Skills for Employment Investment Program (SEIP)

COMPETENCY-BASED LEARNING MATERIAL

(STUDENT GUIDE)

FOR

ELECTRICAL INSTALLATION AND MAINTENANCE

(CONSTRUCTION SECTOR)

Finance Division, Ministry of Finance
Government of the People's Republic of Bangladesh

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How to Use this Competency-based Learning Material

Welcome to the competency-based learning material for Electrical Installation and Maintenance for use in construction works. These modules contain training materials and learning activities for you to complete in order to become competent and qualified as an Electrical Installation and Maintenance worker.

There are eight (8) modules that make up this course which comprises the skills, knowledge and attitudes required to become a skilled worker including:

1. Perform channel wiring
2. Install earthing and atmospheric lightning protection system
3. Perform conduit wiring
4. Perform service connection
5. Perform motor connection
6. Install and maintain electric motor with control system
7. Perform motor rewinding and servicing
8. Install and troubleshoot solar electrical system

As a learner, you will be required to complete a series of activities in order to achieve each learning outcome of the module. These activities may be completed as part of structured classroom activities or simulated workplace demonstrations.

These activities will also require you to complete associated learning and practice activities in order to gain the skills and knowledge needed to achieve the learning outcomes. You should refer to **Learning Activity** pages of each module to know the sequence of learning tasks and the appropriate resources to use for each task.

This page will serve as the road map towards the achievement of competence. If you read the **Information Sheets,** these will give you an understanding of the work, and why things are done the way they are. Once you have finished reading the Information Sheets, you will then be required to complete the **Self-Check Quizzes**.

The self-check quizzes follow the Information Sheets in this learning guide. Completing the self-check quizzes will help you know how you are progressing. To check your knowledge after completion of the Self-Check Quizzes, you can review the **Answer Key** at the end of each module.

You are required to complete all activities as directed in the **Learning Activity and Information Sheet**. This is where you will apply your newly acquired knowledge while developing new skills. When working, high emphasis should be laid on safety requirements. You will be encouraged to raise relevant queries or ask the facilitator for assistance as required.

When you have completed all the tasks required in this learning guide, formal assessment will be scheduled to officially evaluate if you have achieved competency of the specified learning outcomes and are ready for the next task.

List of Icons

Icon Name	Icon
Module content	
Learning outcomes	
Performance criteria	
Contents	
Assessment criteria	
Resources required	
Information sheet	
Self-check Quiz	
Answer key	
Activity	
Video reference	
Learner job sheet	
Assessment plan	
Review of competency	

Module 1: Perform channel wiring

MODULE CONTENT

Module Descriptor: This module covers the skills, knowledge and attitudes to perform channel wiring. This specifically includes interpreting drawings and specifications, collecting tools, equipment and materials, drawing the layout and setting channels and cables, installing boards and setting all other accessories of wiring, performing circuit operation as per diagram and layout and cleaning the workplace. It also includes information sheets, job sheets, self-checking quizzes and answer keys.

Nominal Duration: 35 hours

LEARNING OUTCOMES:

Upon completion of the module, the student/trainee will be able to:

1.1 Interpret drawings and specifications
1.2 Collect tools, equipment and materials
1.3 Draw the layout and set channels and cables
1.4 Install boards and set all other accessories of wiring
1.5 Perform circuit operation as per diagram and layout
1.6 Clean the workplace

PERFORMANCE CRITERIA:

1. Electrical drawings are collected and interpreted.
2. Sign and symbols are identified.
3. Terms and abbreviations are identified.
4. Specifications are interpreted.
5. Tools, equipment and materials are collected and checked for usability.
6. PPE is collected and used as per requirements.
7. Wiring layout is drawn according to supplied drawing.
8. Rowel plug points are located, drilled and inserted as per requirements.
9. Bottom part of the channel is installed and screwed.
10. Cables with ECC are laid on the bottom part of the channel.
11. Boards are collected and fitted as per wiring diagram.
12. Switches, sockets, fan regulator are fitted on the board and connected to the circuits.
13. Ceiling rose and different types of holders are fitted on the board and connected to the circuit.
14. MCB and MCCB are connected and fitted on the board.
15. Circuit materials are placed on the board and other accessories are connected and fitted.
16. The bottom part of the channel is covered with upper part of the channel.
17. Tools and equipment are cleaned and stored as per standard practice.
18. Waste materials are disposed of and workplace is cleaned in accordance with standard procedure.

Learning Outcome 1.1 - Interpret Drawings and Specifications

Contents:

- Electrical plans/drawings
- Sign and symbols
- Terms and abbreviations
- Specifications

Assessment criteria:

1. Drawings are collected and interpreted.
2. Sign and symbols are identified.
3. Terms and abbreviations are identified.
4. Specifications are interpreted.

Resources required:

Students/trainees must be provided with the following resources:

- Electrical plans/drawings
- Sign and symbols related to construction and electrical works
- Terms and abbreviations
- Specification sheets

Learning Activity 1.1.1

Learning Activity	Resources/Special Instructions/References
Interpret drawings and specifications	▪ Information Sheet: 1.1.1 ▪ Self-Check Quiz: 1.1.1 ▪ Answer Key: 1.1.1 ▪ http://en.wikipedia.org/wiki/Electrical wiring

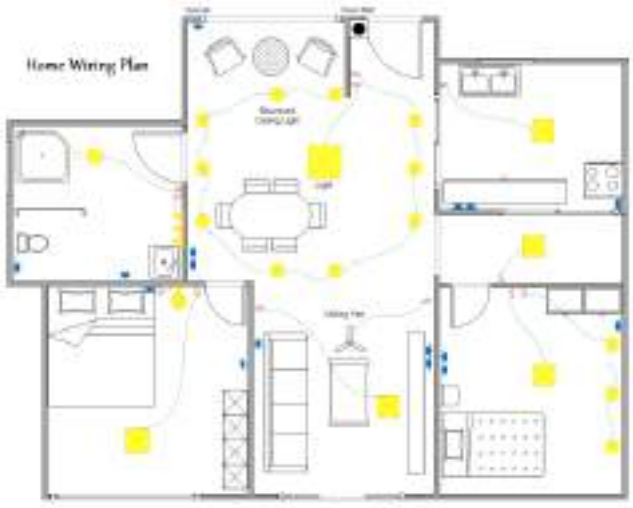
Information Sheet 1.1.1

Learning Objective: interpret drawings and specifications in a workplace.

- **Electrical drawings/plans:**
  - An electrical drawing is a type of technical drawing that shows information about power, lighting and communication for an engineering or architectural project. Any electrical working drawing

consists of lines, symbols, dimensions and notations to accurately convey an engineering's design to the workers who install the electrical system on the job.

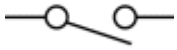
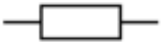
- Electrical plans can include electrical outlets, telephones, communication devices and other items requiring electrical power. In small projects, these items can be shown together with the lighting. The telephone and other communication systems are also generally shown on the electrical plan.



- **Sign and symbols:**
  A large part of being safe around *electricity* is understanding common electrical safety symbols. Electrical hazard signs help promote electrical safety and prevent accidents by warning workers and people of electrical hazards and ways to avoid them.

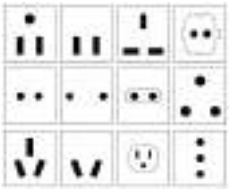
- **Circuit diagram:**
  A circuit diagram is a graphical representation of an electrical circuit. A pictorial circuit diagram uses simple images of components, while a schematic diagram shows the components and interconnections of the circuit using standardized symbolic representations.

- **Circuit symbol:**
  The diagram below shows the standard circuit symbols generally used:

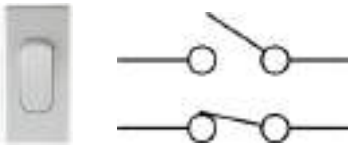
 Open Switch	 Closed Switch	 Lamp	 Cell	 Battery
 Voltmeter	 Resistor	 Fuse	 Ammeter	 Variable resistor

- **Load symbol:**
  An electrical load is an electrical component or portion of a circuit that consumes (active) electric power. In electric power circuits examples of loads are appliances and lights.

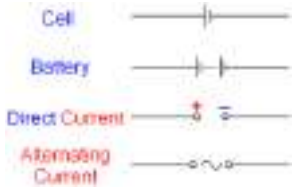
- **Socket symbol:**
  There are different types of socket symbols used in electrical drawing, some are two pins and some are three pins. The pins may be round or rectangular in shapes and also have standard in sizes.



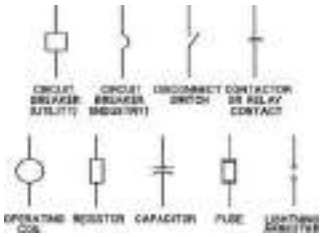
- **Switch symbol:**
  Power buttons and switches are available in shapes and sizes. These are also represented the power on and the power off.



- **Supply symbol:**
  The polarity symbol on the rating plate of an AC to DC power supply indicates if the centre (or tip) of the output plug is positive (+) or negative (-).



- **Circuit breaker and its symbol:**
  A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overcurrent, typically resulting from an overload or short circuit. Its basic function is to interrupt current flow after a fault is detected.



- **Terms and abbreviations:**
  Electrical abbreviations are used for various circuits, conduits, sizes, standardized tools and more. The list of abbreviations used in a set of engineering drawings varies from office to office. Some basic electrical abbreviations are listed below:

Ω: Ohm	Φ: Phase	A: Amperes	AC: Alternating Current
ATS: Automatic Transfer Switch	CKT: Circuit	DC: Direct Current	ECC: Earth Continuity Conductor
F: Fuse	FLA: Full Load Amperes	HZ: Hertz	KVA: Kilovolt-Amperes
L: Line	MW: Megawatt	N: Neutral	NC: Normally Closed
NO: Normally Open	P: Pole	V: Volt	W: Watt or Wire

- **Specifications:**
  A specification is a set of documented requirements to be satisfied by a material, design, product or service. There are different types of technical or engineering specifications and different usages of the term in different technical contexts.

- **Current carrying capacity of cables:**

Cross section	No& Diameter of wire	Thickness of insulation	Outer diameter	Weight	Current rating	
					In conduit at 35*C	In cable tray at 35*C
mm2	mm	mm	mm	Kg/km	amp	Amp
1x1.5re	1/1.38	.7	3.3	22	16	20
1x1.5rm	7/.50	.7	3.4	23	16	20
1x2.5re	1/1.78	.8	3.9	32	22	28
1x2.5rm	7/.67	.8	4.2	33	22	28
1x4.0rm	7/.85	.8	4.8	51	30	37
1x6.0rm	7/1.05	.8	5.4	71	38	47
1x10.rm	7/1.35	1.0	6.8	117	52	63

Self-Check Quiz 1.1.1

Write the correct answer for the following questions.

1. What are the items/components include or shown in an electrical plan?
2. What is circuit diagram?
3. Why electrical signs and symbols are used and showed in plans?
4. What is the function of a circuit breaker?
5. Define electrical load.

Learning Outcome 1.2 - Collect Tools, Equipment and Materials

Contents:

- List of hand tools and their uses/functions
- List of power tools and their uses/functions: electric drill machine, grinders, soldering iron
- List of equipment: multi meter/AVO meter, earth tester, digital weight machine
- List of electrical materials and their uses

Assessment criteria:

1. Tools, equipment and materials are collected
2. Tools, equipment and materials are checked for usability

Resources required:

Students/trainees must be provided with the following resources:

- Hand tools: adjustable wrench, wire stripper, mallet, c-clamp, chisels: (a) wooden (b) cold, drill bits, files: (a) flat (b) round (c) half round, hacksaw, hammers: (a) ball peen (b) claw, hand drill, measuring tape, pliers: (a) combination pliers (b) cutting pliers (c) diagonal cutting pliers (d) long nose pliers, punches, screwdrivers: (a) star (b) flat (c) connecting, try square, neon tester, wire cutters, S.W.G., set squares, electrician knife, ladder
- Power tools: electric drill machine, grinders, soldering iron
- Equipment: multi meter/AVO meter, earth tester, digital weight machine
- Materials: Channel (1/2", ¾", 1",1.25", 1.5" PVC), GI wire, elbow, bend, PVC circular box, rowel plug, saddle, screw, cable lugs, cable tie, thread ball, insulating clip, flexible conduit, plastic forma, electric soldering lead, plastic tape, cable (PVC, VIR)

Learning Activity 1.2.1

Learning Activity	Resources/Special Instructions/References
Collect tools, equipment and materials	▪ Information Sheets: 1.2.1, 1.2.2 ▪ Self-Check Quizzes: 1.2.1, 1.2.2 ▪ Answer Keys: 1.2.1, 1.2.2 ▪ https://www.thespruce.com › Home Repair › Electrical Repair › Electrical Repair Tools

Information Sheet 1.2.1

Learning Objective: to identify, gather and check tools and equipment used in a workplace.

- **Tools and equipment:**

Adjustable/slide wrench: An adjustable/slide wrench allows to work with many different sizes without having to change tools.	
Wire stripper: A *wire stripper* is used for removing the protective coating of an electric wire in order to replace or repair the wire.	
Bolt cutter: A *bolt cutter also* called bolt cropper, is a tool used for cutting chains, padlocks, bolts and wire mesh.	

Hammer: is a tool that delivers a blow to an object. These are used to drive nails, fit parts, forge metal, and break apart objects. They are varying in shape, size and structure.

 Ball peen hammer	 Claw hammer	 Wooden (Mallet)	 Plastic hammer

C-Clamp: is used to hold a wood or metal workpiece. This clamp is called "C" clamp because of its C-shaped frame.	

Chisels: are used to cut or shape wood, stone or metal.

 Wooden chisels	 Cold chisels
Drill bits: are cutting tools used to remove material to usually create circular holes. These are available in sizes and shapes.	
Files: Files are cutting tools used to remove/smooth rough and sharp edges from cut metal. These are available in various shape and size.	
Hacksaw: This is used in cutting metals like plates, pipes, rods, bars, angles with minimal thickness, width and length. This is also used for cutting plastic pipes, channels and other materials.	

Hand drill: A hand *drill* is used for boring holes in various materials to fastening various materials together.	
Measuring tape: This is a common measuring tool with linear measurement markings on both edges and used to measure distance or length in workplace.	

Pliers: These are used for gripping something round like a pipe or rod, for twisting wires and for cutting wires. *Pliers* are made in various shapes and sizes and for many uses.

 Combination plier	 Nose plier	 Cutting plier

Punch: A punch is a hard metal rod with a shaped tip at one end and a blunt butt end at the other, which is usually struck by a hammer.	
Screw drivers: Screw drivers used for screwing. These are available in various shapes and sizes.	
Try square: is used in measuring boards, testing corners and setting the bevel of boards and tools to various angles.	
Neon tester: is used to identify or test the phase / live/hot or positive wire/conductor.	
Wire cutter: is a hand tool that is used for cutting *wire.*	
SWG: Standard Wire Gauge (SWG) is used to measure of thickness or diameter of electrical wire and which is metric standard.	
Set squares: can be used to draw parallel lines. There are two main types of *set square*. One has an angle of 45 degrees and the other 30/60-degree angles.	
Electrician knife: is suitable for both normal wires stripping as well as for heavier duty cable work.	
Ladder: is a vertical or inclined set of steps. They are commonly made of aluminium, steel, wood, fiberglass or tough plastic.	
Electric Drill Machine: is used for boring holes in various materials or fastening various materials together.	

Grinder: is used for grinding and to finish workpieces that must show high surface quality and high accuracy of shape and dimension.	
Soldering iron: is a hand tool used in *soldering*. A *soldering iron* is composed of a heated metal tip and an insulated handle.	
Avometer/Multimeter: is used to measure electrical current, resistance and voltage. A modern multimeter features digital readouts and requires just a bit of knowledge to understand.	
Earth tester: is a hand tool used for ground resistance testing which covers the testing of earth electrodes and the measurement of soil resistivity.	

Self-Check Quiz 1.2.1

Write the name and uses of the hand tools as given below:

No	Identify the hand tools given below	Name and uses
1.		
2.		
3.		
4.		
5.		

Information Sheet 1.2.2

Learning Objective: to identify, gather and check electrical materials used in a workplace.

Electrical materials:

- **Metal Channel**: are specifically shaped for industrial and structural purposes. Channels are widely used for cable drawing.

- **PVC channel/moulding**: is used to run cables through, that mounts on a wall or a desk or some other surface, concealing wires or cables so set-up looks nice and pretty. So, it is used for hiding cables. There are different types and available in sizes of PVC channel/moulding, each suited for a unique application.

- **GI wire:** is mostly used for fencing of all purposes. The length of *GI wire* is measured in meters whereas the diameter/thickness is measured in SWG. These *wires* are extensively used in various electrical equipment and earthing works.

- **Elbow and bend:** are important pipe fitting which are used for changing direction in piping system. All bends are elbows but all elbows are not bend.

- **PVC circular box:** is used as junction box of varied sizes to meet the requirement of electrical wiring regulations. These are available in black, grey & white colour. They may be manufactured in metal sheet also.

- **Rowel plug:** is a fibre or plastic insert used to enable the attachment of a screw in material that is porous or brittle or that would otherwise not support the weight of the object attached with the screw.

- **Saddle:** is a fitting device to support for electrical, control, communication cables. Strong, more durable than cable ties or lashing wire. These are available in shapes and sizes and made of plastic or metal sheet.

- **Screw:** is a metal fastener having a tapered shank with a helical thread and topped with a slotted head, driven into wood or the like by rotating, especially by means of a screwdriver.

- **Cable lugs:** are used for terminating and connecting low and medium voltage cables to equipment. Lugs with a bell mouth ensure smooth transition from lug to cable, avoiding problems of chafing where the cable is subjected to vibration.

- **Cable tie:** is a type of fastener for holding items together, primarily electrical cables or wires.

- **Insulating clip:** is a sprung metal clip with long, serrated jaws which is used for creating a temporary electrical connection. It is used to connect an electrical cable to a battery or some other component. The clip is typically covered by a plastic shroud or boot to prevent accidental short-circuits.

- **Flexible conduit:** protects cables over long runs in industrial, outdoor and underground applications. Full enclosure withstands moisture, vibration, oils and more.

- **Electric soldering lead:** is a fusible metal alloy used to create a permanent bond between metal workpieces. Solder is basically metal wire with a low melting point.

- **Electrical tape:** is a type of pressure-sensitive tape used to insulate electrical wires and other materials that conduct electricity.

- **Cables:** is an assembly of one or more wires running side by side or bundled, which is used to carry electric current.
  - Types of cables are: coaxial cable, direct-buried cable, flexible cables, filled cable, helix cable, non-metallic sheathed cable, metallic sheathed cable.
  - A wire is a single conductor, while cable is two or more insulated wires wrapped in one jacket.

- **Size of cable:**
  - According to SWG cables are identified by 3/22, 3/18, 1/18, 7/18 and 7/22. Here 3/22 means number of wires is 3 and gauge number of each is 22.
  - The size of cable also expressed in diameter (inch or millimetre). For example, 3/0.29”, 3/0.36” and 1/1.4”, 1/1.8”. Here 3/0.29” means number of wires is 3 and diameter of each is 0.29 inch.
  - On other way, size of cable is written by 1.5 mm^2, 2.5 mm^2, 4.0 mm^2, 6.0 mm2, 10.0 mm2, 16.0 mm^2 where, the value is the cross-sectional area of each cable.

- **VIR (Voltage, Input, Resistance):**
  - Voltage is the difference in charge between two points.
  - Current is the rate at which charge is flowing.
  - Resistance is a material’s tendency to resist the flow of charge (current).

  Combining the elements of voltage, current and resistance, Ohm developed the formula: V=I.R
  Ohm's Law can be written three ways: V= I x R, I=V/R, R=V/I
  Where: V = voltage in volts (V), I = input current in amps (A) and R = resistance in ohms (Ω).

Just checking:

- *Why saddles are used?*
- *What is the advantage of cable lug?*
- *What is relation among voltage, current and resistance?*

Self-Check Quiz 1.2.2

Write the correct answer for the following questions:

1. State the uses of channels.
2. What is saddle?
3. What is cable tie?
4. What are the uses of electrical tape?
5. Write down the difference between wire and cable.

Learning Outcome 1.3 - Draw the Layout and Set Channels and Cables

Contents:

- List of PPE and their uses
- Layout and set channels and cables

Assessment criteria:

1. PPE is collected and used.
2. Wiring layout is drawn according to supplied drawing.
3. Rowel plug points are located, drilled and inserted as per procedure.
4. Bottom part of the channels are installed and screwed.
5. Cables with ECC are laid on the bottom part of the channel.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: channels, wire, elbows, bends, PVC circular box, plugs, saddles, screws, cables, cable lugs, cable ties, thread ball, insulating clips, flexible conduit, plastic forma, electric soldering lead

Learning Activity 1.3.1

Learning Activity	Resources/Special Instructions/References
Draw the layout and set channels and cables	▪ Information Sheets: 1.3.1, 1.3.2 ▪ Self-Check Quizzes: 1.3.1, 1.3.2 ▪ Answer Keys: 1.3.1, 1.3.2

Information Sheet 1.3.1

Learning Objective: to identify the personal protective equipment used in a workplace.

- **Personal Protective Equipment (PPE):**

Safety helmet: A safety helmet is used in workplace environments to protect the head from injury due to falling objects.	
Goggles/safety glasses: Goggles are forms of protective eyewear that usually enclose or protect the eye area.	
Ear plug/ear muff: This device is to be inserted in the ear canal to protect the ears from loud noises.	
Dust mask: Dust mask is necessary for dust protection in workplace.	
Safety cloth/apron: Safety cloth/apron has been designed to protect the body from injury in the workplace.	
Safety belt/body harness: A belt/body harness is designed to secure a person in case of falling while working at high level.	
Hand gloves: These are used to protect the hands while working and safeguarding of hands.	

Safety shoes/footwear/boots: Safety shoes are used to protect the legs/feet from any harms or injuries.	

Individual Activity:

- *Watch the video show on 'Safety basics' or other similar videos if facilities available*
- *Check the quality of PPE to be used*

Self-Check Quiz 1.3.1

Fill in the blanks with the correct answer:

1. _____ is used to protect the head from injury due to falling objects.
2. _____ is used to protect eyes from flying particles which may cause injury to the worker.
3. _____ is essential for a worker while working in construction site at high level.
4. _____ is used to protect the hands when working.
5. _____ is used to protect one's feet from sharp object to fall.

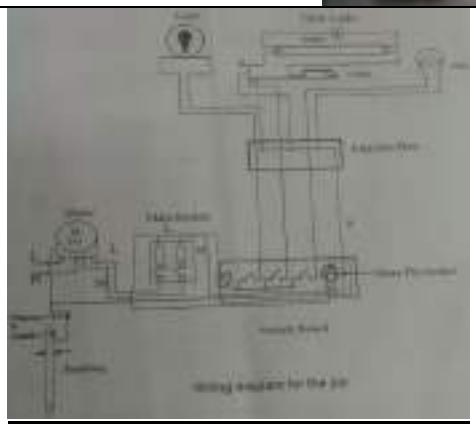
Information Sheet 1.3.2

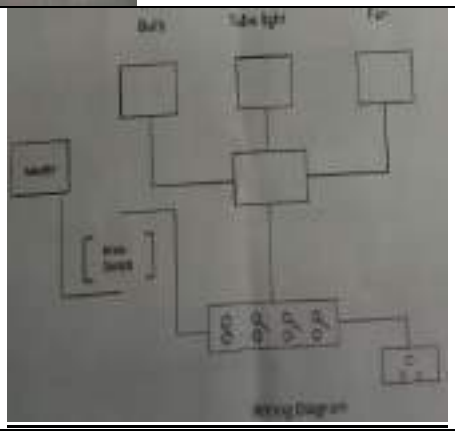
Learning Objective: to draw the layout and setting of channels and cables in a workplace.

- **How to fix PVC channel and install wire?**

  To complete the task, the trainee should follow the steps given below:

  1. Collect all necessary tools, equipment and accessories to fix channel and install wire.
  2. Identify and select usable tools & equipment.
  3. Collect PVC channel, electrical box and electrical wire/cable as per electrical drawing.
  4. Provide layout on wall/board as per electrical drawing.
  5. Calculate, measure, cut and fix the base or bottom part of channel and boxes in accordance with type and size.
  6. Calculate, measure, cut, draw and fix the electrical wire/cable in accordance with type and size.
  7. Check the level, test continuity and finally set cover or top part of channel using appropriate tools & equipment.
  8. While working you should use personal protective equipment for safety.
  9. Clean the workplace and restore the tools, equipment and excess materials.





JOB SHEET 1			
Qualification:	Electrical Installation and Maintenance		
Learning unit:	Draw the layout and set channels and cables		
Learner name:			
Personal protective equipment (PPE):	Safety helmet, goggles, ear plugs, dust mask, safety cloth/apron, safety belt, hand gloves, safety shoes		
Materials:	Rowel plug, screws, cable tie, PVC channels (different size and type), ECC and electrical cables		
Tools and equipment:	Measuring tape, marking chalk, plumb bob, tri-square, thread ball, ball peen hammer, hacksaw, wire stripper, drill bit, files, pliers, screw drivers, wire cutter, poker, electrician knife, electric drill machine		
Performance criteria:	1. PPE is collected and used. 2. Wiring layout is drawn according to supplied drawing. 3. Rowel plug points are located, drilled and inserted as per procedure. 4. Bottom part of the channels are installed and screwed. 5. Cables with ECC are laid on the bottom part of the channel.		
Measurement:	▪ Measurement to be taken physically and/or from electrical drawing ▪ Carefully take the measurement of channels and cables.		
Notes:	▪ Ensure the size and type of PVC channels and electrical cables		
Procedure:	1. Collect PPE, all necessary tools, equipment and accessories to fix channel and install wire. 2. Identify and select usable tools & equipment. 3. Collect PVC channel, electrical box and electrical wire/cable as per electrical drawing. 4. Provide layout on wall as per electrical drawing. 5. Calculate, measure, cut and fix the base or bottom part of channel and boxes in accordance with type and size. 6. Calculate, measure, cut, draw and fix the electrical wire in accordance with type and size. 7. Check the level, test continuity and finally set cover or top part of channel using appropriate tools & equipment. 8. While working you should use personal protective equipment for safety. 9. Clean the workplace and restore the tools, equipment and excess materials.		
Learner signature:		**Date:**	
Assessor signature:		**Date:**	
Quality Assurer signature:		**Date:**	
Assessor remarks:			
Feedback:			

Important:
- Select the size of channel so that cables inside the channel is not over tight or very loose.
- Provide rowel plugs 30 cm to 50 cm on centre for setting channel, two for each load point, two for junction board and 2 to 4 for switch board.

Individual Activity:

- *Watch the video shows on 'How to install channel wiring' or other similar videos and summarize key points (if facilities available)*
- *Draw layout and set channels and cable following Job Sheet 1 (see above)*

Self-Check Quiz 1.3.2

Write the correct answer for the following questions:

1. Why PVC channels are used for electrical wiring?
2. Which part of PVC channel and box is fixed on wall?
3. How many rowel plugs are required for each load point?
4. How far the rowel plugs are provided for setting channel?

Learning Outcome 1.4 - Install Boards and Set All Other Accessories of Wiring

Contents:

- Boards and their uses
- Uses of switches, sockets, fan regulator and ballast
- Ceiling rose and different types of holders
- MCB and MCCB: rewire able fuse, cartridge fuse, glass fuse, HRC fuse, single pole MCB, double pole MCB, MCCB, earth leakage circuit breaker (ELCB)

Assessment criteria:

1. Boards are collected and fitted as per wiring diagram.
2. Switches, sockets, fan regulator and Ballast are fitted on the board with screw.
3. Switches, sockets and fan regulator are connected to the circuits.
4. Ceiling rose and different types of holders are fitted on the board.
5. Those fixtures are connected to the circuit.
6. MCB and MCCB are connected and fitted on the board.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: boards, switches, sockets, fan regulator, ceiling rose, holders, MCB and MCCB

Learning Activity 1.4.1

Learning Activity	Resources/Special Instructions/References
Install boards and set all other accessories of wiring	▪ Information Sheet: 1.4.1 ▪ Self-Check Quiz: 1.4.1 ▪ Answer Key: 1.4.1

Information Sheet 1.4.1

Learning Objective: to install boards and set all other accessories of wiring in a workplace.

- **Boards:** is a component of an electricity supply system that divides an electrical power feed into subsidiary circuits, while providing a protective fuse or circuit breaker for each circuit in a common enclosure. The boards may be made of Plastic board, Ebonite board, Wooden board. Size of boards depends on functions of circuits.

- **Switches:** is an electrical component that can make or break an electrical circuit, interrupting the current or diverting it from one conductor to another.

- **Sockets:** are device that receiving a plug or light bulb to make a connection.

- **Fan regulator:** is a crucial electrical component that serves to increase or decrease the speed of fan according to the needs.

- **Ballast:** is a device placed in line with the load to limit the amount of current in an electrical circuit. Ballast is used in fluorescent lamps to limit the current through the tube.

- **Ceiling rose:** 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.

- **Holders:** provide electrical connections to the lamps and support it in the lighting fixture. There are many different standards for these lamp holders.

- **MCB and MCCB:**
  - MCB is stands for Miniature Circuit Breakers which is mainly used for low-energy requirements, like home wiring or small electronic circuits.
  - MCCB is stands for Moulded Case Circuit Breaker which is suited in providing energy for high-power equipment.
  - The main difference between MCB and MCCB is nothing but their capacity.

MCB	MCCB
	

- **Earth-leakage circuit breaker (ELCB):** is a safety device used in electrical installations with high earth impedance to prevent shock. The main purpose of ECLB is to stop damage to humans and animals due to electric shock.

- **Fuse:** is a self-sacrificial device used to interrupt a circuit under short circuit, excessive overload or over current conditions by melting the fuse element.

 Low voltage fuses (rewireable)	 Low voltage fuses (cartridge) /glass fuse	 High voltage fuses (liquid) /thermal fuse

- **Rewireable Fuse:**
  - It is the simplest and cheapest protective device used in interrupting the circuit during over- current or short circuit conditions.
  - Fuses are always connected before the load in series to the supply.
  - The normally used fuse wires are lead and aluminium.
  - Tinned copper and an alloy of tin-lead can also be used.

- **Rewiring procedure of a fuse:**
  - Switch of the main switch
  - Take out the fuse element carrier.
  - Loosen the terminal screws and remove the blown-out fuse wire.
  - Replace it with a new fuse wire as per the requirement, wrap it around the terminals and tighten the screws.
  - Reinsert the fuse carrier and switch on the main.

Self-Check Quiz 1.4.1

Fill up the gap with correct answer.

1. A _____ is a component of an electricity supply system that divides an electrical power feed into subsidiary circuits, while providing a protective fuse or circuit breaker for each circuit in a common enclosure.
2. A _____ is an electrical component that can make or break an electrical circuit, interrupting the current or diverting it from one conductor to another.
3. A _____ is a device that receiving a plug or light bulb to make a connection.
4. A _____ is a crucial electrical component that serves to increase or decrease the speed of fan according to the needs.
5. _____ is a self-sacrificial device used to interrupt a circuit under short circuit, excessive overload or over current conditions.

Learning Outcome 1.5 - Perform Circuit Operation as Per Diagram and Layout

Contents:

- Cables and their uses
- Circuits and accessories

Assessment criteria:

1. Bottom parts of the channels are placed and set according to drawing on the board.
2. Cables are drawn through the bottom part of the channels.
3. Circuit materials required for the specified circuit are placed on the board.
4. Other accessories are connected and fitted.
5. The bottom parts of the channels are covered with upper part of the channel.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: electrical channel/mould, cables

Learning Activity 1.5.1

Learning Activity	Resources/Special Instructions/References
Perform circuit operation as per diagram and layout	▪ Information Sheet: 1.5.1 ▪ Self-Check Quiz: 1.5.1 ▪ Answer Key: 1.5.1

Information Sheet 1.5.1

Learning Objective: to identify electrical channel/mould and cables for fixing as per circuit diagram on a surface in a workplace.

- **Electrical wire and cable:**

The amount of current a cable or wire can safely carry depends on the installation conditions or amount of power demand on the circuit, type of occupancy and size of the building/industry, environment and national/local electrical regulations.

- **Wire**: The low current conductor of single or multiple stranded with insulated or uninsulated is called wire. Wire is a single electrical conductor and used for low and medium voltage supply in making internal connections inside electrical or electronic devices.

  - Types of wire: Bare wire or non-insulated wire and insulated wire.
  - It may be single solid and or stranded.
  - Size of wire expressed as per standard wire gauge: Like- 3/22, 3/18, 1/18, 7/18, 7/22 etc.
  - The meaning of 3/22 is, 3 wires of each 22 gauge.



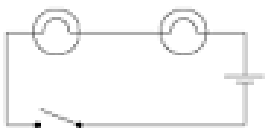
- **Cable**: The high current conductor of single or multiple stranded with insulated is called cable. Cable is a multiple electrical conductor and used for high voltage supply in making external connections of overhead and underground line. Classification of cable may be as follows:

  - As per core: Single core, Twin core, Three core, Four core, Five core.
  - As per installation and structure: Aerial cable and Underground cable.
  - As per voltage grading: Low voltage cable (250V to 1000V). High voltage cable (1000V to 1100V). Super tension cable (1100V to 33000V). Extra high-tension cable (33000V to 6KV) and Extra super voltage cable (66KV to 132 KV).
  - As per millimetre size: 1.0mm^2, 1.5mm^2, 2.5mm^2, 4.0mm^2, 6.0mm^2, 10.0mm2, 16.0mm^2, 25.0mm^2, 38.0mm^2, 50.0mm^2, 75.0mm^2, 100.0mm^2, 150.0mm^2, 200.0mm^2, 300.0mm^2 PVC cable.
  - As per inch size: 1/0.044”, 3/0.029”, 3/0.036”, 7/0.029”, 7/0.044”, 7/0.052”, 7/0.064”, 19/0.044”, 19/0.052”, 19/0.064”, 19/0.072”, 19/0.083”, 37/0.064”, 37/0.072”.
  - As per covering/coating: Single cotton covering (SCC), Volcanized India rubber insulated (VIR), Tough rubber sheathed (TRS), Lead cover or sheathed (LS), Cab tire sheathed (CTS), Polyvinyl chloride (PVC), Paper insulated cable (PIC), Mineral insulated cable (MIC).

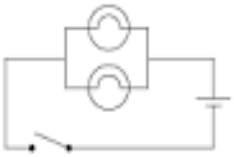
- **Electrical circuit:** is defined as a complete and closed path around which a circulating electric current can flow.
  - Types of circuit: A closed circuit has a complete path. An open circuit does not. In order for a circuit to work, it must be closed; thus, when a circuit is open, the current can’t flow through.

- **Circuit diagram:** is a graphical representation of an electrical circuit. Circuit diagrams are used for the circuit design, construction and maintenance of electrical and electronic equipment.

- **Series circuit:**
  In a series circuit the current flows through one globe after another, each being able to make use of only a part of the energy carried by the current. The circuit diagram shows a circuit with two lamps connected in series. If one lamp breaks, the other lamp will not light.

- **Parallel circuit:**
  In a parallel circuit the current can pass simultaneously through each globe and the energy of the current is available to each globe. The circuit diagram shows a circuit with two lamps connected in parallel. If one lamp breaks, the other lamp will still light.



Did you know?

- *If two lamps are connected in series and one lamp breaks, the other lamp will not light.*
- *If two lamps are connected in parallel and one lamp breaks, the other lamp will light.*

Self-Check Quiz 1.5.1

Write the correct answer of the following questions:

1. What is called electrical wire?
2. What is called electrical cable?
3. What is electrical circuit.
4. State the uses of circuit diagram.

Learning Outcome 1.6 - Clean the Workplace

Contents:

- Importance and necessity of cleaning tools, equipment and workplace
- Methods of cleaning, tools and equipment required for cleaning
- Display and/or storing of tools and equipment used

Assessment criteria:

1. Tools and equipment are prepared for cleaning.
2. Tools and equipment are stored as per standard.
3. Waste materials are disposed as per workplace standard.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools and equipment: brooms, dusters, dust pans, cleaning brushes, mops, waste containers and cotton rags
- Materials: water, detergents, abrasives, bleaches and lubricants (oil, grease and powder)

Learning Activity 1.6.1

Learning Activity	Resources/Special Instructions/References
Clean the workplace	▪ Information Sheet: 1.6.1 ▪ Self-Check Quiz: 1.6.1 ▪ Answer Key: 1.6.1 ▪ https://www.worksafe.qld.gov.au/injury-prevention-safety/workplace.../cleaning

Information Sheet 1.6.1

Learning Objective: to clean and lubricate electrical tools/instruments and store the same as per standard procedures and clean the workplace.

After electrical works cleaning is very important and essential for both tools and equipment used and also the workplace. To keep the tools and equipment clean, extra attention and experience required considering

how to remove dirt, including dust, stains, bad smells and clutter on surfaces. For this, we can use some cleaning agents as follows:

- Water (the best cleaning agent)
- Soap or detergent
- Calcium hypochlorite (powdered bleach)
- Sodium hypochlorite (liquid bleach)
- Acetic acid (vinegar)

Methods of cleaning: cleaning can be done with the following methods:

- Dusting
- Shaking and beating
- Sweeping
- Mopping
- Washing
- Polishing

Rough Cleaning:

- First remove all debris either by hand or use of brushes, brooms, scrapers, squeegees etc.
- Collect and dispose of all debris appropriately.
- A warm rinse is recommended to complete the rough cleaning.

Tools and equipment used for cleaning:

Broom: A broom is a cleaning tool consisting of usually stiff fibres, also known as coconut broom.	
Dusters/Dust protector: A duster/dust protector is a light, loose-fitting long coat.	
Dust pan: A dustpan is used in combination with a broom. It is used to collect dust/waste/small debris.	
Cleaning brushes: Cleaning brushes are tool with bristles, wire or other filaments, used for cleaning, painting, and surface finishing, and for many other purposes.	
Mop: A mop is a bundle of coarse strings or a piece of cloth, sponge or other absorbent material, attached to a stick. It is used to soak up liquid, for cleaning floors and other surfaces, to mop up dust or for other cleaning purposes.	

Waste container: A waste container is a container for temporarily storing waste and is usually made out of metal or plastic. Some common terms are dustbin, garbage can, trash can and dumpster.	
Cotton rags: A rag is a piece of old cloth which can be used to clean or wipe things.	

Lubricant: is used to reduce friction between surfaces. Adequate lubrication allows smooth operation of equipment, reduces the rate of wear and prevents excessive stresses.

Advantages of proper storage of tools and equipment:

- Ensures that tools and equipment remain in good condition and last for a long time.
- Easy to find when needed and are less likely to be lost.
- Productivity is increased because time is not lost looking for tools and equipment.

After cleaning the tools and equipment, you should follow the good habits of inventry, display and/or store the same in accordance with the workplace requirements.

Common types of storage on tool rack

Self-Check Quiz 1.6.1

Write the correct answer for the following questions:

1. What are the methods of cleaning?
2. What is a broom?
3. Write the uses of mops.
4. What is the common type of storage for electrical tools and equipment?
5. What are the advantages of properly storing electrical tools and equipment?

ANSWER KEY

Answer Key 1.1.1

1. Electrical plans can include electrical outlets, telephones, communication devices and other items requiring electrical power. In small projects, these items can be shown together with the lighting. The telephone and other communication systems are also generally shown on the electrical plan.
2. A circuit diagram is a graphical representation of an electrical circuit.
3. Electrical signs and symbols are used in plans to show the different kind of electrical elements used. Electrical symbols are used to represent various electrical and electronic devices in a schematic diagram of an electrical or electronic circuit.
4. Function of a circuit breaker is to protect an electrical circuit from damage caused by overcurrent, typically resulting from an overload or short circuit.
5. An electrical load is an electrical component or portion of a circuit that consumes (active) electric power.

Answer Key 1.2.1

1. Combination pliers: used for gripping something, twisting wires, and others are designed to be used for a combination of tasks including cutting wire.
2. Wire stripper: used for removing the protective coating of an electric wire in order to replace or repair the wire. It is also capable of stripping the end portions of an electric wire in order to connect them to other wires or to terminals.
3. Electrician's knife: suitable for both normal wires stripping as well as for heavier duty cable work.
4. Soldering iron: is a hand tool used in soldering. It supplies heat to melt solder so that it can flow into the joint between two workpieces.
5. Standard Wire Gauge (SWG): is a hand tools used to measure of thickness or diameter of electrical wire and which is metric standard.

Answer Key 1.2.2

1. Channels are used to run cables through, that mounts on a wall or a desk or some other surface, concealing wires or cables so set-up looks nice and pretty. So, it is used for hiding cables.
2. Saddle is device or fitting to support for electrical, control, communication cables.
3. A cable tie or wire tie is a fastener for holding items together primarily electrical cables or wires.
4. Electrical tape or insulating tape is a pressure-sensitive tape used to insulate electrical wires and other materials that conduct electricity.
5. Difference between wire and cable: A wire is a single conductor, while cable is two or more insulated wires wrapped in one jacket.

Answer Key 1.3.1

1. Safety helmet
2. Eye protector/goggles/safety glasses
3. Safety belt
4. Hand gloves
5. Safety shoes/footwear/boots

Answer Key 1.3.2

1. PVC channels are used to conceal or hide the electrical wire/cable.
2. Base or bottom part of PVC channel and box is fixed on wall.
3. Two rowel plugs are required for each load point.
4. The rowel plugs are provided 30 to 50 cm on centre for setting channel.

Answer Key 1.4.1

1. Board
2. Switch
3. Socket
4. Fan regulator
5. Electric fuse

Answer Key 1.5.1

1. The low current conductor of single or multiple stranded with insulated or uninsulated is called wire. Wire is a single electrical conductor.
2. The high current conductor of single or multiple stranded with insulated is called cable. Cable is a multiple electrical conductor.
3. Electrical circuit is a complete and closed path around which a circulating electric current can flow.
4. Circuit diagrams are used for the circuit design, construction and maintenance of electrical and electronic equipment.

Answer Key 1.6.1

1. Methods of cleaning are: dusting, shaking and beating, sweeping, mopping, washing, polishing.
2. A broom is a cleaning tool consisting of usually stiff fibres, also known as coconut broom.
3. Mops are used to soak up liquid, for cleaning floors and other surfaces, to mop up dust, or for other cleaning purposes.
4. Common types of storage are: cabinet, bin, tool box, tool rack, shelving.
5. Advantages of proper storage of tools and equipment:
   - Ensures that tools and equipment remain in good condition and last for a long time.
   - Easy to find when needed and are less likely to be lost.
   - Productivity is increased because time is not lost looking for tools and equipment.

Module 2: Install earthing and atmospheric lighting protection system

MODULE CONTENT

Module Descriptor: This module covers the knowledge, skills and attitudes to installing earthing and atmospheric lighting protection system. It specifically includes identifying the type of earthing to be used, identifying the type of lightning protection system to be used, selecting and collecting tools, equipment and materials, excavating the hole for earthing element installation, installing earthing components, finishing earth pit chamber for pipe earthing method, installing lightning protection system and cleaning/maintaining the work area. It also includes information sheets, job sheets, self-checking quizzes and answer keys.

Nominal Duration: 20 hours

Learning Outcomes:

Upon completion of the module, the student/trainee will be able to:

2.1 Identify the type of earthing to be used
2.2 Identify the type of lightning protection system to be used
2.3 Select and collect tools, equipment and materials
2.4 Excavate the hole for earthing element installation
2.5 Install earthing components
2.6 Finish earth pit chamber for pipe earthing method
2.7 Install lightning protection system
2.8 Clean/maintain the work area

Performance Criteria:

1. Types and method of earthing is identified in accordance to electrical plan/design.
2. Types and sizes of earthing materials are identified in accordance to electrical plan/design.
3. Types of lightning protection system is identified in accordance to electrical plan/design.
4. Types and sizes of lightning protection system materials are identified in accordance to electrical plan/design.
5. Tools, equipment and materials are collected and checked for usability.
6. Earthing materials are collected and checked for conformance in accordance to specification.
7. Lightning protection materials are collected and checked for conformance in accordance to specification.
8. PPE is collected and used in accordance to OHS requirements.
9. Hole is dug following with safety requirements.
10. Hole is shaped and sized in accordance to electrical plan/design specification.
11. Earthing element is fitted in the bottom of the excavated hole following standard earthing procedure.
12. Earth lead is connected to the earth element tightly and brought up the meter board through the conduit.
13. Powdered charcoal and salt are laid around the earthing element in accordance to workplace procedure.
14. A proper sized and length of GI pipe is fitted from top of the earth element to the bottom of the earth pit chamber.
15. Rest of the excavated hole is filled with earth.
16. Earth pit chamber is constructed with brick chips, cement and sand mixture in accordance with

standard/specification.
17. Pit chamber cover is made and fitted/installed in accordance with electrical plan/design.
18. Check earth resistance in accordance with electrical plan/specification.
19. Lightning rod is installed at specified location and earth down conductor is connected as per diagram.
20. Performance of lightning protection system (LPS) is tested as per standard procedure.
21. Tools and equipment are cleaned and stored as per standard practice.
22. Waste materials are disposed and workplace is cleaned in accordance with standard procedure.

Learning Outcome 2.1 - Identify the Type of Earthing to be Used

Contents:

- Type and methods of earthing
- Earthing materials

Assessment criteria:

1. Types and method of earthing is identified in accordance to electrical plan/design.
2. Types and sizes of earthing materials are identified in accordance to electrical plan/design.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: adjustable wrench, wire stripper, mallet, C-clamp, chisels: (a) wooden (b) cold, drill bits, files: (a) flat (b) round (c) half round, hacksaw, hammers: (a) ball peen (b) claw, hand drill, measuring tape, pliers: (a) combination pliers (b) cutting pliers (c) diagonal cutting pliers (d) long nose pliers, punches, screwdrivers: (a) star (b) flat (c) connecting, try square, neon tester, wire cutters, S.W.G., set squares, electrician knife, ladder
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, megger tester, electrical plans/drawings
- Materials: continuity conductor/cable, earthing lead, earth electrode/plate, connector, G.I. pipe/conduit, bolts and nuts, powdered charcoal and salt

Learning Activity 2.1.1

Learning Activity	Resources/Special Instructions/References
Identify the type of earthing to be used	▪ Information Sheets: 2.1.1, 2.1.2 ▪ Self-Check Quizzes: 2.1.1, 2.1.2 ▪ Answer Keys: 2.1.1, 2.1.2 ▪ https://en.wikipedia.org/wiki/Earthing_system

Information Sheet 2.1.1

Learning Objective: to identify different type and methods of earthing and uses in a workplace.

- **Electrical earthing:**

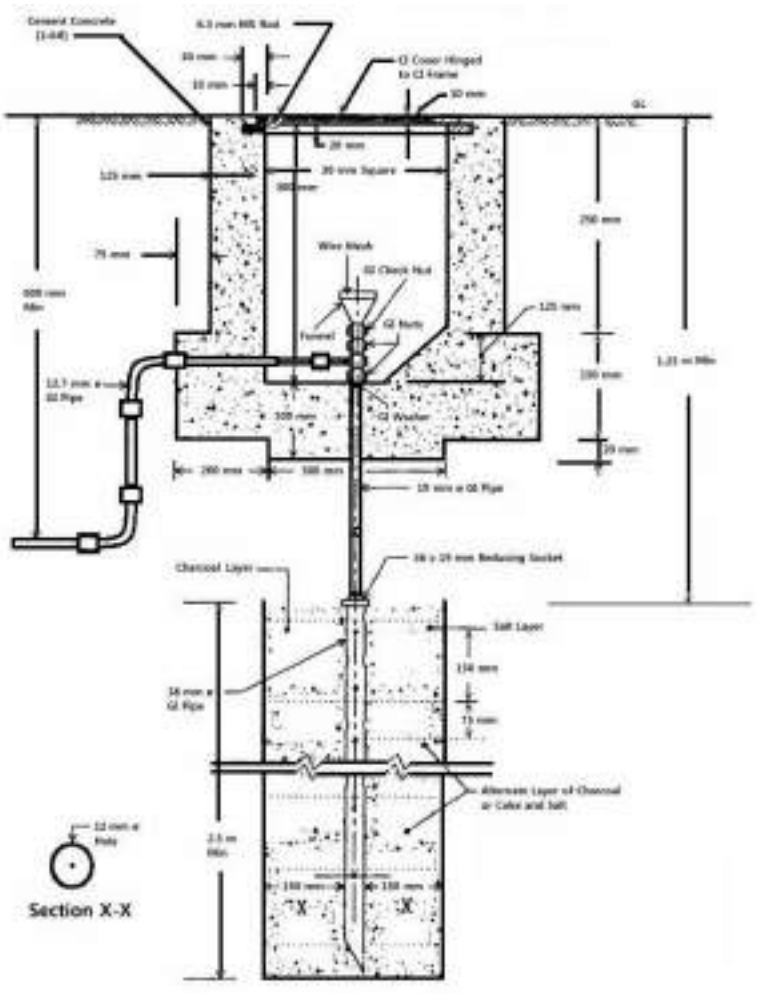
The process of transferring the immediate discharge of the electrical energy directly to the earth by the help of the low resistance wire is known as the electrical earthing.

- **Electrical fault:**
  The fault is the abnormal condition of the electrical system which damages the electrical equipment and disturbs the normal flow of the electric current.

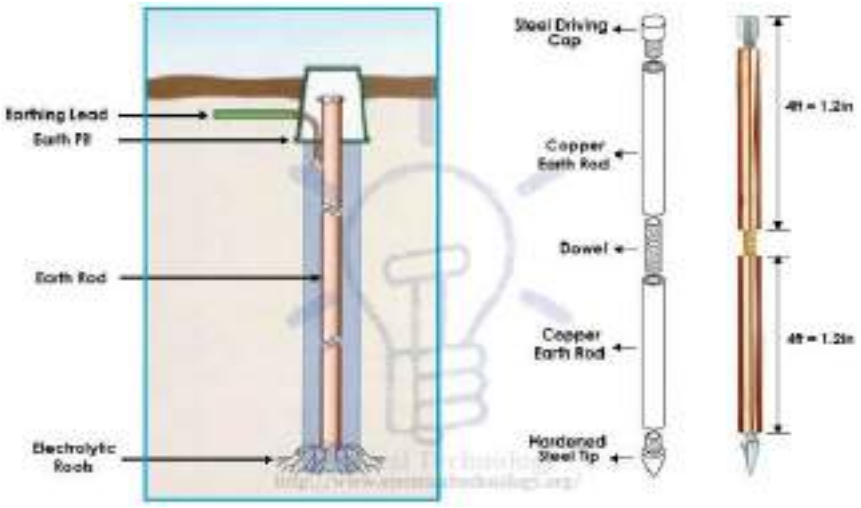
- **Basic needs of earthing:**
  - To protect human lives as well as provide safety to electrical devices and appliances from leakage current.
  - To keep voltage as constant in the healthy phase.
  - To protect electric system and buildings form lightning.
  - To avoid the risk of fire in electrical installation systems.

- **Types and methods of earthing:**
  The various methods employed in earthing are pipe earthing, rod earthing, plate earthing, water mains earthing and strip or wire earthing.

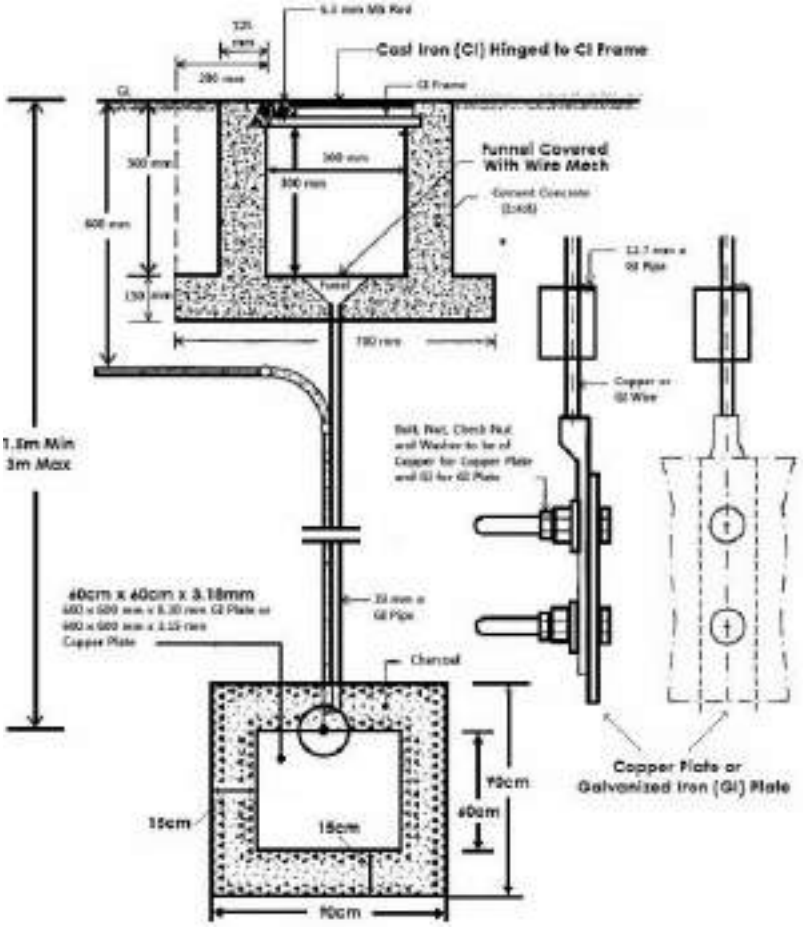
1. **Pipe Earthing:**
   - This is the most common system of earthing.
   - In this kind of earthing system, a galvanized iron and a perforated pipe of approved length and diameter is placed vertically in a wet soil.
   - The size of pipe to use depends on the magnitude of current and the type of soil.
   - The dimension of the pipe is usually 40mm in diameter and 2.75m in length for ordinary soil.
   - The length of the pipe to be buried usually should be 4.75m.
   - The top of the earthing point is covered by constructing a small chamber.



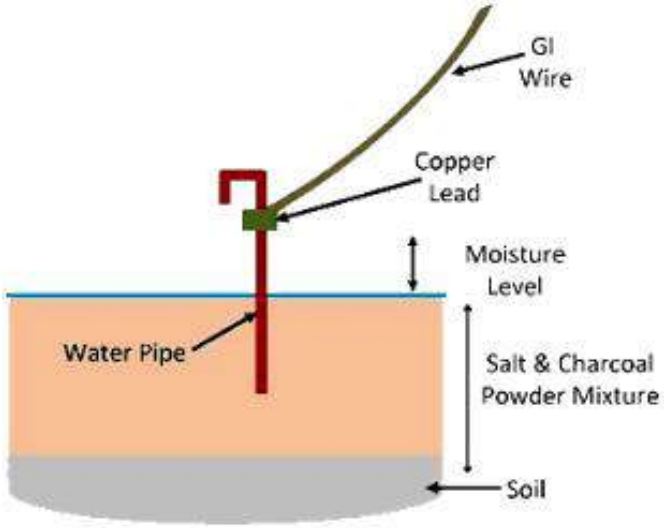
2. **Rod Earthing:**
   - This is the same method as pipe earthing.
   - A copper rod of 12.5mm diameter or 16mm diameter of galvanized steel or hollow section 25mm of GI pipe of length above 2.5m are buried.
   - The length of embedded electrodes in the soil reduces earth resistance to a desired value.



3. **Plate Earthing**:
   - In plate earthing system, a plate made up of either copper with dimensions 600mm x 600mm x 3mm or galvanized iron (GI) of dimensions 600mm x 600m x 6 mm is buried vertical in the earth which should not be less than 3.0m from the ground level.



4. **Earthing through water mains:**
   - In this method of earthing, the water supply pipes are used for earthing purpose.
   - Make sure to check the resistance of GI pipes and use earthing clamps to minimize the resistance for proper earthing connection.
   - If stranded conductor is used as earth wire, then clean the end of the strands of the wire and make sure it is in the straight and parallel position which is possible then to connect tightly to the water supply pipe.



5. **Strip or wire earthing:**
   - In this method of earthing, strip electrodes of cross-section not less than 25mm x 1.6mm is buried in a horizontal trench of a minimum depth of 0.5m.
   - The length of the conductor buried in the ground would give a sufficient earth resistance and this length should not be less than 15m.

Self-Check Quiz 2.1.1

Write the correct answer for the following questions.

1. What is electrical earthing?
2. What is meant by electrical fault?
3. What is earth conductor(s)?
4. What is earthing conductor?
5. Name various methods of earthing.

Information Sheet 2.1.2

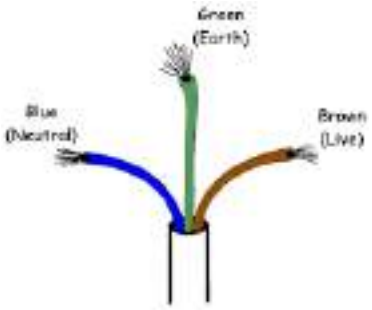
Learning Objective: to identify and uses of earthing materials in a workplace.

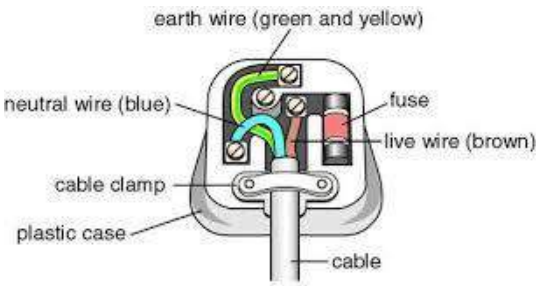
Earthing materials:

- **Earth Electrode:** If a conductor is buried in the earth for electrical earthing system, it is known to be earth electrode.

- **Earthing Lead**: The conductor wire connected between earth electrode and electrical installation system and devices in called earthing lead.

- **Earth Continuity Conductor:** The conductor wire between earthing lead and electrical device or appliance is called earth continuity conductor.





- **Connector:** It is an electro-mechanical device used to join electrical terminations and create an electrical circuit.

- **Galvanised Iron (GI) pipes:** These are generally used for distribution of water and also used in electrical installation works.

- **Bolts and nuts:** These are types of fastener with a threaded hole.
  - Nuts are almost always used in conjunction with a mating bolt to fasten multiple parts together.

  - Bolts are used for the assembly of two unthreaded components, with the aid of a nut..

- **Powdered charcoal:** This is a black or dark grey form of carbon, produced by heating wood or another organic substance.

- **Salt:** This is mineral composed primarily of sodium chloride (NaCl) used in earthing system.

Self-Check Quiz 2.1.2

Fill in the blanks with appropriate word or words.

1. When a conductor is buried in the earth for electrical earthing system then it is known as _____.
2. The conductor wire which is connected between earth electrode and electrical installation system and devices in called _____.
3. The conductor wire between earthing lead and electrical device or appliance is called _____.
4. The electro-mechanical device used to join electrical terminations and create an electrical circuit, is known as _____.
5. _____ is produced by heating wood or another organic substance.

Learning Outcome 2.2 - Identify the Type of Lightning Protection System to be Used

Contents:

- Types of lightning protection system
- Lightning protection system materials

Assessment criteria:

1. Types of lightning protection system is identified in accordance to electrical plan/design.
2. Types and sizes of lightning protection system materials are identified in accordance to electrical plan/design.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: adjustable wrench, wire stripper, mallet, C-clamp, chisels: (a) wooden (b) cold, drill bits, files: (a) flat (b) round (c) half round, hacksaw, hammers: (a) ball peen (b) claw, hand drill, measuring tape, pliers: (a) combination pliers (b) cutting pliers (c) diagonal cutting pliers (d) long nose pliers, punches, screwdrivers: (a) star (b) flat (c) connecting, try square, neon tester, wire cutters, S.W.G., set squares, electrician knife, ladder
- Equipment: electric drill machine, soldering iron, multimeter, earth tester, megger tester
- Materials: continuity conductor/cable, earth lead, lightning rod (spike arrester), earth down conductor (arrester), bolts and nuts

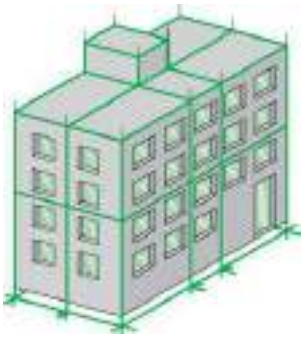
Learning Activity 2.2.1

Learning Activity	Resources/Special Instructions/References
Identify the type of lighting protection system to be used	▪ Information Sheet: 2.2.1 ▪ Self-Check Quiz: 2.2.1 ▪ Answer Key: 2.2.1 ▪ https://www.ingesco.com/en/noticias/lightning-protection-system-installation

Information Sheet 2.2.1

Learning Objective: to identify different type of lightning protection system and materials uses in a workplace.

- **Lightning protection system:** means by which a lightning discharge may enter or leave earth without passing through and damaging personnel, electrical equipment and non-conducting structures such as buildings.
  - Main parts of a properly installed lightning protection system: copper air terminals, copper cable, copper clad ground rods, surge suppressors. The air terminals and cable are typically copper, but sometimes they can be aluminium.
  - To protect a building, conductor cables are run along the tops and around the edges of roofs, then down one or more corners of a building to the ground rods.
  - Ground rods - long, thick, heavy rods buried deep into the earth around a protected structure.



- **Lightning rod:** provides a safe path for lightning to ground, which are placed on the highest point of a building. Copper and its alloys are the most common materials used in lightning protection.

- **Earth down conductor:** is connected between lightning rod and earth pit for making a discharge path.

- **Ground rod:** provides a safe path for the electricity to reach the ground.

- **Types of Lightning Protection Systems:**
  1. Protection for buildings and installations includes the following:
     A: Conventional lightning protection system
     B: Non-Conventional lightning protection system
  2. Protection against overvoltage on incoming conductors and conductor systems.
  3. Protection against the electromagnetic pulse of the lightning.

Remember:
- *Lightning protection systems are used to prevent or lessen lightning strike damage to structures.*
- *Copper and its alloys are the most common materials used in lightning protection*.

Self-Check Quiz 2.2.1

Write the correct answer to the following questions.

1. What is meaning of lighting protection system (LPS)?
2. List the main parts of a lightning protection system.
3. Write the functions of a lightning rod.
4. Which are the most common materials used for lightning protection?
5. Where the lightning protection systems are installed?

Learning Outcome 2.3 - Select and Collect Tools, Equipment and Materials

Contents:

- List of hand tools and their uses/functions
- List of power tools and their uses/functions
- List of equipment and their uses/functions
- List of earthing materials and their uses

Assessment criteria:

1. Tools, equipment and materials are checked for usability.
2. PPE is collected and used.
3. Drawings are collected and interpreted.

Resources required:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: adjustable wrench, wire stripper, mallet, C-clamp, chisels: (a) wooden (b) cold, drill bits, files: (a) flat (b) round (c) half round, hacksaw, hammers: (a) ball peen (b) claw, hand drill, measuring tape, pliers: (a) combination pliers (b) cutting pliers (c) diagonal cutting pliers (d) long nose pliers, punches, screwdrivers: (a) star (b) flat (c) connecting, try square, neon tester, wire cutters, S.W.G., set squares, electrician knife, ladder
- Equipment: electric drill machine, grinder, soldering iron, multimeter, earth tester, megger tester, digital weight machine
- Materials: continuity conductor/cable, earthing lead, earth electrode/plate, connector, G.I. pipe/conduit, bolts and nuts, powdered charcoal and salt

Activity

Learning Activity 2.3.1

Learning Activity	Resources/Special Instructions/References
Select and collect tools, equipment and materials	▪ Information Sheet: 2.3.1

Information Sheet 2.3.1

Learning Objective: to identify, gather and check tools and equipment used in a workplace.

Same as Information Sheet 1.2.1 of Module 1: Performing channel wiring (page 13-15)

Learning Outcome 2.4 - Excavate the Hole for Earthing Element Installation

Contents:

- List of PPE and their uses
- Tools and equipment used for digging hole in wall, floor/roof and earth

Assessment criteria:

1. PPE is collected and used in accordance to OHS requirements.
2. Hole is dug following with safety requirements.
3. Hole is shaped and sized in accordance to electrical plan/design specification.

Resources required:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: shovel, trowel, spading fork, drain spade, pick, auger, wheelbarrow

Learning Activity 2.4.1

Learning Activity	Resources/Special Instructions/References
Excavate the hole for earthing element installation	▪ Information Sheet: 2.4.1 ▪ https://www.wikihow.com/Dig-Post-Holes

Information Sheet 2.4.1

Learning Objective: to apply plastic emulsion paint in a workplace.

- **Personal Protective Equipment (PPE):**

Same as Information Sheet 1.3.1 of Module 1: Perform channel wiring (page 19-21)

- **Digging**: is the combination of two processes, the first being the breaking or cutting of the surface and the second being the removal and relocation of the material found there.
  - Tools required for digging: hammer, level, posthole digger, measuring tape, tile spade, shovel.

- **How to excavate the hole for earthing element installation?**

  To complete the task, you should follow the steps given below:

  1. Collect all necessary tools, equipment and accessories to excavate the hole.
  2. Identify and select usable tools and equipment to excavate the hole.
  3. Collect earthing element for installation as per electrical drawing.
  4. Provide detail of layout as per electrical drawing.
  5. Make appropriate holes where necessary.
  6. Dig hole in the earth as per design of earthing installation.
  7. While working you should use personal protective equipment for safety.
  8. Clean the workplace and restore the tools, equipment and excess materials.

Learning Outcome 2.5 - Install Earthing Components

Contents:

- Earthing element and earthing lead
- Powdered charcoal and salt
- GI pipe, bolts and nuts

Assessment criteria:

1. Earthing element is fitted in the bottom of the excavated hole following standard earthing procedure.
2. Earth lead is connected to the earth element tightly and brought up the meter board through the conduit.
3. Powdered charcoal and salt are laid around the earthing element in accordance to workplace procedure.
4. A proper sized and length of GI pipe is fitted from top of the earth element to the bottom of the earth pit chamber.
4. Rest of the excavated hole is filled with earth.

Resources required:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: rods, tape, terminals, bars, conductors, electrodes

Learning Activity 2.5.1

Learning Activity	Resources/Special Instructions/References
Install earthing components	▪ Information Sheet: 2.5.1 ▪ www.swaonline.co.uk/earthing-components-accessories ▪ www.electrical-installation.org/enwiki/Earthing_connections

Information Sheet 2.5.1

Learning Objective: to identify earthing components and install the same in a workplace.

- **Earthing components:**
  Component parts of earthing system are to include the following:
  - Earth electrode (rods, tapes etc.)
  - Main earthing terminals or bars.
  - Earthing conductors.
  - Protective conductors.
  - Equipotential bonding conductors.
  - Electrically independent earth electrodes for special systems.

- **Conductor:**
  A range of conductor materials is required for earthing installation system. Above ground, copper, aluminium and steel may be used. Below ground, copper is the most common choice due to its high resistance to corrosion. It is important that earthing conductors should be correctly sized for their application, as they may be required to carry a considerable current for several seconds.

- **How to installation earthing components?**
  To complete the task, you should follow the steps given below:
  1. Collect all necessary tools, equipment and accessories to install earthing components/elements.
  2. Identify and select usable tools and equipment to install earthing components/elements.
  3. Collect earthing components/elements for installation as per electrical drawing.
  4. Calculate, measure, cut and fix the earthing elements in accordance with standard requirements.
  5. Check the installation and test continuity using appropriate tools & equipment.
  6. While working you should use personal protective equipment for safety.
  7. Clean the workplace and restore the tools, equipment and excess materials.

Did you know?
- *Above ground, copper, aluminium and steel may be used as conductors*
- *Below ground, copper is the most common choice of conductor*

Learning Outcome 2.6 - Finish Earth Pit Chamber for Pipe Earthing Method

Contents:

- Earth pit chamber
- Pit chamber cover

Assessment criteria:

1. Earth pit chamber is constructed with brick chips, cements sand and water mixture in accordance with standard/specification.
2. Pit chamber cover is made with G.I sheet in accordance with electrical plan/design.
3. Pit cover is fitted/installed on the pit chamber.
4. Check earth resistance in accordance with electrical plan/specification.

Resources required:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: shovel, trowel, spading fork, drain spade, pick, auger, wheelbarrow
- Equipment: multimeter, earth tester, electrical plans/drawings
- Materials: water, brick chips, sand, cement, GI sheet

Learning Activity 2.6.1

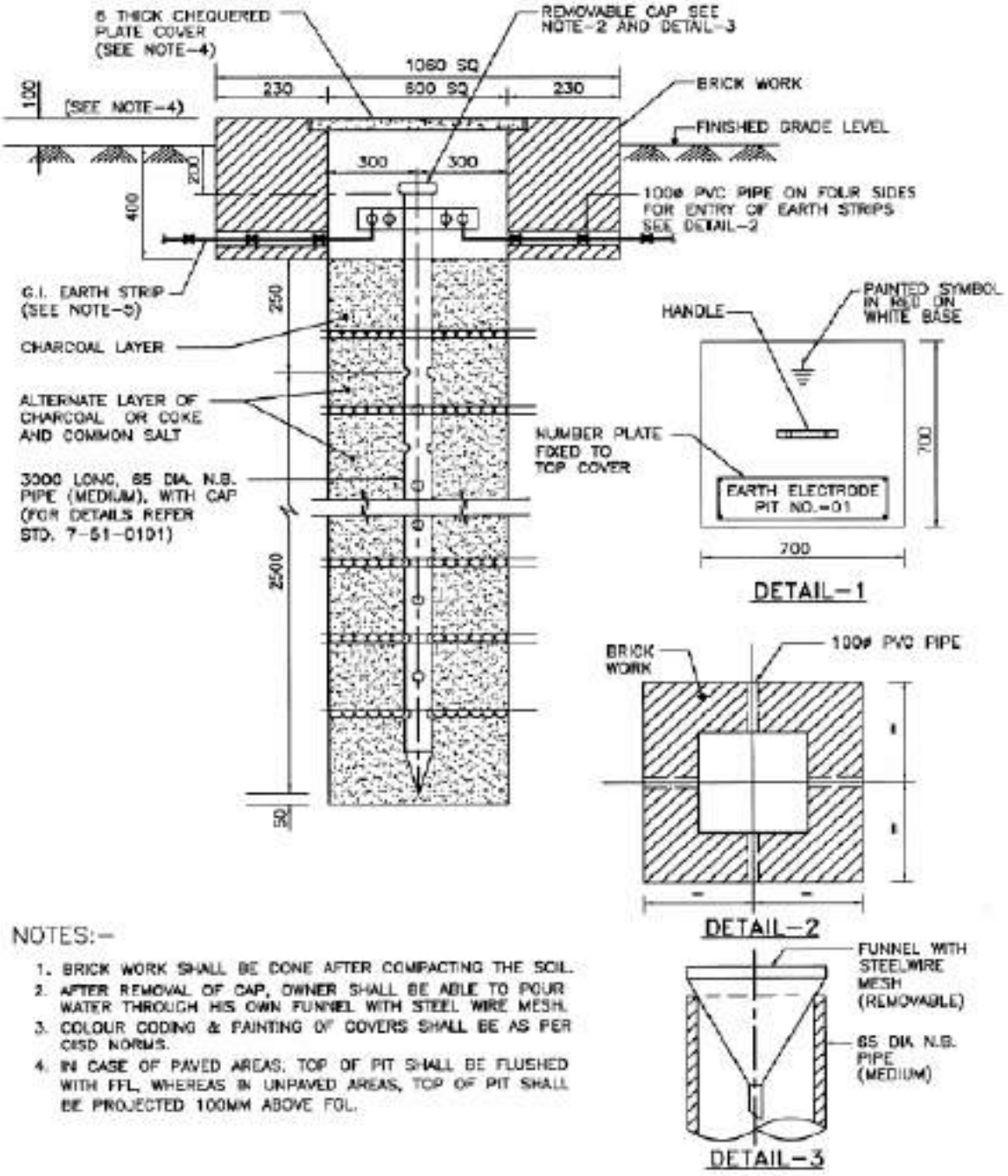
Learning Activity	Resources/Special Instructions/References
Finish earth pit chamber for pipe earthing method	▪ Information Sheet: 2.6.1 ▪ https://www.indiamart.com › Electric Fittings & Components › Earth Pit

Information Sheet 2.6.1

Learning Objective: to identify and construction earth pit chamber for pipe earthing method in a workplace.

- **Earth pit chamber**: It can be constructed with bricks and/or concrete using appropriate materials and proper techniques.

- A cover is made with GI sheet or any other suitable elements on top of the earth pit chamber must be provided so that can easily check the earth resistance of the conductor and maintain the system as well.
- A typical earth pit detail is shown below.



How to construct an earth pit chamber for pipe earthing method:

To complete the task, you should follow the steps given below:

1. Collect all necessary tools, equipment and accessories to construct an earth pit chamber.
2. Identify and select usable tools and equipment for construction of an earth pit chamber.
3. Calculate the quantity of materials for construction of an earth pit chamber.
4. Collect all materials required for construction of an earth pit chamber.
5. Construct and finish the earth pit chamber using appropriate tools & equipment.
6. While working you should use personal protective equipment for safety.
7. Clean the workplace and restore the tools, equipment and excess materials.

Learning Outcome 2.7 - Install Lightning Protection System

Contents:

- Uses of lightning rod
- Earth down conductor

Assessment criteria:

1. Lightning rod is installed at specified location.
2. Earth down conductor is connected as per diagram.
3. Performance of lightning protection system (LPS) is tested as per standard.

Resources required:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape, plumb bob
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: channels, wire, elbows, bends, PVC circular box, plugs, saddles, screws, cables, cable lugs, cable ties, thread ball, insulating clips, flexible conduit, conductors, plastic forma, electric soldering lead, protective tubing, lighting protection system

Learning Activity 2.7.1

Learning Activity	Resources/Special Instructions/References
Install lightning protection system	▪ Information Sheet: 2.7.1 ▪ https://www.ingesco.com/en/noticias/lightning-protection-system-installation

Information Sheet 2.7.1

Learning Objective: to identify and install the lightning protection system in a workplace.

- **The following points should be considered while installing the lightning protection system:**
  - The lightning rod is connected to ground with at least two down conductors located on opposite facades whenever possible.
  - It is also advisable to place the down conductors on exposed corners of the building whenever possible.
  - The down conductors must be installed outside the building, avoiding the proximity of electrical cables.
  - Its path must be as straight as possible, using the shortest path to earth, avoiding any sharp bend or lift.
  - Protect the bottom of the downspout by a protective tube of at least 2 m.

- **How to install lightning protection system:**

  To complete the task, you should follow the steps given below:

  1. Collect all necessary tools, equipment and accessories to install lightning protection system.
  2. Identify and select usable tools and equipment to install lightning protection system.
  3. Collect lightning protection components/elements for installation as per electrical drawing.
  4. Calculate, measure, cut and fix the lightning protection elements in accordance with standard requirements.
  5. Check the installation and test continuity using appropriate tools and equipment.
  6. While working you should use personal protective equipment for safety.
  7. Clean the workplace and restore the tools, equipment and excess materials.

JOB SHEET 2			
Qualification:	Electrical Installation and Maintenance		
Learning unit:	Install lightning protection		
Learner name:			
Personal protective equipment (PPE):	Safety helmet, goggles, ear plugs, dust mask, safety cloth/apron, safety belt, hand gloves, safety shoes		
Materials:	Lightning rod, lightning down-conductor, connectors, nut-bolts, GI pipe, rowel plug, screws, clamps.		
Tools and equipment:	Measuring tape, marking chalk, plumb bob, tri-square, thread ball, ball peen hammer, cold chisel, hacksaw, wire stripper, drill bit, files, pliers, screw drivers, wire cutter, poker, electrician knife, electric drill machine, adjustable wrench, earth tester		
Performance criteria:	1. Lightning rod is installed at specified location. 2. Earth down conductor is connected as per diagram. 3. Performance of lightning protection system (LPS) is tested as per standard.		
Measurement:	▪ Measurement to be taken physically and/or from electrical drawing		
Notes:	▪ Placement of lightning rod and the route of down conductor must be in proper way. ▪ Ensure the components are secured and tightened properly.		
Procedure:	1. Collect all necessary tools, equipment and accessories to install lightning protection system. 2. Identify and select usable tools & equipment to install lightning protection system. 3. Collect lightning protection components/elements for installation as per electrical drawing. 4. Calculate, measure, cut and fix the lightning protection elements in accordance with standard requirements. 5. Check the installation and test continuity using appropriate tools & equipment. 6. While working you should use personal protective equipment for safety. 7. Clean the workplace and restore the tools, equipment and excess materials.		
Learner signature:		**Date:**	
Assessor signature:		**Date:**	
Quality Assurer signature:		**Date:**	
Assessor remarks:			
Feedback:			

Individual Activity:

- *Watch the video shows on 'Installing lightning protection system' or other similar videos and summarize key points (if facilities available)*
- *Install lightning protection system following Job Sheet 2 (see above)*

Group Activity

Field Visit:

- *Visit an industry/practical site in the neighbourhood.*
- *Observe the activities there related to earthing installation and atmospheric lightning protection system:*
  - *What tasks are being performed?*
  - *Which tools are being used and for what purpose?*
  - *What are the materials used? List out the names.*
  - *Anything more observed you may mention.*
- *Fill-up the 'Field Visit Format' given and submit to your trainer.*
- *Present the experience group wise as per instruction of your trainer.*

Learning Outcome 2.8 - Clean/Maintain the Work Area

Same as Learning Outcome 1.6: Clean the workplace (page 32-34)

ANSWER KEY

Answer Key 2.1.1

1. The process of transferring the immediate discharge of the electrical energy directly to the earth by the help of the low resistance wire is known as the electrical earthing.
2. The electrical fault is the abnormal condition of the electrical system which damages the electrical equipment and disturbs the normal flow of the electric current.
3. Earth electrode is the conductor or group of conductors in intimate contact with and providing an electrical connection with earth.
4. Earthing conductor is a protective conductor connecting the main earthing terminal of an installation to an earth electrode or to other means of earthing.
5. The various methods employed in earthing are pipe earthing, rod earthing, plate earthing, water mains earthing and strip or wire earthing.

Answer Key 2.1.2

1. Earth electrode
2. Earthing lead
3. Earth continuity conductor
4. Electrical connector
5. Char-coal

Answer Key 2.2.1

1. A Lighting Protection System (LPS) is the system that provides a means by which a lightning discharge may enter or leave earth without passing through and damaging personnel, electrical equipment, and non-conducting structures such as buildings.
2. There are four main parts of a properly installed lightning protection system: copper air terminals, copper cable, copper clad ground rods, surge suppressors.
3. A lightning conductor or rod is mounted on top of a building and electrically connected to the ground through a wire or earthing copper strips, to protect the building for discharge of lightning current from cloud.
4. Copper and its alloys are the most common materials used in lightning protection.
5. Lightning protection systems are installed on top of the structures, trees, monuments, bridges or water vessels to protect from lightning damage.

Module 3: Perform conduit wiring

MODULE CONTENT

Module Descriptor: This module covers the skills, knowledge and attitudes to perform conduit wiring. It specifically includes collecting tools, equipment and materials, installing conduits and setting of cables, installing boards and other accessories of wiring, testing the wiring, measuring the earth resistance and cleaning the workplace. It also includes information sheets, job sheets, self-checking quizzes and answer keys.

Nominal Duration: 35 hours

Learning Outcomes:

Upon completion of the module, the student/trainee will be able to:

3.1 Collect tools, equipment and materials
3.2 Install conduits and set cables
3.3 Install boards and set all other accessories of wiring
3.4 Test the wiring
3.5 Measure the earth resistance
3.6 Clean the work place

Performance Criteria:

1. Tools, equipment and materials are collected and checked for usability.
2. PPE is collected and used as per requirements.
3. Drawings are collected and interpreted.
4. Layout is drawn on the wall as per drawing.
5. Wall is cut and grooved.
6. Collected conduits are cut and set.
7. Conduits are installed on the wall and clamped.
8. Fish wires are measured, cut and inserted.
9. Cables are collected, cut, tied with fish wire and insert into the conduit.
10. Boards are collected and fitted as per wiring diagram.
11. Switches, sockets, fan regulator and ballast are fitted on the board and connected to the circuits.
12. Ceiling rose and different types of holders are fitted on the board and connected to the circuit.
13. MCB and MCCB are connected and fitted on the board.
14. Polarity of wiring is checked by megger and justified each of the switches, fuses and circuit breakers.
15. The main switches and circuit breakers are disconnected and all loads are connected and checked the continuity each of the switches and circuit breakers.
16. Continuity is tested and insulation resistance is measured.
17. The earth terminals are connected as per appropriate measurement and position.
18. Tools and equipment are cleaned and stored as per standard practice.
19. Waste materials are disposed and workplace is cleaned in accordance with standard procedure.

Learning Outcome 3.1 - Collect Tools, Equipment and Materials

Contents:

- List of hand tools and their uses/functions
- List of power tools and their uses/functions
- List of equipment and their uses/functions
- List of electrical materials and their uses

Assessment criteria:

1. Tools, equipment and materials are checked for usability.
2. PPE is collected and used.
3. Drawings are collected and interpreted.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: conduit (1/2", ¾", 1",1.25", 1.5" PVC), GI wire, elbow, bend, PVC circular box, rowel plug, saddle, screw, cable lugs, cable tie, thread ball, insulating clip, flexible conduit, plastic forma, electric soldering lead, plastic tape, cable (PVC, VIR)

Learning Activity 3.1.1

Learning Activity	Resources/Special Instructions/References
Collect tools, equipment and materials	▪ Information Sheets: 3.1.1, 3.1.2, 3.1.3 ▪ https://www.ecmag.com/section/your-business/tools-most-used-electricians ▪ https://www.kele.com/electrical-wiring-materials.aspx

Information Sheet 3.1.1

Learning Objective: to identify, gather and check tools and equipment used in a workplace.

- **Tools and equipment:**

  Same as Information Sheet 1.2.1 of Module 1: Performing channel wiring (page 13-15)

Information Sheet 3.1.2

Learning Objective: to identify, gather and check electrical materials used in a workplace.

Electrical materials:

- **PVC conduit**: is a tube used to protect and route electrical wiring in a building or structure.
  - Electrical conduit may be made of metal, plastic, fibre or fired clay.
  - Most conduit is rigid, but flexible and or corrugated conduit is also used for some purposes.
  - These are available in various diameters or sizes.

Note: *Other materials are same as Information Sheet 1.2.2 of Module 1: Performing channel wiring (page 15-18)*

Information Sheet 3.1.3

Learning Objective: to identify the personal protective equipment used in a workplace.

- **Personal Protective Equipment:**

Same as Information Sheet 1.3.1 of Module 1: Performing channel wiring (page 19-21)

Learning Outcome 3.2 - Install Conduits and Set Cables

Contents:

- Layout and wall cutting
- Conduit cutting and setting
- Fish wire and cables inserting

Assessment criteria:

1. Layout is drawn on the wall as per drawing.
2. Wall is cut and grooved.
3. Collected conduits are cut and set.
4. Conduits are installed on the wall and clamped.
5. Fish wires are measured and cut.
6. Fish wire is inserted.
7. Collected cables are cut.
8. Cables are tied with fish wire and insert into the conduit.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: conduits and setting cables, clamps, fish wire

Learning Activity 3.2.1

Learning Activity	Resources/Special Instructions/References
Install conduits and set cables	▪ Information Sheet: 3.2.1 ▪ Self-Check Quiz: 3.2.1 ▪ Answer Key: 3.2.1 ▪ https://www.wikihow.com/Install-Electrical-Conduits

Information Sheet 3.2.1

Learning Objective: to install conduits and set cables in a workplace.

- **Fish wire:** is used to route new wiring through walls and electrical conduit. Made of a narrow band of spring steel by careful manipulation the tape can be guided through confined spaces such as wall cavities.

- **How to fix conduit and install wire?**

  To complete the task, you should follow the steps given below:

  1. Collect all necessary tools, equipment and accessories to fix conduit and install wire.
  2. Identify and select usable tools and equipment.
  3. Collect conduit, fish wire, electrical box and electrical wire/cable as per electrical drawing.
  4. Provide layout on wall as per electrical drawing.
  5. Calculate, measure, cut and fix the conduit and boxes in accordance with type and size.
  6. Calculate, measure, cut, draw and fix the electrical cable in accordance with type and size.
  7. While working you should use personal protective equipment for safety.
  8. Clean the workplace and restore the tools, equipment and excess materials.

JOB SHEET 3			
Qualification:	Electrical Installation and Maintenance		
Learning unit:	Install conduits and set cables		
Learner name:			
Personal protective equipment (PPE):	Safety helmet, goggles, ear plugs, dust mask, safety cloth/apron, safety belt, hand gloves, safety shoes		
Materials:	Rowel plug, screws, cable tie, conduits (different size and type), ECC and electrical cables, fish wire		
Tools and equipment:	Measuring tape, marking chalk, plumb bob, tri-square, thread ball, ball peen hammer, hacksaw, wire stripper, drill bit, files, pliers, screw drivers, wire cutter, poker, electrician knife, electric drill machine		
Performance criteria:	1. Layout is drawn on the wall as per drawing. 2. Wall is cut and grooved. 3. Collected conduits are cut and set. 4. Conduits are installed on the wall and clamped. 5. Fish wires are measured and cut. 6. Fish wire is inserted. 7. Collected cables are cut. 8. Cables are tied with fish wire and insert into the conduit.		
Measurement:	▪ Measurement to be taken physically and/or from electrical drawing ▪ Carefully take the measurement of conduit and cables.		
Notes:	▪ Ensure the size and type of conduits and electrical cables		
Procedure:	1. Collect PPE, all necessary tools, equipment and accessories to fix conduit and install cable. 2. Identify and select usable tools & equipment. 3. Collect conduit, fish wire, electrical box and electrical wire/cable as per electrical drawing. 4. Provide layout on wall as per electrical drawing. 5. Calculate, measure, cut and fix the conduit and boxes in accordance with type and size. 6. Calculate, measure, cut, insert and draw the cable in accordance with type and size. 7. While working you should use personal protective equipment for safety. 8. Clean the workplace and restore the tools, equipment and excess materials.		
Learner signature:		**Date:**	
Assessor signature:		**Date:**	
Quality Assurer signature:		**Date:**	
Assessor remarks:			
Feedback:			

Important:
- Select the size of conduit so that cables inside the channel is not over tight or very loose
- Provide rowel plugs 30 cm to 50 cm on centre for setting channel, two for each load point, two for junction board and 2 to 4 for switch board

Individual Activity:

- *Watch the video shows on 'How to make surface conduit wiring' or other similar videos and summarize key points (if facilities available)*
- *Install conduit wiring following Job Sheet 3 (see above)*

Self-Check Quiz 3.2.1

Write the correct answer of the following questions:

1. Why conduits are used for electrical wiring?
2. Why fish wire is used in electrical wiring?
3. What are the main tools required to cut brick wall?

Learning Outcome 3.3 - Install Boards and Set all other Accessories of Wiring

Contents:

- Boards and their uses
- Switches, sockets, fan regulator and ballast
- Ceiling rose and different types of holders
- MCB and MCCB

Assessment criteria:

1. Boards are collected and fitted as per wiring diagram.
2. Switches, sockets, fan regulator and ballast are fitted on the board with screw.
3. Switches, sockets and fan regulator are connected to the circuits.
4. Ceiling rose and different types of holders are fitted on the board.
5. Those fixtures are connected to the circuit.
6. MCB and MCCB are connected and fitted on the board.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: boards, setting accessories, rewire able fuse, cartridge fuse, glass fuse, HRC fuse, single pole MCB, double pole MCB, MCCB, earth leakage circuit breaker (ELCB), sockets, fan regulator, ceiling rose, holders, MCB, MCCB

Learning Activity 3.3.1

Learning Activity	Resources/Special Instructions/References
Install boards and set all other accessories of wiring	▪ Information Sheet: 3.3.1 ▪ Self-Check Quiz: 3.3.1 ▪ Answer Key: 3.3.1 ▪ https://wazipoint.blogspot.com/2015/08/electrical-distribution-board-db-wiring.html

Information Sheet 3.3.1

Learning Objective: to install boards and set all other accessories of wiring in a workplace.

Same as Information Sheet 1.4.1 of Module 1: Performing channel wiring (page 26-28)

Self-Check Quiz 3.3.1

Read the statements carefully and state whether they are True or False:

1. A board is a component of an electricity supply system that divides an *electrical power* feed into subsidiary circuits, while providing a protective fuse or circuit breaker for each circuit in a common enclosure.
2. A switch is an electrical component that can make or break an electrical circuit, interrupting the current or diverting it from one conductor to another.
3. A ballast is a crucial electrical component that serves to increase or decrease the speed of fan according to the needs.
4. Ceiling roses are typically square in shape and display a variety of ornamental designs.

5. Electric fuse is a self-sacrificial device used to interrupt a circuit under short circuit, excessive overload or over current conditions by melting the fuse element.

Learning Outcome 3.4 - Test the Wiring

Contents:

- Testing of the wiring
- Polarity of wiring
- Continuity of wiring
- Insulation resistance

Assessment criteria:

1. Polarity of wiring is checked by megger as per procedure.
2. Polarity is justified and checked each of the switches, fuses and circuit breakers.
3. The main switches and circuit breakers are disconnected.
4. All loads are connected and checked the continuity each of the switches and circuit breakers.
5. By observing the zero positions of the megger continuity is tested and insulation resistance is measured.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: boards, switches, sockets, fan regulator, ceiling rose, holders, MCB, MCCB

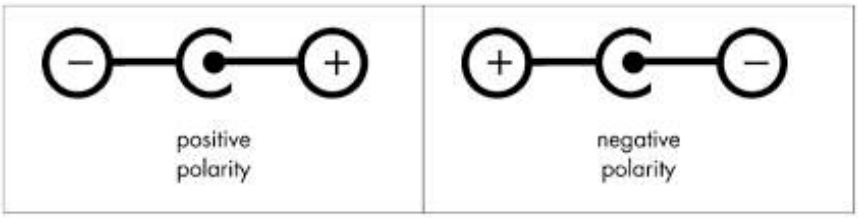
Learning Activity 3.4.1

Learning Activity	Resources/Special Instructions/References
Test the wiring	▪ Information Sheet: 3.4.1 ▪ Self-Check Quiz: 3.4.1 ▪ Answer Key: 3.4.1 ▪ https://www.familyhandyman.com/electrical/how-to-use...electrical-testers/view-all/ ▪ https://www.familyhandyman.com › Electrical

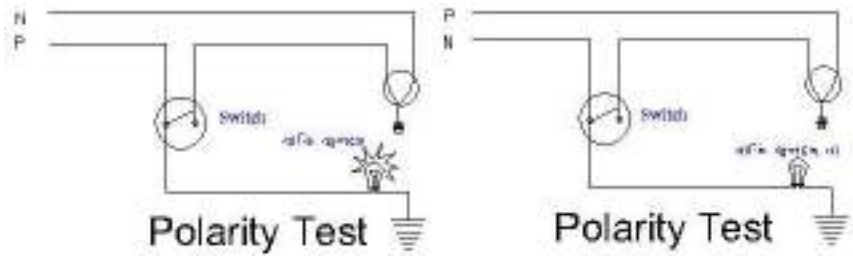
Information Sheet 3.4.1

Learning Objective: to test electrical wiring as per circuit diagram in a workplace.

- **Polarity:** is a term used in electricity, magnetism and electronic signalling.
  - The pole with relatively more electrons is said to have negative polarity; the other is assigned positive polarity.
  - If the two poles are connected by a conductive path such as a wire, electrons flow from the negative pole toward the positive pole.

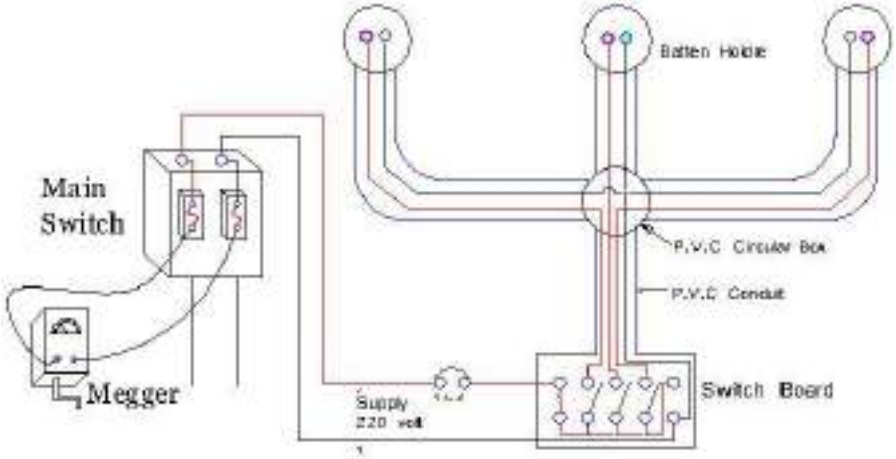


- **Polarity test:** is used to find out the electrical polarity (positive or negative) of the voltage at a given point within a circuit relative to some.
  - The polarity test is done to ensure that the line and neutral conductors are connected the correct way.



- **Testing electrical wiring:**
  - Voltage and current are two of the most common electrical measurements taken at panels and the surrounding wiring.

- **Continuity test:** is the checking of an electric circuit to see if current flows.
  - A continuity test is performed by placing a small voltage across the chosen path or, the act of testing the resistance between two points.
  - If there is very low resistance (less than a few Ω), the two points are connected electrically and a tone is emitted.
  - If there is more than a few Ω of resistance, than the circuit is open and no tone is emitted.



- **Continuity testing overview:**
  - Continuity is the presence of a complete path for current flow.
  - A digital multimeter's continuity test mode can be used to test switches, fuses, electrical connections, conductors and other components.
  - A digital multimeter emits an audible response (a beep) when it detects a complete path.
  - The beep, an audible indicator, permits technicians to focus on testing procedures without looking at the multimeter display.
  - When testing for continuity, a multimeter beeps based on the resistance of the component being tested. That resistance is determined by the range setting of the multimeter. Examples:
    - o If the range is set to 400 Ω, a multimeter typically beeps if the component has a resistance of 40 Ω or less.

- o If the range is set 4.000 kΩ, a multimeter typically beeps if the component has a resistance of 200 Ω or less.
- The lowest range setting should be used when testing circuit components that should have low-resistance value such as electrical connections or switch contacts.

- **Insulation resistance:** testing is used as a quality control measurement.
  - This is a spot insulation test which uses an applied DC voltage (typically either 250V, 500V or 1000V) for low voltage equipment.
  - Insulation resistance measurement is based on Ohm's Law. By injecting a known DC voltage lower than the voltage for dielectric testing and then measuring the current flowing, it is very simple to determine the value of the resistance.
  - The insulation resistance test consists in measuring the insulation resistance of a device under test, while phase and neutral are short circuited together.

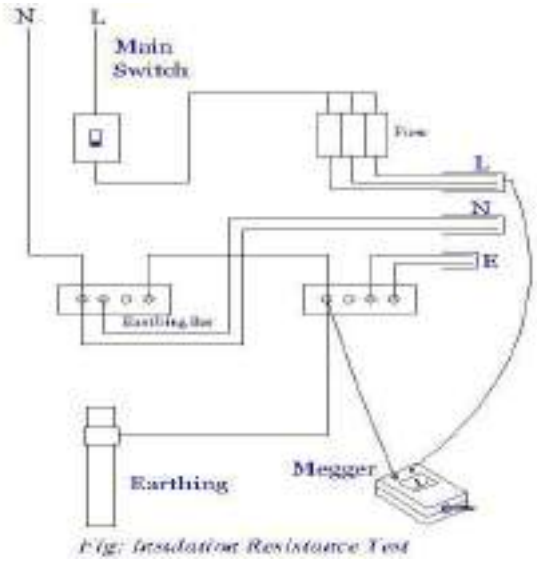


Fig: Insulation Resistance Test

Did you know?
- *The polarity test is done to ensure that the line and neutral conductors are connected the correct way*
- *Continuity is the presence of a complete path for current flow*

Individual Activity:
- *Watch the video shows on 'Polarity test, Continuity rest and Resistance test and summarize key points (if facilities available)*
- *Perform Polarity test, Continuity rest and Resistance test under the guidance of your trainer*

Self-Check Quiz 3.4.1

Write the correct answer for the following:

1. Define polarity.
2. Why is the polarity test is done?
3. What are the most common electrical measurements taken at panels and the surrounding wiring?
4. What is continuity testing?

5. On which law the insulation resistance measurement is based?

Learning Outcome 3.5 – Measure the Earth Resistance

Contents:

- Measurement of earth resistance

Assessment criteria:

1. The earth terminals are connected as per the appropriate measurements and positions.
2. By observing the positions of the pointer of the megger earth resistance is measured.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Equipment: earth resistance tester

Learning Activity 3.5.1

Learning Activity	Resources/Special Instructions/References
Measure the earth resistance	▪ Information Sheet: 3.5.1 ▪ Self-Check Quiz: 3.5.1 ▪ Answer Key: 3.5.1 ▪ https://testguy.net/content/233-4-Important-Methods-of-Ground-Resistance-Testing

Information Sheet 3.5.1

Learning Objective: to measure the earth resistance in the workplace.

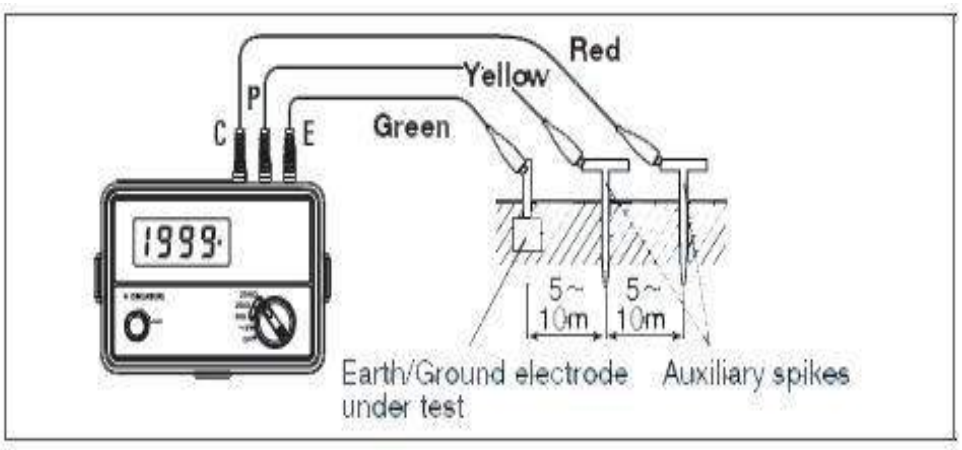
- **Earthing system:** or grounding system connects specific parts of that installation with the Earth's conductive surface for safety and functional purposes.
- **Earth resistance:**
  - Earth resistance is the resistance of soil to the passage of electric current.
  - Earth is a relatively poor conductor of electricity compared to normal conductors like copper wire.
  - Earth resistance is measured in two ways for two important fields of use:

1. Determining effectiveness of ‘ground’ grids and connections that are used with electrical systems to protect personnel and equipment.
2. Prospecting for good (low resistance) ‘ground’ locations or obtaining measured resistance values that can give specific information about what lies some distance below the earth’s surface.

- **Methods of earth resistance:**

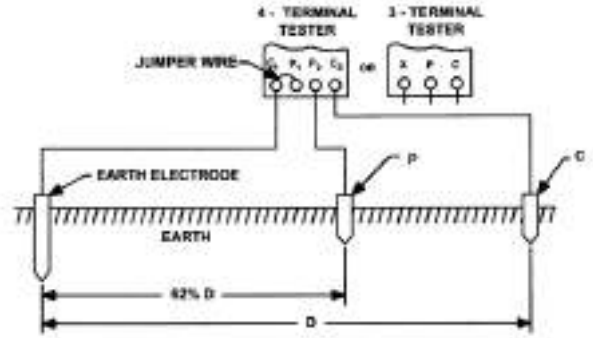
1. 2-point (dead earth) method:

- In areas where driving ground rods may be impractical, the two-point method can be used.
- In this method, the resistance of two electrodes in a series is measured by connecting the P1 and C1 terminals to the ground electrode under test; P2 and C2 connect to a separate all-metallic grounding point (like a water pipe or building steel).
- 2-point method is the simplest way to obtain a ground resistance reading but is not as accurate as the 3-point method and should only be used as a last resort.
- It is most effective for quickly testing the connections and conductors between connection points.
- The earth electrode under test must be far enough away from the secondary grounding point to be outside its sphere of influence.



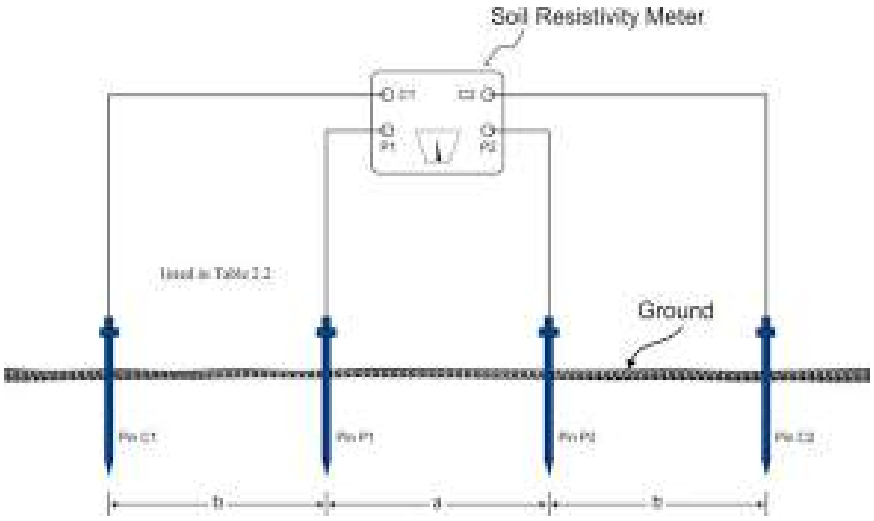
2. 3-point (fall-of-potential) method:

- 3-point method is the most reliable test method for measuring resistance to earth of an installed grounding electrode.
- The standard used as a reference for fall-of-potential testing is IEEE Standard 81: Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Grounding System**.**
- With a four-terminal tester, P1 and C1 terminals on the instrument are jumped and connected to the earth electrode under test while the C2 reference rod is driven into the earth straight out as far from the electrode under test as possible.
- Potential reference P2 is then driven into the earth, at a set number of points, roughly on a straight line between C1 and C2.
- Resistance readings are logged for each P2 point.
- Measurements are plotted on a curve of resistance vs. distance.
- Correct earth resistance is read from the curve for the distance that is roughly 62% of the total distance between C1 and C2.



3. 4-point method:

- 4-point method is the most commonly used for measuring soil resistivity, which is important for designing electrical grounding systems.
- In this method, four small-sized electrodes are driven into the earth at the same depth and equal distance apart - in a straight line - and a measurement is taken.
- The amount of moisture and salt content of soil radically affects its resistivity.
- Soil resistivity measurements will also be affected by existing nearby grounded electrodes.
- Buried conductive objects in contact with the soil can invalidate readings if they are close enough to alter the test current flow pattern.
- This is particularly true for large or long objects. This is the most commonly used technique for soil resistivity measurements.



4. Clamp-on method:

- This method is unique in that it offers the ability to measure resistance without disconnecting the ground system.
- It is quick, easy and also includes the bond to ground and overall grounding connection resistances in its measurement.
- Measurements are made by 'clamping' the tester around the grounding electrode under test**,** similar to how you would measure current with a multi-meter current clamp.
- The tester applies a known voltage without a direct electrical connection via a transmit coil and measures the current via a receive coil.
- The test is carried out at a high frequency to enable the transformers to be as small and practical as possible.

Individual Activity:

- *Watch the video shows on "Earthing system' and summarize key points (if facilities available)*
- *Measure the earth resistance under the guidance of your trainer*

Self-Check Quiz 3.5.1

Write the correct answer for the following:

1. What is earth resistance?
2. What is earthing system?
3. What are the methods of earthing?
4. What are the tests to be done after a wiring?

Learning Outcome 3.6 - Clean the Work Place

Same as Learning Outcome 1.6: Performing channel wiring (page 32-34)

ANSWER KEY

Answer Key 3.2.1

1. Conduits are used to protect electrical wires or cables from damage.
2. Fish wire is used to draw electrical wires or cables through conduit and wall/ceiling cavity.
3. Main tools used to cut brick wall are cold chisel and hammer.

Answer Key 3.3.1

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

Answer Key 3.4.1

1. Polarity is a term used in electricity, magnetism and electronic signalling.
2. The polarity test is done to ensure that the line and neutral conductors are connected the correct way.
3. Voltage and current are two of the most common electrical measurements taken at panels and the surrounding wiring.
4. A continuity testing is the act of testing the resistance between two points.
5. Insulation resistance measurement is based on Ohm's Law.

Answer Key 3.5.1

1. Earth resistance is the resistance of soil to the passage of electric current.
2. In an electrical installation an earthing system or grounding system connects specific parts of that installation with the Earth's conductive surface for safety and functional purposes.
3. Methods of earthing are- (a) 2-point (dead earth) method, (b) 3-point (Fall-of-potential) method, (c) 4-point method and (d) Clamp-on method.
4. After wiring the following tests to be done: polarity test, continuity test, earth continuity test, insulation test, earth resistance test and short circuit test

Module 4: Perform a service connection

MODULE CONTENT

Module Descriptor: This module covers the skills, knowledge and attitudes to perform a service connection. It specifically includes installing interpreting drawings and specifications, collecting tools, equipment and materials, measuring the distance of service line and installing cables for service connection, installing energy meter and connecting with main switch and cleaning the workplace. It also includes information sheets, job sheets, self-checking quizzes and answer keys.

Nominal Duration: 20 hours

Learning Outcomes:

Upon completion of the module, the student/trainee will be able to:

4.1 Interpret drawings and specifications
4.2 Collect tools, equipment and materials
4.3 Measure the distance of service line and install cables for service connection
4.4 Install energy meter and connect with main switch
4.5 Clean the workplace

Performance Criteria:

1. Drawing are collected and interpreted.
2. Sign and symbols are identified.
3. Terms and abbreviations are identified.
4. Specifications are interpreted.
5. Tools, equipment and materials are collected and checked for usability.
6. PPE is collected and used as per requirements.
7. Distance between distribution pole and meter are checked and measured.
8. Distance between main switch and meter are checked and measured.
9. Size of cables are selected as per load.
10. Quality cables are selected and collected for service connection.
11. Collected cables are cut and set.
12. Cables are held on and clamped properly with distribution pole.
13. Cables are joined and connected with the pole and energy meter.
14. Energy meter is collected and set on the board.
15. Energy meter is connected with service line.
16. Cables are measured and sized.
17. Cables are laid into the conduit.
18. Connection between energy meter and main switches are performed.
19. Tools and equipment are cleaned and stored as per standard practice.
20. Waste materials are disposed and workplace is cleaned in accordance with standard procedure.

Learning Outcome 4.1 - Collect and Check Tools, Equipment and Materials

Contents:

- Electrical plans/drawings
- Sign and symbols
- Terms and abbreviations
- Specifications

Assessment criteria:

1. Drawings are collected and interpreted.
2. Sign and symbols are identified.
3. Terms and abbreviations are identified
4. Specifications are interpreted.

Resources required:

Students/trainees must be provided with the following resources:

- Electrical plans/drawings
- Sign and symbols related to construction and electrical works
- Terms and abbreviations
- Specification sheets

Learning Activity 4.1.1

Learning Activity	Resources/Special Instructions/References
Collect and check tools, equipment and materials	▪ Information Sheet: 4.1.1 ▪ http://en.wikipedia.org/wiki/Electrical wiring

Information Sheet 4.1.1

Learning Objective: to interpret drawings and specifications in a workplace.

Same as Information Sheet 1.1.1 of Module 1: Performing channel wiring (page 8-11)

Learning Outcome 4.2 - Collect Tools, Equipment and Materials

Contents:

- List of hand tools and their uses/functions
- List of power tools and their uses/functions
- List of equipment and their uses/functions
- List of materials and their uses

Assessment criteria:

1. Usability of tools and equipment are checked and verified.
2. Materials are collected.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: GI wire, connector, distribution board, energy meter, main switch, cables, guy instructor, clamps, tie, hook

Learning Activity 4.2.1

Learning Activity	Resources/Special Instructions/References
Collect tools, equipment and materials	▪ Information Sheets: 4.2.1, 4.2.2 ▪ https://quizlet.com/.../tools-and-materials-used-in-electrical-installation-and-maintenan...

Information Sheet 4.2.1

Learning Objective: to identify, gather and check tools and equipment used in a workplace.

Same as Information Sheet 1.2.1 of Module 1: Performing channel wiring (page 13-15)

Information Sheet 4.2.2

Learning objective: to identify, gather and check electrical materials used in a workplace.

Same as Information Sheet 1.2.2 of Module 1: Performing channel wiring (page 15-18)

Learning Outcome 4.3 - Measure the Distance of Service Line and Install Cables for Service Connection

Contents:

- List of PPE and their uses
- Size and quality of cables
- Cutting and setting of cables
- Clamping of cables
- Cable joints and connections with pole and meter

Assessment criteria:

1. PPE is collected and used.
2. Distance between distribution pole and meter are checked and measured.
3. Distance between main switch and meter are checked and measured.
4. Size of cables are selected as per load.
5. Quality cables are selected and collected for service connection.
6. Collected cables are cut and set.
7. Cables are held on and clamped properly with distribution pole.
8. Cables are joined and connected with the pole and energy meter.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: electrical cables, clamps

Learning Activity 4.3.1

Learning Activity	Resources/Special Instructions/References
Measure the distance of service line and install cables for service connection	▪ Information Sheets: 4.3.1, 4.3.2 ▪ Self-Check Quiz: 4.3.2 ▪ Answer Key: 4.3.2 ▪ https://www.fpl.com/partner/pdf/electric-service-standards-meter-connections.pdf

	▪ https://www.quora.com/What-are-the-different-types-of-wire-joints

Information Sheet 4.3.1

Learning Objective: identify the personal protective equipment used in a workplace.

Same as Information Sheet 1.3.1 of Module 1: Performing channel wiring (page 19-21)

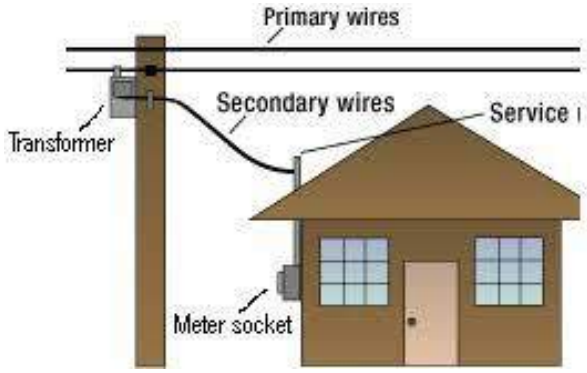
Information Sheet 4.3.2

Learning Objective: identify the service line and install cables for a service line in a workplace.

- **Power line:**
  - Power lines and equipment inside your property boundary are known as service lines or mains and are generally owned by the consumer.

- **Transmission and distribution lines:**
  - Transmission lines are higher off the ground and carry higher voltage than distribution lines while distribution lines can be a lower voltage.
  - Transmission lines run between substations and distribution lines run from the substation to the end-user location.
  - Transformers are always connected with the distribution lines.

- **Distribution pole:**
  - Distribution poles are to be used, depending on the importance of load, location and place, cost effect of such construction, including maintenance cost.
  - There are different types of poles used in the electrical system which are made of wooden, steel, concrete and sometimes composite.
  - In electric power distribution, a service drop is an overhead electrical line running from a utility pole, to a customer's building or other premises.

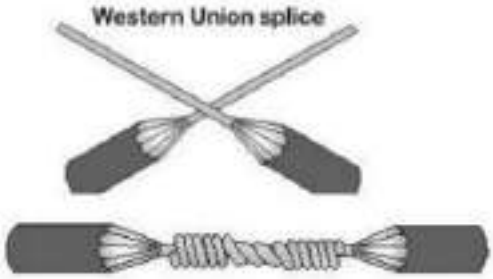


- **Cable jointing methods:**

A. Western union splices joint: This is a straight joint used for small solid cables.

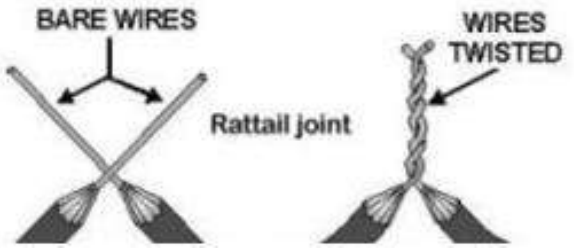
- Remove the insulation
- Bring the two conductors to a crossed position and then make a long bend or twist in each wire.
- Wrap the end of one of the wires around the straight portion of the other wire and then do the same for the other wire. Repeat this for about four or five times.
- Press ends of the wires down close to the straight portions of the wire to prevent the ends from piecing through the insulation tape.

- Insulate the joint using the tape.



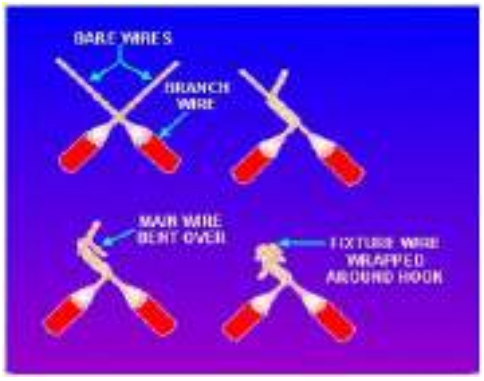
B. Rattail joint: The rattail joint is usually used in the junction boxes. It allows the connection of branch or multiple circuits in buildings. To create the joint, follow the steps**:**

- Strip the insulation off the ends of the cable to be joined
- Twist the wires to create the rattail effect.



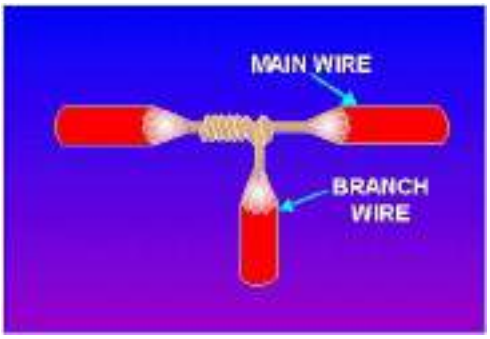
C. Fixture joint: This is a type of branch joint connecting a small-diameter wire to the large diameter conductor, such as those used in lighting fixtures.

- Remove the insulation
- Wrap the fixture wire around the branch wire
- Bend the branch wire over the completed turns
- Wrap the remaining fixture wire over the bent branch wire
- This can be followed by soldering and taping, or simply taping of the joint.



D. Knotted tap joint: The knotted tap joint is used to for branch joints to connect a branch wire to a continuous wire.

- Remove about 1 inch of insulation from the main wire and about 3 inches from the branch wire.
- Place the branch wire behind the main wire so that three-fourths of its bare wire extends above the main wire.
- Bring the branch wire over the main wire, around itself, and finally over the main wire so that it forms a knot. Wrap the wire around the main conductor in short, tight turns and trim its end.



E. Joints using wire nut and split bolt: The wire nut replaces the rattail joint splice. The nut is usually housed in a plastic insulating casing. To make a joint,

- Strip the conductors
- Place the two to be joined into the wire nut
- Twist the nut.

Split bolt connector:

- The split bolt is mainly used to joint large conductors.
- This replaces the knotted tap joint and can be used to join three ends or join a branch wire to a continuous conductor.
- The bare wires are placed through the space between the two bolts, after which the nut is tightened to ensure a sound joint.

Individual Activity:

- *Watch the video shows on 'How to connect service line' from online and summarize key points (if facilities available)*
- *Practice the cable jointing methods for your jobs*

Self-Check Quiz 4.3.2

Check your understanding by answering the following questions.

1. What are types of poles used in electrical system?
2. What are the methods of cable jointing?
3. Where the transformers are connected?
4. What is called service drop?
5. In junction boxes which joint is usually used?

Learning Outcome 4.4 - Install Energy Meter and Connect with Main Switch

Contents:

- Setting of energy meter
- Connection of energy meter

Assessment criteria:

1. Energy meter is collected and set on the board.
2. Energy meter is connected with service line.
3. Cables are measured and sized.
4. Cables are laid into the conduit.
5. Connection between energy meter and main switches are performed.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, energy meters, electrical plans/drawings
- Materials: energy meter, main switch, cables

Learning Activity 4.4.1

Learning Activity	Resources/Special Instructions/References
Install energy meter and connect with main switch	▪ Information Sheet: 4.4.1 ▪ Self-Check Quiz: 4.4.1 ▪ Answer Key: 4.4.1 ▪ https://www.youtube.com/watch?v=7gdQoImH8QU

Information Sheet 4.4.1

Learning Objective: to identify and install energy meter and connect with main switch in a workplace.

- **Energy meter:** is an instrument which measures amount of electrical energy used by the consumers.
- **Unit of energy:**
  - 1 Joule (J) is the MKS unit of energy, equal to the force of one Newton acting through one meter.
  - 1 Watt is the power from a current of 1 Ampere flowing through 1 Volt.
  - 1 kilowatt-hour is the energy of one kilowatt power flowing for one hour.

- **Types of energy meters:**

1. Electromechanical Energy Meters: The electromechanical induction meter operates by counting the revolutions of a non-magnetic, but electrically conductive, metal disc which is made to rotate at a speed proportional to the power passing through the meter. The number of revolutions is thus proportional to the energy usage.	
2. Electronic Energy Meters: Electronic meters display the energy used on an LCD or LED display and some can also transmit readings to remote places. In addition to measuring energy used, electronic meters can also record other parameters of the load and supply such as instantaneous and maximum rate of usage demands, voltages, power factor and reactive power used etc.	
3. Smart Energy Meters: These are capable of communicating in both directions. They can transmit the data to the utilities like energy consumption, parameter values, alarms etc. and also can receive information from utilities such as automatic meter reading system, reconnect/disconnect instructions, upgrading of meter software's and other important messages. Advantage of smart metering is complete avoidance of tampering of energy meter where there is scope of using power in an illegal way.	

- **How to install a new energy meter?**
  - The energy meter shall be located in places readily accessible to authorized organization representatives for installation, maintenance, reading or removal.
  - To complete the task, you should follow the steps given below:
    1. Collect all necessary tools, equipment and accessories to install an energy meter.
    2. Identify and select usable tools & equipment to install an energy meter.
    3. Collect an energy meter from the house owner for installation.
    4. Install the energy meter in accordance with standard requirements.
    5. Check the installation and test continuity using appropriate tools & equipment.
    6. While working you should use personal protective equipment for safety.
    7. Clean the workplace and restore the tools, equipment and excess materials.

- **Main switch:** is an intermediate installation in the power distribution circuit connecting the power generators and power consumers.
  - Main switch allows to disconnect all electricity coming into the home.
  - Main switch is a central cut-off switch that controls the smaller cut-off switches and machines of a building.

- Main switch can be cut off by a human or a computerized system to control the flow of power in the building.

How to install and connect main switch?

- The main switch shall be located in places readily accessible to power users or consumers for installation, operation and maintenance.
- To complete the task, you should follow the steps given below:
  1. Collect all necessary tools, equipment and accessories to install and connect main switch.
  2. Identify and select usable tools & equipment to install and connect main switch.
  3. Collect a main switch from the house owner for installation and connection.
  4. Install and connect main switch in accordance with standard requirements.
  5. Check the installation and test continuity using appropriate tools & equipment.
  6. While working you should use personal protective equipment for safety.
  7. Clean the workplace and restore the tools, equipment and excess materials.

Individual Activity:

- *Watch video shows on "Meter and Main switch connection" and summarize key points (if facilities available)*
- *Install an energy meter and connect main switch as per standard requirements*

Self-Check Quiz 4.4.1

Fill in the blanks with the correct answer.

1. _____ is an instrument which measures amount of electrical energy used by the consumers.
2. In MKS unit of energy is _____.
3. _____ is the power from a current of 1 ampere flowing through 1 volt.
4. _____ is the energy of one kilowatt power flowing for one hour.
5. The _____ allows to disconnect all electricity coming into the home.

Learning Outcome 4.5 - Clean the Workplace

Same as Learning Outcome 1.6: Performing channel wiring (page 32-34)

ANSWER KEY

Answer Key 4.3.2

1. There are different types of poles used in the electrical system which are made of wooden, steel, concrete and sometimes composite.
2. Following are the common methods of cable jointing:
   - Western union splices joint
   - Rattail joint
   - Fixture joint
   - Knotted tap joint
   - Joints using wire nut and split bolt.
3. Transformers are always connected with the distribution lines.
4. A service drop is an overhead electrical line running from a utility pole to a customer's building or other premises.
5. The rattail joint is usually used in the junction boxes.

Answer Key 4.4.1

1. Energy meter
2. Joule
3. Watt
4. Kilowatt-hour
5. Main switch

Module 5: Perform motor connection

MODULE CONTENT

Module Descriptor: This module covers the skills, knowledge and attitudes to perform motor connection. It specifically includes identifying and selecting controlling and protective devices for motor connection, collecting tools, equipment and materials, Installing, controlling and protective devices, performing motor connection, checking and testing circuit and cleaning the workplace. It also includes information sheets, job sheets, self-checking quizzes and answer keys.

Nominal Duration: 30 hours

Learning Outcomes:

Upon completion of the module, the student/trainee will be able to:

5.1 Identify and select controlling and protective devices for motor connection
5.2 Collect tools, equipment and materials
5.3 Install, controlling and protective devices
5.4 Perform motor connection, check and test circuit
5.5 Clean the workplace

Performance Criteria:

1. Manuals and documents of controlling and protective devices are collected.
2. Drawings and symbols of controlling and protective devices are sorted.
3. Types of controlling and protective devices are listed.
4. Tools, equipment and materials are identified, collected and checked for usability.
5. PPE is collected and used as per requirements.
6. Controlling and protective devices are selected and collected according to the need of the operations.
7. Controlling and protective devices are installed according to the layout plan.
8. Controlling and protective devices are set and connected to the motor.
9. Direct on-line starter is collected and its diagram interpreted.
10. Direct on-line starter is connected with the motor.
11. Star-delta starter is collected and its diagram interpreted.
12. Star-delta starter is connected with the motor.
13. Auto- transformer starter is collected and its diagram interpreted.
14. Auto-transformer starter is connected with motor.
15. All the connections of each starter are checked and justified.
16. Connection between motor and starter is checked and tested.
17. Tools and equipment are cleaned and stored as per standard practice.
18. Waste materials are disposed and workplace is cleaned in accordance with standard procedure.

Learning Outcome 5.1 - Identify and Select Controlling and Protective Devices for Motor Connection

Contents:

- Manuals and documents
- Drawings and symbols
- Symbols

Assessment criteria:

1. Manuals and documents of controlling and protective devices are collected.
2. Drawings and symbols of controlling and protective devices are sorted.
3. Types of controlling and protective devices are listed.

Resources required:

Students/trainees must be provided with the following resources:

- Manuals and documents related to controlling and protective devices
- Electrical plans/drawings
- Sign and symbols related to construction and electrical works
- Controlling and protective devices

Learning Activity 5.1.1

Learning Activity	Resources/Special Instructions/References
Identify and select controlling and protective devices for motor connection	▪ Information Sheets: 5.1.1, 5.1.2 ▪ Self-Check Quizzes: 5.1.1, 5.1.2 ▪ Answer Keys: 5.1.1, 5.1.2 ▪ http://www.businessdictionary.com/definition/technical-manual.html ▪ https://en.wikipedia.org/wiki/Motor_controller

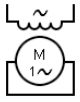
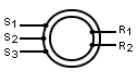
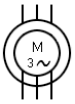
Information Sheet 5.1.1

Learning Objective: identify and select controlling and protective devices for motor connection in a workplace.

- **Manuals and documents:**
  - A user guide or user's guide also commonly known as a manual.
  - It is a technical communication document intended to give assistance to people using a particular system and the document contain instructions for installation, operation, use, maintenance, parts list, support and training requirements for the effective deployment of an equipment, machine, process or system.
  - Manuals are comprehensive and step-by-step guide to a particular topic for both beginners and practitioners that also serves as a reference book.
  - All electrical systems require periodic maintenance in addition to non-scheduled maintenance caused by unpredictable events such as storms, accidents, and equipment failure.
  - The intent of periodic maintenance is to keep the system operating at an acceptable level of service to the public.
  - A typical quality manual will include the company's quality policy and goals as well as a detailed description of its quality control system that might include staff roles and relationships, procedures, systems and any other resources that relate to producing high quality goods or services.
  - An instruction manual is a booklet that instructs the users on how to operate or install is usually included as part of a video game package. Manuals can be large or small, such as the single sheet of paper.

- **Starter symbol:**
  - A Starter is a device that controls the use of electrical power to equipment, usually a motor.
  - As the name implies, starters 'start' motors.
  - Starter can also stop, reverse and protect the motor.
  - Starters are made from two building blocks: Contactors and Overload Protection.

- **Motor symbols:**

Serie winding	Shunt winding	 Electric motor generic symbol	 2-speed symbol
 Electric motor with terminals	 Linear motor	 Induction motor	 Repulsion motor
 Single phase synchronous motor	 Synchro with wound rotor	 3-phase electric motor	 3-phase motor with wound rotor

Did you know?

- *A Manuals can be large or small, such as the single sheet of paper*
- *A Starter can stop, reverse and protect the motor*
- *Function of an electric motor **i**s to transform electrical energy into mechanical energy through electromagnetic interactions*

Self-Check Quiz 5.1.1

Write the correct answer for the following questions:

1. What is manual?
2. What is starter?
3. What are the uses of electrical symbols?

Information Sheet 5.1.2

Learning Objective: to identify and select controlling and protective devices for motor connection in a workplace.

A. Controlling devices:

- A motor controller is a device that serves to govern in some predetermined manner the performance of an electric motor.
- Motor control devices can be classified as Primary control devices and Pilot control devices.
- Primary motor control device is one which connects to or disconnects the motors or loads from the line.
- Pilot control devices control the primary control devices and do not control the load directly.

Switches:

- A switch is an electrical components that can 'make' or 'break' an electrical circuit, interrupting the current or diverting it from one conductor to another.
- The mechanism of a switch removes or restores the conducting path in a circuit when it is operated.

Push-button switch:

- The most common type is a 'push-to-make' switch, which makes contact when the button is pressed and breaks when the button is released.
- A 'push-to-break' switch, breaks contact when the button is pressed and makes contact when it is released.

Rotary switch:

- A rotary switch operates with a twisting motion of the operating handle with at least two positions.
- One or more positions of the switch may be momentary, requiring the operator to hold the switch in the position.

- **Toggle switch:**
  - A toggle switch is a class of electrical switches that are manually actuated by a mechanical lever.

- **Knife switch:**
  - Knife switches consist of a flat metal blade, hinged at one end with an insulating handle for operation and a fixed contact.
  - When the switch is closed, current flows through the hinged pivot and blade and through the fixed contact.
  - Such switches are usually not enclosed and since the electrical contacts are exposed, the switch is used only where people cannot accidentally come in contact with the switch or where the voltage is so low as to not present a hazard.

- **Foot switch:**
  - A foot switch is a rugged switch which is operated by foot pressure.
  - An example of use is in the control of a machine tool, allowing the operator to have both hands free to manipulate the workpiece.

- **Light switches**:
  - In building wiring, light switches are installed at convenient locations to control lighting and occasionally other circuits.

- **Direct on-line starter:**
  - A direct on line (DOL) starter applies the full line voltage to the motor terminals, the starters or cubicle locations, can usually be found on an electrical layout drawing.
  - A DOL motor starter also contains protection devices and, in some cases, condition monitoring.
  - Direct on-line motor starter consists a MCCB or circuit breaker, contactor and an overload relay for protection.

- **MCCB:**
  - MCCB is most suited in providing energy for high-power equipment.
  - Based on the number of poles, the breakers are classified as - Single Pole (SP), Single Pole and Neutral (SPN), Double pole (DP), Triple Pole (TP), Triple Pole and Neutral (TPN) and Four Pole (FP).
  - SP breaker is used with a typical 120v circuit, having one hot wire and one neutral wire.
  - DP breaker is used with a typical 220v circuit having two hot wires.

- **Earth-leakage circuit breaker (ELCB):**
  - ELCB is used in electrical installations with high earth impedance to prevent shock.
  - It detects small stray voltages on the metal enclosures of electrical equipment and interrupts the circuit if a dangerous voltage is detected.
  - The main purpose of *E*CLB is to stop damage to humans & animals due to electric shock.

- **Change over switches:**
  - A changeover switch, switches a house's electricity supply from the general grid power supply to a 'generator system' in case of power outage.
  - The changeover switch connects to the main power grid, generator or alternate source and the house wiring.
  - When you switch or 'changeover' all the power on that circuit changes from either Grid or Generator (not allowing it to flow back into each other).

B. Protective devices:

- Protection devices are installed with the aims of protection of assets and ensure continued supply of energy.
- Switchgear is a combination of electrical disconnect switches, fuses or circuit breakers used to control, protect and isolate electrical equipment.
- Switches are safe to open under normal load current, while protective devices are safe to open under fault current.

Circuit breaker:

- This is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overcurrent, typically resulting from an overload or short circuit.
- Its basic function is to interrupt current flow after a fault is detected.
- Unlike a fuse, which operates once and then must be replaced, a circuit breaker can be reset to resume normal operation.

Types of circuit breaker:

According to the voltage level:

- High voltage circuit breaker.
- Medium voltage circuit breaker.
- Low voltage circuit breaker.

According to the operating mechanism:

- Spring operated circuit breaker.
- Pneumatic circuit breaker.
- Hydraulic circuit breaker.

According to the service-

- Outdoor circuit breaker
- Indoor circuit breaker.

According to their arc quenching media:

- Oil circuit breaker.
- Air circuit breaker.
- SF_6 circuit breaker.
- Vacuum circuit breaker.

Relays:

- Relay is an electrically operated switch that open and close circuits electromechanically or electronically.
- Relays control one electrical circuit by opening and closing contacts in another circuit.
- Relays are used where it is necessary to control a circuit by a separate low-power signal or where several circuits must be controlled by one signal.
- Relays can be classified on the basis of their function into five broad categories which are:
  i. Protection Relays
  ii. Regulating Relays
  iii. Reclosing Relays
  iv. Monitoring relays
  v. Auxiliary Relays.

Starter:

- A starter turns an electric motor or motor controlled electrical equipment on or off, while providing overload protection.
- Starters represent another evolution in motor control applications.
- The two main types of starters are Manual Starters and AC Magnetic Motor Starters, commonly known as motor starters.
- Manual Starter: is operated manually to start or stop the connected electrical equipment.
- Magnetic starter: is an electromagnetically operated, provide under-voltage and overload protection and an automatic cut off in the event of a power failure.
- Auto starter: is a radio-controlled device, which is installed in a vehicle to start the vehicle automatically for a predetermined time.
- Star-delta starter: is a very common type of starter, used extensively as compared to the other type of starting methods of the induction motor. A star delta is used for a cage motor designed to run

normally on the delta connected stator winding. In a squirrel cage induction motor, the starter is used only to decrease the input voltage to the motor so as to decrease the starting current.

Just checking:

- *What is the difference between controlling and protective devices used for electric motor?*
- *Is a changeover switch allowing electricity to flow back into grid or generator?*

Self-Check Quiz 5.1.2

Read the statement carefully and state whether it is True or False.

1. In electrical engineering, a switch can ‘make’ or ‘break’ an electrical circuit, interrupting the current or diverting it from one conductor to another.
2. The interior lamp of a household refrigerator is controlled by a toggle switch that is held open when the door is closed.
3. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by more than one signal.
4. A starter turns an electric motor or motor controlled electrical equipment on or off, while providing overload protection.
5. The Star Delta Starter is a very common type of starter and is used extensively as compared to the other type of starting methods of the induction motor.

Learning Outcome 5.2 - Collect Tools, Equipment and Materials

Contents:

- List of hand tools and their uses/functions
- List of power tools and their uses/functions
- List of equipment and their uses/functions
- List of materials and their uses
- List of PPE and their uses

Assessment criteria:

1. Tools, equipment and materials are identified and collected.
2. Tools, Equipment and Materials are checked for usability.
3. PPE is collected and used.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, nail gun, soldering iron, megger, multimeter, ammeter, volt meter, tachometer, wattmeter, electrical plans/drawings
- Materials: GI wire, connector, distribution board, motor, main switch, starter, cables, conduit, saddle, rowel plug, wooden screw, insulating tape

Learning Activity 5.2.1

Learning Activity	Resources/Special Instructions/References
Collect tools, equipment and materials	▪ Information Sheets: 5.2.1, 5.2.2, 5.2.3

Information Sheet 5.2.1

Learning Objective: to identify, gather and check tools and equipment used in a workplace.

Same as Information Sheet 1.2.1 of Module 1: Performing channel wiring (page 13-15)

Information Sheet 5.2.2

Learning Objective: to identify, gather and check electrical materials used in a workplace.

Same as Information Sheet 1.2.2 of Module 1: Performing channel wiring (page 15-18)

Information Sheet 5.2.3

Learning Objective: to identify the personal protective equipment used in a workplace.

Same as Information Sheet 1.3.1 of Module 1: Performing channel wiring (page 19-21)

Learning Outcome 5.3 - Install Controlling and Protective Devices

Contents:

- Types of controlling devices
- Protective devices

Assessment criteria:

1. Controlling and protective devices are selected and collected according to the need of the operations.
2. Controlling and protective devices are installed according to the layout plan.
3. Controlling and protective devices are set and connected to the motor.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: switches, direct online starter, MCCB, ELCB, change over switches, main switches, circuit breaker, relays, magnetic starter, auto starter, star-delta starter

Learning Activity 5.3.1

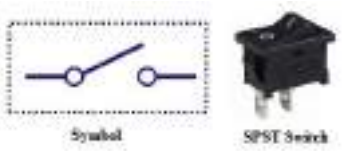
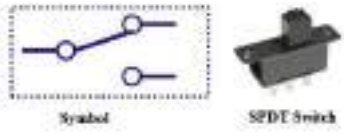
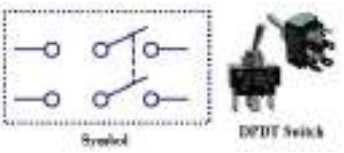
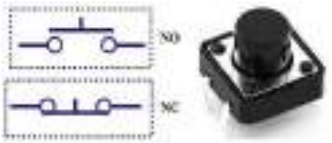
Learning Activity	Resources/Special Instructions/References
Install controlling and protective devices	▪ Information Sheets: 5.3.1, 5.3.2 ▪ Self-Check Quizzes: 5.3.1, 5.3.2 ▪ Answer Keys: 5.3.1, 5.3.2 ▪ https://www.schneider-electric.hu/...and.../asg-4-motor-starting-and-protection.pdf

Information Sheet 5.3.1

Learning Objective: to identify and install controlling devices in a workplace.

- **Controlling devices:** are used to turn ON or OFF current flow in an electrical circuit. Control devices include a variety of switches, relays and solenoids.

- **Different types of Switches:**

1. Single Pole Single Throw Switch (SPST): ▪ This is the basic ON and OFF switch consisting of one input contact and one output contact. ▪ It switches a single circuit and it can either make ON or break OFF the load. ▪ The contacts of SPST can be either normally open or normally closed configurations.	
2. Single Pole Double Throw Switch (SPDT): ▪ This switch has three terminals, one is input contact and remaining two are output contacts. ▪ Consists of two ON positions and one OFF position. ▪ Used as changeover to connect the input between two choices of outputs.	
3. Double Pole Single Throw Switch (DPST): ▪ Consists of four terminals, two input contacts and two output contacts. ▪ Behaves like a two separate SPST configurations, operating at the same time. ▪ It has only one ON position, but it can actuate the two contacts simultaneously, such that each input contact will be connected to its corresponding output contact.	
4. Double Pole Double Throw Switch (DPDT): ▪ Dual ON/OFF switch consisting of two ON positions. ▪ Six terminals, two are input contacts and remaining four are the output contacts. ▪ Behaves like a two separate SPDT configuration, operating at the same time.	
5. Push Button Switch: ▪ Momentary contact switch that makes or breaks connection as long as pressure is applied. ▪ Internal spring mechanism operates two states of a push button. ▪ Classified into normally open, normally closed and double acting.	
6. Toggle Switch: ▪ Commonly used as light control switches. ▪ Used for switching high currents and can also be used for switching small currents. ▪ Available in different ratings, sizes and styles and are used for different type of applications.	
7. Limit Switch: ▪ Operated by presence or absence of objects or by the motion of machine instead of human hand operation. ▪ Consist of a bumper type of arm actuated by an object.	
8. Float Switches: ▪ Used for controlling DC and AC motor pumps according to the liquid or water in a tank or sump. ▪ Operated when the float moves downward or upward based on water level in a tank.	

9. Flow Switches: ▪ Used to detect the movement of liquid or air flow through a pipe. ▪ The air flow switch is constructed by a snap-action. ▪ Liquid flow switches are designed with a paddle that inserted across the flow of liquid in a pipe.	
10. Pressure Switches: ▪ Used in industrial applications in order to sense the pressure of hydraulic systems and pneumatic devices. ▪ Depends on the range of pressure to be measured. ▪ These switches may be either normally open or normally closed type configurations.	
11. Temperature Switches: ▪ The most common heat sensing element is the bimetallic strip that operates on the principle of thermal expansion. ▪ The switch contacts are operated when the temperature causes the strip to bend or wrap.	
12. Rotary Switches: ▪ Used for connecting one line to one of many lines. ▪ Examples are range selectors in electrical metering equipment, channel selectors in communication devices and band selectors in multi-band radios.	

Self-Check Quiz 5.3.1

Write the correct answer for the following questions:

1. State the function of a switch.
2. Write the full name of SPST.
3. What is stands for MCCB?
4. State the mechanism of a toggle switch.
5. What is the main purpose of an earth leakage circuit breaker (ELCB)?

Information Sheet 5.3.2

Learning Objective: to identify and install protective devices in a workplace.

Same as Information Sheet 5.1.2 of Module 5: Perform motor connection (page 95-99)

Self-Check Quiz 5.3.2

Write the correct answer for the following questions:

1. What is the difference between switches and protective devices considering safety measure?
2. What are the types of circuit breakers according to voltage level?

3. Classify relays on the basis of their functions.
4. How does a starter work?
5. What is Star Delta Starter?

Learning Outcome 5.4 - Perform Motor Connection, Check and Test Circuit

Contents:

- Types of starter with their uses
- Check and test circuit

Assessment criteria:

1. Direct on-line starter is collected and its diagram interpreted.
2. Direct on-line starter is connected with the motor.
3. Star-delta starter is collected and its diagram interpreted.
4. Star-delta starter is connected with the motor.
5. Auto- transformer starter is collected and its diagram interpreted.
6. Auto-transformer starter is connected with motor.
7. All the connections of each starter are checked and justified.
8. Connection between motor and starter is checked and tested.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, energy meter, electrical plans/drawings
- Materials: main switch, cables, starter

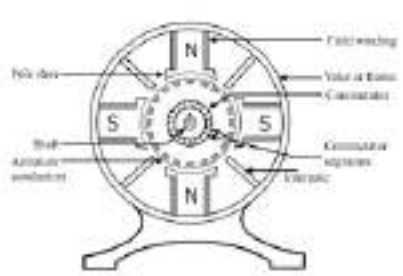
Learning Activity 5.4.1

Learning Activity	Resources/Special Instructions/References
Perform motor connection, check and test circuit	▪ Information Sheet: 5.4.1 ▪ Self-Check Quiz: 5.4.1 ▪ Answer Key: 5.4.1 ▪ https://www.testandmeasurementtips.com › New Articles

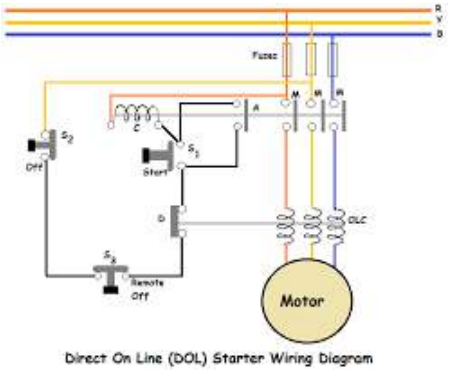
Information Sheet 5.4.1

Learning Objective: to identify and perform motor connection, check and test circuit in a workplace.

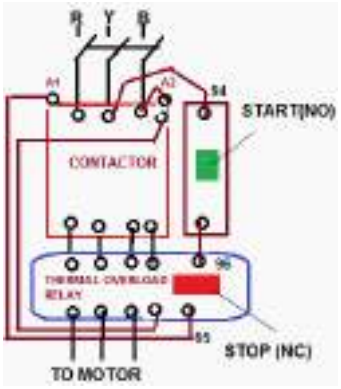
- **Motor:**
  - An electric motor is an electrical machine that converts electrical energy into mechanical energy.
  - The reverse of this is the conversion of mechanical energy into electrical energy and is done by an electric generator, which has much in common with a motor.
  - Most electric motors operate through the interaction between an electric motor's magnetic field and winding currents to generate force.
  - The universal electric motor can operate on AC or DC power.



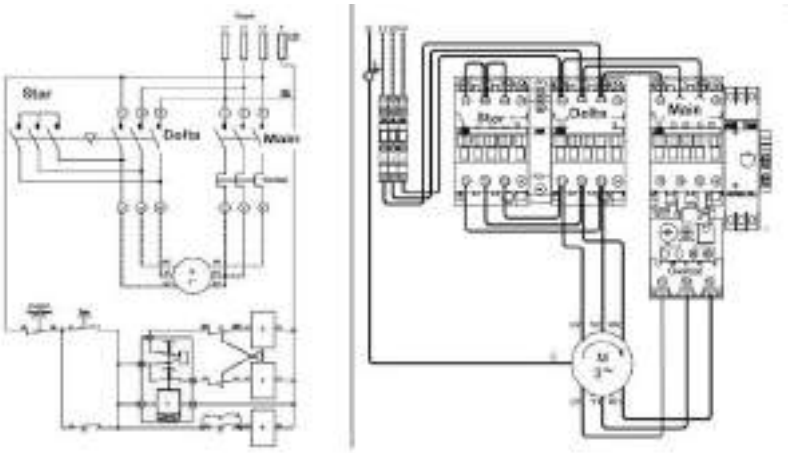
- **Direct on-line starter:**
  - A direct on-line starter applies the full line voltage to the motor terminals, the starters or cubicle locations, can usually be found on an electrical layout drawing.
  - Contains protection devices and in some cases, condition monitoring.
  - Consists a MCCB or circuit breaker, contactor and an overload relay for protection.
  - Electromagnetic contactor which can be opened by the thermal overload relay under fault conditions.



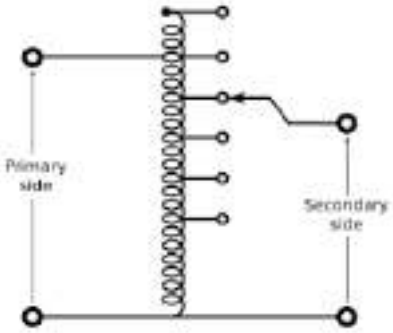
Direct On Line (DOL) Starter Wiring Diagram

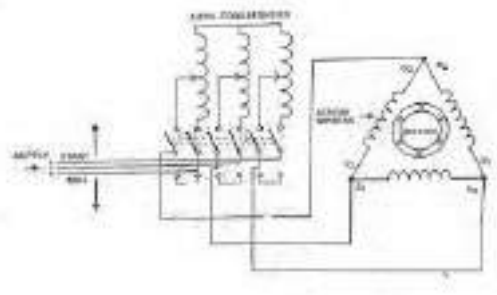


- **Star-delta starter:**
  - Star and Delta means here two separate states of motor running, first Star connection and then Delta connection.
  - Used only to decrease the input voltage to the motor so as to decrease the starting current.
  - It is T.P.D.T switch used to first start the motor with the winding connected in star and then switch for delta connection in running position.



- **Auto-transformer starter:**
  - Suitable for both star and delta connected motors.
  - In this method, the starting current is limited by using a three-phase auto transformer to reduce the initial stator applied voltage.





JOB SHEET 4			
Qualification:	Electrical Installation and Maintenance		
Learning unit:	Install controlling and protective devices and perform motor connection		
Learner name:			
Personal protective equipment (PPE):	Hand gloves, apron, safety goggles, safety shoes, helmet and dust mask		
Materials:	GI wire, connector, distribution board, motor, main switch, starter, cables, conduit, saddle, rowel plug, wooden screw, insulating tape		
Tools and equipment:	Measuring tape, thread ball, ball peen hammer, hacksaw, wire stripper, drill bits, files, pliers, screw drivers, wire cutter, poker, electrician knife, electric drill machine. Megger, multi meter/AVO meter, ammeter (AC/DC), volt meter (AC/DC), tachometer, wattmeter.		
Performance criteria:	1. PPE is collected and used. 2. Controlling and protective devices are selected and installed according to need of the operations. 3. Starters are connected with motor as per standard requirements. 4. All connections are checked and justified.		
Measurement:	▪ Measurement to be taken physically and/or from electrical drawing ▪ Carefully take the measurement of channel/conduit and cables.		
Notes:	▪ Ensure the connections are properly made following the manuals.		
Procedure:	1. Collect PPE, all necessary tools, equipment and materials/accessories. 2. Identify and select usable tools & equipment. 3. Collect controlling & protective devices and wire/cable as per electrical drawing. 4. Prepare all sorts of materials & accessories and controlling & protective devices. 5. Install/set controlling and protective devices. 6. Connect starters with the motor. 7. Check and justify all connections as per diagram and test. 8. While working you should use personal protective equipment for safety. 9. Clean the workplace and restore the tools, equipment and excess materials.		
Learner signature:		**Date:**	
Assessor signature:		**Date:**	
Quality Assurer signature:		**Date:**	
Assessor remarks:			
Feedback:			

Individual Activity:

- *Watch the video shows on "DOL starter, Star-Delta starter and Auto-Transfer starter connection in motor' and summarize key points (if facilities available)*
- *Install controlling and protective devices and perform motor connection works following Job Sheet 4 (see above)*

Self-Check Quiz 5.4.1

Fill in the blanks with the correct answer.

1. An _____ is an electrical machine that converts electrical energy into mechanical energy.
2. A _____ starter is used for a cage motor designed to run normally on the delta connected stator winding.
3. _____ is generally uses in big size motor to overcome some technical limitation.
4. An _____ starter is suitable for both star and delta connected motors.

Learning Outcome 5.5 - Clean the Workplace

Same as Learning Outcome 1.6: Performing channel wiring (page 32-34)

ANSWER KEY

Answer Key 5.1.1

1. A manual is a technical communication document intended to give assistance to people using a particular system and the document contain instructions for installation, operation, use, maintenance, parts list, support and training requirements for the effective deployment of an equipment, machine, process, or system.
2. A Starter is a device that controls the use of electrical power to equipment, usually a motor.
3. Electrical symbols are used to represent various electrical and electronic devices in a schematic diagram of an electrical or electronic circuit.

Answer Key 5.1.2

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

Answer Key 5.3.1

1. In electrical engineering, a switch is used to 'make' or 'break' an electrical circuit, interrupting the current or diverting it from one conductor to another.
2. The full name of SPST is Single Pole Single Throw Switch.
3. MCCB is stands for Moulded Case Circuit Breaker.
4. A toggle switch is manually actuated (pushed up or down) by a mechanical handle, lever or rocking mechanism. These are commonly used as light control switches.
5. The main purpose of ECLB is to stop damage to humans & animals due to electric shock.

Answer Key 5.3.2

1. Switches are safe to open under normal load current, while protective devices are safe to open under fault current.
2. According to the voltage level there are three types of circuit breakers: Low voltage, Medium voltage and High voltage circuit breaker.
3. On the basis of their function Relays can be classified into five broad categories: (a) Protection Relays; (b) Regulating Relays; (c) Reclosing Relays; (d) Monitoring relays and (e) Auxiliary Relays.
4. A starter turns an electric motor or motor controlled electrical equipment on or off, while providing overload protection.
5. The Star Delta Starter is a very common type of starter and is used extensively as compared to the other type of starting methods of the induction motor.

Answer Key 5.4.1

1. Electric motor
2. Star-Delta starter
3. Star-Delta starter
4. Auto-transformer starter

Module 6: Install and maintain electric motor with control system

MODULE CONTENT

Module Descriptor: This module covers the skills, knowledge and attitudes to perform installing and maintaining electric motor with control system. It specifically includes identifying and selecting controlling devices for motors, connecting starter with the motors, monitoring and testing conditions of motor, servicing motors and maintaining tools, equipment, materials and workplace. It also includes information sheets, job sheets, self-checking quizzes and answer keys.

Nominal Duration: 40 hours

Learning Outcomes:

Upon completion of the module, the student/trainee will be able to:

6.1 Identify and select controlling devices for motors
6.2 Connect starter with the motors
6.3 Monitor and test conditions of motor
6.4 Service motors
6.5 Maintain tools, equipment, materials and workplace

Performance Criteria:

1. Manuals and documents of motors with controlling devices are collected.
2. Drawings and symbols of controlling devices are sorted.
3. Tools, equipment and materials are identified, collected and checked for usability.
4. PPE is collected and used as per requirements.
5. Necessary controlling devices for motor are selected and collected.
6. Starter is collected, its diagram is interpreted and connected with the motors.
7. Wire up control and power circuits as per job requirement.
8. Test and commission the motors as per job requirement.
9. Mechanical defects are checked visually in accordance with standard practices.
10. Electrical defects of motors are checked such as loose or burned electrical connections.
11. Motors are tested by using specified instruments.
12. Motors are tested under running conditions for detecting faults.
13. Work order for maintenance is obtained from concern section according to established procedure.
14. Motor mains is disconnected before inspection and testing in accordance with standard procedure.
15. Motor is dismantled for replacing bearings and greasing, repairing windings, varnishing, heating or any other tests if required as per standard procedures following safety precautions.
16. Service parts of the motor are cleaned by using specified cleaning agent and tools in accordance with manufacturer's specification.
17. Check winding insulation of motors with megger/insulation resistance tester if necessary in accordance with standards.
18. Motors are assembled according to the manufacturer's specification.
19. No load and load test are conducted and noted down results in accordance with specification.
20. Tools and equipment are cleaned and stored as per standard practice.
21. Waste materials are disposed and workplace is cleaned in accordance with standard procedure.

Learning Outcome 6.1- Identify and Select Controlling Devices for Motors

Contents:

- Manuals and documents
- List of hand tools and their uses/functions
- List of power tools and their uses/functions
- List of materials and their uses

Assessment criteria:

1. Manuals and documents of motors with controlling devices are collected.
2. Drawings and symbols of controlling devices are sorted.
3. Tools, Equipment and materials are collected for required job.
4. Necessary controlling devices for motor are selected and collected.

Resources required:

Students/trainees must be provided with the following resources:

- Manuals and documents
- Drawings and symbols
- Tools, equipment and materials (as required)
- Controlling devices for motor

Learning Activity 6.1.1

Learning Activity	Resources/Special Instructions/References
Identify and select controlling devices for motors	▪ Information Sheets: 6.1.1, 6.1.2, 6.1.3 ▪ https://en.wikipedia.org/wiki/Motor_controller ▪ www.electrical-online.com/electrical-tools-and-equipment/

Information Sheet 6.1.1

Learning Objective: to identify and select controlling devices for motor in a workplace.

- **Manuals and documents:**

Same as Information Sheet 5.1.1 of Module 5: Performing motor connection (page 93-95)

Information Sheet 6.1.2

Learning Objective: to identify, gather and check tools and equipment used in a workplace.

- **Tools and equipment:**

Same as Information Sheet 1.2.1 of Module 1: Performing channel wiring (page 13-15)

Information Sheet 6.1.3

Learning objective: to identify, gather and check electrical materials used in a workplace.

- **Electrical materials:**

Same as Information Sheet 5.2.1 of Module 5: Performing motor connection (page 95-99)

Learning Outcome 6.2 - Connect Starter with the Motors

Contents:

- List of PPE and their uses
- Types of starter uses

Assessment criteria:

1. PPE is collected and used.
2. Starter is collected, and its diagram is interpreted.
3. Wire up control and power circuits as per job requirement.
4. Starter is connected with the motors.
5. Test and commission the motors as per job requirement.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: starter and motor for connection

Learning Activity 6.2.1

Learning Activity	Resources/Special Instructions/References
Connect starter with the motors	▪ Information Sheets: 6.2.1, 6.2.2 ▪ Self-Check Quizzes: 6.2.2 ▪ Answer Keys: 6.2.2 ▪ https://en.wikipedia.org/wiki/Motor_starter ▪ https://www.elprocus.com/motor-starter/

Information Sheet 6.2.1

Learning objective: to identify the personal protective equipment used in a workplace.

- **Personal Protective Equipment (PPE):**

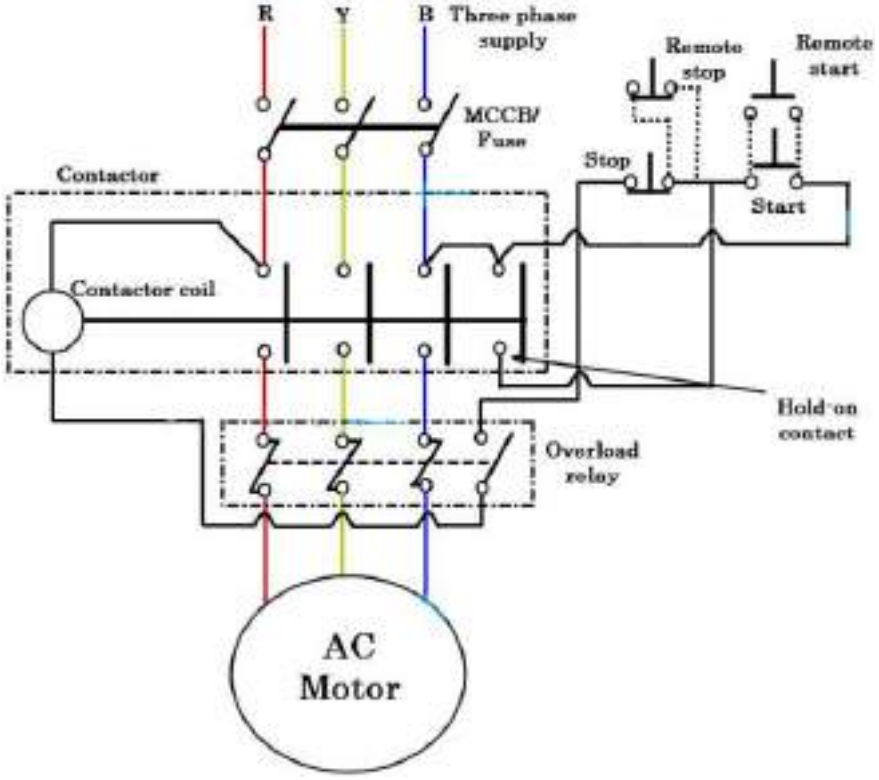
Same as Information Sheet 1.3.1 of Module 1: Performing channel wiring (page 19-21)

Information Sheet 6.2.2

Learning Objective: to identify starter and connect with motors in a workplace.

- **Starter:**
  - A starter is a device used to rotate an internal-combustion engine so as to initiate the engine's operation under its own power.
  - Starters can be electric, pneumatic or hydraulic.
  - A starter turns an electric motor or motor controlled electrical equipment on or off, while providing overload protection.

- **Direct on-line starter:**
  - The wiring connection of direct on-line starter with start and stop buttons is shown in figure below.
  - The DOL starter main terminals are connected between the mains supply terminals and motor terminals while the control circuit is energized with two terminals of three phase supply as illustrated in figure.



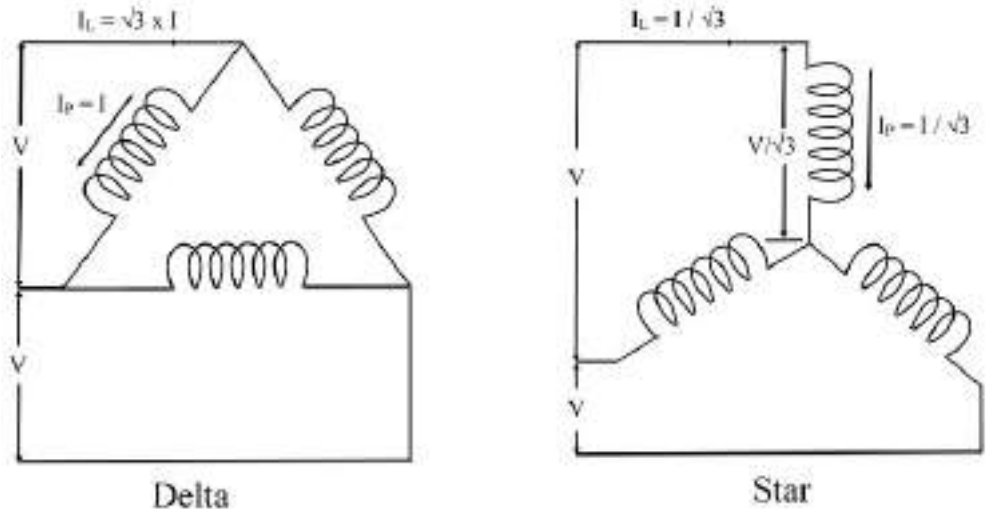
- **Advantages of DOL Starter:**
  - It provides high starting torque.
  - Simple to use and most economical.
  - Control circuitry is simple to establish and troubleshoot.
  - Easy to find fault and make necessary connections.
  - More compact in size and thus occupies less space.

- **Disadvantages of DOL Starter:**
  - High starting current, typically in the range of 6 to 8 times the full load current

- The inrush current of large motor may cause a big voltage dip or drop in electrical supply system which will affect other electrical appliances connected to it.
- The unnecessary high starting torque required by the load may cause increasing mechanical stresses on motor mechanical parts as well as the loads.
- It is not feasible for high rating motors, typically above 10 KW.

Star-delta starter:

- Star-delta starter, which is sometimes called as Y – Δ starter, is a common type of reduced voltage starter.
- Star-delta starter can reduce the starting current without the need of any external devices.
- The initial connection of the stator windings is in the form of star.
- If V_L is the Line Voltage and V_P is the phase voltage, then the voltage at each stator phase is given by $V_P = V_L / \sqrt{3}$.
- **Delta** (shown in the first image): The line voltage and phase voltage are equal in delta connection and let the voltage across the stator windings be V. If I is the phase current through the stator winding in delta connection, then line current is $I_L = \sqrt{3} \times I$.
- **Star** (shown in the second image): As V is the line voltage, the voltage across the windings in star connection is given by $V / \sqrt{3}$. As the voltage across the winding is reduced by $1 / \sqrt{3}$ times, the current flowing in each winding is also reduced by the same amount. Hence, the phase current or the current through winding becomes $I_P = I / \sqrt{3}$. Since the line current and phase current in star connection are equal, the line current $I_L = I / \sqrt{3}$.



Advantages of star-delta starter:

- Star-delta starters are widely used due to their relatively low price.
- There are no limits to the number of times they can be operated.
- The components require very little space.
- The starting current is reduced to approximately one-third.

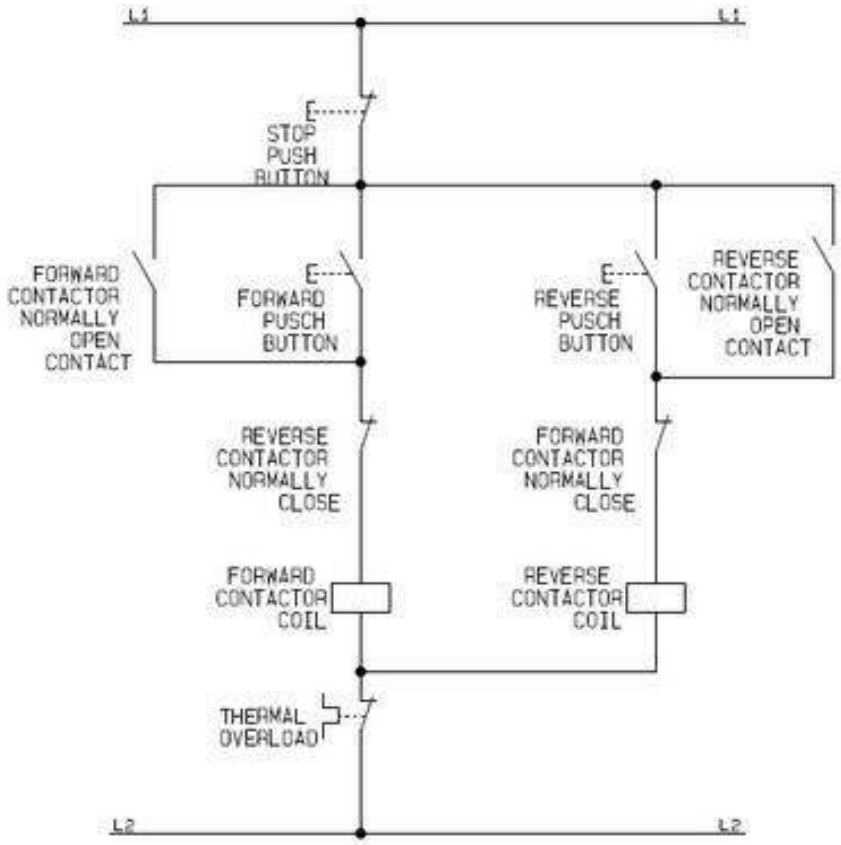
Disadvantages of star-delta starter:

- The starter can only be applied to motors where the six leads or terminals can be accessed.
- The supply voltage must be the same as the rated motor voltage for delta connection.
- If the motor does not reach at least 90% of its rated speed at the time of switching from star to delta the current peak will be as high as in a DOL start, thus causing harmful effects to the contacts of the contactors and the connection system brings no advantage to the electrical system.

Forward-reverse starter:

- The reversing starter is a special type of push button starter wherein addition to starting / stopping of motors the director of rotation of a three-phase induction motor can be done by inter changing the connection of any two terminals of the supplies which is done through two separate contactors, one for forward and other for reverse.

- The *forward* and *reverse* contactors are mechanically interlocked i.e., if one of them is closed the other cannot close.
- This is done to avoid dead short circuit in case both the contactors closing simultaneously.
- Controlling the AC induction motor's rotation either in the forward or reverse direction with the push of a button is made possible by the forward-reverse control circuit.
- The electrical diagram below illustrates the operational sequence of the forward-reverse control system specific for the command of the forward-reverse power circuit used in every electrical industry involving industrial process automation control technology.
- The forward-reverse motor control circuit consists of two DOL motor controller circuit which are connected side by side to accommodate the required forward and reverse function of the system.



Forward Reverse Motor Control Circuit

Did you know?

- *DOL starters are easy to find fault and make necessary connections*
- Y – Δ starter components require very little space
- *The forward-reverse motor control circuit consists of two DOL motor controller circuit which are connected side by side*

Self-Check Quiz 6.2.2

Write the correct answer for the following questions:

1. State the main advantage of DOL starter.
2. State the main disadvantage of DOL starter.
3. State the main advantage of Star-Delta starter.
4. State the main disadvantage of Star-Delta starter.

Learning Outcome 6.3 - Monitor and Test Conditions of Motor

Contents:

- Mechanical defects: tight bearings, bent shape, vibration, humming sound, misalignment
- Faults: tripping of protective devices, difficulty in starting, low rpm, high vibration, unusual noises, excessive heat

Assessment criteria:

1. Mechanical defects are checked visually in accordance with standard practices.
2. Electrical defects of motors are checked such as loose or burned electrical connections.
3. Motors are tested by using specified instruments.
4. Motors are tested under running conditions for detecting faults.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, electrical plans/drawings
- Materials: motor

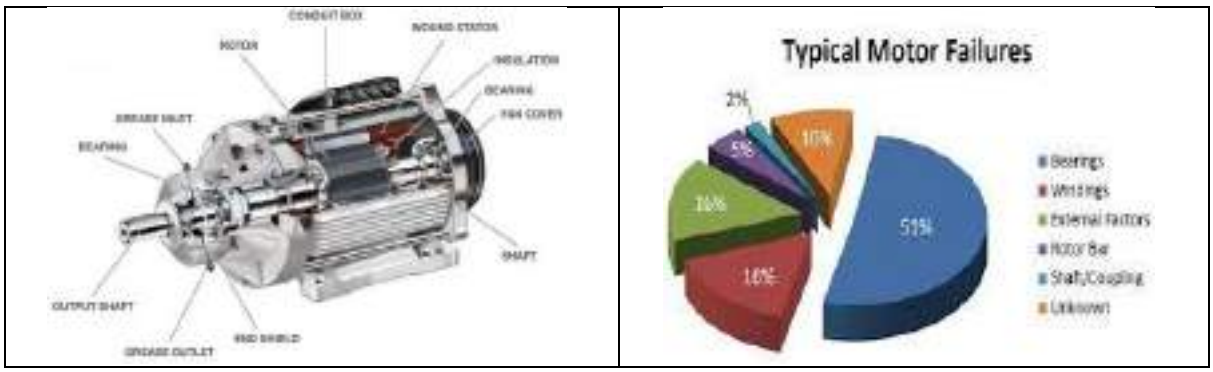
Learning Activity 6.3.1

Learning Activity	Resources/Special Instructions/References
Monitor and test conditions of motor	▪ Information Sheet: 6.3.1 ▪ Self-Check Quiz: 6.3.1 ▪ Answer Key: 6.3.1 ▪ https://irispower.com/asset/motor-monitoring/ ▪ https://www.engineerlive.com/content/common-causes-electric-motor-failure

Information Sheet 6.3.1

Learning Objective: to identify, monitor and test conditions of motor in a workplace.

- **Electric motor:**
  - Motors need to be inspected regularly and other maintenance activities need to be performed to ensure efficient operation.
  - Whenever a problem occurs, it should be corrected immediately to avoid further loss.



- **Common causes of electric motor failures:**

1. Over-Current (Overload):

- Electrical devices will sometimes start to draw more current than their overall capacity.
- This unpredictable event will happen very suddenly and will greatly impact the motor.
- To avoid an over-current, there are some devices that need to be installed that can prevent it from happening.
- These devices are usually wired in the circuits and will automatically shut down the extra amount of current flowing in the circuit.

2. Resistance:

- Most motor failures occur due to low insulation resistance.
- This issue is considered to be the most difficult one to tackle.
- In the initial stages of motor installation, the insulation resistance is observed to be more than one thousand megaohms.
- After some time, the insulation performance starts to degrade at an alarming level because the resistance starts to decay gradually.

3. **Over Heating:**

- Overheating causes the motor winding insulation to deteriorate quickly.
- For every ten-centigrade rise in temperature, the insulation life is cut in half.
- More than 55% of the insulating failures are caused by overheating.
- Overheating also occurs when an electric motor is forced to operate in a high temperature environment.
- The area where electric motors are operating must have a proper cooling system and a ventilation system should be there in case the cooling system stops working.

4. **Dirt:**
   - Dirt can damage the motor by blocking the cooling fan which causes its temperature to raise.
   - It can also affect the insulating value of the winding insulation if it settles on the motor windings.
   - Proper steps should be taken to prevent the motors from dirt.
   - Shielding devices are available which are used for this purpose.

5. **Moisture:**
   - Moisture also affects the performance of electric motors.
   - It greatly contributes in the corrosion of the motor shafts, bearings and rotors.
   - This can lead to an insulation failure also.
6. **Vibration:**
   - There are a number of possible causes of vibration, such as misalignment of the motor.
   - Corrosion of parts can also cause the motor to vibrate.
   - The alignment of the motor should be checked to eliminate this issue.

- **Motor bearing:**
  - The loose or tight bearing will cause damage of motor and sometime accident may occur.

- Too much or too little lubrication, along with the improper form of lubrication, can lead to premature wear and tear.
- All motor greases should be polyurea-based and one should always take the plug out of the bottom so that old grease can be drained properly.

Humming sound:
- A hum or other excessive *noise* can be caused by a misaligned or bent *motor* shaft.
- Noise can be created if there is a minor fault in the transmission dividing the *motor* from the driven equipment or even in the equipment itself.

Misalignment:
- Shaft misalignment will destroy bearings well before their full working life.
- Another significant cause of bearing failure is misalignment.
- The motor shaft must be directly in-line with the shaft it is driving.
- This can only be achieved using precision alignment techniques such as laser.

Faults:
- About 70% of electrical motor failures are a result of bearing faults and winding damage in the motor stator.
- Fault *protection* is accomplished with circuit breakers which have a magnetic tripping mechanism.

Tripping of protective devices:
- A thermal protection device will trip and shut down the circuit to the motor windings.
- It allows the motor to cool down and may well save from complete failure.
- Thermal protection is generally a good feature to look for when buying equipment with electrical motors.

Difficulty in starting:
- Blown Fuse
- Broken Wiring
- Corroded Control Switch Contacts
- Bad Starter Coil
- Failed Starting Capacitor.

Low Revolutions Per Minute (RPM):
- RPM is a measure of the frequency of rotation, specifically the number of rotations around a fixed axis in one minute.

Unusual noises:
- Noise indicates motor problems but ordinarily does not cause damage.
- Noise, is usually accompanied by vibration.
- Whenever noise or vibrations are found in an operating motor, the source should be quickly isolated and corrected.

Did you know?
- *Overheating causes the motor winding insulation to deteriorate quickly and more than 55% of the insulating failures are caused by overheating*
- *About 70% of electrical motor failures are a result of bearing faults and winding damage in the motor stator*

Self-Check Quiz 6.3.1

Write down the correct answer for the following questions:

1. What are the main parts of an electric motor?
2. What are the main causes of an electric motor failures?
3. What will happen if the shaft of a motor is misaligned?

Learning Outcome 6.4 - Service Motors

Contents:

- Cleaning of motor service parts
- Assembling of motor
- No load and load test of motor

Assessment criteria:

1. Work order for maintenance is obtained from concern personnel according to established procedure.
2. Motor mains is disconnected before inspection and testing in accordance with standard procedure.
3. Motor is dismantled for replacing bearings and greasing, repairing windings, varnishing, heating or any other tests if required as per standard procedures following safety precautions.
4. Service parts of the motor are cleaned by using specified cleaning agent and tools in accordance with manufacturer's specification.
5. Check winding insulation of motors with megger/insulation resistance tester if necessary in accordance with standards.
6. Motors are assembled according to the manufacturer's specification.
7. No load and load test are conducted and noted down results in accordance with specification.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: pressure cleaner, electrical plans/drawings
- Materials: cleaning agents/materials required for servicing

Activity

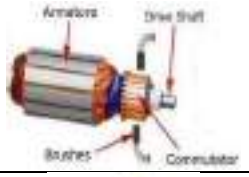
Learning Activity 6.4.1

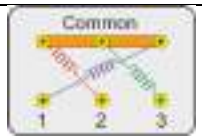
Learning Activity	Resources/Special Instructions/References
Service motors	▪ Information Sheet: 6.4.1 ▪ Self-Check Quiz: 6.4.1 ▪ Answer Key: 6.4.1 ▪ https://www.amazon.com/Electric-Motor-Maintenance-Troubleshooting.../007176395...

Information Sheet 6.4.1

Learning Objective: to identify the components of motor, inspect and test for servicing in a workplace.

- **Main components of electric motors:**

Shaft: A drive shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them.	
Winding: In the field circuit, a set of windings that produces a magnetic field so that the electromagnetic induction can take place in electric machines.	
Ball/Roller/Sleeve/Antifriction bearings: An *antifriction bearing* contains moving elements to provide a low friction support surface for rotating or sliding surfaces.	
Electromagnetic coil: The role of the *coil* is to provide inductance to an electric circuit. The most common use of an *electromagnetic coil* is that of an inductor that stores energy within its magnetic field.	
Armature: The *armature* is the coils in which a voltage is induced by a magnetic field. The rotation of the armature is caused by the interaction of two magnetic fields. One magnetic field is produced by the field winding, as the field coil is fixed in place this force causes the armature to move.	
Stator: The *stator* is a stationary part of electric motors. Energy flows through a *stator* to or from the rotating component of the system.	
Commutator: It is a rotary switch in certain types of electric motors that periodically reverses the current direction between the rotor and the external circuit.	
Brushes: The *brushes are* device which conducts current between stationary wires and moving parts, most commonly used in a rotating shaft of motor.	

Terminals: A three-phase induction *motor* have six *terminals* at the *terminal* box i.e. A1, B1, C1, A2, B2, C2.	
Case: A case or *motor case* is generally consisting of a steel or aluminium tube.	

- **Maintenance of motors:**
  - Lubrication: Lubricate regularly according to manufacturer's instructions.
  - Bearing inspection: Check bearings daily using a stethoscope or infrared scanner.
  - Rotor/stator inspection: Check air gap between the rotor and stator with feeler gages at least annually. Measurements should be made at the top, bottom and on both sides of the stator.
  - Belt inspection: Check belt tension; belts should have about 1 in. of play. Couplings should be tight, within tolerances and should operate without excessive noise.
  - Brush/commutator inspection: Inspect and check brushes for proper type, hardness, conductivity and fit in brush holders.
  - Motor mount inspection: Check mounting bolts, steel base plates for possible warping and concrete base for cracking or spalling.
  - Vibration-analysis tests: Field vibration analysis can be accomplished by using a portable instrument that identifies vibrations and displays their amplitudes and frequencies.
  - Temperature control: In high-temperature locations, consider the use of energy-efficient motors that operate cooler than standard motors.
  - Record keeping: Perform annual insulation-resistance and other appropriate tests. All values should be recorded and compared each year and keep the accurate records.

- **No load test of electric motor:**
  - *No load* and blocked rotor *tests* are performed on the *motors*.
  - As the name suggest *no load test* is performed when rotor rotates with synchronous speed and there is *no load* torque.
  - Actually, to achieve synchronous speed in an *induction motor* is impossible.
  - *No load test* is an indirect method used for determining the efficiency and also to determine the circuit parameters of the equivalent circuit of the 3-phase *induction motors*.
  - The *test* is performed at rated frequency and with balanced poly-phase voltages applied to the stator terminals.

- **Greasing of electric motor:**
  - Lock and tag out the electric motor.
  - Wipe grease from the pressure fitting, clean dirt, debris and paint around the grease relief plug.
  - Remove the grease relief plug and insert a brush into the grease relief as possible.
  - Remove the brush and wipe off any grease.
  - Allow the motor to operate for approximately 30 to 40 minutes before replacing the grease relief plug.

- **Varnishing of motor winding:**
  - *Varnishing* the *windings* of an electric *motor* or generator functions to insulate the *windings* from contaminants to make the *windings* rigid and tight and to dissipate heat.

Just checking:
- *What is a shaft?*
- *Why stator is used in electric motor?*
- *How to grease an electric motor?*

Self-Check Quiz 6.4.1

Write the correct answer for the following questions:

1. What is meant by armature?
2. What is a commutator?
3. How many terminals are there in the terminal box of a three-phase induction motor?
4. What is No Load Test?
5. What are the functions of varnishing windings of an electric motor?

Group Activity:

Field Visit:

- *Visit a potential workshop in the neighbourhood.*
- *Observe some activities there like:*
  - *What tasks are being performed?*
  - *Which tools are being used and for what purpose?*
  - *Are the workers worn adequate PPE? List out the names.*
  - *Anything more observed you may mention.*
- *Fill-up the 'Field Visit Format' given and submit to your trainer.*
- *Present the experience group wise as per instruction of your trainer.*

Learning Outcome 6.5 - Maintain Tools, Equipment, Materials and Workplace

Same as Learning Outcome 1.6: Performing channel wiring (page 32-34)

ANSWER KEY

Answer Key 6.2.2

1. The main advantages of DOL Starter that it provides high starting torque.
2. Main disadvantage of DOL is that it needs high starting current, typically in the range of 6 to 8 times the full load current.
3. The main advantages of Star-Delta starters are widely used due to their relatively low price.
4. Main disadvantage of Star-Delta starter that it can only be applied to motors where the six leads or terminals can be accessed.

Answer Key 6.3.1

1. The main parts of an electric motor are: shaft, bearing, rotor, stator, insulation, body.
2. The main causes of an electric motor failures are: over-current, low resistance, overheating, dirt, moisture, vibration.
3. Shaft misalignment will destroy bearings well before their full working life.

Answer Key 6.4.1

1. The armature of an electric motor or generator or of an electric apparatus is the coil or coils in which a voltage is induced by a magnetic field.
2. A commutator is a rotary electrical switch in certain types of electric motors and electrical generators that periodically reverses the current direction between the rotor and the external circuit.
3. There are six terminals at the terminal box of a three-phase induction motor.
4. No Load Test is an indirect method used for determining the efficiency and also to determine the circuit parameters of the equivalent circuit of the 3 phase induction motors.
5. Varnishing the windings of an electric motor or generator functions to insulate the windings from contaminants, to make the windings rigid and tight, and to dissipate heat.

Module 7: Perform motor rewinding and servicing

MODULE CONTENT

Module Descriptor: This module covers the skills, knowledge and attitudes to perform motor rewinding and servicing. It specifically includes checking the machine physically and dismantle it to detect the actual fault, selecting tools and prepare material for winding/rewinding, carrying out winding/rewinding of stator, rotor and armature, making connections, carrying out pre-assembly tests and assembling of machine, carrying out final test and recording the test result. It also includes information sheets, job sheets, self-checking quizzes and answer keys.

Nominal Duration: 55 hours

Learning Outcomes:

Upon completion of the module, the student/trainee will be able to:

7.1 Check the machine physically and dismantle it to detect the actual fault
7.2 Select tools and prepare material for winding/rewinding
7.3 Carry out winding/rewinding of stator rotor and armature
7.4 Make connections, carry out pre-assembly tests and assembly of machine
7.5 Carry out final test and record the test result

Performance Criteria:

1. Check the machine physically and dismantle it to detect the actual fault.
2. Visual and manual inspection is carried out to detect the mechanical damage/defects.
3. Burnt winding is checked by smelling.
4. The machine is dismantled as per standard procedure and manufacturer instructions.
5. Winding data is collected and winding diagram is prepared.
6. Winding is checked with specified measuring instrument to detect the fault.
7. Bearing, carbon brushes, rockers, slip rings are checked visually and tested by specified instrument.
8. Specified tools, materials and equipment are selected and used for winding work.
9. Winding wire of required gauge, insulation and binding material are prepared.
10. Formers are prepared and coil is formed on former according to winding data.
11. Stator/rotor and armature are cleaned by using specified tools.
12. Insulation material is inserted into slots.
13. Formed coil is insulated, bind and inserted into slot.
14. Winding resistance and insulation level is checked by specified test instrument.
15. Coil ends are terminated and insulated.
16. Winding continuity is checked.
17. Dry running is carried out, performance is checked.
18. Insulating varnish is applied to winding and baked it up to specified temperature in baking oven.
19. Assembly of stator, rotor and other parts are assembled.
20. Rotor free movement is checked.
21. No load/load/locked rotor tests are performed.

22. Rotor static and dynamic balancing are carried out.
23. Test result are documented in the relevant recorded sheet.
24. Tools, equipment and materials are cleaned and stored as per workplace standard.

Learning Outcome 7.1 - Check the Machine Physically and Dismantle it to Detect the Actual Fault

Contents:

- Types of machine: Single phase AC motor, DC motor, 3-Phase AC motor
- Types of measuring instrument: ammeters, voltmeters, ohmmeter, wattmeter, megger, clamp-on-AVO meter, AC and DC power supply unit
- Associated accessories: bearing, carbon brushes, rockers, slip rings

Assessment criteria:

1. Check the machine physically and dismantle it to detect the actual fault.
2. Visual and manual inspection is carried out to detect the mechanical damage/defects.
3. Burnt winding is checked by smelling.
4. The machine is dismantled as per standard procedure and manufacturer instructions.
5. Winding data is collected and winding diagram is prepared.
6. Winding is checked with specified measuring instrument to detect the fault.
7. Associated accessories faults are checked as per manufacturer data and noted down.
8. Bearing, carbon brushes, rockers, slip rings are checked visually and tested by specified instrument.
9. Fault is detected and noted down for proper repair.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Equipment: single phase AC motor, DC motor, 3-Phase AC motor, ammeters, voltmeters, ohmmeter, wattmeter, megger, clamp-on-AVO meter, AC and DC power supply unit
- Materials: bearings, carbon brushes, rockers, slip rings

Learning Activity 7.1.1

Learning Activity	Resources/Special Instructions/References
Check the machine physically and dismantle it to detect the actual fault	▪ Information Sheets: 7.1.1, 7.1.2 ▪ Self-Check Quizzes: 7.1.1, 7.1.2 ▪ Answer Keys: 7.1.1, 7.1.2 ▪ https://www.precision-elec.com/difference-between-ac-and-dc-motors/

	▪ https://www.slideshare.net/Pramodalathur/basic-electrical-measuring-instruments

Information Sheet 7.1.1

Learning Objective: to check the machine physically and dismantle it to detect the actual fault of electric motor in a workplace.

- **1-phase AC motor:**
  - Consists of two basic parts, an outside stator and an inside rotor.
  - Widely used as compared to 3-phase system for domestic purpose, commercial purpose and to some extent in industrial purpose.

- **Types of AC motor:**
  - Induction (asynchronous) motors
  - Synchronous motors.

- **Advantages of Induction Motor:**
  - Construction is simple in nature and cost is quite low.
  - Due to the absence of brushes, there are no sparks in the motor.
  - Can also be operated in hazardous conditions.
  - 3-phase induction motor has a high starting torque, good speed regulation and reasonable overload capacity.
  - Highly efficient machine with full load efficiency varying from 85 to 97 percent.

- **Disadvantages of Induction Motor:**
  - Does not have a self-starting torque.
  - Auxiliaries are required to start a single-phase motor.
  - During light load conditions, the power factor of the motor drops to a very low value.
  - Speed control of an induction motor is very difficult to attain.

- **DC motor:**
  - A DC motor's speed can be controlled over a wide range.
  - Small DC motors are used in tools, toys, and appliances.
  - Larger DC motors are used in propulsion of electric vehicles, elevator and hoists.
  - The permanent magnets are stationary, so they are called the stator.
  - The armature rotates, so it is called the rotor.

- **Difference between AC and DC motor:**
  - The basic difference is the power source:
  - AC motors are powered from AC and DC motors are powered from DC.
  - DC wound field motors are constructed with brushes and a commutator.
  - AC induction motors do not use brushes.
  - The final basic difference is speed control:
  - Speed of DC motor is controlled by varying the armature winding's current and speed of AC motor is controlled by varying the frequency.

- **3-Phase AC motor:**
  - In a 3-phase motor, the current in the stator sets up a rotating magnetic field.
  - The magnetic field rotates due to the 120° phase offset in each phase of the power supply.
  - This rotating magnetic field induces a current in the bars of the rotor.
  - The current in the rotor sets up its own magnetic field.
  - The interaction between the stator and rotor magnetic fields causes the rotor to rotate.
  - All 3-phase motors are self-starting motors.
  - 3-phase motors are more efficient than 1-phase motors.

- **Difference between 1-Phase and 3-Phase motor:**

1-Phase Supply	3-Phase Supply
▪ Power delivered is pulsating	▪ Power delivered is constant
▪ Single phase induction motors are not self-starting as it does not have starting torque	▪ Three phase induction motors are self-starting
▪ Parallel operation is not easy	▪ Parallel operation is easy
▪ Efficiency of single-phase motor is lesser	▪ High efficiency
▪ Single phase motors have pulsating torque	▪ Three phase motors have uniform torque
▪ Single phase motors have lower power factor	▪ Three phase motors have higher power factor

- **Advantages and Disadvantages of Universal Motor:**

Advantages	Disadvantages
▪ Can run from AC or DC supplies	▪ Speed control is bad or poor
▪ It is a cheap motor	▪ It is not easy to reverse the motor
▪ It has good torque at low speeds - this makes it useful in hand held power tools	▪ Brushes and commutator create sparking which can cause electromagnetic interference and may be an ignition source

Self-Check Quiz 7.1.1

Read the statements carefully and state whether they are True or False:

1. An AC motor is an electric motor driven by an alternating current (AC).
2. All AC motors have the same basic components, a stator and a rotor.
3. Single-phase induction motors are self-starting without an auxiliary stator.
4. A DC motor is an electrical machine that converts alternating current into mechanical energy.
5. 3-phases motors are not self-starting.

Information Sheet 7.1.2

Learning Objective: to identify and use the measuring instrument while performing motor rewinding and servicing in a workplace.

- **Ammeters:**
  - The function of an ammeter is to measure the AC and DC current in a circuit.
  - Measure electric current in units of amperes.
  - Must be connected in series with the path of the current being measured.
  - Setting the ammeter up in parallel will create a short circuit and will not measure the current correctly.
  - Ammeters are available in different ranges of ampere depending upon the expected magnitude of the current to be measured.

- **Types of ammeter:**
  - Moving-coil ammeter
  - Electrodynamic ammeter
  - Moving-iron ammeter
  - Hot-wire ammeter
  - Digital ammeter
  - Integrating ammeter

- **Voltmeters:**
  - Measure electrical potential difference between two points in an electric circuit.
  - Analogue voltmeters move a pointer across a scale in proportion to the voltage of the circuit; digital voltmeters give a numerical display of voltage by use of an analogue to digital converter.
  - A voltmeter is connected in parallel with a device to measure its voltage.

- **Ohmmeter:**
  - Measure electrical resistance in units of ohms.
  - Micro-ohmmeters make low resistance measurement.
  - Megohmmeters measure large values of resistance.

- **Wattmeter:**
  - Measure the electric power in watts of any given circuit.
  - Electromagnetic wattmeter is used for measurement of utility frequency and audio frequency power; other types are required for radio frequency measurements.

- **Megger:**
  - The Megger insulation tester is a small, portable instrument that gives a direct reading of insulation resistance in ohms or megaohms.
  - The device enables to measure electrical leakage in wire, results are very reliable as passing electric current through device while testing.
  - Basically, uses for verifying the electrical insulation level of any device such as motor, cable, generator winding etc.

- **Clamp-on-AVO meter:**
  - A clamp meter is basically a current-measuring tool with some voltage abilities.
  - Clamps are typically used to read the magnitude of alternating current and with additional instrumentation, the phase and waveform can also be measured.

- **AC & DC power supply unit:**
  - A power supply is an electronic circuit that converts an AC voltage to DC voltage.
  - It contains: transformer, rectifier, filter and regulator circuits.
  - These units are used in computers, amateur radio transmitters and receivers and all other electronic equipment that use DC voltage as an input.

Self-Check Quiz 7.1.2

Fill in the blanks with the correct answer.

1. An ammeter is an instrument used for measuring electric current in units of _____.
2. A _____ is an instrument used for measuring electrical potential difference between two points in an electric circuit.
3. An ohmmeter is an electrical instrument that measures_____, in units of ohms.
4. To verify the electrical insulation level of a device such as motor, cable, generator winding, _____ is used.
5. Clamp meters are typically used to read the magnitude of _____ current.

Learning Outcome 7.2 - Select Tools and Prepare Material for Winding/Rewinding

Contents:

- List of tools and their uses/functions
- List of equipment and their uses
- List of materials

Assessment criteria:

1. Technical information and winding data are collected, and winding diagram is prepared as per winding data.
2. Specified tools, materials and equipment are selected for winding work.
3. Winding wire of required gauge, insulation and binding material are prepared.
4. Formers are prepared according to winding data.
5. Coil is formed on former as per collect winding data.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: continuity tester, bearing puller, electric oven, manual coil winder, electric motor winding, winding head cutter, winding puller.
- Equipment: electric oven, manual rewinding machine, power driven rewinding machine, winding head cutter, winding puller, electric hand drill machine with bits, AC & DC power supply unit, single phase AC motor, DC motor, three phase AC motor, universal motor
- Materials: super enamel wires, insulating plastic film, PVC tape, laminates, insulating paper, ceramic fibre, flexible cables, slot insulation paper, binding thread, varnish, thinner, grease, bearings, solder, resin, winding string

Learning Activity 7.2.1

Learning Activity	Resources/Special Instructions/References
Select tools and prepare material for winding/rewinding	▪ Information Sheets: 7.2.1, 7.2.2 ▪ Self-Check Quizzes: 7.2.1, 7.2.2 ▪ Answer Keys: 7.2.1, 7.2.2

Information Sheet 7.2.1

Learning Objective: to identify, gather and check tools and equipment for motor winding/rewinding in a workplace.

- **Tools and equipment:**

Continuity tester: A continuity tester is an electrical test equipment used to determine if an electrical path can be established between two points; that is if an electrical circuit can be made. The circuit under test is completely de-energized prior to connecting the apparatus.	
Bearing puller: *Bearing pullers* are used for dismounting bearings. These are available in various types, shapes and sizes.	
Electric oven: *Electric ovens* are easy to use to prepare or heat up anything metals without the hassle. It is available in a variety of sizes and finishes.	
Manual rewinding machine: A coil winder is a device which is used to create tight, evenly wound coils. Handheld winding machines are perfect for home electronics projects to commercial packaging of products typically sold in coils.	
Power rewinding machine: Electric motor winding allows this machine to automatically wind coil in even layers with concise tension. It has a counter which is easy to read when determining the number of rings on the coil.	
Winding head cutter: In winding wire stripper with self-adjusting *cutter* with small *cutter head* for stripping very close to terminals are used and operate with a low voltage unit with plug able power supply.	
Winding puller: *Puller* is used for leading and pulling out a wire from *winding* machine is designed for production of armature banding, coil and form *windings* and transformer coil *winding*.	

Self-Check Quiz 7.2.1

Write the name and uses of the following tools and equipment:

No.	Identify the hand tools given below	Name and uses
1.		
2.		
3.		
4.		
5.		

Information Sheet 7.2.2

Learning Objective: to identify, gather and check materials for motor rewinding/servicing in a workplace.

- **Super enamel wire:**
  - Super enamelled wire also known as magnet wire or is a copper or aluminium wire coated with a very thin layer of insulation.
  - It is used in the construction of transformers, inductors, motors, speakers, hard disk head actuators, electromagnets and other applications that require tight coils of insulated wire.

- **Insulating plastic film:**
  - Insulation film *is a* plastic film which can be applied to glass windows to reduce heat transfer.
  - There are two types in common use designed to reduce heat flow via radiation and convection respectively.

- **Laminates:**
  - Lamination is the technique of manufacturing a material in multiple layers, so that the composite material achieves improved strength, stability, sound insulation, appearance or other properties from the use of differing materials.
  - A laminate is a permanently assembled object by heat, pressure, welding, or adhesives.

- **Insulating paper*:***
  - Insulating papers are used as electrical insulation in many applications due to pure cellulose having outstanding electrical properties.
  - Cellulose is a good insulator and is also polar, having a dielectric constant significantly greater than one.

- **Ceramic fibre flexible cables:**
  - The ceramic fibre yarn's upper temperature limit often exceeds the melting point of the material it insulates.
  - Ceramic fibre cloth is a woven fabric that is manufactured from high purity alumina-silicate based ceramic fibre*,* reinforced with fiberglass filament and optional alloy steel *wire*.
  - The product is white and odourless and suitable for high temperature applications.

- **Slot insulation paper:**
  - Slot insulation is the common name for shielding material used for the rotor inside a power generator.
  - The slot insulation process for electric motors provides a barrier between the copper wirings and the steel lamination for all stator, armature and rotor products.
  - This shielding material separates the rotor's electrically conductive winding from its body.

- **Varnish:**
  - Varnish is a transparent, hard, protective finish or film that is primarily used in wood finishing but also for other materials.
  - Varnish is traditionally a combination of a drying oil, a resin and a thinner or solvent, that is prepared by resin dissolved in a liquid for applying on wood, metal or other materials to form a hard, clear, shiny surface when dry.

- **Thinner:**
  - Thinner is a liquid substance used to thin the consistency of another liquid.
  - A paint thinner is a solvent used to thin oil-based paints or clean up after their use.
  - Turpentine or mineral spirits can be used as a thinner for oil-based paints.

- **Grease*:***
  - Grease is a semisolid lubricant.
  - Greases are a type of shear-thinning or pseudo-plastic fluid, which means that the viscosity of the fluid is reduced under shear.
  - Greases are applied only to mechanisms that can be lubricated infrequently and where a lubricating oil would not stay in position.
  - Grease-lubricated bearings have greater frictional characteristics due to their high viscosity.

- **Resin:**
  - Resin is a 'solid or highly viscous substance' of plant or synthetic origin that is typically convertible into polymers.
  - Resin can be defined as, any of a class of non-volatile, solid or semisolid organic substances, as copal or mastic, that consist of amorphous mixtures of carboxylic acids and are obtained directly from certain plants as exudations or prepared by polymerization of simple molecules: used in medicine and in the making of varnishes and plastics.

Self-Check Quiz 7.2.2

Write the correct answer for the following questions:

1. What are the uses of super enamelled wire?
2. What is grease?
3. What are the uses of resin?

Learning Outcome 7.3 - Carry Out Winding/Rewinding of Stator Rotor and Armature

Contents:

- Stator/rotor and armature
- Insulation material
- Formed coil

Assessment criteria:

1. Stator/rotor and armature are cleaned by using specified tools.
2. Insulation material is inserted into slots.
3. Formed coil is inserted into slots as per standard.
4. Rotor is cleaned and checked.
5. Servicing and repaired works is carried out as necessary.
6. Formed coil is insulated, banded and inserted into slot.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: stator, rotor and armature, insulation materials and formed coil

Learning Activity 7.3.1

Learning Activity	Resources/Special Instructions/References
Carry out winding/rewinding of stator rotor and armature	▪ Information Sheet: 7.3.1 ▪ Self-Check Quiz: 7.3.1 ▪ Answer Key: 7.3.1 ▪ https://www.wikihow.com/Rewind-an-Electric-Motor

Information Sheet 7.3.1

Learning Objective: to identify and uses of stator, rotor and armature in a workplace.

- **Stator/rotor:**
  - The stator is the stationary part of a rotary system, found in electric generators, motors, sirens, mud motors or biological rotors.
  - The stator provides a rotating magnetic field that drives the rotating armature; in a generator, the stator converts the rotating magnetic field to electric current.
  - *Rotor* is the non-stationary part of an alternator or electric motor, operating with a stationary element so called the stator.

- **How to carryout winding/rewinding of stator/rotor?**
  1. Collect proper tools, equipment and materials for winding/rewinding of stator/rotor.
  2. Stator core preparation, including cleaning, repairs to interlaminar insulation, testing and re-painting.
  3. Installation of upgraded end winding support system.
  4. Installation of new surge and bus rings.
  5. Installation of stator bars, RTDs and wedging and blocking system and testing of individual coils or groups of coils at specified points in the installation.
  6. Brazing and circuit connections.
  7. Testing of the completed winding/rewinding.
  8. Complete the painting and miscellaneous finishing details.
  9. To prevent harms and injuries use proper personal protective equipment while working.
  10. Clean and store the tools, equipment and workplace as per standard procedure.

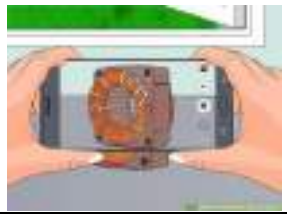
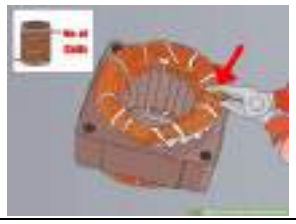
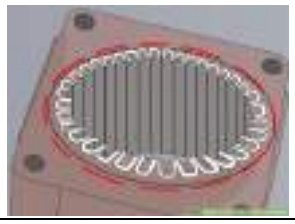
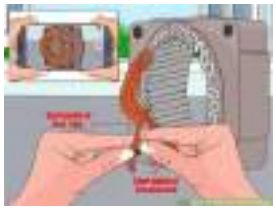
- **Insulation materials:**
  - A material that responds with very high resistance to the flow of electrical current or totally resists electric current is called an insulating material.
  - The main aim of an insulating material is to separate electrical conductors without passing current from one to the other and to safeguard individuals from electrically energized wires and parts.
  - Material like PVC, glass, asbestos, rigid laminate, varnish, resin, paper, Teflon and rubber are very good electrical insulators.
  - Insulating material is used as a protective coating on electrical wire and cables.

- **Necessity of electrical insulation:**
  - Electrical shock caused by the flow of current through the human body can result in physiological effects raging from fatal injuries resulted by involuntary moments to death from ventricular fibrillation or muscular contraction.
  - DC voltage up to 40 volts and AC voltage up to 60 volts are considered safe limits, in the best circumstances, for the human body but beyond this is consider a hazard and to prevent it electrical insulation is required.

- **Formed coil:**
  - It is an electric coil wound by a machine upon a form and transferred afterward to an armature as distinguished from a coil wound directly on the armature.
  - Armature coil that is formed or shaped over a fixture before being placed on the armature of a motor or generator.
  - Formed coils are manufactured in various design and requirements and available in market today.

- **Rewinding procedures of a motor:**
  1. Clean the work surface to make sure it's free of dirt and dust.
  2. Remove the motor housing to reveal the armature, stator and the windings.
  3. Document the present configuration by taking notes or photographs.
  4. Take the wire from the tabs on the brush pads. Bend the tabs gently and completely remove the wire from the tabs before cutting the coils of the wind.
  5. Cut the coils in the wind free from the armature and/or stator. The easiest place to cut is at the tops of the coils at the top of the armature and/or stator posts. Count the number of winds in each coil so that it can rebuild the motor to its original configuration.
  6. Check the insulation that lines the actual steel laminate areas of the stator before the rewind of an electric motor. If it's in good shape, put it back in place before beginning of rewind.
  7. Rewind the armature and/or stator using the same gauge and type of magnet wire that was on the original motor.

8. Recreate the exact winding pattern and number of coils around each winding. When beginning the first winding, leave the end of the first winding free but long enough to reach the first tab. The last winding will attach to the same point.
9. Connect the end of the last winding and the loose wire left in the first winding to the tab.
10. Check to make sure that none of the wires connecting to the tabs are touching.
11. Reassemble the motor housing.
12. Get a good electric motor.

1 	2 	3 
4 	5 	6 
7 	8 	9 
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Individual Activity:

- *Watch the video shows on 'How to rewind a DC motor' and summarize key points (if facilities available)*
- *Perform rewinding of electric motor as per standard procedure*

Self-Check Quiz 7.3.1

Write the correct answer for the following questions:

1. What is stator?
2. What is rotor?
3. What is armature?
4. What is called insulation materials?
5. Define formed coil.

Learning Outcome 7.4 - Make Connections, Carry Out Pre-Assembly Tests and Assembly of Machine

Contents:

- Pre-assembly tests
- Winding continuity
- Dry running
- Insulating varnish

Assessment criteria:

1. Winding resistance and insulation level is checked by specified test instrument.
2. Coil ends are terminated and insulated.
3. Winding continuity is checked.
4. Dry running is carried out, performance is checked and remedial action has taken if necessary.
5. Insulating varnish is applied to winding and baked it up to recommended temperature in baking oven.
6. Assembly of stator, rotor and other parts are assembled.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: motor with all parts and accessories

Learning Activity 7.4.1

Learning Activity	Resources/Special Instructions/References
Make connections, carry out pre-assembly tests and assembly of machine	▪ Information Sheet: 7.4.1 ▪ Self-Check Quiz: 7.4.1 ▪ Answer Key: 7.4.1 ▪ www.pcbheaven.com/userpages/check_the_windings_of_a_3phase_ac_motor/

Information Sheet 7.4.1

Learning Objective: to identify, carryout necessary tests of motor at pre-assembly and assemble the same in a workplace.

- **Winding resistance:**
  - This is the resistance of a length of copper wires or bars from one end to the other, is a measure of DC voltage and current and the application of Ohm's law as follows: R= V/I; where R is resistance in Ohms, V is voltage applied in Volts and I is the resulting current in Amperes.
  - The *w*inding resistance tells us about the condition of the motor winding.

- **Checking:**
  - Using Ohm meter: Disconnect all power from machine.
  - Check all three wires singly T1, T2, T3 to the ground wire.
  - Readings should be infinite.
  - If its zero or reads any continuity at all, then a problem exists with either the motor or cable.

- **Insulation level:**
  - Insulation level defines various insulation thicknesses within a single voltage rating.
  - Insulation levels in electrical equipment are characterized by the withstand voltages used during the design tests.
  - The two most common levels are 100 percent and 133 percent.
  - 100 percent insulation level is used on a grounded system.
  - 133 percent level is normally used on an ungrounded system and is referred to as an ungrounded insulation thickness.

- **Checking:**
  - If the insulation resistance of a new, cleaned or repaired motor is stored for some time is less than 10 MΩ, the reason might be that the windings are humid and need to be dried.
  - If the motor has been operating for a long period of time, the minimum insulation resistance may drop to a critical level.
  - As long as the measured value does not fall below the calculated value of minimum insulation resistance, the motor can continue to run.
  - If it drops below this limit, the motor has to be stopped immediately, in order to avoid that people, get hurt due to the high leakage voltage.

- **Winding continuity:**
  - The continuity test is performed by placing a small voltage across the chosen path.
  - If electron flow is inhibited by broken conductors, damaged components or excessive resistance, the circuit is OPEN.

- **Checking:**
  - Check all three wires singly T1, T2, T3 (all three phases) to the ground wire.
  - Readings should be infinite.
  - If its zero or reads any continuity at all, then a problem exists with either the motor or cable.
  - If it is going directly to the motor and disconnect from cable and check motor and cable separately.

- **Dry running:**
  - It is a rehearsal of a performance or procedure before the real one or a practice of a particular activity or performance.
  - A dry run or practice *run* is a testing process where the effects of a possible failure are intentionally mitigated.

- **Insulating varnish:**
  - Electrical insulating varnishes are *used* under harsh conditions, including high temperature and high voltage conditions and contribute to improved reliability in items such as the enamel wires *used* in motors and other equipment.
  - Insulating varnish is applied to coils on rotor and stator windings in a motor but can be used for anything from insulating the coils in a tattoo to the coils of a generator in a power plant.

- Motor varnish immobilizes windings so the coils do not move.
- Varnishes are also *used* in repairing of fans, armatures and transformers.

Keep in mind:

- *During the measurement and immediately afterwards, some of the terminals carry dangerous voltages and* ***MUST NOT BE TOUCHED****.*

Self-Check Quiz 7.4.1

Write the correct answer for the following questions:

1. What is the meaning of winding resistance?
2. Define insulation level.
3. What is meant by winding continuity?
4. What do you understand by dry run?
5. What are the uses of insulating varnishes?

Learning Outcome 7.5 - Carry Out Final Test and Record the Test Result

Contents:

- Final test
- Test result recording
- Meaning, importance and necessity of cleaning tools/instruments and workplace
- Methods of cleaning, tools and equipment required for cleaning
- Storage of tools, equipment and materials used

Assessment criteria:

1. Rotor free movement is checked.
2. No load/load/locked rotor tests are performed.
3. Rotor static and dynamic balancing are carried out.
4. Test result are documented in the relevant recorded sheet.
5. Test reports are prepared.
6. Machine performance is demonstrated.
7. Tools, equipment and materials are cleaned and stored as per workplace standard.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: reporting forms for test result, cleaning agents/materials required for servicing

Learning Activity 7.4.1

Learning Activity	Resources/Special Instructions/References
Carry out final test and record the test result	▪ Information Sheets: 7.5.1, 7.5.2 ▪ Self-Check Quiz: 7.5.1 ▪ Answer Key: 7.5.1 ▪ https://www.wikihow.com/Check-an-Electric-Motor ▪ https://www.electrical4u.com/no-load-test-of-induction-motor/

Information Sheet 7.5.1

Learning Objective: to carry out a final test and record of the test result of electric motor in a workplace.

- **Electric Motor Test for all types of motor:**
  - Check the appearance of the motor.
  - Check for body damage or damage to the cooling fan blade or shaft.
  - Manually rotate the shaft to check the bearing condition.
  - Check for free & smooth rotation.
  - Note the motor data from the motor NAME PLATE.
  - Earth continuity: Using the ohmmeter, verify the resistance between earth and motor frame is less than 0.5 Ω.
  - Power supply: correct voltage (230V per line), 415V between L1 to L2, L2 to L3 and L3 to L1.

- **Single Phase motor:**
  - Check the motor winding ohms reading using multimeter or ohmmeter (C to S, C to R, S to R).
  - The reading for start to run should be equal to C to S + C to R.
  - Correct electrical terminal identification.
  - There are three terminals connections on a hermetically sealed motor compressor and are as follows: Common (C), Start (S) and Run (R).

- **Identify the correct terminal connection:**
  - The highest resistance reading is between the start and run terminal.
  - The middle resistance reading is between the start and common terminals.
  - The lowest resistance reading is between the run and common terminals.
  - Insulation resistance of motor winding using insulation tester meter set to the 500V scale.
  - Check from windings to earth (C to E, S to E, R to E).
  - Minimum test value of the electric motor is 1 MΩ.
  - Check the running amps of motor using Clamp on meter and compare with the name plate.
  - If every step is completed, decide the condition of electrical motor either OK or need to REPAIR.

- **Three Phase motor:**
  - Ensure the terminal for power supply is in good condition.
  - Check the connection bar for terminal (U, V, W). Connection type: STAR OR DELTA.
  - Confirm the power supply VOLTAGE for electric motor: 230/400 V.
  - Use multimeter to check the continuity of winding from phase to phase (U to V, V to W, W to U).
  - Each phase to phase must have a continuity if winding is OK.
  - Check the motor winding ohms reading using multimeter or ohmmeter for phase to phase terminal (U to V, V to W, W to U).
  - The ohms reading for each winding must be the same (or nearly the same).
  - Insulation resistance of motor winding using Insulation tester meter set to the 500 V scale.
  - Check from phase to phase (U to V, V to W, W to U) and (b). check from phase to earthing (U to E, V to E, W to E).
  - Minimum test value of the electric motor is 1 MΩ.
  - Check the running amps of motor using Clamp on meter and compare with the name plate.
  - If every step is completed, decide the condition of electrical motor either OK or need to REPAIR.

- **Electric Motor Impulse Testing:**
  - This is an integral part of predictive maintenance of electrical motors.
  - Through the following questions the influence that extensive impulse testing has on a motor is investigated.
  - Can impulse testing damage healthy or deteriorated insulation?
  - Can DC resistance, Inductance, Megger or HiPot tests diagnose weak turn-to-turn insulation?
  - After failing an impulse test, are motor with weak insulation able to operate?
  - Are motors with a turn-turn short capable of continued operation?

- **Electric Motor Rotation Testing:**
  - Check for fan or pump motor rotation when testing offline with the MCE.

- Fans may continue to slowly rotate due to drafting in the Plenum.
- Pumps that are connected to a common header may continue to rotate if other pumps connected to the header are operating.
- This will adversely affect the Standard Test results, possibly creating higher than normal resistive and inductive imbalances.

Wound Rotor Electric Motor Testing:

- Wound rotor motors have a three-phase winding wound on the rotor which is connected to three phases of start-up resistors in order to provide current and speed control on start-up.
- Failed components in the resistor bank are common and often overlooked when troubleshooting.
- These faults can have a significant impact on the overall operation of the motor and should be given considerable focus when troubleshooting these motors.

Electric Motor Insulation Resistance Testing:

- Electric motor insulation exhibits a negative temperature coefficient, meaning as temperature increases, resistance decreases.
- This would lead to believe that insulation resistance of a de-energized motor will decrease after starting the motor.

The recommended off-line in-service, spare and new/refurbished electric motor tests are:

- Stator winding resistive imbalance
- Stator winding insulation resistance (Meg-Ohm checks)
- Polarization Index (PI)
- Step voltage test
- Surge test.

Test reports:

- All values should be recorded in report form and preserve for future use.
- The test readings will indicate the condition of the motor and offer a guide to its reliability.

Individual Activity:

- *Watch the video shows on ''No load and Full load test of a single-phase induction motor' and summarize key points (if facilities available)*
- *perform the 'No load and Full load test' of an electric motor as per standard procedure*

Self-Check Quiz 7.5.1

Write the correct answer for the following:

1. What are the steps to be followed for testing electric motors?
2. What is electric motor impulse testing?
3. Write the benefits of recording test reports in a prescribed report form

Information Sheet 7.5.2

Learning Objective: to maintain electrical tools, equipment, materials and store the same as per standard procedures in the workplace.

Same as Information Sheet 1.6.1 of the Module 1: Performing channel wiring (page 32-34)

ANSWER KEY

Answer Key 7.1.1

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

Answer Key 7.1.2

1. Amperes
2. Voltmeter
3. Resistance
4. Megger
5. Alternating

Answer Key 7.2.1

1. Bearing puller: is used for dismounting bearings. These are available in various types, shapes and sizes.
2. Continuity tester: is an item of electrical test equipment used to determine if an electrical path can be established between two points or an electrical circuit can be made.
3. Electric oven: helps to prepare or heat up anything metals without the hassle.
4. Winding puller: is used for leading and pulling out a wire from *winding* machine is designed for production of armature banding, coil and form *windings* and transformer coil *winding*.
5. Winding head cutter: In winding wire stripper with self-adjusting cutter with small *cutter head* for stripping very close to terminals are used and operate with a low voltage unit with plug able power supply.

Answer Key 7.2.2

1. Super enamelled wire is used in the construction of transformers, inductors, motors, speakers, hard disk head actuators, electromagnets and other applications that require tight coils of insulated wire.
2. Grease is a semisolid lubricant.
3. Resin is used in medicine and in the making of varnishes and plastics.

Answer Key 7.3.1

1. The stator is the stationary part of a rotary system, found in electric generators, electric motors, sirens, mud motors or biological rotors.
2. Rotor *i*s the non-stationary part of an alternator or electric motor, operating with a stationary element so called the stator.
3. The armature of an electric motor or generator or of an electric apparatus is the coil or coils in which a voltage is induced by a magnetic field.
4. A material that responds with very high resistance to the flow of electrical current or totally resists electric current is called an insulating material.
5. Formed coil is an electric coil wound by a machine upon a form and transferred afterward to an armature as distinguished from a coil wound directly on the armature.

Answer Key 7.4.1

1. Winding resistance is the resistance of a length of copper wires or bars from one end to the other, is a measure of DC voltage and current and the application of Ohm's law (R= V/I).

2. Insulation level defines various insulation thicknesses within a single voltage rating. Insulation levels in electrical equipment are characterized by the withstand voltages used during the design tests.
3. Winding continuity is a type of *continuity* test, which is performed by placing a small voltage across the chosen path. If electron flow is inhibited by broken conductors, damaged components or excessive resistance, the circuit is 'open'.
4. Dry run is a rehearsal of a performance or procedure before the real one or a practice of a particular activity or performance.
5. Insulating varnish is applied to the coils on the rotor and stator windings in a motor but can be used for anything from insulating the coils in a tattoo machine to the coils of a generator in a power plant and/or varnishes are used in repairing of fans, armatures and transformers.

Answer Key 7.5.1

1. The following steps should be considered while electric motor test:
   - Check for body damage or damage to the cooling fan blade or shaft
   - Check for free and smooth rotation
   - Verify the resistance between earth and motor frame is less than 0.5 Ω
2. Electric Motor impulse testing is an integral part of predictive maintenance of electrical motors.
3. All values should be recorded in report form and preserve for future use. The test readings will indicate the condition of the motor and offer a guide to its reliability.

Module 8: Install and troubleshoot solar electrical system

MODULE CONTENT

Module Descriptor: This module covers the skills, knowledge and attitudes to install and troubleshooting of solar electrical system. It specifically includes estimating electrical load of customer, identifying tools, equipment and materials, setting solar panel, installing solar home system and accessories, diagnosing and repairing faults in solar home system unit and wiring and cleaning and storing the tools and materials. It also includes information sheets, job sheets, self-checking quizzes and answer keys.

Nominal Duration: 40 hours

Learning Outcomes:

Upon completion of the module, the student/trainee will be able to:

8.1 Estimate electrical load of customer
8.2 Identify tools, equipment and materials
8.3 Set solar panel
8.4 Install solar home system and accessories
8.5 Diagnose and repair faults in solar home system unit and wiring
8.6 Clean and store the tools and materials

Performance Criteria:

1. Customer required electrical load are estimated.
2. Layout drawing of selected work plan is prepared.
3. Capacity of panel, battery, inverter, charge controller and other accessories are selected.
4. Following the layout plan required quantity and size of cable, wire and other installation materials are estimated.
5. Information on cost of equipment, accessories and materials are collected.
6. Cost of equipment, accessories and materials are estimated.
7. Installation charges are estimated.
8. Tools, installation materials and components and accessories are collected.
9. Personal protective equipment (PPE) is used while working.
10. Frames are constructed as per panel size.
11. Appropriate place with maximum sunlight exposure for panel setting is located.
12. Setting of panels within frame is demonstrated between 23 to 30 degrees.
13. Solar home system and accessories are installed as per layout plan.
14. Channel or conduit wiring is performed, switches and sockets are fixed as per layout diagram.
15. Connections with all related components are performed.
16. Testing of solar electrical system for operation is performed.
17. Physical faults in inverter, charger, charge controller, panel, battery and wiring system are checked.
18. Operational faults in the inverter and charge controller are checked by testing instrument.
19. Panel is tested for appropriate functioning.
20. Battery is checked by meter for appropriate voltage and water is added if needed.
21. Electrolyte of battery is checked by hydrometer.
22. Electrical connections are checked and loose connections are repaired throughout the wiring.
23. Charge controller and inverter are tested.

24. Burn components and inactive or faulty components are replaced.
25. Tools, equipment and materials are cleaned and stored as per workplace standard.

Learning Outcome 8.1 - Estimate Electrical Load of Customer

Contents:

- Electrical load
- Other accessories
- Equipment, accessories and materials

Assessment criteria:

1. Customer required electrical load are estimated.
2. Layout drawing of selected work plan is prepared.
3. Capacity of panel, battery, inverter, charge controller and other accessories are selected as per guidance.
4. Following the layout plan required quantity and size of cable, wire, and, other installation materials are estimated.
5. Information on cost of equipment, accessories and materials collected from suppliers/manufacturers.
6. Cost of equipment accessories and materials are estimated.
7. Installation charges are estimated.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: light fixtures, ceiling fans, television, refrigerator, water pump, computer, switch board, switch, sockets, MCB, cables, wires, solar panel, charge controller, battery, inverter, switch and sockets, conduit, fixing materials

Learning Activity 8.1.1

Learning Activity	Resources/Special Instructions/References
Estimate electrical load of customer	▪ Information Sheet: 8.1.1 ▪ Self-Check Quiz: 8.1.1 ▪ Answer Key: 8.1.1 ▪ https://www.slideshare.net/.../preliminary-electrical-load-calculation-course-share ▪ https://www.shopyourway.com/questions/1000700

Information Sheet 8.1.1

Learning Objective: to estimate electrical load for solar electrical system in a workplace.

- **Load calculation:**
  To calculate the electrical load, follow the steps below:
  1. Decide the appliances to be used;
  2. See the specification chart of the appliances for power rating;
  3. Calculate the watt-hour of each appliance;
  4. Calculate the total watt-hour for all appliances.

Example:
- Two lights (2x30) = 60 W x 5 hr = 300 W-hr
- A ceiling fan = 60 W x 3 hr = 180 W-hr
- A television = 80 W x 3 hr = 240 W-hr

Total load in W-hr = 300+180+240 = 720 Watt-hour.
Considering 30% energy lost in the system, So total Watt-hour per day= 720 x 1.30 = 936 W-hr.

- **Light fixtures:** A light fixture is an electrical device used to create artificial light by use of an electric lamp for indoor and outdoor lighting. Types of fixtures that provide ambient indoor lighting are Chandelier, Ceiling & wall mounted, Recessed fixtures and down-light, Track light, Floor lamp, Table lamp etc.
- **Ceiling fans:** are range in size from 36 inches to 56 inches using *55 to 100 watts.* Actually, the power used by a ceiling fan varies depending on the model, the size and the speed setting. Each fan is controlled by a switch or remote.
- **Television (TV):** power consumption varied by as much as 50-70 watts depending on the size and technology used by the manufacturer.
- **Solar panels:** are environmentally friendly way of producing electricity for use. They absorb sunlight as a source of energy to generate electricity or heat. A photovoltaic (PV) module is a packaged, connect assembly of typically 6x10 photovoltaic solar cells.

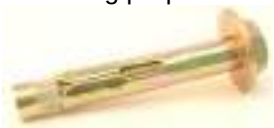
- **Charge controller:** is an essential part of nearly all power systems that charge batteries, whether the power source is photovoltaic, wind, hydro, fuel or utility grid. Its purpose is to keep your batteries properly fed and safe for the long term. The basic function of the controller is to regulates or limits the rate at which electric current is added to or drawn from electric batteries. There are three different types of solar charge controllers, which are as follows:
  - Simple 1 or 2 stage controls.
  - PWM (pulse width modulated)
  - Maximum power point tracking (MPPT).

- **Battery:** is a combination of one or more electrochemical cells that are capable of converting stored chemical energy into electrical energy. It has two ends: a positive terminal (cathode) and a negative terminal (anode).

- **Inverter:** is an electronic device that changes DC to AC. The input voltage, output voltage and frequency and overall power handling depend on the design of the specific device. The inverter does not produce any power; the power is provided by the DC source.

- **Fixing materials:** In electrical engineering, various types of fixing materials are used, such as; super plug, sleeve anchors, spring toggle.
  - Super plugs: These are used for vibration resistance purposes.

  - Sleeve anchors: Sleeve anchors can be used in concrete, brick and block base material and are best suited for light to heavy duty fastening purposes.



  - Spring toggle: Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly. These are used for heavy tension loads in board materials.

Did you know?

- *About 30% energy loss is considered during electrical load calculation of a customer.*

Self-Check Quiz 8.1.1

Write the correct answer for the following questions:

1. State the principle of solar panel.
2. What is charge controller?
3. Define battery.
4. What is power inverter?
5. Which type of plug is suitable for vibration resistance purposes?

Learning Outcome 8.2 - Identify Tools, Equipment and Materials

Contents:

- List of tools and their uses
- Installation materials
- Solar electrical system components: panel, inverter, charge controller, battery
- Solar electrical system accessories: light fixtures, switches, sockets, junction boxes

Assessment criteria:

1. Tools are selected and collected.
2. Installation materials, and, solar electrical system components and accessories are collected.
3. Battery is collected and tested.

Resources required:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: inverter, charge controller, battery, junction boxes
- Materials: cables, channels, screws, rowel plugs, clips, nails, plastic board, conduits, plastic connectors, cable ties, panel, , light fixtures, switches, sockets

Learning Activity 8.2.1

Learning Activity	Resources/Special Instructions/References
Identify tools, equipment and materials	▪ Information Sheets: 8.2.1, 8.2.2 ▪ https://www.ecmag.com/section/your-business/tools-most-used-electricians ▪ https://www.scribd.com/document/97899235/Electrical-Supplies-and-Materials

Information Sheet 8.2.1

Learning Objective: to identify, gather and check tools and equipment used for solar system in a workplace.

 Tools and equipment:

Spirit level: Spirit level is a device consisting of a sealed glass tube partially filled with alcohol or other liquid, containing an air bubble whose position reveals whether a surface is perfectly level.	
Neon tester: Phase or line tester is a tool which is used to identify or test the phase/live/hot or positive wire/conductor.	
Battery tester: A battery tester is an electronic device intended for testing the state of an electric battery, its capacity for accumulating charge and any possible flaws affecting the battery's performance and security.	

Note: *Other tools and equipment required for this module is same as Information Sheet 1.2.1 of Module 1: Performing channel wiring (page 13-15)*

Information Sheet 8.2.2

Learning Objective: to identify, gather and check installation materials, solar home system components and accessories used in a workplace.

 Materials required:

Same as Information Sheet 1.2.2 (page 15-18) and Information Sheet 1.4.1 (page 26-28)

Learning Outcome 8.3 - Set Solar Panel

Contents:

- List of PPE and their uses
- Setting of solar panels

Assessment criteria:

1. Personal protective equipment (PPE) is used while working.
2. Special rope, safety belts, and ladder are used for working on the roof.
3. Frames are constructed as per panel size.
4. Appropriate place with maximum sunlight exposure for panel setting is located.
5. Setting of panels within frame is demonstrated between 23 to 30 degrees.

Resources required:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings

Learning Activity 8.3.1

Learning Activity	Resources/Special Instructions/References
Set solar panel	▪ Information Sheets: 8.3.1, 8.3.2 ▪ Self-Check Quiz: 8.3.2 ▪ Answer Key: 8.3.2 ▪ https://en.wikipedia.org/wiki/Solar_panel

Information Sheet 8.3.1

Learning Objective: to identify the personal protective equipment used in a workplace.

- **Personal Protective Equipment (PPE):**

Same as Information Sheet 1.3.1 of the Module 1: Performing channel wiring (page 19-21)

Information Sheet 8.3.2

Learning Objective: to set solar panels in a workplace.

- **Correct angle of solar panel:** Take latitude and add 15 degrees for the winter or subtract 15 degrees for the summer. For example: if latitude is 40 degrees, the angle to tilt the panels in the winter will: 40 + 15 = 55 degrees and in the summer, it would be: 40 - 15 =25 degrees.

- **Tilt angle:** Solar panels are most efficient when they are perpendicular to the sun's rays. The default value is a tilt angle equal to the station's latitude plus 15 degrees in winter or minus 15 degrees in summer.

- **Good place of setting panels:** a southern-facing roof is the good place of setting panels. Solar panels facing east or west won't get as much light as those on a southern-facing roof.

- **How to set solar panel?**
  1. Collect tools, equipment and materials as per standard requirements.
  2. Select the suitable place to set solar panels with maximum sunlight exposure.
  3. Determine the size of panels and mount the panels.
  4. Bury conduit and build a platform and secure the rear legs.
  5. Wire the solar modules and connect the cables to the control panels.
  6. Ground the solar system and make the electrical connections inside.
  7. Diagnose and repair faults in solar system.
  8. For safety use personal protective equipment while working on solar system.
  9. Clean the tools, equipment and workplace and store those in proper places.

JOB SHEET 5			
Qualification:	Electrical Installation and Maintenance		
Learning unit:	Install and troubleshoot solar electrical system		
Learner name:			
Personal protective equipment (PPE):	Hand gloves, apron, safety goggles, safety shoes, helmet and dust mask		
Materials:	Solar panel, charge controller, battery, inverter, switch & sockets, cables/wires, conduit, channel, screws, rowel plugs, clips, nails, plastic board, junction board, connectors, cable ties, fixing materials etc.		
Tools and equipment:	Measuring tape, screw driver, pliers, adjustable wrench, socket wrench, marking chalk, hammer, electric hand drill with bits, sprit level, neon tester, battery tester.		
Performance criteria:	1. Frames are constructed as per panel size. 2. Appropriate place with maximum sunlight exposure for panel setting is located. 3. Setting of panels within frame is demonstrated between 23 to 30 degrees.		
Measurement:	▪ Measurement to be taken physically and/or from electrical drawing ▪ Carefully take the measurement of channel/conduit and cables.		
Notes:	▪ Set the frame between 23 to 30 degrees. ▪ Ensure the size and type of cable		
Procedure:	1. Collect PPE, tools & equipment and materials 2. Check the usability of PPE, tools & equipment and materials 3. Collect and read the electrical drawing 4. Determine the length and size of conduit/channel and cables 5. Select the suitable place to set solar panels with maximum sunlight exposure. 6. Determine the size of panels and mount the panels. 7. Bury conduit and build a platform and secure the rear legs. 8. Wire the solar modules and connect the cables to the control panels. 9. Ground the solar system and make the electrical connections inside. 10. Diagnose and repair faults in solar system. 11. While working use personal protective equipment for safety 12. Clean the workplace and restore the tools, equipment and excess materials.		
Learner signature:		**Date:**	
Assessor signature:		**Date:**	
Quality Assurer signature:		**Date:**	
Assessor remarks:			
Feedback:			

Individual Activity:

- *Watch the video shows on 'Solar panel systems for beginners', 'How to set up a solar panel, charge controller and battery' and summarize key points (if facilities available)*
- *Install and troubleshoot solar electrical system, following Job Sheet 5 (see above)*

Self-Check Quiz 8.3.2

Write the correct answer to the questions below:

1. Write the significance of tilt angle.
2. What is the variation of tilt angle between winter and summer?

Learning Outcome 8.4 - Install Solar Home System and Accessories

Contents:

- Installation of solar home system with accessories
- Testing of solar electrical system

Assessment criteria:

1. Solar home system and accessories are installed as per layout plan.
2. Channel or conduit wiring is performed as per layout diagram.
3. Switches and sockets on board are fixed.
4. Connections with all related components are performed.
5. Testing of solar electrical system for operation is performed.

Resources required:

Students/trainees must be provided with the following resources:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: drill, ladder, grinder, soldering iron, multimeter, earth tester, electrical plans/drawings
- Materials: solar home system

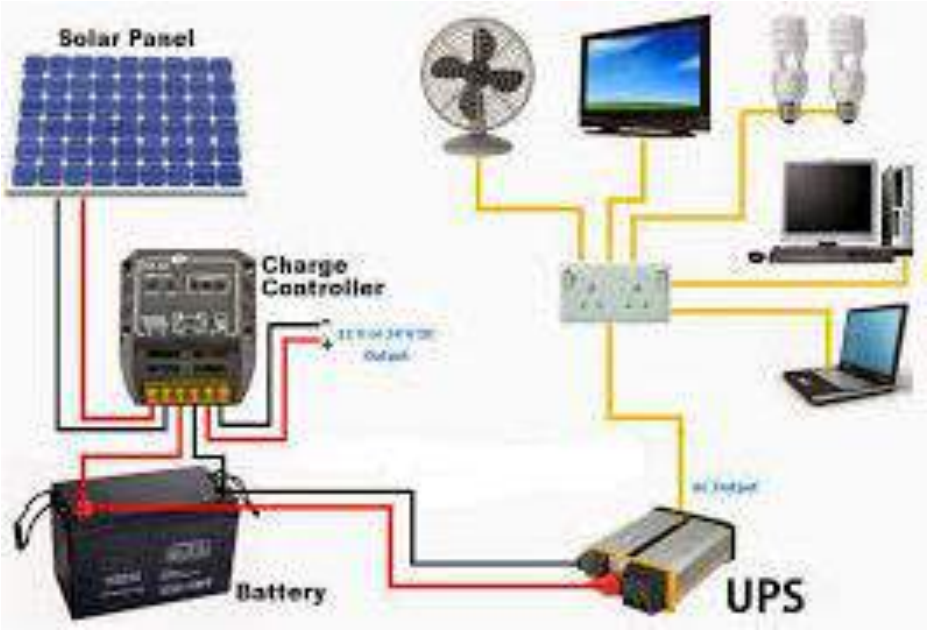
Learning Activity 8.4.1

Learning Activity	Resources/Special Instructions/References
Install solar home system and accessories	▪ Information Sheet: 8.4.1 ▪ Self-Check Quiz: 8.4.1 ▪ Answer Key: 8.4.1 ▪ https://www.wikihow.com/Set-Up-a-Small-Solar-(Photovoltaic)-Power-Generator

Information Sheet 8.4.1

Learning Objective: to identify accessories and use of those for solar home system in a workplace.

- **Solar home system (SHS):** can be used to meet a household's energy demand fulfilling basic electric needs. SHS usually operate at a rated voltage of 12 V direct current and provide power for low power DC appliances. It includes one or more photovoltaic modules consisting of solar cells, a charge controller which distributes power and protects the batteries and appliances from damage and at least one battery to store energy for use when the sun is not shining.



- **Planning, installation and maintenance:** before installing a photovoltaic SHS, its size has to be calculated according to different assumptions, such as measurement of solar radiation, solar insolation and power demand.

- **Testing of solar electrical system:**
  a. **Performance Testing:** many people aren't aware of how much energy their system should produce or if its production has decreased due to a fault that has developed in a PV module or string since installation. A regular system performance test can identify any hidden problems and leave re-assured that the system is in good working order.
  b. **Shade Impact Assessment:** is usually carried out prior to site selection and installation. It is also being beneficial to assess an existing solar system that may now be affected by shading that wasn't present at the time of installation.
  c. **Full System Check:** a full safety and performance of solar system to be checked by an expert on a regular basis will give peace of mind knowing that the solar system and its components are safe and functioning correctly.

- **System Check Overview:**
  - Full electrical inspection - AC, DC and earthing.
  - Full mechanical inspection - inverter, panel arrays, fittings and fixtures.
  - Earth resistance testing.
  - Testing and checking the switchboard and/or sub-board.
  - Inverter test to ensure it is operating correctly.
  - All switches and isolators tested to ensure safe operation.
  - Water and moisture ingress check for all wiring entries, connections and enclosures.
  - Shading assessment.
  - Analysis of stored inverter data to ascertain system performance history.

Just checking:
- *Why a battery is used in solar home system (SHS)?*
- *When and why the shade impact assessment is carried out to install a Solar Home System?*

Self-Check Quiz 8.4.1

Write the correct answer to the questions below:

1. In which areas and when solar home system mostly can be used?
2. What are the points to be assumed while calculating size of SHS?
3. Why should check the full safety and performance of solar system on regular basis?

Learning Outcome 8.5 - Diagnose and Repair Faults in Solar Home System Unit and Wiring

Contents:

- Physical faults
- Operational faults
- Testing instrument
- Electrical connections
- Repair faults in solar home system unit and wiring

Assessment criteria:

1. Physical faults in the inverter, charger, charge controller, panel, battery, and wiring system are checked visually.
2. Operational faults in the inverter and charge controller are checked by testing instrument.
3. Panel is tested for appropriate functioning.
4. Battery is checked by meter for appropriate voltage.
5. Electrolyte of battery is checked by hydrometer.
6. Electrical connections are checked throughout the wiring.
7. Charge controller and inverter are tested.
8. Burn components are replaced.
9. Inactive and faulty components are replaced.
10. Battery water is added if required.
11. Loose connections are repaired throughout the wiring.

Resources required:

- Personal protective equipment (PPE): gloves, dust mask, safety shoes, hard hat, belt/body harness, goggles, working clothes, apron
- Tools: wrench, wire stripper, bolt cutter, hammer, clamp, chisel, files, hacksaw, hand drill, measuring tape, pliers, punch, screwdrivers, try square, set square, knife, plastic tape
- Equipment: testing, electrical plans/drawings

Learning Activity 8.5.1

Learning Activity	Resources/Special Instructions/References
Diagnose and repair faults in solar home system unit and wiring	▪ Information Sheets: 8.5.1, 8.5.2 ▪ Self-Check Quizzes: 8.5.1, 8.5.2 ▪ Answer Keys: 8.5.1, 8.5.2

Information Sheet 8.5.1

Learning Objective: to diagnose and repair faults in solar home system unit and wiring in a workplace.

- **Faults in solar home system:** In solar home system, there are some common faults occur, which should be repaired in accordance with requirements and standard procedures.

  - **Fault in inverter:** Defective inverters can lead to significant production losses. Whilst the modules are responsible for generating electricity, the inverters are responsible for converting and feeding the power to the grid.

  - **Isolation fault:** This fault occurs as a result of a short-circuit between various parts of the circuit and the inverter will then report an isolation alarm.

  - **Loose wiring:** Loose wiring can cause unexpected electrical issues as the solar panel system includes a specific network of wiring, linking individual PV cells to each other, to home solar batteries and to inverters.

  - **Overheating:** Due to overheating of solar panel system you may receive less power during the hottest times of the day. High temperatures may lead to a significant reduction in production and can even stop the production.

  - **Dirty or Damaged:** From dust and pollen to leaves and other debris, mother nature has a knack for reducing panel efficiency.

  - **Battery water:** Under normal conditions a battery loses water and only water should be replaced. The most common type of water used in batteries is distilled water. Ordinary tap water should not be used because it may contain an excessive amount of impurities that will degrade battery performance.

- **Testing instruments:**
  - Volt meter (Analogue/Digital)
  - Ammeter (Analogue/Digital)
  - Multi meter (Analogue/Digital)
  - Hydro meter.

Attention:
- *An isolation fault can cause potentially fatal voltages in the conducting parts of the system!*
- *Ensure that maintenance is always carried out in accordance with the applicable safety standards*

Self-Check Quiz 8.5.1

Write the correct answer to the questions below:

1. What is the meaning of isolation fault?
2. What is the effect of loose wiring?
3. What type of water is used in battery? Why ordinary tap water is not used?

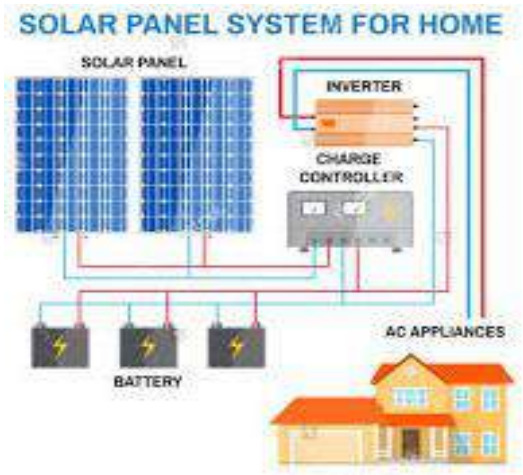
Information Sheet 8.5.2

Learning Objective: to identify and perform terminal connections in solar home system in a workplace.

- **Electrical connections:**
  - An electrical connector is an electro-mechanical device used to join electrical terminations and create an electrical circuit.
  - A terminal is the point at which a conductor from an electrical component, device or network comes to an end and provides a point of connection to external circuits.

  - Solar panels in series are generally used when a grid connected inverter or charge controller that requires 24 volts or more. To series wire the panels together, connect the positive terminal to the negative terminal of each panel until left with a single positive and negative connection.

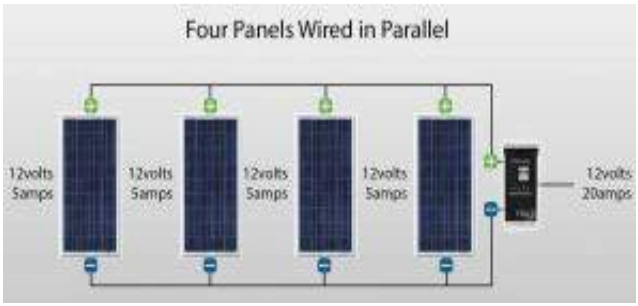
  - Parallel circuits have multiple paths for the current to move along. If an item in the circuit is disconnected or broken, current will continue to move along the other paths, while ignoring the broken one. This type of circuit is used for most household electrical wiring.



- **Wiring Solar Panels in a Series Circuit:**
  - Series circuits have only one path for current to travel along.
  - All the current in the circuit must flow through all the loads.
  - Connecting solar panels together in series is used to increase the total system voltage.
  - A series circuit is a continuous, closed loop - breaking the circuit at any point stops the entire series from operating.
  - Solar panels in series, the voltage is additive, but the amperage remains the same.
  - Example, if 4 solar panels in a series and each was rated at 12 volts and 5 amps, the entire array would be 48 volts and 5 amps.

- **Wiring Solar Panels in a Parallel Circuit:**
  - Solar panels in parallel, the amperage (current) is additive, but the voltage remains the same.
  - Connect all the positive terminals of all the solar panels together and all the negative terminals of all the panels together.

- Example, 4 solar panels in parallel and each was rated at 12 volts and 5 amps, the entire array would be 12 volts and 20 amps.



Remember:

- *Just like batteries, solar panels have a negative terminal (-) and a positive terminal (+).*

Self-Check Quiz 8.5.2

Write the correct answer to the questions below:

1. What is an electrical connector?
2. What is a terminal?
3. State about the series circuit of solar panels.
4. State about the parallel circuit of solar panels.

Group Activity

Field Visit:

- *Visit a practical site of solar electrical system in your building or the neighbourhood.*
- *Observe some activities there like:*
  - *What tasks are being performed?*
  - *What components and accessories are being used and for what purpose?*
  - *How connections are being made?*
  - *Anything more observed you may mention.*
- *Fill-up the 'Field Visit Format' given and submit to your trainer.*
- *Present the experience group wise as per instruction of your trainer.*

Learning Outcome 8.6 - Clean and Store the Tools and Materials

Same as Learning Outcome 1.6: Performing channel wiring (page 32-34)

ANSWER KEY

Answer Key 8.1.1

1. Solar panels absorb sunlight as a source of energy to generate electricity or heat.
2. A charge controller is an essential part of nearly all power systems that charge batteries.
3. A battery can be defined as; it is a combination of one or more electrochemical cells that are capable of converting stored chemical energy into electrical energy.
4. A power inverter or inverter is an electronic device or circuitry that changes DC to AC. The inverter does not produce any power; the power is provided by the DC source.
5. Super plugs are suitable for vibration resistance purposes.

Answer Key 8.3.2

1. The tilt angle of the photovoltaic array is the key to an optimum energy yield. Solar panels or PV arrays are most efficient when they are perpendicular to the sun's rays.
2. The default value is a tilt angle equal to the station's latitude plus 15 degrees in winter or minus 15 degrees in summer.

Answer Key 8.4.1

1. In rural areas, that are not connected to the grid, solar home system can be used to meet a household's energy demand fulfilling basic electric needs.
2. Before installing a SHS, its size has to be calculated according to different assumptions, such as measurement of solar radiation, solar insolation and power demand.
3. A full safety and performance check of solar system on a regular basis will give peace of mind knowing that the solar system and its components are safe and functioning correctly.

Answer Key 8.5.1

1. The isolation fault occurs as a result of a short-circuit between various parts of the circuit and the inverter will then report an isolation alarm. Isolation fault is a common problem in solar home systems.
2. Loose wiring can cause unexpected electrical issues. Because of this, there are many places where connections might fail.
3. The most common type of water used in batteries is distilled water. Ordinary tap water should not be used because it may contain an excessive amount of impurities that will degrade battery performance.

Answer Key 8.5.2

1. An electrical connector is an electro-mechanical device used to join electrical terminations and create an electrical circuit.
2. A terminal is the point at which a conductor from an electrical component, device or network comes to an end and provides a point of connection to external circuits.
3. Series circuits have only one path for current to travel along. Therefore, all the current in the circuit must flow through all the loads. A series circuit is a continuous, closed loop - breaking the circuit at any point stops the entire series from operating. When wiring solar panels in a series, the voltage is additive, but the amperage remains the same.
4. When wiring solar panels in parallel, the amperage is additive, but the voltage remains the same. Connect all the positive terminals of all the solar panels together and all the negative terminals of all the panels together.