on the stay wire		Yes	No		
23.	Guy pits have been washed away/sunk		Yes	No		
24.	The sleeve concreting is in order		Yes	No		
AB Switches and Fuse						
25.	There is any visual indication for the defective closing of the switch		Yes	No		
26.	The lock is missing		Yes	No		
27.	The earth wire is cut or damaged		Yes	No		
28.	There is too much of dust accumulated on the insulators		Yes	No		
29.	The blades/contacts/arcing horns are burnt out or charred		Yes	No		
Lightning Arresters						
30.	The porcelain is damaged		Yes	No		
31.	The line and earth connections are intact		Yes	No		
32.	There is any external indication to show the lightning arresters have been punctured		Yes	No		
11 kV Cable and Cable Boxes						
33.	The cable and cable boxes are properly supported		Yes	No		
34.	The insulators are damaged and compound leaking from the box		Yes	No		
35.	The terminal connection with the overhead line is intact		Yes	No		
36.	The earthing lead from the cable box is intact		Yes	No		
Earthing System						
37.	The earthing connections of the metal supports and fittings are intact		Yes	No		
Schedule of Periodical Routine Inspection of Lines Lightning Arresters						
38.	The porcelain is damaged		Yes	No		



39.	The line and earth connections are intact		Yes	No		
40.	There is any external indication to show the lightning arresters have been punctured		Yes	No		
	11 kV Cable and Cable Boxes					
41.	The cable and cable boxes are properly supported		Yes	No		
42.	The insulators are damaged and compound leaking from the box		Yes	No		
43.	The terminal connection with the overhead line is intact		Yes	No		
44.	The earthing lead from the cable box is intact		Yes	No		

Schedule of Periodical Routine Inspection of Lines

The lineman should adhere to the time limits as per the performance standard prescribed by the State Electricity Regulatory Commission.

The following table indicates the time standards as prescribed by the Delhi Electricity Regulatory Commission (DERC):

Table 4.8 Schedule for Inspection of Lines

Nature of Cause of Power Supply Failure	Maximum Time Limit for Power Restoration
Fuse blown out or MCB tripped	<ul style="list-style-type: none"> • Within three hours for urban areas. • Within eight hours for rural areas
Service line broken, snapped from the pole	<ul style="list-style-type: none"> • Within six hours for urban areas. • Within 12 hours for rural areas.
Fault in distribution mains	<ul style="list-style-type: none"> • Temporary supply to be restored within four hours from alternate source, wherever feasible. • Rectification of fault and thereafter restoration of normal power supply within 12 hours.
Distribution transformer failed/burnt	<ul style="list-style-type: none"> • Temporary restoration of supply through mobile transformer or another backup source within eight hours, wherever feasible. • Replacement of failed transformer within 48 hours.
HT mains failed	<ul style="list-style-type: none"> • Temporary restoration of power supply within four hours wherever feasible • Rectification of fault within 12 hours.



Problem in grid 33 kV substation	<ul style="list-style-type: none"> • Restoration of supply from alternate source, wherever feasible within six hours. • Roster load shedding may be carried out to avoid overloading of alternate source. • Repair and restoration of supply within 48 hours.
Failure of power transformer	<ul style="list-style-type: none"> • Restoration of supply from alternate source, wherever feasible within six hours. • Roster load shedding may be carried out to avoid overloading of alternate source. • Replacement action to be intimated to the Commission within 72 hours and replacement of power transformer within 20 days.
Burnt meter	<ul style="list-style-type: none"> • Restoration of supply by bypassing the burnt meter within six hours. • Replacement of burnt meter within three days
Street light complaint	<ul style="list-style-type: none"> • Restoration within 72 hours.

Check Your Progress

A. Fill in the blanks

1. Resistance opposes _____ flow and inductance opposes _____ flow.
2. Load shedding is normally carried out when the power _____ is more than the power _____ at a given point of time to shed excess load on the generating station.
3. _____ is used for cutting, removing insulation, jointing and twisting the electric wires and cables even on live line.
4. Bench vice is use to _____ the object.
5. The flow of current towards an undesired path or abnormal stoppage of current is termed as a _____.

B. Multiple choice questions

1. The selection of poles for erection of lines depends on a number of factors such as:
 - (a) Distribution of power
 - (b) Pole strength
 - (c) Type and size of conductor
 - (d) wind pressure
 - (e) All of above
 - (f) Only (a) and (c)



2. What are the causes of insulator damage?
 - (a) Due to difference in temperatures
 - (b) Improper calibration
 - (c) Broken service line
 - (d) None of the above
3. Current transformers are:
 - (a) Small transformer
 - (b) Supply low values of current
 - (c) Used where the current or voltage is too high
 - (d) (a) and (c)
 - (e) (a) and (b)
 - (f) (a), (b) and (c)

C. Match the columns

Group A		Group B	
1.	AAC	(a)	high-capacity, high-strength stranded conductor
2.	ACSR	(b)	made out of high strength Aluminum-Magnesium-Silicon Alloy
3.	AAAC	(c)	made up of one or more strands of hard drawn 1350 aluminum alloy
4.	Shackle Insulator	(d)	mounted axially

D. Short answer questions

1. Why maintenance is important?
2. What maintenance should be done during pre monsoon inspections?
3. What are the causes of insulation damage?
4. Why material testing equipment is required? Explain with reasons.

