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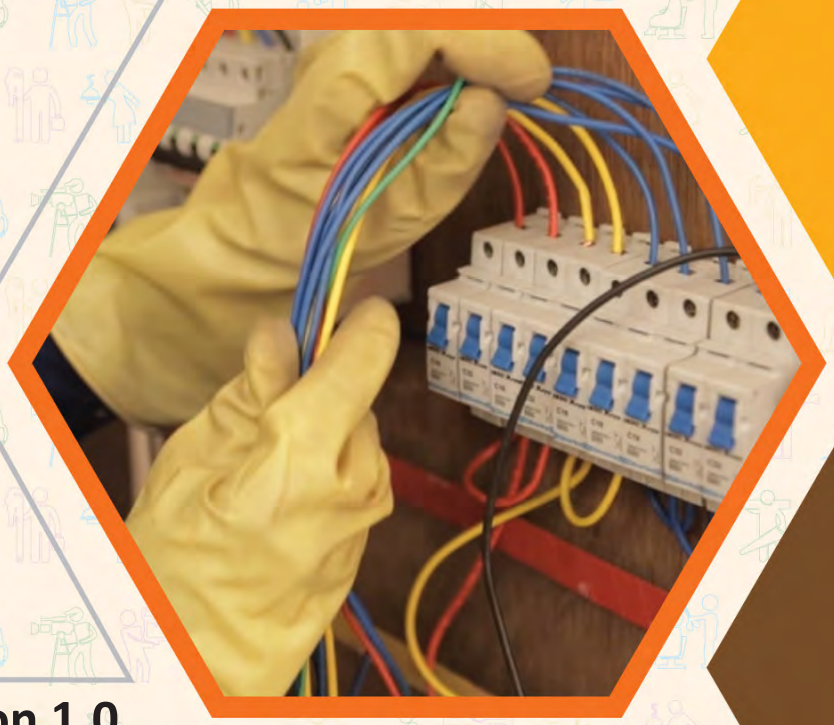
Participant Handbook



Sector
Construction

Sub-Sector
Real Estate and Infrastructure Construction

Occupation
Construction Electrical Works

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NSQF Level 3

Assistant Electrician

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Skilling is building a better India. If we have to move India towards development then Skill Development should be our mission.

Shri Narendra Modi

Prime Minister of India

PMKVY
प्रधानमंत्री कौशल विकास योजना

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Certificate

This is to certify that

(AadhaarNo -)
has successfully cleared the assessment for the role of
Assistant Electrician-Level 3 (QP No. - CON/Q0602)
conforming to National Skill Qualifications Framework Level-3

Date of Issuance

System Identification Number

Issued by.....

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Ashwani Kumar Joshi
Chief Executive Officer
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CEO

March 2016

CSDCI

About this Book

Construction industry is the second largest employer in India. As one of the leading avenues for employment in the country, the role played by this industry in the economic development of India is pivotal. However despite its vast potential, the construction industry faces a key challenge of shortage of skilled manpower. This hampers the progress of the industry, as the quality of constructed structure is poor and most projects fail to get completed within timelines.

There is a vast difference between the required skill and available skills of workers in the industry today. To reduce the skill gap, appropriate skilling of workforce needs to be carried out .This will not only empower the worker but also benefit the construction industry in terms of quality and productivity.

This Participant book is developed to impart training for the skill and knowledge required to work as an Assistant Electrician in construction industry. It is designed based on Assistant Electrician Qualification Pack under the National skill qualification framework. It comprises of the following NOS/ topics.

- Select and use hand, power tools and electrical devices relevant to construction electrical works
- Install temporary lighting arrangement at construction sites
- Install LV electrical wiring at permanent structures
- Assemble, install and maintain temporary LV electrical panels (distribution boards)at construction site
- Work effectively in team to deliver desired results at the workplace
- Plan and organize to meet expected outcomes
- Work according to personal health, safety, and environmental protocol at construction site.

This book is designed considering the lower educational background of the construction worker. Therefore special efforts have been made to explain the concept required for the job mostly through photos and illustrations.

Units and symbols used in the book have been listed below.

Symbol Used


Key Learning Outcomes


Steps


Exercise


Tips


Notes


Objectives

Table of Contents

The book on New Employability Skills is available at the following location: https://eskillindia.org/Home/handbook/NewEmployability

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1. Introduction

Key Learning Outcomes

At the end of this unit, you will be able to:

1. Explain the purpose of training.
2. Describe about National Occupation Standards and Qualification Pack.
3. Describe about the construction sector in India.
4. State the roles and responsibilities of an assistant electrician.
5. Describe the personal attributes of an assistant electrician in the construction sector.
6. Outline the career progression path for an assistant electrician.
7. Describe the principle of electrical current.
8. Explain what is resistance.
9. Describe the relation of temperature with resistance.
10. Describe the effect of temperature on various materials.
11. State the Ohm's law.
12. Explain series, parallel and combination of resistances.
13. Explain what is an electromagnetic field and its effects.
14. State the Ampere's law.
15. Describe the basic concept of AC and DC generation.
16. Explain the basic concept of LV of Single phase connection and their uses as per electrical voltage load.
17. Describe the basic concept of LV (low voltage) of three phase connection and their uses as per electrical voltage load.

UNIT 1.1: Introduction to the Training Programme

Unit Objectives

At the end of this unit, you will be able to:

1. Explain the purpose of training.
2. Describe about National Occupation Standards and Qualification Pack.

1.1.1 Purpose and Benefits of the Training Programme

This training program is developed to impart specific skills to individuals who wish to perform as an Assistant Electrician. The training program is based upon National occupation standards for construction electrical works. The National occupation standards have been described in the following subsection of this chapter.

The training program will enable an individual to:

- select and use hand, power tools and electrical devices relevant to construction electrical works;
- install temporary lighting arrangement at construction sites;
- install LV electrical wiring at permanent structures;
- assemble, install and maintain temporary LV electrical panels (distribution boards)at construction site;
- work effectively in team to deliver desired results at the workplace;
- plan and organize to meet expected outcomes;
- work according to personal health, safety, and environmental protocol at construction site.

After successful completion of training and passing the assessment you will be issued a certificate. This will get you an employment as an Assistant Electrician in construction companies or independently. This certificate will help you to get job and earn better wages than an untrained person.

Fig. 1.1.1. Skill cards

Fig. 1.1.2. Certificate

1.1.2 Introduction to QP and NOS

This training programme is intended for imparting basic skill and knowledge relevant to construction electrical works occupation required to perform at a construction site .This programme is based on qualification pack called Assistant Electrician. The Qualification Pack Code for Assistant Electrician is CON/Q0602.This is also called a QP.

A QP consists of a set of National Occupational Standards (NOS). NOS specify the standard competency a worker must achieve when carrying out a function in the workplace.

Under Assistant Electrician QP, there are seven NOSs which detail the functions to be performed at work site by as Assistant Electrician.

NOS Code	Major Function/Task
CON/N0602	Select and use hand, power tools and electrical devices relevant to construction electrical works
CON/N0603	Install temporary lighting arrangement at construction sites
CON/N0604	Install LV electrical wiring at permanent structures
CON/N0605	Assemble, install and maintain temporary LV electrical panels (distribution boards)at construction site
CON/N8001	Work effectively in team to deliver desired results at the workplace
CON/N8002	Plan and organize to meet expected outcomes
CON/N9001	Work according to personal health, safety, and environmental protocol at construction site

UNIT 1.2: An Overview to Construction Sector

Unit Objectives

At the end of this unit, you will be able to:

1. Explain about construction sector in India.

1.2.1 Introduction to Construction Sector

Construction refers to building of different types of structures. The sector comprises of many small, medium and large industries or companies that involve in many different types of projects in the construction sector creating a diverse but specific requirement of workmen.

The construction sector can be broadly classified in two sub sectors, namely:

1. **Real Estate and Infrastructure construction:** This sub sector comprises of all the works that are required for construction of all types of infrastructure and real estate projects. Infrastructure projects are those that directly or indirectly affect the growth of the nation e.g. Roads, airports, railway bridges, dams, power plants, metros, industries etc.The real estate projects are those which are mainly focused on providing residential and commercial workplaces to all categories of people e.g. residential towers, independent houses, malls, sports complex etc.
2. **Rural Construction:** This sub sector focuses on the constructional requirements of rural India and includes construction of rural households, warehouses, village roads etc.

1.2.2 Modernization of Construction Sector

From the early age to present day construction sector has not only generated increasing employment but also undergone extensive modernization from raw material used to use of giant equipment. The use of modern equipment and technique has increased the speed of construction work and enhanced quality of finished structures. Further, by modernization of construction it is now possible to construct in under water as well as very high altitude, from hi-tech buildings to atomic power generation plants.

Construction is the second largest employment generating sector in India after agriculture. Though there are many different occupations in construction depending on nature of work, some occupations cater to the maximum number of employments and are more prominent than others.

Following occupations are very common in most of the construction projects.

1. Masonry
2. Bar Bending
3. Shuttering Carpentry
4. Scaffolding
5. Painting
6. Construction Electrical works.

1. Masonry

Masonry involves the work to install materials bonded with mortar such as brick, block, stone, and others to build walls and buildings. Their basic objectives include:

- Building of structure by laying material such as bricks, blocks, tiles and other construction materials, and bonding them by mortar.
- Constructing, altering, repairing and maintaining walls, sidewalks, street curbs, floors, sink counters, partitions, manholes, and other related structures or surfaces.
- Carry out structural finishes like grit wash, cement wash, POP, plastering, stone cladding etc. on finished masonry surface to impart an aesthetic appeal to the finished structure.

The following are some of the job roles under this occupation:

- Helper Mason
- Assistant Mason
- Mason General
- Mason Tiling
- Mason Concrete
- Mason Marble, Granite and Stone
- Mason Special Finishing
- Mason Form Finished & Special Concrete

2. Bar Bending and Fixing

The job of Bar Bending and Fixing includes shifting, cutting, bending and placing the reinforcement bar in order to assemble cage/mesh according to given drawing or specifications.

The following are some of the job roles under this occupation:

- Helper Bar Bender & Steel Fixer
- Assistant Bar Bender & Steel Fixer
- Bar Bender & Steel Fixer

3. Shuttering Carpentry

A shuttering carpenter is a person who specializes in creating shuttering especially using wood/ timber, steel or fibre elements, which are temporary structures used for casting concrete.

Some of the job roles under this occupation are:

- Helper Shuttering Carpenter
- Assistant Shuttering Carpenter
- Shuttering Carpenter – Conventional
- Chargehand Shuttering Carpenter – Conventional

4. Scaffolding

Scaffolding is temporary support structure. The materials used are bamboos, timbers or steel members. This support structure helps during construction activities. Scaffolding is made for workmen to do their work and keep their tools and materials.

Some of the Scaffolding job roles include:

- Scaffolder – System
- Chargehand Scaffolding – System
- Foreman Scaffolding
- Scaffolder – Conventional
- Assistant Scaffolder – Conventional
- Assistant Scaffolder – System

5. Construction Painting

Painting is a key part of the overall finishing work of a construction project. Application of paint lends aesthetic value to a constructed structure. This may also involve a component of decorative painting basis designs and patterns.

The following are some of the job roles under this occupation:

- Assistant Paint Inspector
- Helper Painter

- Assistant Painter
- Foreman Painting and Decorating

6. Construction Electrical Works

Electrical work at construction site involves installation and maintenance of heavy machineries. It also includes installing, repairing and maintaining critical electrical connections/equipment. Additionally, it involves setting up permanent wiring in buildings adhering to standards practices. Some of the job roles under this occupation are:

- Helper Electrician
- Assistant Electrician
- Construction Electrician – LV
- Foreman – Electrical Works (Construction)
- Supervisor - Electrical Works

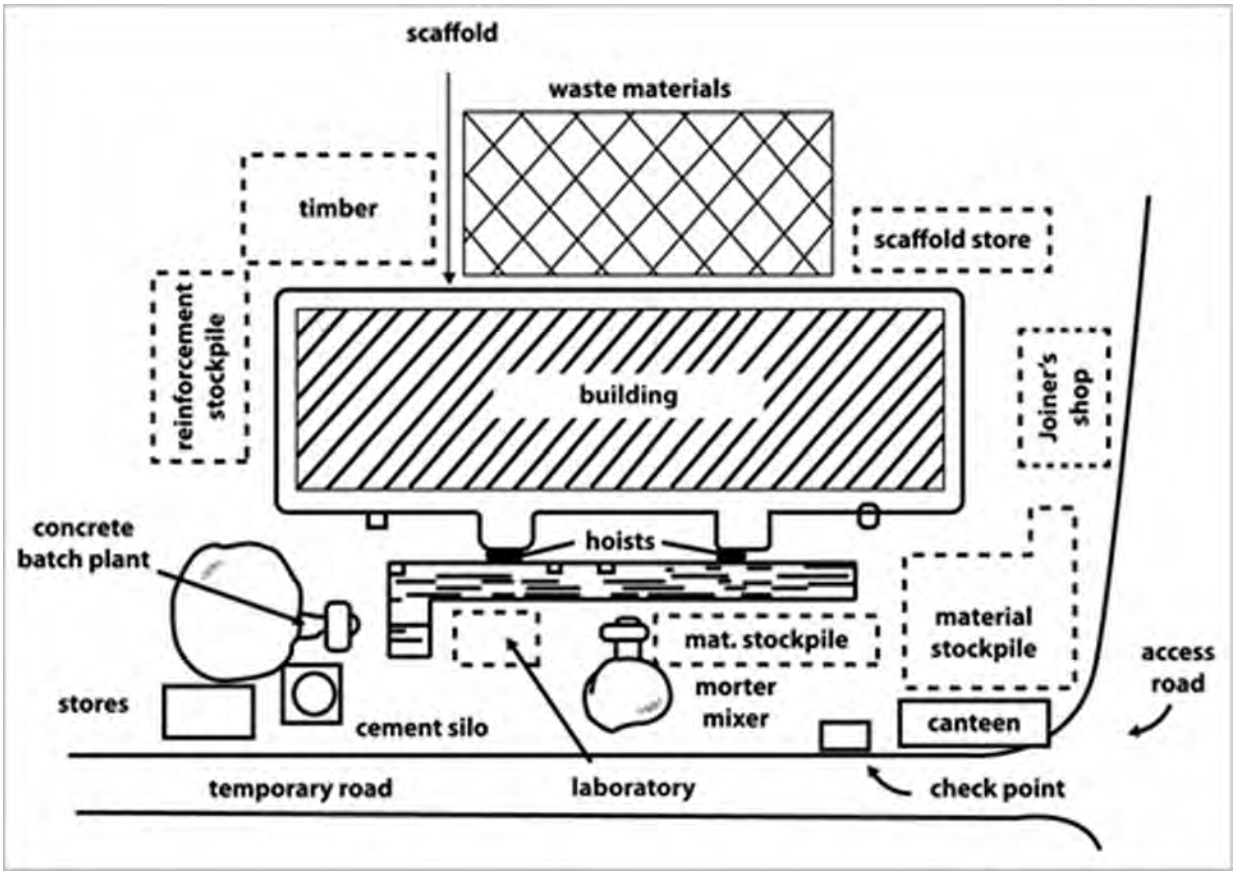

Fig. 1.2.1. Construction site layout

UNIT 1.3: Roles and Responsibilities of an Assistant Electrician

Unit Objectives

At the end of this unit, you will be able to:

1. State the roles and responsibilities of an assistant electrician.
2. Describe the personal attributes of an assistant electrician in the construction sector.
3. Explain the career progression path for an assistant electrician.

1.3.1 Introduction to Electrical Works in the Construction Sector

At a construction site, electrical work involves installation and maintenance of heavy machineries. It also includes installing, repairing and maintaining critical electrical connections/equipment. As part of electrical works, permanent wiring is also conducted in buildings adhering to standards practices. Additionally, it requires planning and utilisation of resources to meet electrical work requirement at construction sites or permanent structures.

1.3.2 Roles and Responsibilities of Assistant Electrician

Roles	Responsibilities
Use appropriate tools	• Select hand tools, power tools and electrical devices as per requirement • Use appropriate tools to complete to complete construction electrical works • Handle and maintain tools adhering to safety guidelines
Installing, repairing and maintaining lighting arrangement	• Install, repair and maintain temporary lighting arrangement at construction sites as per instructions
Installing, repairing and maintaining LV electrical wiring and panels	• Install, repair and maintain LV electrical wiring at permanent structures • Assemble, install and maintain temporary LV electrical panels (distribution boards)at construction site
Laying conduits for LV single phase wiring	• Lay conduits for LV single phase wiring as per instructions provided by superior in electrical work
Support the team to complete assigned tasks	• Work in the team to achieve the desired results
Plan and organise tasks allotted	• Plan and organize tasks in order to meet expected outcomes
Follow health and safety guidelines	• Follow and maintain personal health, safety, and environmental protocol

1.3.3 Personal Attributes of an Assistant Electrician

In addition to technical skills, an assistant electrician should also possess some soft skills and personal attributes. He/she should be able to:

- communicate clearly with superiors/ subordinates;
- support co-workers to execute project requirements;
- work effectively in a team;
- create and maintain a healthy and cooperative work environment among workers;
- maintain mental and physical fitness to perform at work;
- be reliable and honest;
- be courteous while interacting with coworkers;
- maintain personal hygiene at all times;
- plan, organize and complete assigned tasks.

1.3.4 Description of Course Content, Mode of Learning and Duration of the Course

This course aims to impart training to unskilled and semi-skilled trainees into skilled Assistant Electricians. The course has been designed to ensure participants are able to take up jobs at construction sites.

The course is a combination of theory-based modules and hands-on practice. It aims to provide a holistic learning experience wherein participants are able to develop domain skills as well as generic and soft skills.

The total duration of the course is approximately 400 hours, out of which 114 hours have been allotted to theory sessions. 286 hours of practical sessions would ensure participants are able to get hands-on experience in the field.

1.3.5 Career Progression Path

Growth chart signifies the professional growth of a workman who begins his career as a Helper Electrician. He further progresses towards the job role of an Assistant Electrician with some training and experience. He later specialises as a Construction Electrician - LV by obtaining skills, knowledge and five years of experience for the job role. The growth chart advances and denotes the progression in the career path to become a Foreman - Electrical Works (Construction) and later Supervisor Electrical Works.

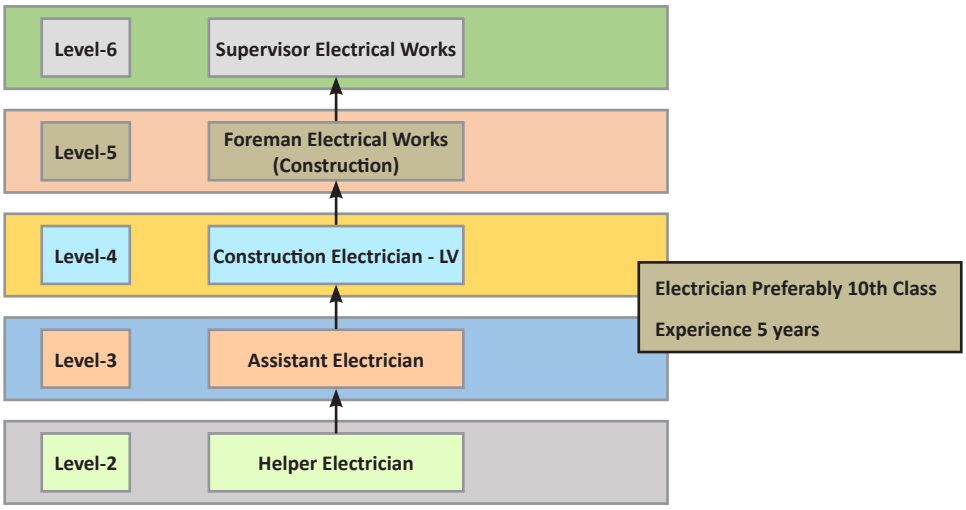

Fig.1.3.1. Carrer progression chart

Exercise

Fill in the blanks

1. At a construction site, electrical work involves _____ repairing and maintaining critical electrical connections/equipment.
2. Construction is the _____ largest employment generating sector in India.
3. As an assistant electrician, you need to follow _____ and safety practices.

Notes

UNIT 1.4: Basic Concepts of Electricity

Unit Objectives

At the end of this unit, you will be able to:

1. Describe the principle of electric current.
2. Explain what is resistance.
3. Describe the relation of temperature with resistance.
4. Describe the effect of temperature on various materials.
5. State the Ohm's law.
6. Explain series, parallel and combination of resistances.
7. State the Ampere's law.
8. Explain what is an electrical field and its effects.
9. Describe the basic concept of AC and DC generation.
10. Explain the basic concept of LV of Single phase connection and their uses as per electrical voltage load.
11. Describe the basic concept of LV (low voltage) of three phase connection and their uses as per electrical voltage load.

1.4.1 Electric Current

An electric current is a flow of electric charge carriers, such as subatomic charged particles (e.g., electrons having negative charge, protons having positive charge), ions (atoms that have lost or gained one or more electrons), or holes (electron deficiencies that may be thought of as positive particles).

Current is a rate at which a charge passes by a point on the electric circuit. Electric charge flows when there is voltage present across a conductor. In electric circuits this charge is often carried by moving electrons in a wire. It can also be carried by ions in an electrolyte.

$$\text{Current} = I = \frac{Q}{t}$$

Electric current is generally denoted by symbol 'I'. The SI unit for measuring current is called ampere. One amphere is the flow of electric charges through a surface at the rate of one coloumb per second, and it is measured using an ammeter.

Electric current causes many effect like heating and inducing magnetic fields, which have wide application in many modern day appliances like motors, inductors and generators.

In a typical home, commercial power line make 100 amps current where light bulb consumes 1 amps and installation of a single AC unit consumes power approximately 15 amps.

Flow and Direction of Current

Electrons which are the mobile charge carriers are responsible for electric current in conductors, such as wires. Current is said to be the flow of either positive or negative charges or both. In a cuircuit flow of positive charges have same electic current and same effect as an equal flow of negative charges in the opposite direction.

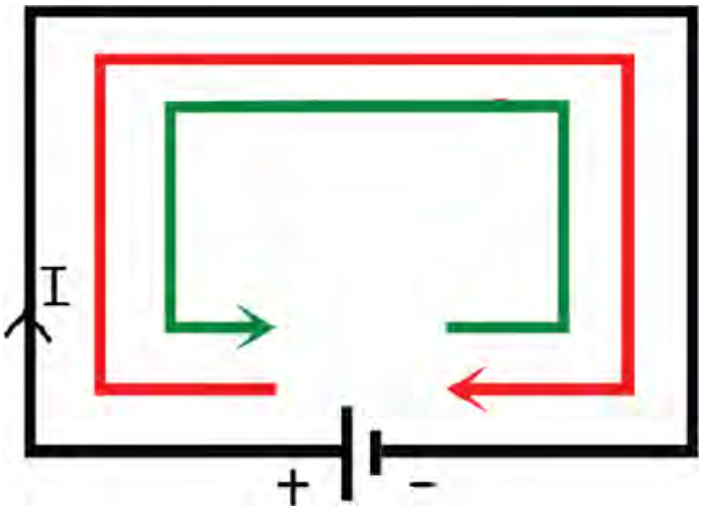

Fig. 1.4.1. Voltage Source

The direction of current is defiend as the direction of flow of positive charges. Thus, the current in the external circuit is directed away from the positive terminal and toward the negative terminal of the battery.

Similarly flow of current in gas and liquids are generally occurs due to flow of positive ions in one direction and negative ions in opposite direction. While current in semiconductor is due to motion of holes in conventional direction and electrons in the opposite direction.

1.4.2 Resistance

Resistance is the opposition to the flow of electric current offered by a substance. In simple words, atoms and molecules of a substance obstruct the flow of free electrons. The amount of opposition, or resistance, applied against the electric current depends on the nature of the substance.

Metals like silver, copper, aluminium offer very little resistance to the electric current. Hence, they are called conductors. Some substances, on the other hand, provide high amount of resistance to the flow of electric current. They are called insulators. Glass, rubber, dry wood, mica are some examples of insulators.

Metals like silver, copper, aluminium offer very little resistance to the electric current. Hence, they are called conductors. Some substances, on the other hand, provide high amount of resistance to the flow of electric current. They are called insulators. Glass, rubber, dry wood, mica are some examples of insulators.

The resistance of a conductor depends upon:

- the length of the conductor; to which it is directly proportional;
- its area of cross-section, to which it is inversely proportional;
- nature of the material;
- temperature.

Symbol:

Resistance: $R \propto \frac{l}{a}$

$$R = \rho \frac{l}{a}$$

Where $\rho\ (rho)$ is constant and is known as resistivity or specific resistance.

Measurement: The unit of measurement for resistance is ohm (Ω).

Resistance can be measured by using an ohmmeter in Ω, a multimeter in kΩ and a megger in m Ω.

1.4.3 Effect of Temperature on Resistance

The resistance of a material is affected by a change in temperature. The effect of temperature on resistance depends upon the type of material.

The resistance of conductors like copper and aluminium increases with the increase in temperature. Since the resistance of these metals is directly proportional to the rise in temperature, they are said to have “positive temperature co-efficient of resistance”.

The resistance of electrolytes, semiconductors like germanium, silicon, etc., and insulators like glass, mica, rubber, etc. decreases with the increase in temperature. Hence, these materials are said to have “negative temperature co-efficient of resistance”.

Contrary to this, the resistance of alloys increases with the rise in temperature but is irregular and almost negligible.

Conductors, Insulators and Semi-Conductors

Substances through which a flow of current, i.e., a flow of free electrons, can be set up easily are called conductors.

The conductivity of a substance depends on the number of free electrons present in the substance. Most metals are good conductors.

Properties of Conductors:

- Low specific resistance
- Mechanically rigid
- Easily available
- Affordable
- Ductile (in the case of metals)
- Resistance that increases when the temperature increases (except in the case of carbon)
- Ability to create a conduction path for current flow when conducting wires or strips are connected.

Insulators

Substances through which a current cannot be passed under normal conditions are called insulators. Insulators have unusually high resistance. Dry-air has a high resistance, which makes it a good insulator. Glass, mica, abonite etc have less resistance than air.

Some common insulators are dry air, asbestos,glass, mica, paper, wax, porcelain, cotton, rubber, etc.

Properties of Good Insulators

For substances to be good insulators they need to have certain properties.

Good insulators:

- Have high specific resistance
- Have high dielectric strength (Dielectric strength, also called breakdown voltage, is the voltage bearing capacity of a dielectric. It is measured in kilo volts per millimetre.)
- Have high temperature bearing abilities
- Have good mechanical strength
- Have a permanent nature
- Are moisture and water proof

Semi-Conductors

Substances that are neither good conductors nor good insulators are termed as semi-conductors. Such substances have few free electrons, as compared to the number of electrons found in conductors. For this reason, the resistance of semi-conductors is quite high. Impure semi-conductors, that is, semi-conductors mixed with a small amount of some other substance, have a reduced resistance.

Semi-conductors are used for making diodes, transistors etc. Germanium, silicon, carbon and boron are some examples of semi-conductors.

1.4.4 Ohm's Law

Ohm's law states that so long as the physical state of a conductor remains the same, the potential difference (V) applied between the ends of the conductor bears a constant ratio to the electric current (I) passing through it.

In simple words this means, that the ratio of potential difference (V) across the conductor and the current flowing through the conductor will remain constant when physical state of the conductor will remain constant (i.e. temperature, length, cross sectional area etc.) therefore $\frac{V}{I}$ = Constant and this constant is called as resistance which is denoted by R therefore, $\frac{V}{I}$ = R

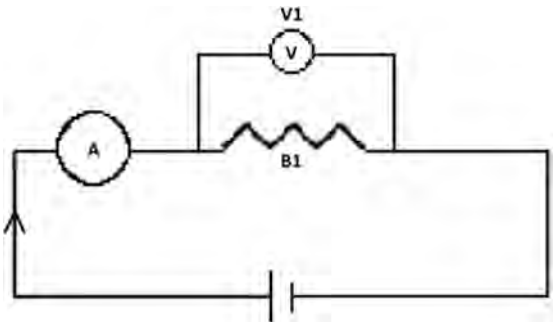

Fig. 1.4.2. Ohm's Law

If, for example, the current (I) is unknown but the voltage (E) and resistance (R) are known,

Where,

I = Current in amperes (A)

E = Electromotive force (EMF) in volts (V)

R = Resistance in ohms (Ω)

Then, $V = I \times R$, $I = \frac{V}{R}$ and $R = \frac{V}{I}$

Example

If battery EMF is 12.8 volts and supplies a current of 3.2 A, then what is the resistance of the circuit?

According to Ohm's law,

$V \propto I$

$\therefore \frac{V}{I} = R$

$\therefore R = \frac{12.8}{3.2}$

$R = 4\Omega(ohm)$

1.4.5 Series, Parallel and Combinations Circuits

Series Circuits

A series circuit is a circuit in which the resistors are connected end to end, so the current has only one path to take. The current is the same through each resistor. The total resistance of the circuit is found by simply adding up the resistance values of the individual resistors.

Equivalent resistance of resistors in series: $R = R_1 + R_2 + R_3$

Fig. 1.4.3. Series Circuits

Here,

V = Voltage source

I = Current flowing in the circuit

R_1, R_2, R_3 = Resistance of resistors

Voltage across $R_1 = I \times R_1 = V_1$

Voltage across $R_2 = I \times R_2 = V_2$

Voltage across $R_3 = I \times R_3 = V_3$

Total voltage $= IR_1 + IR_2 + IR_3$

$$V = V_1 + V_2 + V_3$$

$$V = I(R_1 + R_2 + R_3)$$

$$V/I = R_1 + R_2 + R_3$$

$V = I \times R = R_1 + R_2 + R_3$

Parallel Circuits

A parallel circuit is a circuit in which the resistors are arranged in such a manner that positive ends are connected to positive ends of the other resistors. Same applies to the negative ends. The current in parallel circuit is not same. Different currents are flowing through all the parallel paths.

Here, current $I = I_1 + I_2 + I_3$

The voltage across each resistor in parallel is the same. The total resistance of a set of resistors in parallel is found by adding up the reciprocals of the resistance values, and then taking the reciprocal of the total.

Equivalent resistance of resistors in parallel: $\therefore \frac{1}{R} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$

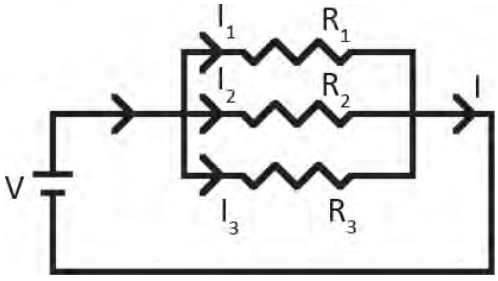

Fig. 1.4.4. Parallel Circuits

According to Ohm's law,

$$V = IR$$

$$\therefore I = \frac{V}{R}$$

In parallel circuit,

$$I = \ell 1 + \ell 2 + \ell 3$$

$$\therefore \frac{V}{R} = \frac{V}{R1} + \frac{V}{R2} + \frac{V}{R3}$$

$$\therefore \frac{1}{R} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$

Series-Parallel Circuits

A series–parallel circuit is the combination of a series circuit and a parallel circuit. Equivalent resistance of a series-parallel circuit depends on the number of series and parallel circuit forms in the circuit.

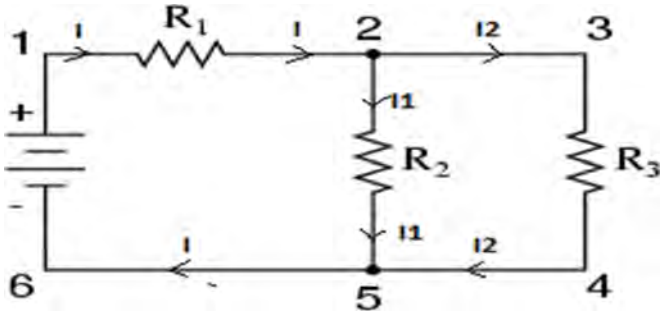

Fig. 1.4.5. Series-Parallel Circuits

Here, equivalent resistance of the circuit: R = R3 II R2 and this parallel combination is in series with R1.

$$\therefore R = \left(\frac{R3 \times R2}{R3 + R2}\right) + R1$$

Hence Total current $= \frac{V}{R}$ ampere

1.4.6 Electromagnetic Field and its Effects

Magnetic Field

Electric field exists near a charged object. Similarly, magnetic field exists around a magnet. If an isolated magnetic pole is brought near a magnet, it experiences force and the region near the magnet, where forces act on a magnet pole, is called magnetic field.

The space in which magnetic poles experience force is called magnetic field. The magnetic lines of force emerge from N pole and enters in south pole, thus forming close loop for magnetic circuit.

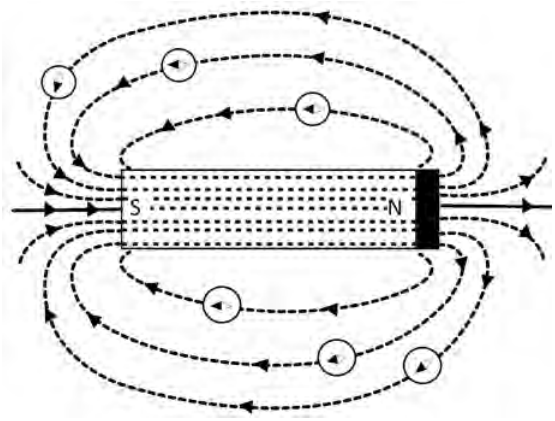

Fig. 1.4.6. Magnetic Field

Electromagnetism

It is the production of magnetic field from electricity. When an electric current flows through a conductor, magnetic field is set up all along the length of the conductor.

Fig. 1.4.7. Electromagnetism

Magnetic Effect of Electric Current:

1. Greater the current through the conductor, stronger the magnetic field and vice versa.
2. Magnetic field near the conductor is stronger and becomes weak as we go away from the conductor.
3. Magnetic lines of force around the conductor will either be clockwise or anti-clockwise. It depends on the direction of current.
4. The shape of the magnetic field depends on the shape of the conductor.

Current-Carrying Conductor in Magnetic Field

When a current carrying conductor is placed in a uniform magnetic field, it experiences a force and the conductor starts rotating.

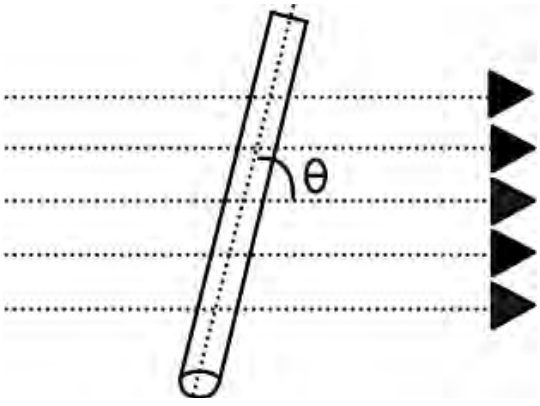

Fig. 1.4.8. Current-Carrying Conductor

Consider a straight conductor carries a current of I ampere has an effective length of l metre. It is found that the force F on the conductor is given by $V = I \times R$ newtons

1.4.7 Ampere's Law

The law states that MMF (magnetomotive force corresponding to EMF i.e. electromotive force) around a closed circuit is equal to the current enclosed by that path.

This means, when current increases, MMF also increases. MMF is given by ampere turns (AT). AT is given by product of number of turns of the magnetic circuit and current (in amperes) in those turns.

1.4.8 Basic Concept of AC and DC Current Generation

AC Power Supply

In alternating current (AC), the flow of electric current periodically reverses direction. Ac power is commonly used in residential and commercial buildings . In AC power circuit the usual wave form is sinewave.

But in certain applications, other waveforms are also used such as triangular or square waves.

Other examples of alternating currents are Audio and Radio signals carried on electricals wires.

The frequency for AC is denoted as 'f', where f = 50 Hz (of supply frequency)

Formula:

N = 120f/P

Therefore, f = N x P/120 where:

- N is number of revolutions done by the conductor;
- P is number of poles of alternator.

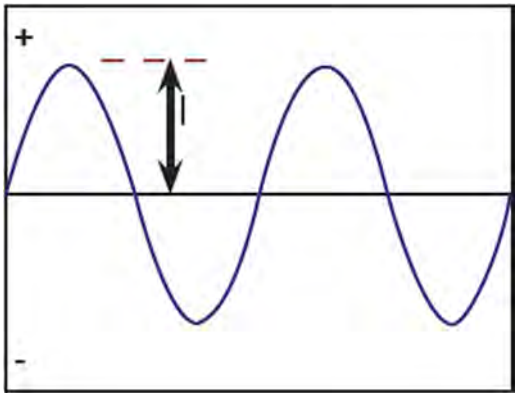

Fig. 1.4.9. Current time graph for AC

Distribution of AC Power Supply

AC input supply is created by an AC electric generator. The AC electricity is more suitable than DC current for long distance transmission as the voltage can be readily changed. In this process Transformer is widely used to increasing or decreasing AC voltage. For use of a high voltage power supply it is necessary to more efficient transmission of power, and also it decreases the transmission losses and increases the efficiency of the system.

It was found that transmission with high voltage direct current was not feasible. For this reason, currently the three-phase electrical generation is very commonly used as an alternative. In the three-phase electrical generation, three current waveforms are produced, which are equal in magnitude and are 120° out of phase to each other.

Phase Sequence

The order in which the voltages in the three phases reach their maximum positive value is called the phase sequence. It is determined by the direction of rotation of alternator. There are three voltages which are produced by three coils. They are displaced from each other at 120°. From this diagram, it is observed that the voltage of coil 1 attains maximum positive value first, then coil 2 and then coil 3. Hence, the phase sequence is 1-2-3.

If the direction of rotation of alternators reverses, then the order also changes. That depends on which coil attains maximum voltage first.

Naming the Phases

The three phases or windings may be numbered as 1,2,3 or lettered as 'A, B, C. However, it is a usual practice to name the three phases or windings after the three neutral colours. They are: 'R' Red, 'Y' Yellow and 'B' Blue, that is RYB.

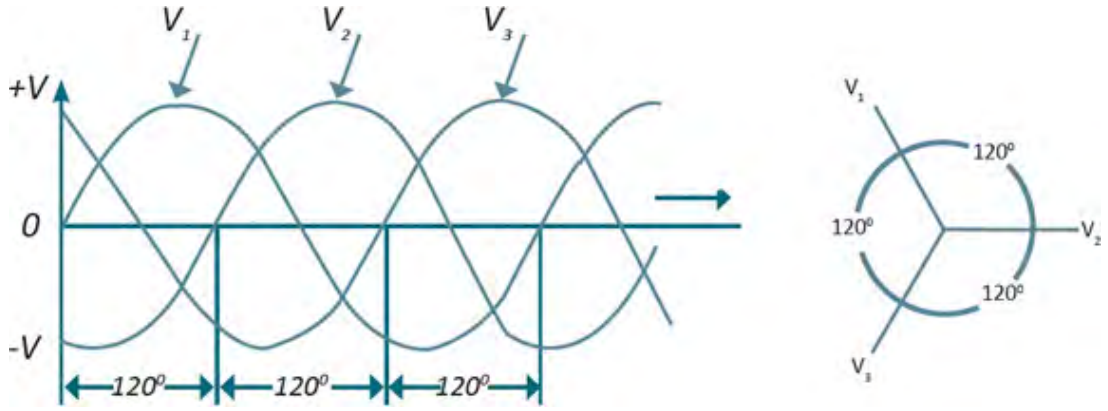

Fig. 1.4.10. Three windings connected in star and delta connection.

These three windings are connected in star connection and in delta connection.

DC Power Supply

Direct current (DC), could also be converted from an alternating current (AC) supply by means of a current-switching arrangement known as a rectifier. The rectifier generally have electronic elements (diodes) which allow the current to flow in unidirection. Direct current can also be converted into alterneting current by use of a inverter or motor-generated (AC generator) set. Direct current is widely used to charge batteries in all the electronic devices.

Fig. 1.4.11. Voltage-time graph for DC

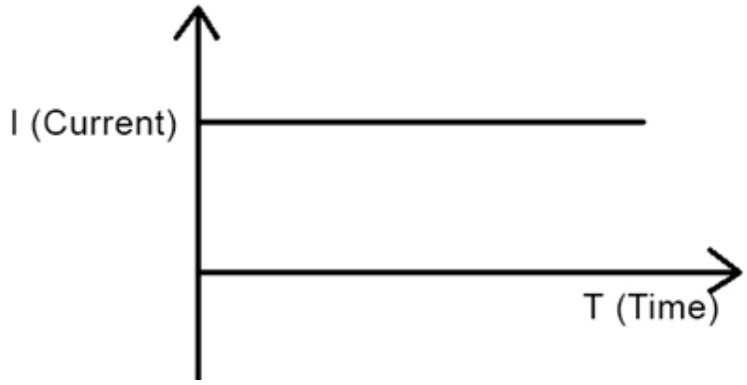

Fig. 1.4.12. Current -time graph for DC

Direct current (DC), could also be converted from an alternating current (AC) supply by means of a current-switching arrangement known as a rectifier. The rectifier generally have electronic elements (diodes) which allow the current to flow in unidirection. Direct current can also be converted into alterneting current by use of a inverter or motor-generated (AC generator) set. Direct current is widely used to charge batteries in all the electronic devices.

An electrical circuit consists of a source of DC power and a wire, which makes a complete circuit that is required for DC electricity to flow.

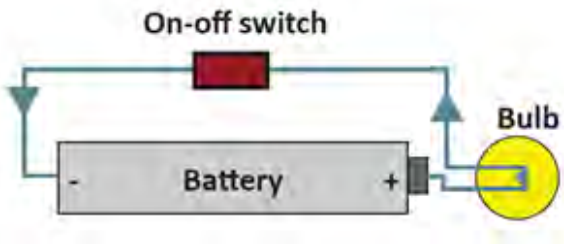

Fig. 1.4.13. Working of a battery

Direct-current installations usually have different types of sockets, connectors, switches, and fixtures. This is mostly due to the low voltages used for alternating current. DC is commonly found in many extra-low voltage applications and some low-voltage applications, especially powered by batteries, which can produce only DC.

The vast majority of automotive applications use “12V” DC power. A few have a 6-volt or a 42-volt electrical system. Light aircraft electrical systems are typically 12V or 28V.

DC does not have any frequency.

1.4.9 LV of Single Phase Connections

LV of Single phase connection refers to low voltage single phase connection. It is used for home appliances and lighting load. Let’s understand about this connection in detail with the help of this diagram.

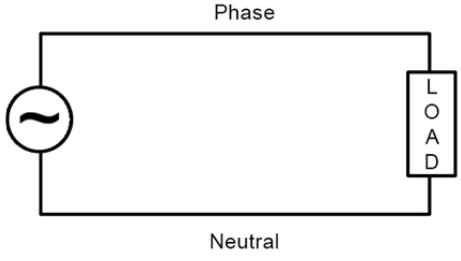

Fig. 1.4.14. Single phase AC supply

For single phase connection, there are only two wires. One is phase wire, the other is neutral wire. Phase wire carries the current. Full voltage is coming across the phase wire. Neutral is at zero potential.

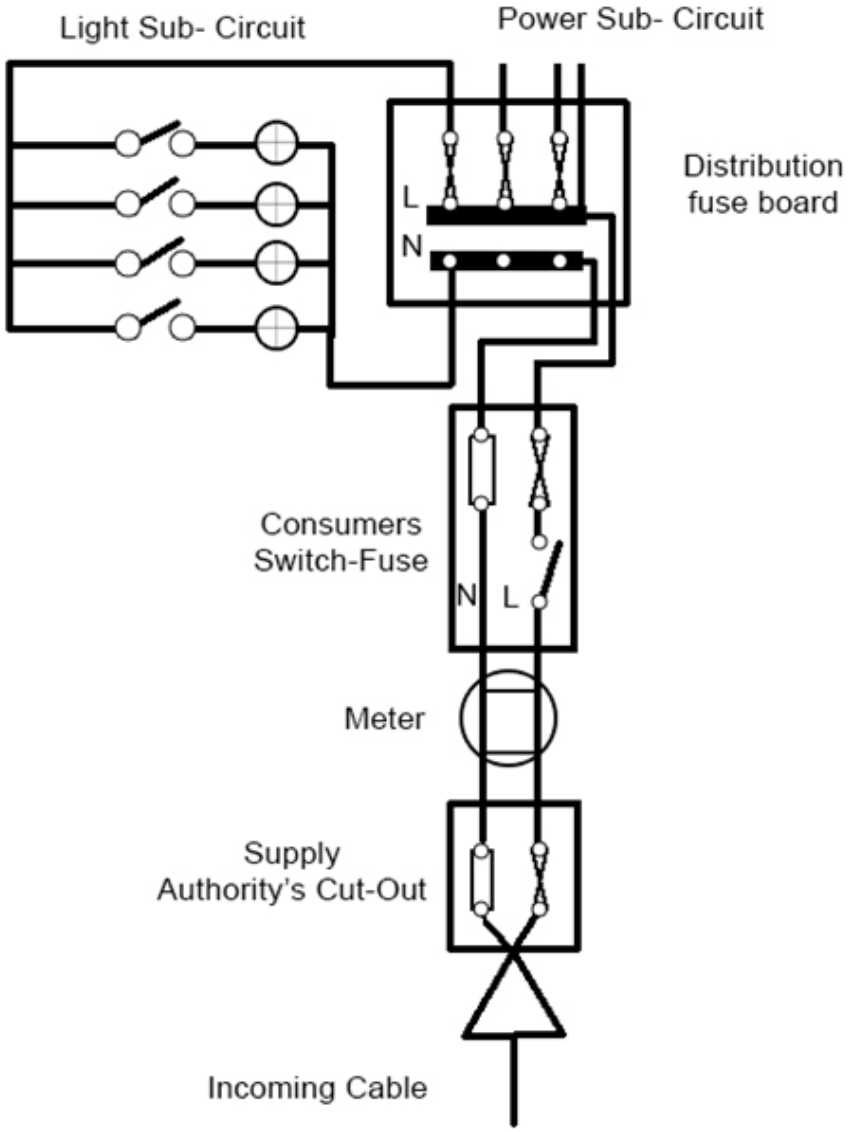

Fig. 1.4.15. Single phase installation

All loads in single phase installation are connected in parallel and supplied at the same voltage. The feeder cables and installation wiring should be designed such that switch on or off any load in the system does not affect any other load in the system. The figure shows a simple diagram for single phase installation.

The consumer's main switch fuse is connected after the metre and feeds a distribution fuse board. Fuses should be placed only in the live or phase wire and never in the neutral wire. All the switches should be installed on the live lines, i.e phase lines.

Never install switches on the neutral wire. This is because neutral is at zero potential. If the fuse is in the neutral and has blown, there will be no flow of current. A lay person may assume that the supply is off. However, the supply may be at full voltage. A simple act of disconnecting wire could be dangerous as there is a risk of touching live parts.

Similarly, if the switch is on neutral but the phase wire is not making full contact, the appliance will not work. Here again, the supply may seem to be off. But, full voltage is acting on the appliance. Handling such an appliance may lead to an accident.

1.4.10 LV of Three Phase Connections

LV of three phase connection is used for AC distribution system. This includes the range of voltages at which the end users utilize the electrical energy delivered to them. The range of voltages is 415V, 230 V, 50 Hz AC supply. The following diagram explains LV of three phase connection in detail.

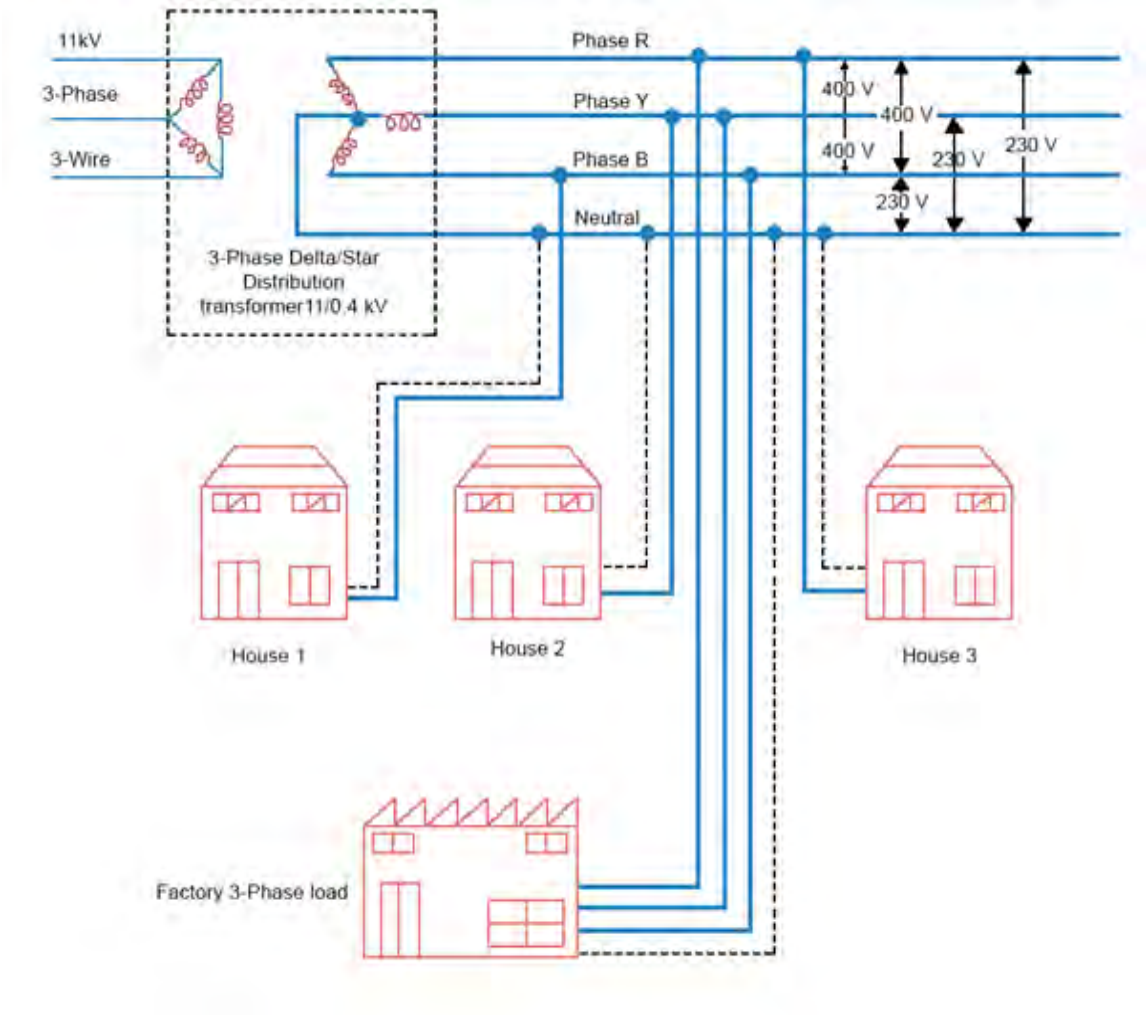

Fig. 1.4.16. Distribution system

In a three phase four wire connection, power is supplied from the substation through four wires. Three of these wires are called live or phase or line wires. The fourth wire is neutral wire which is at zero voltage. The neutral wire is earthed at the substation. The voltage between any two of the line wires in a three phase system is three times the voltage between any phase wire and the neutral wire.

Electric loads of the consumers are connected in such a way that all three phases are equally loaded. In such cases, the current through the neutral wire will be zero. Three phase motors, ovens, etc. are designed in this manner. In such cases, the neutral wire may be omitted.

When large number of single phase loads have to be supplied, loads on three phases are balanced by connecting various single phase consumers or groups of consumers to different phases of 3-phase supply.

Large consumers, who require heavy motor loads, are supplied with a 3-phase, 4-wire supply. Motors and heavy heating loads are connected to 400V 3-phase supply and are called as three phase loads. The load is balanced over the three phases by equally distributing the lighting load and small power loads over the three phases.

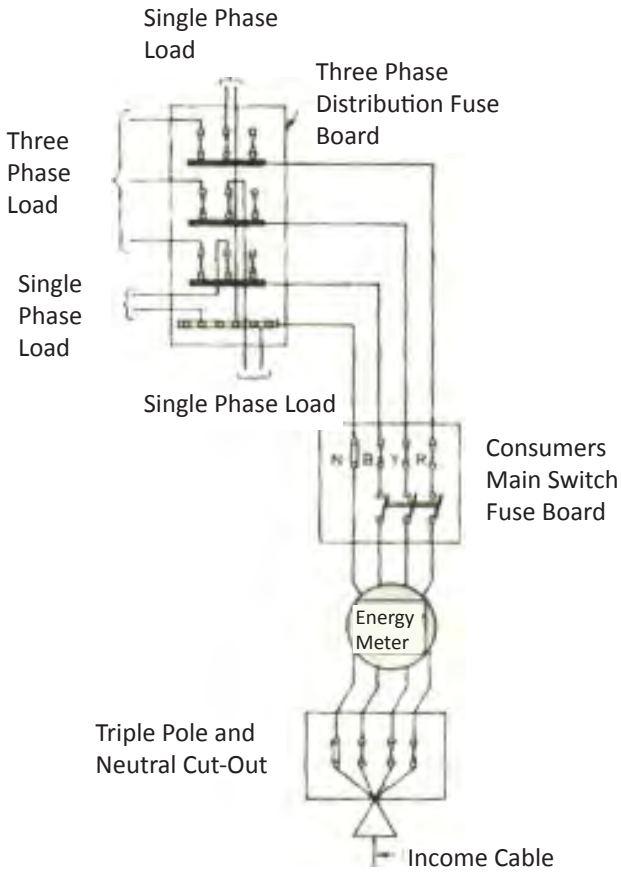

Fig. 1.4.17. Three-phase four-wire distribution for single and three phase loads

Consumers with load requirement more than 250 kVA are provided with supply at high voltage with a substation installed in the consumer's premises. Here, voltage is stepped down to 400/230V.

Single Phase Connection	Three Phase Connection
• Domestic loads are connected between any one phase and neutral	• Domestic loads of 400 motor volts are connected across three phase lines directly
• Standard voltages: 240V 50 Hz, 2 wire	• Standard voltages: 415V, 50 Hz, 4 wire

Exercise

1. Explain DC power supply.
2. Describe a series-parallel circuit.
3. Explain AC power supply.
4. State Ohm's law.
5. State Ampere's Work Law
6. Explain LV for single phase connection.
7. Explain LV for three phase connection.
8. Discuss the difference between single phase and three phase connection.

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2. Generic Skills

Unit 2.1 – Work Effectively in a Team

Unit 2.2 – Plan and Organize Work to Meet Expected Outcome

CON/N8001
CON/N8002

Key Learning Outcomes

At the end of this unit, you will be able to:

1. Explain the process of communication.
2. Develop oral and written communication skills.
3. Effectively communicate with others.
4. Describe the reporting procedure to a concerned authority.
5. Plan activities and schedules.
6. Prioritize tasks to achieve desired results.
7. Organize man, material resources effectively.

UNIT 2.1: Work Effectively in a Team

Unit Objectives

At the end of this unit, you will be able to:

1. Explain the process of communication.
2. Develop oral and written communication skills.
3. Effectively communicate with others.
4. Describe the reporting procedure to a concerned authority.

2.1.1 Communication

Communication is the give and take of an idea or information.

E.g. Talking to a friend about the latest cricket match.

In this example, if you are telling your friend about runs scored by a batsman;

- you become the 'sender';
- your friend becomes the 'receiver';
- the runs scored become the 'information'.

Now, let's say, your friend responds to the information with a nod or says, "That is a really good score!"

This response of your friend is called feedback.

The process of communication can be explained with this chart.

Figure 2.1.1. Modes of Communication

Modes of Communication

Communication takes place through 4 modes, namely:

1. Written
2. Verbal/oral
3. Non-verbal
4. Visual

1. **Written communication** refers to conveying or receiving some information in writing. Example: Filling forms.
2. **Verbal/oral communication** refers to communication with someone by saying something. Example: Talking to a foreman or a supervisor at the workplace.

3. **Non-verbal communication** refers to communicating a message with the help of body language, posture, eye contact, handshake, gestures, etc. Example: Nodding your head (before the supervisor) to confirm that you have understood the task assigned.
4. **Visual communication** refers to communicating information with the help of a visual medium. Example: Safety signs put up near a construction site.

Tips for Effective Communication

- Be a good listener.
- Always maintain eye contact.
- Maintain a good posture.
- Use appropriate gestures
- Clarify doubts when you haven't clearly understood the message.
- Accept feedback.
- Be soft and clear when you speak.
- Always speak with courtesy.
- Avoid being nervous or speaking too fast.

2.1.2 Developing Oral and Written Communication Skills

As an assistant electrician, you are expected to have good oral and written communication skills. As part of your job, you will be expected to follow instructions given by your supervisors as well as work effectively with the team.

Communication plays a crucial role in job completion as it is the first step that takes place before the actual execution process. You also need to interact with subordinates, coworkers and seniors when you need support for completion of work. Hence, it is necessary to develop good rapport with your colleagues and seniors while at work.

Tips to Develop Oral Communication

- Speak in a language that most people on the construction site understand.
- If you are unable to follow some instructions, ask your coworkers or supervisor to explain the task in detail.
- Speak to your seniors with respect.
- Speak to your subordinates and other workmen with courtesy.
- Discuss with co-workers how work could be completed in the given time and in a better manner.
- If a co-worker shares their experiences (good or bad), listen to them carefully.
- When giving instructions to subordinates, ensure that you speak in a soft tone.
- Never let any hint of dominance appear in your tone.
- Try to ensure that your way of communicating makes people feel comfortable around you.

Tips to Develop Written Communication

As an Assistant Electrician, you are expected to possess basic writing skills. Tasks related to writing may include:

- list out the assigned work and tasks;
- fill safety formats for near miss, unsafe conditions and safety suggestions;
- fill any other forms.

While writing something to your seniors, make sure:

- your writing is clear and legible;
- the language used is simple to understand;
- in case of accidents or emergencies, you provide details in written format.

2.1.3 Communication with Others

Ways to Communicate Effectively in the Workplace

1. **Communicate with a Single Person:** At times, people are receptive to conversations on a one-on-one basis. You should maintain eye contact with them to enable the message to sink in.
2. **Be Confident and Serious**: Ensure that you display confidence and seriousness so that you are not taken for granted. Team members may be led treat the information with disdain or disregard if you are not serious.

Fig 2.1.2. Communication with the team

3. **Use Simple Words:** To be effective in your communications with your team members, use words that can be easily understood. When difficult words are used, you can be misunderstood and/or waste precious time having to explain yourself.
4. **Use Visuals:** Visuals help comprehension as workers are able to not just hear the message but also see it.
5. **Be a Good Listener:** Being a leader you must also be a good listener. Encourage your team members to communicate openly. This will help you guide them better.
6. **Use Effective Body Language:** Mastering the art of effective body language will help you pass your message faster and better. It plays an important role in communicating with your team. Stand/sit up straight, use smiles, handshakes and eye contact.
7. **Maintain Appropriate Tone of Voice:** While communicating your message use the appropriate tone of voice to avoid misunderstanding.
8. **Avoid Unnecessary Repetition:** Repeat what you want your team members to know or do only if it is required and if they are not clear about it.
9. **Create a Receptive Atmosphere:** Avoid tense environment as while communicating in an intense manner, the message you are trying to convey might not be well understood or retained well.
10. **Be Humorous:** Calm down the unfriendly and intense atmosphere by being humorous at times. It has being proven to be highly effective method of relieving tension.
11. **Be Articulate:** Communicating in a simple, clear and precise manner will make easier to your team members to understand your message. When communicating with your team members do not mumble words or speak too quickly. It will not give clarity of the subject to the listener. It also shows a lack of confidence on your part.
12. **Encourage Feedback:** Communication is a two way process. The process is complete only when the feedback is received. It shows that the message is well understood by the listener or the receiver.
13. **Be Expressive with your Hands:** Use your hands and body to demonstrate your message. It establishes the seriousness of your subject matter when communicating with them.
14. **Be Appreciative:** Always appreciate your team members for listening to you and remember to thank them for their time.

2.1.4 Reporting Procedure

As an Assistant Electrician, you may have to report to either Foreman-Electrical Works or a supervisor at the construction site. As part of your duties, you will have to report to your senior about the following:

- shortage of equipment and electrical goods;
- failure to follow safety norms by other workmen;
- unsafe working conditions;
- risk of an impending accident or emergency.

Reporting to a Concerned Authority

- Ask for their time/permission before you have to share any information.
- Speak in a language that they understand well.
- Ensure that you speak in a calm tone.
- Make them understand the importance of issues which need immediate attention.
- Never go to an authority to complain about a co-worker or subordinate.
- If someone misbehaves with you, inform your authority and let them take necessary action.

Exercise

1. List the four components of communication.

2. List the four modes of communication.

3. State whether the following statements are correct or incorrect.
   a. If someone misbehaves with you, you must show them your strength.
   b. You should always speak with courtesy.
   c. You should dismiss feedback at all times.
   d. You must always maintain an erect posture.
   e. If you are unable to understand instructions, you must ask your subordinates for help.

Notes

UNIT 2.2: Plan and Organize Work to Meet Expected Outcome

Unit Objectives

At the end of this unit, you will be able to:

1. Plan activities and schedules.
2. Prioritize tasks to achieve desired results.
3. Organize man, material resources effectively.

2.2.1 Prioritise Work

Priortising work involves steps that help to achieve the desired results:

1. **Plan activities and schedule**

   List of tasks for Assistant Electrician

   - Discussion with superiors
   - Reading the drawing
   - Wearing PPE
   - Gathering tools and materials
   - Locating the site
   - Allocation of work
   - Execution and quality checks
   - Informing superiors after completion of work

Fig. 2.2.1. Task to do

2. **Recognising urgent vs. important task:** Identify the task that needs immediate attention. Ensure that the work gets completed as planned without missing any commitments or dependency of completion of your work on others.
3. **Evaluating the value of the task:** The important work should be given highest value. Identify which types of task are on top priority over the others. It will help increase your team's efficiency.

Fig. 2.2.2. Urgent vs. important

4. **Ordering task by estimating efforts:** Check and estimate efforts that will go in performing the task. Target to start the task that will require more amount of time.
5. **Flexibility and adaptability in task completion:** Change is evident. Be flexible and adapt to the priorities that may change.
6. **Focusing on the priorities:** Prioritise your task by analysing and estimating the efforts and focus on the derived priorities.

Fig. 2.2.3. Set Priority

2.2.2 Organisation of Resources

Organising

Organising is a process of engaging co-workers and developing a productive relationship amongst them for the purpose of completing a given task. Organising and planning are the two most important factors for efficient and successful job.

Organising includes:

- Identification, classification and grouping of activities.
- Identification of appropriate tools, equipment and materials before starting work.
- Identification and arranging required manpower.
- Assignment of duties to appropriate subordinates.
- Creation and delegation of responsibilities among co-workers for completion of work.
- Coordination of work among the team and across teams.
- Organising training or providing guidelines to avoid damage of equipment.
- Planning and organising work environment to avoid accidents.
- Organising resources to avoid waste of materials.

Benefits of Organising

- Make better decisions.
- Identify available resources.
- Anticipate needs and problems.
- Get work done accurately by avoiding mistakes.
- Be more efficient and productive.
- Complete desired tasks and activities.

Controlling

- The purpose of controlling is to ensure that everything goes as per set guidelines and standards. An efficient system of control helps to predict deviations before they actually occur.

Steps for Controlling

- Establishing a plan.
- Measuring actual work progress at regular intervals.
- Comparing actual work done with the plan and identifying the gaps if any.
- Analysing the performance and making amendments to the scheduling of tasks so as to streamline the plan.
- Finding out the reasons for deviation from the schedule.
- Taking corrective measures to rectify the deviation.

Optimising use of Resources

- Resources can be used in an optimum way by following the guidelines mentioned below.
- Analyse the capabilities of individuals and the characteristics job requirements.
- Match the right people with the right job.
- Rotate jobs to avoid boredom.
- Rotate people to give them varied experience and training opportunities.
- Make provisions for absenteeism.

Exercise

1. State whether the following statements are correct or incorrect.
   a. You should plan and schedule activities prior to work.
   b. You should manage time effectively.
   c. You should organize adequate man an materials

Notes

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3. Health and Safety while Performing Electrical Works

Unit 3.1 – General Safety

Unit 3.2 – Personal Health and Safety

Unit 3.3 – Waste Disposal

CON/N9001

Key Learning Outcomes

At the end of this unit, you will be able to:

1. List the types of hazards involved in construction sites.
2. Describe the safety control measures and actions to be taken under emergency situation.
3. Explain what is first aid.
4. Describe the uses of fire extinguishers.
5. Explain how to classify fire and fire extinguishers.
6. Explain how safety drills are conducted.
7. Describe the safety norms applicable in construction sites and electrical works.
8. Explain the use of PPEs used by an assistant electrician.
9. List the type of electrical hazards associated with domestic wiring work.
10. Describe the effects of faulty/improper wiring works.
11. Describe the standard safety control measures.
12. Explain the importance of safe disposal of waste.
13. Discuss about electrical waste management at a construction site.

UNIT 3.1: General Safety

Unit Objectives

At the end of this unit, you will be able to:

1. List the types of hazards involved in construction sites.
2. Describe the safety control measures and actions to be taken under emergency situation.
3. Explain how to administer first aid.
4. Describe the uses of fire extinguishers.
5. Explain how to classify fire and fire extinguishers.
6. Explain how safety drills are conducted.

3.1.1 Hazards at Construction Sites

Working at a construction site comes with a set of hazards and safety issues. Not abiding to safe practices at the workplace may lead to accident, and in worst cases, death.

Construction sites are at high risk of electrical fire and shocks. It may my pose a tremendous risk of serious injury or prove fatal for the workers at site. However, by following safety precautions, most of the accidents can be avoided. Let us look at some common hazards at construction sites.

Types of Hazards

Hazards for construction workers can be classified into:

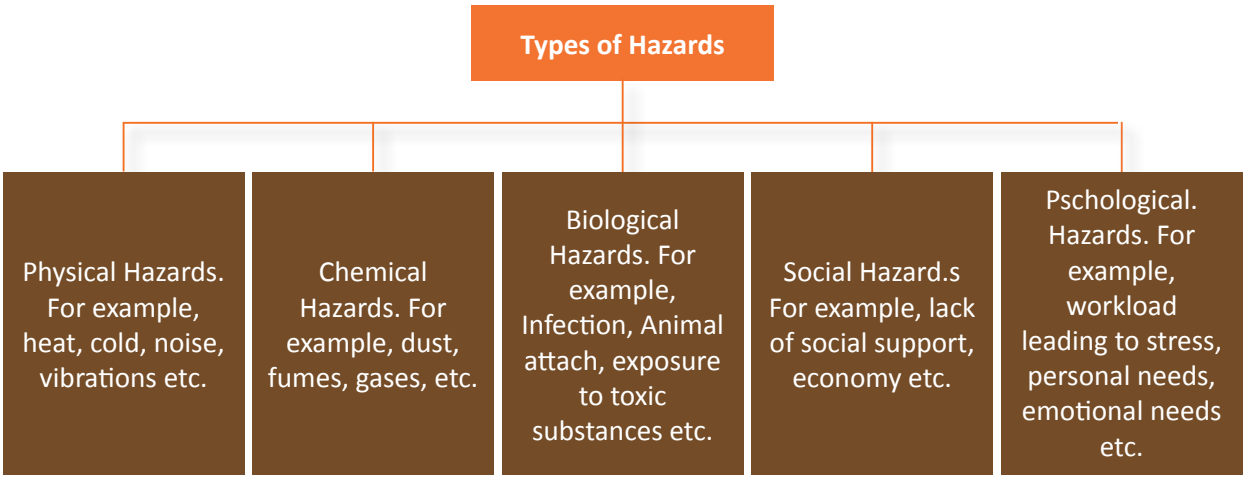


Fig. 3.1.1. Types of Hazards

Occupational hazards at a construction site can be categorised into two types:

a. Occupational accidents: Accidents that take place due to lack of safety measures. These accidents may be fatal.

For example,

- Falling from height. For example, falling from scaffold, roof, platform etc.;
- Caught between the machinery. For example, improper use or machinery not functioning properly, etc.;
- Excavation. For example, unsafe excavation site, etc.;
- Electrocution or shock. For example, contact with power supply, power tools, etc.;
- Struck by an object. For example, falling objects from the roof top etc.

Fig. 3.1.2. Caught between the machinery

Fig. 3.1.3. Falling from height

Fig. 3.1.4. Electrocution or shock

Fig. 3.1.5. Unsafe excavation

Fig. 3.1.6. Struck by an object

b. Occupational illness: Injury or illness that may take place due to the unsafe working condition. It may affect the health of a person suffering in a short or long term.

For example,

- Back injuries (lifting heavy loads and inappropriate lifting positions, etc.);
- Respiratory diseases (ingestion of dust, fumes, etc.);
- Musculoskeletal disorders (sprains in the muscles, injuries that affects neck, shoulders, hand, wrist, back, knees, etc.);
- Hearing losses (long term exposure to loud noise); and
- Skin diseases (exposure to harmful chemicals or fumes).

Fig. 3.1.7. Inappropriate lifting positions

Fig. 3.1.8. Exposure to harmful chemicals

Fig. 3.1.9. Ingestion of dust

Fig. 3.1.10. Exposure to loud noise

Fig. 3.1.11. Injury that affects knees

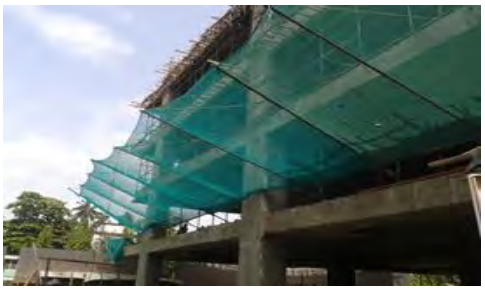
Some of the hazards at a construction site and their preventive measures:

Hazards at Construction site	Preventive Measures
Damaged Tools and Equipment	**Safe Tools and Equipment**
Injury or cuts by unmaintained tools and equipment	Ensure proper maintenance of tools and equipment and check for any defects
 *Fig. 3.1.12. Damaged tool*	 *Fig. 3.1.13. Maintained tool*

Unsafe Trench	Safe Trench
Injuries occur due to collapsing of trench	Inspect the trench prior to entry. Ensure to have angle inclined away from excavation. Keep ladder or ramp to provide exit way.
	
Fig. 3.1.14. Unsafe trench	*Fig. 3.1.15. Safe trench*
Not Wearing Personal Protective Equipment (PPE)	**Wearing Personal Protective Equipment (PPE)**
Injuries due to PPE not used while working	Use proper PPE while working for specify task
	
Fig. 3.1.16. Not wearing PPE	*Fig. 3.1.17. Wearing PPE at work*
Slips and Trips due to chemical spillage	**Avoiding Slips and Trips due to chemical spillage**
Spillage of chemicals on floor may cause chemical burns, respiratory problems, fire and explosion	Train the workers to read Material Safety Data Sheet (MSDC) in vernacular language. Store chemicals safely. Ensure to use PE.
	
Fig. 3.1.18. Chemical spillage	*Fig. 3.1.19. Adhering to safety*
Poor Light and Ventilation	**Illuminated workplace**
Dimly lit areas	Keep workplace Illuminated and airy
	
Fig. 3.1.20. Poor light at workplace	*Fig. 3.1.21. Illuminated workplace*

Falling from Height	Wearing Safety Harness
Unsafe harness may lead to fall from height	Wear safety harness while working at height
	
Fig. 3.1.22. Unsafe harness	*Fig. 3.1.23. Safe harness*
Fire Due to Unsafe Practices	**Safe Practices**
Exposure to damaged wires, electrical cords, may lead to fire hazard	Replace worn out or damaged wires or cords promptly. Ensure the extension cords and electrical devices are grounded (three-pronged).
	
Fig. 3.1.24. Fire due to damaged wires	*Fig. 3.1.25. Follow safe practices*
Unsafe Scaffold or Ladder	**Following safety measures**
Unsafe footing, weak, defected or rusted scaffold/ ladder may cause injury or sometimes may be fatal.	Use scaffold/ladder that is strong, rust free and sturdy to carry weight that is four times the weight of the intended load. Ensure that the scaffold is erected on solid base. Inspect for any defects such as broken steps, missing rungs, grease or paint on ladders.
	
Fig. 3.1.26. Unsafe scaffold	*Fig. 3.1.27. Following safety measures*

Electrical Shocks	Use safety equipment
Danger of electric shocks due to unsafe or damaged electrical equipment	Use Safety equipment like GFCI to protect from shocks
	
Fig. 3.1.28. Damaged electrical equipment	*Fig. 3.1.29. Using safety equipment*
Accidents	**Use barriers and guards**
Accident arising from lack of safety measures	Use barriers and guards to prevent entry through high voltage electrical equipment
	
Fig. 3.1.30. Accidents	*Fig. 3.1.31. Barriers and guards*
Heavy Vehicles at Site	**Maintain traffic safety rules**
Damage or fatal accidents involving heavy vehicles at site like cranes and forklift	Maintain safety rules for heavy vehicles at site. Train the operator to operate such vehicles. Inspect for any defect and keep regular maintenance of the vehicle.
	
Fig. 3.1.32. Damage due to heavy vehicle	*Fig. 3.1.33. Follow traffic safety rules*
Poor Housekeeping	**Good Housekeeping**
Scattered tools and equipments on the floor, passages or stairways may lead to small accidents	Arrange and store the material at proper place to avoid falls and trips
	
Fig. 3.1.34. Poor housekeeping	*Fig. 3.1.35. Good housekeeping*

Lack of Safety Measures	Follow Safety Measures
Danger of falling heavy objects from the height	Use safety net to prtoect from objects falling from height
	
Fig. 3.1.36. Falling from height	*Fig. 3.1.37. Follow safety measures*

3.1.2 Dealing with Emergency Situations

As an Assistant Electrician at a construction site, you may have to encounter emergencies day in day out. Neither should they be ignored nor should you panic. In case of an emergency,

- stay calm;
- do not panic;
- ensure people around you also stay calm;
- inform your immediate supervisor;
- if you need to stay with the victim, ask someone from your team to inform your supervisor;
- inform supervisor so that the victim receives first aid;

Fig. 3.1.38. Dealing with Emergency Situations

If you are asked to report the case to your supervisor, you should provide detailed information about:

- day, date, time, location of the accident/emergency;
- name of the workers and their job titles (if you know them);
- what led to the accident/emergency;
- names of workers who witnessed the accident/emergency;
- conditions around the area where the accident/emergency took place;
- whether the victim(s) had worn PPE at the time of accident/emergency;
- injuries that occurred;
- first aid or any other treatment given to the victim(s);
- damage caused to the worker or the equipment that the worker was using.

3.1.3 Concept of First Aid

As an Assistant Electrician, the most common emergency situation that you may encounter is electrical shock. This may happen to anyone around you. As an alert individual, you need to administer first aid to the victim. Here's how:

Fig. 3.1.39. First aid

The most important thing to remember about electrical shocks is even if a shock victim appears to be unharmed, they should still be treated as a victim of shock. This is because electrical shock can lead to injuries or complications that may not be immediately recognised.

When a person has suffered from an electric shock, the following first aid must be carried out immediately:

- Disconnect the power supply. Never touch the injured person until the power supply is turned off.
- Check the person's response.
- Check the person's breathing. Perform CPR if necessary.
- Call an ambulance.
- If the person is breathing normally and is responsive, check for injuries.
- If the person has suffered burns, run cool running water over the burn areas for 20 minutes.
- Cover the burn areas with dressings that will not stick to the affected area. Remember, never use ointments or oils on burns.
- Talk to the person and keep him/her calm.

When dealing with a victim of electrical shock, it is important that you do not move the person. Moving the person can lead to further injuries and complications. Follow the first aid steps and wait for paramedic assistance.

3.1.4 Classification of Fire and Fire Extinguishers

At a construction site, fire may be caused by:

1. heating of metal;
2. electrical heating or short circuits;
3. loose fires caused by welding or smoking;
4. ignition of combustible material;
5. chemical fires;
6. lack of proper housekeeping and/or accumulation of waste.

Tips to Deal with Fire

- Keep the work area clean.
- Containers with remnants of flammable materials must be filled with water.
- Never wear inflammable material like nylon at work.
- Ensure there are no unattended cables or wires lying around the work area.
- Avoid using power tools near combustible materials.
- Avoid using power tools near combustible materials.
- Keep an eye on sparks and metals falling off at all times.
- Immediately report about any emergency situation that may cause fire to your senior at work.

In Case of Fire

- Douse the fire, if it is small, with a fire extinguisher.
- If the fire is big and growing, call the fire brigade.
- Move towards the fire exit. Take coworkers along.
- Ensure there is no panic in and around the area.
- Keep an eye on sparks and metals falling off at all times.
- Immediately report about any emergency situation that may cause fire to your senior at work.

Types of Fire

A	Paper, wood, plastic, fabric, rubber, trash	
B	Gasoline, Oil, Grease, Some Paints and Solvents	
C	Electrical Equipment, Appliances, Computers, Circuit Breakers, Wiring	

Types of Fire Extinguishers

Fig. 3.1.40. Dealing with Emergency Situations

Using the Right Fire Extinguisher

Choosing the right extinguisher can prevent property damage and save lives				
Types of fire extinguisher → / Types of fire ↴	Water	Foam	CO_2	Dry chemical
A Paper, wood, plastic, fabric, rubber, trash	✓	✓	✗	✓
B Gasoline, Oil, Grease, Some Paints and Solvents	✗	✓	✓	✓
C Electrical Equipment, Appliances, Computers	✗	✗	✓	✓

Method of Using a Fire Extinguisher

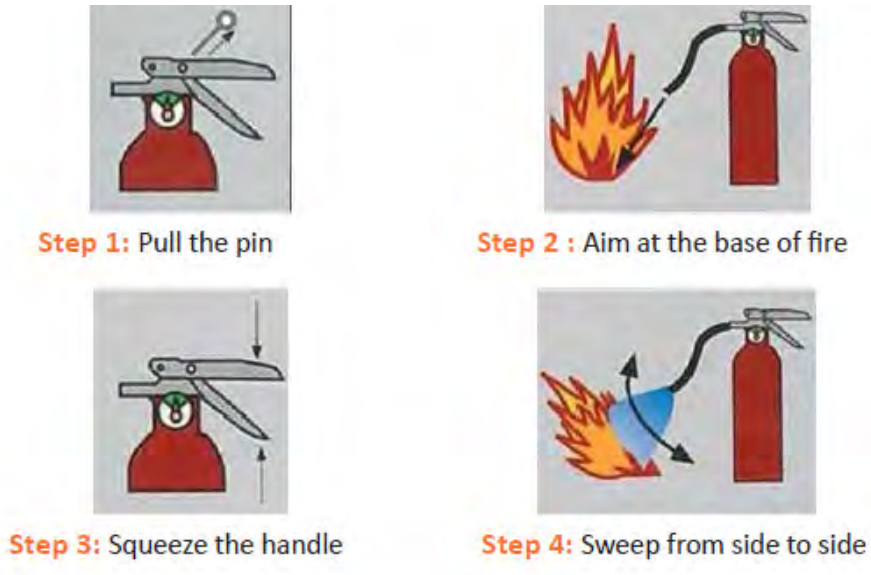


Fig. 3.1.41. How to use fire extinguisher

As an Assistant Electrician, you may often come across electrical fires. There are two types of fire extinguishers that can be used for electrical fires. These are:

- Carbon dioxide (CO_2) extinguishers
- Dry chemical extinguishers

CO_2 extinguishers:

CO_2 extinguishers are specially designed to put out electrical fires. They have a wide nozzle that expels the CO_2 gas. When the extinguisher is sprayed on an electrical fire, the oxygen on the surface of the fire is displaced. This results in the fire dying out. However, it should be noted that the fire can reignite once the CO_2 gas dissipates – this is why it is very important to remove the ignition source in time.

When CO_2 extinguishers are sprayed on electrical equipment, no messy residue is left behind. This makes them perfect for putting out fires on delicate electrical equipment.

Dry chemical extinguishers:

Dry chemical extinguishers are also designed to put out electrical fires. These extinguishers are better than CO_2 extinguishers as they prevent fires from reigniting. This is because they leave a layer of non-flammable material on the area that they have been sprayed over. On the down side, these extinguishers are very messy and they leave behind a fine powder that irritates the throat and lungs.

In case of an electrical fire, the following precautions should be taken:

- Switch off the mains.
- Throw sand on the fire. This will extinguish an electrical fire.
- Use carbon dioxide extinguishers to put out such fires.
- Ensure that the extinguisher is not outdated.
- Remember, never use water to put out a fire if the mainline is live.

3.1.5 Tool Box talks and Safety Drills

Toolbox Talks:

- Toolbox meetings are conducted to provide information to workers, and for workers to have their say about hazards/controls, incidents/accidents, work processes and company rocedures.
- Toolbox meetings should be run on a regular basis for 10-15 minutes.
- The frequency of meetings will depend on the size, nature, hazardous activities at workplace.
- Some hazardous activities could require daily meetings, while others may need weekly/fortnightly meetings.

Importance of Toolbox Talks

- Inform workers about company norms and changes in any norms
- Identify new hazards and review existing hazards
- Develop/review hazard controls
- Discuss/review accident and incident data
- Communication between teams
- Develop/review work processes
- Short training sessions

Fig. 3.1.42. Toolbox Talks

In order to keep workmen aware of the emergency situations that may arise at the workplace, safety drills are conducted at regular intervals. Safety drills are situations where a fake emergency is announced. Workmen are asked to follow the emergency evacuation plan, prescribed by the organization. This helps in familiarizing workmen with emergency situation and act according to the plan. As part of the safety drill, workmen are expected to: raise the alarm by smashing the glass cover of the nearest break-glass alarm unit;

Fig. 3.1.43. Safety Drills

Fig. 3.1.44. fire fighting safety Drills

- keep calm and ensure no one around panics;
- turn off all electrical apparatus except lights;
- if possible, close doors around the fire area to stop it from spreading;
- evacuate the workplace/site immediately;
- follow the evacuation queue;
- if it's dark and smoky, get down on their hands and knees and crawl to the nearest exit by counting the number of the door;
- hold onto their nose with a wet towel or handkerchief;
- be aware of the hot exit door and watch out for the thick smoke in the staircase;
- if the staircase is free from smoke, walk down by following the directional signs and handrails;
- gather at the designated assembly point.

Exercise

1. State whether the following statements are correct (✓) or incorrect (✗).
   a. During an emergency situation, you must panic and create confusion. ( )
   b. While reporting about an emergency, you must inform your supervisor about the injuries that occurred. ( )
   c. In case of electrical shock, first disconnect the power supply. ( )
   d. You wear nylon clothes to work. ( )
   e. During the safety drill, you must assemble at the assembly point. ( )

2. How will address the below given issues.
   a. You see sparks coming out from the open electric board near a water tank used for masonry work.

   b. You see a person doing electrical work standing on a broken ladder

   c. You see fire breaking out at the construction site you are working and many people stuch on the higher floors

3. State any three reasons for:
   a. Electric Shocks

   b. Burns

UNIT 3.2: Personal Health and Safety

Unit Objectives

At the end of this unit, you will be able to:

1. Describe the safety norms applicable in construction sites and electrical works.
2. Explain the use of PPEs used by an assistant electrician.
3. List the type of electrical hazards associated with domestic wiring work.
4. Describe the effects of faulty/improper wiring works.
5. Describe the standard safety control measures.

3.2.1 Safety Norms Applicable in Construction Sites

Safety is of utmost importance at a construction site. Hence, every organisation lays down a set of safety norms that must be followed by each and every worker.

Before learning about the safety norms, it is important to know the meaning of safety signs. Such signs warn us of danger, restrict access to a particular area, provide direction and allow us to take precautionary measures. There are four types of safety signs:

- Prohibition signs:
  - A Prohibition sign refers to the actions or behaviour that is not permitted at the site.
  - The action symbols are in black over which annulus and slash is shown.
  - The wordings are in black letters on a white background.

- Mandatory signs:
  - A Mandatory sign gives clear instructions about health and safety messages to workers, visitors and contractors.
  - A mandatory sign is represented in a blue circle with a white picture in it.

- Warning signs :
  - A warning sign is to warn or alert of any hazard or a hazardous condition that is not expected to be dangerous to life.
  - The hazard symbol is black on a yellow background. A triangle is depicted around the hazard symbol.
  - The wordings, if required, are in black letters on a yellow background.

- Information signs:
  - Construction site must provide visual warnings to the workers, visitors and contractors at site.
  - The information sign ensures that multiple messages are communicated to the workers at the same time.

Some of the important signs at construction site are mentioned below:

Smoking and Naked Flames Prohibited

Do Not Extinguish with Water

Wear Head Protection

Wear Eye Protection

Wear Foot Protection

Wear Hand Protection

Risk of Fire

Risk of Electric Shock

Risk of Explosion

Safety Colours and Their Meanings

There are generally four safety colours – red, yellow, green and blue. The purpose of safety colours and safety signs is to draw attention to objects and situations affecting safety and health and also to understand a message quickly.

Colour	Meaning	Used for
Red	Danger/Stop	Containers of flammable liquids; emergency stop bars; stop buttons; fire protection equipment
Orange	Warning	Hazardous parts of machines which may cut, crush or otherwise injure a worker, inside movable guards or the inside of transmission guards for gears, pulley chains, etc
Yellow	Caution	Physical hazards which might result in striking against stumbling, falling
Green	First aid/safety equipment/ emergency exit	First aid kits, stations, stretchers, exit routes
Blue	Safety information	Signs requiring use of PPE

Safety Norms to Follow while Handling Hand Tools

Ensure that:

- safety goggles and gloves are used at all times while working with tools;
- cutting tools are sharp;
- chisel is driven outward and away from the body;
- when passing sharp tools to co-worker, pass them handle first;
- hammer heads and handles do not have cracks and splits;

Fig. 3.2.1. Damaged tools

- handle heads are fastened to the handle securely;
- floor surface where working is free from debris and tripping or slipping hazards;
- chisels are not used when heads have mushroomed;
- tools with loose or cracked handles are not used;
- chisel is not used as a screwdriver.

Safety Norms to Follow while Handling Power Tools

Ensure that you:

- always unplug a tool when it is not in use, (even when you are adjusting it);
- guard against electric shocks;
- check cords for cracks;
- plug three-pronged tools into the corresponding three-pronged, grounded sockets only;
- do not use an adapter or an extension board, unless you are sure it is properly grounded;
- turn off a tool immediately, if it is overheated, and let it cool;
- always stand on a dry surface when you are working;
- do not to touch water pipes with any part of your body when you work with power tools;
- do not keep power tools on the floor or in damp area;
- do not use any electric equipment without complete knowledge of the equipment.

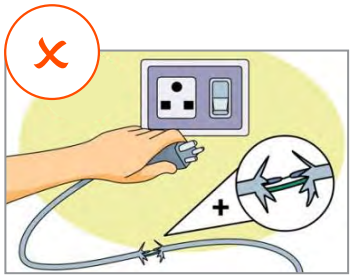


Fig. 3.2.2. Torn electric cable

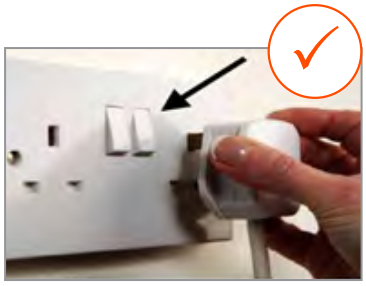


Fig. 3.2.3. Switch off power while inserting the plug

Safety Norms to Follow while Using Ladder

When using a ladder, the following precautions need to be taken.

- Inspect the ladder for cracks before you lean it against a wall.
- Get on and off the ladder by stepping onto the centre of the rung.
- Grip the rails using with both the hands.
- Reposition the unsteady ladder by getting down.
- Reposition the ladder instead of leaning outwards to reach and grabs things.
- Ensure that only one person is standing on the ladder at one time.
- Ensure to install rubber safety shoes at the base of the ladder feet.
- Avoid standing on the top two rungs of the ladder.
- Use the rope to send material and store them at the top.

Fig. 3.2.4. Unsafe ladder base

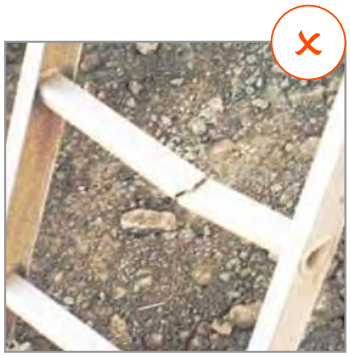


Fig. 3.2.5. Cracks in ladder

Safety Norms to Follow while Working on a Scaffold or Stairway

- Make sure that the stairways are free from debris or any material.
- Remove the tools and nails from the floor when they are not in use.
- Tag or close the holes or trenches properly to avoid falling into them.
- Ensure that the base of the ladder is free of wires, hoses, debris etc.
- Lap the scaffold plank properly or otherwise secure to prevent its shifting.

Fig. 3.2.6. Safety Precautions while working on scaffold and stairway

- While working at unprotected high places, use harnessess with safety lines
- Do not keep any material or tools or cables on walkways.
- Do not be in a hurry while walking and carrying something at the construction site.
- Do not use defective ladders.
- Do not work on scaffolding without wearing the safety belt and harness.

Other Safety Norms

- Do not consume drugs or alcohol while at work
- Do not smoke at the construction site.
- Do not throw nails or pointed material at the construction site.
- Do not lift heavy weights without seeking help.
- Never forget to wear PPE.

3.2.2 Using PPE

As part of the health and safety standards laid by the organisation, an Assistant Electrician is expected to wear PPE (Personal Protective Equipment) at all times. He is expected to wear the following PPE while at work:

	When to use	Why to use	How to use	Injuries that occurs when not used
Safety goggles	 *Fig.3.2.7 Safety goggles*		 *Fig.3.2.8. Protection of eyes*	
	Wear when you are: • cutting and drilling cables and wire • working on high volts electrical unit	They help to protect from any injury to the eyes due to flying particles or sparks.	• Ensure that the goggles fit you. • Check for any damage.	Loss of vision partially or totally
Dust mask	 *Fig.3.2.9. Dust mask*		 *Fig.3.2.10. Protection from suffocation*	
	Wear when you are: • working in dusty area • cutting and drilling cables and wires	It helps against dust going into the mouth or nose, thereby preventing allergies.	Wear it properly, that is neither too loose nor too tight.	Suffocation or inhalation problems
Safety Harness	 *Fig.3.2.11. Safety Harness*		 *Fig.3.2.12. Protection from fall*	

	When to use	Why to use	How to use	Injuries that occurs when not used
	Wear when you are: • Working at height on scaffolds or ladders	It helps to save person from falling from a height.	Secure it firmly with the buckles tightly fastened.	Broken bones or sometimes fatal accidents
Safety gloves	 *Fig. 3.2.13. Safety gloves*		 *Fig. 3.2.14. Protection from hand injury*	
	Wear when you are: • working with electrical wires, cement, and holding bricks or tools	Wearing insulated safety gloves protects you from electrical hazards.	Check if they are fit to be worn.	Burns and wounds
Safety shoes	 *Fig. 3.2.15. Safety shoes*		 *Fig. 3.2.16. Protection from foot injury*	
	Wear when you are: • Exposed to nails, wires, cement, bricks etc. • Working with heavy equipment and tool etc.	• This helps from falling or tripping over the ground. • It also protects from shocks and burns • It prevents toes when working around heavy equipment or falling objects.	• Ensure to wear slip-resistant shoes that have a strong grip. • Check if they are not damaged. • Fasten the bootlaces firmly	Shocks, Burns and wounds

<table>
<tr><th></th><th>When to use</th><th>Why to use</th><th>How to use</th><th>Injuries that occurs when not used</th></tr>
<tr><td rowspan="2">Reflective jacket</td><td colspan="2"> 
Fig. 3.2.17. Reflective jacket</td><td colspan="2"> 
Fig. 3.2.18. Protection from injury</td></tr>
<tr><td>Wear when you are:
• Working in a hot area or with hot metals and hazardous chemicals</td><td>It protects skin from exposure to heat and hazardous chemicals</td><td>Secure it with proper button/ zipper/Velcro</td><td>Burns, wounds and skin diseases</td></tr>
<tr><td rowspan="2">Protective helmet</td><td colspan="2"> 
Fig. 3.2.19. Helmet</td><td colspan="2"> 
Fig. 3.2.20. Protection from head injury</td></tr>
<tr><td>Wear when you are:
• Working on floor where the objects may fall from roof
• Working or moving in bent position
• Working at a place surrounded by electric wires</td><td>It protects head from getting injury by heavy metal objects or exposure to sparks.</td><td>• Check if it does not have dents or cracks.
• Wear it so that it sits snugly on head.
• Fasten the chinstrap of the helmet properly.</td><td>Head injury, sometimes may be fatal accident.</td></tr>
</table>

<table>
<tr><th></th><th>When to use</th><th>Why to use</th><th>How to use</th><th>Injuries that occurs when not used</th></tr>
<tr><td rowspan="2">Earplugs</td><td colspan="2"> 
Fig. 3.2.21. Earplugs</td><td colspan="2"> 
Fig. 3.2.22. Protection from ear injury</td></tr>
<tr><td>Wear when you are:
• Working in the area with high noise work areas where chainsaws or heavy equipment is used.</td><td>It protects ears from loud noise entering into ears.</td><td>• Clean or replace earplugs regularly
• Wear earplugs as directed.
• Ensure no sound enters into ears.</td><td>Deafness partial or complete.</td></tr>
</table>

3.2.3 Electrical Hazards Associated with Domestic Wiring Work

One of the most common types of electrical accidents is electrical shock, also known as electrocution. Accidents by electrocution are common in construction sites as well as in workplaces and households.

Electrocution is a major occupational hazard for construction workers. This is because as construction takes place and something new is built, new electrical wiring and electrical boxes are fitted in place. If the electrical fittings are done incorrectly, or if proper precautions are not taken, it can lead to accidents caused by electrical shock.

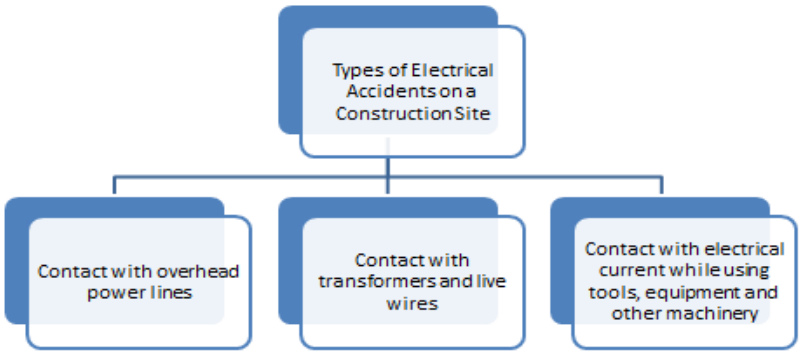


Fig. 3.2.23. Types of electrical accidents

Outcome of the Electrical Hazards at construction site that leads to damage, injury or death are:

- Shocks and Electrocutions
- Blast and Burns
- Falls
- Explosions
- Fires

Fig. 3.2.24 Electrical hazards

Electrical accidents occur when:

- loose wires are inserted in sockets, without a plug pin;
- gloves are not worn while working on a live line;
- cables and wires are joined in an improper manner;
- switches are kept exposed;
- switch plug socket units are installed in an open area, without any protection from rain/water;
- appliances or switches come in contact with water;
- equipment has not been permanently grounded;
- cords in use are old or worn out;
- unused sockets are unsealed or uncovered;
- failure to remove fuses before carrying out electrical repairs;
- circuit breakers are not turned 'off' before carrying out electrical repairs;
- contact is established with bare wires.

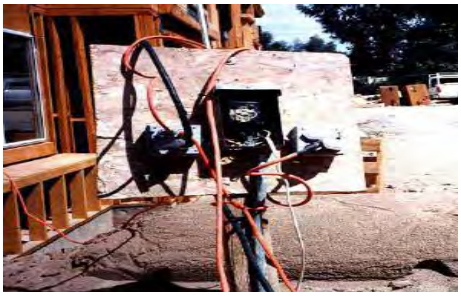


Fig. 3.2.25. Exposed switches

Fig.3.2.26. Worn cords

Fig. 3.2.27. Wires joined improperly

Fig. 3.2.28. Worn insulation around wire

Fig. 3.2.29. Wires laying on the ground

Fig. 3.2.30. Circuit breakers not turned off before use

Fig. 3.2.31. Wires in contact with water

Some of the causes of electrical accidents are:

- Damaged or defective tools, cables, wires and equipment
- Not maintaining clearance distances
- Not following standard procedures
- Not guarding live parts
- Not using proper electrical PPE
- Untrained personnel
- Improper installed temporary electrical systems
- Not using electrical protective devices
- Lack of supervision
- No proper construction site specific safety training
- Not implementing approved safety plan

Fig. 3.2.32. Overloaded extension

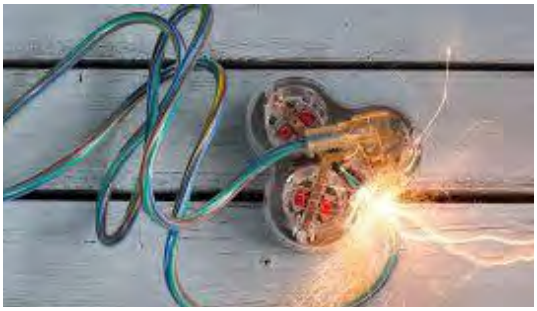


Fig. 3.2.33. Open sockets

Fig. 3.2.34. Improperly joined cables and wires

Fig. 3.2.35. Unsafe ovehead power lines

Fig. 3.2.36. Damaged tool

Fig. 3.2.37. Not following standard procedure

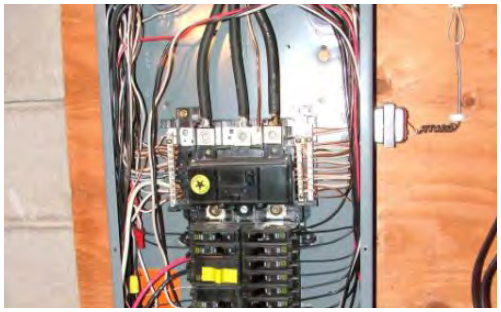


Fig. 3.2.38. Open wiring system

Fig. 3.2.39. Untrained personnel

In order to avoid accident, some nominal precautionary measures need to be taken. This includes:

- Shut off power supply before working on the system
- Identify all live power lines before starting work
- Ensure that appliances and switches never come in contact with water;
- Make sure that equipment is maintained and taken good care of;
- Never leave old and worn out cords around the work area;
- Ensure to keep unused sockets safely and covered at all times;
- Remove fuses before carrying out electrical repairs;
- Check that circuit breakers are turned 'off' before carrying out electrical repairs;
- Ensure there are no bare wires lying around the work area.
- Replace worn out and broken cords and devices promptly.
- Use grounded-type (three-pronged) electrical devices and extension cords.
- Safeguard cords and cables from sharp corners and projections to avoid damage.
- Use extension cord sets that are the three-wire type.
- Store all electrical tools and equipment in safe condition. Inspect regularly for defects if any.
- Keep a lookout for overhead electrical power lines.
- Ensure that ladders, scaffolds, equipment or materials never come within 10 feet of electrical power lines.
- Make sure that all electrical tools are properly grounded. Use only if they are of the double insulated type.
- Don't use worn cords and cables when working with energized electrical supply.
- Use proper foot protection

Fig. 3.2.40. Use safety devices

Fig. 3.2.41. Locked control panel safety warning

Fig. 3.2.42. Use plug with grounding pin

- Never hang extension cords on nails
- Use rubber insulating gloves, hoods, and blankets
- Use and test GFCI's
- Check switches and insulation
- Use three prong plugs
- Use extension cords only when necessary. Check the condition before using
- Use correct connectors
- Get proper training before working on electric equipment and safe work practices
- Use appropriate protective equipment
- Use fuses and circuit breakers
- Guard live parts and close electric panels

Fig. 3.2.43. Guard live parts

Fig. 3.2.44. Use PPE

Symptoms of Electrical Shocks

- Muscle pain
- Seizures
- Skin burns
- Heart attack
- Unconsciousness
- Breathing difficulties

For protection from electrical shock:

- Use barriers and guards to prevent entry through high energized equipment
- Post hazard warnings
- Use PPE
- Keep working and passages clear of cords and wires

Fig. 3.2.45. Post hazard warnings

Exercise

1. Match the following:

Group A	Group B
Red	Caution
Yellow	Danger/Stop
Blue	First aid
Green	Warning
Orange	Safety information

2. Which out of these are symptoms of electrical shocks? Tick (✓) the right options.

Acidity ( )

Seizures ( )

Headache ( )

Heart Attack ( )

Unconsciousness ( )

3. State true or false.
   a. While working near overhead wire one must keep a lookout for safety
   b. You must never place yourself between a vehicle and an immovable object at a site
   c. Always watch an crane operator while working near excavation site
   d. A steel rods being carried from one level to another hitting a worker can be an example of falling objects from height.
   e. Wearing safety equipment at site will not make a worker feel safe at work.
   f. A worker must wear safety harness while working at height on scaffold.
   g. Reading safety sign boards are not a good practice.
   h. A worker should work only under supervision near energised control panel.

4. How will address the below given issue?
   You see a worker performing electrical work without using any PPE

Notes

UNIT 3.3: Waste Disposal

Unit Objectives

At the end of this unit, you will be able to:

1. Explain the importance of safe disposal of waste.
2. Discuss about electrical waste management at a construction site.

3.3.1 Safe Disposal of Waste

Construction waste consists of unwanted material generated as a result of construction work.

Fig.3.3.1. Construction waste

This includes building materials such as nails, bricks, mortar, cables and wires, insulation, nails, wood and concrete. It also includes materials like debris, tree stumps, and rubble.

Construction waste may contain materials that are hazardous or harmful to environment, and health and safety of the workers such as lead, asbestos etc. For example when wires are burned in open it releases fumes that are toxic in nature. A toxic substance means any chemical or mixture that may be harmful to the environment and to human health if inhaled, swallowed, or absorbed through the skin.

In order to avoid damage to health, safety and environment, construction waste material should be reduced, reused and recycled. Materials that cannot be used should be disposed and managed in a right manner.

Assistant Electrician should inform the supervisor about the waste accumulated at the site to seek guidance for appropriate ways of reuse, reduce, recycle and disposal.

For example,

1. Debris, rubble, concrete can be used for landfills and new site formation.
2. Concrete, mortar, bricks can be recycled for construction work.
3. Packaging waste, wood can be reused or recycled.

Construction waste can be classified into the following types:

1. Wood: Plywood or sawdust
2. Masonry: brick, concrete, mortar
3. Metal: rebars, pipes, beams
4. Plastic: plumbing pipes, PVC, plastic sheets
5. Cardboard: Cardboard packaging material
6. Electrical: wires, cables and other material
7. Other such as Paper, fibreglass etc.

Fig.3.3.2. Segregation of construction waste

This waste needs to be disposed of in a suitable environmental friendly way.

Fig. 3.3.3. Disposal of construction waste

DOS and Don'ts in disposing construction waste

DOS	Don't
• Eliminate waste by storing materials and avoiding damage or loss	• Do not put waste into wrong waste container
• Reduce the amount of waste by keeping materials their packaging to protect from damage	• Do not open new cans or pdrepare mortar in large amount before the ones is used or empty.
• Reuse materials like wood or plastic for alternative purposes	• Do not leave the material in rain or ground as they may get damaged
• Recycle materials whenever possible packaging paper and cardboard	• Do not burn wires as they may emit hazardous fumes
• Segregate waste into different types like wires, wood, plastic	• Do not mix different types of waste as it may prevent from recycling and reusing.
• Store waste as marked on the waste container kept at site	
• Follow instructions about waste disposal laid by the organisation or supervisor.	

Exercise

1. State whether the following statements are true or false.
   a. Leaving waste unattended does not affect anyone at a construction site.
   b. You must never leave used cables and wires out in the open.
   c. It is extremely important to follow instructions about waste management.
   d. Keeping wires and cables near wet areas increase the risk of shock.
2. Do you follow environmental norms in disposing waste at your construction site? Explain.

3. How do you segregate construction waste at your construction site

Notes

Skill India
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4. Electrical Drawings

Unit 4.1 – Wiring Symbols

Unit 4.2 – Single Line Diagram

Unit 4.3 – Interpreting Electrical Specifications

Key Learning Outcomes

At the end of this unit, you will be able to:

1. List the wiring symbols.
2. Read and interpret wiring symbols.
3. Read and interpret single line diagrams.
4. Read and interpret electrical specifications and manufacturer's guidelines.

UNIT 4.1: Wiring Symbols

Unit Objectives

At the end of this unit, you will be able to:

1. List the wiring symbols.
2. Read and interpret wiring symbols.

4.1.1 Wiring Symbols

Wiring Symbols

Types of Current	Symbol
a. DC	
b. AC	
c. Power Frequency	
d. Apparatus and machines suitable for both AC or DC (universal)	

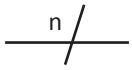
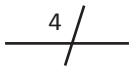
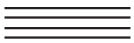
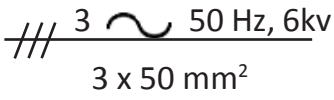
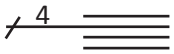
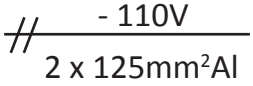
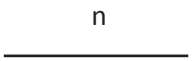
Power Distribution

Types of Current	Symbol
a. AC, single-phase, 50 Hz	1 ~ 50 Hz
b. AC, three-phase, 50 Hz	3 ~ 50 Hz
c. AC, three-phase, 50 Hz, 415 415V	3 ~ 50 Hz
d. AC, three-phase, with neutral, 50 Hz	3N ~ 50 Hz
e. AC, three-phase, with neutral, 50 Hz, 415V	3N 415V ~ 50 Hz
f. DC 2-conductors 110V	2 —— 11 OV
g. Positive polarity	+
h. Negative polarity	—

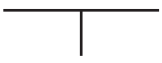
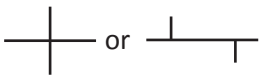
Symbols of Transmission / Distribution Lines

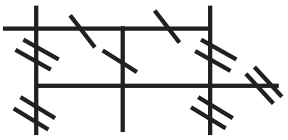
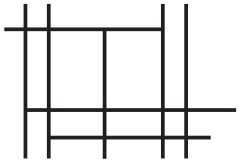
Types of Current	Symbol
a. Existing line or cable	
b. Planned line or cable	
c. Underground cable	
d. Overhead line	

Conductors

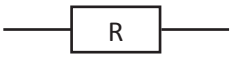
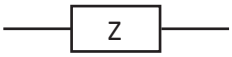
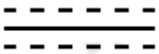
Conductors	Symbol
a. Flexible conductor	
b. 'n' No. of conductors (Single line presentation)	
c. e.g. for 4 conductors	
d. 'n' No. of conductors (Multiline presentation)	['n' No. of parallel lines] e.g. for 4-conductors 
e. Three-phase circuit, 50 Hz, 6 kV, three conductors of 50mm^2	
f. Changing over from a single line representation	
g. DC Circuit, 110V, two conductors of 125mm^2 of aluminium	
h. Group of 'n' conductors which follow the same way on the diagram	

Connection of Conductors

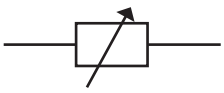
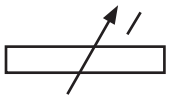
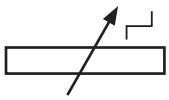
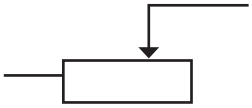
Terminal	Symbol
a. Junction of Conductors	
b. Double junction of conductors	
c. Crossing without electrical connection	
d. Crossing and connecting conductors	

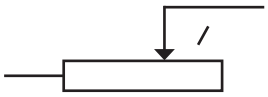
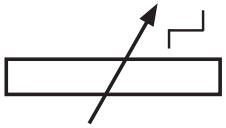
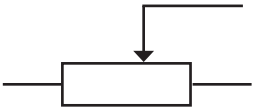
i. Single-line representation	
ii. Multi-line representation	

Circuit Element

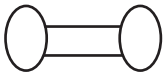
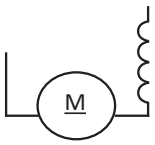
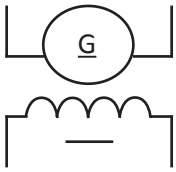
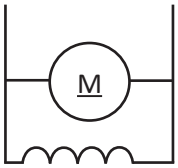
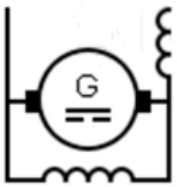
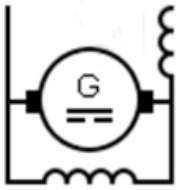
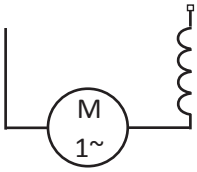
Element	Symbol
a. Non-reactive resistance	
b. Impedance	
c. Inductance	
d. Capacitance	
e. Winding	
f. Earth point	
g. Fault	
h. Screened conductor or screened cable	
i. Magnetic core	
j. Laminated core	

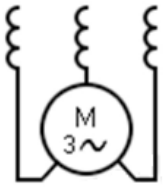
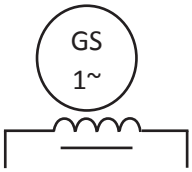
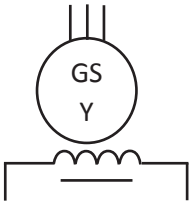
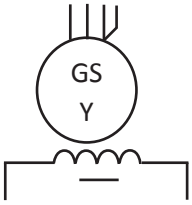
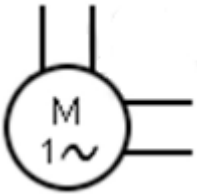
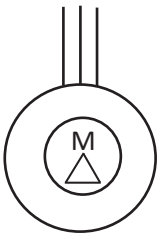
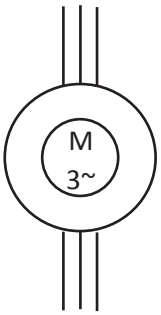
Veriable resistors

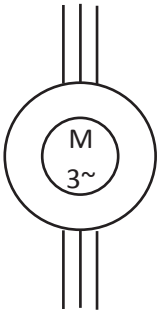
Variable Resistors	Symbol
a. General symbol	
b. Continuously variable	
c. Variable in steps	
d. With moving contact (general symbol)	

e. With moving contact continuously variable	
f. With moving contact, variable in steps	
g. Voltage divider with moving contact	

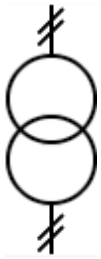
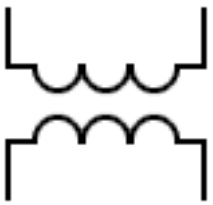
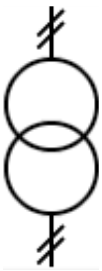
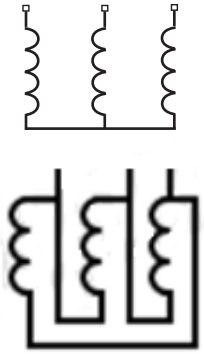
Rotating Machines

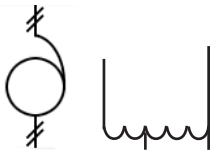
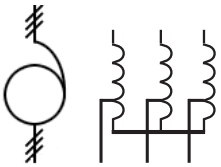
Machines	Symbol
a. Mechanically coupled machines	
b. DC two-wire series motor	
c. DC two-wire separately excited generator	
d. DC two-wire shunt motor	
e. DC two-wire compound excited, short shunt generator	
f. DC two-wire compound excited, short shunt generator, 240V, 30kW	 240 V 30 KW
g. AC single-phase series motor	

h. AC three-phase series motor	
i. Single-phase synchronous generator	
j. Three-phase, star connected, neutral not brought out synchronous generator	
k. Three-phase, star connected, neutral brought out, synchronous generator	
l. Squirrel cage, single phase, leads of split phase brought out induction motor	
m. Induction motor, squirrel cage, three-phase delta connected	
n. Three-phase, squirrel cage, both leads of each phase brought out induction motor	

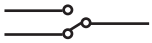
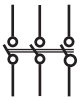
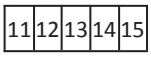
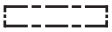
o. Three-phase, wound motor, induction motor	

Transformers

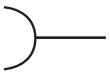
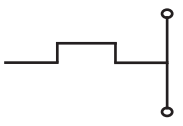
Transformer Specification	Single-line representation		Multi-line representation
a. Single-phase transformer with two windings (11kV/415V, 250kVA, 50Hz); Short circuit voltage 4%		11kV 250KVA 50Hz 4% 415V	
b. Three-phase transformer with two separate windings (Star) 66kV/11kV(delta), 4MVA, 50Hz Connection Yd 11 Short circuit voltage 7.5%		66kV 4MVA 7.5% Y d 11kV 50Hz	

Transformer Specification	Symbol
a. Single-phase auto-transformer	
b. Three-phase star connected auto-transformer	
c. Single-phase auto-transformer	

Switches, Circuit-breaker and links switch

a. General	
b. Two-way	
c. Intermediate	
d. Three-pole switch multi line representation	
e. Three-pole switch single line representation	
f. Circuit Breaker	
g. Isolator	
h. Terminal strip	
i. Link	
j. Open link	
k. Distribution board cubical box	

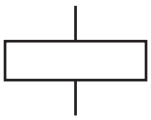
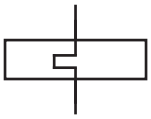
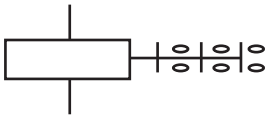
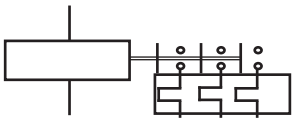
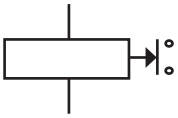
Contacts

a. Socket	
b. Plug	
c. Plug and socket	
d. Relay or contactor contact, normally open	
e. Relay or contactor normally closed	
f. Thermal overload relay contact	

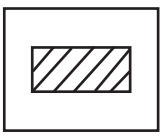
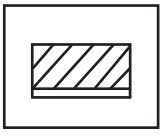
Socket outlets

a. Socket outlet, 5 A	
b. Socket outlet, 15 A	
c. Combined switch and socket outlet, 5 A	

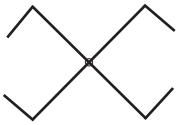
Relays and contactors

a. Coil of electromagnetic relay or contactor	
b. Thermal overload relay	
c. Electrically operated three-pole contactor	
d. Electrically operated three-pole contactor with thermal overload device in all three poles	
e. Time delay relay	

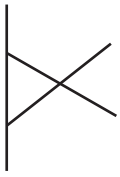
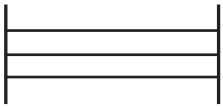
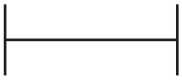
Fuse boards

a. Main fuse board without switches	
b. Main fuse board with switches	
c. Distribution fuse board without switches	
d. Distribution fuse board with switches	

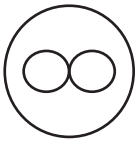
Switch outlets

a. One-way switch	
i. Single pole	
ii. Two-pole	
iii. Three-pole	
b. Two-way switch	
c. Intermediate switch	
d. Push-button or bell-push	

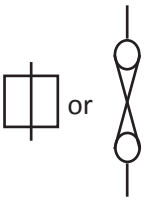
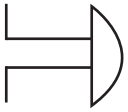
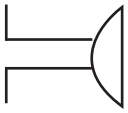
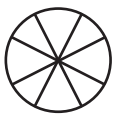
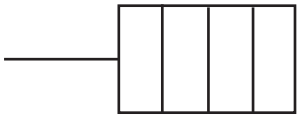
Fuse boards

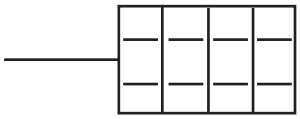
a. Lamp or outlet for lamp	
b. Group of three 40W lamps	3  40 W
c. Lamp mounted on wall or light bracket	
d. Lamp mounted on ceiling	
e. Group of three 40W fluorescent lamps	
f. Fluorescent lamp	

Fans

a. Ceiling fan	
b. Bracket fan	
c. Exhaust fan	
d. Fan regulator	

Household Apparatus

a. Fuse	
b. Signal lamp	
c. Indicator	
d. Horn	
e. Bell	
f. Buzzer	
g. Siren	
h. Heater	

i. Storage type electric water heaters	

Exercise

1. Match the following

Symbol	Reading
	AC three phase 50 Hz
	Overhead line
	Earth point
	AC
	Non-reactive resistance

2. Draw the Symbols

   a. Direct Current

   b. Fuse

   c. Positive polarity

   d. Capacitance

   e. Socket

   f. Two-way switch

   g. Induction motor, squirrel cage, single-phase

   h. Socket Outlet, 5 A

   i. Single-phase transformer with two windings

   j. Ceiling Fan

UNIT 4.2: Single Line Diagrams

Unit Objectives

At the end of this unit, you will be able to:

1. Read and interpret single line diagrams.

4.2.1 Single Line Diagrams

The diagrams used in electrical field are classified according to the purpose and method of representation.

Classification of diagrams according to the purpose:

- **Wiring diagram**

  A wiring diagram shows the connection of installation or part of an installation. It shows how the connections are actually made and also gives the layout of wiring. The wiring diagrams are intended to guide the execution and checking of the internal and external or both, connections of an installation, or part of an installation. This drawing may sometimes, show the layout of different parts and accessories, such as terminal blocks and the wiring between them.

- **Circuit diagram**

  This is diagram for easy understanding for the operation of an electric circuit. The diagram is arranged in such a way that, as far as possible, every circuit is drawn in a straight line so that it may be easy to follow. While designing the electric circuit it is easier and therefore usual, first to draw schematic diagram. Therefore, schematic diagram should be simple and clear as possible.

Wiring Diagrams

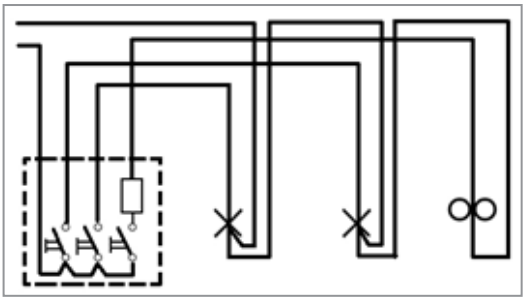


Fig. 4.2.1. Multiline wiring diagram

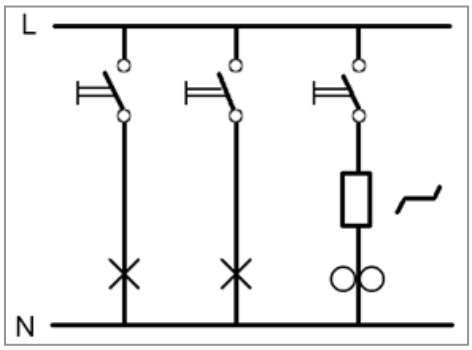


Fig. 4.2.2. Schematic diagram

Fig 4.2.1 shows the wiring diagram of two lights controlled by two individual switches and one fan controlled by one switch and a fan regulator.

Fig 4.2.2 shows the schematic diagram for electrical circuit of the wiring diagram.

By comparing Fig 4.2.1 and 4.2.2, we understand that Fig 4.2.1 shows

- how the connections are made;
- how the wiring is laid out;
- the location of switches, lamps, fans, regulators, etc

Fig 4.2.2, the schematic diagram, gives details of operation.

While drawing schematic diagrams ensure that;

- the supply lines should be drawn horizontal;
- various circuit connections should be drawn vertical;

- branched circuits of equal importance should be drawn similar to one another;
- switches, push buttons and contacts should be drawn in such a way that their movement is from left to right;
- switches, push buttons and contacts should be drawn in the "off" position;
- when there is a sequence of operation, the circuit which is activated first should be drawn more to the left;
- crossing of lines should be avoided as far as possible.

Different Ways to Represent a Wiring Diagram

A wiring diagram may be shown in a multiline representation or a single line representation, depending on the number of lines.

Let's compare Fig 4.2.1 to 4.2.3 to understand this concept.

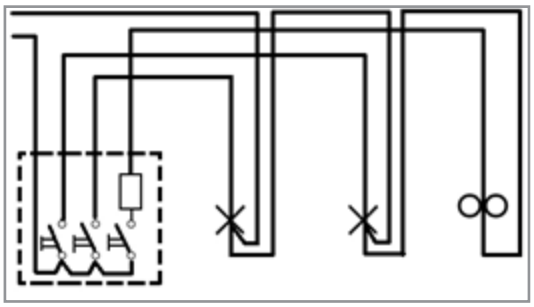


Fig. 4.2.3. Multiline wiring diagram

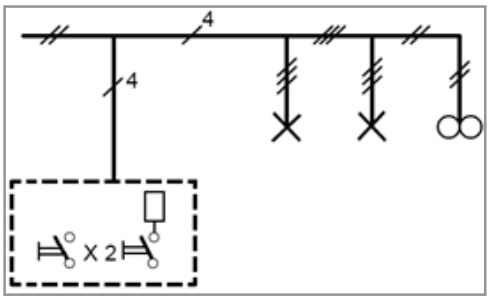


Fig. 4.2.4. Single line wiring diagram

Figure 4.2.1 shows a wiring diagram in a multiline representation. The same diagram has been represented in a single line in figure 4.2.3. Those lines that run together in figure 4.2.1, which are represented as multiple lines, are represented by a single line in figure 4.2.3.

The number of wires is represented by an equal number of short thin slanting lines marked over the single line. If the number of wires running together is more than three, drawing only one slanting line over the single line is sufficient. The number of wires can be indicated with a figure.

Similar accessories which are mounted side by side in one place can be represented by one single symbol along with a figure which indicates the number of accessories used.

In fig 4.2.3, two switches have been represented by symbol for one switch and a number.

In actual practice, single line diagrams give sufficient information to the wireman to indicate the material required and to actually carry out the installation.

Exercise

1. Fill in the blanks:

   a. A wiring diagram shows the _____ of installation or part of an installation.

   b. A _____ helps in the easy understanding of the operation of an electric circuit.

   c. _____ diagrams give sufficient information to the wireman to indicate the material required and to actually carry out the installation.

UNIT 4.3: Interpreting Electrical Specifications

Unit Objectives

At the end of this unit, you will be able to:

1. Read and interpret electrical specifications and manufacturer's guidelines.

4.3.1 Interpreting Electrical Specifications

As an Assistant Electrician, you are expected to:

- use lights, fittings and fixtures only after reading the electrical specifications;
- choose the appropriate lights, fittings and fixtures;
- install them in the right place, as per instructions given by the supervisor.

Let's look at an example of an LED lamp and understand how to interpret electrical specifications.

Generic Name	:	9W LED Lamp
Product Name	:	LED PRO
Quantity	:	1 No.
Rated Wattage	:	220V-240V. 50Hz.
Colour Temp.	:	CDL
Lumen	:	800lm**
Base	:	B22
Lamp Current	:	0.045A
P.F.	:	0.90

Fig. 4.3.1 - Electrical specifications for an LED lamp

Specification	Refers to
9W LED Lamp	Generic name of the product.
LED PRO	Name of the product (as named by the manufacturer).
Quantity	Number of lamps in the box/pack. Here, it is 1.
Rated Wattage	Power rating of the lamp. Here, it is 9 watts.
Rated Voltage	Voltage capacity of the lamp. Here, the lamp will operate for 220 to 240 Voltage supply with a frequency of 50Hz only. If the lamp is connected to higher voltage, it will burn. A voltage capacity lower than 50Hz may result in lower intensity and poor performance of the LED lamp.
CDL	Colour of the light being emitted by the lamp.
Lumen	How much area the LED lamp will illuminate. More lumens means brighter light and vice versa.
Base	The type of holder that will be required to fix this LED lamp. B22 stands for the size and type of holder.

Specification	Refers to
Lamp Current	The current rating of the LED lamp. Here, a current rate above 0.045 A would lead to burning of the lamp.
P.F.	The power factor of the lamp. Here, the P.F. is 0.90. This means that the efficiency of the LED is higher and it will also enhance the efficiency of the power system.

4.3.2 Interpreting Manufacturer's Guidelines

Let's look at the example of the same LED lamp and understand how to interpret manufacturer's guidelines.

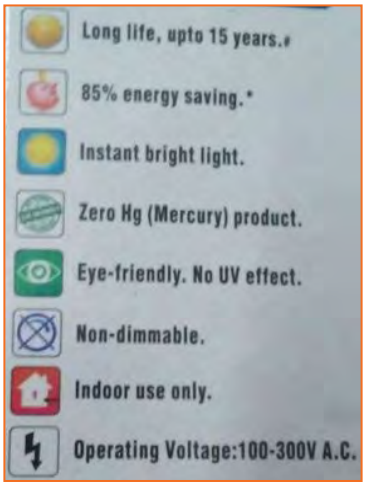


Fig. 4.3.2 - Manufacturer's Guidelines for an LED lamp

Manufacturer's Guidelines	Meaning
Long life, upto 15 years	It means that the shelf life of the LED lamp is 15 years.
85% energy saving	It means that the efficiency of the lamp is 85% and the losses may be 15%.
Instant Bright Light	This indicates that as soon as the LED lamp shall be switched on, there will be bright light, no flickering. If there is flickering, it means the product is defective.
Zero Hg (Mercury) Product	This means that the mercury content in the LED lamp is 0. It only has diode inside the lamp.
Eye-friendly. No UV effect.	It means that the light emitted by the lamp would not cause any harm to the eyes.
Non-dimmable	This means, the LED lamp will operate only at the rated voltage. Below the rated voltage, the intensity of light will be zero.
Indoor Use Only	This means, the LED lamp can be used inside a room, not to be used in an open space.
Operating Voltage: 100-300V A.C.	It indicates that the LED lamp will operate only at 100-300 volts voltage range and it should be AC only.

Exercise

1. Match the following:

Group A	Group B
Lumen	Refers to the power rating of the lamp
Rated Wattage	Refers to the type of holder to be used
CDL	Refers to the voltage capacity of the lamp
Rated Voltage	Refers to the area the LED lamp will illuminate
Base	Refers to the colour of the lamp

Notes

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5. Select and Use Electrical Tools and Devices in Electrical Occupation

Unit 5.1 – Introduction to Electrical Hand and Power Tools

Unit 5.2 – Introduction to Electrical Measuring Tools and Devices

Unit 5.3 – Introduction to Electrical Devices

Unit 5.4 – Storing Electrical Devices

CON/N0602

Key Learning Outcomes

At the end of this unit, you will be able to:

1. List the various types of electrical, hand and power tools.
2. Describe how to maintain/store electrical tools and devices.
3. List the different types of electrical measuring tools and devices.
4. Explain the uses of these devices.
5. List the various types of electrical devices used in circuits.
6. Describe about the various types of cables.
7. Recall the types of conduits and fixtures.
8. Describe how to select the right conduits and fixtures based on power rating and respective uses in electrical works.
9. List the types of lights, units, their wattage and respective use in construction sites.
10. Describe the specification and details of material, tools, equipment used for electrical earthing works.
11. List the types of electrical materials and fixtures used for domestic wiring.

UNIT 5.1: Introduction to Electrical, Hand and Power Tools

Unit Objectives

At the end of this unit, you will be able to:

1. List the various types of electrical hand and power tools.
2. Describe how to maintain/store electrical tools and devices.

5.1.1 Select and Use Electrical Hand and Power Tools

1. Pliers

Pliers are used to:

- cut wires;
- twist wires;
- hold wires in place.

Fig. 5.1.1. Pliers

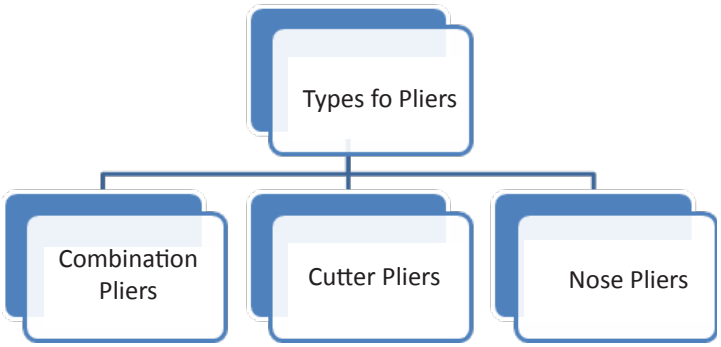


Fig. 5.1.2 - Types of Pliers

Combination Plier

- Used to cut and twist wires
- Also called as join pliers

Fig. 5.1.3. Combination Pliers

Cutter plier

- Used specifically to cut wires

Fig. 5.1.4. Cutter Pliers

Nose plier

- Used to hold wires in place
- Help to grip nuts
- Used to loosen and tighten terminals while fixing wires

Fig. 5.1.5. Nose Pliers

2. Wire Stripper

This is the most useful tool for any electrician. It is used to remove the insulation coating from wires. The wire does not get cut in the p rocess of peeling the insulation.

Fig. 5.1.6. Wire Stripper

3. Screw Driver

Screw drivers are used to:

- Tighten screws
- Loosen screws (open screws)

Screwdrivers tips come in many different shapes and sizes. The tips can be fixed to the metal blade and used as per the cuts on screw heads.

Fig. 5.1.7. Screw Driver

4. Centre Punch

A centre punch is like a marker to mark hole to be drilled. It is also used in place of a poker to mark holes. Before drilling, use a centre punch to mark the spot to be drilled.

Fig. 5.1.8. Centre Punch

5. Pipe Wrench

The pipe wrench is used to open the joints of a carrier pipe. It is also used to fix the joints of a carrier pipe. A pipe wrench has an adjuster nut which is used to adjust the distance between the two saws.

Fig. 5.1.9. Pipe Wrench

6. Hack Saw

The hack saw is a type of saw with a long blade and is a very useful tool. It comes in various lengths. It is used to cut:

- Metal
- Plastic
- PVC.

Fig. 5.1.10 - Hack Saw

7. Raul Plug Tool

The raul plug tool is used to makes holes in concrete and brick. It has a small cutting part called a bit. The plugs are fit into the holes made by the raul plug tool.

8. Ball Pin Hammer

The ball pin hammer is used to:

- hammer nails;
- hit chisels to cut through the wall;
- beat nails to clip wires.

Fig. 5.1.11. Ball Pin Hammer

9. Pincer or Crow Hammer

The pincer or crow hammer is used to:

- remove nails;
- straighten the nails;
- hammer the nails back in.

Fig. 5.1.12. Pincer or Crow Hammer

10. Neon Tester

A neon tester is a small tool that helps to detect if the supply is on. When you put the metal end on a terminal, if the bulb glows it means the supply is on.

Fig. 5.1.13. Neon Tester

They are used to fix, fit and remove pulleys and bearings. Depending on the use, they are classified as:

- Pulley pullers
- Bearing pullers

Fig. 5.1.14. Pullers

11. Hand Tongs

These tongs are used to hold hot joints and substances.

12. Spanners

Spanners are used to tighten and loosen bolts, screws and nuts, etc. They come in various sizes depending on the type of work. E.g. Ring spanner, double-ended spanner, torque wrenches, slide wrenches, etc.

Fig. 5.1.15. Spanners

13. Pocker and Scratch Awl

These are used to make holes by punching the wood for fixing the nails and screws.

Fig. 5.1.16. Pocker and Scratch Awl

14. Plumb Bob with Twin Thread

They are used to mark vertical lines in the walls.

Fig. 5.1.17. Plumb Bob with Twin Thread

15. Saw

It is used to cut batten, round blocks and boards. It comes in three types: tenon, keyway and handsaws.

Fig. 5.1.18. Saw

16. Mallet

It is used to strike firmer chisels and to bend metal plates.

Fig. 5.1.19. Mallet

17. Electrician's Knife

These are used to remove insulation covers from wires and cables. They also help in cutting insulating materials.

Fig. 5.1.20. Electrician's Knife

18. Files

Contact surfaces, conduits, bus bars and holes, etc. are made smoother with the help of files.

19. Drilling machines

Drilling machines are very useful when you need to fix electrical fittings. Drilling machines can be used to drill holes in all kinds of surfaces like:

- wooden surfaces,
- wall surfaces,
- metal surfaces,
- plastic surfaces.

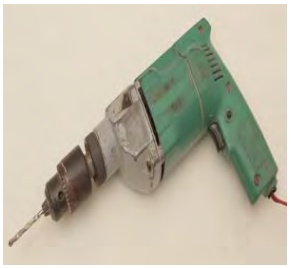


Fig. 5.1.21. Drilling machines

20. Soldering Iron

A soldering iron is used to:

- connect wires,
- weld terminals.

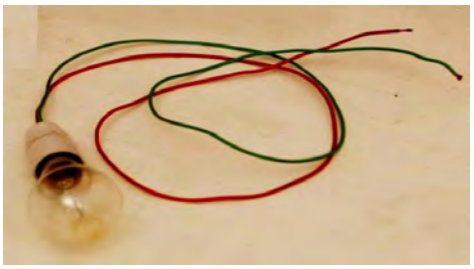
Fig. 5.1.22. Soldering Iron

21. Test Lamp

The test lamp is used to check if a part is functioning by doing a continuity check. During the test, if the bulb in the test lamp glows then the equipment under test is ok.

For example, it can be used to test whether the starter in a tube light is in working condition or faulty. If the bulb glows it means the starter is ok.

For a few inspections the test lamp is connected in series with the equipment using a piece of wire.



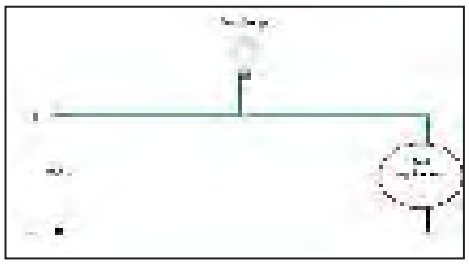


Fig. 5.1.23. Test Lamp

Storage of Tools

- Keep your tools properly stored and cleaned
- Make it a habit to clean tools after each use before you return them to storage.
  - Always your protective gloves before cleaning the tools.
  - Wipe them down with a rag or old towel and be sure they are free of dust, grease and debris before you put them into their proper places.
  - Use brush or duster for cleaning the tools and equipment.
  - Lubricate the tools and equipment from the lubricant as specified by the manufacturer's manual.
  - Regularly clean the tools after short intervals.
- Store the tools as per the availability of the space and visibility like, hang the tools, store them in boxes, bags, drawers or on shelves.
- To avoid rusting of tools follow the points mentioned below:
  1. Keep tools in a dry place.
  2. Store power tools in the hard plastic cases they usually come with. This will protect them from humidity,
  3. Use silica gel packs or rust collector.
  4. Clean tools after every use

Maintenance of Tools

To keep the tools and equipment in work condition for long time, taking care of maintenance of tools and equipment is necessary. Few maintenance tips are:

- Check tools handles for splinters, breaks and cracks. Also, make sure that metal parts show no signs of corrosion or rust. Repair or replace any tools that show signs of damage.
- If the metal head separates from the handle while in use, this could result in a dangerous projectile. To prevent this hazard, just grind off the metal edges with a powered grinder on a regular basis.
- Always check the working of all bearing, rollers, shafts etc. and oil all moving parts of the equipment on a periodic basis. If found any damage remove it, it may completely damage the total equipment.
- Check the working of non-moving parts and periodically conduct preventive maintenance to prevent machine failure.
- Periodically check the tools and equipment calibration and report any errors to the maintenance teams for rectification.
- Prepare periodic log sheets of equipment maintenance dates, maintenance schedules and maintenance activity
- Tools which are used during the construction activities should be placed in safe and clean conditions on completion of work so that they can be easily accessed and used by an authorized person whenever required. This also prevents tool from being cut or damaged insects/animals and also from rusting.

Exercise

1. Match the following

Group A	Group B
Saw	
Neon Tester	
Pipe Wrench	
Plier	
Soldering Iron	

2. Identify the hand tools used at the site. Write the use of each.

UNIT 5.2: Introduction to Electrical Measuring Tools

Unit Objectives

At the end of this unit, you will be able to:

1. List the different types of electrical measuring tools and devices.
2. Explain the uses of these devices.

5.2.1 Measuring Tools:

1. Ammeter

An ammeter is a commonly used electrical measuring instrument. It is used to measure the electric current in a circuit. The unit of measurement for electric current is amperes (A). There are also special ammeters that are used for measuring smaller currents such as milli-amperes and micro-amperes. To measure milli-amperes, a milli-ammeter is used, while to measure micro-amperes, a micro-ammeter is used.

Fig. 5.2.1. Ammeter

A frequency meter is an electronic measuring instrument. It is used to measure the frequency of an intermittent electrical signal. It performs this function by measuring the repetitions per unit of time, of a complete electromagnetic waveform. The unit of time used is usually a second.

Fig. 5.2.2. Frequency Meter

An oscilloscope, c ommonly referred to as a CRO (cathode-ray oscilloscope) is a commonly used electronic test instrument. This instrument is used to discover the exact wave shape of an electrical signal. Most of these instruments are calibrated, making it possible for information such as voltage and time to be easily read out. The unit of measurement is Hertz (Hz).

Fig. 5.2.3. CRO

2. Multimeter

A multimeter, also called a multi-tester, is a popularly used electronic measuring instrument. It is a very useful instrument as it can be used to measure voltage, current and resistance. Its prime purpose is to find basic faults and troubleshoot electrical devices.

Fig. 5.2.4. Multimeter

Multimeters can use analog circuits or digital circuits. This results in two types of multimeters:

- Analog multimeters
- Digital multimeters

Analog multimeters (AMM) have a pointer and a calibrated scale showing different measurements. The pointer moves across the scale to provide a reading.

Digital multimeters (DMM) have a display screen. The reading is provided digitally on this screen and can be easily read out.

The unit of measurement is as per the settings – it can be volts (V), ohms (Ω) or ampere (A).

A trivector meter is an electronic measuring instrument. It is a type of electronic energy meter. This instrument is used to measure energy parameters such as active and reactive energy, frequency, power factor etc. The purpose of a trivector meter is to find the amount of energy that has been received or sent. The unit of measurement is Joule (J).

Fig. 5.2.5. Trivecto Meter

3. Megger

A megger is an electrical measuring and continuity testing device. It is used to measure electrical resistance and to test the insulation on a grounded wire, as well as between the conductors on a circuit board. The purpose of using a megger to test grounding systems is to prevent electrical surges. There are also special meggers called ohmmeters that are used for measuring low resistance as well as high resistance. The unit of measurement is Ohms (Ω).

Fig. 5.2.6. Megger

4. Voltmeter

A voltmeter is an instrument used for measuring electrical potential difference between two points in an electric circuit. Voltmeters are of two types – analog and digital. Analog voltmeters move a pointer across a scale in proportion to the voltage of the circuit. Digital voltmeters give a numerical display of voltage. The unit of measurement is volts (V).

Fig. 5.2.7. Voltmeter

5. Wattmeter

This is a device which is used for measuring power. It has two coils – current coil and voltage coil. Current coil is always connected in series with the line. Voltage coil is connected in parallel with the line.

The unit of measurement is watt. Depending on the measurement of power, there are various types of wattmeter available such as wattmeter and kilo wattmeter.

Fig. 5.2.8. Wattmeter

Exercise

1. Match the columns

Group A	Group B
Ammeter	
Multimeter	
Megger	
Wattmeter	

2. Identify the power tools used at the site. Write the use of each.

UNIT 5.3: Introduction to Electrical Devices

Unit Objectives

At the end of this unit, you will be able to:

1. List the various types of electrical devices used in circuits.
2. Describe about the various types of cables.
3. Recall the types of conduits and fixtures.
4. Describe how to select the right conduits and fixtures based on power rating and respective uses in electrical works.
5. List the types of electrical materials and fixtures used for domestic wiring.
6. State the types of safety equipment used for electrical works.
7. List the types of lights, units, their wattage and respective use in construction sites.
8. Describe the specification and details of material, tools, equipment used for electrical earthing works.

5.3.1 Electrical Devices and Use in Circuits

Electrical devices consist of power carrying devices as well as protecting devices.

Power Carrying Devices:

1. Generators

These are used to generate voltage.

Fig. 5.3.1. Generators

2. Transformers

They are electrical devices which transfer electrical energy from one circuit to another, at constant frequency. In this device, step up or step down of voltage takes place depending on how many windings are connected in primary and secondary transformers. If the windings in secondary are more, it is called step up transformer. If the windings in secondary are lesser than primary, it is called step down transformer.

Fig. 5.3.2. Transformers

It carries power from one device to other at a particular voltage and current.

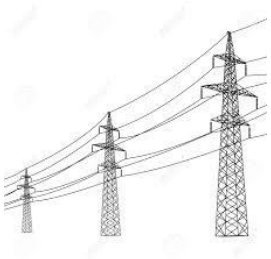


Fig. 5.3.3. Transmission Line

3. Bus bar

It is a metallic strip which maintains constant voltage. It helps to maintain the same voltage injected by incoming feeder line (transmission line). It then provides the same voltage to all the transmission lines or feeder lines which are connected to it.

Fig. 5.3.4. Bus bar

Protecting Devices:

These are the devices which protect the circuit. These are:

1. Circuit breakers

It is a device which breaks the circuit when a fault occurs. It isolates the faulty part of the circuit from healthy part of the circuit. This way, the entire circuit is protected. Circuit breakers are connected in series with transmission lines or feeder lines. It is connected to relays, that is, output of relay becomes input of circuit breaker.

Fig. 5.3.5. Circuit breakers

2. Fuses

It is a current interrupting device, which interrupts the circuit when there is overcurrent flowing through the circuit. In fuse, there is one metallic wire which will melt when heavy current flows through it. There are various types of fuses but mainly two fuses are used in the circuit. That are, rewirable fuse and HRC fuse, which is high rupturing capacity fuse. They are placed in distribution boards or DBs. When heavy current flows through it, the metallic link inside the fuse will melt and disconnect the whole circuit from the distribution board.

Fig. 5.3.6. Fuses

3. Isolators

It is a protecting device which only disconnects the circuit when a fault occurs in the circuit. First, circuit breaker operates and then isolator operates. Because of this, it is called as no load switching device.

Fig. 5.3.7. Isolators

4. Contactors

They just connect and disconnect the circuit. It is like a switch in the circuit.

Fig. 5.3.8. Contactors

It is a protecting device which is connected between transmission line and ground. This is called as lightning arrestor because it arrests lightning and protects the circuit from high voltage because lightning carries high voltage across the transmission line. If it is not protected, that same heavy voltage is coming across the load as well as other devices. This leads to failure of other devices.

Fig. 5.3.9. Lightning Arrestors

5.3.2 Types of Cables

In wiring terms, wires and cables are the same thing. For easy identification of the different wire or cable types, certain colours like red, blue, yellow, green and black are used.

Take a look at the most commonly used colours for the three main types of wires.

Type of Wire	Colour
Neutral	Black
Earth	Green
Phase	Red or Blue

Cables are classified in three ways.

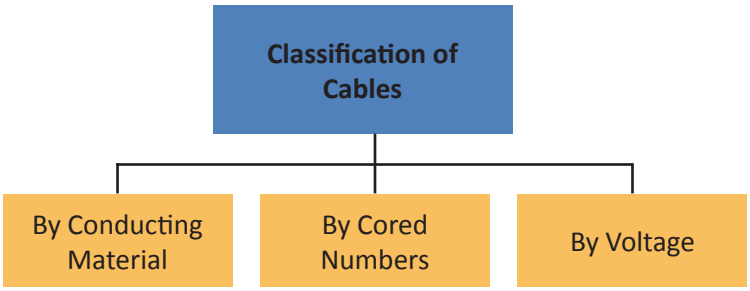


Fig.5.3.10. Classification of cables

By Conducting Material:

Based on conducting material, cables can be of two types:

Copper conductor cables

Aluminium conductor cables

Fig. 5.3.11. Copper Conductor Cables

Fig. 5.3.12. Aluminum Conductor Cables

By Cored Numbers:

Based on cored numbers, cables can be of six types:

Single core cables

Double core cables

Double core with earthing wire cables

Triple core cables

Three and a half core cables

Four core cable

By Voltage:

Based on voltage, cables can be of two types:

250 or 440 V grade

650 or 1100 V grade

Cables are also classified based on their mode of laying, construction and application, viz. aerial cable and underground cable.

1. **Aerial cables:**

   These cables are laid along the wall poles and exposed to atmosphere. They are used by supplier for distribution purposes as service line a nd for other general outdoor works. They are mechanically protective and weather proof. E.g. V.I.R cable, P.V.C cable, varnish cambric cable.

   Varnish cambric cables, also known as cambric cables, are used for both outdoor and indoor distribution purposes.

Fig. 5.3.13. Aerial cables

2. **Underground cables:**

   These are cables which are laid in ground for carrying current. The power generated at generating stations can be transmitted by over-head lines or under-ground cables. They are especially used in crowded areas.

Fig. 5.3.14. Underground cables

Different types of Cables:

1. **PILC cable:**

   PILC cables are used in early stage where paper was the only insulation available for cable.

   Limitations:

   - Low Working temperature 65° C.
   - Hygroscopic in nature, hence lead sheath require which increases cost.
   - Scope for moisture ingress.

Fig. 5.3.15. PILC cable

2. **PVC cable:**

   To overcome limitations of PILC cable PVC [Poly vinyl chloride] insulation is introduced. It is a thermo plastic material can work continuously maximum upto 65°C

   Limitations

   - If the temperature increases PVC losses its shape & cannot regain its original shape, causes failure of cable in run.

Fig. 5.3.16. PVC cable

1. XLPE cable:

This is commonly used in LT Network.

Cross linking of carbon atom in polyethylene gives good mechanical and electrical strength. The maximum continuous working temperature for this is 90°C. Hence for same conductor size we can take 20% more current compare to PVC cables. It has higher short time overload capacity because of its improved resistance to thermal deformation hence suitable for city distribution network. The conductors are sector shape to reduce the diameter of the cable & hence reduction in total cost

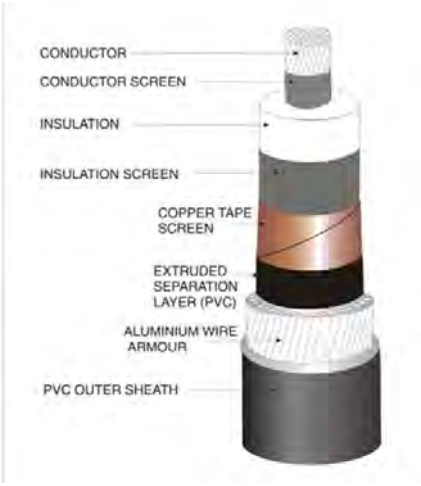


Fig. 5.3.17. XLPE cable

Limitations

- Water Trees are formed in the XLPE insulation which subsequently develop into electrical trees.

Diameter and Current Ratings :

Area (mm)	Diameter of Cable		Current rating	
	PVC	XLPE	PVC	XLPE
25	25.8	24	76	90
50	31.4	29	100	126
150	46.1	44	210	240

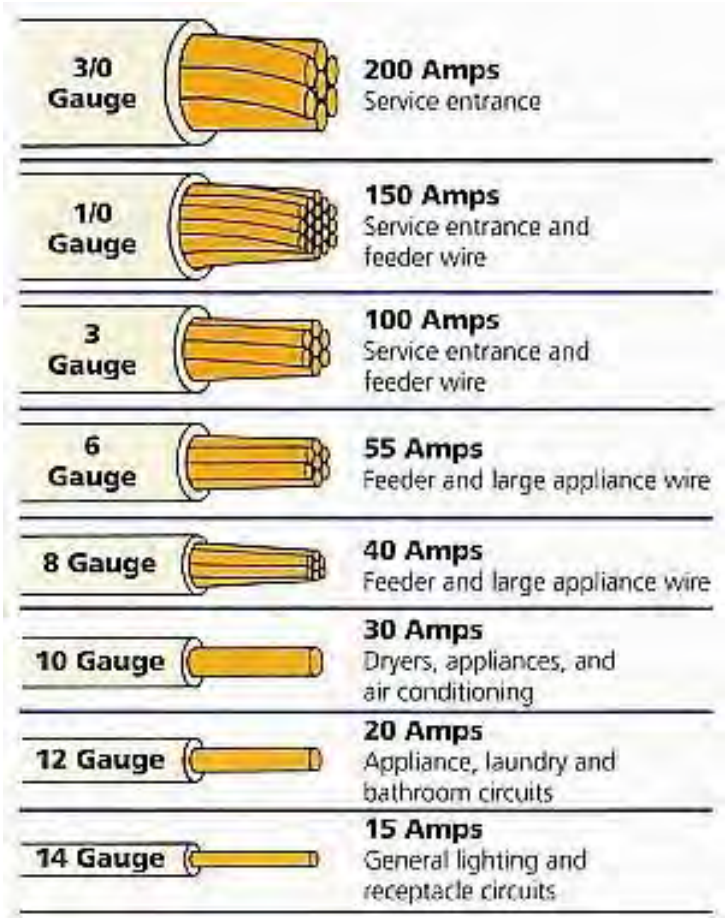


Fig. 5.3.18. Diameter and Current Ratings

SR. No.	Cable Size	Voltage Level	Cable Type	CURRENT RATING OF CABLES (Amps)						APPROX. AC RESISTANCE (OHM/KM)	REACTANCE OHM/ KM (ARMOURED CABLE)
				IN GROUND		IN DUCT		IN AIR			
				CU	AL	CU	AL	CU	AL	AL/CU	AL
1	31/2 C/300 SQMM	1.1 kV	XLPE	464	366	418	312	575	378	0.129	0.0705
2	31/2 C/240 SQMM	1.1 kV	XLPE	416	326	374	282	508	336	0.161	0.071
3	31/2 C/225 SQMM	1.1 kV	PILC	345	275	285	225	385	300	0.185	
4	31/2 C/285 SQMM	1.1 kV	XLPE	361	282	325	254	430	337	0.21	0.0718
5	31/2 C/150 SQMM	1.1 kV	XLPE	321	249	289	210	375	292	0.264	0.0716
6	31/2 C/120 SQMM	1.1 kV	XLPE	287	222	258	186	330	216	0.323	0.0712
7	4C/ 50 SQ MM	1.1 kV	XLPE	172	132	155	114	183	126	0.818	0.075
8	4C/ 25 SQ MM	1.1 kV	XLPE	122	91	110	76	123	84	1.53	0.0805
9	2C/ 25 SQ MM	1.1 kV	XLPE	152	97	137	78	153	94	1.53	0.0805
10	4C/ 16 SQ MM	1.1 kV	PVC	88	68	73	57	79	61	2.29	0.0859
11	4C/ 10 SQ MM	1.1 kV	PVC	68	52	57	44	62	48	3.7	0.0908
12	3 1/2 C/0.2 SQ INCH	1.1 kV	PILC/ PVC	287	225	258	200	330	255	**0.15**	
13	3 1/2 C/0.15 SQ INCH	1.1 kV	PILC/ PVC	239	195	200	180	240	220	**0.18**	
14	3 1/2 C/0.1 SQ INCH	1.1 kV	PILC/ PVC	200	175	171	160	198	190	**0.23**	
15	3 1/2 C/0.075 SQ INCH	1.1 kV	PILC/ PVC	165	150	143	135	162	155	**0.4644**	
16	3 1/2 C/0.06 SQ INCH	1.1 kV	PILC/ PVC	137	125	113	110	132	125	**0.6288**	
17	3 1/2 C/0.04 SQ INCH	1.1 kV	PILC/ PVC	113	85	92	88	108	98	**0.8724**	
18	4C/0.0225 SQ INCH	1.1 kV	PILC/ PVC	88	65	73	74	79	81	**1.38**	
19	4 C/0.0145 SQ INCH	1.1 kV	PILC/ PVC	68	51	57	45	62	48	**2.196**	
20	2 C/0.0145 SQ INCH	1.1 kV	PILC/ PVC	80	62	66	51	72	55	**2.196**	

5.3.3 Types of Conduits and Fixtures

Conduit and its types

Electrical conduit protects wires and cables from moisture, impact and vapours.

- It serves as a path for either communication (low voltage) or power electrical wiring.

- It is usually tubular in shape.
- It is made of metal such as, aluminium, stainless steel, galvanized steel or non-metallic materials such as plastics.
- It is either rigid or flexible.
- For wet and hazardous areas special types of conduit are used.

Advantages of all types of conduit:

- Protects electrical wires from accident or damage
- Allows cables to be easily pulled off to inaccessible areas
- Allows wiring changes in safe and simple
- Protects from water as it can be made submersible and waterproof
- Provides protection from fire and explosion hazards

Conduit systems are differentiated by their:

- thickness of wall,
- mechanical stiffness,
- material used for tubing.

Conduit materials are selected for their corrosion resistance, overall installation cost and mechanical protection.

Two types of conduits are:

1. Metal conduits
2. Non-metal conduit.

1. Metal Conduit

Metal conduit comes in many forms.

They are made from aluminium, galvanized steel or stainless steel.

They are also be used as an earthing conductor.

Rigid Metal Conduit (RMC)

RMC is thick walled, threaded tubing. It is made of coated steel, stainless steel, or aluminium.

- The conduit is connected to each other by screwing connectors to the main tubes.
- It can be made corrosion-resistant by applying a coating by galvanizing the metal or PVC. This resists any damage from water or other chemicals.
- It protects from impact and other damage.
- It is used as a grounding conductor for short runs,
- Due to its thickness it protects the cables inside from electromagnetic interference (EMI), which can be harmful to sensitive equipment.

Fig. 5.3.19. Rigid Metal Conduit (RMC)

Electrical Metallic Tubing (EMT)

EMT is thin-walled, unthreaded, thin-wall metal tubing.

- They are generally made of aluminium or coated steel.
- It is popularly used in commercial buildings.
- It is connected together using clamp-type fittings that slide onto the tubing and then are secured with a set-screw.
- It is used in hazardous areas like power plants or around vehicle traffic.
- It is not suitable for wet areas or where corrosive fumes and vapours exist.

Fig. 5.3.20. Rigid Metal Conduit (RMC)

Intermediate Metal Conduit (IMC)

Intermediate Metal Conduit (IMC) has walls that are thinner than RMC, but thicker than EMT.

The weight is between RMC and EMT.

- It is threadable, but it can also be un-threaded and used with clamp-type fittings.
- It is made from steel and can be coated.

Flexible Metal Conduit (FMC)

Flexible metal conduit (FMC)is generally between 3/8" and 3" diameter.

- It is made by coiling self-interlocked aluminum or steel strips, which forms a hollow tube that wires can be pulled through.
- It comes in a standard wall thickness or a reduced wall thickness.
- Standard FMC is used in dry areas where EMT or other non-flexible conduit cannot be used.
- Liquid-Tight Flexible Metal Conduit (LFMC) is FMC covered by a plastic waterproof coating.

Fig. 5.3.21. Flexible Metal Conduit (FMC)

Types of Non-Metal Conduit

PVC Conduit

Non-metal conduit is made of plastic, also called PVC.

- It is used in areas where metals cannot be used, such as in hospital MRI rooms.
- It is also used below ground or encased in concrete where it comes in contact with water.
- PVC conduit does not rust or corrode when exposed to water.

Fig. 5.3.22. Flexible Metal Conduit (FMC)

Rigid Nonmetallic Conduit (RNC)

RNC is the lightest and least expensive conduit.

- Fittings are slipped onto the tubing.
- It is welded with a solvent. The joints are water-tight.
- It can be heated with special tools so that it can be bent in the field.

Fig. 5.3.23. Rigid Nonmetallic Conduit (RNC)

Disadvantages of Plastic Conduits

- Plastic conduit will not stand up to impacts as that of metal conduits.
- It cannot be used for grounding. A grounding conductor is required to pull along with the other conductors.
- It expands and contracts more than metal conduit when exposed to heat, which need to be take care of for designing for long runs.

Electrical Non-metallic Tubing (ENT)

ENT is thin-walled corrugated tubing. The tubing is flexible so it can be bent without special tools.

But it cannot hold the bend permanently.

- It is easier to install than RNC around obstructions without cutting and welding the pipe.
- Special ENT connectors are used that are not watertight.

Fig. 5.3.24. Electrical Non-metallic Tubing (ENT)

Liquid-tight Flexible Nonmetallic Conduit (LNFC)

Liquid-tight Flexible Nonmetallic Conduit (LNFC) is also a flame resistant types of non-metallic tubing. The interiors of this conduit may be corrugated or smooth.

- It is used as a raceway for the installation of approved conductors.
- The nominal rating is of 600 Volts or less for non-hazardous locations.

Fig.5.3.25. Liquid-tight Flexible Nonmetallic Conduit (LNFC)

Types of Fixtures used for Conduit Wiring System:

Crewed coupler  *Fig. 5.3.26. Crewed coupler*	Conduit bend  *Fig. 5.3.27. Conduit bend*	Conduit elbow  *Fig. 5.3.28. Conduit elbow*
Inspection elbow  *Fig. 5.3.29. Inspection elbow*	Flexible conduit fixedwith connector and lock-nut  *Fig. 5.3.29. Flexible conduit fixedwith connector and lock-nut*	Four way box  *Fig. 5.3.30. Four way box*

Three-way box

Fig. 5.3.30. Three-way box

Spaces or Distance saddles

Fig. 5.3.32. Spaces or Distance saddles

Back plate and saddle

Fig. 5.3.33. Back plate and saddle

Saddle

Fig. 5.3.34. Saddle

Space bar saddle

Fig. 5.3.35. Space bar saddle

Clip

Fig. 5.3.36. Clip

Looping in box

Fig. 5.3.37. Looping in box

S. No.	Size of cond		19 mm		25.4 mm		31.8 mm		38.1 mm		50.4 mm		63.5 mm	
	Size of cable		No. of cable of insulation grade											
	No. and dia. in mm	No. SWG App. No.	250 V	660 V	250 V	660 V	250 V	660 V	250 V	660 V	250 V	660 V	250 V	660 V
1	1/1.12	1/18	6	4	10	9	14	12	-	-	-	-	-	-
2	3/0.736	3/22	6	4	10	9	14	10	-	-	-	-	-	-
3	1/1.40	1/17	5	4	10	8	14	9	-	-	-	-	-	-
4	3/0.925	3/20	5	3	10	6	14	8	-	-	-	-	-	-
5	1/1.80	1/15	4	2	6	5	10	7	-	8	-	-	-	-
6	7/0.736	7/22	4	-	6	4	10	6	-	7	-	-	-	-
7	1/2.80	1/11	2	-	4	3	8	5	-	6	-	-	-	-
8	1/3.55	1/9	-	-	3	2	5	4	6	4	-	8	-	-
9	7/1.70	7/16	-	-	2	2	4	3	5	3	-	7	8	-
10	19/1.32	19/18	-	-	-	-	3	2	4	2	-	6	7	-
11	7/2.24	7/13	-	-	-	-	2	-	3	-	5	5	6	-
12	19/1.60	19/17	-	-	-	-	-	-	-	-	3	3	-	4

Fig. 5.3.38. Comparison of Various Wiring Systems

This table shows how many wires can suitably be run through various size of conduits. It helps you select the appropriate conduit required for any given electrical work and power rating. Let's understand how to identify the appropriate conduit with the help of this table.

This table lists the voltage rating, current rating and size of the cable, with respect to current rating. With respect to all this data, the size of conduit is given. For example, 19mm size of conduit carries diameter of cable 1/1.2 and 1/18 which carry current of 6 amperes and 4 amperes across which the voltage is 250 V and 660 V.

5.3.4 Types of Safety Equipment

The safety equipment used in electrical works is based upon the type of wiring and usage. It can either be:

- temporary wiring or
- domestic/permanent wiring.

Temporary Wiring

In case of temporary wiring, cables are open and lying on the ground. As a result, there is a high chance of

- the cables coming in contact with water;
- short circuit taking place;
- insulation failure, that is, rubber covers of the wire breaking;
- two conductors coming in contact with each other.

All of this can result in fire and accidents. Hence, it is important to use safety equipment at a temporary wiring site. The following safety equipment are used for circuit safety.

1. **Fuses**

   These are connected in distribution boxes. It contains metallic link. When overcurrent flows through the circuit, metallic link melts and disconnects the circuit from supply.

Fig. 5.3.1. Fuses

2. **GFCI**

   Ground Fault Circuit Interrupters, also known as GFCI, is an equipment that helps to prevent electrocution. As soon as it senses that a person may receive a shock, or when it detects that the current is flowing in an unintended direction or coming in contact with water, it immediately cuts off the supply.

Fig. 5.3.2. GFCI

3. MCBs

When overload takes place, it results in heavy current flowing through the circuit. Miniature Circuit Breakers, or MCBs, help to break the circuit from the supply.

Fig. 5.3.3. MCBs

4. Earthing equipment

When current does not flow through the circuit but flows through any other metallic part of the circuit or the outer covering of the circuit, there is a chance of current leakage, resulting in shock. An earthing equipment helps to bypass this leakage current into the ground. A person handling such a circuit is protected from an accident.

Fig. 5.3.4. Earthing equipment

Permanent Wiring

In case of permanent/domestic wiring, cables are not open. They are placed inside conduits or casing. Permanent/domestic wiring network includes household appliances like microwave, geyser, mixer, grinder, washing machine, etc. There is a high chance of short circuit when overloading takes place in the circuit. This happens when most appliances are used at one time. This results in overloading. To protect a person using it from accidents, safety equipment like fuses, MCBs, MCCBs and ELCBs are used.

1. MCCB

MCCB stands for moulded case circuit breaker. Depending upon the application and required protection, an MCCB will use one or a combination of different trip elements that protect against the thermal overload, short circuit and ground fault.

Fig. 5.3.5. MCCB

2. ELCB:

Many electrical installations have relatively high earth impedence. This may be due to the use of local earth rod or dry local ground condition. These installations have major problems if there is no Earth Leakage Circuit Breaker or ELCB. When there is phase fault, current takes place between live and earth. In such a case, ELCB operates and protects domestic wiring from earth fault current.

Fig. 5.3.6. ELCB

5.3.5 Types of Lights Used in Construction Sites

Construction sites are usually dark places with minimum light. An electrician has to work for long hours in limited space to complete his work. Hence, it is important to use lamps that provide proper illumination on the circuits. This helps to improve the efficiency of output. The following lamps are used at construction sites:

1. **Incandescent light**

   This includes three types of lights. They are:

   a. 40 W tungsten incandescent
   b. 60 W tungsten incandescent
   c. 100 W tungsten incandescent

These lights are used depending on the area of work and the illumination required. Example, a 40 W incandescent light will be used in a smaller area whereas a 100 W light will be used where the circuit covers large area.

Incandescent lamp

It uses electricity to heat a tungsten filament in the bulb until it glows. The filament is either in a vacuum or in a mixture of argon/nitrogen gas.

Fig. 5.3.1. Incandescent lamp

2. **Halogen**

   This includes two types of lights. They are:

   a. Glass halogen
   b. Quartz halogen

They are usually used when construction work has to be carried out at night. Their efficiency is lower than incandescent lights.

Halogen

These bulbs work by passing electricity through a tungsten filament, which is enclosed in a tube containing halogen gas.

Take care not to touch the glass portion of the bulb with fingers. As this will shorten the bulbs life and cause the bulb to burst because of the burning of the filament.

Halogen lights have longer life than the incandescent bulb.

They are small in size but expensive and burn at a higher temperature which can be a cause of fire hazard.

Fig. 5.3.2. Incandescent lamp

3. **Fluorescent**

A current passes through a tube filled with mercury and argon gas. This in turn radiates ultraviolet rays that enable the phosphorous coating to produce light.

Fig. 5.3.3. Fluorescent

- Life of a bulb is very long - 10,000 to 20,000 hours.
- They are very efficient as it produces very little heat.
- They are used for lighting large areas which helps construction workers to do minute work with lots of detailing.
- Fluorescent bulbs need components called ballasts. Ballast provide the right amount of voltage.

They are of two types.

1. Magnetic
2. Electronic.

A “starter” is required for some ballast to work.

Starters are small mechanical timers, which causes a tube to glow.

4. Compact Fluorescent Lamps (CFL)

CFLs are very efficient and produce little heat.

- CFLs either consist of a number of two or three small tubes like loops or short glass sticks.
- They also come in a glass bowl that is like a regular incandescent bulb.
- They are used as decorative dimmers.
- They normally last up to 10,000 hours.

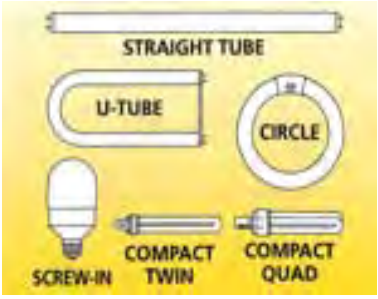


Fig. 5.3.4. Compact Fluorescent Lamps (CFL)

5. High-Intensity Discharge Lamps (HPS)

High Pressure Sodium (HPS), Self-Ballasted Mercury Lamps, Mercury Vapour and Metal Halide are all high intensity discharge lamps (HID).

HID lamps produce a large quantity of light from a small bulb by striking and arc across tungsten electrodes which are inside a glass tube. The glass tube is filled with both gas and metals. The gas helps in starting of the lamps and then the metals produce the light.

Fig. 5.3.5. Mercury bulb

Fig. 5.3.6. Metal Halide

6. Low-Pressure Sodium Lamps

Low-pressure sodium lamps are of very higher efficacy than any available lighting sources.

They emit a yellow light and is operated much like a fluorescent lamp. It also requires ballast. It take a brief warm-up time for the lamp to glow its full brightness

The lamps are commonly used for outdoor, tunnel, parking lot, and passages

Fig. 5.3.7. Fluorescent

7. LED (Light Emitting Diodes)

- Light Emitting Diodes (LED) are bulbs without a filament.
- They are low in power consumption with a long life span.

Fig. 5.3.8. LED (Light Emitting Diodes)

5.3.6 Equipment Used for Electrical Earthing Works

Earthing means connecting a terminal to electrodes installed solidly in the mass of earth. Earthing should generally be carried out in accordance with the requirements of Indian Electricity rules.

Earth conductivity naturally carries current of low resistance. Hence, it is affected by moisture content in the soil and its chemical composition and concentration of salts dissolved. In places where underground cable system exists, earth terminals are obtained by connecting the terminals to the lead sheath or the steel armour of the cables. The lead sheaths or steel armours serve as the earth electrode. Earth electrodes are mainly of two types.

1. Rod and Pipe Electrodes
2. Plate Electrodes

Rod Electrode	
	Metal rods (steel of galvanized iron) Specification: 16 mm in diameter
	Metal rods (copper) Specification: 12.5 mm in diameter
Pipe Electrode	
	Metal pipes (steel of galvanized iron) Specification : More than 38 mm in internal diameter
	Metal pipes (Cast iron) Specification :10 mm in internal diameter

Other Equipment	
	Layer of Cement Specification : 60 cm in length
	Concrete Specification: 12.5 cm in diameter
	Nuts Specification: As per rod diameter

Besides that, there is a minimum 2.5 meter alternate layer of charcoal and salt.

Exercise

1. Fill in the blanks
   a. _____ are devices which transfer electrical energy from one circuit to another.
   b. _____ is a device which breaks the circuit when a fault occurs.
   c. Cables are classified on the basis of conducting material, cored numbers and _____.
   d. Conduit wiring system is supported on walls with the help of _____ and hooks.
   e. _____ is the equipment that helps to prevent electrocution.

2. Give any one example of each:
   a. Power carrying device
   b. Protecting device
   c. Fixture used in wiring system
   d. Cables
   e. Safety equipment
   f. Conduit used in wiring system
   g. Light used at construction site
   h. Electrical earthing equipment

UNIT 5.4: Storing Electrical Devices

Unit Objectives

At the end of this unit, you will be able to:

1. Explain the standard conditions for storing and stacking electrical units, materials, fixtures, tools and devices

5.4.1 Storing Electrical Devices

Points to be considered while storing electrical devices:

- Properly disconnect the power source before storing the equipment.
- Make sure that the handles of the equipment are non-conductive.
- Avoid storage of equipment in cold rooms or places where condensation takes place. If at all equipment is to be used in such areas than it must be mounted on walls or vertical panels.
- Avoid spilling of any water or chemicals in storage.
- Do not store highly flammable liquids near electrical equipment.
- If the room is specified only for electrical equipment storage than storage of any other thing should be prohibited.
- The exhaust of the room is very important to keep the dust out of the room. If at all dust is observed on the tools than it must be cleaned to keep the tools dust-free.
- Tools should be checked on regular basis for wear and tear, damage, defects, etc.
- Make sure that the tool is completely dry and does not contain dirt / soil particles before keeping it in the storage.
- Parts of the tools should be lubricated on regular basis.

Exercise

1. Store and stack the electrical devices at your construction site and ask your supervisor to examine.
2. State true of false.
   a. Tools should be checked on regular basis for wear and tear, damage, defects
   b. Store highly flammable liquids near electrical equipment.
   c. Do not disconnect the power source before storing the equipment.
   d. Avoid spilling of any water or chemicals in storage.

Notes

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6. Temporary Electrical Works at Construction Site

Unit 6.1 – Cable Laying

Unit 6.2 – Installation of Light

CON/N0603

Key Learning Outcomes

At the end of this unit, you will be able to:

1. Explain the standard practice of cable laying at construction sites.
2. Describe the method of joining cables.
3. Explain how electrical termination is performed at construction sites.
4. Describe how to trace short circuits, power interruptions/continuity.
5. Describe the method of fixing lights and their respective accessories.
6. State the different types of faults associated with lighting arrangements.
7. Explain the standard procedure of shifting and installing lights and its accessories.

UNIT 6.1: Cable Laying

Unit Objectives

At the end of this unit, you will be able to:

1. Explain the standard practice of cable laying at construction sites.
2. Describe the method of joining cables.
3. Explain how electrical termination is performed at construction sites.
4. Describe how to trace short circuits, power interruptions/continuity.

6.1.1 Cable Laying at Construction Sites

Before the commencement of construction, the site needs temporary electrical supply for executing various tasks, such as lighting, grinding, cutting, welding of steel structures for temporary erection of scaffoldings, etc. Apart from this, the temporary supply may get converted into permanent supply for the site. Hence, it is important to bring proper size of cables to the site and lay them as per standard procedure.

Cable Laying Through Underground Conduits

This is done by two methods. They are:

Direct Laying Method

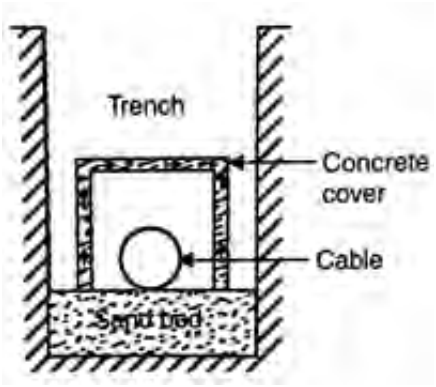

Fig. 6.1.1. Direct Laying Method

6.1.1.1 Procedure for Direct Laying Method

Step 1: Dig a trench of about 1.5 m deep and 45 cm wide.

Step 2: Cover the trench with a layer of fine sand (10 cm thick).

Step 3: Lay the underground cable over the sand bed. Sand prevents the entry of moisture from the ground, thus, protecting the cable from decay.

Step 4: Cover the cable with another layer of sand, about 10 cm thick.

Step 5: Cover the trench with bricks and other materials in order to protect the cable from mechanical injury.

Step 6: If more than one cable is to be laid in the same trench, provide a horizontal or vertical inter-axial spacing of at least 30 cm. This is done to reduce the effect of mutual hitting. It also helps to ensure that a fault occurring on one cable does not damage the adjacent cable.

6.1.1.2 Procedure for Draw-in Method

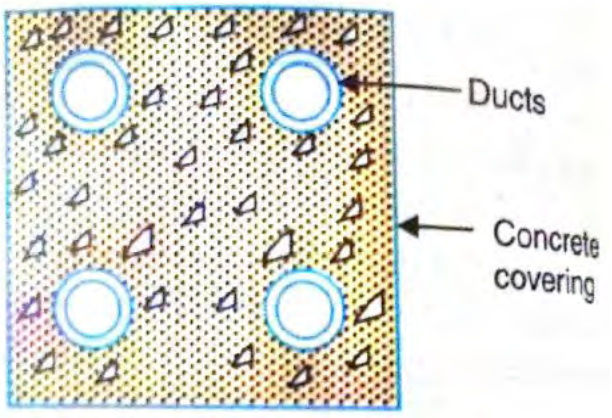

Fig. 6.1.2. Draw-in Method

Draw-in Method

Step 1: Lay conduit or duct of glazed stone or cast iron or concrete in the ground with manholes at suitable positions along the cable route.

Step 2: Pull the cables into position through the manholes.

Step 3: Ensure that where the duct line changes direction; depths, dips and offsets be made with a very long radius. Otherwise, it will be difficult to pull large cables between manholes.

Step 4: Ensure that the distance between manholes is not too long to simplify the pulling in of the cables.

6.1.1.3 Procedure for Cable Laying through Poles

Obtaining service connection for temporary electrical supply can be made available through overhead poles. This is done by connecting overhead wires to overhead distribution poles situated near the site.

Step 1: Measure the length of the conductor required for bringing the supply.

Step 2: Select the proper quality of conductor suitable for the site.

Step 3: Before connecting the supply to the feeder, the feeder should be made off with the help of circuit breakers or fuses.

Step 4: Ensure that the connections of the outgoing feeder is proper.

Fig. 6.1.3. Cable laying through poles

6.1.2 Joining of Cables

Joining of cables is done when a part/section of a cable is faulty or there is risk of short circuit. It may also be done as an extension to a cable. It is done with the help of 'straight through joint' method. The method is as follows:

6.1.2.1 Procedure for Joining of Cables

Fig. 6.1.4. joing of cables

Step 1: Identify the faulty section of the cable with the help of cable fault detector.

Step 2: Switch off the feeder in order to stop the current.

Step 3: Dig the area or prepare a trench where the faulty part lies.

Step 4: Cut the faulty section of the cable.

Step 5: Remove the insulation from the cable on either ends.

Step 6: Remove the armouring and connect it to the adjoining cable properly.

Step 7: Ensure that each and every conductor is joined thoroughly with the adjoining conductor as per the colour coding (R to R, Y to Y and B to B).

Step 8: Make sure that insulations like fabric and PVC tapes and paper are provided on each conductor. This helps to prevent leakage current.

Step 9: Ensure that the entire joint assembly is executed at the protective box made of high grade cast iron and has two halves bolted section. (However, nowadays, cast iron boxes are being replaced by cast resin boxes which employ plastic moulds.)

Step 10: Pour bitumen base hard setting compound inside the assembly to provide proper insulation between the conductors.

Step 11: Place the two halves of the moulds around the joint and clamp firmly..

6.1.3 Electrical Termination

Electrical termination is used to provide:

- electrical connection;
- mechanical support;
- physical protection to the cable.

The method of electrical termination of cables depends upon the type of cable, the type of conductor and the application. The common types of termination are:

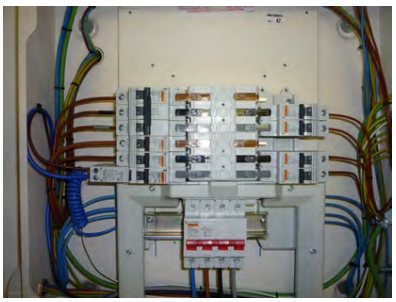

Fig. 6.1.4. Electrical Termination

1. crimp connection,
2. soldered connection,
3. compression termination,
4. wire-wrapping connection,
5. direct connection,
6. loop or eye connection

Factors that fetermine the appropriate type of termination:

- Outdoor or indoor use
- Voltage
- Current
- Overhead, or underground cable
- Type of connector on the equipment, where the cable will be connected

6.1.3.1 Procedure for Electrical Termination

Termination of cables is done using cable terminal boxes or sealing boxes.

Step 1: Inside the terminal boxes, join the conductors properly.

Step 2: Fill the boxes with a bituminous cable compound to insulate all connections. This helps to prevent them from moisture.

Fig. 6.1.5. Electrical Termination

6.1.4 Tracing Short Circuits, Power Interruptions Continuity

If the load is interrupted, the cause of the interruption may be:

1. **Short circuit within the cable**

   This may happen due to overloading of current. It results in heating of the cable, which leads to damaging of the insulation. When this happens, it leads to short circuits. It may also happen due to rodents biting wires.

   It can traced with the help of cable fault detectors. This equipment helps to trace the location where the cable has been damaged. Short circuits can also be traced by physical examination.

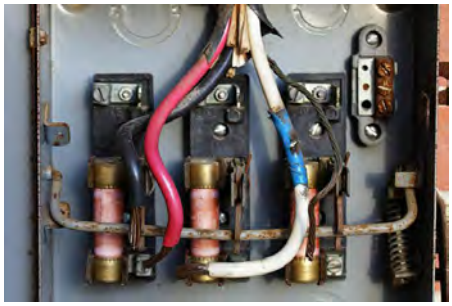

Fig. 6.1.6. Fault short circuit

2. **Open circuit at the termination**

   This may be caused by the breakage of cables or loosening of terminal or loose connections. Open circuit is traced by checking the continuity of the cable with the help of continuity tester. This can also be done with the help of ohmmeter.

Fig. 6.1.6. Open circuit

3. **Mechanical damage to the cable**

   Cables may be affected due to mechanical pressure. This may result in the cables getting burnt, damaged, bent. This may also lead to short circuits.

Exercise

1. Fill in the blanks

   a. Before the commencement of construction, the site needs _____ electrical supply for executing various tasks.

   b. Obtaining service connection for temporary electrical supply is done with the help of _____ poles.

   c. Termination of cables is done using cable _____ boxes.

   d. Short circuit within the cable can be traced with the help of _____ fault detectors.

UNIT 6.2: Installation of Light

Unit Objectives

At the end of this unit, you will be able to:

1. Describe the method of fixing lights and their respective accessories.
2. State the different types of faults associated with lighting arrangements.
3. Explain the standard procedure of shifting and installing lights and its accessories.

6.2.1 Fixing Lights and their Respective Accessories

While fixing lights and accessories for temporary electrical works, ensure that:

- light fixture installed is away from moisture and damp areas;
- wiring made for lighting and the wires, wherein the light fixtures, are connected should be properly conduited to avoid mechanical damage;
- light fittings provided for illumination must be installed at a suitable height in order to illuminate the requisite space;

Fig. 6.2.1. Light fixing

6.2.1.1 Procedure for Installation of Lights and Fixtures

Step 1: Lay the wire where the light points are to be connected.

Step 2: Connect the lamp holders for putting lamps such as CFL, incandescent lamps, etc.

Step 3: In order to regulate the operation of the lamp, use appropriate size of switchboards.

Step 4: Provide separate cable connections to the switchboards from the incoming distribution panel.

Step 5: Ensure that the switchboard provided for lighting and other plug-in controls consists of MCBs or fuses of appropriate size.

Fig. 6.2.3. light installation

6.2.2 Faults Associated with Lighting Arrangements

1. Insufficient Illumination

   If the light source being used is of lower wattage, then it can affect illumination. Lack of illumination can result in migraine, headache, strain on the eyes and affect productivity.

2. Wrong selection of light source

   If the light source (example, street lights) used does not meet the requirement of the site, it can either result in insufficient illumination or over illumination. Over illumination can result in more energy consumption.

3. Faulty light source

   If the fittings or lamp holders are damaged, then it can result in lack of illumination. It may also affect the output of the device or its working condition.

4. Spacing between two lamps

   Ensure that the spacing between two lamps is adequate. If there is inadequate or excess space between two lights, it can affect the area of illumination.

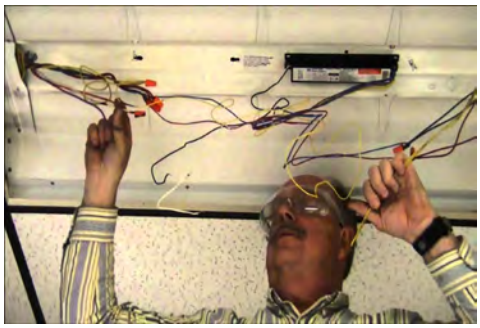

Fig. 6.2.4. Fault associated with light

5. Inadequate number of fittings

   As per the requirement of the site, one must use the appropriate number of fittings. Inadequate fittings may result in insufficient illumination and thus, affect productivity.

6.2.3 Shifting and Installing Lights and Accessories

The standard procedure for shifting and installing lights and accessories is as follows:

6.2.3.1 Procedure for Shifting and Installing Lights and Accessories

Step 1: Switch off the light points from the switch board.

Step 2: Disconnect the lighting circuit from the main distribution board.

Step 3: Dismantle the lamp fixture from the wire. OR

Step 4: If it is an incandescent lamp or CFL tube from the lamp holder, disconnect the lamp holder from the wire.

Step 5: Remove the wire from the root.

Step 6: Subsequently, remove the DB from the temporary location.

Step 6: Move the lighting equipment, fixtures, accessories, switchboards, DB to the required location.

Step 7: Connect the DB to the switchboard/mains of the new site.

Step 8: Complete the wiring as per the requirement for the new site.

Step 9: Connect the switchboard to the distribution box.

Step 10: Connect wires, through the switches, to the switchboard.

Step 11: Ensure the safe operation of lighting circuit by providing circuit breakers, MCBs or fuses.

Step 12: Reconnect the lamp holders or fixtures to the terminals of the wires.

Exercise

1. Fill in the blanks

   a. Light fixture installed is away from _____ and damp areas.

   b. If the light source being used is of lower wattage, then it can affect _____.

Notes

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7. Wiring in Permanent Structures

Unit 7.1 – Conduit and Cable/Wire Laying

Unit 7.2 – Earthing

CON/N0604

Key Learning Outcomes

At the end of this unit, you will be able to:

1. Describe the standard procedure for conduit laying and fixing through brick and concrete structures;
2. Explain the standard practices of cable/wire laying through conduits;
3. Describe the concept of electrical earthing procedure in domestic wiring;
4. State the importance of electrical earthing procedure in domestic wiring;
5. Describe the concept of electrical earthing procedure in temporary panels;

UNIT 7.1: Conduit and Cable/Wire Laying

Unit Objectives

At the end of this unit, you will be able to:

1. Describe the standard procedure for conduit laying and fixing through brick and concrete structures;
2. Explain the standard practices of cable/wire laying through conduits

7.1.1 Conduit Laying and Fixing Through Brick and Concrete Structures

Let's understand how concealed conduit wiring is done in residential, commercial and public buildings.

Method of Concealed Conduit in Slab

Here concealed P.V.C conduits instead of steel conduits are used, as they are more economical and lighter to handle. Also, they are resistant to acids, alkalies, moisture and oil. Concealed conduits in slab are done before casting the slabs as per electrical layout. In concealed wiring, standard bends are fixed by bending the conduit pipe itself, to permit easy pulling of wires.

Fig. 7.1.1. Concealed Conduits in Slab

7.1.1.1 Procedure for laying and fixing concealed conduit in slab

Step 1: Study the electrical drawings for the positions of the various points.

Step 2: Fix the location of the distribution board in such a way that it cannot be seen while entering the flat/office.

Step 3: Provide the conduits for mains, light circuits, TV and telephone as per drawings

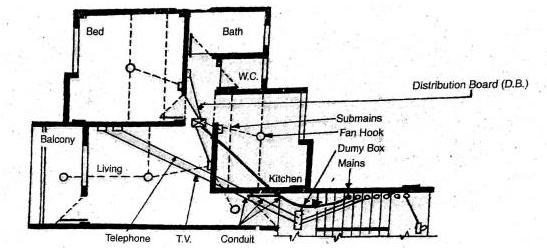

Fig. 7.1.2. Electrical Drawing of Concealed Conduits in Slab

Step 4: Ensure that the centre of the fan hook box is diagonal as per centre alignment, considering the loft position in the room.

Step 5: Check the locations of all points.

Step 6: Apply the bonding solution to all the pipes and accessories to avoid loose fixing of pipes with accessories.

Step 7: Tie the conduits, using binding wire, to each other and to the slab steel.

Step 8: Provide suitable inspection boxes for periodical inspection and to facilitate removal of wires.

Step 9: Ensure that conduits do not get damaged during movement of labourers on the slab.

Step 10: Ensure that fan box entries/holes are intact to prevent the cement slurry from entering.

7.1.2 Method of Concealed Conduits in Brick Wall

This is also called as drop work. It is done only after completion of masonry work and satisfactory curing period.

7.1.2.1 Procedure for laying and fixing concealed conduits in brick wall

Step 1: Lay G.I wire of 16 gauge in every conduit in the slab upto the concealed box. Keep an extra length of 15 cm for convenient pulling of wires.

Step 2: Study the drawings in detail and mark the position of switch boxes with respect to the height from F.F.I.

Step 3: Do the line out on the wall by colour marking.

Step 4: Start chasing on the wall with cutting tools

Step 5: Provide thick conduit pipes of the approved quality in the chased portion and tie with the help of binding wires and nails.

Step 6: Ensure that the conduit pipe is at least 5mm inside the surface of the wall.

Step 7: Provide an inspection box on the wall, at a suitable location.

Step 8: Fix all the boxes flush to the adjacent finished wall, considering the thickness of plaster.

Step 9: Finish the chased portion with cement mortar.

Step 10: Roughen the surface.

Step 11: Provide a chicken mesh over conduits portion before finishing, if there are 3 or more conduits.

Fig. 7.1.1. Chasing on the wall with cutting tool

Fig. 7.1.2. Chasing according to cross sectional area of conduit and switch board

Step 12: Cover all the boxes with dummy plates to prevent damage during plastering.

Step 13: Pass G.I. wires of 16 gauge inside the conduits with additional loop length of 15 cm for mains and sub-mains in case of batten/casing capping wiring.

Step 14: After completion of all plastering work, clean the concealed boxes.

Fig. 7.1.3. Fixing of wires in coduit

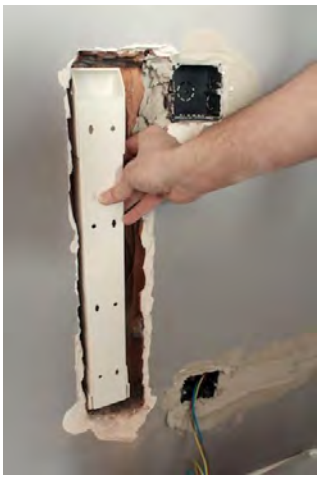

Fig. 7.1.4. Fixing of conduit in wall

7.1.3 Wiring and Fitting Fixtures

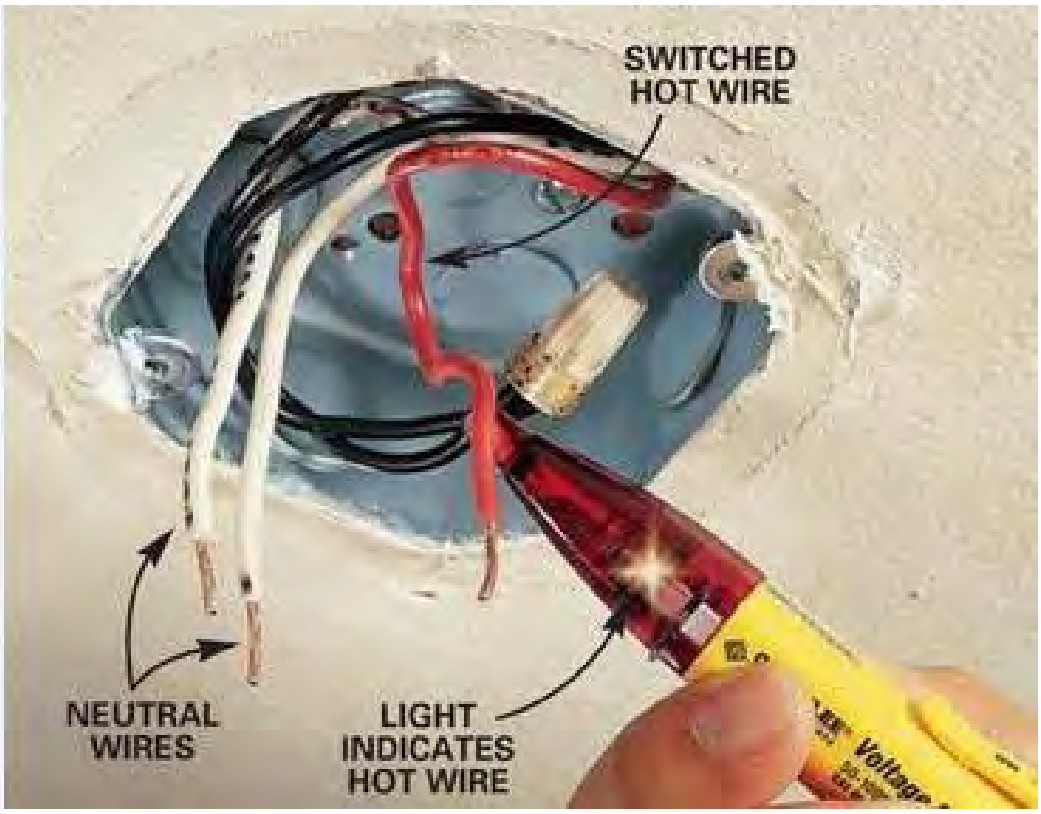

Fig. 7.1.5. Wiring and Fitting Fixtures

Wiring and fitting fixtures starts only after completing the plastering and curing work. Before staring the work check:

- the quality,
- brand name of wires,
- gauge,
- specification of the wire for various points,
- colour codes.

7.1.3.1 Procedure for wiring and fitting fixtures

Step 1: Fix the accessories on the boards with line and level.

Step 2: Terminate the extra length wires in accessories.

Step 3: Put the fuse wire of required current rating in the fuse box.

Step 4: Connect the wires in DB and main switch or MCB.

Step 5: Start the supply, switch on the mains and check all the points with megger or test lamp.

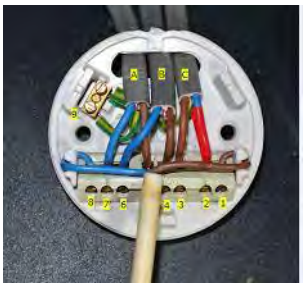

Fig. 7.1.6. Wiring in conduit

Fig. 7.1.7. Fitting fixture in wall

7.1.4 Standard Practices of Cable/ Wire Laying Through Conduits

Let us understand how to lay cable/wire for open conduit wiring.

7.1.4.1 Procedure for Open Conduit Wiring

Step 1: Cut the P.V.C. pipes as per the lines marked.

Step 2: Fix the saddles as per the lines on wall and ceiling.

Step 3: Fix only one side of the saddle on the wall.

Step 4: Fix the other side with screws, while laying the conduit.

Step 5: Fix the accessories serially to the conduit pipe.

Step 6: Use P.V.C. adhesive to join accessories, as an additional precautionary measure in P.V.C. conduits.

Step 7: Cut wires according to the route and the required length.

Step 8: Keep an excess length of 20-30cm in each wire for termination.

Step 9: Insert wires in appropriate pipes and accessories.

Step 10: Pull the wires to the other end of the pipe.

Step 11: Use fish wire/fish tape to pull cables for longer lengths of P.V.C. conduit runs.

Step 12: Make a hole in the teak wood boxes to accommodate P.V.C. pipes.

Step 13: File the edges with a filer and make a round hole. Use half round wooden scraper filer.

Step 14: Fix the accessories to the wooden board.

Step 15: Terminate the wires in the accessories.

Step 16: Start the electricity supply.

Step 17: Test electricity supply with test lamp or megger.

Fig. 7.1.7. Procedure for open conduit wiring

Fig. 7.1.8. Fitting open conduit on wall

Exercise

1. Fill in the blanks

   a. While laying conduit in slab, _____ are used instead of steel conduits.

   b. Conduit in wall is also called _____.

2. List the preparatory task before starting the wiring and fitting fixture.

3. List the steps in laying and fixing conduit in brick wall.

4. List the steps in laying and fixing conduit in slab.

Notes

UNIT 7.2: Earthing

Unit Objectives

At the end of this unit, you will be able to:

1. Explain the need for earthing;
2. State the types of earthing;
3. Describe the importance of earthing;
4. List the steps involved in pipe earthing;
5. List the steps involved in plate earthing;
6. Identify electrical appliances need earthing at construction site;
7. Describe the concept of electrical earthing procedure in domestic wiring;
8. Describe the concept of electrical earthing procedure in temporary panels.

7.2.1 What is Earthing

Earthing is a very important safety device that is used to prevent shocks caused by leakages arising from weak insulation, element breakage and the like. The device consists of a copper or GI wire that comes out of an electrode. Earthing is placed 2.5 to 3 meters underground. The potential of earth is always assumed to be zero. Electrical equipment is said to be earthed when it is added to the wire.

7.2.2 Need for Earthing

Earthing is a safety device that performs a lot of important functions. Some of its most important functions are:

It prevents accidents caused by shock. If electrical equipment or machinery leaks current, the earthing fuses the fuse. This prevents those using the equipment or machinery from getting a shock.

- It protects large buildings from lightening.
- It saves machines in cases where overhead lines are fixed with lightening holders. The earthing sends the lightening voltage to the earth.
- It stabilises the line voltage. This is because earth is neutral for every alternator and transformer

Relevant regulations of the Electricity Supply Authority concerned and as indicated below:

- 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.
- Similarly at consumer's premises a suitable earthing point would be provided. Consumer has to make arrangement for independent earthing.
- Sub-stations structures etc. should be provided with two independent earthing points. This should be interconnected or a matting in the s/s area could be laid-down for connecting to the earth points.
- 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.
- All special structures on which switches, transformers, fuses, etc., are mounted should be earthed.
- The supports on either side of the road, railway or river crossing should be earthed.

- 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 consists of 10m length of 8 SWG. G.I. wire compressed into a coil 450 mm length and 50 mm dia and buried 1500 mm deep.

7.2.3 Importance of Earthing

- Earthing ensures that leakage current has a safe path to flow to ground so that a person may not suffer from electric shock.
- It provides safety to electrical equipment.
- It eliminates the chances of fires due to electrical failures and short circuits.
- It provides a path for heavy current to travel to the ground which – may damage/melt the fuses.
- It provides voltage stabilisation as well as over voltage protection.

7.2.4 Types of Earthing

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.

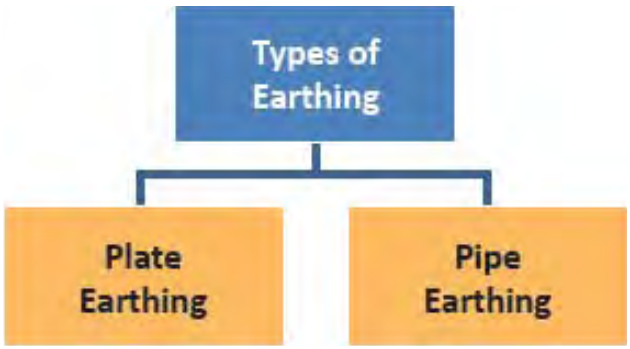

Fig. 7.2.1. Types of Earthing

Earth resistance depends on:

1. Types of soil,
2. Temperature of soil,
3. Wetness of soil,
4. Minerals in soil,
5. Size of Electrode,
6. Cross section of electrode,
7. Deepness of electrode in ground,
8. Distance between two electrodes.

Earth tester measures Earth resistance and its unit is ohm.

7.2.4.1 Procedure for Plate Earthing

Plate earthing is a type of earthing. The procedure for plate earthing is as follows:

- A pit is dug 3 meters deep in the earth.
- A copper plate of size 60 cms X 60 cms X 3 mm thick is placed in the pit
- A copper wire is attached to the plate with the help of a copper nut, bolt and washer.
- While the plate remains in an upright position, a 15 cm layer of salt is poured over it.
- A 15 cm layer of charcoal is poured over the salt. The salt and charcoal reduce the earth resistance and keep the area damp.
- A G.I pipe is placed over the plate
- The copper wire is taken through the pipe and brought to the surface.
- A funnel with a wire mesh cover is placed over the pipe.
- A cast iron cover is placed over the pipe and plate.
- Water is regularly poured in the pipe, through the funnel. Keeping the area around the earth plate damp, helps keep the earth resistance low.

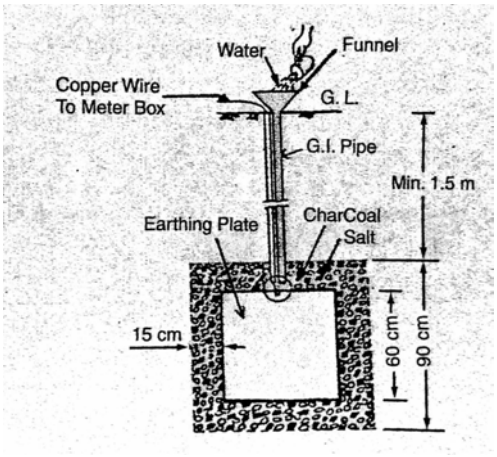

Fig. 7.2.2. Procedure for Plate Earthing

Note: This type of earthing can be carried out with a GI plate instead of a copper plate. If a GI plate is used, then the wire, nut and bolt should also be made from GI material.

Now that you know the procedure, take a look at a diagram of plate earthing.

7.2.4.2 Procedure for Pipe Earthing

Pipe earthing is another type of earthing. The procedure for pipe earthing is as follows:

- A 2 meter long GI pipe of 38 mm diameter is directly buried about 3 meters deep in the ground. The pipe acts as an earth electrode.
- An earth wire is attached to the pipe with the help of a nut and bolt.
- The wire is brought to the surface.
- A layer of salt is poured around the pipe.
- A layer of charcoal is poured around the pipe. The salt and charcoal help make the earthing system more efficient.

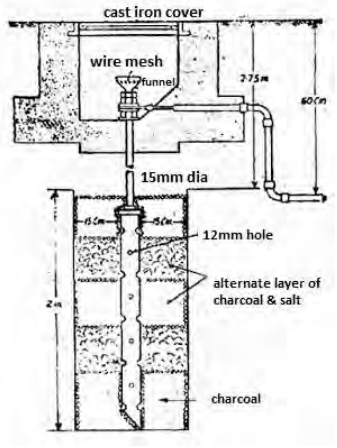

Fig. 7.2.3. Procedure for Pipe Earthing

The system of pipe earthing has two big advantages over plate earthing.

Advantages of Pipe Earthing :

- Pipe earthing is more effective than plate earthing. This is because the pipe is round and can handle more current leakage than the plate.
- Continuity testing for pipe earthing is very easy. This is because the wire remains on the surface. Continuity testing for plate earthing, on the other hand, is very difficult.

7.2.5 Measuring Ground Resistance with an Ohmmeter

Ground resistance can also be measured using an ohmmeter. To test using an ohmmeter, the following items are required:

- A digital multi-meter
- A sufficiently long length of wire
- A metal stake.

Take a look at the process for this method.

7.2.5.1 Process for Measuring Ground Resistance Using an Ohmmeter

- The metal stake is fixed in the ground.
- The wire is connected to the metal stake. Remember to strip back the insulation from both ends of the wire for better connection.
- The electricity in the testing area should be turned off. Never test a live circuit.
- The digital multi-meter is set on the ohms setting. In case of multiple ohm settings, it should be placed on less than 100 ohms.
- One lead of the multi-meter is touched to the test wire.
- The other lead of the multi-meter is touched to the test location.
- The reading is checked. If the resistance is less than 25 ohms, it means the system is properly connected.

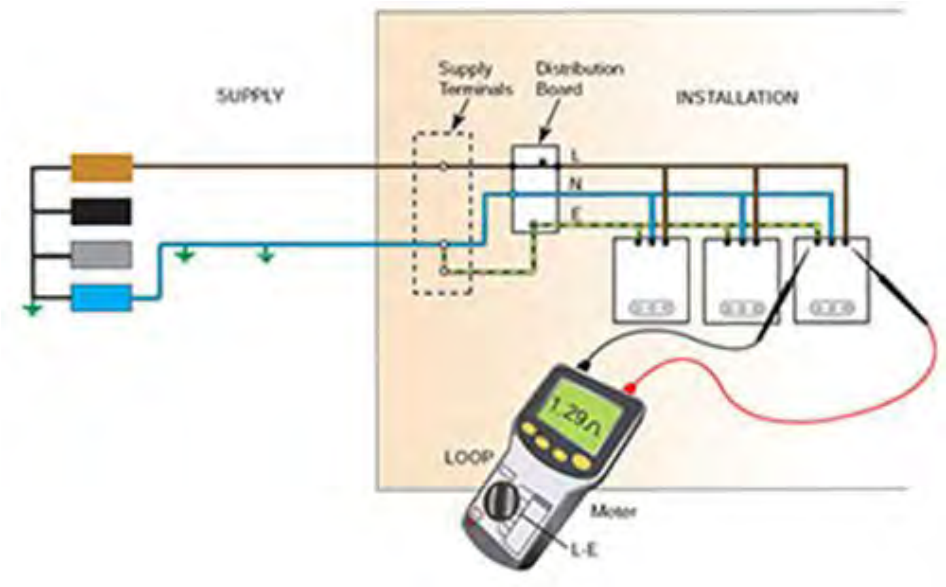

Fig. 7.2.4. Process for Measuring Ground Resistance Using an Ohmmeter

7.2.6 Earthing for Electrical Appliances

Earthing is essential for all the equipment with metallic enclosures like; Energy meters, cutouts, fuse unit and SDF. Service cable armor also has to be grounded. Earthing is an important aspect of board wiring considering personal safety which needs to carry out as per following guidelines and IS: 3043.

- Neutral of the service cable should not be connected to earthing at the service end. It is only armor of the cable and the LT switchgear that needs grounding/earthing at the service end.
- A single run of 25 x 3 mm GI strip in the meter room connected to earthing spike in the earth Pit. This GI flat will be earthed at one place and all the other equipment will be connected to this GI flat with 25/50 sq mm aluminum jumpers with crimping at both ends with aluminum lugs.
- Earthing pit of size 1' x 1' x 3' should be provided near the service cable
- Earth resistance measurement is some times difficult, if the ground surface near or in the meter cabin is made using cement concrete. It is therefore essential to have earth measurement pits (of the above
- size) at about three places in one direction with maximum distance form the service cabin/room of 25 meters.
- LT Switchgear earthing to main GI strip by 25 sq mm aluminum at diagonally opposite earthing bolts provided on FU / SDF.
- Cable gland earthing by 25 sq mm aluminum jumper.
- Iron clad cut-out of metal meter body should be earthed using 3/16 bare aluminum wire, as shown in figure.

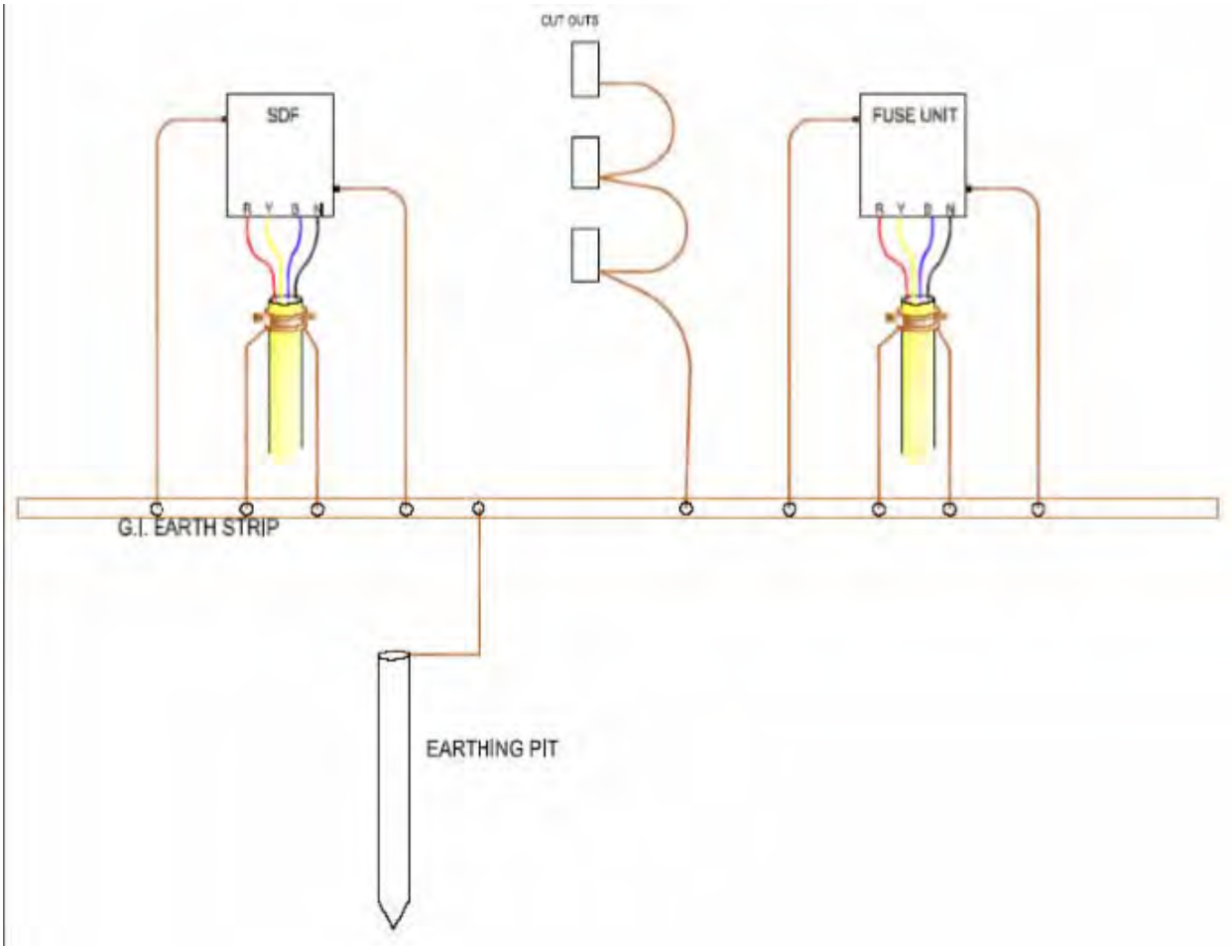

Fig. 7.2.5. Earthing for Electrical Appliances

7.2.7 Electrical Earthing in Domestic Wiring

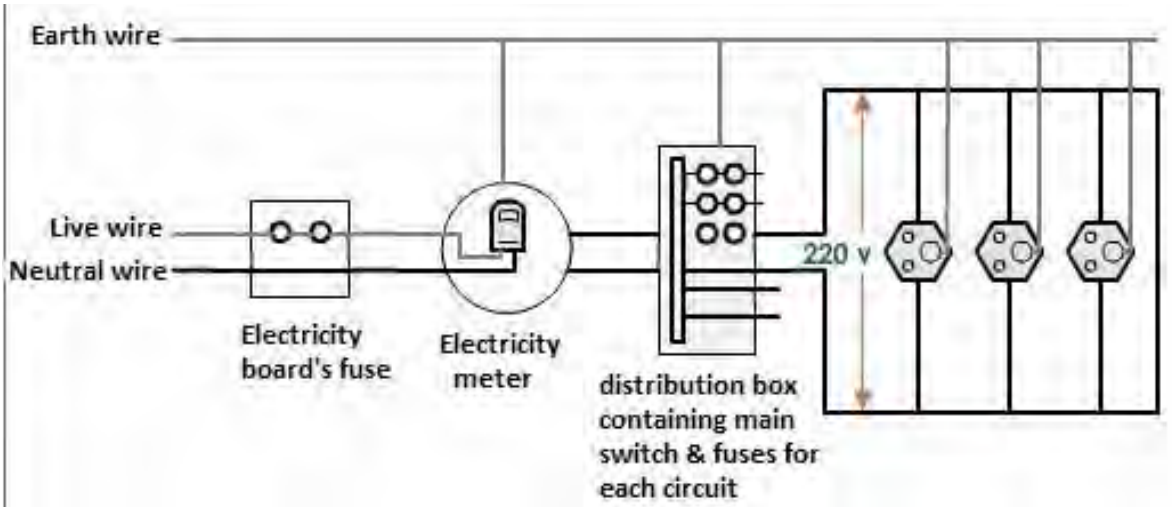

Fig. 7.2.6. Earthing given to common Domestic Circuit

The electric power lines for domestic purposes consist of three wires- namely the live wire, the neutral wire and the earth wire. Colour code is used for insulating the wires. Generally live wire is coded with red colour, neutral wire is given by black and green plastic insulation is given for earth wire.

- The live wire or red wire is carried high potential of 220 volts and neutral wire or green wire has zero potential. So potential difference between these two wires becomes 220 volts.
- The earth wire is much thicker in size and is made of copper. One end of it is connected to a copper plate buried deep under the earth. The earth connection is made to the electric meter and then to the main switch
- In our homes, we receive supply of electric power through a main supply (mains), either supported through overhead electric poles or by underground cables
- The live wire and neutral wire, coming from the electric pole, enter a box fitted just outside our house which has a main fuse F1. The fuse is connected in series with the live wire. This is done so because it is only the live wire which has a high potential of 220 volts unlike the neutral wire which carries zero potential. The fuse F1 has a high rating of about 50 amperes. Thus it prevents any damage such as fire to the entire electrical wiring entering the house due to short-circuit or overloading.
- These two wires enter the electricity meter installed by electric supply department which records the elctric power consumed by consumer.
- These two wires coming out of the meter are then again connected to a main switch which is placed in a distribution box. Another fuse is placed in series with the live wire in this box for the safety of consumer.
- Most of the residential buildings mainly consist of two seprate cuircuit such as lighting cuircuit and power circuit. Lighting circuit have a 5 amphere fuse which is used for running low requirement of electricity, power cuircuit which have 15 amphere is used for running heavy appliances.
- The distribution cuircuits are always connected in parallel combination, because if there is a fault or short-circuiting in any one line, the corresponding fuse blows off and prevents the other cuircuit and appliances from damage.
- As shown in figure, a third wire along with the two wires also connected to the electric meter in the residencial unit. The earth connection is first made to the electric meter and than to the main switch, this wire than goes to the rooms along with the two other wires.

7.2.8 Electrical Earthing in Temporary Panels

- Temporary panel is used to give electrical supply for a short period of time (eg. For construction site)
- If the new construction site in being developed after demolishing a previous site then the cables of the previous site is used for the temporary panel.
- The old meter cabin is removed and cables of the same are excavated.
- A separate wall is constructed after demolition of the site.
- The temporary panel is constructed on this wall.
- In case if the site is being constructed on new grounds then the cable for temporary panel is obtained from the nearest pillar / pole.
- Generally 4 core 25mm or 4 core 50mm cables are used for 3 phase supply or 2 core cables of similar diameter are used for Single phase supply.

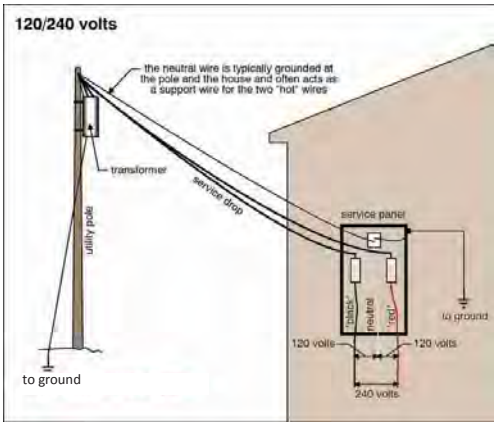

Fig. 7.2.7. Electrical Earthing in Temporary Panels

Fig. 7.2.8 MSB

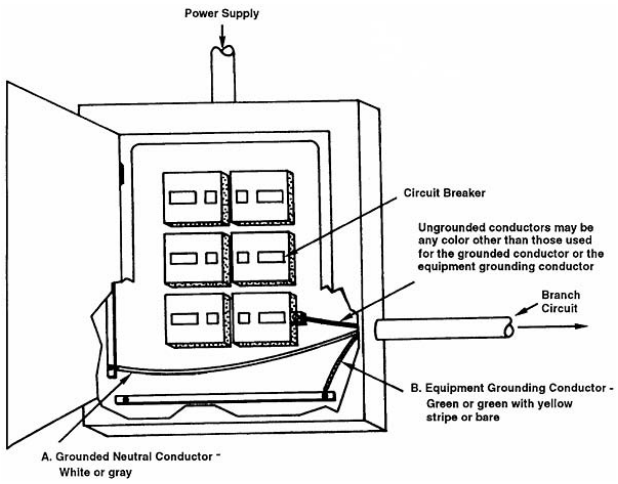

Fig. 7.2.9. MSB Diagram

- The incoming cable can be conveniently inserted in the box from any 4 corners.
- There are 2 links provided for Neutral and Earthing. The link that is in contact with the body is called Earthing link (Here the bottom link)
- Neutral from the cable is connected to Neutral link and Earthing cable to Earthing link.
- The number of Earthing connections is decided according to the requirement of the supply.
- From the Earthing link it is connected to the screw that is provided either on the bottom or upper side of the box.
- For earthing of it a cable is connected between the metal body screw and the earthing point
- For such panels a rod mainly made up of galvanized iron or copper is used as earthing point.
- The length of the rod is approx. 2.5M
- This rod is inserted deep in the ground vertically and part of it is left open to the surface
- This upper surface that remains outside the ground acts as the earthing point.
- So in case if any leakage current is observed it will be passed to the ground by the copper / iron rod.

Exercise

1. State whether the following statements are true or false.
   a. One way of testing ground resistance is with a voltmeter.
   b. It is unsafe to test a live circuit.
   c. When testing with a multimeter, both leads should touch the test wire.
   d. The auxiliary ground method requires the use of a multimeter.
   e. Earthing is used to prevent shocks.
   f. Plate earthing is more effective than pipe earthing.
   g. Earthing protects buildings from earthquakes.

2. Tick the correct options.
   a. In the auxiliary ground method, the ground stick should be pitched:
      i. 1.22 meters deep
      ii. 2.44 meters deep
      iii. 3.66 meters deep
   b. When measuring ground resistance with an ohmmeter, the wire should be connected to:
      i. A copper pole
      ii. An earthing pin
      iii. A metal stak
   c. The two types of earthing are:
      i. Plate Earthing
      ii. Pipe Earthing
      iii. Pan Earthing
   d. Which of the following is used to reduce earth resistance?
      i. Sugar
      ii. Salt
      iii. Charcoal
   e. Earthing is placed:
      i. About 1 meter underground
      ii. About 3 meters underground
      iii. About 5 meters underground

3. Fill in the blanks
   a. _____ refers to the electrical connection to the general mass of earth.
   b. _____ is a panel formed for connecting electrical circuit which is used at construction site for doing electrical work to the main power supply.

4. List the procedure for pipe earthing

   _____

   _____

5. List the procedure for plate earthing

   _____

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8. Installation and Maintenance of Temporary LV Electrical Panels

Unit 8.1 – Installation and Maintenance of Temporary LV Electrical Panels

Unit 8.2 – Faults Associated with Temporary Electrical Panels

CON/N0605

Key Learning Outcomes

At the end of this unit, you will be able to:

1. Describe the method of connecting temporary panel/DBs with main power outlet.
2. Describe the method of electrical termination at power outlets using appropriate fixtures.
3. Explain the standard procedure of shifting and installing DBs among different work location.
4. List the types of faults associated with temporary electrical panels/DBs and its accessories.

UNIT 8.1: Installation and Maintenance of Temporary LV Electrical Panels

Unit Objectives

At the end of this unit, you will be able to:

1. Describe the method of connecting temporary panel/DBs with main power outlet.
2. Describe the method of electrical termination at power outlets using appropriate fixtures.
3. Explain the standard procedure of shifting and installing DBs among different work location.

8.1.1 Connecting Temporary Panel/DBs with Main Power Outlet

Temporary panel is only allowed for:

- construction, remodeling, maintenance, repair, or demolition of buildings, structures, or equipment;
- emergencies, tests, experiments, and developmental work.

Hence, temporary panel must be removed immediately upon completion of construction or the purpose for which it was installed.

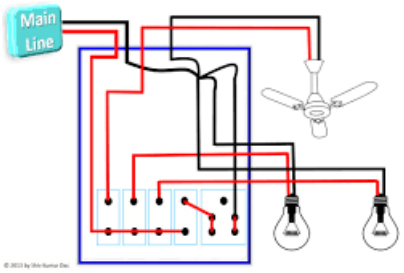


Fig. 8.1.1 . Connecting distribution panel with main board

8.1.1.1 Procedure for Connecting Temporary Panel

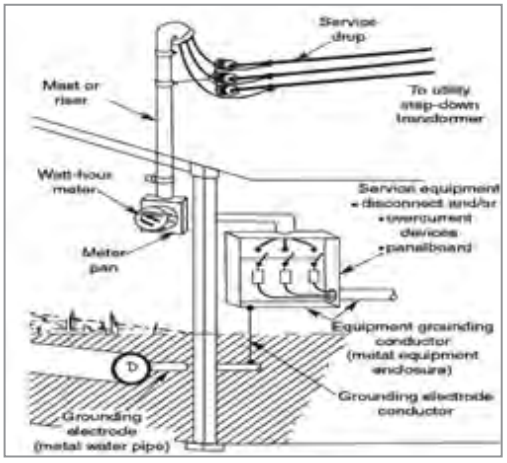


Fig. 8.1.2. Connection of Temporary Panel with Overhead Transmission Line

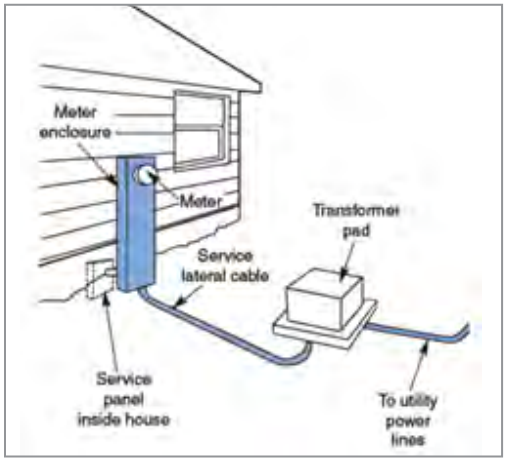


Fig. 8.1.3. Connection of Temporary Panel to Underground Cable

Step 1: Calculate the requirement of the load at construction site.

Step 2: Depending upon the load, decide the rating of the panel.

Step 3: Use safety equipment according to the rating of the load.

Step 4: Use cross sectional area of the conductor, according to current rating of the load.

Step 5: Ensure that the energy meter and SFU(switching fuse unit) unit is connected between temporary panel and main supply

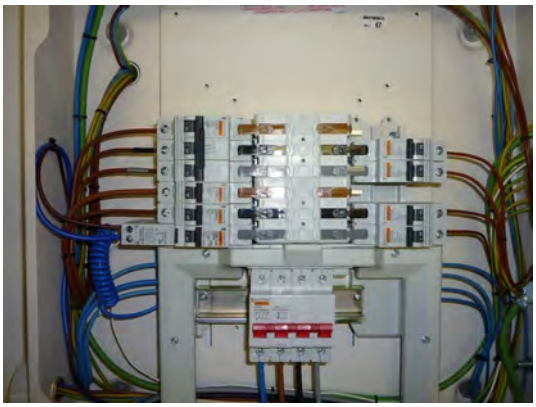
Step 6: The outgoing of the SFU should be the incoming for the temporary panel.

Step 7: Depending on the rating of panel and if the main supply has more voltage rating, then step down the transformer connected to the temporary panel.

- The output of the transformer i.e. R,Y,B and neutral connection of the transformer is given to temporary panel.
- Earthing is provided to the whole panel.
- Inside the temporary panel, there are safety devices such as fuse in each line and MCB,GFCI connection is given for the safety protection.
- Outgoing terminals of the panel through these safety devices are then given to the various switchboards.

8.1.2 Electrical Termination at Power Outlets

Take a look at the steps for electrical termination at power outlets using appropriate fixtures



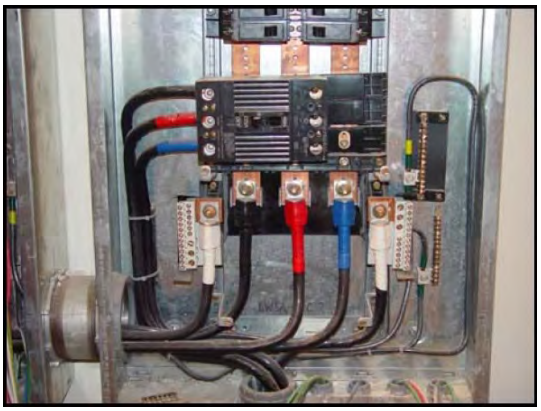


Fig. 8.1.4. Electrical termination

8.1.2.1 Procedure for Electrical Termination at Power Outlets using Appropriate Fixtures

Step 1: Place all the cables in proper conduit.

Step 2: Ensure that branch circuits originate in an approved power outlet or panel board.

Step 3: Make sure that cables are not laid on the ground.

Step 4: Ensure no bare conductors nor earth returns are being used for the wiring of any temporary circuit.

Step 4: Ensure no bare conductors nor earth returns are being used for the wiring of any temporary circuit.

Step 5: Check that branch circuits which supply receptacles or fixed equipment contain a separate equipment grounding conductor, if they run as open conductors.

Step 6: The mechanical strength of the conduits should be proper as it has to protect the cable from concrete and other raw materials used at construction.

Step 7: Support the cable assemblies and flexible cords and cables in place at proper intervals to ensure they are protected from physical damage. Support shall be in the form of staples, cables ties, straps, or similar type fittings installed so as not to cause damage.

Step 8: Install suitable disconnecting switches or plug connectors to permit the disconnection of all ungrounded conductors of each temporary circuit.

Step 9: Keep the corner point cable should flexible to avoid any breaking of insulation.

Step 10: Connect the conduit or raceway which carries all the conductors to the switchboard.

8.1.3 Shifting and Installing DBs

Take a look at the steps for Shifting and Installing DBs

8.1.3.1 Procedure of Shifting and Installing DBs

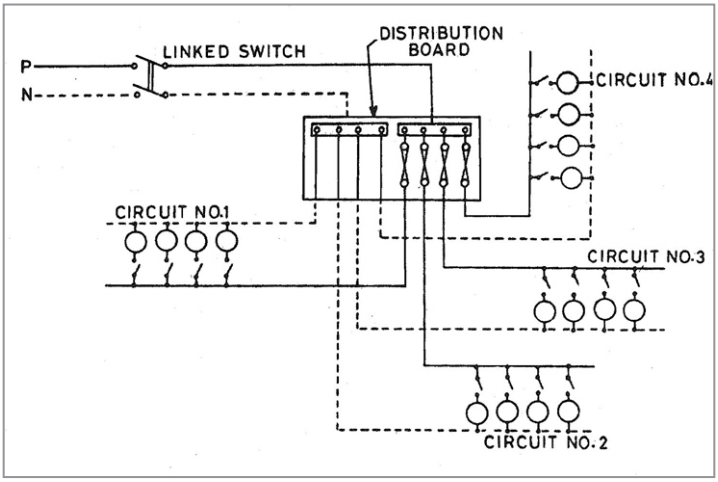


Fig. 8.1.5. Procedure for Shifting and Installing DBs among Different Locations

Step 1: Switch off the temporary panel with the help of the SFU unit and disconnect it from main supply

Step 2: Switch off the initial DB which is connected to the temporary panel by disconnecting the whole load of that DB.

Step 3: With the help of switches connected to the bus bar, disconnect the initial DB.

Step 4: Connect SFU to the temporary panel. Now, the temporary panel is connected the main supply lines.

Step 5: Check that the bus bar which is connected to the temporary panel consists of various feeder lines which are connected to each DB.

Step 6: With the help of switches connected to the bus bar, the other feeder lines which are connected to the other DB will switch on.

The power from temporary panel will flow through the new DB.

Exercise

1. Fill in the blanks

   a. _____ panel is only allowed for construction, remodeling, maintenance, repair, or demolition of buildings, structures, or equipment.

   b. The _____ strength of the conduits should be proper as it has to protect the cable from concrete and other raw materials used at construction.

UNIT 8.2: Faults Associated with Temporary Electrical Panels

Unit Objectives

At the end of this unit, you will be able to:

1. List the types of faults associated with temporary electrical panels/DBs and its accessories.

8.2.1 Faults Associated with Temporary Electrical Panels

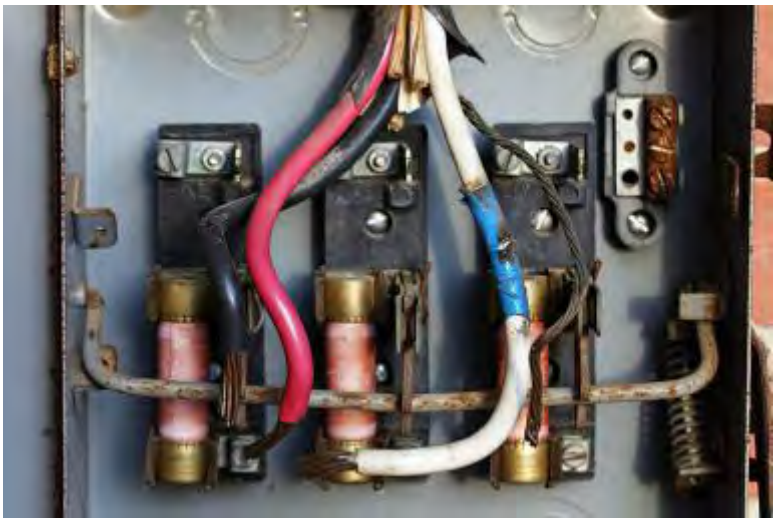


Fig. 8.2.1. Faults in Temporary Panel

Sr. no	Type of Fault	Description
1.	Short circuit fault/phase to phase fault	This fault takes place due to overloading of current. In such a case, heavy current flowing through the wire leads to rise in temperature. This results in insulation failure and current carrying conductors come in contact with each other. This is how short circuit takes place.
2.	Earth fault	This fault occurs if earthing is not proper in the circuit. In this case, resistance of the earthing is more than the rated resistance. It results in opposition to the flow for earthing current. Thus, the current which flow through the earthing wire will not pass.
3.	Leakage fault	This is a current which flows through the outer body of the panel. It happens when the earthing is not proper. The person operating such a panel can suffer from a shock.
4.	Open circuit fault	When any of the current carrying conductor breaks down, open circuit occurs. This results in no continuity of supply in the circuit.
5.	Faults caused by external factors	If DBs are not located at the correct place, they may get damaged due to concrete falling on them.

Sr. no	Type of Fault	Description
6.	Safety equipment fault	This fault occurs if the fuses, circuit breakers, MCBs, etc. connected in the panel are not proper, i.e. they are not connected according to the load capacity of the circuit. In this case, although there is no overloading in the circuit, these safety devices, which are connected to the panel, will operate. For e.g. Metallic link of the fuse will melt at rated current and circuit interruption may take place.
7.	GFCI fault	If the GFCI (Ground fault current interruption) is not proper, then the fault current will not bypass in the ground through the ground wire.
8.	Cable line fault	If the cable line passing from the corners or edges of the construction site is not covered properly, there is a chance of breakdown of conductor as well as short circuit of the conductor.

Exercise

1. Fill in the blanks

   a. _____ fault takes place due to overloading of current.

   b. Leakage fault is the _____ flows through the outer body of the panel.

   c. If the _____ is not proper, then the fault current will not bypass in the ground through the ground wire.

Notes

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9. Tests and Quality Checks

Unit 9.1 – Tests and Quality Checks

CON/N0602
CON/N0603
CON/N0604
CON/N 0605

Key Learning Outcomes

At the end of this unit, you will be able to:

1. List the type of tests to be undertaken in lighting units and its accessories.
2. State the methods to trace out short circuit, power interruptions/continuity using appropriate electrical devices.
3. Recall the tests to be done to ensure that there is no breakage/leakage from the wire.
4. List the tests to be performed in domestic electrical wiring works using appropriate measuring devices.
5. State the type of tests to be undertaken in temporary panels/DBs and its accessories.

UNIT 9.1: Tests and Quality Checks

Unit Objectives

At the end of this unit, you will be able to:

1. List the type of tests to be undertaken in lighting units and its accessories.
2. State the methods to trace out short circuit, power interruptions/continuity using appropriate electrical devices.
3. Recall the tests to be done to ensure that there is no breakage/leakage from the wire.
4. List the tests to be performed in domestic electrical wiring works using appropriate measuring devices.
5. State the type of tests to be undertaken in temporary panels/DBs and its accessories.

9.1.1 Testing Lighting Units and Accessories

Providing the correct intensity of light and color spectrum is extremely important because:

- over-illumination can lead to loss of energy
- it can adversely affect the health of those using it;
- excess light can affect the efficiency of workers.

Now let us understand how to check and assemble a tube light (fluorescent lamp) and its accessories. For this activity, you will require:

- Tool kit
- Nose pliers
- Hand drilling machine with a 6.3mm drill bit
- Hammer
- Flourescent tube light fitting
- Two-way connector
- PVC power cable
- Raw plug no. 10
- Wood screws
- Test lamp
- BC lamp
- Switchboard

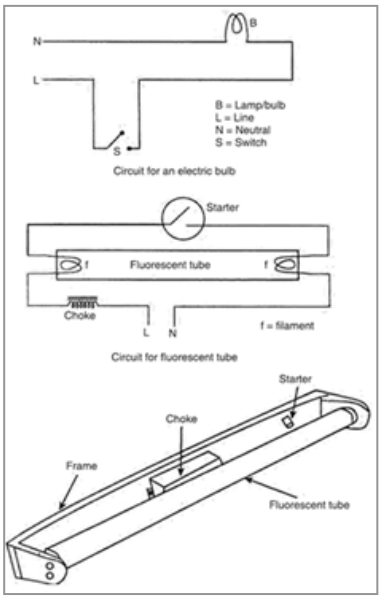

Fig. 9.1.1. Assembling a tubelight

9.1.1.1 Procedure for Testing Lighting Units

Step 1: Check the choke for its short.

Step 2: Open with a test lamp.

Step 3: Record the results.

Step 4: To test the starter, connect the starter with a series test lamp.

Step 5: Observe the flickering of the lamp.

- This indicates that the starter is in good condition.
- If there is no flickering, it means the starter is defective.

Step 6: Make the connection to test the filament on both sides of the fluorescent tube for its continuity.

- If the tube is in good condition, the lamp will glow normally.
- If the filament is not glowing, it means the tube has burnt out.

Step 7: Discard the fluorescent tube if there is an open or fused filament on either side of the tube.

Step 8: Assemble the fluorescent tube accessories like starter, holder, choke in the fitting base with the help of screws.

Step 9: Fix the tube in the tube holder.

Always ensure that:

- lamps are connected at proper angle and at proper height;
- the place where the light is connected is dry;
- the outer surface of the lamps is clean and gives proper illumination;
- the power rating of the lamp selected is according to area where the work has to be done;
- the wiring which connects the lamp to lamp holder should be proper i. the insulation of wiring should be proper.

Testing for Accessories

Always make sure that,

- the fixtures should be proper;
- the lamp holder should be damage free;
- the phase, neutral, earthing point in the switchboard is proper.

9.1.2 Tracing Short Circuits, Power Interruptions and Continuity

When two conductors come in contact with each other (i.e. phase and neutral conductor) due to improper insulation, short circuit takes place in the circuit. Due to this, heavy current starts flowing through the circuit and the person who is operating the circuit suffers from a shock.

9.1.2 Tracing Short Circuits, Power Interruptions and Continuity

Tracing Short Circuits

- Keep multimeter terminal at resistance side.
- Connect two terminals of multimeter to switchboard.
  - Two terminals means phase and neutral or neutral and earthing.
- If multimeter gives zero resistance reading, then there is short circuit

Tracing Power Interruptions

Power interruptions in the circuit take place when:

- there is breakdown of any conductor in the circuit;
- the plug is not inserted properly in the supply;
- the safety devices used are not proper;
- the metallic link of the fuse is not proper.

Power interruption takes place when there is an open circuit.

Testing for Open Circuits

- Keep multimeter terminal at resistance side.
- Connect two terminals of multimeter to switchboard two terminals.
- If multimeter gives mega ohm resistance reading, then there is open circuit.

Testing for Earth Fault

- Keep multimeter terminal at voltage side.
- Connect two terminals of multimeter to switch board two terminals i.e. neutral earthing.
- If multimeter shows some voltage reading, then there is earth fault.

Performing Continuity Test

There are 3 main types of continuity tests for the final circuits:-

1. Protection Conductor Continuity Test.
2. Final Ring Circuit Conductor Continuity Test.
3. Live and Neutral Conductor Continuity Test.

1. Protection Conductor Continuity Test

- To ensure that all protection conductors are connected in the correct and effective manner.

  Test equipment – Multimeter (Ohm range) or Ohm meter.

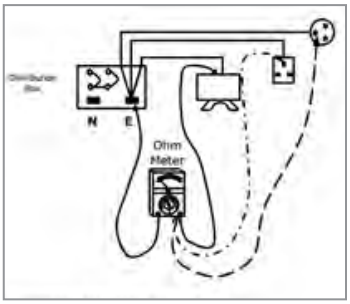

Fig. 9.1.2. Protection Conductor Continuity Test

Test Method:

Step 1: Ensure that the main switch, MCB are open circuited (switched off) and all loads are disconnected.

Step 2: Connect the test leads as shown in the figure.

- The meter reading should be less than 1 ohm.

2. Final Ring Circuit Conductor Continuity Test

- To make sure that all conductors around the ring circuit have continuity

  Test Equipment – Multimeter (Ohm range) or Ohm Meter

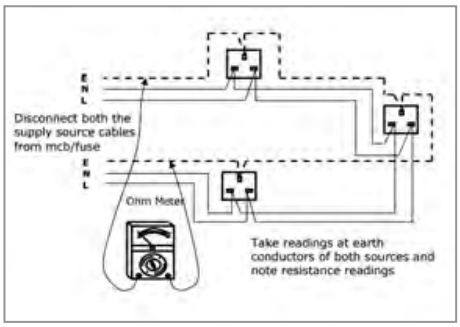

Fig. 9.1.3. Final ring circuit conductor continuity test

Test Method:

Step 1: Disconnect both the supply source live conductors from the MCB, the neutral conductor from the neutral terminals and the earth conductor from the earth terminal in the distribution fuse box.

Step 2: Connect the test leads as in the figure.

Step 3: Repeat the procedure for live to live and neutral to neutral.

- The meter reading value should be less than 1 ohm.

3. Live and Neutral Conductor Continuity Test

- To ensure that each conductor in the circuit has continuity;

  Test Equipment – Multimeter (Ohm range) or Ohm Meter

Test Method:

Step 1: Switch off the mains, RCD and MCB.

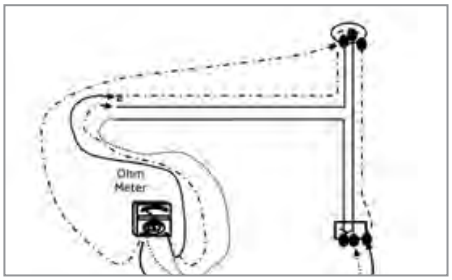

Fig. 9.1.4. Live and neutral conductor continuity test

Step 2: Disconnect all loads.

Step 3: Switch on all switches in the circuit.

Step 4: Disconnect the fuses/final circuit breakers and close the circuit.

Step 5: Carry out the test as shown the figure.

Step 6: Connect two terminals of multimeter to two end terminals of phase conductor.

- The meter reading value shall be less than 1 ohm.

9.1.3 Quality Checks for Domestic Electrical Wiring Works

Quality checks for domestic electrical wiring works is done at four levels:

1. Initial testing of an installation
   - This includes electrical continuity and conductivity tests of conductors.
   - It also tests the insulation resistance of live conductors and protective conductors connected to the earthing arrangement.
   - It tests the compliance of SELV (Safety Extra Low Voltage) and PELV (Protection by Extra Low Voltage) circuits for electrical separation.
   - It includes checking the insulation resistance/impedance of floors and walls.
   - It includes checking the protection by automatic disconnection of the supply.
2. Putting existing electrical installations out of danger
   - It includes replacing defective electrical installations with a new one.
3. Periodic testing of installation
   - This includes checking the effectiveness and adjustments of RCD, MCB and fuse.
   - It helps to make sure that appropriate measures are taken for ensuring safety of persons against effects of electric shock and protection against damage to property against fire and heat
   - It helps to ensure that the installation is not damaged in any way.
   - It helps to identify defects in a timely manner.
4. Assessing the conformity of equipment
   - It helps to ensure quality assurance for equipment used.

When these control procedures are followed diligently, quality and safety is assured. This can also be ensured when:

- The design has been done according to the latest edition of the appropriate wiring rules.
- The electrical equipments comply with relevant product standards.
- The initial checking of conformity of the electrical installation with the standard and regulation has been achieved.

9.1.4 Quality Checks for Temporary Panels

Temporary power panels or power outlet panels (POP) provide safe and reliable temporary power for construction sites. When performing quality check for temporary panels, you must ensure that:

- earthing (GFCI) should be proper;
- MCB should be proper;
- insulation of the wiring should be proper;

- conductor size should be according to current carrying capacity of the wire;
- temporary panel should be properly covered from water;
- panel is given proper protection against lightning;
- clip on meter is there to check leakage current is flowing through the neutral.

Exercise

1. Fill in the blanks

   a. Over-illumination can lead to loss of _____.

   b. Always ensure that the lamp holder is _____ free.

Notes

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