ELECTRICAL WIRING

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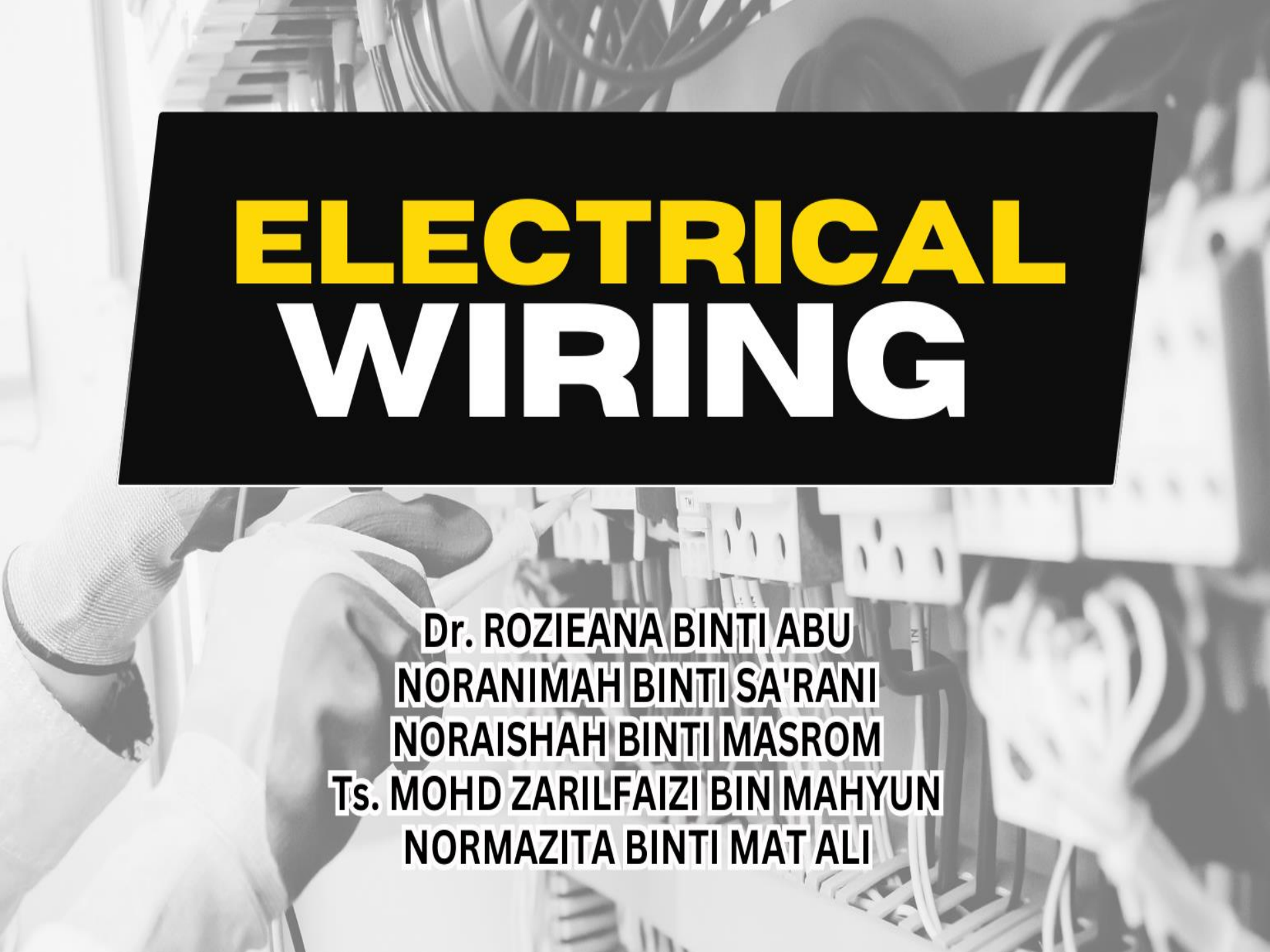

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PREFACE

e-Book for Electrical Wiring: Student Edition

This e-book is a compilation of notes tailored for students pursuing a Diploma in Electrical and Instrumentation under the Department of Petrochemical Engineering at Tun Syed Nasir Syed Ismail Polytechnic, as well as undergraduate students new to the field of electrical studies. It is particularly relevant for those studying disciplines such as electrical engineering, electronics engineering, mechatronics engineering, and instrumentation engineering.

Designed as a self-study aid, the content is systematically organized to align with the curriculum requirements of major public and private universities in Malaysia. This e-book provides comprehensive notes on basic electrical wiring, making it highly suitable for beginner learners.

The e-book is divided into eight units, each covering essential topics in electrical wiring as outlined by the Ministry of Higher Education. Every section within the e-book offers step-by-step explanations, enabling students to understand the theoretical principles, processes, and concepts underlying electrical wiring practices.

Although primarily intended for diploma and undergraduate students, this resource is equally valuable for secondary school and Kolej Vokasional students seeking foundational knowledge in electrical wiring.

We sincerely hope this e-book proves to be a beneficial and practical resource for its users. Feedback, including constructive criticism and suggestions, is welcomed and greatly appreciated to improve future editions.

CONTENT

ELECTRICAL WIRING
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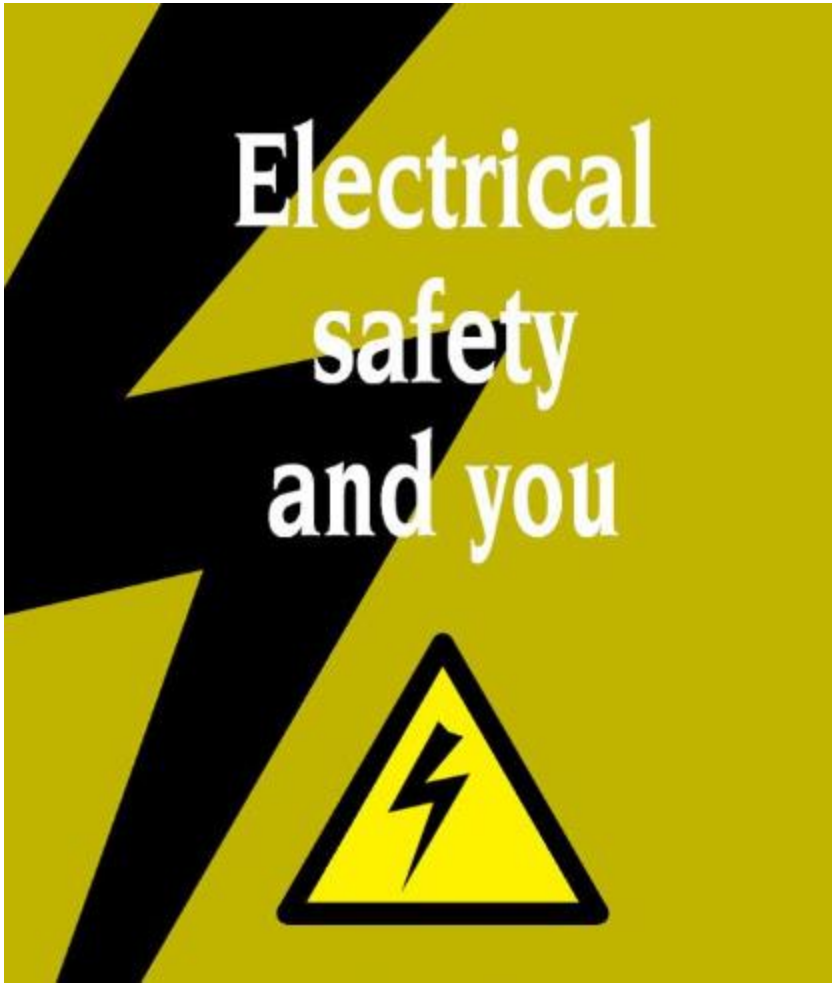
CONTENT

SAFETY IN ELECTRICAL WORK



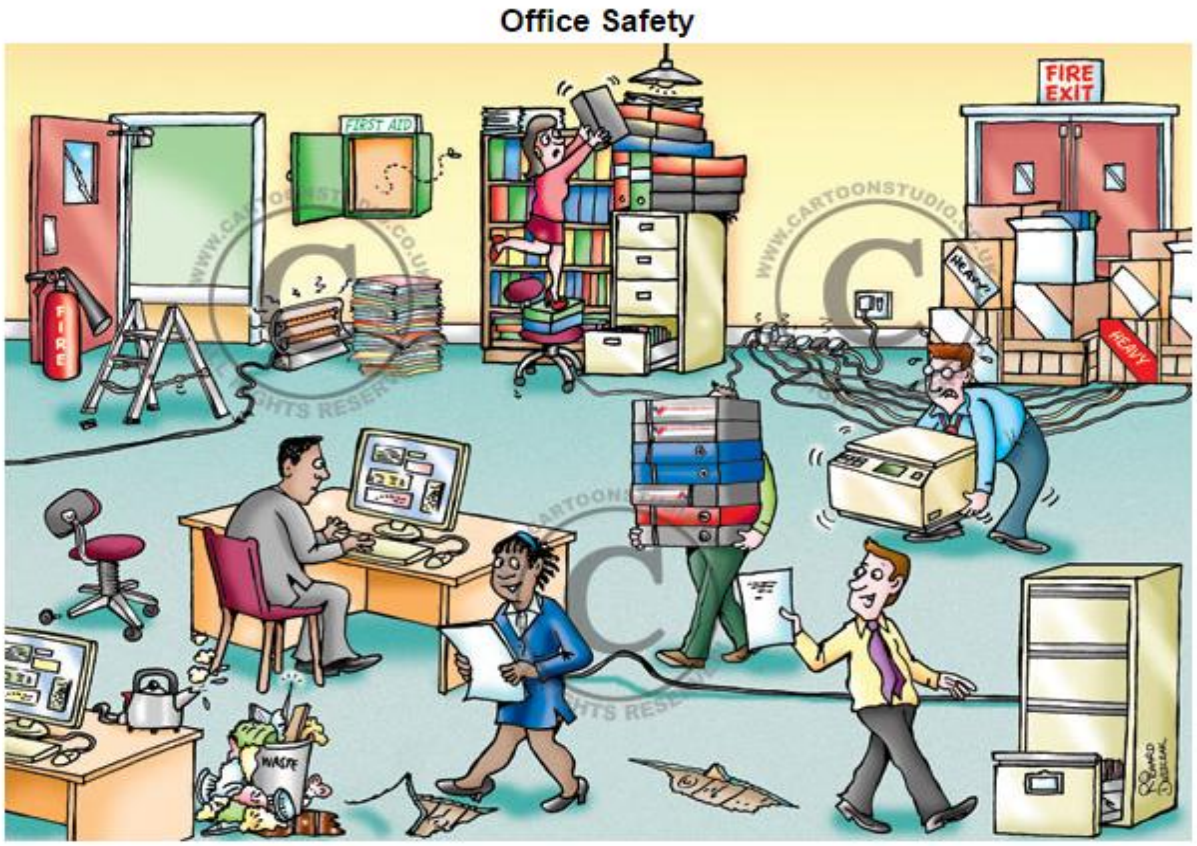

Electricity - a great friend...a deadly enemy!


Just Say ...
NO To Electrical Hazards
ON
OFF
Before you turn it on, make sure you say no to the following:
✔ Are outlets, motors or circuits overloaded?
✔ Are cords running near heat or water sources?
✔ Are cords twisted or tangled?
✔ Do I see sparks or smoke?
✔ Are my hands wet?
✔ Am I wearing any metal jewelry?

UNIT 1 HEALTH AND SAFETY

Activity 1 : Identify the problems

Safety Quote: Prepare & prevent instead of repair & repent.



UNIT 1 HEALTH AND SAFETY

Activity 1 : Identify the problems

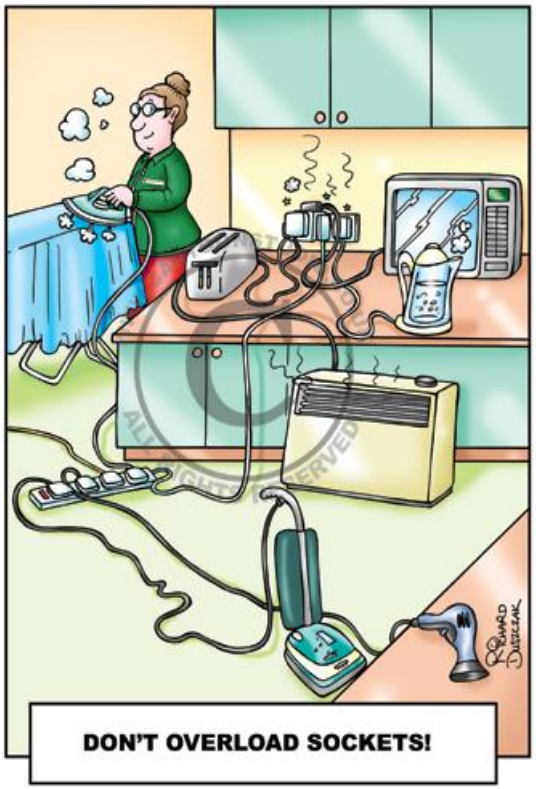
UNIT 1 HEALTH AND SAFETY

Activity 1 : Identify the problems

UNIT 1 HEALTH AND SAFETY

Activity 1 : Identify the problems

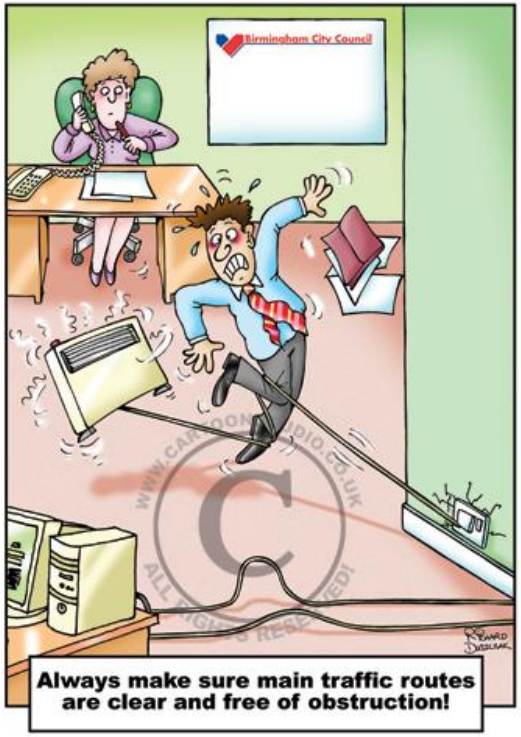
Overloaded Socket!



Safety Quote: Ignoring a warning can cause much mourning.

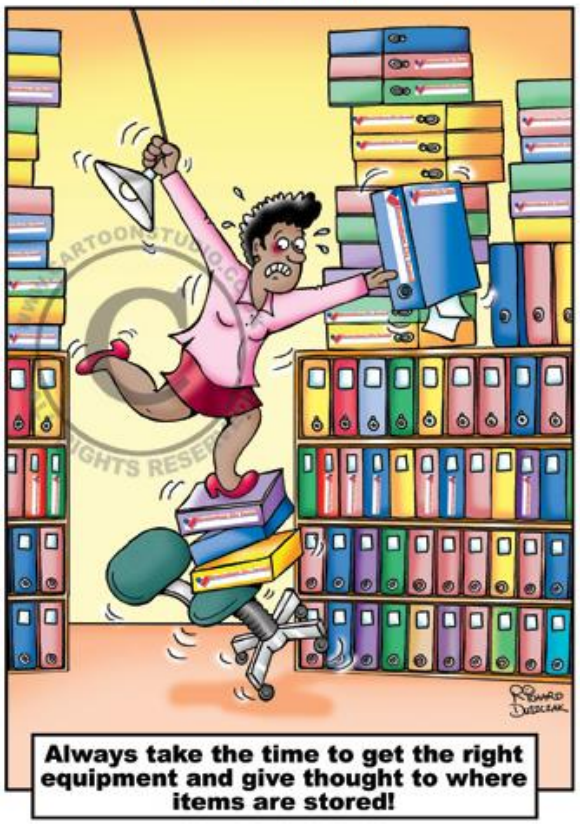
Safety Quote: Open the Door to Safety: Awareness is the Key!

Trip Hazard



UNIT 1 HEALTH AND SAFETY

Activity 1 : Identify the problems



Safety Quote: Working safely may get old, but so do those who practice it.

ZERO HARM OR ZERO RISK HOW CAN WE DO THE BEST WE CAN?

OSHA STANDARD FOR ELECTRICAL SAFETY

WORK PROCEDURES, TOOLS, AND PPE

- OSHA 1910.333 outlines the standards for choosing and applying safe work practices related to electrical safety in the workplace. Under OSHA 1910.333(a), the general requirement specifies that employers must adopt safe practices to protect workers from electrical hazards when working on or near exposed energized parts or performing electrical tasks. This includes ensuring proper grounding, following lockout/tagout procedures, and providing the appropriate personal protective equipment (PPE) to minimize the risk of electrical shock or arc flash injuries.

- OSHA 1910.335 and NFPA 70E-2000, Part II, Chapter 3 provide detailed requirements for insulated tools, safety measures, and different types of personal protective equipment.

ELECTRICAL SAFETY

ELECTRICAL ACCIDENTS are caused by several factors such as:

i. unsafe equipment and / or installation e.g. loose connections, faulty insulation, improper grounding

ii. unsafe work environment or working in potentially hazardous environments or situations e.g. static discharge, combustible dust, corrosive atmospheres, explosive environments, poor housekeeping, wet or damp location

iii. unsafe work practices

SAFETY IN ELECTRICAL WORK

ELECTRICAL HAZARDS

Hazard mean anything which can cause harm

are caused by several factors such as:

i hazard caused by over current flow that can damage equipments, cable, and eventually lead to fire

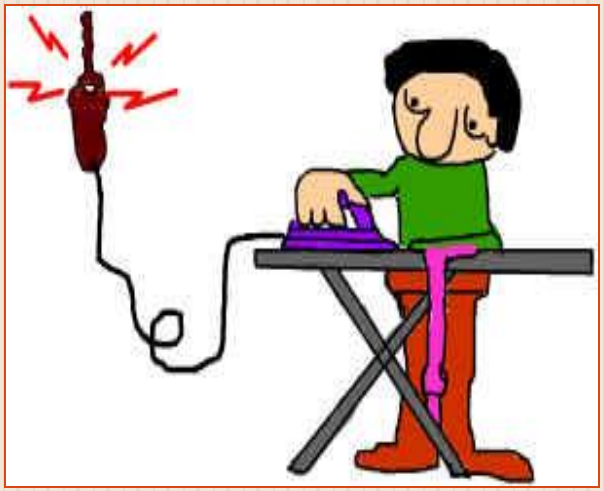
ii dangers due to leakage current to the ground that can caused electrocution or fire,

iii dangers that causes electrocution or fire while working on repairing, maintenance or installation or additional circuits

ELECTRICAL HAZARDS

Here are some hazards associated with electricity:

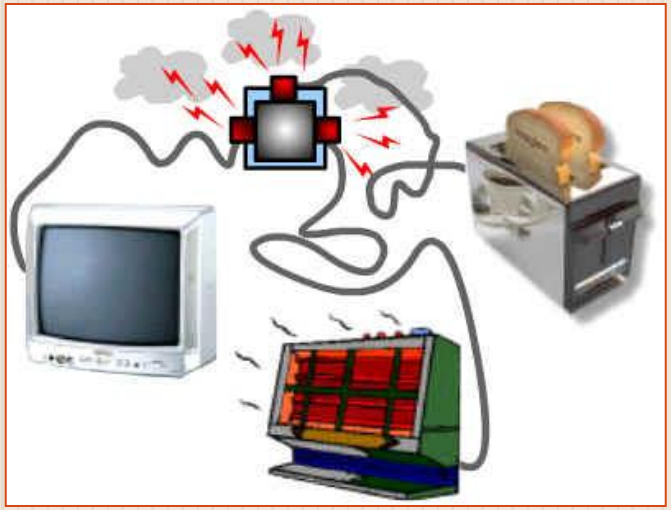
1. Only plug light bulbs into light sockets; do not use them for other devices.



2. Ensure that leads are not damaged, frayed, cut, or exposed at any point.

ELECTRICAL HAZARDS

3. Avoid overloading electrical sockets.

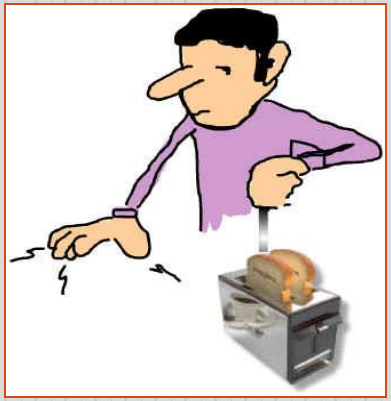


4. Do not place extension cords in the bathroom.

ELECTRICAL HAZARDS

5. Always unplug the device before changing fuses or filling an electric kettle. Do not rely solely on switches, as they may malfunction and the "OFF" position could still be live.

6. Do not poke into sockets or electrical equipment.



ELECTRICAL HAZARDS

Precautions

- Keep fingers and objects away from electrical outlets.
- Never touch electrical items when you are wet.
- Avoid using radios, hair dryers, or any electrical appliance near a bathtub or pool.
- Stay clear of utility electrical equipment, such as transformers and meters.
- Always disconnect appliances by pulling the plug, not by tugging the cord.
- Follow all safety signs.

SAFETY IN ELECTRICAL WORK

3 major controlled methods:

- Isolation
- Over current protection (over load and short circuit)
- Earth leakage current protection

SAFETY IN ELECTRICAL WORK

In electrical installation safety 3 important factors to remember

1. Self safety
2. Working environment safety
3. Working practices safety

SAFETY IN ELECTRICAL WORK

1. Self safety

a. Wear appropriate personal protective equipment (PPE) such as safety shoes, gloves, and helmets when working.
b. Use safety clothing that is appropriate for the specific tasks being performed.
c. Avoid wearing jewelry or decorative items like rings, watches, and chains while performing electrical work.

SAFETY IN ELECTRICAL WORK

Electrical installation practices

- Ladder safety
- Procedures to avoid of wet working conditions and other danger
- Procedures to avoid of overhead power lines
- Procedures to install or test new wiring, additional wiring, old wiring
- Select proper wiring cables, cables marking
- Use and maintain tools properly

SAFETY IN ELECTRICAL WORK

Working environment safety

- Labels the circuits and equipment
- Use the right size and type of cables
- Using isolation devices to prevent the exposure to live electrical part
- Using insulation to prevent the exposure to wires and parts
- Grounding the electrical system
- Using over current protection devices to prevent current flowing in circuit

SAFETY IN ELECTRICAL WORK

Safety at the work place

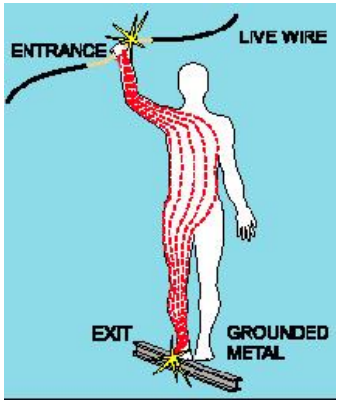
a. Gain knowledge about the potential dangers of electrical work and how to handle them.
b. Always follow the established safety regulations for the workplace.
c. Make sure the electricity supply is turned off before starting any electrical work.
d. Use electrical equipment that is in good working condition and ensure it is supplied through a residual current device (RCD) with a sensitivity of 30 mA.
e. Ensure that exposed temporary supply cables are properly protected from mechanical damage.

SAFETY IN ELECTRICAL WORK

Hazards of Electrical Shocks:

- Electrical shocks can happen from either direct or indirect contact:
- **Direct Contact:** This occurs when a person comes into physical contact with exposed live electrical parts, such as wires or electrical outlets, which can lead to immediate shock.
- **Indirect Contact:** This occurs when a person touches a conductive object that is connected to a live electrical source, such as metal parts of a tool or equipment that has become energized due to faulty wiring or grounding.

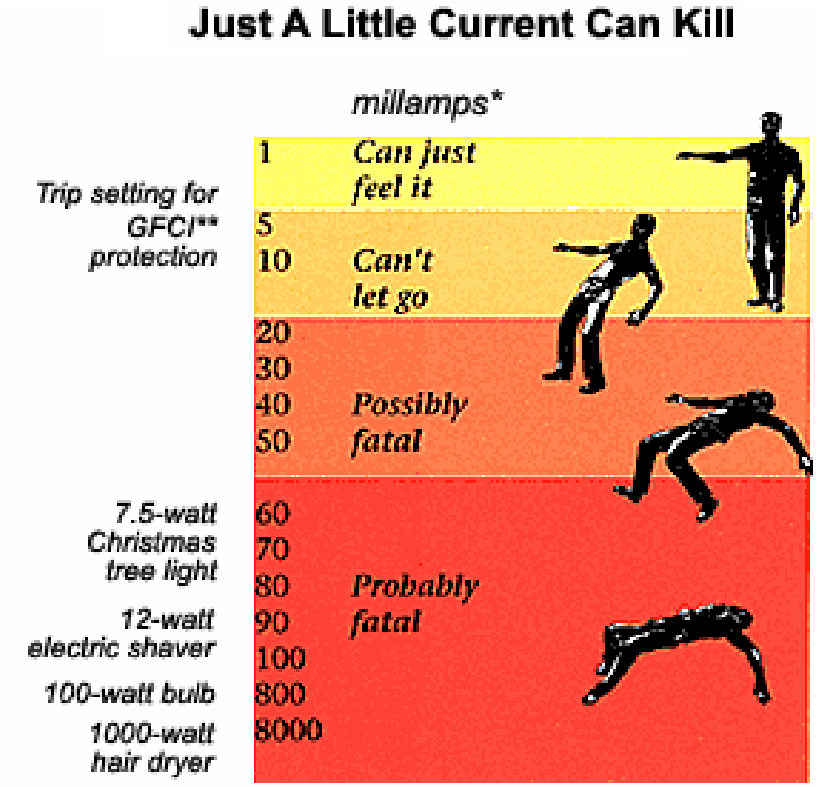
SAFETY IN ELECTRICAL WORK



ELECTRICAL SHOCK

- An electrical shock occurs when electric current passes through the body.
- The severity of the shock depends on several factors:
- **Path of Current:** The route the electrical current takes through the body affects the damage. For example, current passing through the heart or brain is more dangerous than through a finger or toe.
- **Amount of Current:** The strength of the current flowing through the body plays a critical role in determining the shock's severity. Higher current increases the risk of severe injury or death.
- **Duration of Exposure:** The longer the body remains in contact with the electrical source, the greater the damage. Prolonged exposure can lead to more serious injuries or fatal outcomes.

SAFETY IN ELECTRICAL WORK



* A milliamp is 1/1000th of an ampere, a measure of electrical current
**A GFCI is a Ground Fault Circuit Interrupter, a device which protects against serious shock.

SAFETY IN ELECTRICAL WORK

DANGER OF ELECTRICAL SHOCK

i. Currents greater than 75 mA can cause ventricular fibrillation, a condition where the heart beats rapidly and ineffectively. This can lead to death within a few minutes unless a defibrillator is used to restore normal heart rhythm.

ii. It's important to note that 75 mA is a relatively small amount of current – for comparison, a small power drill uses 30 times this amount of current.

iii. This highlights the danger of even seemingly low levels of electrical current when they pass through the body.

ELECTRICAL SHOCK

Why Electric Shocks Occur?

- **Unsafe Work Methods or Actions**

  i. **Undertaking Electrical Work Without Disconnecting the Supply**: Performing maintenance or circuit testing without first disconnecting the electrical supply increases the risk of electrical shocks. Working on live circuits can lead to accidental contact with energized parts, resulting in shocks.

  ii. **Not Following Safe Work Procedures**:
  Electrical shocks are more likely to occur when workers do not adhere to established safety protocols and standards. It is crucial for workers to always follow the set safety guidelines to prevent accidents and reduce the risk of electrical injuries.

ELECTRICAL SHOCK

Defects in the Electrical System

i. **Leakage Current**

Leakage currents, also known as earth leakage currents, can cause metallic frames of electrical equipment to become live and energized. If workers, consumers, or the public come into contact with these metallic frames, they are at risk of receiving an electrical shock.

ii. **Exposed Conductor or Disconnected Cable**

Exposed or broken conductors and cables that are still live (energized) pose a serious shock hazard. If touched, they can deliver a dangerous electrical shock. In such cases, the power supply should be immediately isolated or switched off, and the issue must be reported to the responsible authority for further action.

SAFETY IN ELECTRICAL WORK

First Aid and Basic Pulmonary Resuscitation

- **First Aid**
  First aid refers to the immediate help provided to someone who has experienced an accident, illness, or injury. The goal is to prevent the condition from worsening while waiting for paramedics (ambulance) to arrive or before the person is transported to the hospital for further medical treatment.

SAFETY IN ELECTRICAL WORK

- **Pulmonary Resuscitation**
  Pulmonary resuscitation (CPR) should be performed on a person who is experiencing difficulty breathing due to causes such as drowning, electrical shock, or similar incidents. CPR must be conducted following the proper techniques outlined in first aid manuals provided by accredited first aid organizations.

SAFETY IN ELECTRICAL WORK

- Cardio Pulmonary Resuscitation (CPR)

(**Mouth to Mouth Ventilations)**

- Holger Nielson Technique
- Silvester Technique
- Schafer Technique

SAFETY IN ELECTRICAL WORK

- **First Aid Kit**
  The building owner, construction site supervisor, or the worker themselves, under the supervision of the responsible person, must provide a first aid kit.

SAFETY IN ELECTRICAL WORK

- **Fire Prevention**
  Fire Extinguisher
  A proper and functional fire extinguisher must be available at the workplace at all times to control potential fires.

SAFETY IN ELECTRICAL WORK

Class A fires are fires in **ordinary combustibles** such as **wood, paper, cloth, trash, and plastics**.

Class B fires are fires in **flammable liquids** such as **gasoline, petroleum oil** and **paint**.
Class B fires also include **flammable gases** such as **propane** and **butane**. Class B fires do not include fires involving cooking oils and grease.

Class C fires are fires involving **energized electrical equipment** such as **motors, transformers**, and **appliances**. Remove the power and the Class C fire becomes one of the other classes of fire.

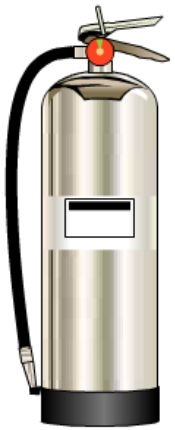
Class D fires are fires in **combustible metals** such as **potassium, sodium, aluminum** and **magnesium**.

SAFETY IN ELECTRICAL WORK

Type fire	water	foam	CO2	Dry powder
Class A	/	/	X	X
Class B	X	/	/	/
Class C	X	X	/	/
Class D	X	X	/	/

/ - suitable
X – not suitable

SAFETY IN ELECTRICAL WORK



Water and Foam fire extinguishers extinguish the fire by taking away the heat element of the fire triangle. Foam agents also separate the oxygen element from the other elements.

Water extinguishers are for Class A fires only - they should not be used on Class B or C fires. The discharge stream could spread the flammable liquid in a Class B fire or could create a shock hazard on a class C fire.

Foam extinguishers can be used on Class A & B fires only. They are not for use on Class C fires due to the shock hazard.

SAFETY IN ELECTRICAL WORK

Carbon Dioxide fire extinguishers extinguish the fire by taking away the oxygen element of the fire triangle and also by removing the heat with a very cold discharge.

Carbon dioxide can be used on Class B & C fires. They are usually ineffective on Class A fires.

SAFETY IN ELECTRICAL WORK

Dry Chemical fire extinguishers extinguish the fire primarily by interrupting the chemical reaction of the fire triangle.

Today's most widely used type of fire extinguisher is the multipurpose dry chemical that is effective on Class A, B and C fires. This agent also works by creating a barrier between the oxygen element and the fuel element on Class A fires.

Ordinary dry chemical is for Class B & C fires only. It is important to use the correct extinguisher for the type of fuel! Using the incorrect agent can allow the fire to re-ignite after apparently being extinguished successfully.

SAFETY AND WORKSHOP PROCEDURE

- Never eat, drink, or smoke while working in the workshop.
- Always read labels carefully.
- Only use equipment that you are trained and authorized to operate by your instructor.
- Wear safety glasses or face shields when handling hazardous materials or equipment.
- Clothing: Avoid wearing shorts and sandals in the lab at all times. Closed-toed shoes are required in machine shops.
- Tie back long hair and secure loose clothing to prevent accidents.

SAFETY AND WORKSHOP PROCEDURE

- Keep the work area free of all materials except those needed for your task.
- Store coats in the hall or in a locker.
- Keep extra items like books and purses away from equipment that requires airflow or ventilation to avoid overheating.
- Disposal: Students are responsible for properly disposing of any used materials in the appropriate containers.
- Equipment Failure: If equipment malfunctions during use, report it immediately to your lab instructor. Never attempt to fix it yourself as this could pose a risk to your safety and others.
- Never use your mouth to pipette anything.
- Clean your work area before leaving.
- Wash your hands before leaving the workshop and before eating.

SAFETY AND WORKSHOP PROCEDURE

Electrical safety

- Always obtain permission before operating any high-voltage equipment.
- Ensure that there is unobstructed access to all electrical panels at all times.
- Never modify, attach, or alter any high-voltage equipment.
- When adjusting high-voltage equipment or a laser powered by high-voltage supply, use only one hand.
- Keep your other hand in your pocket or behind your back for safety.

HANDS TOOLS FOR WIRING

1. The importance of hands/power tools proper usage
2. Hands tools basics: a review
3. Power tools basics: a review
4. Maintenance of hands and power tools after used

ELECTRICIANS TOOL AND EQUIPMENT

- INTRODUCTION

An electrician needs to have the right tools to do the job properly.

Tool requirement vary with the job, meaning that sometimes need only minimum of tools, or others require some rather complicated devices.

Tool is divided into 2:

1) Hands tools
2) Power tools

TOOLS BASICS: A REVIEW

- **Terms and definition**

- Tool – A tool is designed for specific tasks like cutting or fitting, operated either manually (referred to as hand tools) or powered by a motor (known as power tools)
- Instrument – A tool or mechanical device, particularly one employed for precise tasks in fields such as science, medicine, or technology

TOOLS BASICS: A REVIEW

- **Terms and definition**

- Device – A device or machine created specifically to carry out a certain task or function.
- Equipment – as necessary items e.g. the tools, clothing or other items needed for a particular activity or purpose
- Appliances – An electrical appliance or machine designed for a specific household purpose, such as a vacuum cleaner or washing machine

HANDS TOOLS BASICS: A REVIEW

- Pliers
- Screwdrivers
- Drilling Equipment
- Sawing And Cutting Tools
- Miscellaneous Tools, Equipment
- Measuring Tools
- Fish Wire Or Tape
- Soldering Equipment
- Multipurpose Tools
- Hammers

Sub Tasks/Step

1. Identify various type and size of hands tools
2. Describe the proper uses and handling requirement of hands tools
3. Describe how to perform job using appropriates hand tools
4. Describe important maintenance hand tools after used

HANDS TOOLS BASICS: PLIERS

- Pliers
  - ✓ Long nose pliers
  - ✓ Side cutting
  - ✓ Lineman's or combination pliers
  - ✓ Slip joint
  - ✓ Diagonal cutting
  - ✓ High leverage end cutting
  - ✓ Oblique cutting with skinning holes
  - ✓ Curved jaw
  - ✓ Chain nose

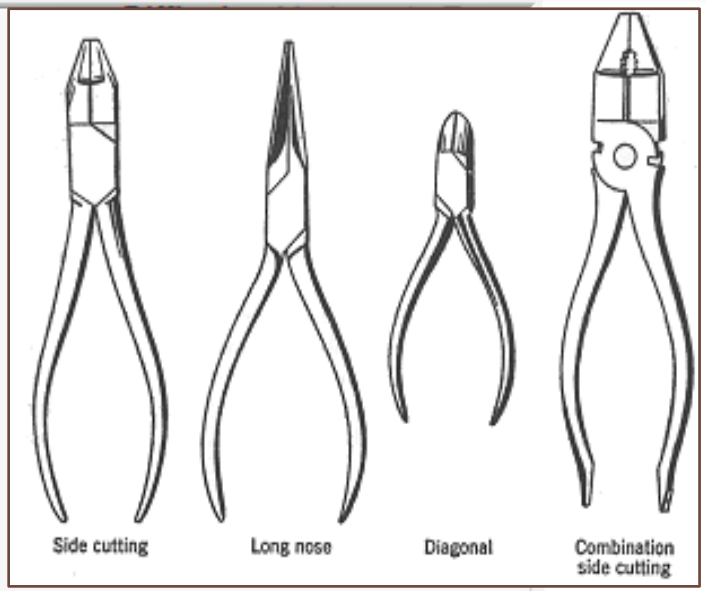
1. Pliers come with either insulated or uninsulated handles.
2. Insulated handles are intended for use when working near live or hot wires.
3. However, handle insulation alone does not provide complete protection, and additional safety measures must be followed

ADHERE TO SAFETY FACTORS

Instructions

1. Choose the right tool for the job. Using your pliers as a hammer may not only damage the tool but could cause you injury.

2. Use good quality tools and inspect them for defects before using them. Replace worn or defective tools.



3. Maintain your tools. Oil your pliers and wire cutters with a drop of oil on the hinge. Be sure that the jaws are clean and the teeth are sharp. Worn or greasy jaws are more likely to slip.

4. Never stick your fingers between the grips and always keep your wrist straight when using pliers.

5. Protect your tools from extreme heat, which can expand the metal and cause dangerous structural problems.

PLIERS

✓Long nose pliers

1. Long nose pliers come in different sizes and shapes.
2. It is uses to :
   - to grip items from small areas where fingers or hands can't reach
   - bend or shape wire
   - cut wire
   - strip protective coating from electrical wire

PLIERS

✓Combination pliers

1. Combination pliers come in different sizes and shapes.
2. Typical uses include:
   - ✓ Cutting
   - ✓ Bending and straightening
   - ✓ Cutting metal-clad (MC) cables
   - ✓ Gripping
   - ✓ Stripping protective coating from electrical wires

PLIERS

✓Side cutting pliers

1. Side cutting pliers also called lineman's pliers come in a great variety of types and sizes, each designed for a particular job
2. The most useful sizes are 6" and 8"
3. Typical uses include:
   - ✓ Gripping
   - ✓ Wire splicing
   - ✓ Wire cutting
   - ✓ Insulation stripping
   - ✓ Crushing insulation (using the heel)

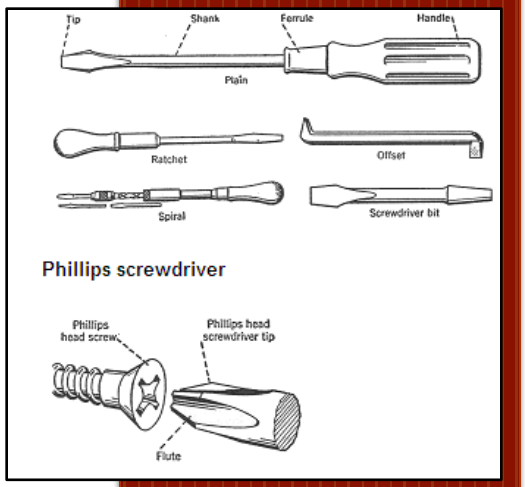
HANDS TOOLS BASICS: SCREWDRIVERS

- Screwdrivers
  - ✓ Conventional straight shank
  - ✓ Phillips
  - ✓ Stub or close quarter
  - ✓ Screwdriver bit

1. Screwdrivers are available in different sizes and tip shapes.
2. To ensure safe and effective use, the tips should be kept sharp and square.
3. When choosing a screwdriver for a task, the tip width should match the width of the screw slot

ADHERE TO SAFETY FACTORS

Screwdrivers



- The shape and size of a screwdriver tip should fit the screw slot snugly.
- Using a tip with the wrong shape or size can cause the tool to slip out of the slot, potentially damaging the workpiece or nearby equipment.
- When using a screwdriver, it must be aligned with the screw's axis and centered in the slot.
- Always keep your hands behind the blade's tip for safety.
- Avoid supporting the workpiece with one hand while using the screwdriver with the other, as this can be hazardous.

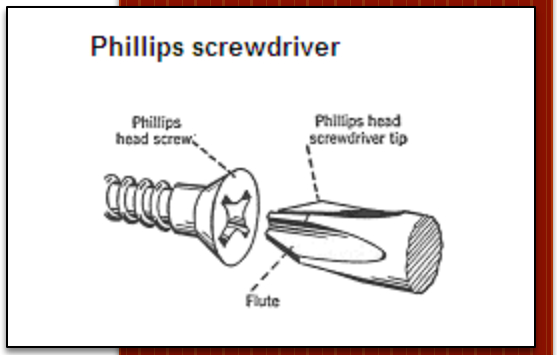
SCREWDRIVERS

✓Shank screwdriver (flat head)

1. Shank screwdrivers, also known as flathead screwdrivers, come in a wide range of types and sizes, each tailored for a specific task.
2. The most useful sizes are 6" and 8"
3. Typical uses
   - to loosen
   - to tighten flat head type screws

SCREWDRIVERS

✓Phillips screwdriver



1. Phillips screws require a screwdriver with a specially shaped tip.
2. The most common sizes are 6" and 8".
3. The tips are sized by numbers:
   - ✓ The #1 tip is for #4 screws or smaller.
   - ✓ The #2 tip is for #5 to #9 screws.
   - ✓ The #3 tip is for #10 to #16 screws.
   - ✓ The #4 tip is for #18 and larger screws.

HANDS TOOLS BASICS: DRILLING EQUIPMENT

- Drilling Equipment
  - ✓ Power drill
  - ✓ Ratchet brace
  - ✓ Bit and drill

Drills

- Drilling equipment is essential for creating holes in building structures to allow the passage of conduit and wiring in both new and existing constructions.
- Drilling offers greater accuracy and a wider range of hole sizes.
- If the machine is operated manually with hand pressure, it is called a hand drill, typically used for light, small tasks.
- When operated by hand but with pressure applied by placing it against the chest and using the body weight, it is known as a breast drill.
- Power drills, which are powered by electricity, reduce the effort required by the mechanic and enable more precise work.

DRILLS

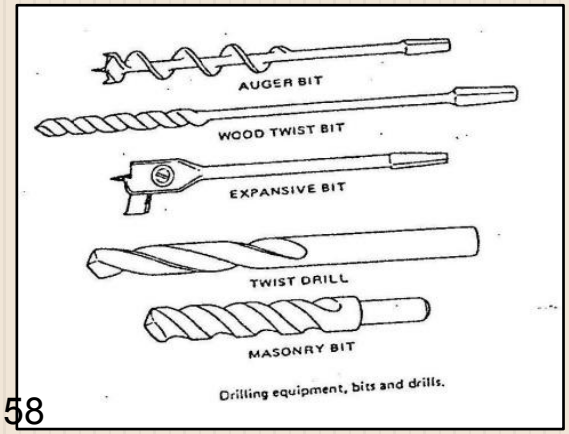
✓Portable Power Drill

1. Portable electric drills come in a wide variety of types and can be classified as light-duty and heavy-duty drills.
2. Light-duty drills can accommodate drill bits up to 1/4" in diameter and typically feature a pistol grip.
3. Heavy-duty drills, which can handle drill bits up to 1" in diameter, are significantly heavier.
4. Higher-quality light-duty drills and most heavy-duty drills are equipped with a chuck that must be tightened using a key. This type is considered the best and safest because it ensures a secure grip on the drill bit.

DRILLS

✓Ratchet Brace Drill

1. Ratchet brace Drill is operated by hand, with hand pressure, it is called a hand drill.
2. Light drills accommodate drill bits up to 1/4" in diameter and typically feature a pistol grip.
3. It may uses as cutting holes into thin wooden especially for light work for



DRILL BITS

HANDS TOOLS BASICS: SAWING AND CUTTING TOOLS

- Sawing And Cutting Tools
  - ✓ Cross cut saw
  - ✓ Key hole
  - ✓ Hacksaw
  - ✓ Junior hack saw
  - ✓ Power saw

Typical saw

- The types of saws commonly used by electricians include the crosscut saw, keyhole saw, hacksaw, and power saw.

Cross

Junior Hack saw

Hack saw

Key hole

Power saw

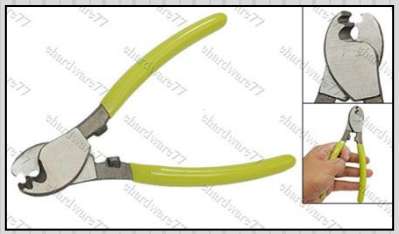
HANDS TOOLS BASICS: MISCELLANEOUS TOOLS, EQUIPMENT

- Miscellaneous Tools, Equipment
  - ✓ Pipe cutter
  - ✓ Pipe reamer
  - ✓ Conduit bender
  - ✓ Wood chisel
  - ✓ BX cutter
  - ✓ Pruning cutter
  - ✓ Shell cable cutter
  - ✓ Test light

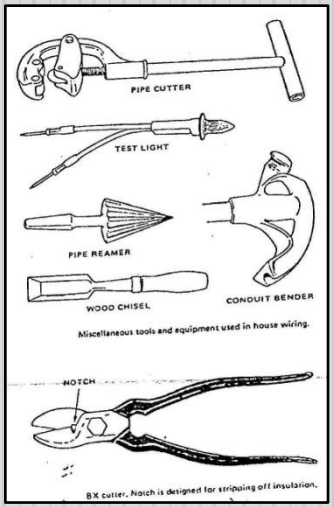
Miscellaneous Tools, Equipment

- Additional tools and equipment needed for handling house wiring jobs include a conduit bender, pipe cutters, test light, wood chisel, and reamer.
- Other items, not illustrated, include wrenches, files, fuse pullers, pipe vices, dies for threading conduit, a plumb bob for establishing a true vertical line, a flashlight, test equipment, wire gauge, and a powder-actuated stud driver.

✓ Pruning cutter



✓ Shell cable cutter

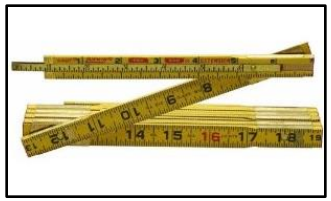


HANDS TOOLS BASICS: MEASURING TOOLS,

- Measuring Tools
  - ✓ Extension rule
  - ✓ Push pull tape rule
  - ✓ Steel tape

Measuring Tools

- To measure wire length, opening sizes, conduit, and other items, electricians commonly use measuring tools such as the extension rule, push-pull rule, and steel tape.



EXTENSION RULE

PUSH PULL TAPE

STEEL TAPE

HANDS TOOLS BASICS: FISH WIRE OR TAPE

- Fish Wire Or Tape
  - ✓ Steel
  - ✓ Nylon

Fish Wire Or Tape

- Fish tapes are used to pull wires through conduits in new constructions and through wall openings in older ones.
- These tapes are made of tempered spring steel and come in various lengths to meet different needs.
- Wire-pulling lubricant or compound is used to facilitate the process and make it easier.

STEEL FISH TAPE REEL & PULLER

NYLON FISH TAPE

WIRE PULLING LUBRICANT

HANDS TOOLS BASICS: SOLDERING EQUIPMENT

- Soldering Equipment
  - ✓ Soldering Paste
  - ✓ Soldering Gun
  - ✓ Solder Leads
  - ✓ Electric Soldering Iron
  - ✓ Soldering Copper
  - ✓ Propane Torch

Soldering Equipment

- When performing electrical wiring, splices and taps should be soldered, unless solderless connectors are used.
- Typical equipment for soldering is shown in the figure below.

ELECTRIC SOLDERING IRON SET

SOLDERING LEADS

SOLDERING SUCKER

SOLDERING PASTE

HANDS TOOLS BASICS: MULTIPURPOSE TOOL

- Multipurpose Tool
  - ✓ Stanley

Multipurpose Tool

- The figure below shows a tool (Stanley) that can be used as a pair of pliers to cut and strip insulation from wires, crimp terminals, and cut screws.

MULTIPURPOSE TOOL

HANDS TOOLS BASICS: HAMMERS

- Hammers
  - ✓Claw hammer
  - ✓Lineman's' hammer
  - ✓Ball peen hammers
  - ✓Warrington hammer

Warrington hammer

Hammers

- Hammers are used with chisels and for nailing and fitting.
- The figure below shows a carpenter's claw hammer, lineman's hammer, Warrington hammer, and machinist's ball peen hammer.

BALL PEEN | CLAW HAMMER | LINEMAN'S HAMMER

POWER TOOLS BASICS: A REVIEW

- **Term And Definition**
- **Multifunction's of power tools**
  - Driving
  - Drilling
  - Cutting
  - Shaping
  - Sanding
  - Grinding
  - Polishing
  - Painting
  - Heating

Sub Tasks/Step

1. Identify various type and size of power tools
2. Describe the proper uses and handling requirement of power tools
3. Describe how to perform job using appropriates of power tools
4. Describe important maintenance power tools after used

POWER TOOLS BASICS: A REVIEW

- Term And Definition
- Classification of power tools

- A power tool is driven by an electric motor, compressed air, an internal combustion engine, direct fuel combustion, propellants, or natural energy sources like wind or flowing water.
- Power tools are categorized as either stationary or portable, with portable tools being those that are handheld.

POWER TOOLS BASICS: A REVIEW

Classification of power tools

- Power tools are classified into two categories: stationary and portable, as described below.

PORTABLE	STATIONARY
▪Cordless	▪Bench
▪Portable	▪Pedestal
	▪Wall mounted

POWER TOOLS

- Drilling is required to create holes in building structures for the passage of conduit and wiring in both new and existing constructions

- Cordless hand drill

- Bench top drill press

POWER TOOLS

Drilling

- Portable power drill

- Pedestal drill press

POWER TOOLS

- CUTTING

to sever something or separate a part of something using a sharp-edged tool such as a cutting machine, scissors, or a saw

- **Abrasive Cutoff**
- **Machine**

- **Universal Cutting Machine and guard system**

POWER TOOLS

- GRINDING

A machine for making something smooth or sharp by rubbing it on a hard surface with a strong twisting movement

- **Bench Top Grinder**

- **Hand Grinder**

WIRING ACCESSORIES

1. The importance of wiring accessories proper usage
2. Wiring accessories: a review

WIRING ACCESSORIES

- **Introduction** :

- Electrical wiring is the process of installing a system of electrical wires complete with required accessories.
- Those accessories are an optional part that may be fitted to the installation processes to perform an additional function or enhance performance.
- The most common accessories in electrical wiring are ceiling rose, lamp holder, connection box, switch socket outlet, cable connector, coupler and others.
- These accessories will complete a wiring and make it safe to be used by users.

WIRING ACCESSORIES: A REVIEW

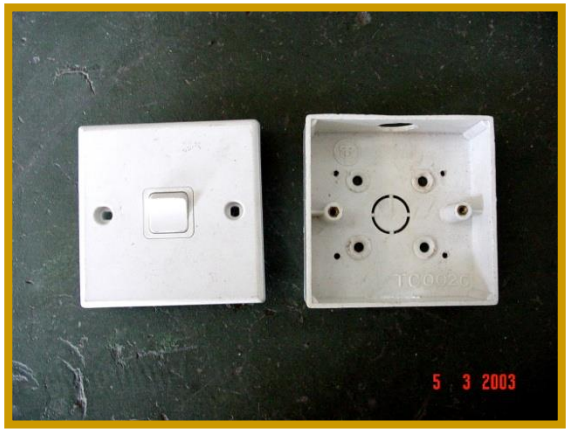
- Switches
- Lamp Holder
- Ceiling Rose
- Distribution Box
- Single Phase Gear Switches
- Switch Socket Outlets (SSO)
- Switch And SSO Base

Sub Tasks/Step

- Identify the wiring accessories to understand installation methods and functions.
- Draw the related wiring accessories.
- Write the purposes and functions of the accessories in laboratory report.
- Identify various symbols of wiring accessories to single phase and 3 phase installation
- Ensure those symbols applied are in accordance to code of practice

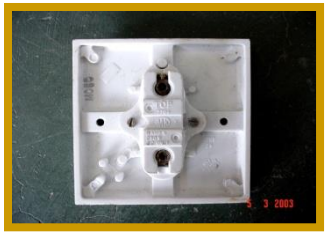
SWITCHES

- There were several types of switches in lamp circuit wiring and it depends to the purpose and the functionality. These are the normally switch that were used :-
  - 1 Way Switch
  - 2 Way Switch
  - Intermediate Switch
- There is also switch called "gang" which means the number of control build in one switch.



Front And Base View Of Switch

Construction Of Switches



Single Pole One Way Switch

Single Pole Two Way Switch

Double Pole Two Way Switch

Or

Intermediate Switch

SWITCHES

Single Pole One Way Switch

- One way switch has 2 points of connection.
- 1 point as common-life input to switch. (labeled as C or L_1)
- 1 point as output-life output to load or lamp (label as L_1 or L_2)
- In lighting installation, one way switch only controlled loads or lamps at one place at one time.

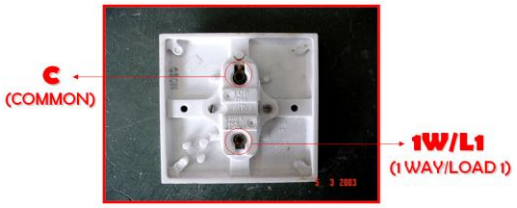


Figure 2: 1 way, single pole

Flush switch

Figure 3: Top, 1 gang c/w base

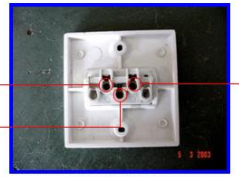


Figure 2: 2 way, single pole

Flush switch

Single Pole Two Way Switch

- Two way switch has 3 points of connection
- 1 point as common-life input to switch, (labeled as C or L_1)
- 2 points as output- life output to load or lamp (labeled as L_2 or L_3)
- In lighting installation, two way switches controlled loads from two different places at one time. How do the two 2 way switches are installed depend on the instructions given. In installation the switches will be wired in series connection to get two way controls.
- Two way switch normally use to control lamps from two or more different places for example at stairways or corridors.

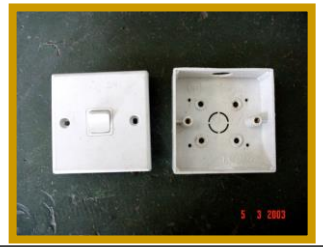


Figure 3: Top, 1 gang c/w base

SWITCHES

Intermediate Switch

- Intermediate switch is a switch that lying or occurring between two different points.
- Intermediate switch normally will be used together with the 2 way switches.
- It can control lamps from more than one place for example along the corridor especially at schools, hostels or hotel path away.
- There are several of samples on how to wire the intermediate switch as shown in two figures below.

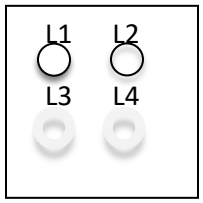


Figure 1 : Sources Of Intermediate Switch

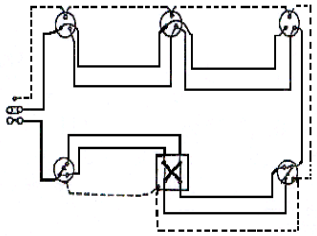


Figure 2: Example 1

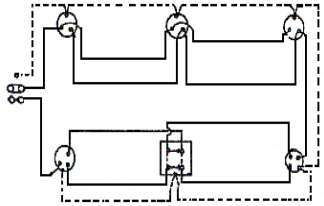


Figure 3: Example 2

SWITCHES

IEE Regulations

1. Cable size is 1.5mm^2 pvc(single) or pvc/pvc(double insulated)
2. Maximum load for lighting circuit is 10 loads or not more than 1000watt
3. Switch wiring for domestic use can be only operating at 240VAC/6Amp.
4. Switch for bathroom must be located outside to avoid danger.

SWITCH SOCKET OUTLET

❑IEE Regulations

- Wiring installation will use 2.5mm² PVC insulated cable (single) or PVC/PVC (double).

Regulations for Radial Socket installation:

- Radial connection starting from the consumer unit and ending at the last SSO 13A.
- The installation required 2.5mm² PVC cable
- Each MCB (20A) able to working with maximum two no's 13A sockets
- The circuit is contained within an area not exceeding 50m².
- Main power socket can be only operating at 240VAC/13Amp.

Regulation for Ring Socket installation:

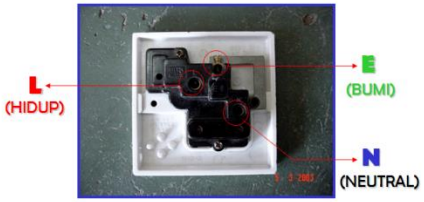
- The installation required 2.5mm² PVC cable
- Begins from the distribution box into some outgoing current sockets, and ends at the distribution box at the same MCB/fuse resources.
- Protective device for ring connection is 32A fuse.
- Unlimited number of socket outlet to be installed on a ring circuit provided that the floor area served does not exceed 100m²excluding kitchen area.
- Main power socket can be only operating at 240VAC/13Amp.

- Radial socket installation: Radial connection starting from the consumer unit and ending at the last SSO 13A.
- Ring socket: Begins from the distribution box into some outgoing current sockets, and ends at the distribution box at the same MCB or fuse resources.
- Ring circuit wiring is encouraged for installation that might require large power such as in the kitchen room and main hall.
- Ring circuit will use 2 pair of same size cable for the whole wiring process and it will return to the same source in the distribution box. This indicates that current has 2 same passages and the advantageous are:

1. Socket is still useable despite damages on one of the cable. This is because the rounding circuit has 2 current passages.
2. Suitable for highly powered load because of the capability of the cable to stream the current 2 times of, compared to, radial circuit (2 pair cables).
3. It can be made as extra socket to the circuit because its amount is not limited as long as it is made in the same building.

SWITCHES SOCKET OUTLET

- SWITCH SOCKET OUTLET 13A



- SWITCH SOCKET OUTLET 15A

- Wiring of switch socket outlets 13A/15A @ SSO 13A/15A circuit is to provide the power source in installation.

LAMP HOLDER

BATTEN LAMP HOLDER

PENDANT LAMP HOLDER

▪SCREW EDISON

▪PIN TYPE-fluorescent

- Lamp holders are accessories used to hold bulb and it can facilitate the connections to the lamp in installation.
- Typical types of lamp holders

a) Bayonet cap
b) Screw Edison
c) Screw goliath
d) Pin type

CEILING ROSE

- Ceiling Rose 3 Plates

- Ceiling rose is the point of connection to fixed wiring terminal, connected with flexible cord or cable to loads, lamps or fans.
- A **ceiling rose** also is a decorative element affixed to the ceiling from which a chandelier or light fitting is often suspended
- They are typically round in shape and display a variety of ornamental designs.
- 3 types of ceiling roses;

1) 2 plates
2) 3 plates
3) 4 plates

- Ceiling roses are made from plastic or Bakelite

CEILING ROSES

IEE Regulations

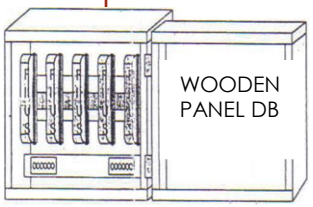
1. Ceiling roses are not allowed for installation which exceeded 250v.
2. Maximum load to be fixed to the ceiling rose is only one load
3. EXCEPT if it is made purposely for multi output loads more than one loads is allowed to be installed.
4. Wiring for ceiling rose use flexible cord.

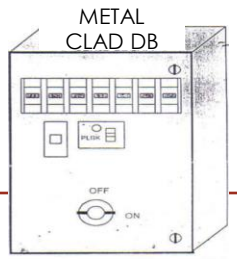
DISTRIBUTION BOX

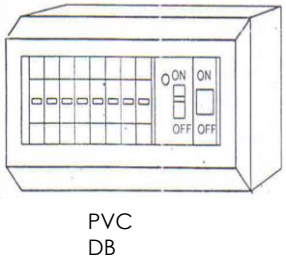
Single Phase Distribution Box

Introduction

- Distribution box (db) is also known as the fuse distribution box or board, made from woods panels.
- Today there are several types of distribution boxes which were made from pvc or metal clad.
- These new inventions are more compatible, practical, and have high efficiency to install the protective devices compared to the wood panels db.







Single Phase Distribution Box

Protective Devices Which Have To Install In DB Are

- Main Switch

  Switch Fuse @ SF (1Ø DB)

  Fuse Switch @ FS (3 Ø DB)
- Residual Current Circuit Breaker (RCCB) * Formerly Known As ELCB – Earth Leakage Circuit Breaker

  40a/0.1a (1ø Db)

  60a/0.3a @ 100a/0.3a (3 Ø Db)
- Miniature Circuit Breaker (MCB)

  6A – Lighting Circuit

  16A – Radial Circuit (SSO)

  20A – Radial Circuit (SSO)

  32A – Ring Circuit (SSO)or Power Circuits
- Molded Case Circuit Breaker (MCCB) For (3 Ø DB)

DISTRIBUTION BOX

I.E.E regulations for DB installation:

- All the protective devices must be complying with the IEE arrangement according to the schematic diagram below.

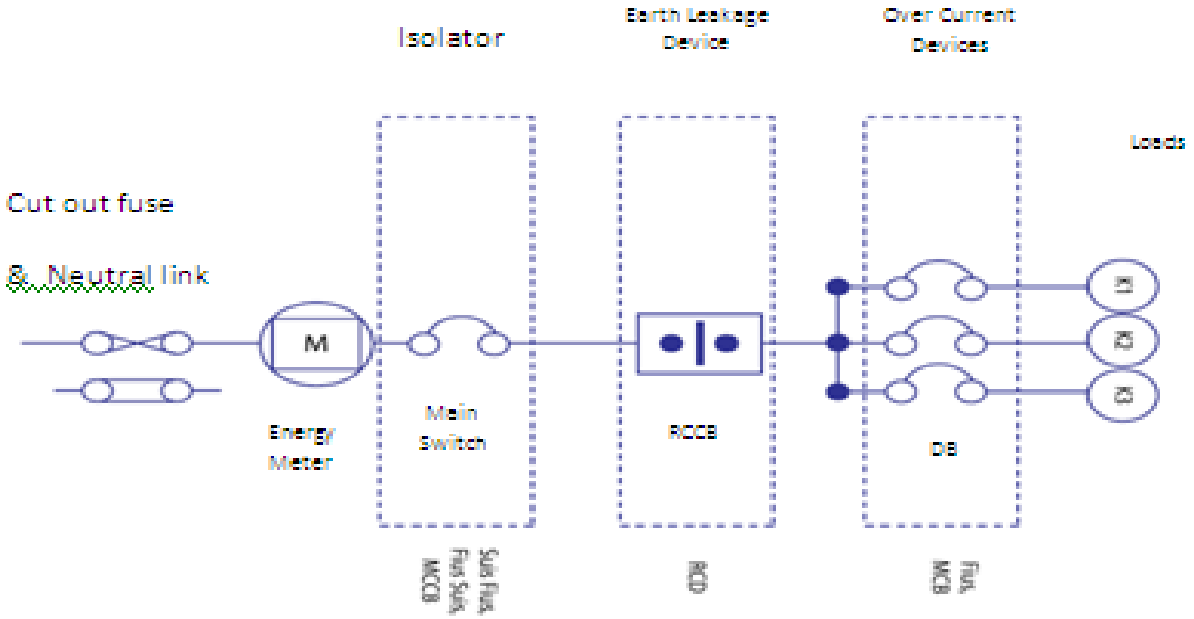


Figure 12.2 Isolator and protective devices for domestic installations

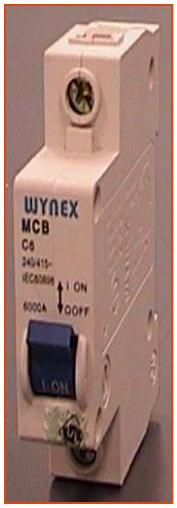
GEAR SWITCHES

- 1Ø Main Switch

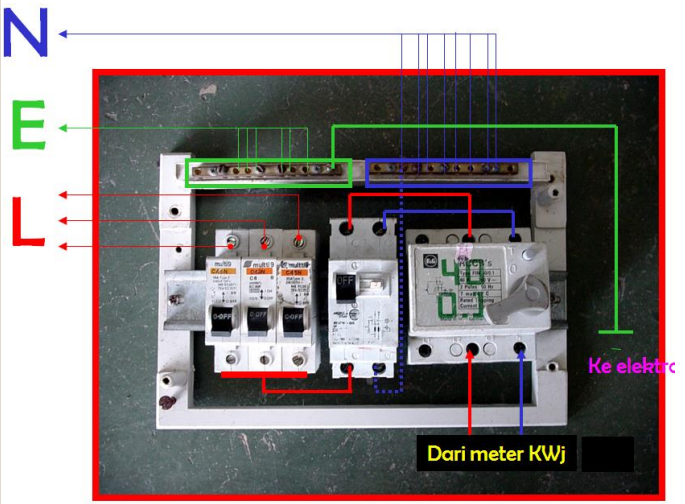
- 1ø Residual Current Circuit Breaker

GEAR SWITCHES

- MCB



- Complete Single Phase DB Installation



ARRANGEMENTS OF CONSUMER CONTROL SEQUENCE UNIT

Consumer Control Sequence Unit	Explanation
Service Cable	■Cables from overhead lines are pulled to premises or houses for voltage supply connecting ■Commonly is connected to service fuse & neutral coupler
Service Fuse & Neutral Link (Cut Out Unit)	■It is to be installed outside wall of premises with energy meter ■Service fuse – fuse to be connected to live cable (phase line, rates 60A, 80A and 100A) ■Neutral link – neutral connection sources from servicing cable ■Is lacrilized with round plumbum pieces and is specially tighten by TNB
Energy Meter KW/J	■Use to measure energy consume per unit ■Energy consume per unit will be charged following fixed tariff by TNB

ARRANGEMENTS OF CONSUMER CONTROL SEQUENCE UNIT

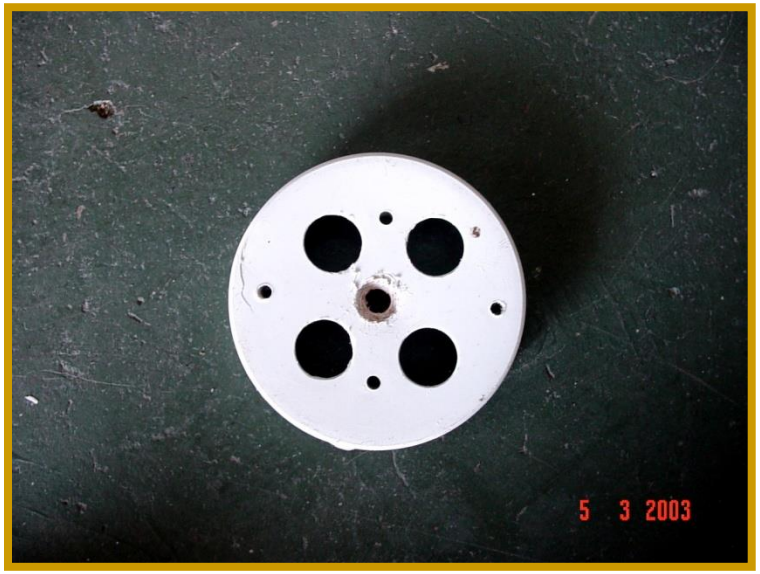
Consumer Control Sequence Unit	Explanation
Main Switch	▪Switch to connect and disconnected power supply installation ▪Disconnected circuit due to over current faults ▪It is double pole connection switch (to disconnect L & N in one moment) ▪Consist of 20A, 30A or 60A rates fuse
Residual Current Circuit Breaker	▪To cut off automatically power supply sources due to earth leakage fault of electrical appliances ▪To avoid electric shock to any user or consumer ▪ 1 phase (tripping points 40/100mA)

ARRANGEMENTS OF CONSUMER CONTROL SEQUENCE UNIT

Consumer Control Sequence Unit	Explanation
Distribution Box	■Consists of fuses or MCB'S arrangements with rates ■Rates are determined depend to types of final circuit ■3 typical fuse/MCB'S distribution box 1) Wooden panel DB 2) Metal cladding DB 3) PVC DB

ADDITIONAL ACCESSORIES

PVC Round Block

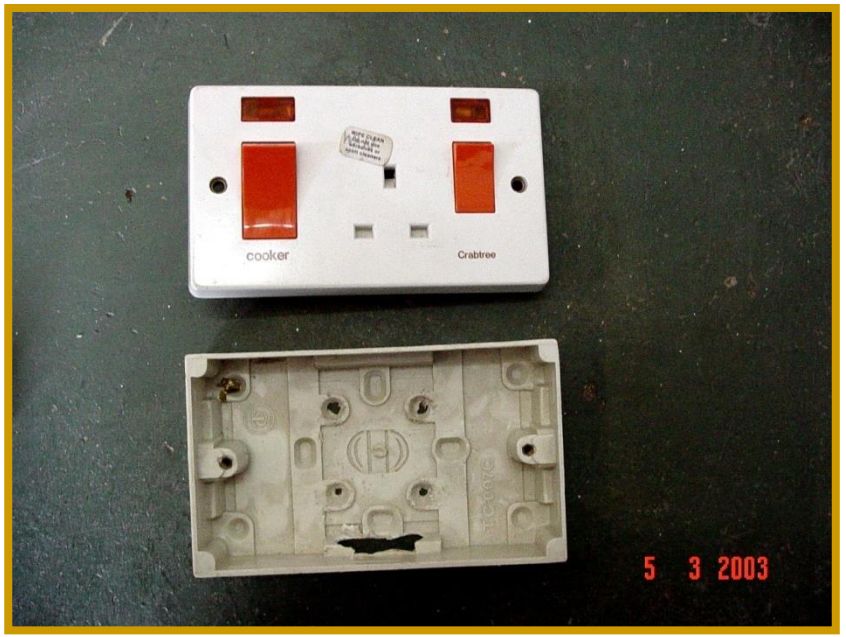


Fan Regulator

ADDITIONAL ACCESSORIES

Dimmer Switch

Cooker unit



Electric Cables

- Definition
- Cables Construction
- Conductor Materials
- Insulation Materials
- Types Of Cables
- Correction Factors
- Cables Terms
- Voltage Drop Calculations

DEFINITION

- Conductors

1. Medium that allows electricity to pass along it or through it. Metals are good conductors of electricity because of the high concentration of free electrons they contain.

2. Conductor has single strand of metal without insulator

DEFINITION

- Wire

  a strand of metal, usually copper, that is encased in plastic or another insulating material and is used to carry an electric current, usually has small sizes of diameter

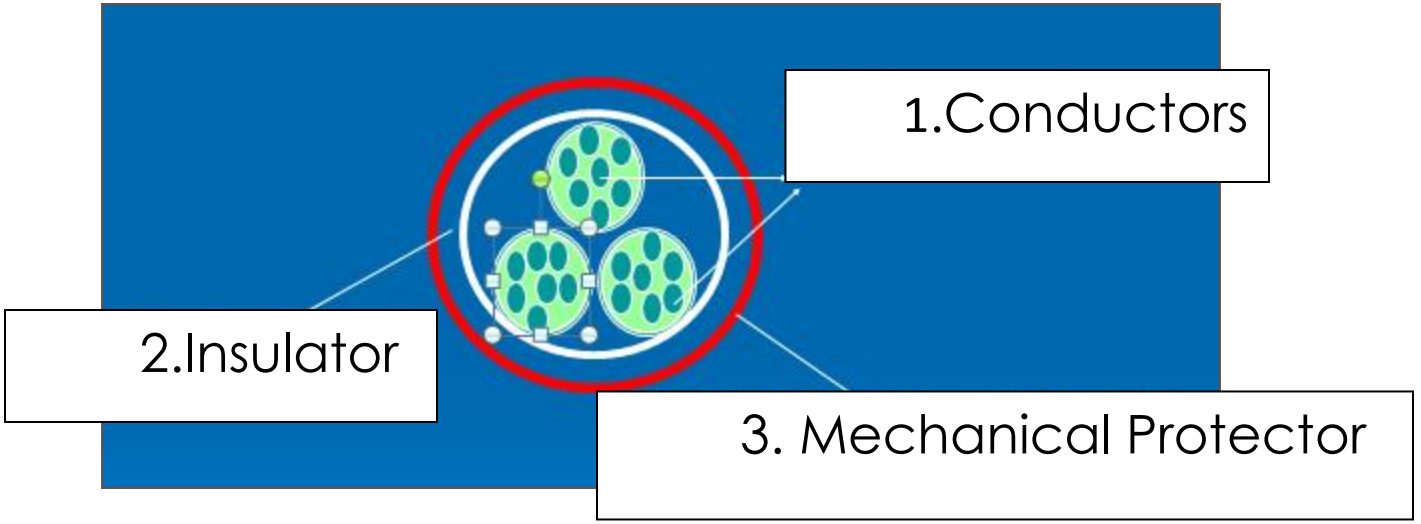
- Cables

  a group of wires for transmitting electrical signals that are bound together and usually have shared or common insulation, a term generally used to describe larger conductor sizes

CABLES CONSTRUCTION

- Conductors
- Insulator
- Mechanical Protector

CABLES CONSTRUCTION



CABLES CONSTRUCTION

A cable consists of 3 main parts:

1.Conductor – is a pure metal which offers low resistance to the electric current flow.

Copper and aluminums are the material widely used as conducting material in electrical industry.

2. Insulation is a material or device that prevents or reduces the passage of electricity.

3. Protective – coverings are such as armouring and sheathing which

used to protect the cable from being mechanical damage.

CONDUCTOR MATERIALS

- A material or element that allows free movement of electrons and therefore allows easy flow of electricity.
- Most conductors are metals e.g.

✓ Aluminums
✓ Copper
✓ Silver
✓ Lead
✓ Gold

INSULATION MATERIALS

- A material that isolates conductive materials and helps to correctly channel electricity. Most wire are covered by insulation.
- Materials of insulation as follows

✓ Rubber (Vulcan, butyl, silicon)

✓ Polyvinyl Chloride

✓ Paper Insulated

✓ Mineral Insulated

✓ Bakelite

MECHANICAL PROTECTOR

- A heavy duty outer covering used to protect a conductors insulating material. Armor is used in situations where a wire is exposed to physical wear and tear.
- Methods used

✓ Polyvinyl chloride sheath
✓ Rubber sheath
✓ Steel tape/strands armor
✓ Lead sheath
✓ Copper sheath
✓ Conduit/trunking/casing

SOLID AND STRANDED CABLES

Solid cable – only one conductor is used in solid conductors.

Stranded cable – a number of strands of wires are used. The numbers of strands are normally in numerical progression form such as 3,7,19,37,61,91,127,169

Advantages of stranded cables:

1. Cables are stranded to increase the current carrying capacity
2. It allow joints to be made
3. Thin wire can be used to increase the flexibility of the cable

TYPICAL ELECTRICAL CABLES

1. Polyvinyl Chloride (PVC) cable

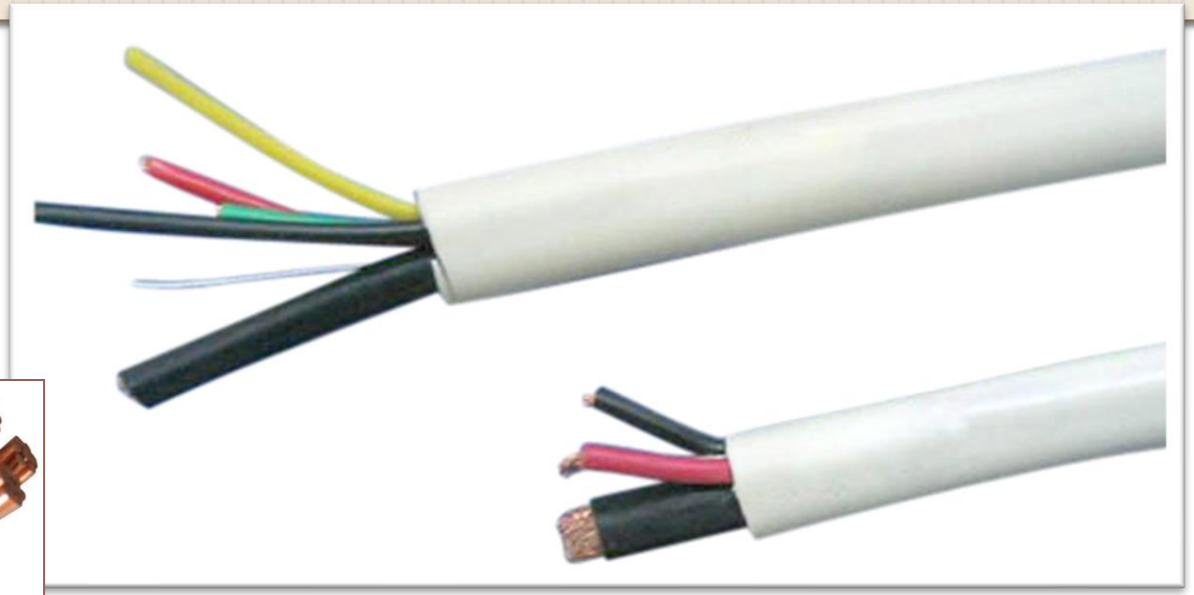
- most common type of cable used in domestic installations.

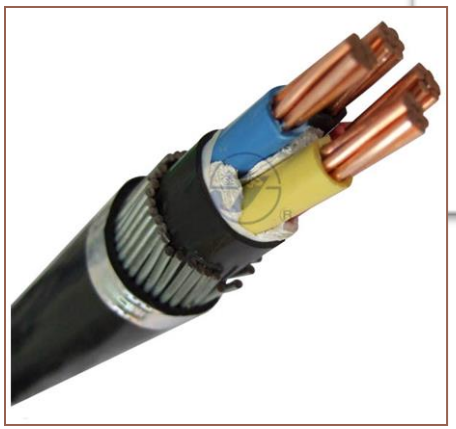
- These cable consists of PVC insulated conductors which are contained in PVC sheath. The sheath designed to protect the conductors from mechanical damage during installation and to increase the life span of the cable

- The cables can be on the surface although it is normally concealed behind the walls

POLYVINYL CHLORIDE (PVC) CABLE

- Features of PVC cables





TYPICAL ELECTRICAL CABLES

2. Mineral Insulated Copper Sheathed (MICS) cable

- cable consists of copper conductor embedded in mineral insulation made from magnesium oxide.

- The sheath is seamless and made from copper conductor.

- Usually used in cases high risk of fire and explosion and nowadays also for fire alarm systems. It can withstand very high temperature up to 250° C.

- The cable is also capable of carrying very much higher current than PVC cables.

MICS CABLE

- Features of Mineral Insulated Copper sheathed cables

PVC-sheathed MICC cable. Conductor

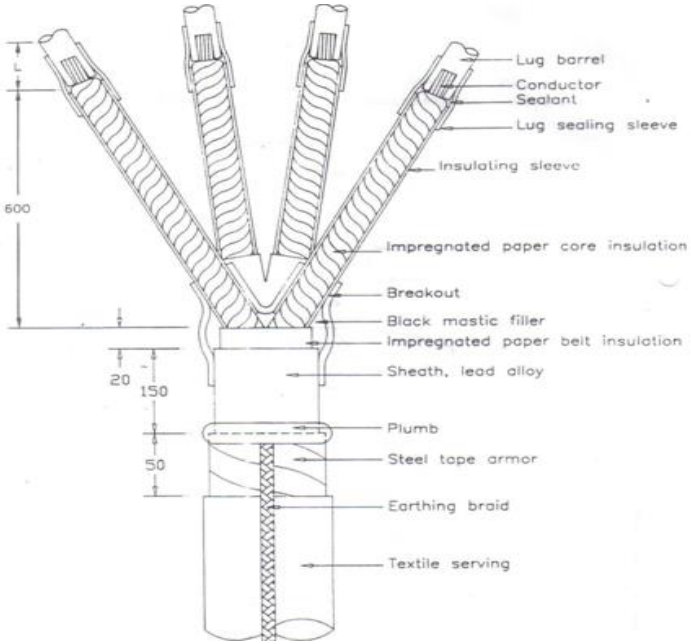
TYPICAL ELECTRICAL CABLES

3. Paper Insulated Lead Sheathed (PILS)cable

- Used in underground distribution systems.
- Can be used for internal distribution in factories and other industrial areas.
- Is used impregnated and must be protected against moisture.
- The current carrying capacity of this cable is very much greater than other types of cables.

PAPER INSULATED LEAD SHEATHED (PILS) CABLE

- Construction of PILS



CABLES SIZES FOR DOMESTIC WIRING

- Uses of minimum cross sectional areas of conductors based on their applications

Conductor Cross Sectional Area in mm^2	Material	Application
1.5 mm^2	Copper	Lighting/fan circuit
2.5 mm^2	Copper	13A socket outlet circuit
4.0 mm^2 – 6.0 mm^2	Copper	General Power Circuit (example: water heater, cooker unit, motor/pump)
16.0 mm^2 / 25.0 mm^2	Copper	Main Circuit

COLOUR CODE FOR CABLES

FUNCTION	CABLE COLOUR
Phase of Single Phase Circuit	Red, Yellow or Blue
Red Phase of Three Phase Circuit	Red
Yellow Phase of Three Phase Circuit	Yellow
Blue Phase of Three Phase Circuit	Blue
Neutral of Circuit	Black
Protection/Earthing Conductor	Green or Green-Yellow

COLOUR FOR FLEXIBLE CABLES

- Flexible cables of cross-sectional area less than 4.0 mm2 are used in installations for electrical accessories such as ceiling roses, lamp fixtures or attachments, socket plugs for mobile appliances, etc.

- Flexible cables shall not be used for permanent wiring.
- Flexible cables for the permanent use of electrical should not exceed 3 meters in length.

COLOUR FOR FLEXIBLE CABLES

No. of Cores	Function	Cable Colour
1, 2 or 3	Phase Conductor	Brown
	Neutral Conductor	Blue
	Protection Conductor	Green or Green-Yellow
4 or 5	Phase Conductor	Brown or Black
	Neutral Conductor	Blue
	Protection Conductor	Green or Green-Yellow

CORRECTION FACTORS

- DEFINITION

✓ Any variables condition that must be accounted for when selecting a wire size.

✓ Correction factors such as temperature, number of conductors, and conductor length influence allowable ampacity

CHOOSING CABLE SIZE

According to IEE wiring regulations,

1) In domestic wiring, it is always appropriate to use 2.5mm cable power circuits and 1.5mm cable for lighting.
2) The method of choosing the correct size of the conductor for a particular load condition is based on the rating of over current protective devices.
3) Certain factors need to be considered when choosing the correct size of cable such as:

a) The ambient temperature of the cable
b) The installation condition (grouped or bunched)
c) The insulation material surrounding cable
d) Cable protection such as whether it is fused or not

CHOOSING CABLE SIZE

- Voltage drop occurs on the cables when carrying the maximum current must not exceed 2.5 %of the voltage source

Formula :

- Single phase of power = VI cos θ
- Three phase of power = $\sqrt{3}$ VI cos θ
- Load current of the circuit , I = power in watts/voltage in volt
- Cable requirement rates = current fuse rating/ correction factor
- Voltage drop = load current of the circuit x length of cable x voltage drop per amp per meter
- Power = Load current of the circuit x voltage drop

TERMS FOR CABLES

- Cores
- Multi-cores
- Width of cross sectional cables
- Voltages rates

- **Core** - conductor that surrounded by insulator
- **Multi-cores** – there is more than one conductor in single insulator
- **Width of cross sectional cables** – width of each of the cores in insulator e.g. 7/0.3mm2 meaning there is 7 strand of conductors and each of the conductor size is 0.3mm2
- **Voltages rates** – rates of cables insulation durability when voltages is passing through

TERMS FOR CABLES

- Current rates
- Ambient temperature
- Color codes

- **Current rates** – cables ampacity due to maximum current passing through without heating both of the conductors or the insulator
- **Ambient temperature** – safe surrounding temperature for cables insulation durability
- **Cables color codes** – used to show the function of specific cables or cord

TERMS FOR CABLES

- Cord
- Flexible cable
- Cable sheathed

- **Cord** – cables terms referring to the conductors which has width of cross sectional within 0.5mm2 – 4mm2
- **Flexible cable**– easy bending cables without using special tools
- **Cables sheathed**– second layer of the cables after insulator. Also known as mechanical protector.

VOLTAGE DROP CALCULATIONS

Cable Size Selection

2 important factors in the selection of cable sizes.

i. The cable must be able to carry current maximum (full load) flowing in a circuit without undue heating.

ii. Depletion voltage occurs on the cable when carrying the maximum current must not exceed 2.5% of the supply voltage.

i.e : 2.5% x 230V = 5.75V

AMPACITY FACTORS OF CABLE RELY TO :

1) Ambient Temperature
2) Type of protective device
3) Position
4) Group
5) Types of conductor or insulator

CALCULATION METHOD FOR SELECTION OF CABLE SIZE

There are 2 ways:

1) Table of IEE regulations (Table 9D1)
2) Ohm'S Law

CALCULATION USING THE TABLE 9D1

- FORMULA:

i. Single phase of power = VI cos θ

Three phase of power = $\sqrt{3}$ VI cos θ

Load current of the circuit , I = power in watts/voltage in volt

ii. Cable requirement rates = current fuse rating/ correction factor

iii. Voltage drop = load current of the circuit x length of cable x voltage drop per amp per meter

iv. Power = Load current of the circuit x voltage drop

EXAMPLE CALCULATION

Exercise 1.

An immersion heater rated at 230V, 3kW is to be installed using twin with protective conductor PVC insulated and sheathed cable. The circuit is protected by a 15A fuse type BS 88 and will be run for much of its 14m length in a roof space which is thermally insulated with glass fiber. The roof space temperature is expected to rise to 50˚C in summer. Determine the suitable cable size, voltage drop and power loss for the installation given.

Answer:

i. Load current (I) = 3kW/230V =13A

ii. Cable requirement rates = 15/0.71 = 21.26A.

Refer to table 9D1, cable size is 2.5mm²

iii. Voltage drop = 13A x 14m x 17/1000 = 2.97V

- Voltage drop not more 5.75V so cable size 2.5mm² is suitable.

iv. Power loss = Voltage drop x load current.

= 2.97 V x 13A =37.13Watt.

- Exercise 2:

Pv cable single core used in surface wiring for the installation of 2.5kW, 230V, 1phase, along 25 meters. Calculate the appropriate cable size and voltage drop and power loss in the cable for this installation. The circuit is protected by a 10A fuse BS3036 semi-enclosed type.

Answer:

i. Load current (I) = 2.5kW /230V = 10.86 A.

ii. Cable requirement rate = 10A / 0.725 = 13.79A

Refer to table 9D1, cable size is 1.0mm²

iii. Voltage Drop = 10.86A x 25m x 42/1000 = 11.403 V.

* Voltage drop 11.403V more than 2.5% x Voltage supply (5.75V)

so cable size 1.0mm² not suitable.

* Refer to table 9D1, take next cable is 1.5 mm² and do calculate voltage drop.

iv. Voltage drop = 10.86A x 25m x 28/1000 = 7.294V.

* Voltage drop 7.29V more than 2.5% x Voltage supply (5.75V)

so cable size 1.5mm² not suitable.

* Refer to table 9D1, take next cable is 2.5 mm² and do

calculate voltage drop.

v. Voltage drop = 10.86A x 25m x 17/1000 = 4.62V

Voltage drop not more 5.75V so cable size 2.5mm² is suitable.

vi. Power loss = 10.86 A x 4.62V = 50.17 Watt.

PVC WIRING WORKS

1. PVC WIRING basics: a review
2. Typical PVC conduits
3. PVC conduits installation equipments
4. Accessories of PVC conduits installation
5. PVC conduits termination connection
6. Typical bar and saddle

PVC CONDUIT WIRING

PVC WIRING BASICS: A REVIEW

- **INTRODUCTION**

- Conduit is a protective casing for electrical cables.
- It is a pipe or tube used to cover and safeguard cables.
- Electrical conduit can be made from various materials, including metal, plastic, fiber, or fired clay.
- PVC (is abbreviation of Poly Vinyl Chloride, white color, easy to bend)conduit commonly used for single phase installation
- GI (is abbreviation of galvanized iron) conduit is always used to install 3 phase systems and for industrial used

PVC CONDUIT WIRING

❑**INTRODUCTION**

- Conduit system is very practical to carry huge number of cables and has low maintenance
- It has high mechanical protection, carried 1Ø and 3 Ø voltages, suitable for large and storied buildings
- Conduit sizes are 4 meter – 8 meter length, and the size of diameter are ½ INCH,¾ INCH,1 ¼ INCH, 1 ½ INCH
- Disadvantages are high cost for installation and need expertise worker to avoid default in fitting

Sub Tasks/Step

1. Identify various type and size of PVC conduit
2. Describe the proper uses and handling requirement of PVC conduit installation
3. Describe the procedures of PVC conduit installation to comply with IEE regulations

PVC CONDUIT

PVC conduit is the lightest in weight among different conduit materials and is typically more affordable than other types of conduit.

1) Electrical non metallic tubing is a thin-walled corrugated tubing that is moisture-resistant and flame retardant. It is pliable such that it can be bent by hand and is often flexible although the fittings are not. It is not threaded due to its corrugated shape although the fittings might be.

2) Rigid non metallic conduit is a non-metallic unthreaded tubing.

2 methods to use

1. Spring bent or
2. Preheat the part to be bent, then left to cool and harden.

   Using the casing (refer to accessory installation) and use a special glue or thread

3. Vessel type is suitable for use at temperatures 60^0C

ADVANTAGES OF CONDUIT WIRING

- Electrical conduit offers excellent protection for enclosed conductors against impact, moisture, and chemical vapors.
- It allows for the easy installation of various conductor types and sizes, making the design and construction process more efficient than running multiple cables or using expensive custom cables.
- Conduit systems are ideal for buildings where wiring systems are frequently modified, as they allow for easy replacement or addition of conductors with minimal disruption.
- Conduit systems can be made waterproof or submersible and some types are approved for direct embedding in concrete.
- This feature is commonly used in commercial buildings, where floor-mounted conduit boxes connect power and communication cables in large open spaces, such as retail displays or open-office layouts.
- Both metal and plastic conduit can be bent on-site, which reduces the need for excessive fittings and simplifies installations that follow irregular or curved building profiles.

Regulations of Conduit Installations

19.1. Draw-in boxes or troughs must be installed at intervals not exceeding 10 meters in straight runs of conduit. Additionally, a draw-in box or trough should be installed after no more than two bends or changes in direction.

19.2. Conduits should either be surface-mounted or embedded within building structures, following the specific requirements outlined in other sections of this specification.

19.3. For surface-mounted conduits, they must be installed parallel to the building lines and secured at intervals no greater than 1.23 meters (4 feet). Spacer bar-type saddles should be used for fixing the conduits in place. These saddles must be installed using the appropriate methods, which include: a) Attaching to brickwork, concrete, or similar surfaces with 25mm (1") x No. 8 brass wood screws and plastic raw plugs. b) Attaching to woodwork using 25mm (1") x No. 8 brass wood screws.

c) For steel structures, conduits should be fixed using cadmium-plated 2 B.A. mild steel machine screws and nuts, or alternatively, by using similar mild steel self-tapping screws.

Conduits that run through roof spaces, accessible trenches, or similar locations are considered to be surface-mounted.

Draw-in inspection and junction boxes, as well as troughs (excluding "adaptable" type boxes) installed in conduit runs, whether surface-mounted or buried, are not required to be fixed separately to the building structure. They should rely on the proper saddling of the conduit for support. Saddles should be fixed directly to the conduit runs immediately adjacent to the boxes or troughs. However, "adaptable" type boxes, regardless of size, must always be fixed separately to the building structure using at least two fixings, similar to the fixings specified for saddles in sub-clause 1 above.

19.4. For conduit attachment to sheet steel cable trunking, fluorescent fitting channeling, and similar equipment, as well as to sheet steel or cast equipment boxes with untapped conduit entries (whether surface-mounted or concealed), except for loop-in type conduit boxes or instances where space limitations apply, the attachment must be made using a flanged coupling, a long-thread male brass bush, and a heavy-duty brass compression washer. The coupling should be installed outside the equipment, while the male bush and compression washer should be placed inside the equipment, with the flanged part of the washer bearing against the head of the bush.

19.5. The attachment of conduits to loop-in type conduit boxes, as well as to sheet steel or cast cases of other equipment (whether surface-mounted or concealed), should be made using a standard conduit coupling, a long-thread male brass bush, and a heavy-duty brass compression washer. The coupling should be fitted on the outside of the equipment, while the male bush and compression washer should be placed inside the equipment, with the flanged part of the washer bearing against the box or case.

19.6. Any attachments not detailed in sub-clauses 10 and 11 must receive prior approval from the Engineer before being accepted.

19.7. When attaching conduits to equipment such as cable trunking, fluorescent fittings, or channeling that is painted or enameled, the paint or enamel must be carefully removed from the areas of the coupling, bush, or washer contact. After attachment, any exposed areas from which paint or enamel has been removed should be carefully touched up to match the original finish.

19.8. The attachment of flexible conduits to solid conduit, conduit accessories, equipment cases, or motor terminal chambers must always be made using brass adapters, to which the flexible conduit must be brazed or soldered securely. The brass adapters should then be fixed to the solid conduit, accessories, equipment cases, or motor terminal chambers in a reliable manner, ensuring efficient earth continuity. To maintain earth continuity, a 2.5mm green/yellow sheathed earth wire should be installed within the flexible conduit and connected to the brass adapters by soldering or another approved method.

19.9. The Contractor must ensure that conduits are dry and free from moisture before any wiring is installed. If there is any doubt or need, the conduits should be swabbed dry.

19.10. During the course of the contract, all conduits and accessories must be effectively protected from the entry of plaster and other building materials.

19.11. Wiring should not be drawn into the conduit system until the entire system is complete.

19.12. For buried or concealed conduit work, draw-in, inspection, and similar boxes, which must be flush with the finished surface of walls or ceilings, should have special overlapping covers or include a white Bakelite break joint ring between the standard cover and the box.

19.13. The use of running couplings is not permitted under this contract. Conduit unions will be used instead.

19.14. All conduit systems must be fully completed before cables are installed.

19.15. All surface-mounted conduits should follow vertical and horizontal routes. Conduits in loft areas and ceiling spaces should also be installed along vertical and horizontal routes. Conduit routes should be determined on-site if not clearly specified in the contract drawings, with all main conduit routes requiring approval from the Engineer before installation.

19.16. Conduits recessed into or installed within walls should follow vertical and horizontal routes, with horizontal routes being positioned at high levels whenever possible.

19.17. Conduits cast into floors may follow diagonal routes.

19.18. All conduits should be installed in a neat and symmetrical pattern, and where possible, follow the same route, even if it requires longer conduit runs. If this approach is not followed during construction, the Contractor will be required to dismantle and reinstall the conduits as specified, with any additional costs for materials and labor borne by the Contractor.

19.19. Conduit routes must include an adequate number of draw-in boxes at agreed positions. Draw-in boxes should be of the correct type for their intended use, with the correct number and positioning of outlet points. These boxes must be securely fixed using steel wood screws or toggle bolts as appropriate, and positioned at each outlet point. Conduits cast into building structures must be positioned clear of and above the first layer of reinforcement. No more than two right-angle bends should be included in any conduit run.

19.20. Conduit fixings should be installed at spacings according to the manufacturer's recommendations. Fixing saddles should be placed at a maximum of 1.2m apart or 0.3m from conduit outlet boxes or changes in direction.

19.21. Surface-mounted conduits, including those routed through loft areas, should be secured with distance saddles, ensuring a minimum clearance of 2mm between the conduit and the wall.

19.22. Flush-mounted conduits should be secured using cram pits or spring saddles, as directed by the Engineer.

19.23. When conduits are run near steam or hot water pipes, they should be placed below these pipes wherever possible and must maintain a minimum distance of 150mm from them.

19.24. The conduit and accessories must maintain both electrical and mechanical continuity throughout.

19.25. Conduits passing through floor slabs must be protected by wrapping them with Denso tape to prevent damage and corrosion.

19.26. For conduits installed externally or in damp conditions, spout outlet boxes or internally threaded cast boxes must be used. Measures to ensure water-tightness, including the use of rubber gaskets, must be implemented.

20.0 Plastic Conduit and Conduit Fittings

20.1. Plastic conduits should be made of rigid PVC, heavy gauge, and may be white, black high-impact, or LSF flexible conduit as specified.

20.2. Conduits should be installed in accordance with the manufacturer's instructions, especially concerning expansion joints.

20.3. Changes in the direction of the conduit must be made using purpose-built accessories.

20.4. Conduits must terminate at accessory boxes using a plastic flange coupling and plastic male bush. They should make a solid connection with all conduit fittings.

20.5. All plastic "slip-on" connections should be cemented using the manufacturer's approved cement.

20.6. Plastic conduits should not be installed in environments with temperatures (either high or low) that could potentially damage the conduits.

20.7. All plastic conduits must include protective conductors to ensure safety and compliance.

20.8. Plastic conduit boxes must be made from high-impact materials and come complete with a box lid. When installed at lighting point positions, the boxes should have external fixing feet for secure attachment.

20.9. Plastic conduits should be firmly fixed to the building structure according to the guidelines outlined in Clause 2.22.3. Additionally, plastic conduit boxes used to support light fittings must either be of a reinforced design to support a 10kg load or be replaced with galvanized boxes for added strength and stability.

Typical Conduit Sizes And Length

- Diameter
- Length

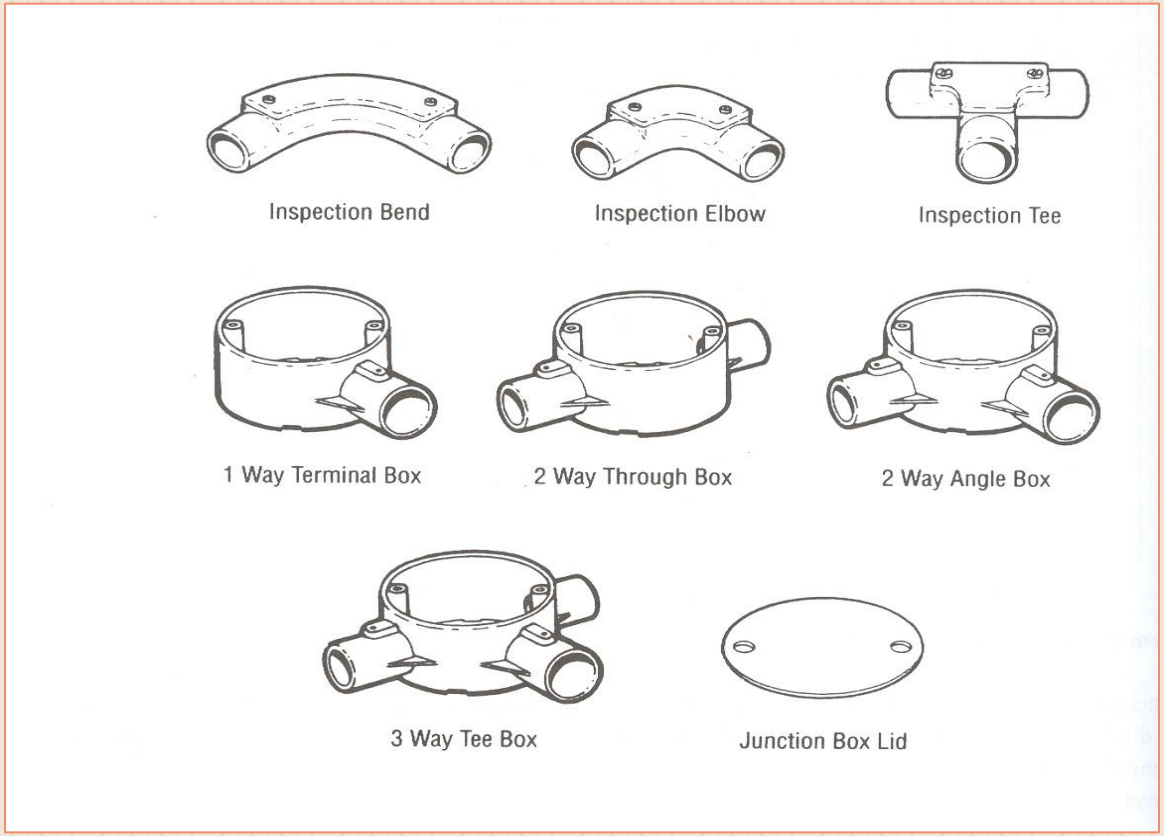
- Diameter
  - ½ INCH
  - ¾ INCH
  - 1 INCH
  - 1 ¼ INCH
  - 1 ½ INCH
- Length
  - 4 - 8 meter

ADDITIONAL ACCESSORIES

- PURPOSES
  - To facilitate conduit PVC installation
  - To pull the cables inside the conduit easily

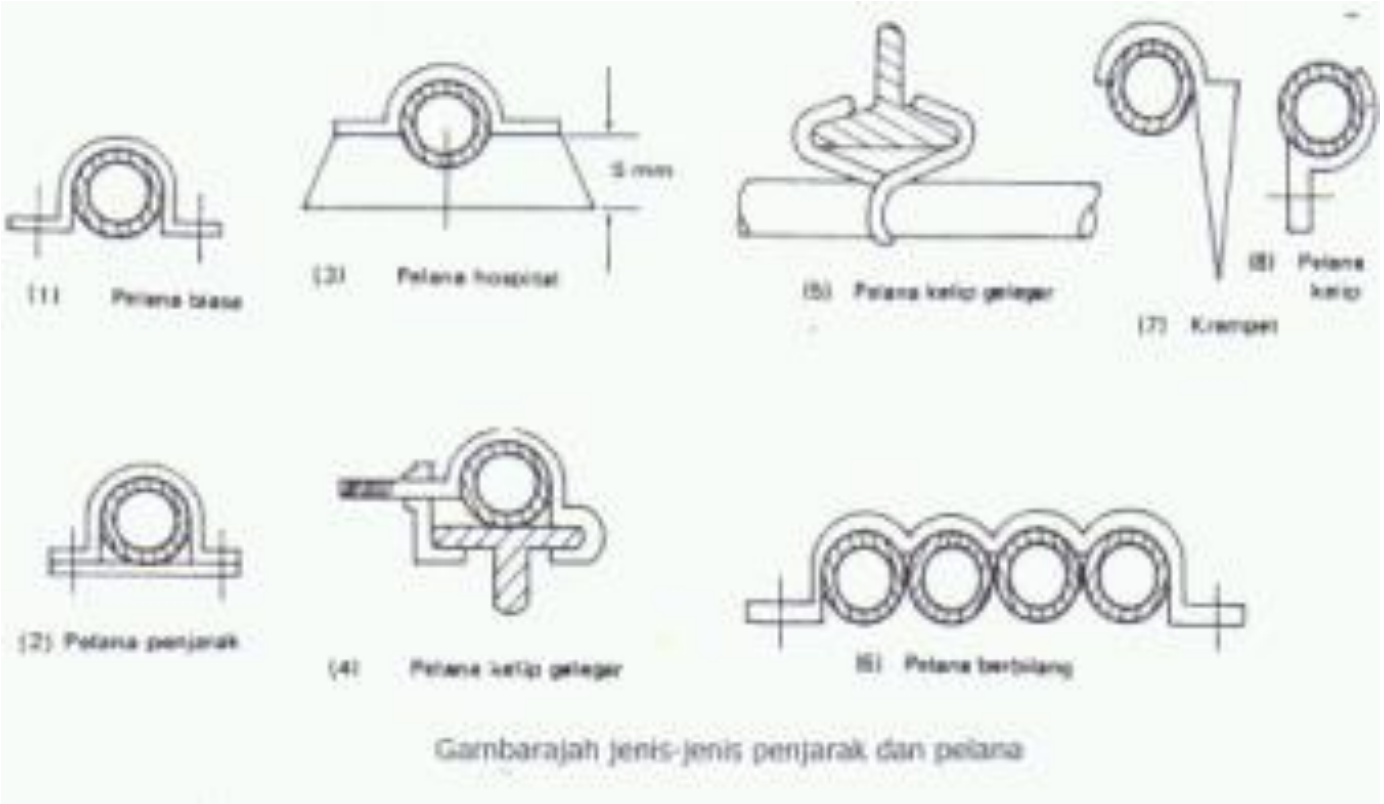
ADDITIONAL ACCESSORIES

- Additional accessories for PVC conduit



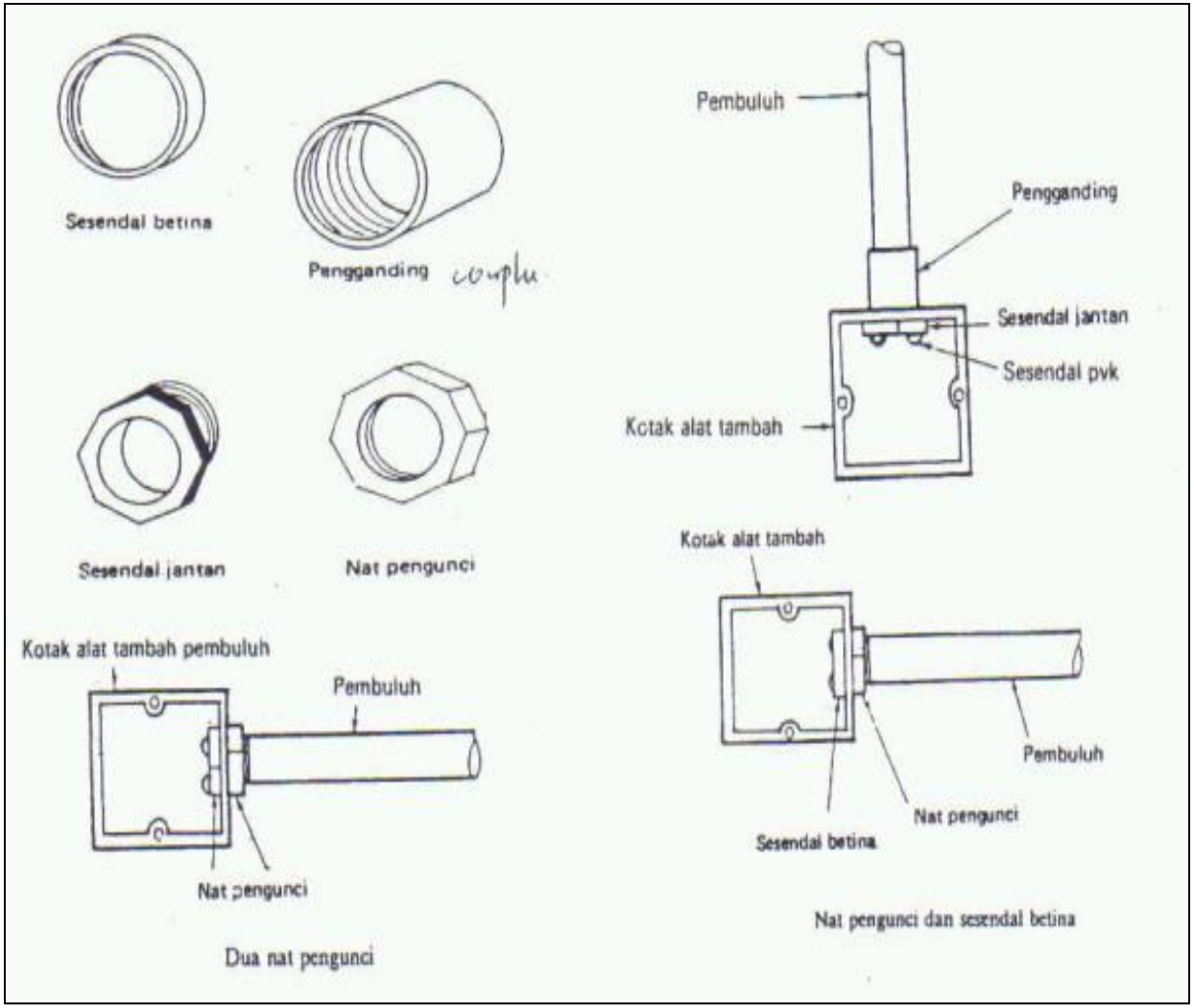
Typical bar and saddle

- Usage - To Grip Or Support PVC Conduit Installation On Wall Or Ceilings Surface



Gambarajah jenis-jenis penjarak dan pelana

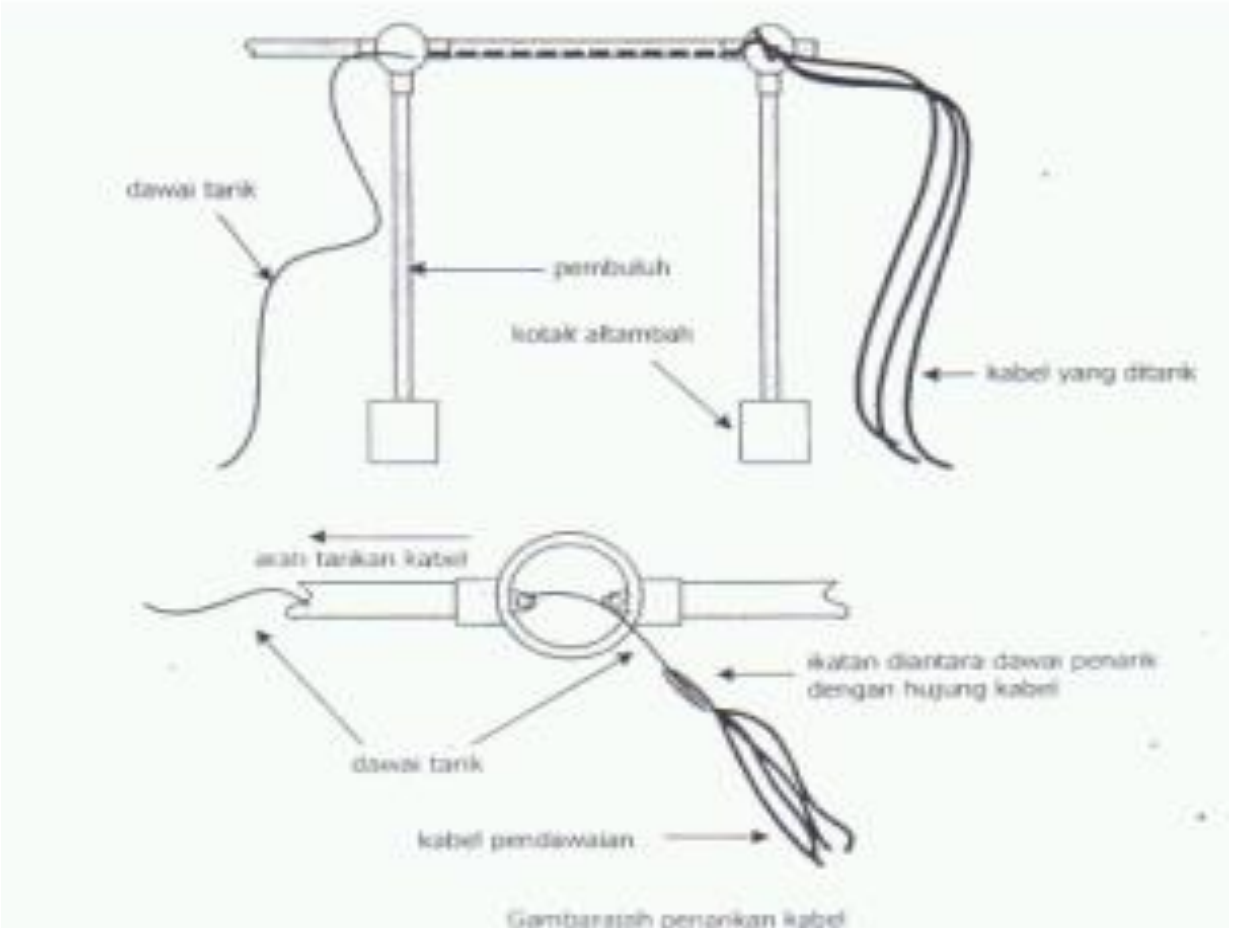
Connectors For Conduit Installation



PVC PIPE BENDER

Usage- To Bend PVC Conduit

PROCEDURES OF PVC WIRING LOADS WORKS



Gambarajah penarikan kabel

PVC WIRING WORKS, VISUAL INSPECTION&TESTING SINGLE PHASE WIRING

OBJECTIVES :

1. TO INSTALL ACCORDANCE TO IEE CONSUMER CONTROL SEQUENCE UNIT (CUT OUT FUSE, NEUTRAL LINK AND METER KW/J 1 PHASE TO CONSUMER UNIT)

2. TO INSTALL FINAL CIRCUIT CORRECTLY BY REFERRING TO SCHEMATIC DIAGRAM GIVEN

3. TO CONDUCT VISUAL INSPECTION AND CIRCUIT TESTING

HOW TO PLAN TO DO THE WIRING

- ✓ Estimation The Loads
- ✓ To Determine The Correct Rates Of Protective Devices
- ✓ To Determine Cables Sizes
- ✓ To Arrange Final Circuit
- ✓ To Determine Arrangement Of Final Circuits

SULIT

AKADEMI BINAAN MALAYSIA
(WILAYAH SELATAN)

UJIAN KEMAHIRAN

PEMASANGAN PENDAWAIAN BANGUNAN

BWI 1

AMALI

TARIKH :

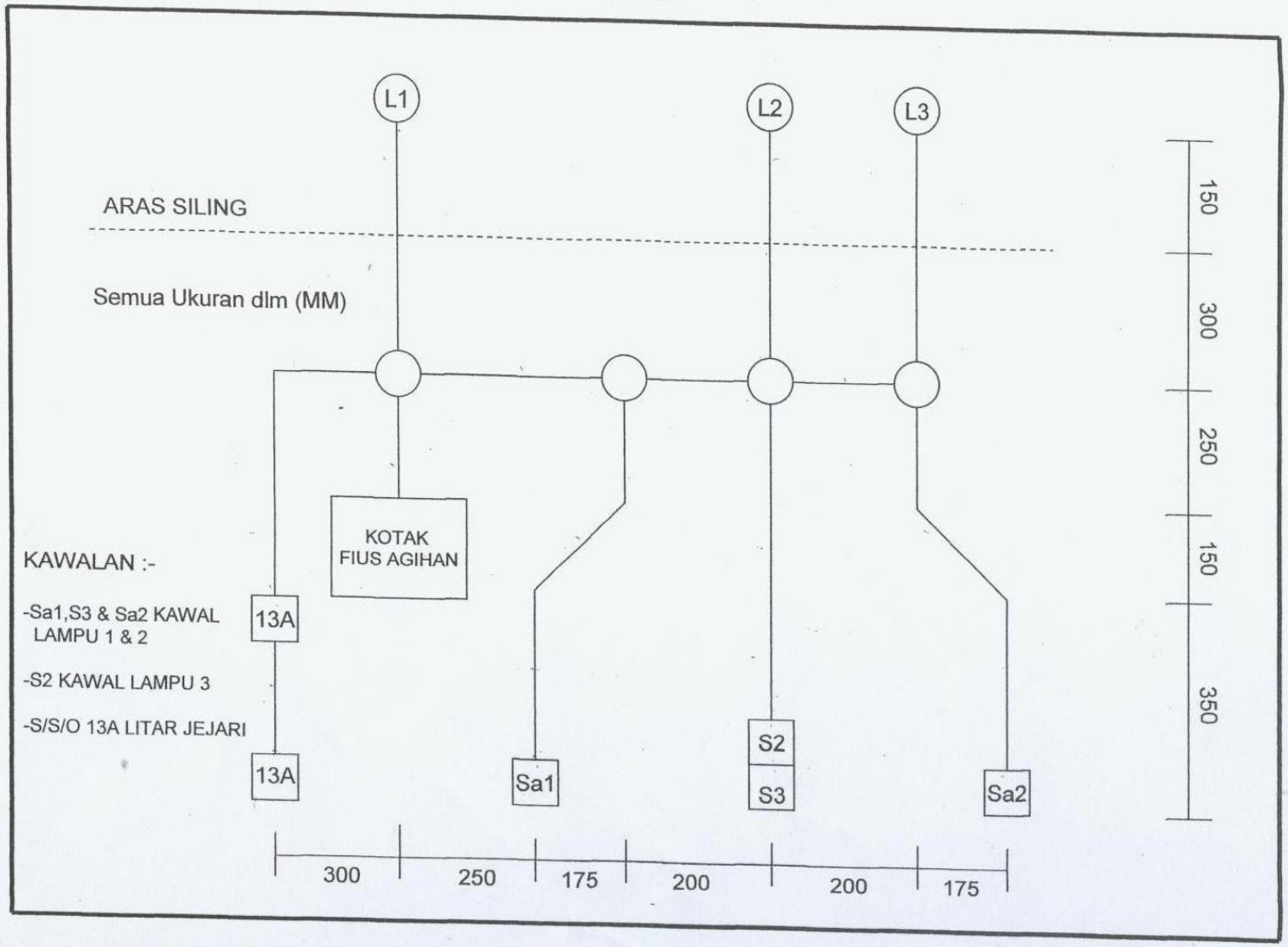
MASA : 3 JAM 30 MINIT

NAMA CALON	
NO. KAD PENGENALAN	- -

ARAHAN :

1. Calon dibenarkan memeriksa kelengkapan, peralatan dan bahan gunahabis mencukupi serta berkeadaan baik.
2. Permohonan bahan gunahabis kali kedua tidak di benarkan.
3. Calon tidak di benarkan membuat pengujian di dalam litar hidup.
4. Sila rujuk kepada Pemeriksa jika terdapat sebarang kemusykilan.

"JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIBERITAHU"


L1
L2
L3
ARAS SILING
Semua Ukuran dlm (MM)
KOTAK
FIUS AGIHAN
KAWALAN :-
-Sa1,S3 & Sa2 KAWAL
LAMPU 1 & 2
-S2 KAWAL LAMPU 3
-S/S/O 13A LITAR JEJARI
13A
13A
Sa1
S2
S3
Sa2
150
300
250
150
350
300
250
175
200
200
175

DB Single Phase Schematic Arrangements

1. All the protective devices must be complying with the IEE arrangement according to the schematic diagram below.

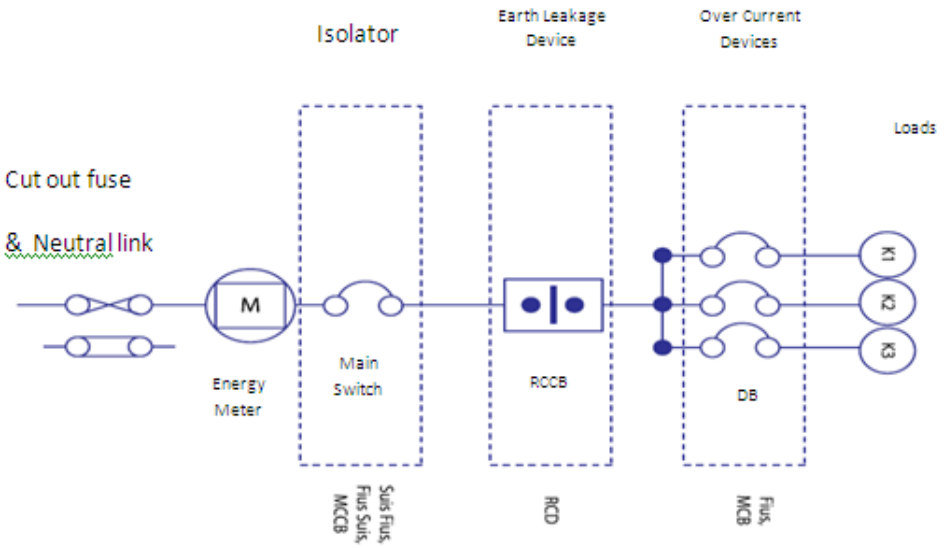
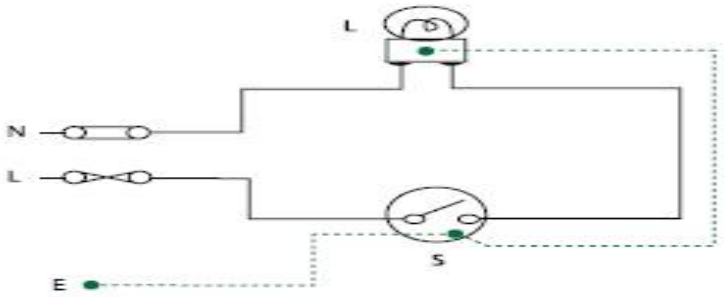
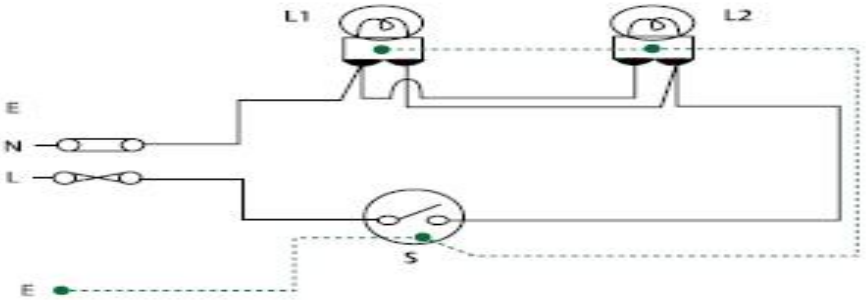


Figure 12.2 Isolator and protective devices for domestic installations

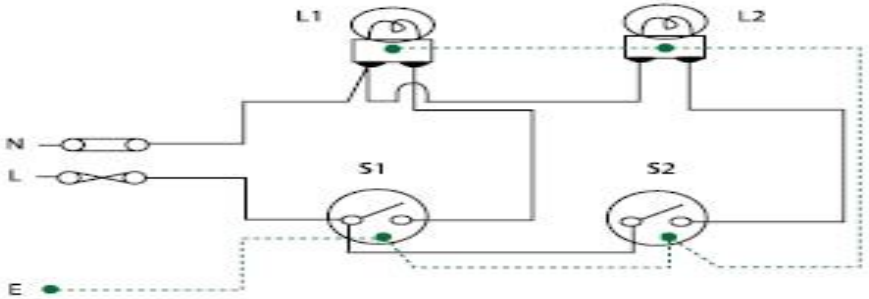
3.4 Contoh-contoh Litar Skematik Pendawaian Lampu



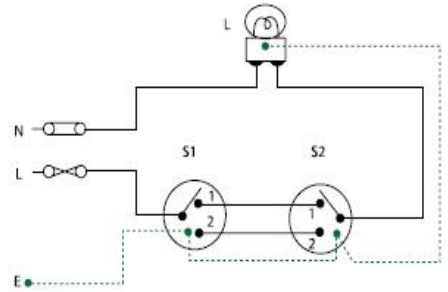
1 Satu mata lampu dikawal oleh satu suis sehala



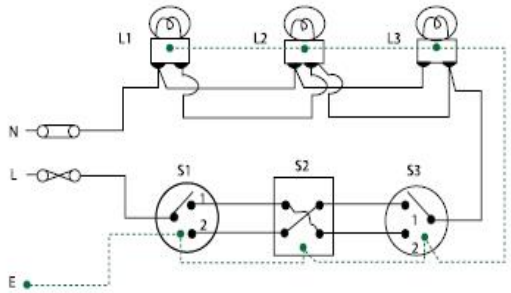
2 Dua mata lampu dikawal oleh satu suis sehala



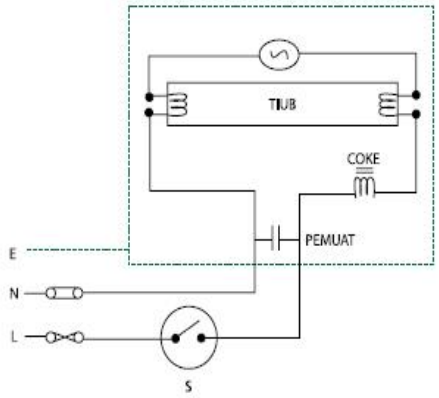
3 Dua mata lampu dikawal oleh dua suis sehala secara berasingan



4 Satu mata lampu dikawal oleh suis dua hala



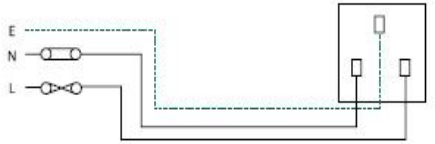
5 Tiga mata lampu dikawal oleh suis dua hala dan suis perantaraan



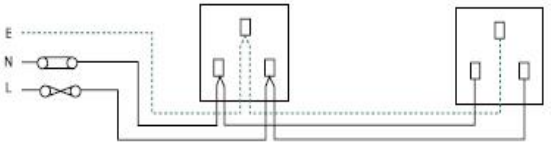
6 Satu mata lampu kalimantang dikawal oleh suis satu hala

3.5 Contoh-contoh Litar Skematik Pendawaian Soket Alir Keluar

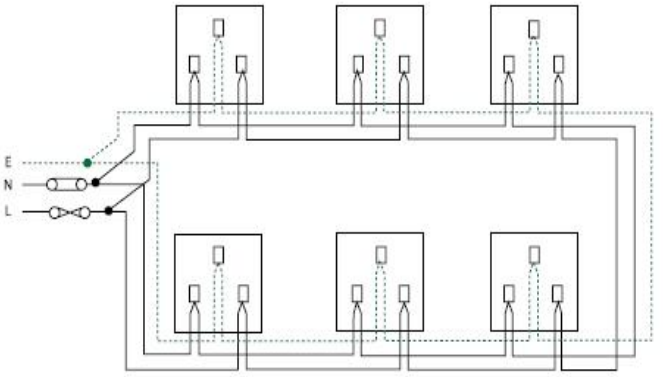
7 Soket Alir Keluar – Satu Soket:



8 Soket Alir Keluar – Disambung Secara Radial:



9 Soket Alir Keluar – Disambung Secara Litar Gelang:



Garis Panduan Pendawaian Elektrik di Bangunan Kediaman

REGULATIONS OF FINAL CIRCUIT

LIGHTING CIRCUIT :1. cable size 1.5mm^2
2. protection rate MCB 6A
3.max loads 10 no's or point
4. max total power1000watt

SWITCH SOCKET OUTLET 13A CIRCUIT

1. cable size 2.5mm^2
2. protection rate MCB 20A control 2 no's of S.S.O 13A, wiring area within 20m^2
3. protection rate MCB 32A control S.S.O 13A wiring area within 50m^2, cable size 4mm^2

TESTING

1. PURPOSE – To ensure the electrical installation comply with IEE regulations, correctness of circuits installment, functionality and safe to use.

TYPICAL TESTING

Installation testing is divided into 2 main type:

1. Visual inspection/naked eyes observation
   - 1.1 cable sizes, correctness of cables color code
   - 1.2 suitable accessories, safe to use
   - 1.3 correct cables connection
   - 1.4 good final termination and screwed tightly

2. Installation testing
   - 2.1 power supply off installation testing
   - 2.2 power supply on installation testing

Types Of Installation Testing

Testing Type	Purposes
POLARITY TESTING	To ensure all the life connection from MCB to common switch, or life MCB to life terminal SSO are correct (POWER SUPPLY OFF)
FINAL CIRCUIT CONTINUITY TESTING	To ensure continuity to all conductors (L+L), (N+N) DAN (E+E) (POWER SUPPLY OFF)
INSULATION AND RESISTANCE TESTING	To ensure the cables insulation is free leakage condition, and short circuit fault free (POWER SUPPLY OFF)

TESTING EQUIPMENTS

1. MULTIMETER
2. INSULATION TESTER
3. CLAMP METER
4. SOCKET TESTER
5. BELL TESTER
6. EARTH TESTER
7. LAMP TESTER

TESTING EQUIPMENTS

- Insulation Tester

- Multimeter

TESTING EQUIPMENTS

- Clamp Tester

- Light Tester

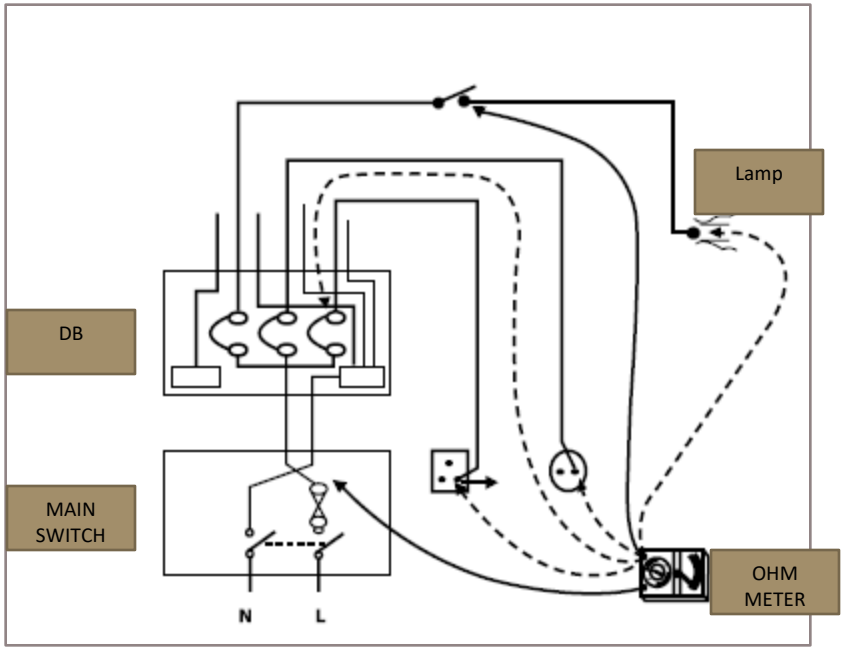
TESTING EQUIPMENTS

- Switch Socket Tester

- Earth Tester

TESTING PROCEDURES

- Polarity Testing



PROCEDURES

- Main switch must open circuit state *(switch off);*
- Remove all the loads
- Circuit control switch must close circuit state *(switch on);*
- Conduct testing as referred diagram
- Test switch and single pole control devices to phase conductors
- Test to sockets outlets connection sources
- Test connection of screw Edison lamp holders
- And good polarity the meter reading must less than 1 ohm.

TESTING PROCEDURES

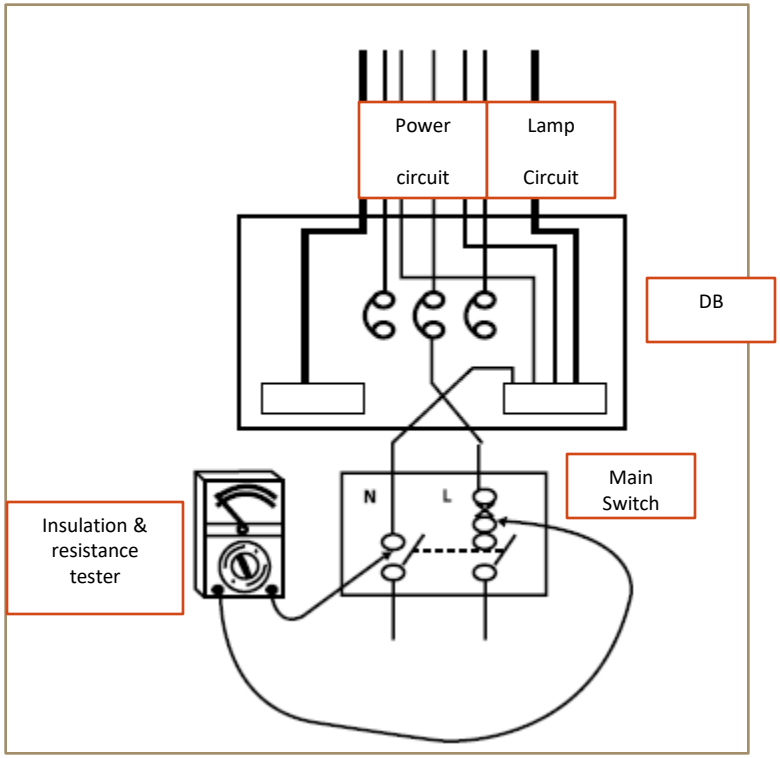
PROCEDURES

- Main switch must be open circuit state *(switch off);*
- Remove all the loads
- Circuit control switch must be close circuit state *(switch on);*
- Conduct testing as table given; and
- Good insulation as meter reading value is less than 1 Mega ohm.

Point	Meter reading
L + L	< 1 Meg Ω
N + N	< 1 Meg Ω
E + E	< 1 Meg Ω

Table 1

- Insulation Testing



CIRCUIT CONTROL & PROTECTION

1. Electrical faulty : an introduction
2. Over current: a review
3. Over current protection devices: a review

Electrical faulty

Introduction

- Definition of electrical faulty

- **What is an electrical fault?**
- An electrical fault is a condition in an electrical system that leads to the failure of equipment in the circuit, such as generators, transformers, bus bars, cables, and other components that operate at a specific voltage level.

Principal Fault Types

Electrical faults can be broadly categorized based on the nature of the electrical system as follows:

- **Short-Circuit Faults:** These occur when insulation fails, leading to a short circuit. This is the most common cause of failure in electrical systems.
- **Open Circuit Faults:** This type of fault happens when there is a failure in the conduction path, interrupting the flow of electricity.

In addition to these, there can also be combination (simultaneous) faults and equipment-level winding faults, although we will not delve into them in detail here. Since short-circuit faults are the most frequent cause of issues in electrical distribution systems, we will focus on them in detail.

Over Current Protection

Objectives:

1.To describe the types of over current

2.To state categories of protective devices

Over Current

Introduction

- Overcurrent or excess current occurs as a result of either an overload or a short circuit
- An overload can happen, for example, if a motor stalls, leading to excessive current draw in the circuit.
- A short circuit occurs when a defect in the insulation of the conductor causes the circuit's resistance to drop to nearly zero. This reduction in overall resistance causes the current to increase proportionally in the conductors. The increased current will quickly affect the cables and other connected equipment.
- If the circuit does not have overcurrent protection, the cables will heat up rapidly and may melt, damaging the equipment. If the overload continues, the situation can become more severe, potentially leading to an electrical hazard such as a fire.

Types of over current

Over current occurred in a system are due to:

- Overload
- Short circuit

Overload

- Over load may happen due to

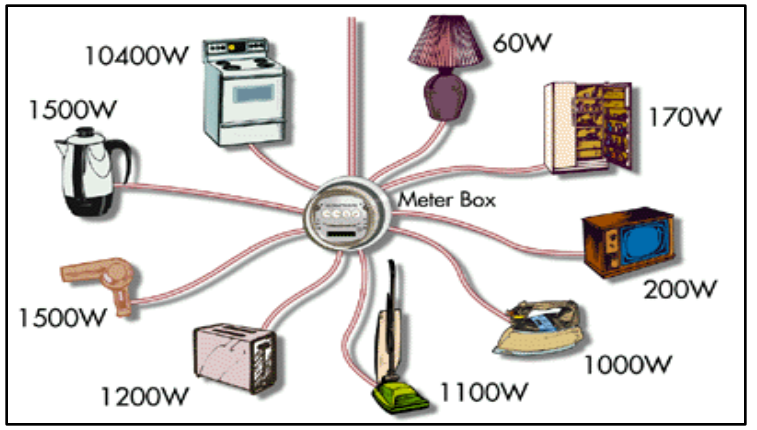
1. Faulty running of industrial motor caused by bearing failure
2. Excess of loading at socket outlet
3. Unbalanced load connection at three phase system

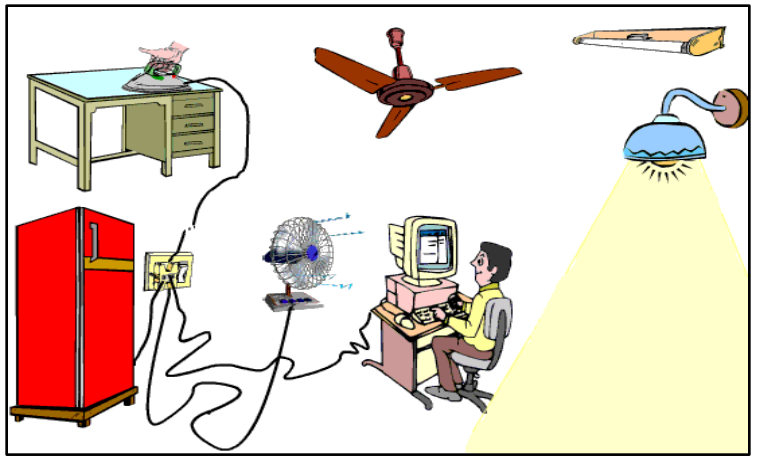
- When overload occurs, the current flow in the circuit will flow

  beyond the limit and become extremely high for the system.
- Overloads usually will not cause immediate damage to conductors and equipments.
- As the duration of overload gradually increased, the damage increased gradually.
- If the fault is not cleared or overcome quickly, the cables may overheat and insulations may melt, causing exposure to bare conductors. This situation can lead to fire.

Overload

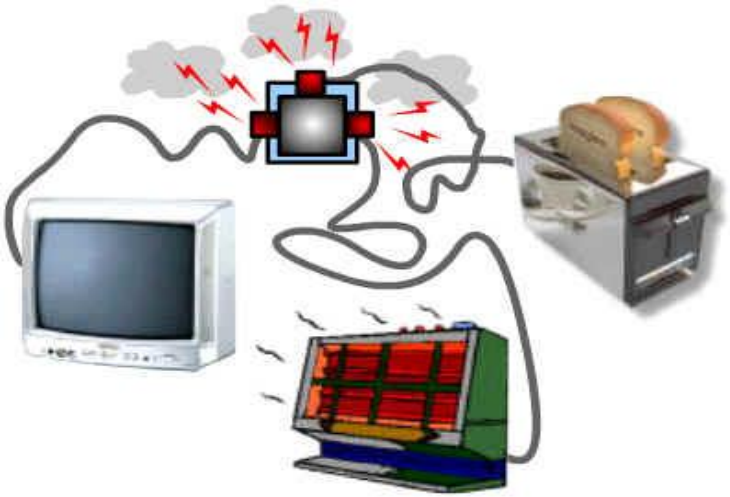
- In residential houses or buildings, overloads are typically caused by using too many appliances simultaneously or by plugging a heavy-duty appliance into a single socket.





Overload Precautions

- Avoid using more power-hungry devices than the capacity of the power source can handle.



- Always use high-quality materials such as fuses, MCBs, electrical wires, plugs, and other components.

Short Circuit

Short-circuit Faults

- In mains circuits, a short circuit fault occurs when there is an insulation failure between phase conductors or between phase conductors and earth, or both. This insulation failure creates a short-circuit path, leading to a short-circuit condition in the circuit, characterized by abnormally high current flow, which can result in visible effects such as arcing or flashing.

Figure 1.0 below depicts a three phase-to-earth balanced **fault condition**:

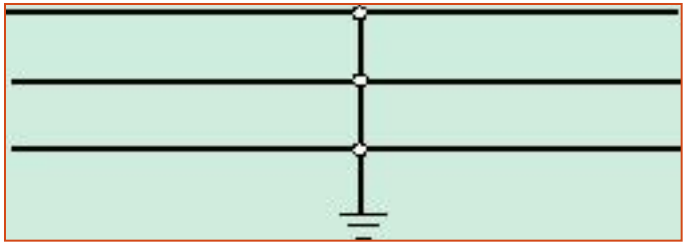


Fig 1.0: Three Phase-to-Earth Balanced Fault Condition

Short Circuit

- Two other most common unbalanced fault conditions seen in a balanced three phase electrical system are:
- Phase-to-Phase Fault: In this type of fault, two of the three phases become short-circuited, leading to an unbalanced fault condition within the system. The diagram in Figure 2.0 below illustrates this fault condition.

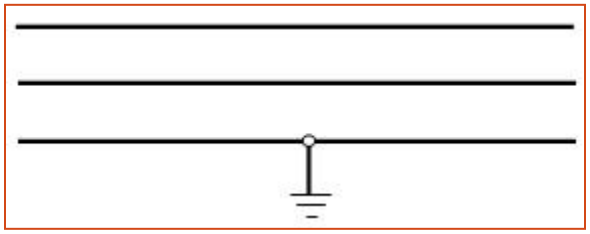


Fig 2.0: Phase-to-Phase unbalanced Fault Condition

- Single phase-to-earth fault: In this type of fault, one of the three phases is short-circuited to the ground, resulting in an unbalanced fault condition in the system. The diagram in Figure 3.0 below illustrates this fault condition.

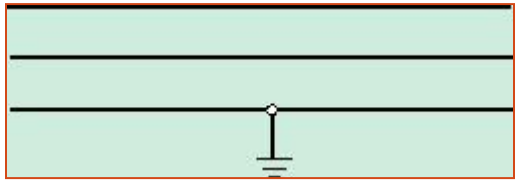


Fig 3.0: Single Phase-to-Earth unbalanced Fault Condition

Short Circuit

- In electrical devices, unintentional short circuits typically occur when a wire's insulation deteriorates or when another conductive material comes into contact, allowing electrical current to flow along an unintended path.

- A common type of short circuit occurs when a low-resistance conductor, such as a wire, connects the positive and negative terminals of a battery. This creates a path with minimal resistance, resulting in a high current flow and causing the battery to release a large amount of energy in a short period.
- High current conditions can also arise in electric motors under stalled conditions, such as when the impeller of an electrically driven pump is blocked by debris. While this is not a short circuit, it can produce effects similar to those of a short circuit

Short Circuit Precautions

- Damage from short circuits can be minimized or prevented by using fuses, circuit breakers, or other overload protection devices, which disconnect the power when excessive current is detected. Overload protection should be selected based on the current rating of the circuit. Circuits for large home appliances need protective devices rated for higher currents than those for lighting circuits. Wire gauges specified in building and electrical codes are chosen to ensure safe operation in combination with the overload protection. An overcurrent protection device must be rated to safely interrupt the maximum possible short-circuit current.

- In an improper installation, overcurrent from a short circuit can cause ohmic heating in parts of the circuit with poor conductivity, such as faulty wiring joints, defective power socket contacts, or the location of the short circuit itself. This overheating is a common cause of fires. Additionally, if an electric arc forms during the short circuit, it can generate a significant amount of heat, potentially igniting combustible materials.
- In industrial and utility distribution systems, the dynamic forces generated by high short-circuit currents can cause conductors to spread apart. These forces can also damage bus bars, cables, and other equipment in the system.

Protective Devices

Objectives:

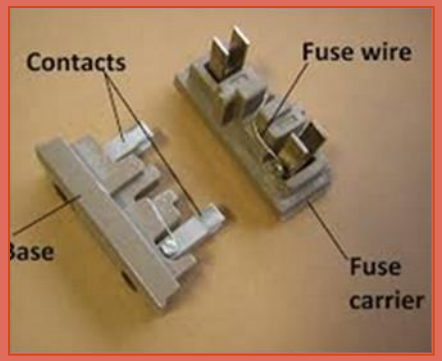
1. Define fuses and circuit breakers
2. Explain operating procedures
3. Explain the advantages and disadvantages for the fuses and circuit breaker

Fuse	Circuit Breaker
An electrical safety device that includes a wire or strip made of fusible metal (or metal alloy) which melts and interrupts the circuit when the current exceeds a specified amperage is called a fuse.	A circuit breaker is a switch that automatically interrupts the flow of electricity if the current exceeds a preset limit, measured in amperes. Circuit breakers are commonly used as safety precautions in situations where excessive current could pose a hazard. Unlike fuses, circuit breakers can typically be reset and reused after tripping

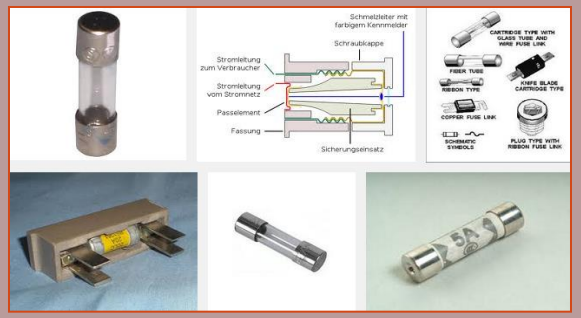
Fuse

- Types of fuses
  i. Rewire able fuse
  ii. Cartridge fuse
  iii. High breaking capacity (HBC)@ high rupturing capacity (HRC)
  iv. Plug fuse

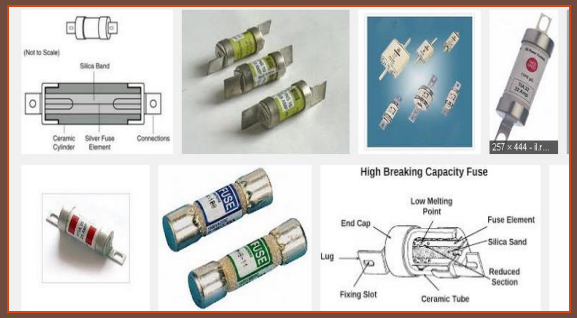
Rewire able fuse



Cartridge fuse



HBC fuse



Plug fuse

Operation of fuses

Objectives:

i. Explain operating procedures

i. In electrical engineering, a fuse is a safety device designed to protect electric circuits from the harmful effects of excessive electric currents. A fuse typically consists of a current-conducting strip or wire made of easily fusible metal. When the circuit carries a current larger than its intended capacity, the metal strip melts, interrupting the flow of electricity.

Fuse

Objectives:

i. Types of fuse element material

Metal	Melting point (^{0}C)	Specific resistance (M-Ω cm)
Silver	980	1.6
Tin	240	11.2
Zinc	419	6
Lead	328	21
Copper	1090	1.7
Aluminum	665	2.8

Parameters of fuse

Current rating

- Current Rating

The current rating of a fuse specifies the maximum current it can safely carry without blowing (breaking the circuit). It is a steady-state value under normal operating conditions. Exceeding this current for an extended period will cause the fuse to overheat and eventually blow.Example: A fuse with a current rating of 10A can continuously conduct up to 10A without damage.

Fusing current

- Fusing Current

The fusing current is the minimum current at which the fuse element melts and interrupts the circuit. It is typically higher than the current rating because the fuse needs to withstand small current fluctuations.Relation to Current Rating: The fusing current is usually 1.25 to 1.5 times the current rating, depending on the fuse design.

Parameters of fuse

Fusing factor

- Fusing Factor

The fusing factor is the ratio of the fusing current to the current rating of the fuse. It indicates the margin between normal operation and fuse activation.

$$\text{Fusing Factor} = \frac{\text{Fusing Current}}{\text{Current Rating}}$$

Example: If a fuse has a current rating of 10A and a fusing current of 13A, the fusing factor is 1.3.

Typical Range: The fusing factor generally falls between 1.1 and 1.5 for standard fuses.

Cut off current

- Cut-Off Current

The cut-off current (also called peak let-through current) is the maximum instantaneous current the fuse allows to pass through before it interrupts the circuit. It is particularly important in short-circuit conditions, where the current surge can be very high.

Purpose: The fuse limits the peak current to protect downstream equipment.

Parameters of fuse

Breaking capacity

- Breaking Capacity

The breaking capacity (or interrupting rating) is the maximum current the fuse can safely interrupt without damage or failure. It defines the fuse's capability to handle short-circuit conditions.

Example: A fuse with a breaking capacity of 10kA can interrupt a fault current of up to 10,000A.

Importance: If the fault current exceeds the breaking capacity, the fuse may not interrupt the circuit, leading to equipment damage or safety hazards.

Ambient temperature

- Ambient Temperature

The performance of a fuse is influenced by the surrounding temperature.

Effect: High ambient temperature may reduce the current rating, causing the fuse to blow at lower currents.

Low ambient temperature can increase the current rating, delaying the fuse's operation.

Compensation: Manufacturers provide derating or correction factors to adjust the current rating based on the ambient temperature.

Fuse

Advantages

i. It is the cheapest type of protection
ii. It requires no maintenance
iii. It interrupts large short-circuit currents without producing noise, flames, gas, or smoke.
iv. The minimum operation time of a fuse can be made shorter than that of circuit breakers.
v. It afford current limiting effects under short circuits conditions
vi. It enables use for overload protection

Disadvantages

i. Times is lost in rewiring or replacing fuse after operation
ii. Discrimination between fuses in series cannot be obtained

Summary Table

Parameter	Definition
Current Rating	Maximum current the fuse can carry continuously without blowing.
Fusing Current	Minimum current at which the fuse melts and interrupts the circuit.
Fusing Factor	Ratio of fusing current to current rating; typically 1.1–1.5.
Cut-Off Current	Maximum instantaneous current allowed before interruption during a fault.
Breaking Capacity	Maximum current the fuse can interrupt safely during a fault condition.
Ambient Temperature	External temperature's effect on the fuse's performance, altering its current rating.

Understanding these parameters is crucial for selecting the right fuse for a specific application to ensure proper circuit protection and safety.

Circuit Breaker

Types of circuit breaker

i. Miniature circuit breaker (MCB)

ii. Residual current circuit breaker (RCCB) @ residual circuit device (RCD)

MCB

- A circuit breaker is a switch that automatically interrupts the flow of electricity if the current exceeds a preset limit, measured in amperes
- Figure shown below is MCB commonly can be used for both single phase or 3 phase supply. MCB'S arrangements with rates are determined depend to types of final circuit.

2-pole residual current device

RCCB @ RCD

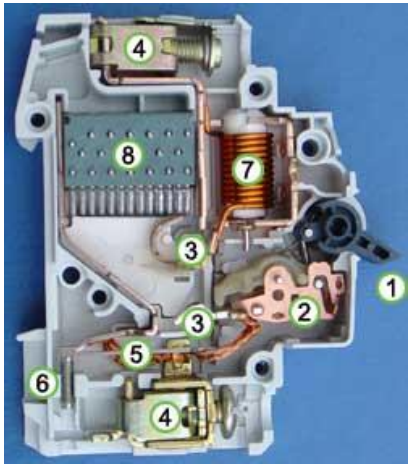
To cut off automatically power supply sources due to earth leakage fault of electrical appliances.
A Residual Current Device (RCD), formerly known as a residual current circuit breaker, detects an imbalance in the current but does not provide over-current protection. It is designed to quickly cut off the power when it detects a difference between the live and neutral wires, helping to protect against electric shock without interrupting normal operation during over-current situations. To avoid electric shock to any user or consumer

- 1 phase (tripping points 40/100mA)
- 3 phase (tripping points 60/300mA)

MCB

Low-voltage types (less than 1,000 VAC) Are widely used in residential, commercial, and industrial applications, and include:

- MCB (Miniature Circuit Breaker)—rated current not more than 100 A. Trip characteristics normally not adjustable. Thermal or thermal-magnetic operation. Breakers illustrated above are in this category.
- There are three main types of MCBs: 1. Type B - trips between 3 and 5 times full load current; 2. Type C - trips between 5 and 10 times full load current; 3. Type D - trips between 10 and 20 times full load current. In the UK all MCBs *must* be selected in accordance with BS 7671.



Circuit Breaker

Selection of circuit breaker:

i. Nominal current
ii. Tripping
iii. The operating time and ranges of circuit breaker

Thermal magnetic circuit breakers

- *Thermal magnetic circuit breakers,* commonly found in distribution boards, combine both methods: the electromagnet reacts instantly to large current surges (such as short circuits), while the bimetallic strip responds to smaller, longer-term overcurrent situations. The thermal component of the circuit breaker offers an "inverse time" response, meaning it takes longer to trip under lower levels of overcurrent and trips faster under higher levels.

Circuit Breakers

Objective:

i. To explain advantages of circuit breaker.

i. Whenever the fault or over current occurs, all the poles are disconnected at the same time
ii. It can be connected to emergency stop buttons
iii. Overload features and time delay function are available
iv. The circuit can be reset quickly after over current had happen
v. The overcurrent setting of the circuit breaker can be easily adjusted.
vi. Immediate indication of faulty is available
vii. It can be reused on each case of faulty
viii. It has very close degree of excess current protection
ix. It will trip on an amount of small overcurrent

Earthing

1. Principles of earthing: an introduction
2. Earthing systems: a review
3. Protective conductors & earth electrodes: a review
4. Earth fault loop impedance & earth electrodes resistance

Earthing System

Introduction

What is the earthing system?

The Earth serves as a large conductor with a reference potential of zero. In the UK, this is referred to as "earth," in the USA, it is known as "ground." Earthing involves connecting components that could become electrically charged to the Earth's general mass. This connection provides a path for fault currents and helps maintain the components at a potential close to that of the Earth. Essentially, this prevents any significant potential difference between the Earth and earthed components while allowing fault currents to flow, enabling the operation of protective systems.

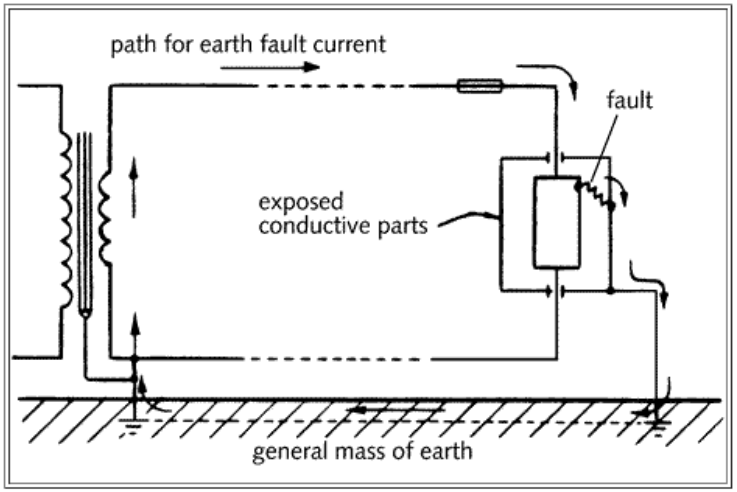
Advantages Of Earthing

The advantages of earthing

- The practice of earthing is common globally, though not universally adopted. While it comes with significant costs, it offers two key advantages:

1. **Stabilized Electrical Potential**: Earthing ensures the entire electrical system is tied to the Earth's general mass potential, preventing it from "floating" at a different potential. For instance, it keeps the supply neutral at or near zero volts (Earth potential), with the phase conductors of a typical supply maintaining a voltage difference of 240 volts from Earth.
2. **Fault Current Path**: By connecting the Earth to non-current-carrying metal components (such as extraneous or exposed conductive parts) using a protective conductor, a path is created for fault currents. This enables the fault to be detected and interrupted when necessary, as illustrated in {Fig 5.2}.

Fig 5.2 Path for earth fault current (shown by arrows)



Disadvantages Of Earthing

The disadvantages of earthing

- The two main disadvantages of earthing are:

1. **High Cost**: Establishing a complete earthing system, including protective conductors, earth electrodes, and related components, is a costly process.
2. **Potential Safety Hazard**: Some argue that complete isolation from the Earth could eliminate the risk of indirect contact shocks, as there would be no return path for shock currents if the supply is not earthed (see {Fig 5.3(a)}. However, this assumption overlooks the effects of earth leakage resistance (caused by imperfect insulation) and phase-to-earth capacitance (where insulation acts as a dielectric). In many cases, the combined impedance of insulation resistance and capacitive reactance is low enough to allow a significant shock current to flow (see {Fig 5.3(b)}.

Fig 5.3 - Danger in an Unearthed System

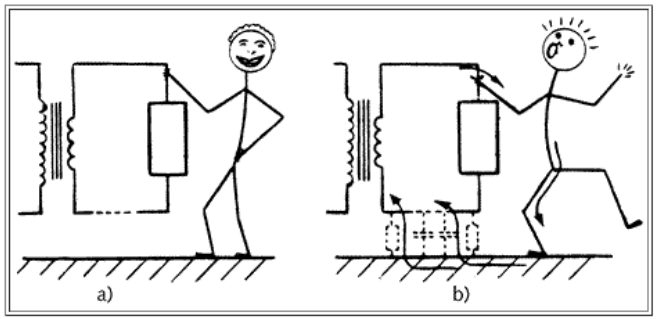


Fig 5.3 - Danger in an unearthed system

a) **Apparent Safety**: At first glance, the absence of an obvious path for shock current might suggest a safer system, as there seems to be no direct route for the current to return through the circuit in the event of a fault.

b) **Actual Danger**: In reality, shock currents can still flow through unintended paths, such as stray resistance from imperfect insulation or phase-to-earth capacitance, where the insulation acts as a dielectric. These factors create a low-impedance path that can allow significant shock currents, posing a hidden safety risk.

Earthing System **Classification**

Objective:

i. To explain types of earthing system

- **System classification**

i. TT systems
ii. TN-S system
iii. TN-C-S system
iv. TN-C system
v. IT system

System Classification

- **System classification**
- Electrical installations are interconnected with the supply system, which forms part of the broader electrical infrastructure. While Electricity Supply Companies often provide an earth terminal, they are not legally required to do so. Earthing systems are classified using letter designations:

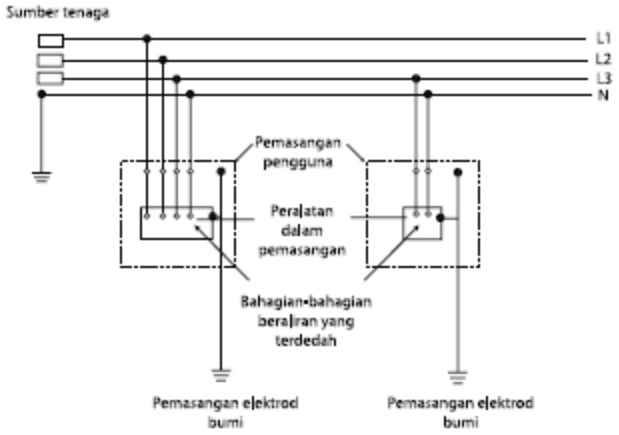
1. **First Letter** (Type of Supply Earthing):
    1. **T**: Indicates that one or more points of the supply, such as the neutral at the transformer, are directly earthed.
    2. **I**: Indicates no direct earthing or earthing with deliberately inserted impedance to limit fault current (not used for public supplies in the UK).
2. **Second Letter** (Installation Earthing):
    1. **T**: All exposed conductive parts are directly connected to Earth.
    2. **N**: All exposed conductive parts are connected to an earthed supply conductor provided by the Electricity Supply Company.
3. **Third and Fourth Letters** (Earthed Conductor System):
    1. **S**: Neutral and Earth conductors are separate.
    2. **C**: Neutral and Earth are combined into a single conductor.

- Various combinations of these classifications (e.g., TN-S, TN-C, TT systems) are commonly used.
- Additionally, protective conductor systems for lightning must connect to the installation's earthing system to prevent hazardous potential differences. In cases where both protective and functional earthing are required, the protective earthing takes precedence.

TT Systems

- **TT systems**
- This arrangement applies to installations where the Electricity Supply Company does not provide an earth terminal. It is commonly used in rural areas served by overhead supply lines. In such setups, the neutral and earth (protective) conductors must remain entirely separate throughout the installation. The final earth terminal is connected to an earth electrode via an earthing conductor.
- Ensuring a reliable earth connection can be challenging in these cases. Therefore, socket outlet circuits must be protected by a residual current device (RCD) with a 30 mA operating current for safety.

- {Fig 5.4} shows the arrangement of a TT earthing system



TN-S system

- The Electricity Supply Company provides an earth terminal at the position of the incoming main. This terminal is connected via the supply protective conductor (PE) to the star point (neutral) of the secondary winding of the supply transformer, which is itself connected to an earth electrode at that point. Typically, the earth conductor is formed by the armour and sheath of the underground supply cable, if present. A diagrammatic representation of this system is shown in {Fig 5.5}.

- **Fig 5.5 – TN-S earthing system**

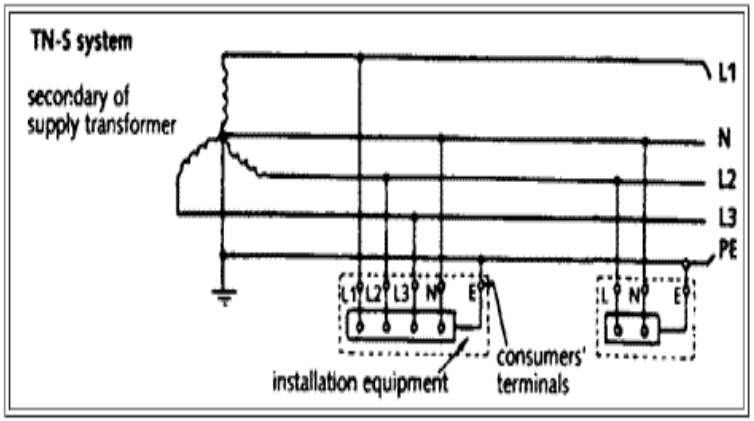


Fig 5.5 - TN-S earthing system

TN-C-S system

- In this system, the installation follows the TN-S configuration, with separate neutral and protective conductors. However, the supply uses a single conductor for both the neutral and earth, known as the combined neutral and earth conductor (CNE) or the protective and neutral conductor (PEN). This setup, commonly referred to as the Protective Multiple Earth (PME) system, is illustrated in {Fig 5.6} and will be explored in more detail in {5.6}.

- Fig 5.6}, protective multiple earth (PME) system

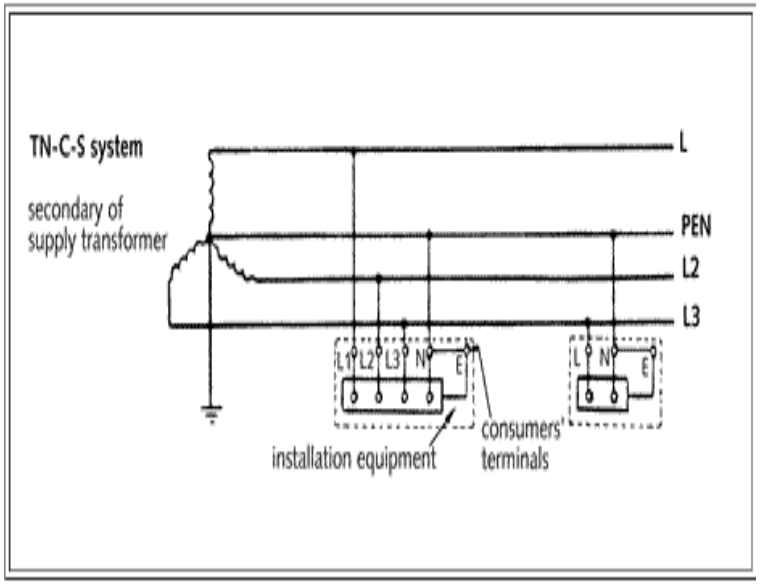
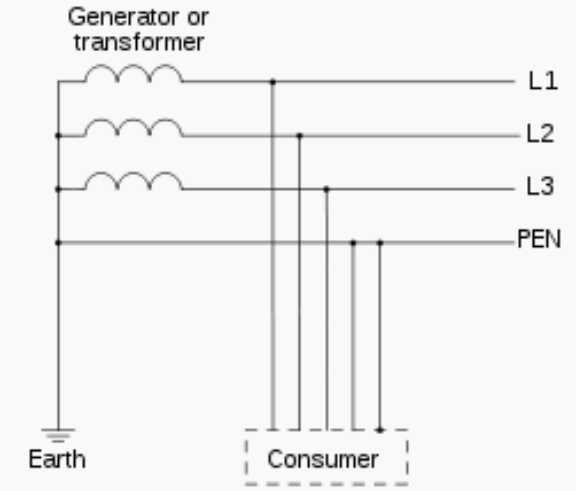


Fig 5.6 - TN-C-S earthing system - protective multiple earthing

TN-C system

- This installation is atypical because combined neutral and earth wiring is used both in the supply and within the installation itself. When this system is employed, it is typically the earthed concentric system, which can only be installed under the specific conditions outlined in {5.7}.

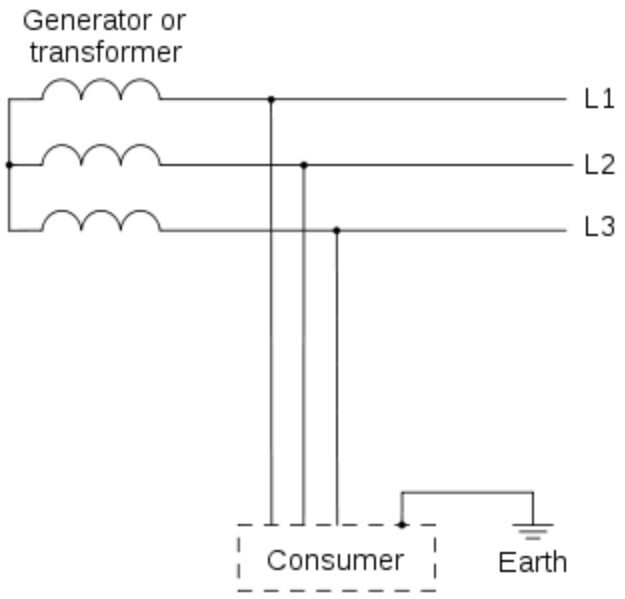


TN-C: combined PE and N conductor all the way from the transformer to the consuming device.

IT Networks

- In an IT network, the electrical distribution system is either completely unconnected to earth or has a high-impedance connection to earth. In these systems, an insulation monitoring device is used to continuously monitor the impedance.

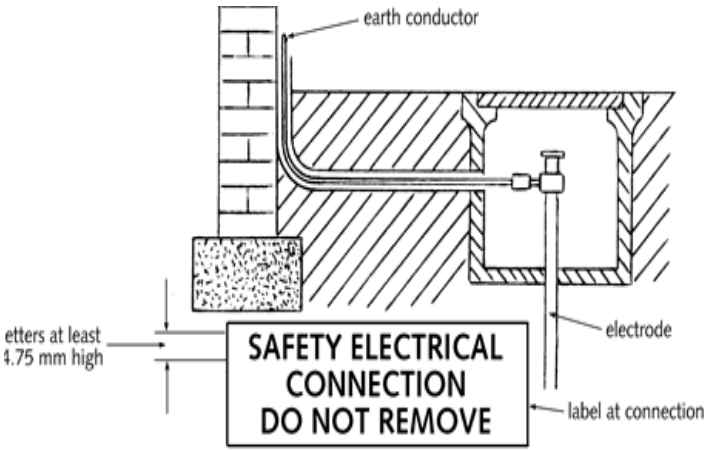
- IT Network



Earthing Conductor

- The earthing conductor, often referred to as the earthing lead, connects the installation's earthing terminal to the earth electrode or the earth terminal provided by the Electricity Supply Company.
- While aluminum conductors and cables can now be used for earthing and bonding, they must be protected from corrosion or electrolytic action, especially where they come into contact with other metals.

- Where the final connection to the earth electrode or earthing terminal is made, a clear and permanent label must be attached to indicate the connection.
- **Safety Electrical Connection - Do not remove**



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