Distribution Lineman

(Job Role)

Qualification Pack: Ref. Id. PSS/Q0102

Sector: Power

Textbook for Class XI

171176

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NCERT

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Foreword

The National Curriculum Framework–2005 (NCF–2005) recommends bringing work and education into the domain of the curricular, infusing it in all areas of learning while giving it an identity of its own at relevant stages. It explains that work transforms knowledge into experience and generates important personal and social values such as self-reliance, creativity and cooperation. Through work one learns to find one's place in the society. It is an educational activity with an inherent potential for inclusion. Therefore, an experience of involvement in productive work in an educational setting will make one appreciate the worth of social life and what is valued and appreciated in society. Work involves interaction with material or other people (mostly both), thus creating a deeper comprehension and increased practical knowledge of natural substances and social relationships.

Through work and education, school knowledge can be easily linked to learners' life outside the school. This also makes a departure from the legacy of bookish learning and bridges the gap between the school, home, community and the workplace. The NCF–2005 also emphasises on Vocational Education and Training (VET) for all those children who wish to acquire additional skills and/or seek livelihood through vocational education after either discontinuing or completing their school education. VET is expected to provide a 'preferred and dignified' choice rather than a terminal or 'last-resort' option.

As a follow-up of this, NCERT has attempted to infuse work across the subject areas and also contributed in the development of the National Skill Qualification Framework (NSQF) for the country, which was notified on 27 December 2013. It is a quality assurance framework that organises all qualifications according to levels of knowledge, skills and attitude. These levels, graded from one to ten, are defined in terms of learning outcomes, which the learner must possess regardless of whether they are obtained through formal, non-formal or informal learning. The NSQF sets common principles and guidelines for a nationally recognised qualification system covering Schools, Vocational Education and Training Institutions, Technical Education Institutions, Colleges and Universities.

It is under this backdrop that Pandit Sunderlal Sharma Central Institute of Vocational Education (PSSCIVE), Bhopal, a constituent of NCERT has developed learning outcomes based modular curricula for the vocational subjects from Classes IX to XII. This has been developed under the Centrally Sponsored Scheme of Vocationalisation of Secondary and Higher Secondary Education of the Ministry of Human Resource Development.

This textbook has been developed as per the learning outcomes based curriculum, keeping in view the National Occupational Standards (NOS) for the job role and to promote experiential learning related to the vocation. This will enable the students to acquire necessary skills, knowledge and attitude.

I acknowledge the contribution of the development team, reviewers and all the institutions and organisations, which have supported in the development of this textbook.

NCERT would welcome suggestions from students, teachers and parents, which would help us to further improve the quality of the material in subsequent editions.

HRUSHIKESH SENAPATY
Director
National Council of Educational
Research and Training

New Delhi
June 2018

About the Textbook

Power is one of the most critical components of infrastructure and crucial for the welfare of the nations. Power sector plays a vital role in the economic growth and human development of any country. Electricity consumption is one of the most important indices for measuring the development level of a nation.

India has the fifth largest power generation capacity in the world. The country ranks third globally in terms of electricity production. As per the 13th Five Year Plan, India is targeting a total of 100 GW of power capacity addition by 2022. In order to meet the increasing demand for electricity in the country, massive addition to the installed generating capacity is required for efficient and effective production of goods and services.

Power Sector Skill Council (PSSC) has been created with a mandate to facilitate skill development across the Power Industry (covering Power Generation, Transmission, Distribution, Renewable Energy and Power Equipment Manufacturing). Pursuing an ambitious target to skill, train and certify over four million workforce in Power Industry over next decade. PSSC has developed 11 National Occupational Standards/Qualification Packs (NOS/QPs).

This textbook has been developed for preparation of manpower in power sector for Distribution Lineman job role in the school system. Distribution Lineman is an important job role in the installation and repair of electrical lines, fittings and fixtures. A Distribution Lineman technician is responsible for installation, minor repair maintenance and servicing of power line in housing, commercial and institutional setups.

This textbook has been developed with the contribution from the subject and industry experts and academicians for making it a useful and inspiring teaching-learning resource material for the students of vocational education. Adequate care has been taken to align the content of the textbook with the National Occupational Standards (NOSs) for the

job role so that the students acquire necessary knowledge and skills as per the performance criteria mentioned in the respective NOSs of the Qualification Pack (QP). The textbook has been reviewed by experts so as to make sure that the content is not only aligned with the NOSs, but is also of good quality. The NOSs for the job role of Distribution Lineman Technician covered through this textbook are as follows:

1. PSS/N 0105 (Repair and maintenance of power distribution lines and components)
2. PSS/N 0107 (Operation and maintenance of 11/0.433 KV Distribution Substation)
3. PSS/N 2001 (Use of basic health and safety practices for power related work)
4. CSC/N 1336 (Work effectively with others)

Unit 1 of the textbook discusses electricity. Unit 2 focuses on the handling of tools and equipment used by distribution linemen. Unit 3 deals with electrical wiring components and accessories. Unit 4 explains the repair and maintenance of power distribution lines.

This book could not be completed without the support of Power Sector Skill Council (PSSC), New Delhi. I hope this textbook will be useful for students and teachers who will opt for this job role. Any further suggestions for improving this textbook are always welcome.

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The Council is grateful to Saroj Yadav, *Professor and Dean* (A), NCERT, and Ranjana Arora, *Professor and Head*, Department of Curriculum Studies, for carefully evaluating and giving suggestions for the improvement of this book and its finalisation. The Council acknowledges the copy editing and valuable contribution of Soumma Chandra, *Assistant Editor* (Contractual) and Shilpa Mohan, *Assistant Editor* (Contractual) in shaping this book. The efforts of Pawan Kumar Barriar, *DTP Operator*, Neha Pal, *DTP Operator* (Contractual) and Naresh Kumar, *DTP Operator* (Contractual), Publication Division, Vikas Kumar Kogey, *Graphic Designer*, Pinki Tiwari, *Graphic Artist*, Akhilesh Kashiv, *Computer Operator*, PSSCIVE, NCERT, for flawless layout design are also acknowledged.

Contents

Acronyms

AC: *Air Conditioner*
AC: *Alternating Current*
ADC: *Analog-to-Digital Converter*
BIS: *Bureau of Indian Standards*
BS: *British Standards*
CEA: *Central Electricity Authority*
CT: *Current Transformer*
CTR: *Current Transformer Ratio*
CTS: *Cabe Tyre Sheath*
CVT: *Capacitor Voltage Transformer*
DC: *Direct Current*
EEPROM: *Electrically Erasable Programmable Read-only Memory*
ELPD: *Earth Leakage Protective Device*
ELT: *Earth Leakage Temper*
GI: *Galvanised Iron*
HT: *High Tension*
HV: *High Voltage*
IEC: *International Electrotechnical Commission*
KCL: *Kirchhoff's Current Law*
KVL: *Kirchhoff's Voltage Law*
LCD: *Liquid Crystal Display*
LED: *Light-emitting Diode*
LT: *Low Tension*
LV: *Low Voltage*
MCB: *Miniature Circuit Breaker*
MDB: *Main Distribution Board*
MDI: *Maximum Demand Indicator*
MRI: *Meter Reading Instrument*
PD: *Potential Difference*
PT: *Potential Transformer*
PVC: *Polymerising Vinyl Chloride*
REV: *Revolution*
RST: *Referred for Phase Sequence*
RTC: *Real Time Clock*
SWG: *Standard Wire Gauge*
T&P: *Tools and Plants*
TRS: *Tough Rubber Sheath*
TV: *Television*
VIR: *Vulcanised Indian Rubber*
VT: *Voltage Transformer*

Unit 1

Electricity

Introduction

We are surrounded by technology and innovation. Electricity is one of the greatest innovations of mankind. It has now become a part of our daily life and one cannot think of a world without electricity. Electricity is now an important part of homes and industries. Almost all the devices at homes, businesses and industries are running because of electricity (Fig. 1.1). The primary use of electricity depends on the place where it is used and the nature of the facility. You have seen bulbs, tubelights, fans, fridges, TVs and electronic gadgets at your home. All these run on electricity. At present electricity plays a vital role in our day-to-day life and in the country's economy.

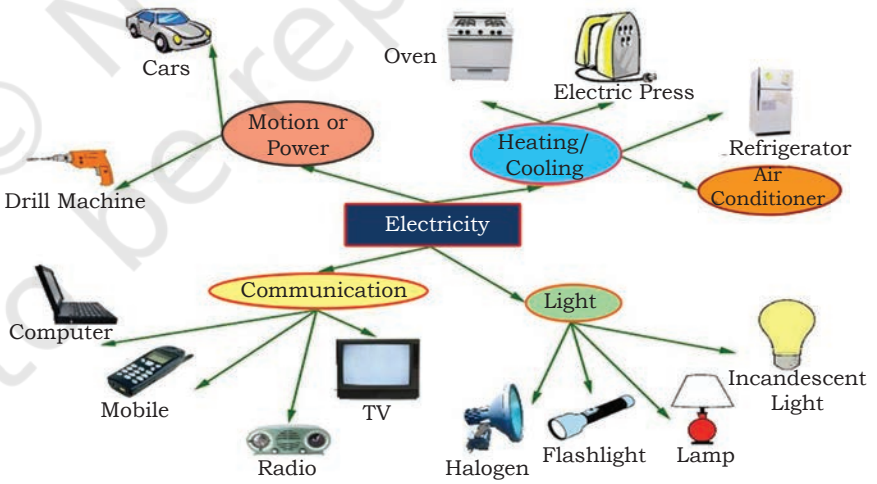


Fig. 1.1 Uses of electricity

Any country's development is measured by the per-person-consumption of electricity. Presently, everything in human life is dependent upon electricity whether it is in the health, transport, agriculture or industrial sectors.

Session 1: Electricity Generation Concept

Origin of Electricity

Electricity is one of the most commonly used forms of energy. The term electricity comes from the Greek word *elektron* which means amber. It is converted from mechanical to electrical energy with the help of a prime mover i.e., from turbine to generator. Many people give credit to Benjamin Franklin for discovering electricity, but his experiments only helped to establish the connection between lightning and electricity.

Basic Concept of Electricity

Electricity is a type of energy which involves the flow of electrons. All elements are made up of atoms. The centre of an atom is called the nucleus. The nucleus has positively charged particles known as protons and electrically neutral particles called neutrons. The nucleus of an atom is surrounded by negatively charged particles known as electrons (Fig.1.2). The negative charge of an electron is the same as the positive charge of a proton, and the number of electrons in an atom is equal to the number of protons.

Distribution of Electrons in the Orbits of Copper Atom

From the generating station electricity arrives at homes through wires. Electric lamps, electric heaters, fans, computers, etc., use electricity to work. Many appliances at home such as washing machines and electric cookers use electricity. In factories, electricity is used to run machines. People who deal with electricity and electrical devices are called Electricians.

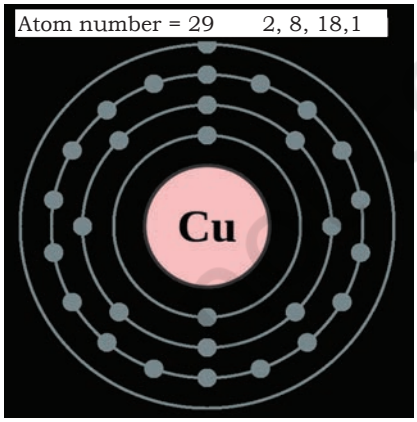
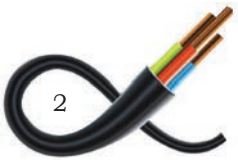


Fig. 1.2 Electrons

There are two types of electric charges—positive and negative. Similar charges repel each other and opposite charges attract. This means that if you put two negative charges close together and let them go, they will move apart. This is also true for two positive charges. But if you put a positive charge and a negative charge close together, they will attract each other.



Importance of Electricity

Electricity makes it possible to light our homes, roads, offices, markets and factories. This helps us to continue work during night hours. A power station provides us electricity. If the electricity supply fails, electrical torches are used for light. We use electricity to operate the pump that lifts water from wells or ground level to roof-top water tank. We need electricity to run computers in shops, offices, banks and other establishments. Other electrical equipment like AC, geyser, electrical iron, television, refrigerator, induction cooker, oven, etc., require electricity to run them.

Fig. 1.3 Electricity used for lighting

Fig. 1.4 Electricity used for heating

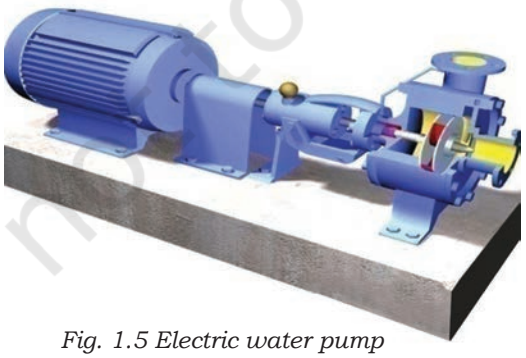


Fig. 1.5 Electric water pump

Generation of Electricity

The basic principle of electrical generator is Faraday's Law of electromagnetic induction. An electrical generator (Fig. 1.6) is used to convert mechanical energy into electrical energy. Generation of electrical energy is conversion of kinetic energy into electrical energy.

Experiment of Michael Faraday

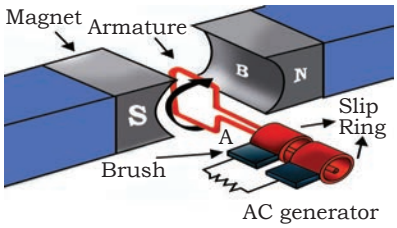


Fig. 1.6 Diagram of electromagnetic generator

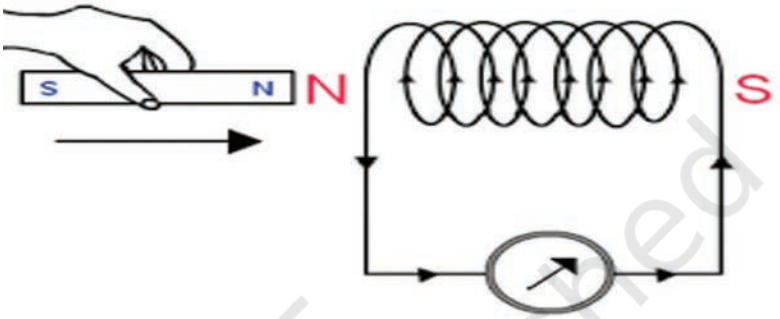


Fig. 1.7 Experiment of Michael Faraday

Electromagnetic induction is the production of an electromotive force across a conductor, when it is exposed to a varying magnetic field. It is described by Faraday's Law of Electromagnetic Induction (Fig. 1.7).

Electricity Generated by Electrochemical Cell

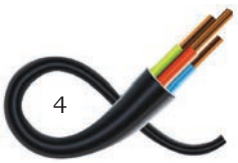
Fig. 1.8 Electrochemical battery

An electrochemical cell is a device which is capable of generating electrical energy through chemical reactions. A common example of an electrochemical cell (Fig. 1.8) is a standard 1.5 V cell meant for consumer use.

Electricity Generated by Solar Cell

Fig. 1.9 Electricity generated by solar panel

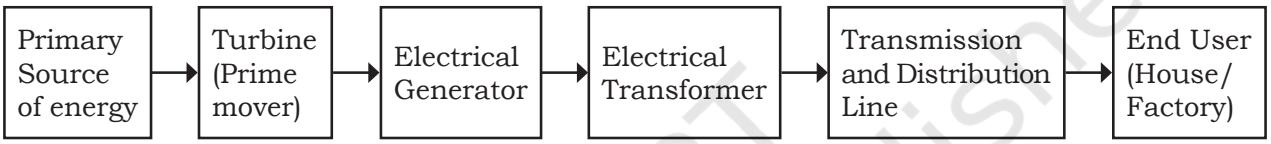
A solar cell (Fig. 1.9) is a device that converts light energy into electrical energy. This conversion is called the photovoltaic effect. Solar cells have many applications. They have been used in situations where electrical power is unavailable, such as in remote areas, earth-orbiting satellites and space probes, consumer systems like handheld calculators or wrist watches.



Electricity Generated by Thermal Power Station

A thermal power station (Fig.1.10) is a power station in which heat energy is converted to electrical energy. In most of the places in the world the turbine is steam-driven. Water is heated, which turns into steam and spins a steam turbine which drives an electrical generator. In a thermal power station fuel, such as coal, oil or gas is burned in a furnace to produce heat-chemical to heat energy. This heat is used to change water into steam in the boiler and this drives the generator to produce electricity by converting mechanical to electrical energy.

Generation and Transmission of Electricity



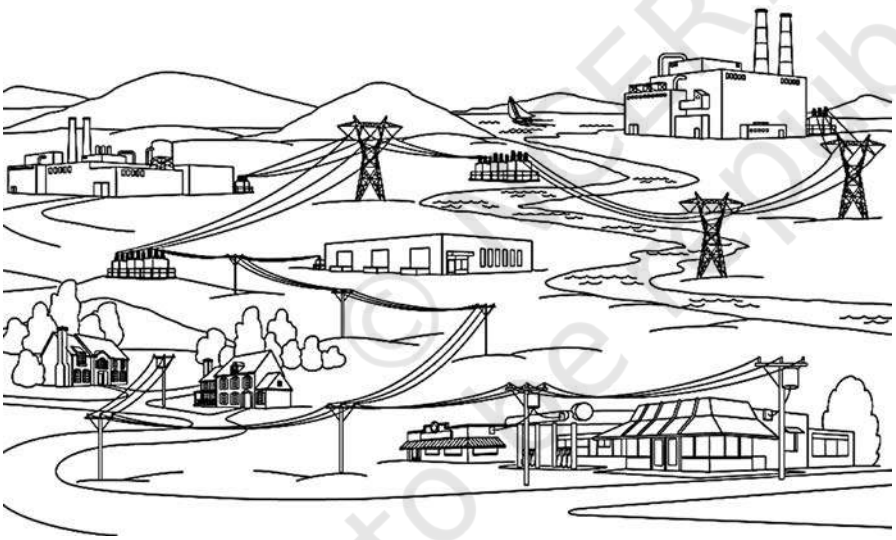


Fig. 1.10 Power Station

Our day starts and ends with the use of various electrical devices. Some of them are LED lights, fan, AC, refrigerator, motor, etc. The source where electricity is generated is far away from residential areas. This place is known as a power station. A power station (Fig. 1.10)

is also known as a power plant or powerhouse. Power station may contain one or more electric generators. Generator converts the mechanical power into electrical power. Most power stations in the world burn fossil fuels like coal, oil and natural gas to generate electricity. But there is an increasing use of cleaner renewable sources, such as solar, wind, wave and hydroelectric energy.

Status of Electricity Production in India

1. Total Installed Capacity (As on 30.06.2017)

Fuel	MW	% of Total
Total Thermal	2,20,576	67.0%
Coal	1,94,553	59.1%
Gas	25,185	7.6%
Oil	838	0.3%
Hydro	44,614	13.6%
Nuclear	6,780	2.1%
Renewable Energy Sources*	57,260	17.4%
Total	**329,231**	**100%**

Source: Central Electricity Authority (CEA)
**Installed capacity with respect to Renewable Energy Sources as on 31.03.2017.*
Renewable Energy sources include small hydro project, gas produced from biomass power, urban and industrial waste power, solar and wind energy.

Practical Exercise

Activity 1

Make an electrical quiz board for list of source of electricity and their sharing percentage (%) in India

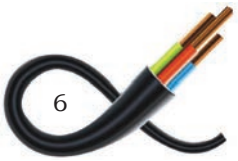
Objective

Students will be able to

1. identify the sources of electrical energy in India,
2. define their sharing percentage (%) and
3. make basic circuit connection.

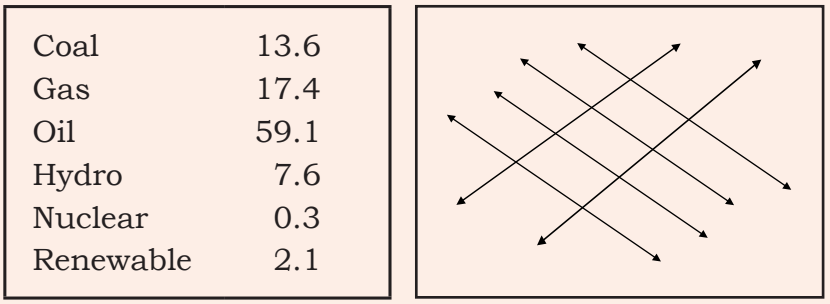
Material required

One card–board (45 cm × 15 cm), insulated copper wire, one 9-volt bulb with holder, one 9-volt battery, 10-connectors with socket.



Tools and Equipment

S. No.	Particular	Specification	Quantity
1	Screw Driver	6”	01
2	Combination Plier	6”	01
3	Wire Stripper	--	01
4	Phase Tester	--	01



Front view of cardboard *Back view of cardboard*

Fig.1 Electrical Cardboard

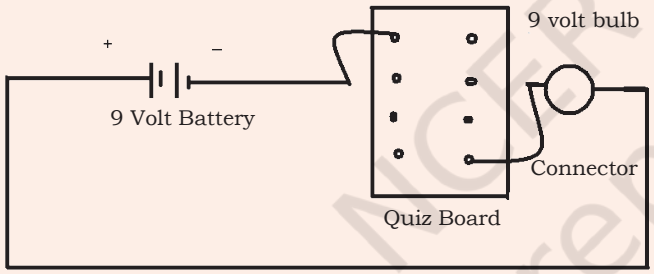


Fig.2 Electrical Circuit Diagram of Electrical Quiz Board

Procedure

1. Take one cardboard (45cm.x15cm.) and fix pieces of insulated wire with two metal connectors at the end of each wire.
2. Paste down name of energy source and percentage as shown in figure.
3. Connect each question to correct answer by a wire at the back of the cardboard.
4. Connect 9-volt battery and 9-volt bulb as shown in figure.
5. Clip one lead of connector to a question and clip the other lead to what you think is the correct answer.
6. If the answer selected by you is correct the bulb will glow because the connection wire on the back side of the board will complete the circuit.
7. If the answer is wrong, the bulb will not glow.

Precautions

1. Every connection should be tight.
2. There should not be any wire left naked.
3. Question and answer should be connected correctly at the back side of the cardboard.

Check Your Progress

A. Fill in the blanks

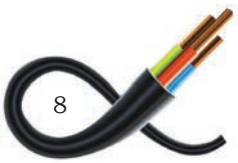
1. The nucleus of an atom is surrounded by negatively charged particles known as _____.
2. Similar electric charges _____ each other and opposite charges _____ each other.
3. Benjamin Franklin's experiments helped in establishing the connection between _____ and _____.
4. Coal, oil or gas is used as a fuel in _____ power stations to convert heat energy into electrical energy.
5. Electromechanical cell is capable of generating electrical energy through _____.

B. Match the columns

1.	Thermal power plant	(a)	Renewable
2.	Wind Power Plant	(b)	Photovoltaic effect
3.	Solar cell	(c)	Water
4.	Michael Faraday	(d)	Law of Electromagnetic Induction

C. Multiple choice questions

1. Electricity was discovered by _____.
   (a) Isaac Newton (b) Benjamin Franklin
   (c) Max Plank (d) Rutherford
2. Which of these is the most commonly used source of energy for power generation in India?
   (a) renewable (b) thermal
   (c) nuclear (d) hydro
3. Which form of energy is converted by a solar cell into electrical energy?
   (a) wind (b) thermal
   (c) nuclear (d) light
4. Electricity is a type of energy which involves the flow of _____.
   (a) protons (b) neutrons
   (c) electrons (d) atoms



5. If you put two negative charges close together, they will _____.
   (a) attract
   (b) repel
   (c) not interact
   (d) attract some time and repel some time.

D. Write short notes on

1. Use of thermal power plant
2. Generation of electricity
3. Different sources of energy

Session 2: Basic Units and Definition of Electricity

Electricity

Electricity is a form of energy which though cannot be seen but its effects can still be felt (Fig. 1.11).

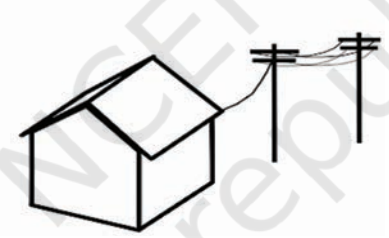


Fig. 1.11 Electricity as form of energy

Various Effects of Electric Current

(a) Heating effect: Heat is produced in a conductor, like nichrome, due to flow of current through it. It is called heating effect (Fig. 1.12) of electric current or Joule's law of heating. When electricity flows through a conductor like tungsten, light is emitted (Fig. 1.13) from the surface of conductor due to heating, such as in an electric bulb.

Fig. 1.12 Electric heater

Fig. 1.13 Electric bulb

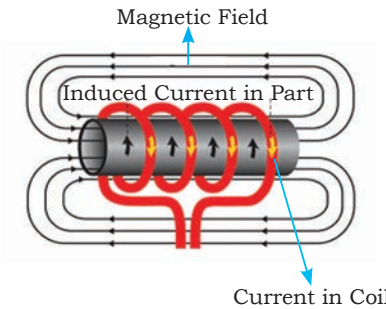


Fig. 1.14 Magnetic effect of electric current

(b) Chemical effect: When current is passed through an electrolyte, it breaks up in its ions. This is known as chemical effect of electric current.

(c) Magnetic effect: It was discovered by Faraday. A magnetic field (Fig. 1.14) is produced around the conductor through which current is flowing. This effect is called magnetic effect of electric current. When electricity flows through the human body contraction of nerves occurs, which can be fatal.

(d) Physical effect: When electricity flows through the human body, contraction of nerves takes place, which may be dangerous for a person's life. This is the physical effect of electric current (Fig. 1.15).

Fig. 1.15 Physical effect of electricity on human body

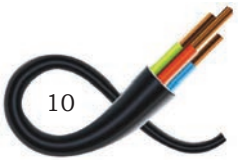
Voltage, Current, Resistance, Capacitance and Inductance

If we place two objects charged to different potential side by side, charge will not move from one object to the other. Now if the two are connected using a conductor, the flow of charge will take place. Charge will flow as long as there is a difference of potential between the two objects. The flow will stop as soon as their potential becomes equal. This flow of electric charge is called electric current.

The potential difference (PD) between two points is one volt, when the work done in moving one coulomb of charge between these points is one joule.

We know that flowing water constitutes water current. Similarly, if the electric charge flows through a conductor that means there is an electric current in the conductor. In a torch, the cells provide necessary potential difference for the flow of charges or an electric current through the torch bulb to glow. We have also seen that the torch gives light only when its switch is on. A continuous and closed path of an electric current is called electric circuit. Now, if the circuit is broken anywhere the current stops flowing. Electric current is expressed by the amount of charge flowing through a particular area in unit time. In other words, it is the rate of flow of electric charges.

Let us understand the analogy of water flow. Water will not flow by itself in a perfectly horizontal tube.



If one end of the tube is connected to a tank of water kept at a higher level, such that there is a pressure difference between the two ends of the tube, water will flow out of the other end of the tube.

Voltage plays an important role for flow of charges in a conducting wire. The electrons move only if there is a difference of electric pressure known as the potential difference or voltage. This difference of potential may be produced by a cell or a battery, consisting more than one electric cell. The chemical action within a cell generates the potential difference across the terminals of the cell. When the cell is connected to a conducting circuit element, the charge flows from one end to other.

Voltage

Voltage is the force required to make electricity flow through a conductor (Fig. 1.16). It is also called electric potential difference or electromotive force (EMF). Voltage may also be defined as the energy difference between the positive and negative terminals of a battery. This energy difference is measured in volts and represented by the symbol 'V' or 'E'.

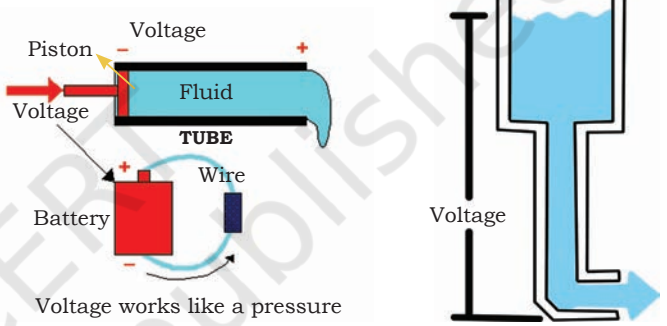
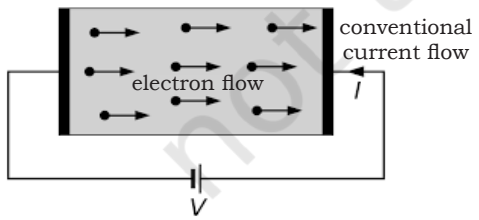


Fig. 1.16 Voltage

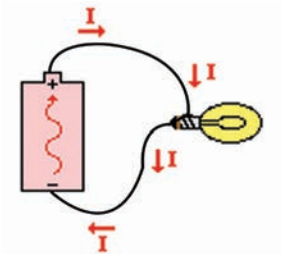
Current

Current is the flow of electrons in a material from one atom to the next atom in the same direction (Fig. 1.17). Just as pressure causes current to flow in a circuit, voltage causes current to flow in the conductor (Fig. 1.18). Current is measured in amperes and is denoted by the symbol 'I'.



Flow of current in conductor (Cu)

Fig. 1.17 Flow of electrons



Electric current in the external circuit is directed from the positive to the negative terminal

Fig. 1.18 Flow of current in conductor

Resistance

Fig. 1.19 Electrical resistance

The electrical resistance of an object is a measure of its opposition to the flow of electric current (Fig. 1.19). It is represented by the symbol 'R'. It is measured in ohms, symbolised by the Greek letter omega (Ω) by a measuring instrument called ohm meter.

Example: Some materials offer more resistance than others. Metals, such as silver, copper, aluminium and iron offer less resistance and are known as good conductors of electricity. On the other hand, materials like plastic, glass, mica and rubber offer high resistance and are called bad conductors of electricity, or good insulators.

Capacitance

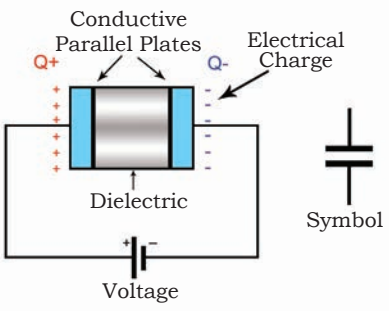


Fig. 1.20 Circuit diagram of a capacitor

Capacitance is a measure of a circuit's ability to store electrical charge (Fig. 1.20). Any object that can be electrically charged exhibits capacitance. If the charges on the plates are +q and −q, respectively, and V is the voltage between the plates, then the capacitance 'C' is given by the formula:

$$C = q/V$$

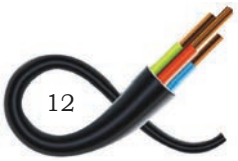
A device manufactured to have a specific amount of capacitance is called capacitor (Fig. 1.21). A capacitor is made up of a pair of conductive plates separated by a thin layer of insulating material. Another name for the insulating material is dielectric material.

Fig. 1.21 Capacitors

A common form of energy storage device is a parallel-plate capacitor. In a parallel plate capacitor, capacitance is directly proportional to the surface area of the conductor plates and inversely proportional to the distance between the plates.

Inductance

Inductance is the property of an electric circuit that opposes any change in electric current. Resistance opposes current flow; inductance opposes changes in the current flow. Inductance is designated by the letter 'L'. The unit of measurement for inductance is Henry (H).



As Henry is a relatively large unit, inductance is often rated in millihenries or microhenries. Inductors are coils of wire wound for a specific inductance. The inductance of a coil is determined by the number of turns in the coil, the coil diameter and length, and the core material (Fig. 1.22).

Current flow produces a magnetic field in a conductor. The amount of current determines the strength of the magnetic field. As current flow increases, field strength increases and as current flow decreases, field strength decreases. Any change in current causes a corresponding change in the magnetic field surrounding the conductor.

Current is constant for a regulated direct current (DC) source, except when the circuit is turned on and off, or when there is a load change. However, alternating current (AC) is constantly changing, and inductance is continually opposing the change. A change in the magnetic field surrounding the conductor induces a voltage in the conductor. This self-induced voltage opposes the change in current. This is known as counter EMF.

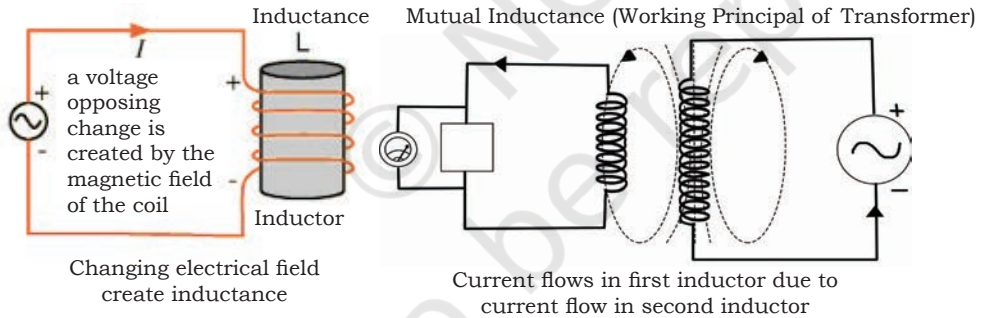


Fig. 1.22 Diagram showing how changes in electrical field create inductance

Electric Circuit

A simple electric circuit (Fig. 1.23) consists of a voltage source, some type of load and conductors to allow electrons to flow between the voltage source and the load. An electric circuit can be either in series or parallel.

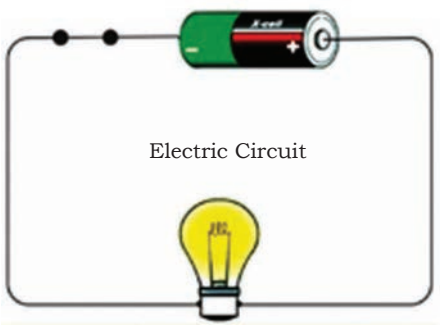


Fig. 1.23 Simple Electric Circuit

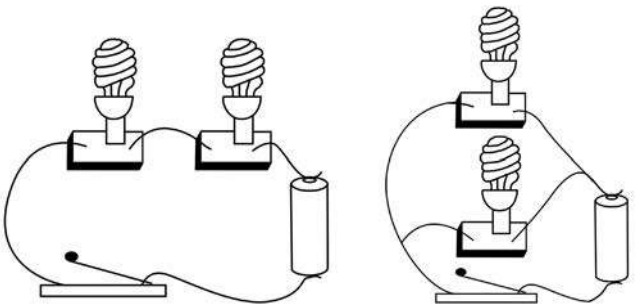


Fig. 1.24 Series and Parallel Circuit

Series Circuit

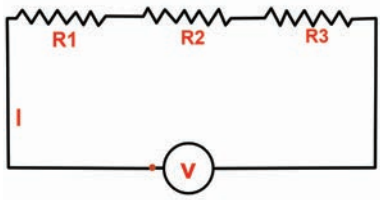


Fig. 1.25 Diagram of Series Circuit

If two or more resistors (loads) are connected in such a way that they form a chain, one after the other, then each carries the same current when the combination is connected with the supply source. They are said to be connected in a series (Fig. 1.25).

This circuit is called series circuit.

In Series Circuit

Resultant Resistance (R)=R1+R2+R3

Parallel Circuit

When two or more resistors (loads) are connected in such a way that each forms a separate path and carries a part of total current, they are said be arranged in parallel and the circuit is called parallel circuit (Fig. 1.26).

In Parallel Circuit

Resultant Resistance $\left(\frac{1}{R_t}\right) = \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}$

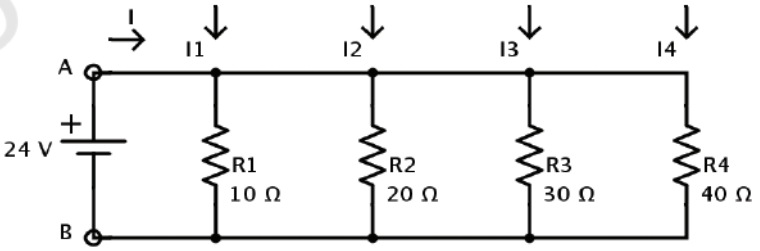


Fig.1.26 Diagram of Parallel Circuit

Ohm's Law

Ohm's law describes the way current flows through a resistance when a different electric potential (voltage) is

applied at each end of the resistance. One way to think of this is as water flowing through a pipe. The voltage is like the water pressure, the current is the amount of water flowing through the pipe, and the resistance is the size of the pipe. The more the resistance, the less the current will flow through the electric circuit. Ohm's law shows that current varies directly with voltage and inversely with resistance.

Voltage is calculated by multiplying the current with the resistance, or

E = IR

This is called Ohm's law (Fig. 1.27). Ohm's law can be expressed in three ways:

E = IR or I = E/R or R = E/I

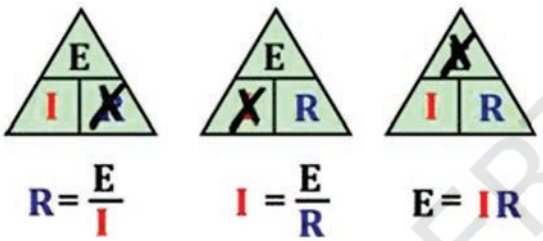


Fig. 1.27 Equation Triangles in Ohm's Law

Kirchhoff's Current Law

It states that the total current or charge entering a junction or node is exactly equal to the charge leaving the node, as no charge is lost within the node. In other words the algebraic sum of ALL the currents entering and leaving a node must be equal to zero I (current entering in the node) + I (current leaving the node) = 0.

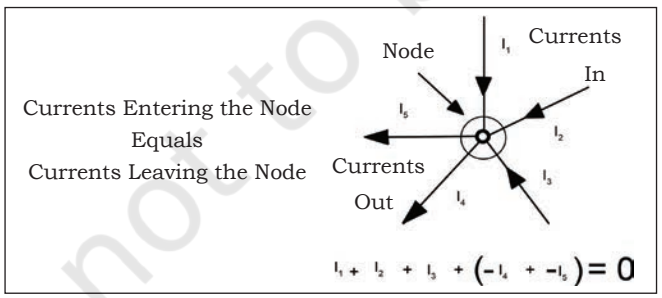


Fig. 1.28 Diagram of Kirchhoff's Current Law

This idea by Kirchhoff is commonly known as the Conservation of Charge or Kirchhoff's Current Law (KCL) (Fig. 1.28).

Here, the three currents entering in the node, I1, I2, I3 are all positive in value and the two currents leaving the node, I4 and I5 are negative in value.
Then this means we can also rewrite the equation as:

$$I_1 + I_2 + I_3 - I_4 - I_5 = 0$$

Kirchhoff's Second Law — the Voltage Law (KVL)

Kirchhoff's Voltage Law or KVL, states that in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop. In other words the algebraic sum of all voltages within the loop must be equal to zero (Fig. 1.29). This is called Kirchhoff's Second Law or law of Conservation of Energy.

The sum of all the Voltage Drops around the loop is equal to Zero

$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$

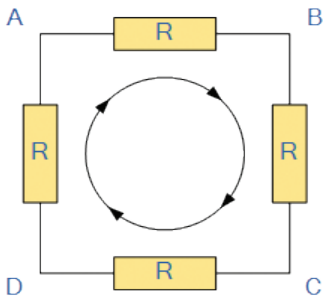


Fig. 1.29 Diagram of Kirchhoff's Second Law

Starting at any point in the loop continue in the same direction noting the direction of all the voltage drops, either positive or negative, and come back to the same starting point. It is important to maintain the same direction either clockwise or anti-clockwise or the final voltage sum will not be equal to zero. We can use Kirchhoff's voltage law when analysing circuits.

When analysing either DC circuits or AC circuits using Kirchhoff's Circuit Laws. The following terminologies are used to describe the parts of the circuit being analysed, such as

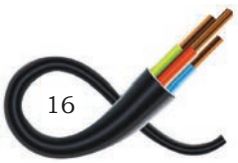
(a) Nodes: when any resistance is connected in the circuit the two terminals of resistance are called nodes.

(b) Loop: when multiple resistances are connected and create a circle, it is called loop.

(c) Path: when multiple resistances are connected with an electrical circuit, the direction of the current flow is called path.

(d) Meshes: hundreds of resistances connected in a circuit in parallel and in series, these are called meshes.

These terms are used in circuit analysis so it is important to understand them.



Check Your Progress

A. Fill in the blanks

1. Light emitted from the surface of conductor is due to _____ of electric current.
2. Magnetic effect of current was discovered by _____.
3. An electric bulb glows when current passes through _____, a conductor.
4. If a changing magnetic field is connected with the coil of a conductor, then _____ is induced in it.

B. Match the columns

1.	Voltage	(a)	Storing Charge
2.	Current	(b)	Obstruction in flow of charge
3.	Resistance	(c)	Flow of charge
4.	Capacitance	(d)	Pressure

C. Multiple choice questions

1. The potential difference between two points is _____
   (a) one volt energy (b) volume
   (c) pressure (d) temperature
2. The chemical reaction within a cell generates _____ across the terminals of the cells.
   (a) energy (b) potential difference
   (c) pressure (d) current
3. Kirchhoff's Current Law states that the algebraic sum of all currents entering and leaving a node must be equal _____.
   (a) one (b) two
   (c) three (d) zero
4. In any electrical circuit when physical condition (temperature, diagram and length) of a conductor are constant voltage is directly proportional to _____.
   (a) current (b) resistance
   (c) power (d) energy
5. If two or more resistors (loads) are connected in such a way that they form a chain it is a _____.
   (a) parallel circuit (b) series circuit
   (c) closed circuit (d) open circuit

D. Short answer questions

1. Explain Ohm's Law in brief with the help of a diagram.
2. Electric current has various effects on chemicals, conductors, the human body, etc. Discuss with suitable examples.
3. An inductor can be defined as an energy storage device. Why?
4. Describe the different parts of a circuit.

Session 3: Concept of Electrical Power and Energy

Difference between Power and Energy

Power is the measurement of energy transfer by an electrical circuit in unit time. Electrical power and energy play a vital role in today's society. Electrical power and energy involve generation, transmission and distribution of electrical energy reliably and efficiently to meet consumer demands. Electrical appliances at home like bulbs, heaters, etc., transfer energy from the mains supply to heat and light our homes. Electric energy also operates our appliances, such as TV, microwave and computers, etc. The units measured by an electricity meter and used to calculate the consumption (electricity bill), are kilowatt hours. The cost of each unit of electricity varies. The electricity bill is calculated by multiplying the number of units used by the cost of a unit.

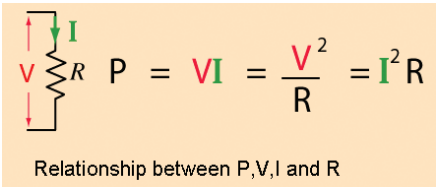


Fig. 1.30 Diagram shows relationship between P,V, I and R

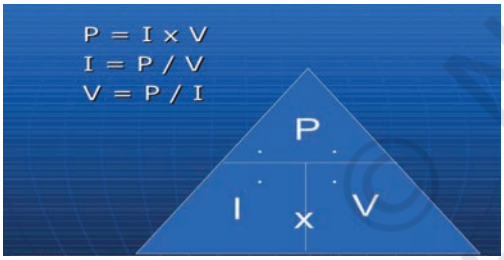


Fig. 1.31 Magic triangle — put your thumb on any one unit and get related Equation

Electrical Power

It is the rate at which electrical energy is consumed by an electrical appliance.

The unit of electrical power is watt.

1000 watt = 1 kilowatt

Electrical Power in DC and AC Circuit

Electrical Power in DC Circuit (Figs. 1.30 and 1.31)

$P = V \times I$

$P = I^2R$

$P = V^2/R$

where V=voltage, I=current and R=resistance

Electrical Power in AC Circuit

P = VI cos ø, where cos ø = power factor and

P = power

Electrical Energy

Electrical energy is the capacity for doing electrical work.

Energy in watt hour is the multiplication of power in watt and time in hour. This is the basic unit of

energy. The commercial unit of energy is kilowatt-hour (Fig. 1.32).

Electrical Energy = power × time

Electrical Energy = watt × hour

Electrical Energy = 1000 watt × 1 hour

Electrical power in a circuit is the rate at which energy is used or generated within a circuit. A source of energy, such as a battery will deliver power while the connected load uses it. Light bulbs and heaters are examples of usage of electrical power and its conversion into either heat, or light, or both. The higher the value or rating in watts, the more electrical power they are likely to consume. Symbols of electrical circuit are shown in Fig. 1.34.

Electrical power (Fig. 1.33) is also expressed as the rate at which energy is transferred in the circuit. If one joule of work is either absorbed or delivered at a constant rate of one second, then the corresponding power will be one watt. So power can be defined as "1Joule/sec = 1Watt". Then we can say that one watt is equal to one joule per second and electrical power can be defined as the rate of doing work or the rate of transferring of electrical energy.

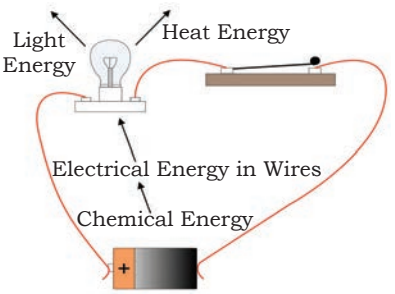


Fig. 1.32 Diagram shows conversion of chemical energy into electrical energy

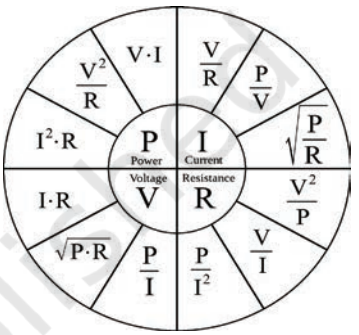


Fig. 1.33 Diagram of electrical power circulation

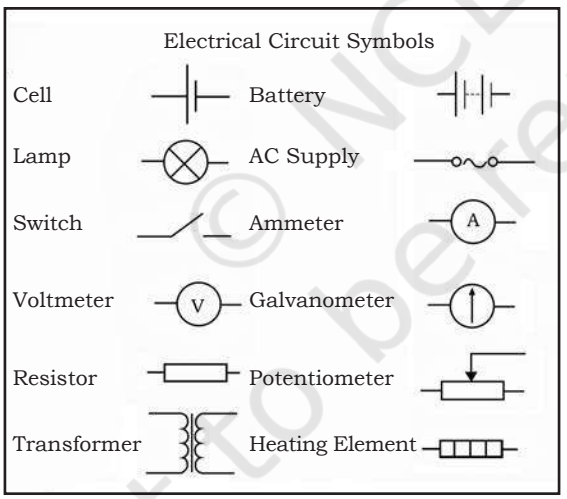


Fig. 1.34 Diagram of electrical circuit symbols

Use of Voltmeters and Ammeters

Voltmeters

1. Voltmeter is always connected across the device or in parallel.
2. Voltmeter has a very high internal resistance, so as not to draw a large current from the circuit.

Ammeters

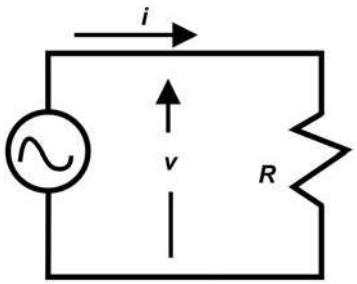
1. Ammeter is always connected in series.
2. Ammeter has a very low internal resistance, so as not to generate a drop in potential.

Power and Energy Calculation in DC and AC system

(a) Watt: This is a unit of power. It is the rate at which electricity is being used at a specific moment: 1 kilowatt= 1000 watt, 1 Megawatt= 1000,000 watt.

Example 1: 09-watt LED light bulb consumes 09 watts of electricity at any moment when turned on.

(b) Watt-hour: This is a unit of energy. One watt-hour is the energy consumed when one watt of power is used for one hour: watt-hour = watt × hour. Commercial unit of energy is 1 kilowatt-hour (1 kWh)



P = V*I ..... For DC
P = V*I*Cos(θ) .....For AC

Electric Power Measurement

Fig. A

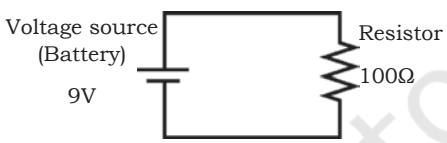
Example 2: 09-watt LED bulb, which draws 09 watts at any one moment, uses 09 watt-hours of electricity in the time of one hour.

Here's the general rule for calculating power dissipation:

Power : P = V × I

where V= voltage, applied across the circuit and I= current flowing in the circuit

Example 3: We begin with one of the simplest circuits: A battery hooked up to a single resistor:



Here, we have a single 9 V battery, and a single 100 Ω (100 Ohm) resistor, hooked up with wires to form a complete circuit. Calculate power and energy in 10 watt-hour.

Calculation of Power: As per formula Power in DC circuit —

Electrical Power = Voltage × Current

$$P = V \times I$$

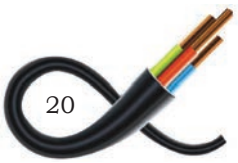
As per Ohm's Law V=IR (where R = resistance of the circuit)

$$I = V/R$$

Then, $P=V \times V/R$

$$P = V^2/R$$

$P=9^2/100=81/100=0.81$ watt



Solution: Power dissipated in the electrical circuit is 0.81 Watt

Calculation of electrical energy: As per the formula of electrical energy in DC circuit —

Electrical energy = Power (in watt) × Time (in hour)

Then, electrical energy consumed for 10 hours = 0.81 × 10 = 8.1 watt-hours

Solution: Energy consumed by above electrical circuit is 8.1 unit.

Question: Calculate the electrical power and energy consumed in 5 hour of the electrical DC given circuit (Fig. B).

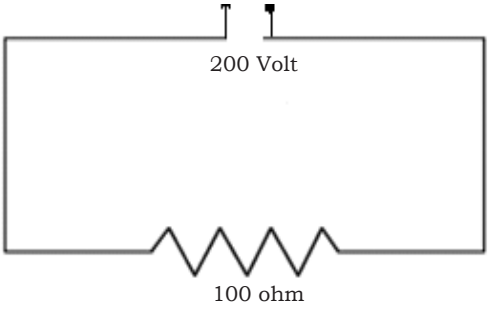


Fig. B

Check Your Progress

A. Fill in the blanks

1. Electrical power involves _____, _____, and _____ of electrical energy.
2. _____ is the rate at which electricity is used at a specific moment.
3. A _____ is always connected across the device or in parallel.
4. The commercial unit of electricity is known as _____.
5. Ammeter has a low internal resistance so as to not generate a _____ in potential.

B. Match the column

1.	Battery	(a)	Current indicating device
2.	Galvanometer	(b)	Resists the flow of a current
3.	Resistor	(c)	A resistance which generates heat
4.	Heating Element	(d)	Combination of two or more cells

C. Multiple choice questions

1. AC stands for _____
   (a) alternating current (b) direct current
   (c) power (d) energy
2. The internal resistance of an ammeter is _____.
   (a) high (b) low
   (c) zero (d) infinite
3. What is required to produce electric current?
   (a) Voltage (b) Source of energy
   (c) Electric field (d) All of these

4. Potentiometer is an electric device that gives variable _____.
   (a) power (b) resistance
   (c) voltage (d) current

D. Short answer questions

1. What is one commercial unit of electrical energy? Explain briefly.
2. An electric iron is connected across 220 volt power supply. If the resistance of the iron is 50 ohm, then calculate
   (a) the current flowing through the iron.
   (b) electrical power of the iron
   (c) energy used in commercial units (kWh) if the iron is connected for 2 hours.
3. One LED bulb is labeled '220 volt and 11 watt'. If the bulb is connected to 220 volt power supply, then calculate
   (a) the current that flows through LED bulb.
   (b) the amount of electrical energy used by the LED bulb in 8 hours.

E. Draw the electrical symbols of the following

1. Cell
2. Battery
3. Bulb
4. Resistance
5. Switch

SESSION 4: IMPORTANCE OF EARTHING SYSTEM

Earthing is set up in an electrical circuit to ensure safety. This system provides an alternative path for high and dangerous current to flow to the earth so that the problem of electric shock and damaging of equipment does not occur.

The metallic connection between electrical machines and devices with the earth plate, commonly known as earth electrode, through a thick wire of low resistance to provide safety is known as earthing.

Metallic parts of all equipment are earthed and if the equipments' insulation fails there can be dangerous current present on the surface of the equipment. This may cause a short-circuit and the fuse will blow off immediately.

Earthing

Earthing means connection of non-current carrying parts (metallic parts) of electrical apparatus to the earth to discharge electrical energy without any danger.

Earthing is done by connecting the appliance or machinery to earth by good conductor known as earth electrode. Earthing is done to save human life from the danger of electrical shock, in case human body comes in contact with live wire of electricity (Fig. 1.35).

If earthing is done correctly and the metallic part comes in contact with live wire, it will be discharged into the earth. In this condition due to zero potential of earth a large amount of current flows to the earth. If the current exceeds the limiting value of the fuse, it blows off or MCB trips and cuts off the appliance from supply.

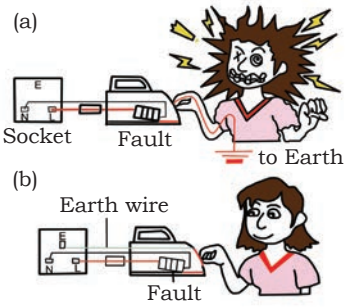


Fig. 1.35 Proper Earthing

Specifications for Earthing

S.No.	Details	Specification
1.	Distance of earth from building	More than 1.5 meter from the building
2.	Size of earth electrode	Not be less then 2.9mm² or 14 SWG
3.	Resistance of earth	Not greater than 8 ohm

The earth electrode and earth wire will be of the same material.

Points to be earthed

1. Earth pin of 3 pin and 5 pin plug and socket.
2. All metal parts of electrical machine, e.g., motor, heater, geyser and mixer.
3. Metallic frame of electrical machines.
4. The neutral conductor of 3-phase 4-wire system.
5. Pole, tower, armouring of cable.
6. Stray wire of overhead lines.

Importance of Electrical Earthing

Electrical earthing is important to

1. save human life from the danger of shock from leakage current.

2. maintain the line voltage constant.
3. protect large machine and building from atmospheric lighting.
4. avoid the risk of accident in electrical substation and other installation.

Earth resistance of different electrical installation

Large Power Station	0.5 Ohm
Major Power Station	1.0 Ohm
Small Sub-Station	2.0 Ohm
In house wiring and such other case	5.0 to 8.0 Ohm

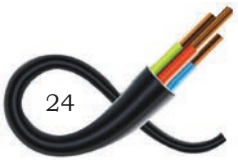
Types of Earthing

1. **Strip earthing:** In this type of earthing galvanised iron strip of 25mm × 4mm or copper strip of 25mm × 1.6mm are laid in horizontal trenches of minimum depth of 0.5 meter and covered with charcoal and salt.
2. **Rod earthing:** In this type of earthing system 12.5 mm diameter of solid rod of copper or 16 mm diameter of solid rod of galvanised iron are fitted vertically into the earth not less than 2.5 meter on the earth's surface.
3. **Pipe earthing:** Pipe earthing is cheaper and the best form of earthing. In this type of earthing a hollow pipe of 38 mm diameter and 2.5 meter long GI is placed underground of the earth and covered with charcoal and salt.
4. **Plate earthing:** In this type of earthing system, a plate of either copper with dimensions 60cm × 60cm × 3.18mm or galvanised iron (GI) of dimensions 60cm × 60cm × 6.35 mm is buried vertical in the earth pit which should not be less than 3 meter from the surface of ground.

The most commonly used types of earthing are

(a) Pipe Earthing

This type of earthing is used widely in industries and house wiring system. In this system of earthing a GI pipe of 30 mm diameter and 2.5 m length is buried vertically



in ground to work as earth electrode. The depth depends upon the soil conditions; there is no hard and fast rule for this. The earth electrodes are connected to the top section of the pipe with nut and bolt. The pit area around the GI pipe is filled with alternate layer of salt and charcoal for reducing earth resistance. It can take heavy leakage current for the same electrode size in comparison to plate earthing. Water is filled through a pipe to maintain the resistance of earth electrode. Pipe earthing (Fig. 1.36) is the best form of earthing and it is also a cheap method of earthing.

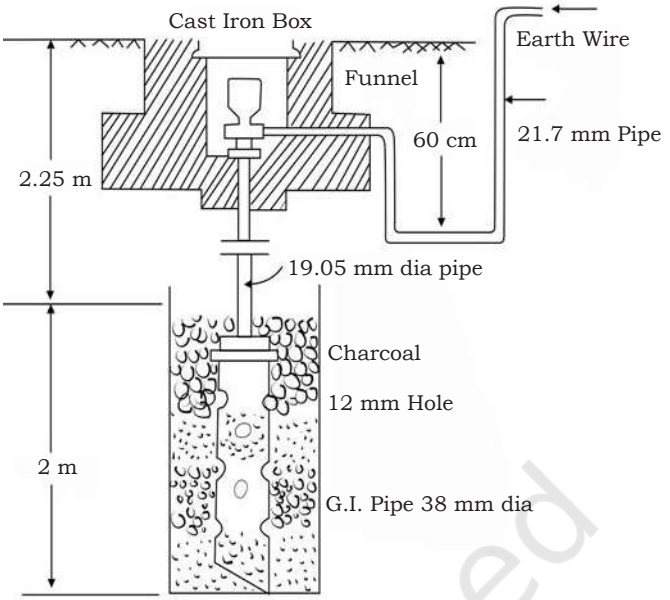


Fig. 1.36 Pipe earthing

Earthing pipes are also known as earthing electrode pipes, these can be used in houses, offices as well as in power stations. Earthing pipes are used in electrical installation, transmission line and other installation. Copper pipe is generally used in earthing system.

The pipe size depends upon the current to be carried and on the soil type. Pipe earthing is reliable, durable, easy to handle and highly secure. Connectivity of the pipe earthing is up to the chamber or earth terminal. The connection of earth wire from machine to galvanised iron pipe, being above the ground level makes it easy to check for any discontinuity. To have an effective earthing in summer season, pipe earthing gives us the freedom to put 2–3 buckets of water through the funnel, which helps in achieving effective earthing. This is one of the most widely used methods of earthing.

(b) Plate Earthing

In this type of earthing, a plate of copper or GI is buried into the ground at a depth of greater than 3 m.

Earthing plate is filled with alternate layers of salt and coke not less than 46 cm (1.5 feet) so to provide lesser resistance due to absorption of moisture. The earth conductor is properly bolted to an earth plate with the help of nut and bolt and washer made of copper, in case of copper plate earthing and of GI in case of GI plate earthing (Fig. 1.37).

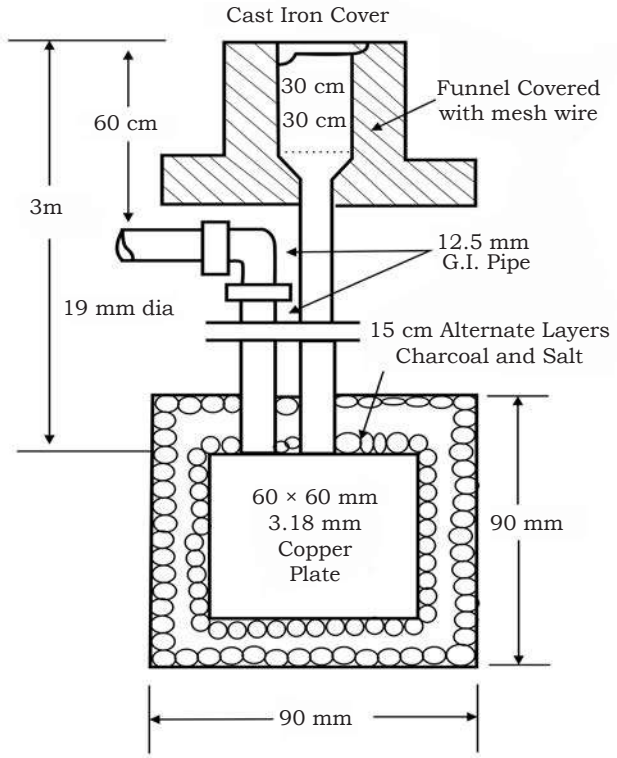


Fig. 1.37 Plate earthing

1. For GI earthing plate size should be – 600 mm × 600 mm × 8.30 mm

2. For copper earthing plate size should be – 600 mm × 600 mm × 3.15 mm

Pit size made for maintenance should be 30 cm × 30 cm. so as to provide ease of accessibility of maintenance of these earthing pits and for testing of earthing pits.

Advantages of Earthing

One of the major objectives of earthing is to ensure safety of persons during leakage fault conditions. Earthing creates the path of least resistance from machine to the earth so that the fault current dissipates quickly. It allows the electrical energy to be safely dissipated thereby minimising the danger caused by leakage. Earthing is the key to safety i.e., protection of personnel, equipment, wiring, machines and instruments. Another advantage of earthing in the context of communication tower is to reduce electromagnetic interference.

Both plate or pipe earthing can be used. However, plate earthing is preferred in small buildings and pipe earthing is preferred for multistorey buildings as well as electrical substations. All metallic parts of electric machines must be earthed for safety of the equipment.

Atmospheric Lightning

Atmospheric lightning is a form of visible discharge of electricity between a rain cloud and the earth. The electric discharge is seen in the form of an arc between the cloud and the earth's surface.

When the electrical potential between two clouds, or a cloud and the earth reaches a sufficiently high value the air becomes ionised along a narrow path and results in a flash of lightning.

The possibility of lightning is more on tall trees and buildings rather than on the ground. Buildings are protected from lightning by metallic lightning rods. These lightning rods are known as lightning arresters. This lightning arrester is fitted at the highest part of the roof and it is extended to the ground through a conductor. The conductor has a pointed edge on one side and the other side is connected to a long thick copper strip which runs down the building. The lower end of the strip is properly connected to the earth. When lightning strikes on the rod, current flows down through the copper strip. These rods provide a low-resistance path for the lightning discharge and prevent it from travelling through the structure of the building itself.

Lightning Arrester

The principle of the lightning arrester was first discovered by Benjamin Franklin in 1749, who in the subsequent years developed his invention for household application.

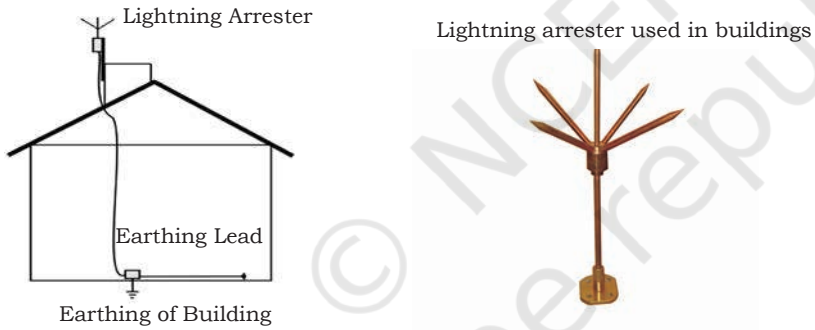


Fig. 1.38 Lightning arresters

Lightning arresters (Fig.1.38) are devices which prevent damage of apparatus due to high lightning voltages. The lightning arrester provides a low resistance path to ground for the current from a lightning strike.

When a high voltage or a voltage greater than the normal line exists in the circuit, the lightning arrester immediately provides a path to the earth and thus limits and drains off the excess voltage.

Working of Lightning Arrester

1. A lightning arrester does not absorb any charge caused by lightning.

2. A lightning arrester diverts the charge towards the ground.
3. A lightning arrester limits the voltage produced by atmospheric lightning.
4. A lightning arrester will work at the time of lightning because it produces very high voltages.
5. A lightning arrester provides protection against lightning surges during the rainy season.

Earth Resistance

1. Earth resistance depends on following factors
   (a) Type of earth soil
   (b) Temperature of earth
   (c) Humidity in earth
   (d) Minerals in earth
   (e) Length of electrode in the earth
   (f) Electrode shape and size
   (g) Distance between two electrodes
   (h) Number of electrodes
2. Maximum earth resistance allowed is as follows:
   (a) Major power station — 0.5 ohms
   (b) Major Sub-stations — 1.0 ohms
   (c) Minor Sub-station — 2 ohms
   (d) Neutral Bushing — 2 ohms
   (e) Service connection — 4 ohms
   (f) L.T Lightning Arrestor — 4 ohms
   (g) L.T. Pole — 5 ohms
   (h) H.T. Pole — 10 ohms
   (i) Tower — 20-30 ohms

Earth Tester and Earth Resistance

Earth tester is used to measure earth's resistance. If earth resistance is high, certain processes need to be adopted.

Working of Earth Tester

Earth tester consists of hand operated D.C. generator, 4 spikes and connecting wire. These spikes are

connected through wire to terminals of earth tester. Spikes are inserted in the ground to check the earth resistance. Current is fed to the spikes through DC generator. DC current is converted into AC current by the converter and AC current received from spike is again converted in DC current with the help of a rectifier. While going to generator, AC current is fed to the spike driven in earth because there should not be electrolytic effect.

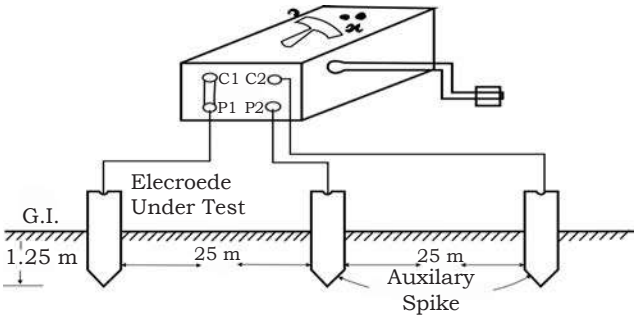


Fig. 1.39 Measurement of Earthing Resistance—Three-Point Method

Three-point Method

In this method, earth tester terminals C1 and P1 are shorted (joined) to each other and connected to the earth electrode (pipe) under test. Terminals P2 and C2 are connected to the two separate spikes driven in earth. These two spikes are kept in the same line at a distance of 25 meters and 50 meters due to which, there will not be mutual interference in the field of individual spikes. If we rotate the generator handle with specific speed, we get the earth's resistance directly on scale. This method of testing is known as three point method (Fig. 1.39).

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

Four-point Method

In this method, four spikes are driven in earth in same line at the equal distance. Outer two spikes are connected to C1 and C2 terminals of earth tester. Similarly inner two spikes are connected to P1 and P2 terminals. Now if we rotate generator handle with specific speed, we get earth's resistance value of that place.

In this method error due to polarisation effect is eliminated and earth tester can be operated directly on AC.

If earth's resistance is higher than done the above values, following treatments can be to minimise resistance:

(a) Oxidation on joints should be removed and joints be tightened.

(b) Sufficient water should be poured in earth electrode.

(c) Earth electrode of bigger size as far as possible should be used.

(d) Electrodes should be connected in parallel.

(e) Earth pit of more depth and width-breadth be made.

Check Your Progress

A. Fill in the blanks

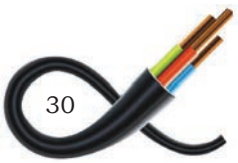
1. The metallic connection between electrical machines and devices with earth plate is known as _____.
2. Absence of earthing causes _____.
3. The resistance between earth electrode and earth in ohms is called _____.
4. Lightning arrester prevents damage of _____.

B. Match the columns

1.	Large Power Station	(a)	5.0 to 8.0 ohm
2.	Major Power Station	(b)	5 ohm
3.	Small Sub-Station	(c)	2 ohm
4.	In House wiring and such other case	(d)	1 ohm

C. Multiple choice questions

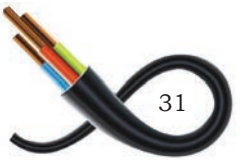
1. Maximum earth resistance value of major power station is _____
   (a) 0.5 ohm
   (b) 2 ohm
   (c) 1 ohm
   (d) 8 ohm
2. One of the most common type of earthing is _____.
   (a) plate earthing
   (b) pipe earthing
   (c) rod earthing
   (d) strip earthing
3. Earthing pipes are not used for _____.
   (a) electrical installation
   (b) transmission line
   (c) industry
   (d) atmospheric light



4. For maintaining moisture around the earthing we use _____.
   (a) salt and charcoal
   (b) sugar
   (c) oil
   (d) none of them
5. Every metallic electrical pole must be _____.
   (a) grounded
   (b) earthed
   (c) phase
   (d) neutral

D. Short answer questions

1. Explain the process of pipe earthing.
2. The high resistance of earth needs to be controlled for certain processes. Analyse the importance of earth tester in this context.
3. Draw a simple diagram of plate earthing.
4. Discuss the factors which affect earth's resistance.



Distribution Lineman-Class 11 Unit-1 Session-1

A. Fill in the blanks

1. The nucleus of an atom is surrounded by negatively charged particles known as _____.
2. Similar electric charges _____ each other and opposite charges _____ each other.
3. Benjamin Franklin's experiments helped in establishing the connection between _____ and _____.
4. Coal, oil or gas is used as a fuel in _____ power stations to convert heat energy into electrical energy.
5. Electromechanical cell is capable of generating electrical energy through _____.

B. Match the columns

1.	Thermal power plant	(a)	Renewable
2.	Wind Power Plant	(b)	Photovoltaic effect
3.	Solar cell	(c)	Water
4.	Michael Faraday	(d)	Law of Electromagnetic Induction

C. Multiple choice questions

1. Electricity was discovered by _____.
   (a) Isaac Newton (b) Benjamin Franklin
   (c) Max Plank (d) Rutherford
2. Which of these is the most commonly used source of energy for power generation in India?
   (a) renewable (b) thermal
   (c) nuclear (d) hydro
3. Which form of energy is converted by a solar cell into electrical energy?
   (a) wind (b) thermal
   (c) nuclear (d) light
4. Electricity is a type of energy which involves the flow of _____.
   (a) protons (b) neutrons
   (c) electrons (d) atoms

5. If you put two negative charges close together, they will _____.
   (a) attract
   (b) repel
   (c) not interact
   (d) attract some time and repel some time.

D. Write short notes on

1. Use of thermal power plant
2. Generation of electricity
3. Different sources of energy

Distribution Lineman-Class 11 Unit-1 Session-2

A. Fill in the blanks

1. Light emitted from the surface of conductor is due to _____ of electric current.
2. Magnetic effect of current was discovered by _____.
3. An electric bulb glows when current passes through _____, a conductor.
4. If a changing magnetic field is connected with the coil of a conductor, then _____ is induced in it.

B. Match the columns

1.	Voltage	(a)	Storing Charge
2.	Current	(b)	Obstruction in flow of charge
3.	Resistance	(c)	Flow of charge
4.	Capacitance	(d)	Pressure

C. Multiple choice questions

1. The potential difference between two points is _____
   (a) one volt energy (b) volume
   (c) pressure (d) temperature
2. The chemical reaction within a cell generates _____ across the terminals of the cells.
   (a) energy (b) potential difference
   (c) pressure (d) current
3. Kirchhoff's Current Law states that the algebraic sum of all currents entering and leaving a node must be equal _____.
   (a) one (b) two
   (c) three (d) zero
4. In any electrical circuit when physical condition (temperature, diagram and length) of a conductor are constant voltage is directly proportional to _____.
   (a) current (b) resistance
   (c) power (d) energy

5. If two or more resistors (loads) are connected in such a way that they form a chain it is a _____.
   (a) parallel circuit (b) series circuit
   (c) closed circuit (d) open circuit

D. Short answer questions

1. Explain Ohm's Law in brief with the help of a diagram.
2. Electric current has various effects on chemicals, conductors, the human body, etc. Discuss with suitable examples.
3. An inductor can be defined as an energy storage device. Why?
4. Describe the different parts of a circuit.

Distribution Lineman-Class 11 Unit-1 Session-3

A. Fill in the blanks

1. Electrical power involves _____, _____, and _____ of electrical energy.
2. _____ is the rate at which electricity is used at a specific moment.
3. A _____ is always connected across the device or in parallel.
4. The commercial unit of electricity is known as _____.
5. Ammeter has a low internal resistance so as to not generate a _____ in potential.

B. Match the column

1.	Battery	(a)	Current indicating device
2.	Galvanometer	(b)	Resists the flow of a current
3.	Resistor	(c)	A resistance which generates heat
4.	Heating Element	(d)	Combination of two or more cells

C. Multiple choice questions

1. AC stands for _____
   (a) alternating current (b) direct current
   (c) power (d) energy
2. The internal resistance of an ammeter is _____.
   (a) high (b) low
   (c) zero (d) infinite
3. What is required to produce electric current?
   (a) Voltage (b) Source of energy
   (c) Electric field (d) All of these

4. Potentiometer is an electric device that gives variable _____.
   (a) power (b) resistance
   (c) voltage (d) current

D. Short answer questions

1. What is one commercial unit of electrical energy? Explain briefly.
2. An electric iron is connected across 220 volt power supply. If the resistance of the iron is 50 ohm, then calculate
   (a) the current flowing through the iron.
   (b) electrical power of the iron
   (c) energy used in commercial units (kWh) if the iron is connected for 2 hours.
3. One LED bulb is labeled '220 volt and 11 watt'. If the bulb is connected to 220 volt power supply, then calculate
   (a) the current that flows through LED bulb.
   (b) the amount of electrical energy used by the LED bulb in 8 hours.

E. Draw the electrical symbols of the following

1. Cell
2. Battery
3. Bulb
4. Resistance
5. Switch

Distribution Lineman-Class 11 Unit-1 Session-4

A. Fill in the blanks

1. The metallic connection between electrical machines and devices with earth plate is known as _____.
2. Absence of earthing causes _____.
3. The resistance between earth electrode and earth in ohms is called _____.
4. Lightning arrester prevents damage of _____.

B. Match the columns

1.	Large Power Station	(a)	5.0 to 8.0 ohm
2.	Major Power Station	(b)	5 ohm
3.	Small Sub-Station	(c)	2 ohm
4.	In House wiring and such other case	(d)	1 ohm

C. Multiple choice questions

1. Maximum earth resistance value of major power station is _____
   (a) 0.5 ohm
   (b) 2 ohm
   (c) 1 ohm
   (d) 8 ohm
2. One of the most common type of earthing is _____.
   (a) plate earthing
   (b) pipe earthing
   (c) rod earthing
   (d) strip earthing
3. Earthing pipes are not used for _____.
   (a) electrical installation
   (b) transmission line
   (c) industry
   (d) atmospheric light

4. For maintaining moisture around the earthing we use _____.
   (a) salt and charcoal
   (b) sugar
   (c) oil
   (d) none of them
5. Every metallic electrical pole must be _____.
   (a) grounded
   (b) earthed
   (c) phase
   (d) neutral

D. Short answer questions

1. Explain the process of pipe earthing.
2. The high resistance of earth needs to be controlled for certain processes. Analyse the importance of earth tester in this context.
3. Draw a simple diagram of plate earthing.
4. Discuss the factors which affect earth's resistance.

Unit 2

Handling of Tools and Equipment

171176CH02

Introduction

When you work with appliance repair, you need to be familiar with working of the tools. You may already be familiar with the typical wrenches and screwdrivers, but you will need to know more, such as about voltage meters and even single and multiphase compressor testers. Therefore, it is necessary to be sure that you are equipped with enough knowledge to properly use the tools that will be needed. Always remember to take them when you are working on a job.

Fig. 2.1 Tools used in electricity

Various tools and equipment are required for maintaining as well as erection of various electrical components (Fig. 2.1). Therefore, it is necessary to know about various tools and equipment to operate them safely.

Fig. 2.2 Screwdriver

Fig. 2.3 Types of screwdrivers

Session 1: Tools and Equipment

The various tools and equipment used by an electrical or electronic technician while working with electrical circuits are explained below:

(a) Screw driver: It is used to turn, tighten or remove screws (Figs. 2.2 and 2.3).

(b) Ratchet: It is used to allow rotary motion in only one direction and preventing the motion in opposite direction. It is used to tighten nuts of various sizes (Fig. 2.4).

(c) Spanner: It is used to provide grip to apply torque for turning objects such as nut or a bolt. A spanner is available with variable diameter to tighten nuts and bolts of various sizes (Fig. 2.5).

(d) Wrench: It is a hand tool used for tightening and loosening of the nuts and bolts (Fig. 2.6). These tools hold slippery or small nuts and bolts for loosening or tightening it.

(e) Wire cutter and Plier: A wire cutter is used for striping and cutting wires whereas a plier is used to hold objects like nuts and bolts firmly also used for cutting metal wires (Fig. 2.7).

(f) Tester: It is used to verify the presence of electric voltage in electrical equipment (Fig. 2.8).

(g) Hammer: It is used to fix nails in walls and wood, fit parts, or forge metal and breaking different materials (Fig. 2.9).

(h) Ladder: It is used to climb upwards to reach higher places (6 to 7 feet) in tall units of a control panel (Fig. 2.10).

(i) Utility Knife: It is used to cut various objects, such as wires, cords, tapes and so on (Fig. 2.11).

(j) Soldering or Desoldering Iron: It is used to embed/ remove the components on/from the panel (Fig. 2.12).

(k) Soldering or Desoldering Station: It is used to hold the hot iron when it is not in use and adjust the temperature of the tip (Fig. 2.13).

Fig. 2.8 Tester

Fig. 2.9 Hammer

Fig. 2.10 Ladder

Fig. 2.11 Utility knife

Fig. 2.12 Soldering or desoldering iron

Fig. 2.13 Soldering or desoldering station

Fig. 2.4 Ratchets

Fig. 2.6 Wrench

Fig. 2.5 Spanner

Fig. 2.7 Wire cutter and plier

Fig. 2.14 Crimping tool

Fig. 2.15 Voltmeter

Fig. 2.16 Ammeter

(l) Crimping Tool: It is used to cut various objects such as wires, cords, tapes and so on. It is also used to join wires with metal or plastic objects (Fig. 2.14).

(m) Voltmeter: It is used to measure potential difference between two points in the electric circuit (Fig. 2.15).

(n) Ammeter: It is used to measure current flow in a circuit (Fig. 2.16).

(o) Watt meter: It is used to measure electrical power of any given circuit (in watts) (Fig. 2.17).

(p) Megohmmeter or Megger: It is used to measure leakage in wires and earth resistance (Fig. 2.18).

(q) Multimeter: It is used to measure various electrical quantities like resistance, voltage, current, etc (Fig. 2.19).

Fig. 2.17 Watt meter

Fig. 2.18 Megger

Fig. 2.19 Multimeter

Check Your Progress

A. Fill in the blanks

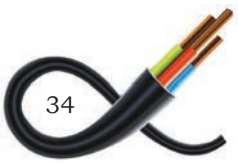
1. _____ is used to allow rotary motion in only one direction. It is used to tighten nuts and bolts.
2. Crimping tool is used for joining wires with _____ or _____ objects.
3. In an electric tester _____bulb is used.

B. Identify whether the following statements are True or False

1. Always examine the tool for damages before use.
2. It is OK to wear loose clothing, dangling objects and jewellery using hand tool.
3. Keep cords and hoses away from heat, oil and sharp edges.
4. Before connecting any electrical equipment to a power source, make sure the power is on.

C. Short answer questions

1. Can a wire cutter be used in place of a plier? Explain in brief.
2. How do tools and equipment help ease an electrical technician's work?



Session 2: Tools and Equipment Used for Cable Laying

Preparations of Cables and Equipment for Cable Laying Activities

Tools and equipment are used for various electrical activities. We should take care while handling the electrical wire laying. While laying the cables necessary precautions and health and safety practices for power related work should be observed as per standard rules. Important tools and equipment used for laying electrical wire (laying works) are given here.

Fig. 2.20 Cable drum with cable

Tools and Equipment used in Cable Laying Activities

Many tools are used for cable laying. These include cable pulling winch, cable guiding device and cable pulling grip, etc.

Fig. 2.21 Cable drum without cable

Cable Drums

Cable gets twisted during laying process. Drums are used to check or avoid twisting of cables. Cable drums (Figs 2.20 and 2.21) help the technicians with the laying of cables. Similarly angle rollers are also used for laying the cable (Fig. 2.22).

Fig. 2.22 Angle rollers

Pulling Methods and Calculations

Proper methods should be used while laying the cable in the field. Suitable equipment and tools must be used in this process. The cable drum should be mounted on jacks and the cable should be rolled off the drum gently avoiding kinks and twists. The free end in the case of heavy cables may be pulled with the help of a winch. Laying cable in an open trench presents no serious difficulty. The cable is first placed on rollers laid in the trench or on the ground above, which is then transferred to the bed of the trench. When laying cables in pipes and ducts, care should be exercised so as not to damage them during installation. The correct method of laying of cables for installation in a duct is shown in Fig. 2.23.

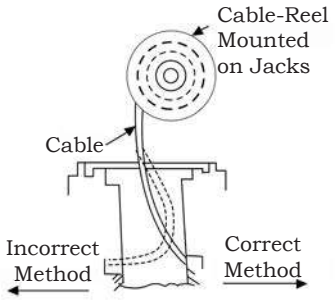
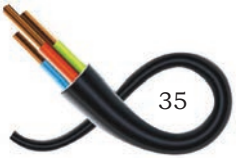


Fig. 2.23 Pulling Methods



Testing of Underground Cables

After laying cables underground or above the ground, proper testing is done to check the faults caused, if any, due to the laying. The cables are tested for short circuiting faults, discontinuity faults and earth fault. Murray and Varley loop tests are done to check these faults.

Tools Used for Erection and Maintenance

Fig. 2.24 Tools for erection and maintenance

A lineman who is doing erection and maintenance work, cannot do his job without proper hand tools, which he carries around on a daily basis. Unlike tools used by any other worker, a lineman's tools require proper insulation, because these tools are used with electrical installations. The handles of these tools are coated with rubber to prevent the worker from getting electrocuted (Fig. 2.24).

Tools are important to carry out a job. The entire job being carried out by a technician is with the help of tools. The following tools are commonly used for working in a distribution system:

(a) Combination Pliers

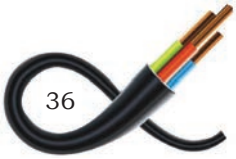
Fig. 2.25 Combination plier

It is used for cutting, removing insulation, jointing and twisting the electric wires and cables even on live-line. A lineman's pliers have special design, which multiplies force through leverage. These pliers usually have grips for better handling than bare metal handles. The grips also have insulation for protection against electric shock when working with live circuits. A lineman's pliers are typically machined from forged steel. The two handles are precisely joined with a heavy-duty rivet that maintains the pliers' accuracy even after repeated use under extreme force on heavy-gauge wire (Fig. 2.25).

(b) Adjustable Wrench

Fig. 2.26 Adjustable wrench

It is used to open and close nuts and bolts in case of proper size spanner not being available. Common sizes are 8" (Inch) to 12" (Inch). Adjustable wrenches are designed to provide a wide range of capacity in a single tool and are a convenient service wrench for



distribution linemen. They are not intended to replace fixed opening wrenches for production or general service work. High dielectric insulated handle types are widely used by linemen and other electrical workers (Fig. 2.26).

(c) Pipe Wrench

It is used to open, close, conduit GI pipes and valves. Common size is 10" (Inch). The design of the adjustable jaw allows it to lock in the frame, such that any forward pressure on the handle tends to pull the jaws tighter together. They are usually made of cast steel. Nowadays, aluminium is also used to construct the body of the wrench, while the teeth and jaw remain steel (Fig. 2.27).

Fig. 2.27 Pipe wrench

(d) Measuring Tape

It is used to measure the length of wires, cables and space. Use of measuring tape makes cable savings efficient for cleaning and reduces wastage. These are made of cotton or metal strips bearing size of 10' (feet) to 100' (feet) (Fig. 2.28).

Fig. 2.28 Measuring tape

(e) Hammer

It is used to pierce nails, centre punch, rawl plug and chisel. Common sizes are 1, 2.5, 3 and 5 lbs (Pounds). A lineman's hammer is best suited to driving in big lag screws and hammering bolts in utility-pole work. They are also used by electricians to drive nails in hard places (Fig. 2.29).

Fig. 2.29 Hammer

(f) Ratchet with Drill Bit (Hand Drill)

It is used to make holes on wooden cross arms and wooden cleats for tight fitting High Tension and Low Tension cables emanating from DP structures, or LT transformer bushings (Fig. 2.30).

Fig. 2.30 Ratchet with drill bit (hand drill)

(g) Electric Drill Machine

It has the below mentioned properties:

- It is a portable electric powered tool used for drilling the surface (Fig. 2.31).
- It has a high speed motor to revolve the chuck.
- It is used to make holes smoothly and easily.

Fig. 2.31 Electric drill

(h) Bench Vice

A vice is a mechanical apparatus used to secure an object to allow work to be performed on it. In electrical

Fig. 2.32 Bench vice

works, cutting does play an important role. Cutting an electrical conduit has to be secure enough so that a smart cut is made. A bench vice (Fig. 2.32) is a perfect way to do this. Bench vice is used to grip the job (object) which has the following features:

- Base Plate (permanently fixed on the working table sides).
- Fixed Jaw (fixed with Base Plate)
- Moving Jaw (could be moved according to the thickness of job)

(i) Chain Pulley

It is a pulley with depressions in the periphery of its wheel, or projections from it, made to fit the links of a chain. The desired capacity chain pulley is hooked at the centre to lift heavy load for loading and unloading at site (Fig. 2.33).

Fig. 2.33 Chain pulley

(j) Tripod

It is a combination of three to four meter long 40 mm GI pipes hinged at upper end for making a tripod formation. Tripods are perfect for utility workers as they are portable and lightweight with high-strength anchor (Fig. 2.34).

Fig. 2.34 Tripod

(k) Come Along Clamp

It is used while laying overhead lines. These are mainly used for holding conductors and ground wires in overhead transmission lines and various other industrial maintenance operations. These clamps are available in multiple diameter, weight and design that are ideal to use in electrical works. They are ideal to pull conductors as they are lightweight and compact in structure (Fig. 2.35).

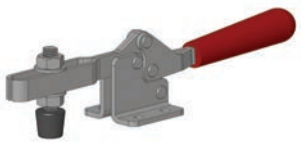


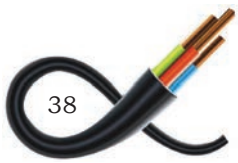
Fig. 2.35 Come along clamp

(l) Ratchet Device

It is a device consisting of a bar or wheel with a set of angled teeth in which a pawl, cog, or tooth engages, allowing motion in one direction only. Ratchets are widely used in machinery and tools as well as maintenance works (Fig. 2.36).

Fig. 2.36 Ratchet device

The senior lineman normally works in a distribution sub-division of a Power Company (Discom). The recommended norms for tools and equipment for a



distribution sub-division are almost same for all states. Electricians working in the field must have the following tools with them as given in Table 2.1.

Table 2.1 List of standard tools for an electrician

S. No.	Particulars	Quantity
1.	Chain pulley block (5 MT)	1
2.	Megger (1000 volts)	1
3.	Earth Tester	1
4.	Portable Drilling Machine	1
5.	Bamboo Ladder	2
6.	Steel Measuring Tape	1
7.	Pulling and lifting machine 3 tone	1
8.	Pipe wrench 3”(7.6 cm)	2
9.	Spirit Level	4
10.	Socket Spanner Set	2
11.	Ring Spanner Set	2
12.	Hammer	2

Fault Indicators and Protective Equipment

The flow of current towards an undesired path or abnormal stoppage of current is termed as fault. Fault indicators (Fig. 2.37) are devices which indicate the passage of fault current. When properly applied, they can reduce operating costs and reduce service interruptions by identifying the section of cable that has failed.

Fig. 2.37 Fault indicator

Dos and Dont’s while Working

1. Never touch a current carrying wire or conductor.
2. Never pull out a flexible cable while removing the plug from the mains.
3. Switch off the supply while checking any electrical appliance.
4. Never play with tools.
5. Handle tools carefully and be alert while working.
6. Never switch on supply unless you are sure about working of an appliance.
7. Ensure that proper earthing is provided for the appliance.

8. Seek guidance of your teacher in case of any doubt and do not try to experiment yourself.
9. Report any damage or breakdown to your teacher immediately.

Precautions

1. In DC measurements check polarities.
2. Select higher range for measurement initially and later select required range for accuracy.

Check Your Progress

A. Multiple choice questions

1. Which of the following is used to measure power of an electric circuit?



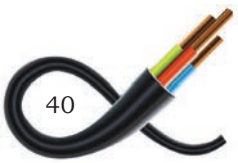
(a) Wattmeter (b) Megger (c) Ammeter

2. Which of the following is used to turn a nut or bolt?



(a) Spanner (b) Plier (c) Cutter

3. If a worker on a live-line gets electrocuted, first _____.
   (a) call a doctor
   (b) switch off supply
   (c) take the person away from the spot
   (d) provide artificial respiration
4. Pliers are classified by their _____
   (a) width
   (b) length
   (c) nose shape and intended work
   (d) handle



5. This tool is known as _____.
   (a) screw driver
   (b) combination plier
   (c) wire cutter
   (d) crimping tool

6. A generator provides the pressure for the electrical current to travel through electrical conductors (wires). What is this measure of electrical force called?
   (a) Watts
   (b) Amps
   (c) Volts
   (d) Current
7. When working on a circuit, use approved tools with _____.
   (a) rubber gloves
   (b) an International Efficiency (IE) rating
   (c) insulated handles
   (d) None of the above
8. If equipment has been repaired, make sure that it has been _____ as safe before using it.
   (a) demonstrated
   (b) listed
   (c) tested and certified
   (d) None of the above
9. Damaged tools must be removed from service and properly _____.
   (a) repaired
   (b) destroyed
   (c) tagged
   (d) carried

B. State whether the following statements are True or False

1. Safety glasses shall always be worn whenever you are using power hand tool.
2. Never use electric tools in wet conditions.
3. If a tool doesn't work for a particular job, you should alter it, so it does work.

Distribution Lineman-Class 11 Unit-2 Session-1

A. Fill in the blanks

1. _____ is used to allow rotary motion in only one direction. It is used to tighten nuts and bolts.
2. Crimping tool is used for joining wires with _____ or _____ objects.
3. In an electric tester _____bulb is used.

B. Identify whether the following statements are True or False

1. Always examine the tool for damages before use.
2. It is OK to wear loose clothing, dangling objects and jewellery using hand tool.
3. Keep cords and hoses away from heat, oil and sharp edges.
4. Before connecting any electrical equipment to a power source, make sure the power is on.

C. Short answer questions

1. Can a wire cutter be used in place of a plier? Explain in brief.
2. How do tools and equipment help ease an electrical technician's work?

Distribution Lineman-Class 11 Unit-2 Session-2

A. Multiple choice questions

1. Which of the following is used to measure power of an electric circuit?



(a) Wattmeter (b) Megger (c) Ammeter

2. Which of the following is used to turn a nut or bolt?



(a) Spanner (b) Plier (c) Cutter

3. If a worker on a live-line gets electrocuted, first _____.
   (a) call a doctor
   (b) switch off supply
   (c) take the person away from the spot
   (d) provide artificial respiration
4. Pliers are classified by their _____
   (a) width
   (b) length
   (c) nose shape and intended work
   (d) handle

5. This tool is known as _____.

   (a) screw driver
   (b) combination plier
   (c) wire cutter
   (d) crimping tool

6. A generator provides the pressure for the electrical current to travel through electrical conductors (wires). What is this measure of electrical force called?
   (a) Watts
   (b) Amps
   (c) Volts
   (d) Current
7. When working on a circuit, use approved tools with _____.
   (a) rubber gloves
   (b) an International Efficiency (IE) rating
   (c) insulated handles
   (d) None of the above
8. If equipment has been repaired, make sure that it has been _____ as safe before using it.
   (a) demonstrated
   (b) listed
   (c) tested and certified
   (d) None of the above
9. Damaged tools must be removed from service and properly _____.
   (a) repaired
   (b) destroyed
   (c) tagged
   (d) carried

B. State whether the following statements are True or False

1. Safety glasses shall always be worn whenever you are using power hand tool.
2. Never use electric tools in wet conditions.
3. If a tool doesn't work for a particular job, you should alter it, so it does work.

Distribution Lineman-Class 11 Unit-4 Session-1

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 erction 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?

Distribution Lineman-Class 11 Unit-4 Session-2

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.

Distribution Lineman-Class 11 Unit-4 Session-3

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 ncessary 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
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.

Distribution Lineman-Class 11 Unit-4 Session-4

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.

Unit 3

Electrical Wiring Components and Accessories

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Introduction

Electricity requires an electric path to flow and there are many conducting materials used for this purpose. There are many semi conducting materials which are used to reduce the voltage and also drop the current flow. There are non-conducting materials which are used as insulation during working on live-lines. In this unit we will study how the household or industrial wiring is done and what materials are essential for household or industrial wiring. We will also study the different types of wiring and how they is done.

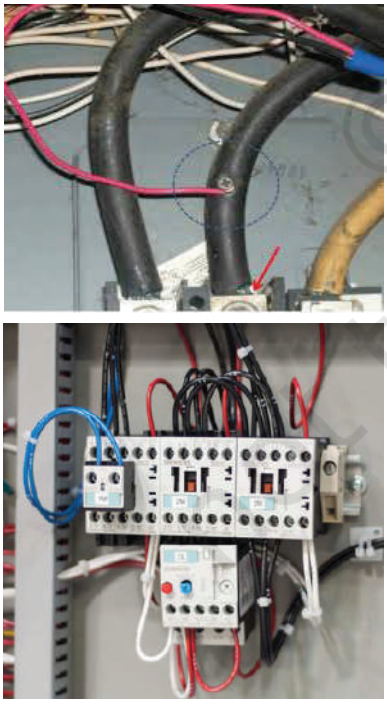


Fig. 3.1 Wiring components

Session 1: Identifying and Selecting the Wiring Materials and Components

Wiring materials

Electrical wire is made of materials like copper, aluminium and silver. As silver is expensive, mostly copper and aluminium are used in wiring.

Materials are classified into three types according to their properties:

1. Conducting materials
2. Insulating materials
3. Semiconductor materials

Conducting Material

(a) Copper

It is a good conductor of electricity. It is used in wiring materials in cables. Its has low resistance and is used for conduction of electricity at high, medium and low voltage (Fig. 3.2).

It is used in wiring and cable making.

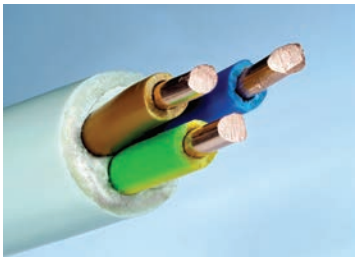


Fig. 3.2 Copper wire

(b) Aluminium

It is light weight and cheaper in comparison to copper. Therefore, this type of conducting material is mostly used in electrical wiring. It is silvery–white in colour and it has a soft texture. It is often used in wiring and making cable (Fig. 3.3).

Fig. 3.3 Aluminium wire

Insulating Materials

Insulating materials are used for insulating purpose. These types of materials are bad conductors of current. For example rubber, paper, mica, wood, glass and cotton.

Wiring Accessories

Wiring accessories are used for connecting appliances (Fig. 3.4).

Fig. 3.4 Sockets

(a) Switch

A switch is used to make or break an electrical circuit. It is used to switch 'on' or 'off' the supply of electricity to an appliance.

There are various switches such as

- surface switch
- flush switch
- ceiling switch
- pull switch
- push button switch
- bed switch

(i) *Surface switch:* It is mounted on wooden boards fixed on the surface of a wall. It is of three types

1. One-way switch
2. Two-way switch
3. Intermediate switch

Fig. 3.5 One-way switch

Fig. 3.6 Two-way switch

Fig 3.7 Intermediate switch

Fig. 3.8 Flush Switch

Fig. 3.9 Bed switch

- **One-way switch:** It is used to control single circuits and lamp (Fig. 3.5).
- **Two-way switch:** It is used to divert the flow of current to either of two directions. The two-way switch can also be used to control one lamp from two different places as in the case of staircase wiring (Fig. 3.6).
- **Intermediate switch:** It is used to control a lamp from more than two locations (Fig. 3.7).

(i) *Flush switch:* It used for decorative purpose (Fig. 3.8).

(ii) *Bed switch:* As the name indicates, it is used to switch 'on' the light from any place, other than switch board or from near the bed. This switch is connected through a flexible wire (Fig. 3.9).

(b) Holders

A holder is of two types.

1. Pendant holder (Fig. 3.10)
2. Batten holder (Fig. 3.11)

Fig. 3.10 Pendant holder

(c) Ceiling rose

It is used to provide a tapping to the pendant lamp–holder through the flexible wire or a connection to a fluorescent tube (Fig. 3.12).

(d) Socket outlet/plug

The socket outlet has an insulated base with the moulded or socket base having three terminal sleeves (Fig. 3.13).

Fig. 3.13 Socket

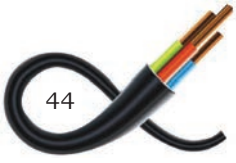
(e) Main switch

To control the electrical circuit a main switch is used. Through the main switch, the power in a building is controlled completely (Fig. 3.14).

Fig. 3.11 Batten holder

Fig. 3.12 Ceiling rose

Fig. 3.14 Main switch/ Main MCB



(f) PVC casing-capping wiring

PVC capping is done in order to cover the wires. It includes casing also. This casing-capping wiring is also known as open wiring, as it is done outside the wall.

Materials required for PVC casing-capping wiring (Figs. 3.15 and 3.16) include

1. wire
2. casing enclosures made up of plastic
3. capping made up of plastic
4. T. Joints VIR (Vulcanised Indian Rubber) or PVC (Polyvinyl chloride) insulated wire
5. junction box
6. elbow
7. casing and capping joints

Fig. 3.15 PVC casing-capping accessories

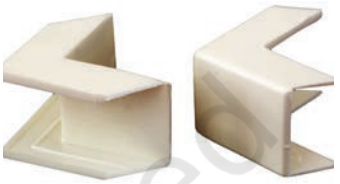


Fig. 3.16 PVC casing-capping bend

Wooden casing-capping wiring is old fashioned. Now PVC or VIR insulated wires are enclosed within the PVC casing enclosure and PVC capping is used to cover the casing.

Advantages of casing-capping wiring

- Easy to install
- Strong and durable wiring
- Customization can be done easily
- Safe from smoke, dust, rain and steam, etc.
- No risk of shock due to casing and capping,

Disadvantages of PVC casing-capping wiring

- Costly
- Not suitable for humid weather
- High risk of fire

Miniature Circuit Breaker (MCB)

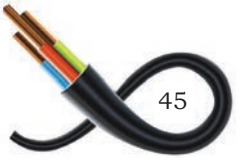
A MCB is used in new constructions instead of the older types of fuses. Circuit breakers are small devices used to control and protect the electrical panel and the other devices from overflowing of electrical power (Fig. 3.17).

Fig. 3.17 MCB Distribution Box

Uses of MCB

Home electrical panels

As with all breakers, the MCB is designed to protect the house from circuit overload. An MCB is much safer



than the typical fuse, because it can be reset manually and can handle larger amounts of power. The breaker can manage the flow of energy, distributing the voltage even when many devices run off the same power circuit.

Lights

MCBs are used in the lighting system of the house, because they can deal with the amount of power needed to lightening a house, especially if specific types of lamps, such as fluorescent lights are used. MCBs overcome the need of additional power required when switching on the lights, especially when lights are used extensively in the entire house.

Industrial applications

There are many small scale industrial buildings where MCBs are used instead of the old fuses. Miniature circuit breakers are largely used in restaurants, bakeries and commercial food stores.

Heaters

When heaters are used at home or in the office, the MCB can be beneficial. It is known in general that heaters can be problematic sometimes, especially with distribution of electrical power. The MCB prevents possible problems, cutting off electricity in the case of overload or fault. In this case, though, you need to choose a miniature circuit breaker of the proper capacity, enabling it to handle the load of power when needed.

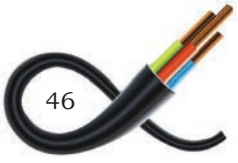
Conduit Wiring

Fig. 3.18 Conduit wiring

Electrical conduits are used to protect and provide the route of electrical wiring in an electrical system. Electrical conduits are made of metal, plastic, or fibre and can be rigid or flexible. Conduits (Fig. 3.18 and 3.19) must be installed by electricians as per standard regulations. For workshops and public buildings, conduit wiring is the best and most desirable system of wiring. It provides protection and safety against fire.

Types of Conduits

1. Class A conduit: Thin layered steel sheet of low gauge
2. Class B conduit: Thick steel sheet of high gauge



Materials used in Conduit Wiring

- GI (Galvanised Iron) wire
- Elbow
- Coupling
- VIR (Vulcanized Indian Rubber) or PVC (Poly Vinyl Chloride) insulated cables
- Lock nut
- Clip
- Junction Box

Advantages of conduit wiring

- Safe
- Better appearance
- No risk of fire
- No risk of damage of cable insulation
- Safe from humidity, smoke, steam, etc.
- No risk of shock
- Long lasting

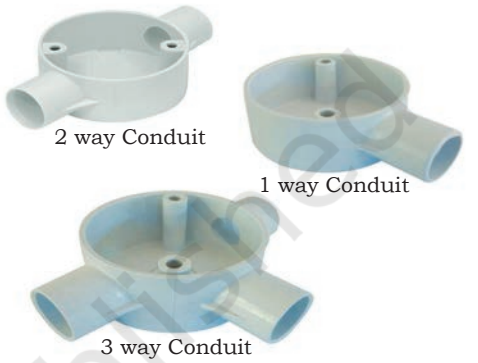


Fig. 3.19 Conduit wiring components

Disadvantages of conduit wiring

- Expensive
- Installation is not easy
- Not easily customisable for future use
- Hard to detect faults

Concealed Wiring

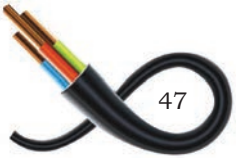
It is laborious to install this wiring. The layout of this wiring is done under the plaster of the wall of the building.

Advantages of concealed wiring

- Safe
- Better appearance
- No risk of fire
- No risk of damage of cable insulation
- Safe from humidity, smoke, steam, etc.
- No risk of shock
- Long lasting

Disadvantages of concealed wiring

- Expensive
- Installation not easy
- Not easily customisable for future use
- Hard to detect faults



Colour Code

Wiring for AC and DC circuit are colour coded for identification of individual wires (Table 3.1).

Table 3.1 AC power circuit wiring colour codes

Function	Label	New colour	Old colour
Protective ground	P G	Green or green-yellow	Green
Neutral	N	White	Gray
Line, single phase	L	Black or red	_
Line, three phase	L1	Black	Brown
Line, three phase	L2	Red	Orange
Line, three phase	L3	Blue	Yellow

Check Your Progress

A. Fill in the blanks

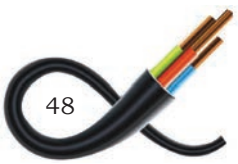
1. Wiring material is of three types _____, _____ and _____.
2. A switch is used to make or break _____.
3. Open wiring is also known as _____ wiring.
4. _____ are devices used to control and protect the electrical panel from overflowing electrical power.

B. State whether the following statements are True or False

1. Silver is a bad conductor of electricity.
2. Switches are made of conducting material.
3. PVC casing and capping are used for covering the wires.

C. Multiple choice questions

1. Concealed wiring is immune to_____
   (a) humidity
   (b) heat
   (c) light
   (d) dust



2. Pendant holder is used for_____
   (a) fixing the bulb
   (b) fixing the fan
   (c) for hanging the bulb
   (d) to hang the fan
3. A two-way switch is used for _____
   (a) control one bulb from 2 points
   (b) control two bulbs from 2 points
   (c) control multiple bulbs from 2 points
   (d) control one bulb from one point

D. Short answer questions

1. Why is PVC casing-capping preferred over wooden casing-capping wiring?
2. How does an MCB help in managing electrical power?
3. Why is conduit wiring used in homes?
4. Discuss the importance of colour codes in electrical wiring.

Session 2: ICTP Switch and Distribution Board

ICTP (Iron Clad Triple Pole) Switch

It is used alongwith the energy meter to isolate the supply of electricity automatically or manually (Fig. 3.20).

Fig. 3.20 ICTP switch

Distribution Board

A distribution board is a component of an electricity supply system that divides an electrical power feed into subsidiary circuits, while providing a protective fuse or circuit breaker for each circuit in a common enclosure. A distribution board is also known as panelboard, breaker panel, or electric panel (Fig. 3.21).

Fig. 3.21 MCB distribution board

Electrical Circuit

In an electric circuit the positive side of wire is connected to the negative side of a load, for example, bulb, TV, etc. and power supply is started by using a switch. The circuit is like an electrical house.

Types of Circuit

1. Open
3. Closed
4. Series
5. Parallel

- **Series circuit:** It is like a stair-case. In this type of circuit r1, r2, r3 are resistances connected in series. In this,

  R = r1+r2+r3

  where R is equivalent to resistance.

- **Parallel circuit:** When various resistances are connected in parallel, then it is called a parallel circuit. Like if r1, r2 and r3 are connected in parallel, then

  1/R = 1/r1+1/r2+1/r3

In this, all resistances having positive sides are connected on one end and all negative sides are connected on another end. In this, voltages are same in all the branches.

Fixing Wiring Accessories on Board

You should know the tools required for fixing the accessories on the board. You should also know the purpose of fixing the accessories.

In-house wiring of the switches, holders and sockets should be fixed on wooden/sunmica boards and blocks. Therefore, it is necessary to learn how to fix these accessories. The ways to fix these accessories have been discussed in the following practical activity.

Let's Practice 1

Adjust the electrical accessories like, switches, holders, sockets, etc. on the given board or round block. And then mark their positions by a pencil. Remove the covers of the accessories and loosen the screws of terminals. Make a powder of chalk and pour it in the holes of the terminal. Mark the point on them by the poker.

Now make the holes on the round block or board by the drilling machine where the points have been marked. Insert the wires in the terminal, after removing the insulation. Then fix all

the accessories on the board or round block by wooden screws after making holes on them by the poker. Then fix all covers on the accessories.

Tools and materials required

Tools

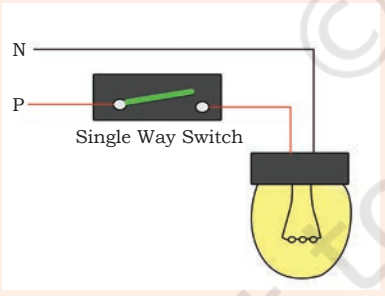
1. Hand drilling machine with a drift bit of 5 centimeter
2. Poker
3. Screwdriver
4. Connector screwdriver 8 cms
5. Combination plier 15 cm
6. Try square
7. Firmer chisel 20 mm
8. Electrician knife 10 cm

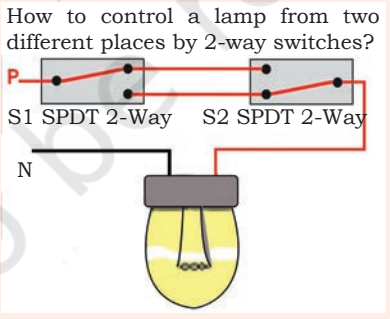
Material

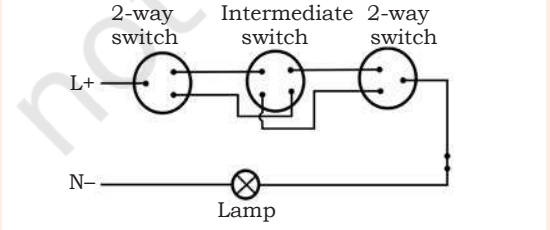
1. Wooden round block/ PVC Round Block
2. Wooden board/ Sun mica Board
3. Single pole one-way switch 5 A, 250V
4. PVC wire
5. Pencil
6. Chalk

Precautions

All the fittings (switch, holder) should be fitted well. No naked portion of the conductor should remain visible. The screws in the accessories fitted should be tight. The tools should be used carefully.







A lamp is switched ON and switched OFF from three different places.

Practical Exercise

Activity 1

Aim: Identify and draw the figure of various wiring materials

Procedure

See the different types of wiring materials as shown in the diagram as well as in classroom and draw the diagram.

Activity 2

Aim: Identify and connect the accessories with the wires

Tools and equipment required

1. Multimeter for measuring the current and voltage.
2. Tools like plier, screw driver will be required.

Procedure

Accessories will be connected with the help of wires.

Precautions

1. All connections should be tight.
2. Do not touch the terminals when supply is on.

Activity 3

Aim : To connect different types of components with wires in a junction box.

Tools and equipment required

1. Multimeter
2. Tools like screw driver, plier.

Procedure

1. Different types of components will be connected with the help of wires in a junction box

Precautions

1. All connections should be tight.
2. Do not touch the terminals when supply is on.

Questions and Answers

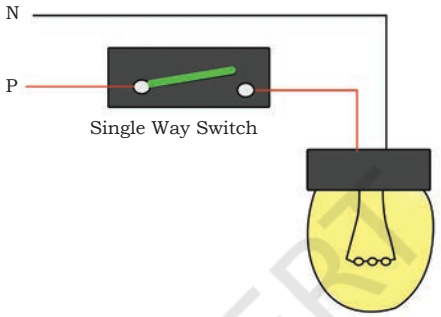
State whether the following are True or False

1. Conduit wiring is used in damp situations.
2. In wiring light point neutral is controlled by switch.
3. In three-pin plug maximum radius pin is used for phase.
4. In conduit wiring CTS wire is used.
5. Lead sheathed wiring age is more than conduit wiring.

Activity 4

Aim

- To familiarise the student with the electrical connection of a lamp to the supply mains.
- To select the proper size of connecting wires and switch for a given load.



Related information

In a lamp, the electrical energy is converted into light. The function of the switch is to turn the lamp "ON" or "OFF" by making and breaking the electrical circuit respectively. The switch should be connected to the phase wire of the supply. It should be connected in series with the lamp. The function of the fuse is to protect an electrical circuit against over current which may be caused by a fault or overloading.

Apparatus and material

1. Lamp
2. Switch
3. Fuse
4. Wooden batten/ PVC Batten
5. Link clips
6. Screws
7. Nails
8. Insulation tape
9. Connecting wires
10. Lamp holder
11. Electricians common hand tools

Precautions

1. Make all the connections tight.
2. Check the rating of the fuse.

Procedure

1. Fix the switch and lamp holder on the board.
2. Connect the switch and lamp.
3. Connect the circuit to the supply mains, while the main switch is "OFF".
4. Put "ON" the main switch.

Activity 5

Aim: To check the connection of the lamp by one switch (series)

Apparatus

Lamp 100W/220V, holder, one-way switch, PVC wire 1/18 SWG etc.

Tools and equipment

S. no.	Particular	Specification	Quantity
1.	Plier	Slide cutting plier Combination plier	1 1
2.	Screwdriver		1
3.	Phase tester	6"	1

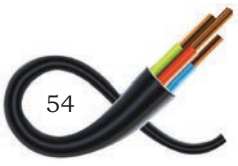
Procedure

Take a PVC 1/18 SWG wire about 1 meter in length and cut it in two pieces of equal length with side cutting plier. Remove the insulation of nearly 1 cm of both ends of each wire with the help of combination plier. Now take the holder and screw the nut with the help of screw driver. Fit each end of both the wire in the bolt and screw the nuts. Now cover the holder, connect one end of the wire to the top point of the switch. Take 1 foot of another wire and connect it to the bottom of the switch.

Connect the switch wire to phase and another wire to neutral. Switch it on. If the bulb glows then our connection is right.

Precautions

1. Phase is always controlled by the switch.
2. Part of the wire with removed insulation should not be open.



3. Twisted wire fitted in the holder should be put in such a way that the two wires should not touch each other.
4. Carefully remove the insulation part so that the wire should not cut.
5. Do not touch any naked electrical wire unless you are sure that there is no current in the wire

Activity 6

Aim: Check the connection of lamp by two switches (parallel)

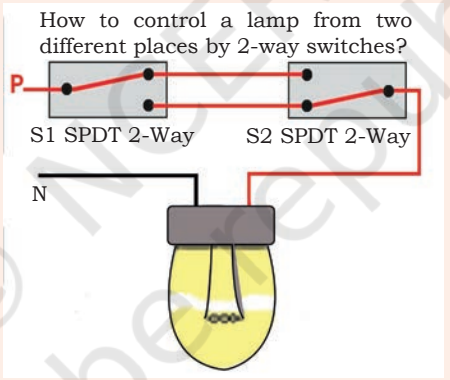
Related information

The circuit consists of one lamp and one pair of two way switches are connected.

The common points in switches S1 and S2 are C1 and C2 respectively. The common point C2 is connected to position 2 of the switch S2. Now if the common C1 is connected to position 1 in switch S1, then the path of the electric circuit is not complete and, hence, the lamp will not glow. However, if C1 is connected to position 1, then the path of the current is completed through S1, S2 and the lamp. The lamp will glow.

Apparatus

1. One lamp holder, (pendent) 5 A, 250V.
2. One lamp 40 Watts, 250V.
3. Two two-way switch, 5A, 250V.
4. Connecting wires
5. Insulated plier
6. Electricians knife
7. Screw driver



Procedure

1. Connect the lamp with the two switches S1and S2
2. Put the lamp in position in the holder
3. Make the positions 1 and 1' on S1 and 2 and 2' on s2
4. Operate switch S1 in position 1and 1'
5. For each position of S1 put switch S2 in position 2 and 2' respectively
6. Observe the results

Precautions

1. All connections should be firmly made
2. Switches S1 and S2 should be connected to the phase wire.

Check Your Progress

A. Fill in the blanks

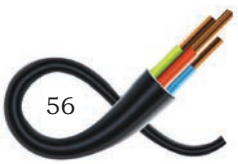
1. Distribution board is used for dividing an electrical power feed into _____.
2. In an electric circuit, the positive side is connected to the _____, and the switch is used to start the power supply.
3. Switches should be connected to the _____wire of supply.
4. The _____ protects an electric circuit.

B. Multiple choice questions

1. Switches, holder and socket are fixed on _____ boards.
   (a) sunmica (b) iron
   (c) steel (d) copper
2. In a lamp, electrical energy is converted into_____
   (a) electric (b) resistance
   (c) light (d) current
3. 3. All branch voltages are same in _____ circuit.
   (a) series (b) shunt
   (c) parallel (d) electrical
4. Distribution board is also known as a _____.
   (a) breaker panel (b) panel board
   (c) electrical panel (d) All of these

C. Short answer questions

1. Silver is a good conductor of electricity, but it is rarely used as a wiring material. Why?
2. Write down the properties of copper and aluminium and about their applications in electrical wiring.
3. Aluminium is the most commonly used metal for electrical wiring. Why?
4. List the different types of holders.
5. List the disadvantages of casing capping wiring.
6. Which material is used in conduit wiring?
7. List the advantages of conduit wiring.
8. Write the colour codes of AC power circuit for single phase circuit.



Session 3: Workplace Health and Safety Measures

Workplace hazardous systems are designed to protect the health and safety of workers. Information must be provided about the safe handling, usage, storage and disposal of hazardous systems. Workplace hazard is something that can have potential to harm the technician. There are hazards in every type of job and every type of workplace. Everyone at the workplace shares the responsibility to identify and control the hazards. The technician must first recognise the hazards at the workplace. When the technician installs or assembles the components, she/he may have to face hazards which are related to the workplace. For instance, these hazards can be associated with the installation and assembly process of a water purifier. The technician should be aware of the hazards associated with the installation of a water purifier. Majority of the hazards can be avoided by being aware and taking appropriate precautions.

Electrical Hazard

An electrical hazard defines a dangerous condition. This dangerous condition is related to energised equipment or a conductor at workplace. If a technician comes in contact with the energised equipment, then the equipment may cause injury to the technician. There is a possibility of being electrocuted or getting an arc flash burn, thermal burn or blast injury while assembling the components in a unit. Many of the hazards can be avoided by being aware and taking appropriate precautions. This will ensure safety at workplace (Fig. 3.22).

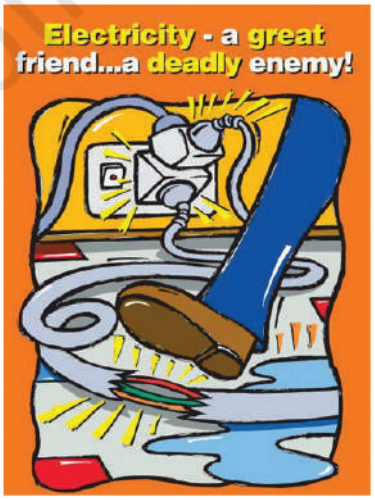


Fig. 3.22 Safe work in an electrical system

Points that need to be remembered for working safely around electrical panel and cabinet are as follows.

1. Watch out for loose cords and wires. Loose cords and wires can cause physical hazards and even electrical hazards. Hazard Tape should be placed if a cord or wire is placed on a pathway.

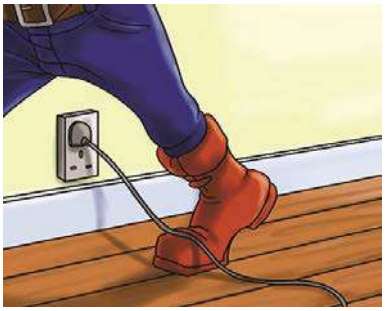


Fig. 3.23 Loose cord which can be hazardous

Fig. 3.24 Hazard tape

2. Wear proper personal protective equipment. The kind of personal protective equipment (PPE) required around a machine will depend upon the type of machine and task the employee is performing. Nevertheless gloves, hardhats, safety glasses, earplugs and other gears are important to use where necessary. For safety, signs can be posted near panels reminding employees to wear PPE (Figs. 3.23 and 3.24).
3. Use caution around heat sources. Some panel and equipment get hot while operating. Everyone should be aware of these areas and use caution when nearby. PPE like gloves or flame-resistant clothing may be required in these areas.
4. Be careful when cleaning: When cleaning around a panel or equipment, one should note other possible hazards too (Fig. 3.24):
   - Fire and explosion hazards
   - Need for PPE during cleaning
   - Risk of electric shock

Follow visual and written instructions panel, equipment has signs and labels on them alerting employees to hazards (Fig. 3.25).

Fig. 3.25 Personal protection equipment

5. Be cautious while testing, replacing the components in the panel. All levels of voltage should be considered equally dangerous. Even the voltage levels which cannot produce electrical shock should also not be ignored. We should check and confirm that the circuit is dead before touching it for repairing maintenance or any other work.
6. Avoid water at all times when working with electricity. Never touch or try repairing any electrical equipment or circuits with wet hands. It increases the conductivity of electric current (Fig. 3.26).
7. Never use equipment with damaged insulation or broken plugs.
8. If you are repairing an electrical device always turn off the mains supply.

9. Always use insulated tools while working.
10. Always use appropriate insulated rubber gloves and goggles while working on any branch circuit or any other electrical circuit.
11. Never try repairing energised equipment. Always check that is de-energised first by using a tester.

Fig.3.26 Avoid water while working with electricity

Chemical hazards are caused due to

1. improper storage of chemicals causing a chemical leakage
2. mishandling of chemicals due to inadequate training or negligence.

Fire Extinguisher

A fire extinguisher (Fig. 3.27) is a protection device used to cease fire. It is the basic first aid equipment which can be effectively used for controlling fire. A fire extinguisher is a cylindrical pressure vessel containing an agent which can be discharged to cease a fire. A fire extinguisher should always be available in areas where persons work with electrical equipment.
Different parts of a fire extinguisher are shown in Fig. 3.27.

The following steps demonstrate the operation of a fire extinguisher in case of a fire emergency.

Step 1: Identify the safety pin of the fire extinguisher which is generally present in its handle

Step 2: Break the seal and pull the safety pin from the handle

Step 3: Use the fire extinguisher by squeezing the lever

Step 4: Sweep it from side to side

Fig. 3.27 Parts of fire extinguisher

First Aid for Electrical Emergencies

Electrical accidents cause countless injuries. Injury could be minimised and many lives saved if proper rescue techniques and treatments are used. Electrical accidents may occur at any time or place. Timely response and treatment of victims is a major concern. When an electrical accident occurs, due to the effect of

muscle clamping, a victim is often incapable of moving or releasing the electrical conductor. Caution should be a primary consideration during any electrical accident or emergency. There should always be an emergency response plan for scheduled electrical maintenance or work.

Electrical Rescue Techniques

(a) Approaching the accident

- Never rush into an accident situation
- Call 108 as soon as possible
- Approach the accident place cautiously

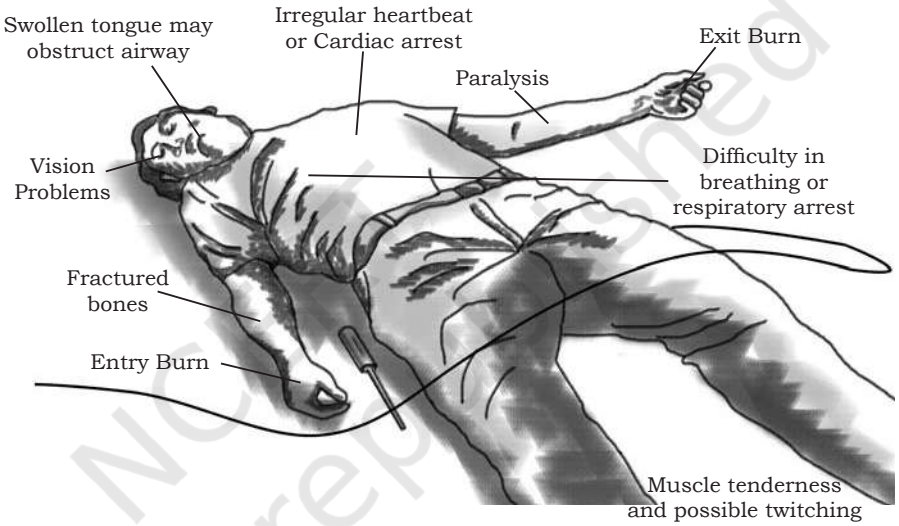


Fig. 3.28 Wireman in an unconscious state because of an electrical shock

(b) Examining the scene

- Visually examine victims to determine if they are in contact with energised conductors (Fig. 3.28).
- Metal surfaces, objects near the victim may also be energised (Figs. 3.29 and 3.30).

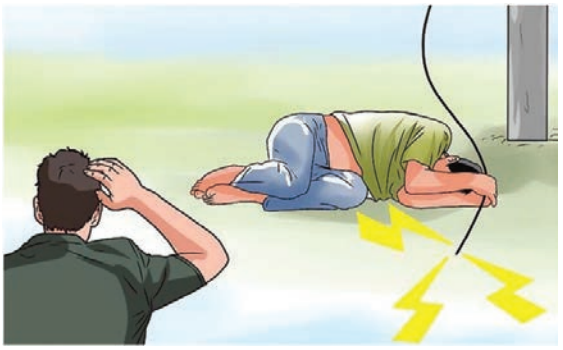


Fig. 3.29 Victim in contact with energised conductor

- You may become a victim if you touch an energised victim or conductive surface. Do not touch the victim or conductive surfaces while they are energised.
- Switch off the electrical circuits if possible.

(c) Hazards and solutions

- Be alert for hazards, such as heated surfaces and fire etc.
- In case you cannot switch off the power source, take extreme care
- Ensure that your hands and feet are dry
- Wear protective equipment, such as gloves and shoes. Stand on a clean dry surface
- Use non-conductive material to remove a victim from the conductor (Fig. 3.30)

Fig. 3.30 Use of non-conductive material to rescue the victim

(d) High voltage rescue

- Special training is required for rescues if high voltage is present
- Protective equipment, such as gloves and shoes must be worn

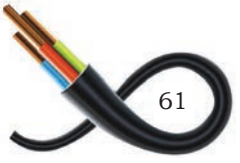
(e) First aid

- A victim may require Cardio-Pulmonary Resuscitation (CPR). Steps to perform in CPR are shown in the Figs. 3.31, 3.32 and 3.33.
- If the victim is breathing and has a heartbeat, give first aid for injuries and treat for shock.
- Ensure the victim gets medical care as soon as possible.
- Physician attending the victim must have detailed information to properly diagnose and care for the victim. The physician must determine whether the victim should be sent to a Trauma or Burn Centre.

Fig. 3.31 Chest compression

Fig. 3.32 Open the mouth for airway

Fig. 3.33 Rescue breathing



Check Your Progress

A. Fill in the blanks

1. While working with electricity, the technician must wear _____ gloves and shoes.
2. Defective or inadequate insulation may result in _____.
3. CPR stands for _____.

B. Multiple choice questions

1. What are the steps to operate fire extinguisher?
   (a) Identify the safety pin of the fire extinguisher which is generally present in its handle
   (b) Break the seal and pull the safety pin from the handle
   (c) Use the fire extinguisher by squeezing the lever
   (d) All of the above
2. When do we use a fire extinguisher?
   (a) In case of flood
   (b) In case of electric shock
   (c) In case of fire
   (d) In case of burn injury
3. Which of the following is a safety item that a wireman must not have while working?
   (a) Safety boots
   (b) Gloves
   (c) Helmet
   (d) Belt
4. Which of the following steps are required to perform CPR?
   (a) Chest compression
   (b) Open airway
   (c) Rescue breathing
   (d) All of the above

Distribution Lineman-Class 11 Unit-3 Session-1

A. Fill in the blanks

1. Wiring material is of three types _____, _____ and _____.
2. A switch is used to make or break _____.
3. Open wiring is also known as _____ wiring.
4. _____ are devices used to control and protect the electrical panel from overflowing electrical power.

B. State whether the following statements are True or False

1. Silver is a bad conductor of electricity.
2. Switches are made of conducting material.
3. PVC casing and capping are used for covering the wires.

C. Multiple choice questions

1. Concealed wiring is immune to_____
   (a) humidity
   (b) heat
   (c) light
   (d) dust
2. Pendant holder is used for_____
   (a) fixing the bulb
   (b) fixing the fan
   (c) for hanging the bulb
   (d) to hang the fan
3. A two-way switch is used for _____
   (a) control one bulb from 2 points
   (b) control two bulbs from 2 points
   (c) control multiple bulbs from 2 points
   (d) control one bulb from one point

D. Short answer questions

1. Why is PVC casing-capping preferred over wooden casing-capping wiring?
2. How does an MCB help in managing electrical power?
3. Why is conduit wiring used in homes?
4. Discuss the importance of colour codes in electrical wiring.

Distribution Lineman-Class 11 Unit-3 Session-2

A. Fill in the blanks

1. Distribution board is used for dividing an electrical power feed into _____.
2. In an electric circuit, the positive side is connected to the _____, and the switch is used to start the power supply.
3. Switches should be connected to the _____wire of supply.
4. The _____ protects an electric circuit.

B. Multiple choice questions

1. Switches, holder and socket are fixed on _____ boards.
   (a) sunmica (b) iron
   (c) steel (d) copper
2. In a lamp, electrical energy is converted into_____
   (a) electric (b) resistance
   (c) light (d) current
3. 3. All branch voltages are same in _____ circuit.
   (a) series (b) shunt
   (c) parallel (d) electrical
4. Distribution board is also known as a _____.
   (a) breaker panel (b) panel board
   (c) electrical panel (d) All of these

C. Short answer questions

1. Silver is a good conductor of electricity, but it is rarely used as a wiring material. Why?
2. Write down the properties of copper and aluminium and about their applications in electrical wiring.
3. Aluminium is the most commonly used metal for electrical wiring. Why?
4. List the different types of holders.
5. List the disadvantages of casing capping wiring.
6. Which material is used in conduit wiring?
7. List the advantages of conduit wiring.
8. Write the colour codes of AC power circuit for single phase circuit.

Distribution Lineman-Class 11 Unit-3 Session-2

A. Fill in the blanks

1. While working with electricity, the technician must wear _____ gloves and shoes.
2. Defective or inadequate insulation may result in _____.
3. CPR stands for _____.

B. Multiple choice questions

1. What are the steps to operate fire extinguisher?
   (a) Identify the safety pin of the fire extinguisher which is generally present in its handle
   (b) Break the seal and pull the safety pin from the handle
   (c) Use the fire extinguisher by squeezing the lever
   (d) All of the above
2. When do we use a fire extinguisher?
   (a) In case of flood
   (b) In case of electric shock
   (c) In case of fire
   (d) In case of burn injury
3. Which of the following is a safety item that a wireman must not have while working?
   (a) Safety boots
   (b) Gloves
   (c) Helmet
   (d) Belt
4. Which of the following steps are required to perform CPR?
   (a) Chest compression
   (b) Open airway
   (c) Rescue breathing
   (d) All of the above

Unit 4

Repair and Maintenance of Power Distribution Lines

171176CH04

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 cheeks performed during maintenance. Proper maintenance of line improves its life drastically.

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

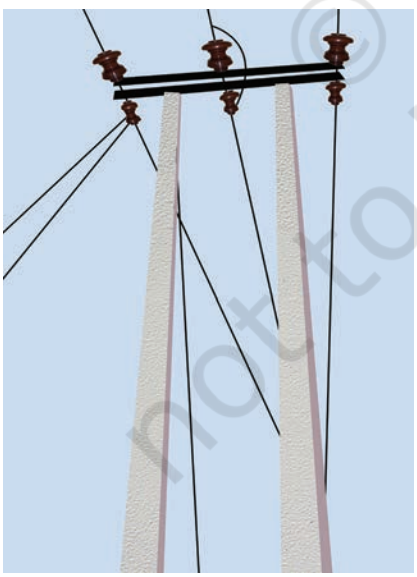
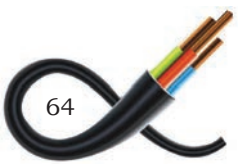


Fig. 4.3 PSC Poles



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

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).

Fig. 4.5 Aluminium Conductor Steel Reinforced

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

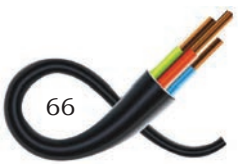
Fig. 4.6 All Aluminium Alloy Conductors

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

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).

Fig. 4.10 Guy Strain Insulator

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:

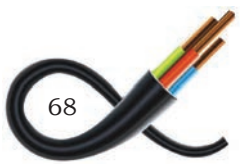
Fig. 4.11 11 kV GI Forged Pins for Pin Insulators

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).

Fig. 4.12 Guy Assembly

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).

Fig. 4.13 G.I. Wires

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.Ps. are used. The conductors

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).

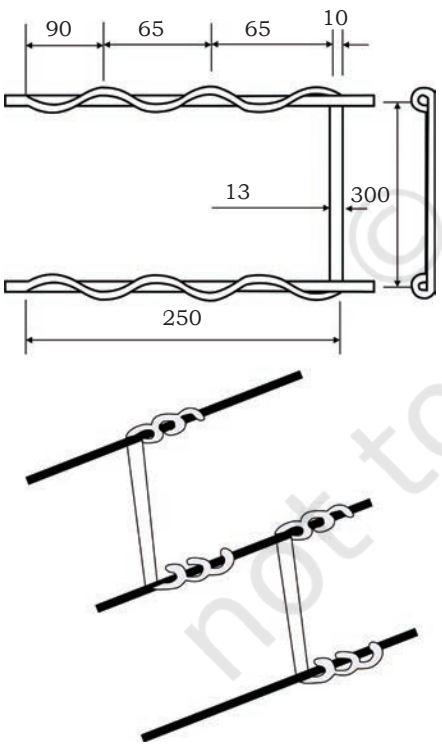


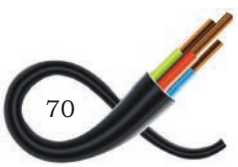
Fig. 4.17 Line Spacers

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

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

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

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

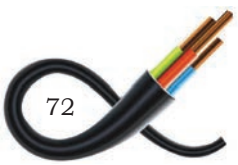
1. The shortest route possible.
2. As close as possible to the road for easy maintenance and approach during the construction.
3. Route should be in the direction of possible future load.
4. Angle points should be less.

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,

(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.

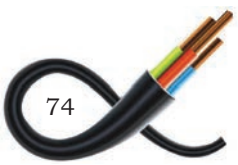
Pole Locations

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:

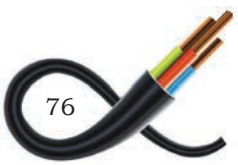
- For obtaining line-clear permit, only an authorised person should apply. He should apply for line clear permit to the authorised person

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.

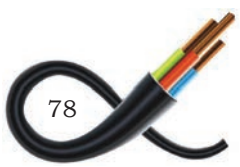
In case he is put in charge of contract work, he shall be responsible for proper supervision of work and see that the work is executed as per standards. Materials issued to the contractor shall properly be accounted:

- 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.

- 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

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 erction 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

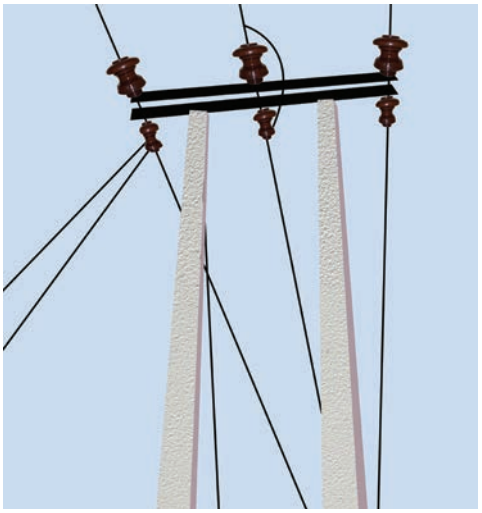


Fig. 4.19 Pole

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

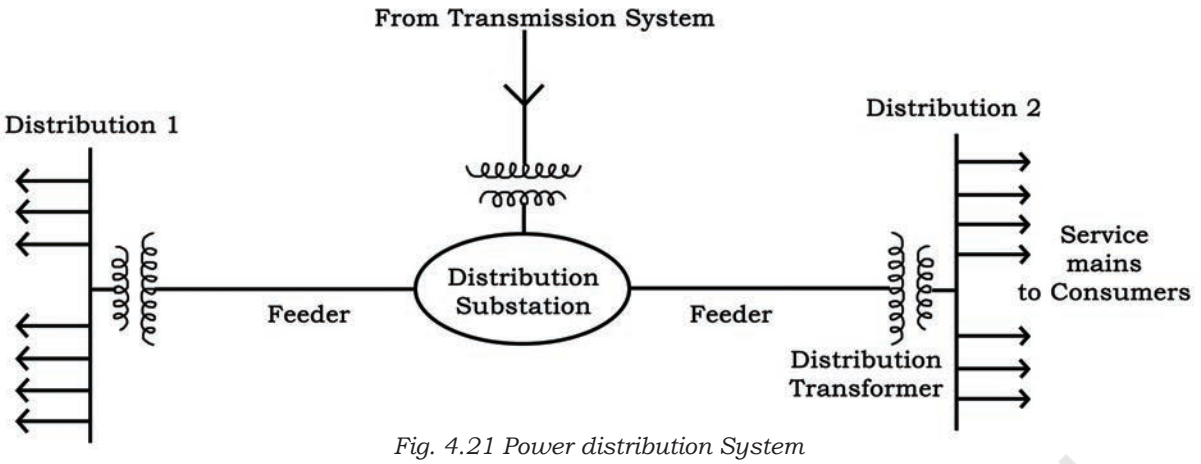


Fig. 4.21 Power distribution System

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.

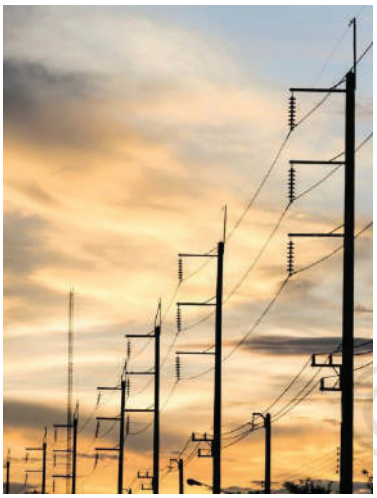


Fig. 4.22 HT Line

- 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.

Check your progress

A. Fill in the blanks

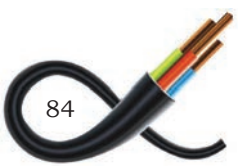
1. _____means any electric supply line which is placed above ground line and in the open air.
2. HT and LT lines upto _____33 kV are erected on poles.
3. The voltage of a local transmission line is _____ volts.
4. Transmission system is used for _____the power for long distances.

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

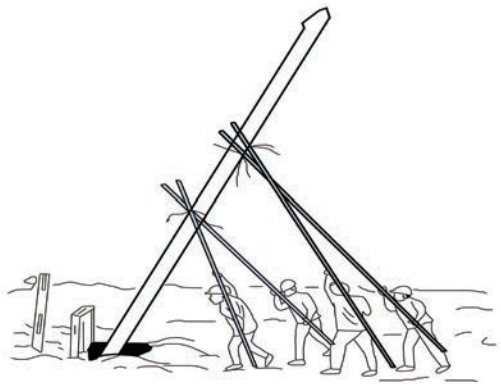


Fig. 4.23 Erection of pole

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 prefect 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

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

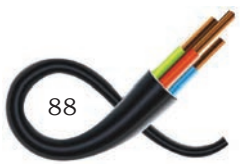
Ordinary Stay: This type of stay is generally used. The size of stay rod, turn buckle and stay wires are to be used as per the line tension. Generally, for H.T. lines of 19 mm (3/4") diameter stay rod, 20 mm (5/6") size eye bolt, and 7/8 size stay wire are used and for L.T. lines of 15 mm (5/6") stay rod, 12.5 mm (½") 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 60^0 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.

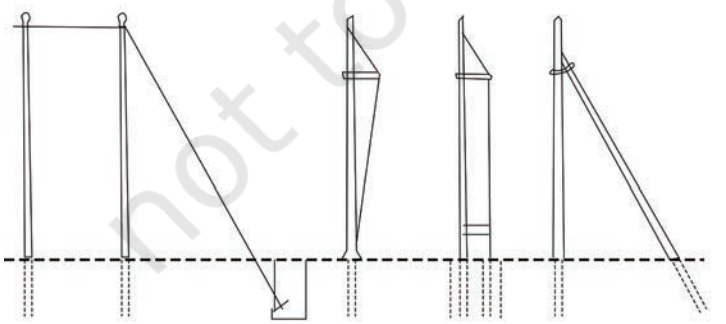


Fig. 4.24 Types of stay

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.

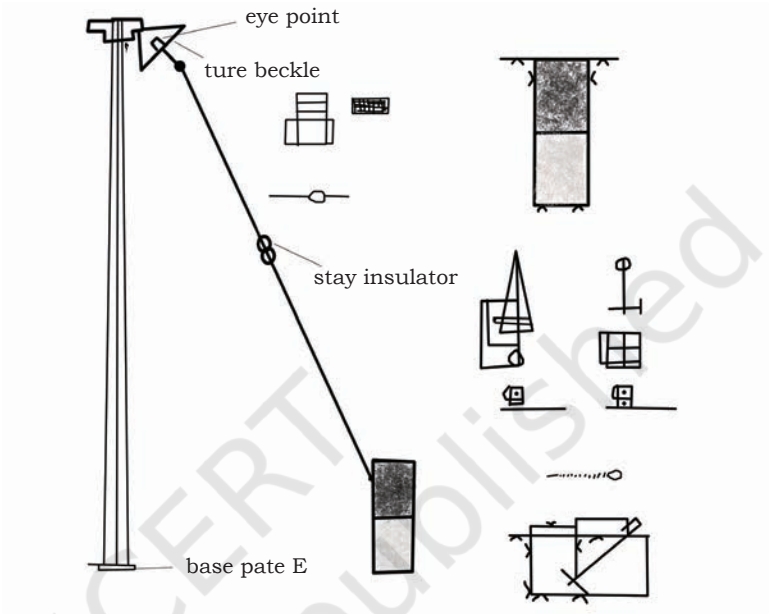


Fig. 4.25 Erection of stay

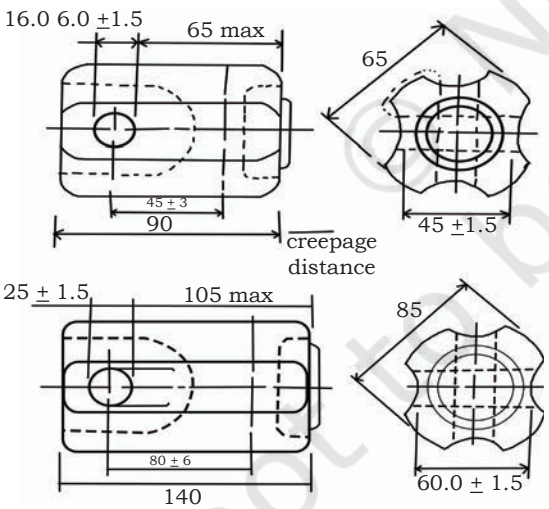


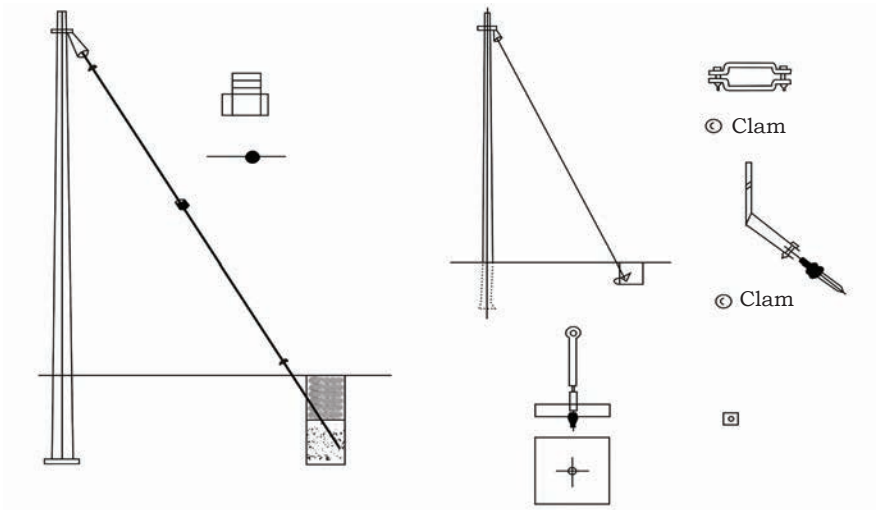
Fig. 4.26 Dimensions of stay

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.



Stay set Arrangement Anchor Rod & Plate

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

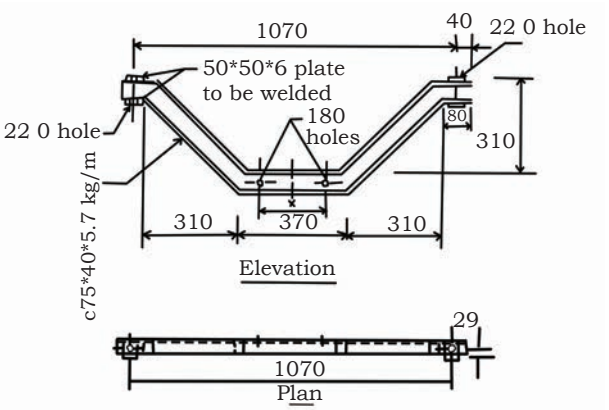


Fig. 4.28 11 kV 'V' cross arm specification

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).

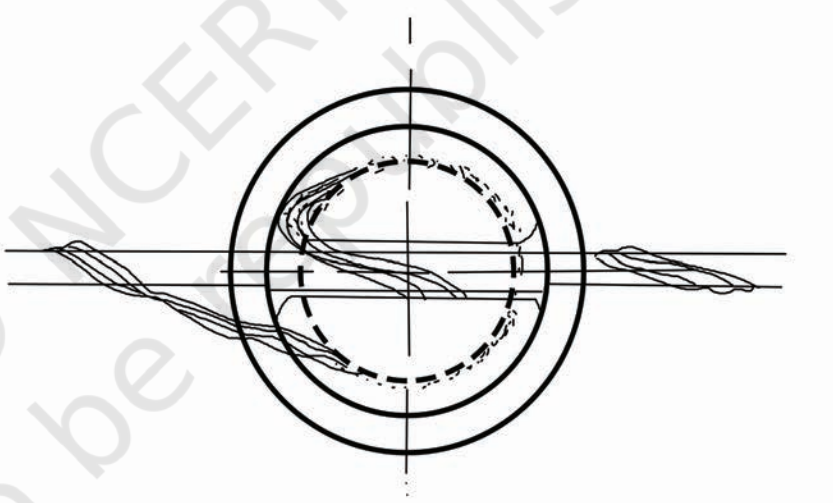


Fig. 4.29 Binding of pin insulator

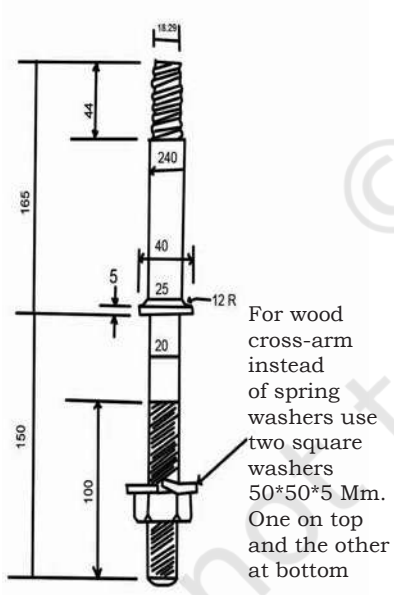


Fig. 4.30 Specification of GI pin

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

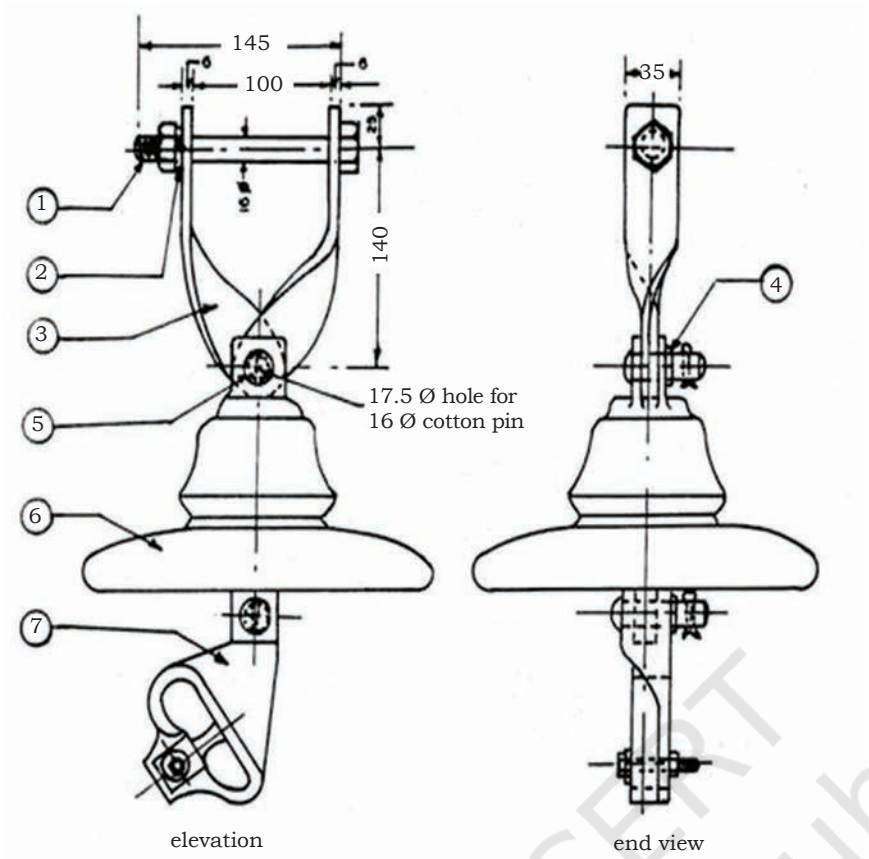


Fig. 4.31 Fixing of Disc Insulator

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

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.

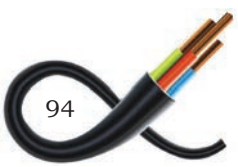
   (iv) Avoid use of pliers.
   (v) Do not use the wire which has been previously used.
   (vi) Do not use hard drawn wires for tying.
2. Good helical accessories are available and can be used.

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

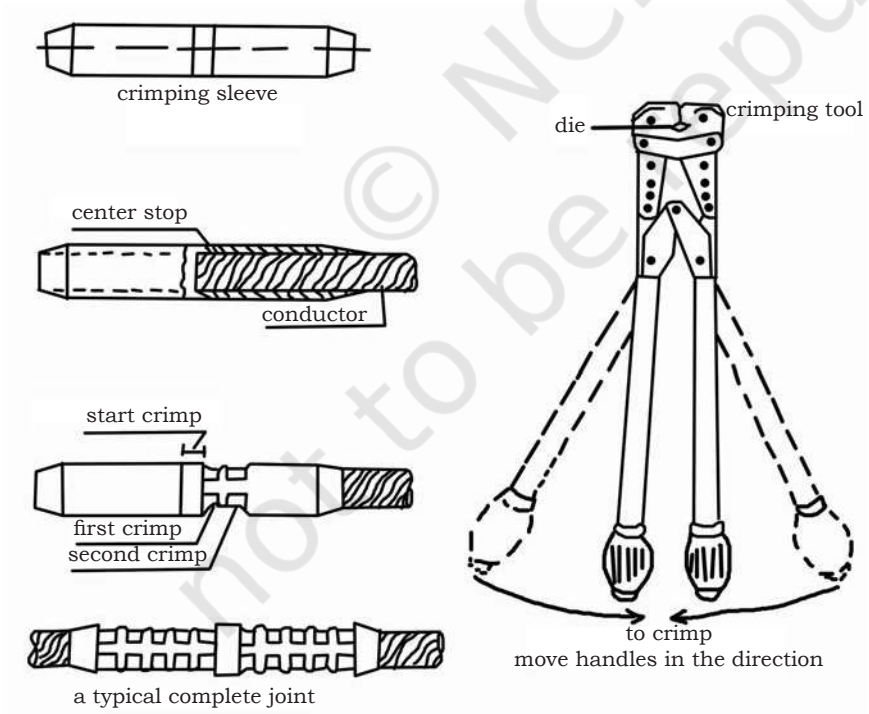


Fig. 4.32 Crimping of ACSR and AAC conductor

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.

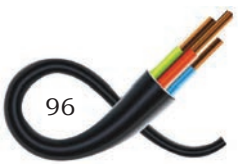


Table 4.5 11 kV Line—Triangular Configuration (Rec Construction Standards)

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 200 kg	99 (103) NR (NR)	62.5 (63) 93.5 (98)	NR (NR) 66.5 (69)
ACSR Weasel (equivalent AAAC 7/2.5)	140 kg 200 kg	99.5 (107) NR (NR)	77.5 (77) 99.5 (107)	NR (NR) 82.5 (83)

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.

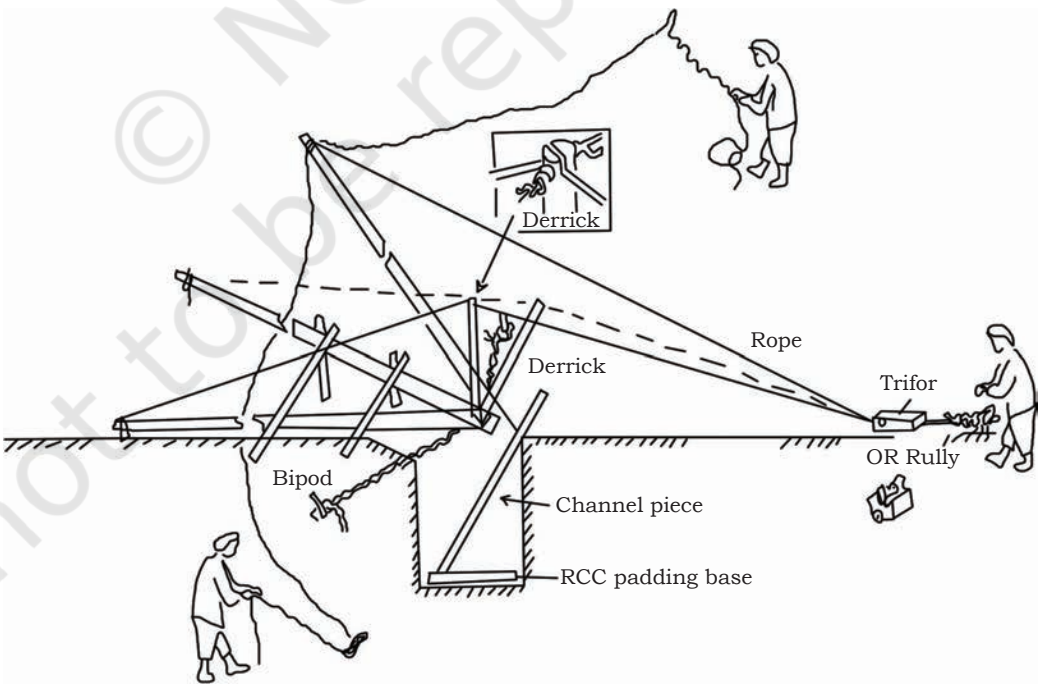


Fig. 4.33 Derrick Method

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

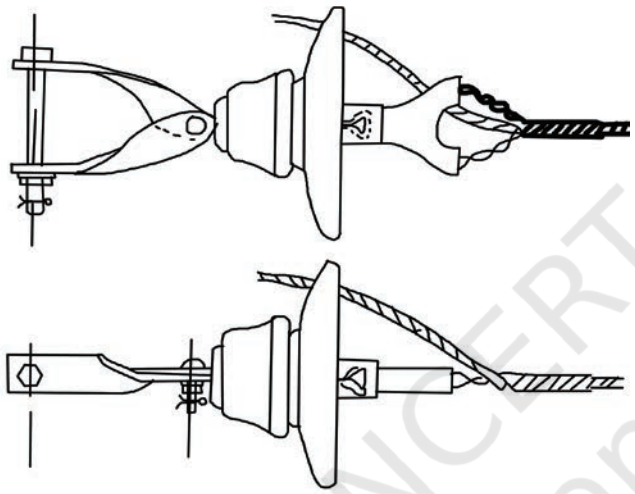


Fig. 4.34 Strain Insulator Assembly with Helically Formed Fittings

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.

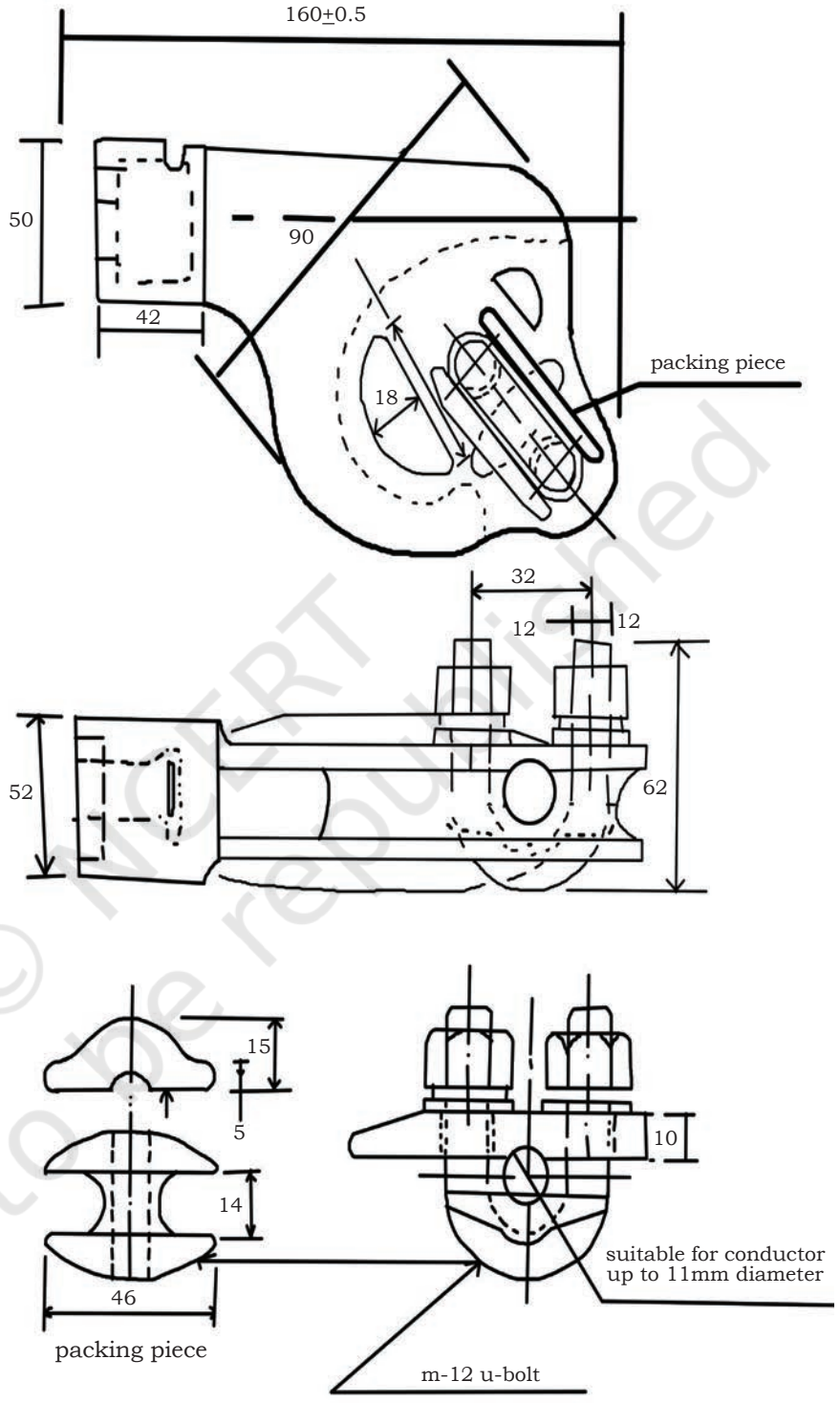


Fig. 4.35 11kV Strain Clamp for Ball and Socket type insulator

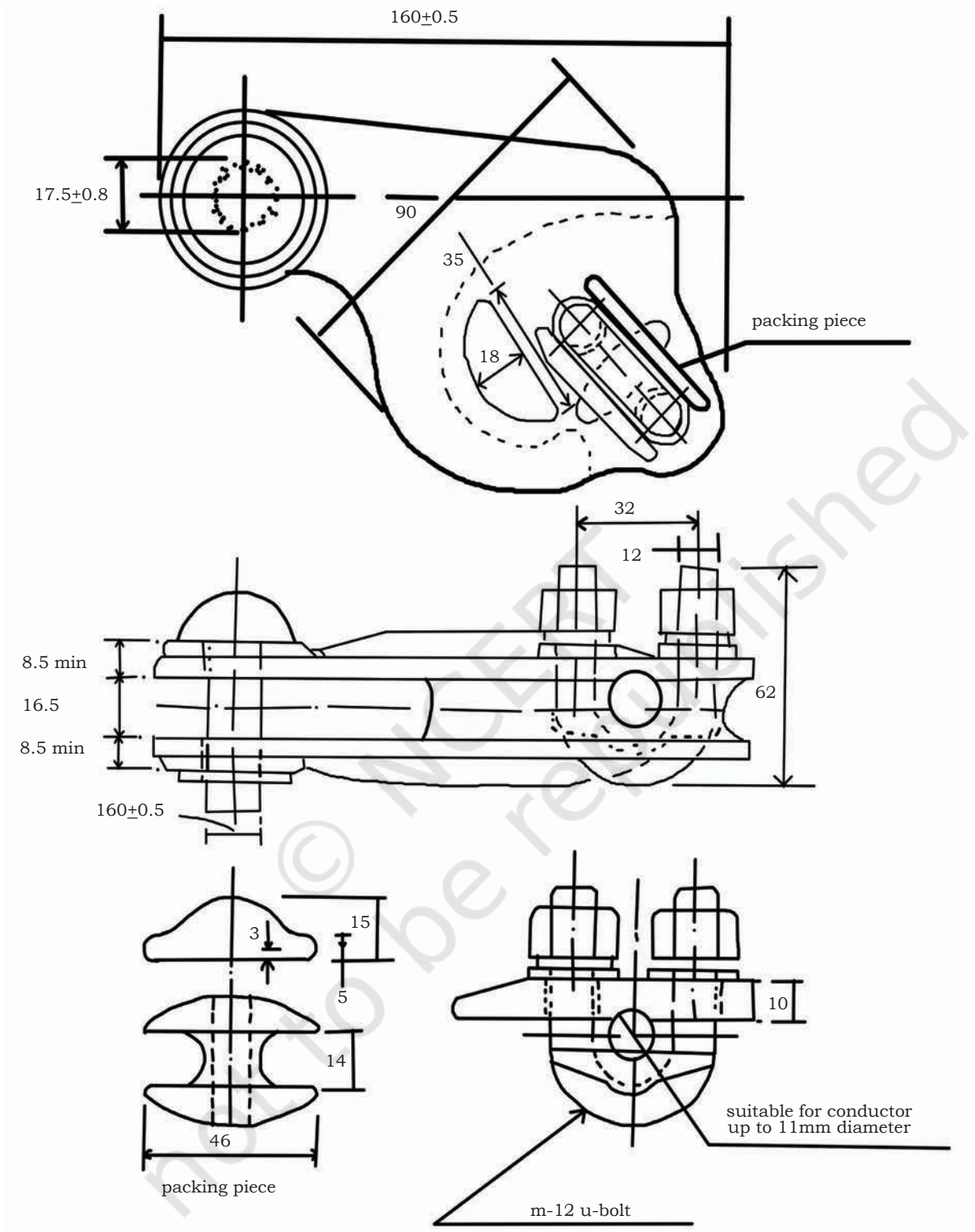


Fig. 4.36 Fixing of Disc insulator

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) Meried Joint, (4) "T" joint, (5) Sleeve joints, (6) Compression joint.

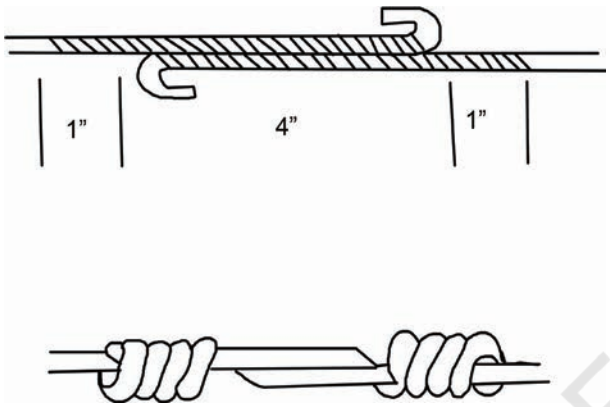
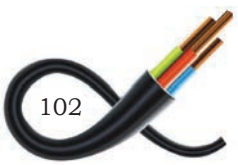


Fig. 4.37 Britannia Joint

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).

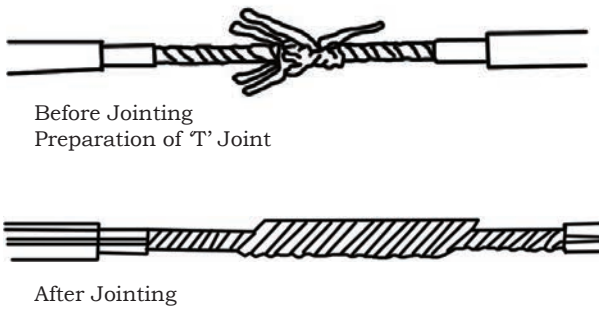


Fig. 4.38 Married Joint

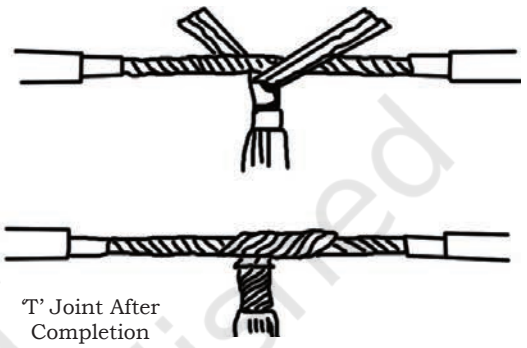


Fig. 4.39 'T' Joint

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

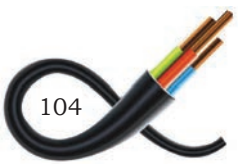
Compression Joint: This joint is used for conductors of more than 0.06 cm^2 sizes. For preparing these joints, two different sleeves are used. There are two holes in Al sleeve. Rebating is done through these holes. Slide aluminium sleeves are slid over one conductor. It is slid until only the working 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

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.

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).

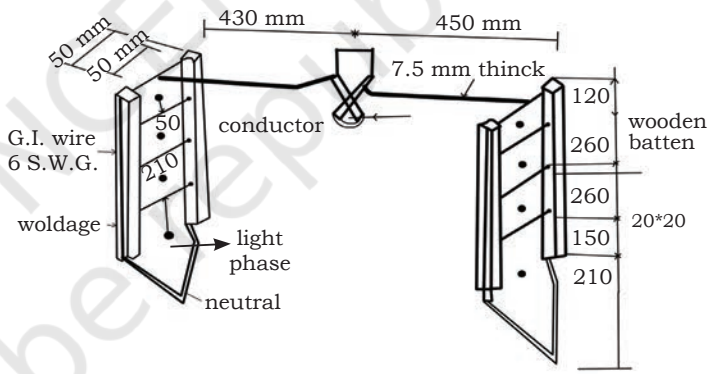


Fig. 4.42 Vertical Type Guarding

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).

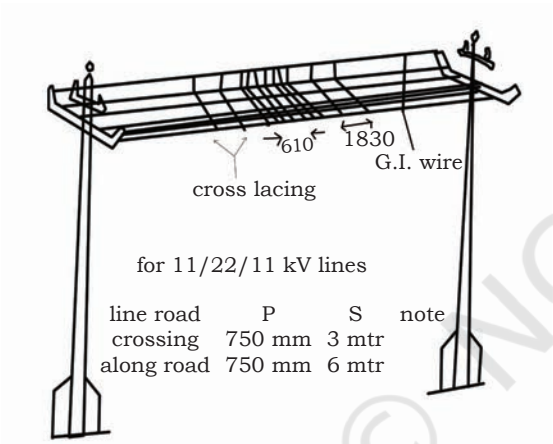


Fig. 4.43 Cradle Type Guarding

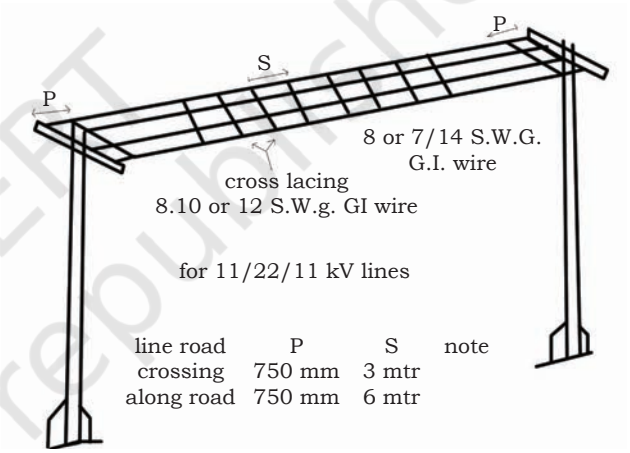


Fig. 4.44 Carpet Guarding

(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

(a) As far as possible road crossing should be at right angle, but not less than an angle of 60 degrees.

(b) Cradle guarding is used for road crossing of power line or along the line.

(c) 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.

(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 (2 ¼'), 750 mm (2 ½') and 840 mm (2 ¾') 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

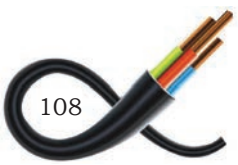
It is essential to fix accessories after pole erection. Line accessories are of two types.

(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.

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

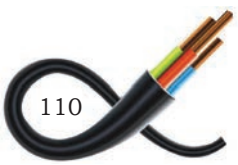
It is very important to earth the line and electrical equipment. It will be electrically unsafe without earthing. The pole/ body of equipment connected solidly to earth are called earthing.

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 Lightening Arrestor*

The lightening arrestor or earthing, discharges the lightening 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)

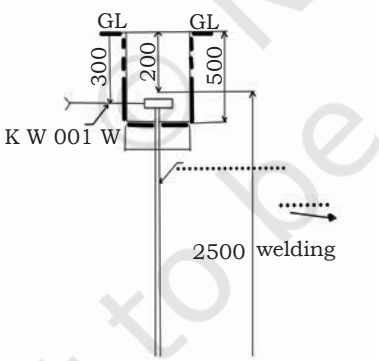


Fig. 4.46 Pipe Earthing

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)

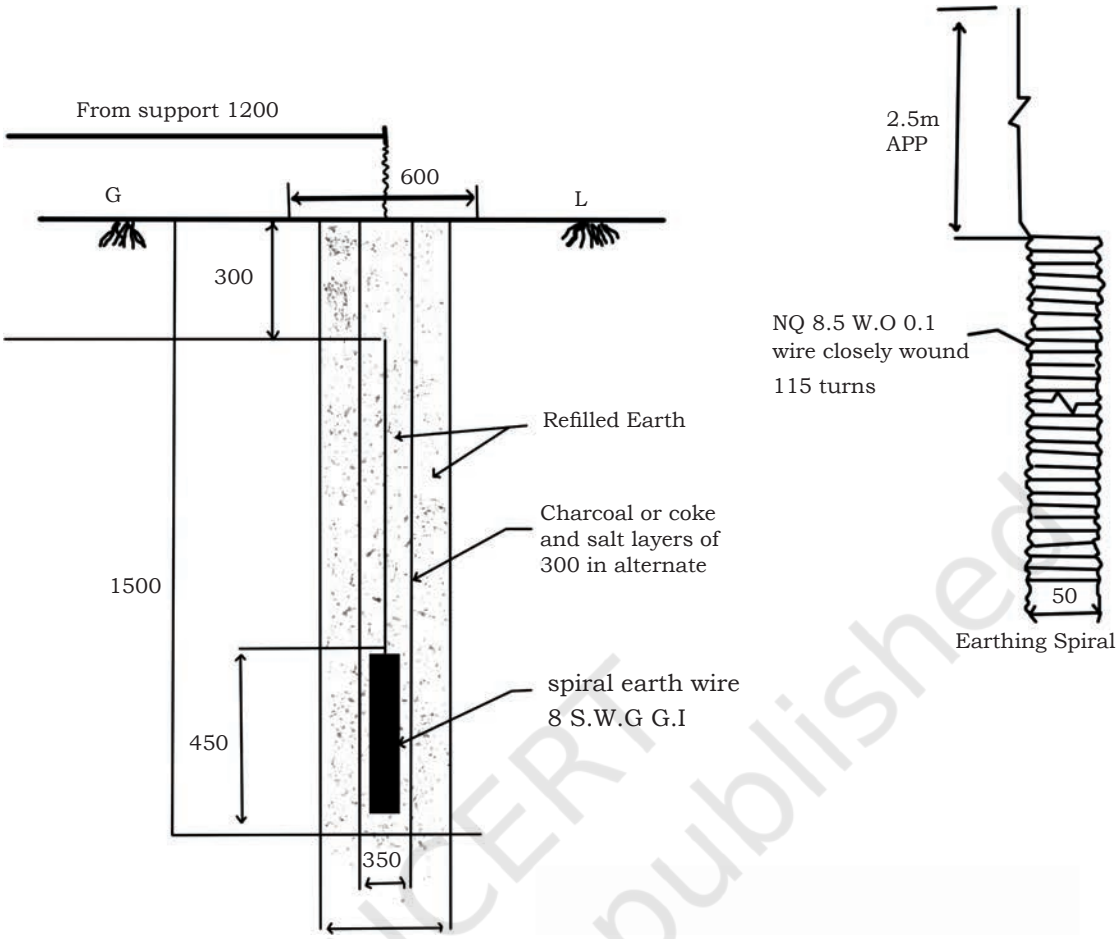


Fig. 4.45 Coil Earthing

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 lightening arrestor 4 ohms
(vii) L.T. pole 5 ohms
(vii) H.T. pole 10 ohms
(viii) 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.

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 s 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 ncessary 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

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.

Fig. 4.50 Power Distribution Lines

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:

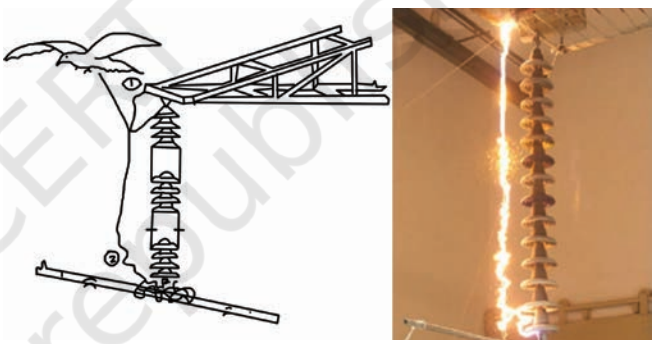


Fig. 4.51 Mitigating Bird Hazards to Overhead Lines

- 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

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.

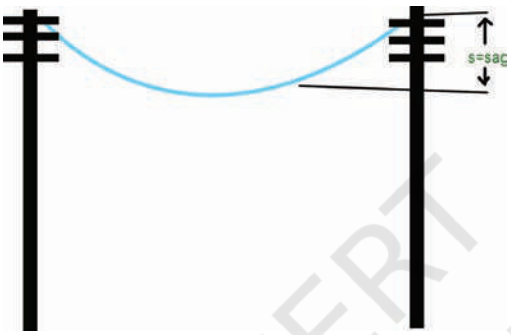


Fig. 4.52 Sag in Overhead Distribution Lines

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.

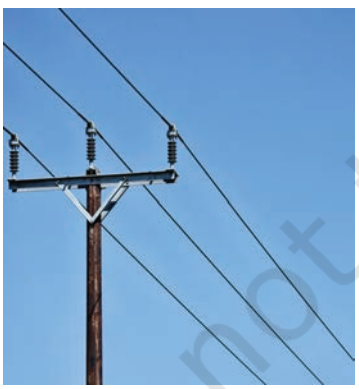


Fig. 4.54 Low Tension Distribution Lines (LT)

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).

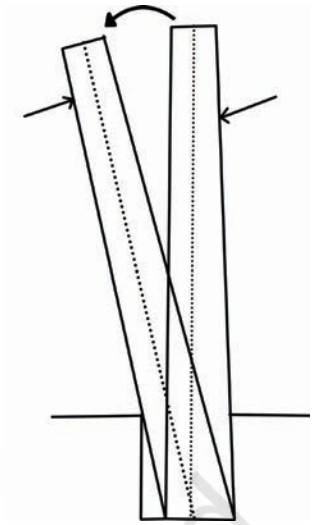


Fig. 4.55 Leaning of Pole due to loose foundation.

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.

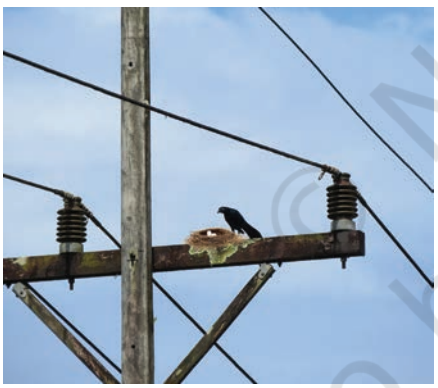


Fig. 4.56 Bird's Nest on Cross Arm

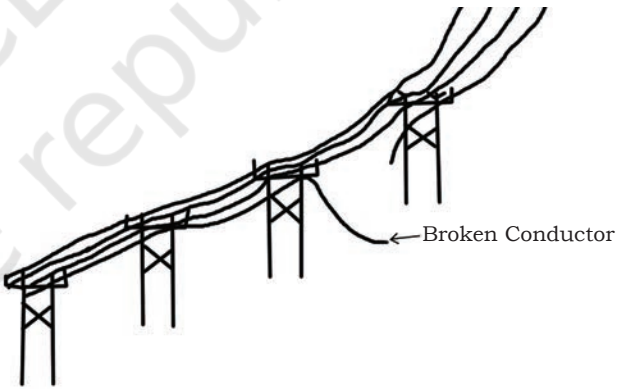


Fig. 4.57 Conductors Distribution System

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

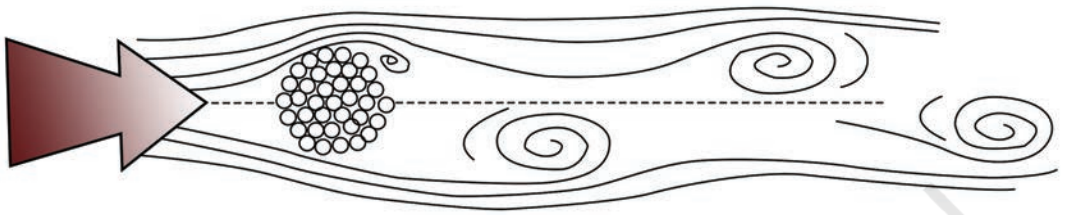


Fig. 4.59 Aeolian Vibration

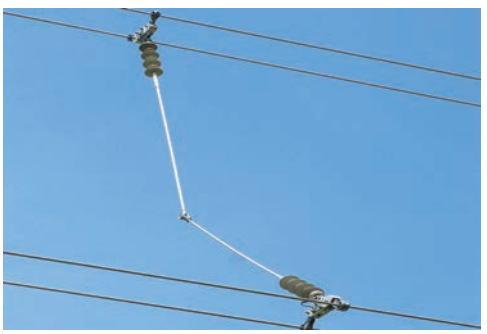


Fig. 4.60 Power Line Galloping

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).

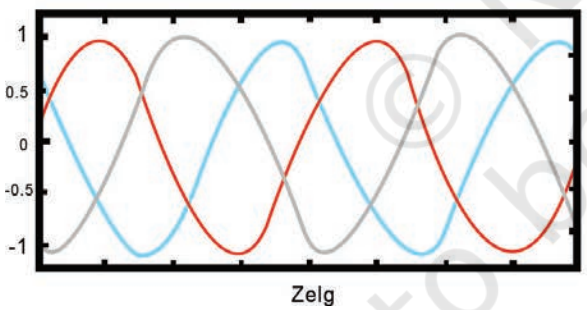


Fig. 4.61 Voltage Balance

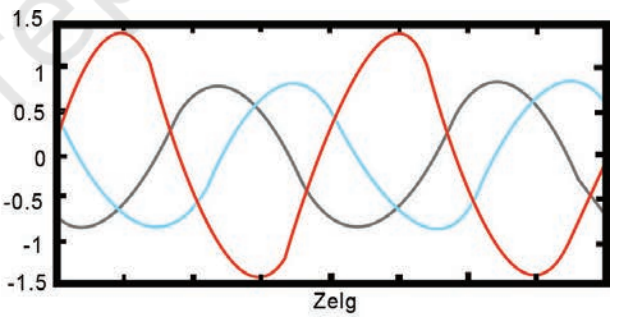


Fig. 4.62 Voltage Imbalance

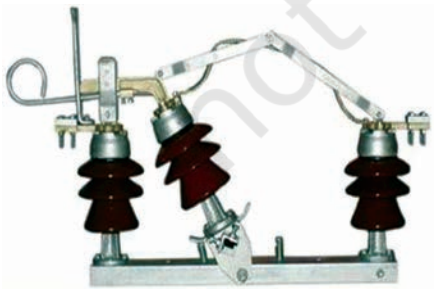


Fig. 4.63 Air Break Switches

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 maintainance 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

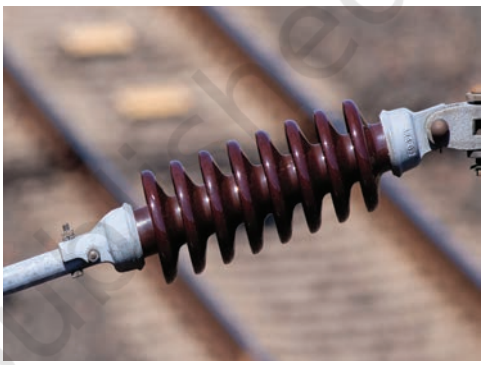


Fig. 4.64 Disc Insulators used in Power Lines

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).

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	• Within three hours for urban areas. • Within eight hours for rural areas
Service line broken, snapped from the pole	• Within six hours for urban areas. • Within 12 hours for rural areas.
Fault in distribution mains	• 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	• 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	• Temporary restoration of power supply within four hours wherever feasible • Rectification of fault within 12 hours.

Problem in grid 33 kV substation	• 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	• 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	• Restoration of supply by bypassing the burnt meter within six hours. • Replacement of burnt meter within three days
Street light complaint	• Restoration within 72 hours.

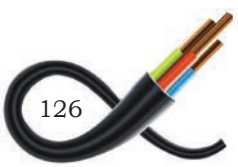
Check Your Progress

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.

Distribution Lineman-Class 11 Unit-4 Session-1

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 erction 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?

Distribution Lineman-Class 11 Unit-4 Session-2

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.

Distribution Lineman-Class 11 Unit-4 Session-3

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 ncessary 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
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.

Distribution Lineman-Class 11 Unit-4 Session-4

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.

Answer Key

Unit 1: Electricity

Session 1: Electricity Generation Concept

A. Fill in the blanks

1. Electrons
2. repel, attract
3. electricity
4. thermal
5. chemical reactions

B. Match the columns

1. (b)
2. (c)
3. (a)
4. (d)

C. Multiple choice questions

1. (b)
2. (b)
3. (d)
4. (c)
5. (b)

Session 2: Basic Units and Effects of Electric Current

A. Fill in the blanks

1. heating effect
2. Michael Faraday
3. tungsten
4. electromotive forces

B. Match the columns

1. (d)
2. (c)
3. (b)
4. (a)

C. Multiple choice questions

1. (a)
2. (b)
3. (d)
4. (a)
5. (b)

Session 3: Concept of Electrical Power and Energy

A. Fill in the blanks

1. generation, transmission
2. Watts

3. Voltmeter
4. kilowatt hour
5. drop

B. Match the columns

1. (b)
2. (c)
3. (d)
4. (a)

C. Multiple choice questions

1. (a)
2. (b)
3. (b)
4. (b)

Session 4: Importance of Earthing System

A. Fill in the blanks

1. earthing
2. short circuit
3. earthing lead
4. apparatus

B. Match the columns

1. (d)
2. (a)
3. (c)
4. (b)

C. Multiple choice questions

1. (a)
2. (b)
3. (d)
4. (a)
5. (a)

Unit 2: Handling of Tools and Equipment

Session 1: Tools and Equipment

A. Fill in the blanks

1. rachet
2. metal, plastic
3. neon

B. State whether the following statements are True or False

1. True
2. False
3. True
4. False

Session 2: Tools and Equipment used for Cable Laying

A. Multiple choice questions

1. (b) 2. (a) 3. (b) 4. (c)
5. (d) 6. (a) 7. (b) 8. (c) 9. (a)

B. State whether the following statements are True or False

1. True
2. True
3. False

Unit 3: Electrical Wiring Components and Accessories

Session 1: Identifying and Selecting the Wiring Material and Components

A. Fill in the blanks

1. conducting, insulating, semiconductor
2. electric circuit
3. capping wiring
4. Circuit breakers

B. State whether the following statements are True or False

1. False
2. False
3. True

C. Multiple choice questions

1. (a)
2. (a)
3. (a)

Session 2: ICTP Switch and Distribution Board

A Fill in the blanks

1. subsidiary circuits
2. negative side
3. Phase
4. fuse

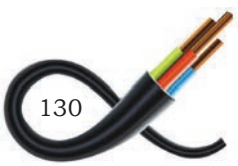
B. Multiple Choice Questions

1. (a)
2. (c)
3. (c)
4. (d)

Session 3: Workplace Health and Safety Measures

A. Fill in the blanks

1. rubber
2. electric hazard
3. Cardio-pulmonary resuscitation
4. Circuit breakers



B. Multiple choice questions

1. (d)
2. (c)
3. (c)
4. (d)

Unit 4: Repair and Maintenance of Power Distribution Lines

Session 1: Prepration of Repair and Maintenance of Power Distribution Line

A. Fill in the blanks

1. better
2. reinforcing
3. 11kV
4. vertical

B. Multiple choice questions

1. (c)
2. (a)
3. (a)
4. (a)

C. Match the columns

1. (c) 2. (d)
3. (b) 4. (a)

Session 2: Specific Terminology in Distribution Line

A. Fill in the blanks

1. Overhead
2. 33 kV
3. 13,800
4. Transmitting

B. Multiple choice questions

1. (d)
2. (d)
3. (d)
4. (b)

Session 3: Construction Activities

A. Fill in the blanks

1. current, changes in current
2. demand, availability
3. Combination pliers
4. grip
5. falt

B. Multiple choice questions

1. (e) 2. (a) 3. (d)

C. Match the column

1. (c) 2. (a) 3. (b) 4. (d)

Glossary

AC Supply: *AC stands for alternating current. In an AC circuit the current changes direction in a cyclic manner. In India, the AC frequency is 50 Hz.*

Ammeter: *It is a device used to measure the current flowing through a circuit. Ammeter is always connected in series.*

Battery: *It is a combination of two or more cells*

Conductor: *It is the type of metal which allows the electrical current to flow through it.*

Dry cell: *It is generally of 1.5 volt.*

D.P.: *It is erected in mid span of electrical transmission line so that no deflection of single pole and wire take place.*

Earthing: *The proper electrical contact between electrical installation and the earth.*

Earthed: *When an electrical machine, appliance or wiring is connected to the earth through earth electrode, it is known as Earthed.*

Earth Electrode: *A pipe or plate buried in the earth for discharge of electricity is known as Earth Electrode.*

Earthing Lead: *The conducting wire or conductive strip connected between earth electrode and electrical installation and machine is called earthing lead.*

Earthing Resistance: *This is the resistance between earth electrode and the earth in Ohms.*

Galvanometer: *Current indicating device.*

Heating Element: *is a resistance which generates heating.*

Potentiometer: *It is an electric element that has a variable resistance. It is used to change the potential difference across the circuit.*

Resistor: *It resists the flow of a current and thereby produce heat.*

Stay: *It is used to sport the angular poll and end pole. Stay is mainly used to hold the tension of conductor/cable.*

Switch: *It is an electrical current flow controlling device.*

Transformer: *It is an element used to step up or step down the voltage. In an ideal transformer energy is conserved. So if the voltage goes up the current goes down and vice versa.*

Voltmeter: *It is a device used to measure potential difference. Voltmeter is always connected in parallel.*

List of Credits

1. Figures have been taken from Course book titled *Power Sector Distribution, Consumer Energy Meter Technician*, 2016 of Power Sector Skill Council, New Delhi
2. Figures have been taken from Course book titled *Technical Helper (Distribution)* of Power Sector Skill Council, NSDC, New Delhi,
3. Figures have been taken from *Physics Textbook*, Class XII, Fig 6.16 page no. 225, NCERT

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Unit 1

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Fig. 1.13	http://www.way2science.com/wp-content/uploads/2012/03/inductionc.jpg
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Fig.1.37	Domestic Appliance Repairer, Instruction–cum-repairer, 1991, NCERT, New Delhi

Unit 2

Fig. 2.8	https://www.google.com/search?hl=en-IN&authuser=0&biw=1366&bih=576&tbm=isch&sa=1&ei=qM-7LXNy_o9QPDvqHQDw&q=tester+png&oq=-tester+png&gs_l=img.3..0j0i5i30l3j0i8i30.6571.7700..8028...0.0..0.144.548.0j4.....0....1..gws-wiz-img.....0i67.kGHlf8C9rjw#imgrc=M-K17D-VGO7GJ-M:

Fig. 2.20	https://www.google.com/search?q=Cable+Drums&tbm=isch&source=iu&ictx=1&fir=hMfVBYNTQPaTZM%253A%252C75pU0pKD5FLMmM%252C_&vet=1&usg=AI4_-kTR9Av3tnKjrNINnWV6VdP3hiyHOA&sa=X&ved=2ahUKEwig4a6Az_7hAhUMu48KHdyuCSEQ9QEwAHoECAgQBA#imgdii=PX43kxl3ngKMmM:&imgrc=hMfVBYNTQPaTZM:&vet=1

Unit 4

Fig. 4.2	https://thumbs.dreamstime.com/b/concrete-electric-pole-power-supply-industry-22457343.jpg
Fig. 4.3	https://dir.indiamart.com/impcat/psc-pole.html
Fig. 4.4	https://zhenglancable.manufacturer.globalsources.com/si/6008853343047/pdtl/Bare-conductor/1162751651/Bare-Aluminum-Clad-Steel-Reinforced-Conductor.htm
Fig. 4.5	https://zhenglancable.manufacturer.globalsources.com/si/6008853343047/pdtl/Bare-conductor/1162751651/Bare-Aluminum-Clad-Steel-Reinforced-Conductor.htm
Fig. 4.6	https://zhenglancable.manufacturer.globalsources.com/si/6008853343047/pdtl/Bare-conductor/1162751651/Bare-Aluminum-Clad-Steel-Reinforced-Conductor.htm
Fig. 4.8	https://images.app.goo.gl/8yLYoUnyTG9xmPdNA
Fig 4.12	https://www.dxengineering.com/parts/tow-ame25-gb
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Fig 4.61	https://www.engerati.com/transmission-and-distribution/article/power-transformers/pole-mounted-transformers-solution-power