CHAPTER 5: ELECTRICAL INSTALLATION WORK PLANNING

Unit of learning code: ENG/CU/EI/CR/01/5/A

Related Unit of Competency in Occupational Standard: Plan electrical installation work

5.1 Introduction to the unit of learning

This unit specifies the competencies required for planning an electrical installation, ranging from surveying the site, determining system size, preparation of materials, tools, and drawings, arranging for logistics, obtaining installation drawings, preparation of work plans, establishing installation team, obtaining necessary work permit and licenses and finally preparation of work site.

5.2 Summary of Learning Outcomes

1. Conduct site survey
2. Perform system sizing
3. Prepare list of tools, equipment and materials
4. Arrange for logistics
5. Obtain installation drawings
6. Prepare installation work plan
7. Establish installation team
8. Obtain necessary permit and licenses
9. Prepare work site

5.2.1 learning Outcome 1: Conduct site survey

5.2.1.1 Introduction to the learning outcome

Site survey involves a physical visit and walk through on the proposed site of the electrical installation works by the electrical design and installation team. It is performed so as to mark out the position of the proposed project and to ensure the building is constructed to its correct design, position and height as approved by the relevant certifier e.g. the county planning department.

It is important too for the team to perform the exercise in order to gather information necessary to enable produce detailed working drawings, comprehensive estimates to complete the project, determine a precise location, access as well as location of obstacles if any that may hinder the best orientation of the installation project.

It in the site survey that unforeseen challenges may be realized and tackled which would otherwise lead to the delay on the completion of the electrical installation work e.g distance from the distribution power transformer, presence of underground water pipes or

drainage system which may affect the routing of underground service cables, tall trees or building in the vicinity of the project etc.

5.2.1.2 Performance Standard

5.2.1.2.1 The site is surveyed for suitability for the type of installation to be done as per the contract

5.2.1.2.2 Conditions of the site are evaluated according to the established procedures

5.2.1.2.3 The best location and route for the installation is identified as per the design

5.2.1.2.4 Actual measurements are taken

5.2.1.2.5 Survey report is generated and shared with relevant parties according to the established procedures

5.2.1.3 Information Sheet

Electrical installations may be categorized as domestic, commercial or industrial installations each of which calls for slightly different installation conditions. There is therefore the need to put into consideration the type of an installation.

While it is true that each type of installation will require to be performed in a building that is certified by the county authority, it is also true that the site must be safe to work in and besides the right voltage levels must be available at the vicinity of that particular building site e.g. single phase i.e., 240V mostly for domestic consumers and three phase 415V/240V for commercial and industrial consumers however it will be necessary to have the following documents during a site survey irrespective of the type of installation involved.

- **Site plans or layout drawings**

These are scale drawings based upon the architect's site plan of the building and they show the position of the electrical equipment, apparatus and routing of the electrical cables which are to be installed. The electrical equipment and apparatus are identified by graphical and schematic standard symbols eg the BS 3939, graphical symbols for electrical Power, Telecommunications and Electronic Diagrams.

The site plan or layout drawing will be drawn to a scale smaller than the actual size of the building, so to find the actual measurement, one must measure the distance on the drawing and multiply by the scale provided.

- **Power Distribution cable route /drawings**

On commercial and industrial installations there may be more than one position for the electrical supplies. Distribution cables may radiate from the site of the electrical mains intake position to other sub-mains positions. The site of the sub-mains and the route taken by the distribution cables may be shown on a blank copy of the architect's site plan or on the electrician's 'as-fitted drawings.

- **Location drawings**

Location drawings identify the place where items are located on the ground at the site. It might be the position of the manhole covers giving access to the drains, the position of all water stop taps or the position of the emergency lighting fittings all of which may in one way or another affect the routing of the electric power cables

- **Wiring diagrams**

A wiring diagram or connection diagram shows the detailed electrical connections between equipment or circuit works. The purpose of a wiring diagram is guiding the electricians when carrying out electrical works to minimize the chances of making errors which may cause electrical faults leading to electric shock and fires. www.EngineeringBooksLibrary.

Domestic installation

This is a type of installation suited for buildings intended for home living
Installation works in a domestic premise may be new or may be an extension to. an already existing work. This will be discovered during a site survey and so the contractor will able to revise the working drawings accordingly and also re adjust the estimates where necessary. Upon visiting the project site, rerouting of installation cables and/or complete replacement of part or whole of the installation can be considered
During a site visit the contractor is able to

- identify the best location for the power intake point based on the location of the power distribution line
- advise the client on the suitable wiring system for the prevailing environmental condition
- advise the client of any extra precautions that he may need to observe such as lightning protection provisions

Commercial installations

These include those that are found in schools, hospitals, hotels, offices etc and they mostly require more electric power than residential or domestic homes. It is during the site survey when the contractor will establish the type of equipment and machinery to be supplied, the number of floors in case of a storey building, approximate tenancy and therefore the type of wiring suitable for the premises.
In this type of an installation where there are a wide range of people usually for long periods of time in a day safety has to be paramount because any electrical accident happening is likely to put hundreds of people at risk
Details revealed in the site survey report will also most probably provide adequate information on the need for the inclusion of extra equipment may be such as air conditioners for ventilation purposes and lifts and/or escalators in case of mall.

Industrial installations

Utilities availability

Electrical sites may be selected on the basis of vicinity towards access to main road, electricity, health services a site survey will reveal whether these utilities are there and if they are not the client or owner of a building will have the responsibility of ensuring that

he obtains all the necessary approvals from the relevant county authorities for temporary or permanent connections to existing utilities ie clean water, electricity, telecommunication network providers. The building owner should pay for the required construction permits and inspection pertaining to the work being carried out and a site visit is a great opportunity for the contractor to confirm that these payments have been made and that the routing of the utilities will not interfere with the installation or project work

Provision of fencing, temporary lighting and reinforcement by security personnel is also an assurance of safety of construction and installation equipment that belongs to the contractor that the contractor needs to confirm during the site survey,

Besides the project owner shall be required to provide sanitation sewer for the workers on site

Taking measurements on site

. The site plan or layout drawing will be drawn to a scale smaller than the actual size of the building, so to find the actual measurement, one must measure the distance on the drawing and multiply by the scale. To accurately locate the electrical fittings the contractor needs to measure the actual floor area, average temperature and humidity of the site if found to be higher or lower than the design value of the equipment the fittings will require to be adjusted to meet the required installation conditions. During a site visit is a great opportunity to perform crucial measurements such as

- distance between the building and the distribution transformer
- the height of the building to be able to identify the ideal location for the electric meter in case of mansionetes or to be able to determine the height of the rising mains in case of storey buildings
- the length and width of the building to be able to determine floor area of the building and the length of conduit runs or trunking
- size of rooms to be able to design for ring circuits
- distance between switches and lighting points
- actual voltage on site
- soil resistance at the site to determine on the type of earth electrodes to use

Procedure of conducting an electrical site survey

- walk through the proposed site to gather basic facts by observing and questioning the client and other persons such as the site manager, quantity surveyor regarding power quality concerns. It's necessary to review the information so gathered to establish the course of action that best serves the site needs
- organize and perform site analysis. It's important that an organization or individual contractor invests in diagnostic equipment, attend safety training workshops and apply proper test methods to be able to achieve objectivity of test results

- document the exercise by writing a survey report.in this report there must be provision for each type of measurement taken. This will allow for the future use of the document as a log sheet to help track any electrical expansion of available apparatus and/or electrical equipment such as transformers, distribution panels etc. over an extended period of time
- evaluate the results and provide cost effective solutions.it is important to brief the client and other relevant persons on the results upon completion of the site survey. This will give one a chance to communicate about potential safety hazards, suspected problem areas and possible recommendations

Organizing documentation is critical part of the survey and pre planning and is mostly required for building permits, and legal utility interconnection.

The key components of a system documentation package may include. System design and equipment specification, site layout drawings, operator manuals for equipment, installation, operation and maintenance procedures

5.2.1.4 Learning Activities

Learning activity	Special instructions
Explain the importance of carrying out a site survey	
Explain the requirements of the relevant regulatory bodies that are necessary to consider before embarking on any work on a construction site	Illustrate the various examples of various permits e.g. county government permits.NCA licenses, KEBS authoriyation
Explain how to identify the locations and routing of the cables	Conduct a field trip on a construction site and illustrate while on site the critical area to consider
Explain the necessary measurements to be taken and the equipment to be used	Illustrate while on site how to operate/use the measuring tools
Discuss the need to write a survey report and what it entails	Trainees to write a sample site survey report based on the previous site visit or field trip

5.2.1.5 Self-Assessment

5.2.1.6 Tools, Equipment, Supplies and Materials

- Spirit level,
- Tri square,
- Measuring tape.
- Thermometer clamp on ammeters

- Harmonics analyzers
- Power line monitors oscilloscopes with line viewe
- Earth/ground resistance rester impedance tester
- Safety equipment appropriate PPE safety glasses
- Safety Shoes
- Gloves
- RFI, Emi
- Stationary
- Assorted cables
- Copy of osha rules
- Copy of county government by laws

5.2.1.6.1 References

5.2.2 **Learning Outcome 2:** Perform system sizing

5.2.2.1 Introduction to the learning outcome

Electricity is much more than a national asset and besides being of deep social importance it is the main influence for good life.it is essential to our daily life and work. There are rules and regulations which govern electrical installation practice. These rules, codes of practice and standards are essential to ensure that all installations provide adequate safety from two types of electric hazards ie electric shock and electric fire. A general requirement of every electrician is that he should be familiar with the regulations that govern the electro technical industry,

5.2.2.2 Performance Standard

5.2.2.2.1 Load estimation is conducted according to the set standard
5.2.2.2.2 Types and sizes of protective devices are determined according to IEE regulations
5.2.2.2.3 Cable sizes are calculated for the estimated load according to IEE regulations
5.2.2.2.4 System sizes are recorded and shared as per established procedures

5.2.2.3 Information Sheet

The Rules and Regulations that guide the electrical installation practice are categorized into two, i.e. statutory and non-statutory regulations.

statutory laws are those that have been passed by parliament and have therefore become laws of the land. None compliance to such laws can lead to prosecution by courts and possible imprisonment

statutory laws are issued to ensure a proper and safe supply of electrical energy up to the consumers terminal

IEE REGS/

These are non-statutory regulations designed to supplement statutory laws in order to ensure maximum degree of safety particularly from electric fire and electric shock.

These regulations relate primarily to the design, selection, erection, inspection and testing of electrical installations, whether in permanent or temporary, inside and outside buildings generally and to Domestic houses, Commercial buildings, Industrial premises, agricultural and horticultural premises as well as in construction sites. They apply only to electrical installations operating at a voltage of up to 1000V. The current edition of the IEE regs is the 17th edition which became law in 2008, following this several guidance notes have been published to help the electricians understand the regulations

https://www.google.co.ke/search?tbm=bks&tbm=bks&q=inauthor:%22The+Institute+of+Engineering%22&sa=X&ved=2ahUKEwjA4Nnvu4_tAhWxtXEKHe1rCJYQ9AgwAHoECAAQBw

KEBS

The Kenya Bureau of Statistics KEBS has a role of promoting standardization of goods in industry and commerce. It provides the facilities for examination and testing of commodities and materials manufactured in Kenya as well as test goods brought in for consumption in Kenya for purposes of certification. Electrical cables locally manufactured must have the diamond mark of quality which qualifies them to be used with an assurance of maximum safety

BS CODES OF PRACTICE

British standards and the codes of practice do not have the force of law but they do represent best practice and they may be referred to in a court of law in the event of an accident or installation failure.it is recommended that everyone involved in an installation project should follow the recommendations as far as is practically possible. These regulations are concerned with all the aspects of installations. They touch on particular aspects relating to the construction of electrical equipment

The electric power supply company is responsible of distributing and supplying electric power according to electricity supply regulations. The electric sub-contractors must carry out installation works as per the supply authority i.e. KPLC by- laws.

The supply regulations are well embedded in the energy act e.g. the energy act of 2019

https://kplc.co.ke/img/full/o8wccHsFPaZ3_ENERGY%20ACT%202019.pdf

The national construction authority NCA is a government organization which regulates, streamlines and builds capacity in the construction industry.it is advisable to consult with the NCA to be sure that the building in which the installation is to be performed is constructed in accordance with the county bye laws and is up to the NCA specifications.

System sizing is determined by the individual sizes of various components such as cables, switchgear.

A cable forms the necessary connections between the generating stations, apparatus and consumers which use electricity. They comprise a very a wide range of types. The necessary requirements of a cable are that they should conduct electricity efficiently, cheaply and safely. The cable should not be too small such as to have large internal voltage drop.

Cables may be classified according to the number of conductors or according to its application.

E.g. two core cables

3 core cables

power cables

communication cables

welding cables

equipment cables

The IEE regulation requires that

- Every cable shall be selected and installed as to be suitable for operation and at such suitable temperature,
- All cables in an installation shall be properly supported so that there shall be no appreciable strain on cable termination
- All cables shall be adequately protected against mechanical protection
- Where cables pass through ceiling walls or partitions, the surrounding holes must be made good with cement or other fire resisting materials to prevent spread of fire

The electrical installation designer should ensure that the choice of the cables for particular installations should be such that the maximum permissible voltage drop as recommended in the IEE

regulations is not exceeded. The current rating tables are provided which indicate the volt drop when a current of 1 Ampere flows through a 1 meter
length of a particular cable
If for a particular size of cable, the voltage drop exceeds the permitted voltage, the next size of the cable is chosen from the tables until the final voltage drop is less than the permitted.
Factors considered while selecting a suitable cable size are,

- Ambient temperature
- Installation conditions ie whether the cable is bunched with others or not
- Type of circuit protection either by use of semi enclosed fuses or MCB
- Type of thermal insulation material used

The IEE regulations require that the choice of a cable to feed a circuit must have regard of all the above factors and not just the current. It is required that the method used to determine the correct size should be based on the rating of the current devices.

Procedure of determining the right size of a cable

- Determine the load current of the circuit IL
- Determine the correction factor for ambient temperature which the cable is to be installed C_t
- Determine the correction factor for grouping if the cable is bunched/run with others ie C_g
- Determine the correction factor if the cable is in contact with or surrounded by a thermal insulation material C_I=0.75 if one side of the cable is in contact with the material or C_i= 0.5 if the cable is completely surrounded by the material
- Select rating of overcurrent device protection eg for MCB for close excess current protection C_P=1.0 and for coarse excess current protection afforded by semi enclosed fuses rating C_P = 0.725
- Determine the size of circuit conductor by calculating the desired current
- Check to ensure that the the voltage drop does not exceed maximum permitted

Current rating of conductor = load current

$$C_t \times C_g \times C_i \times C_p$$

From the appropriate tables in the IEE regs select a cable size and determine the voltage drop from

Total voltage drop = $\frac{\text{milliVolts} \times \text{length of run} \times \text{load current}}{1000}$

Confirm whether the voltage drop so calculated is within the allowed. If yes, select the next bigger size and repeat again and again until the calculated voltage drop is below the maximum permitted.

Cable insulation

Cable insulation has the function of confining the electric current within the conductor. Various types of cable insulations are available such as

- Rubber which is used in vulcanized form and it consists of pure rubber mixed with 5 to 6 % of Sulphur. Rubber is flexible and impervious to water
- Pvc - polyvinyl chloride
  Synthetic substitute for rubber with properties similar to those of copper. Suitable for use in temperatures between 0 and 65

Resists direct sunlight and chemical actions

- Paper
  Used in the impregnated form and for voltages between 600V – 1000V to about 33Kv
  Used mainly in underground cables
- Mineral insulation
  Has high resistance to fire and can withstand severe mechanical damage
- Glass insulation is heat resistant used for high temperatures

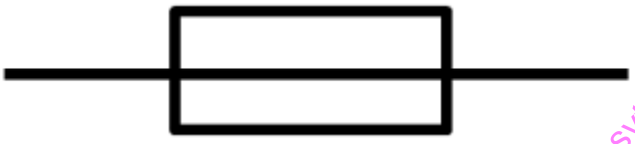
Protective devices

Electric circuits need to be protected against excess current which is likely to flow in conductors and may have a value which may be in excess of the rated resulting to a sudden overload, sustained loads and short circuits between conductors o protect the circuits against this the following protective devices can be used

- Fuse

Symbol of a fuse

The standard IEEE/ANSI symbols for the fuse is as follows:

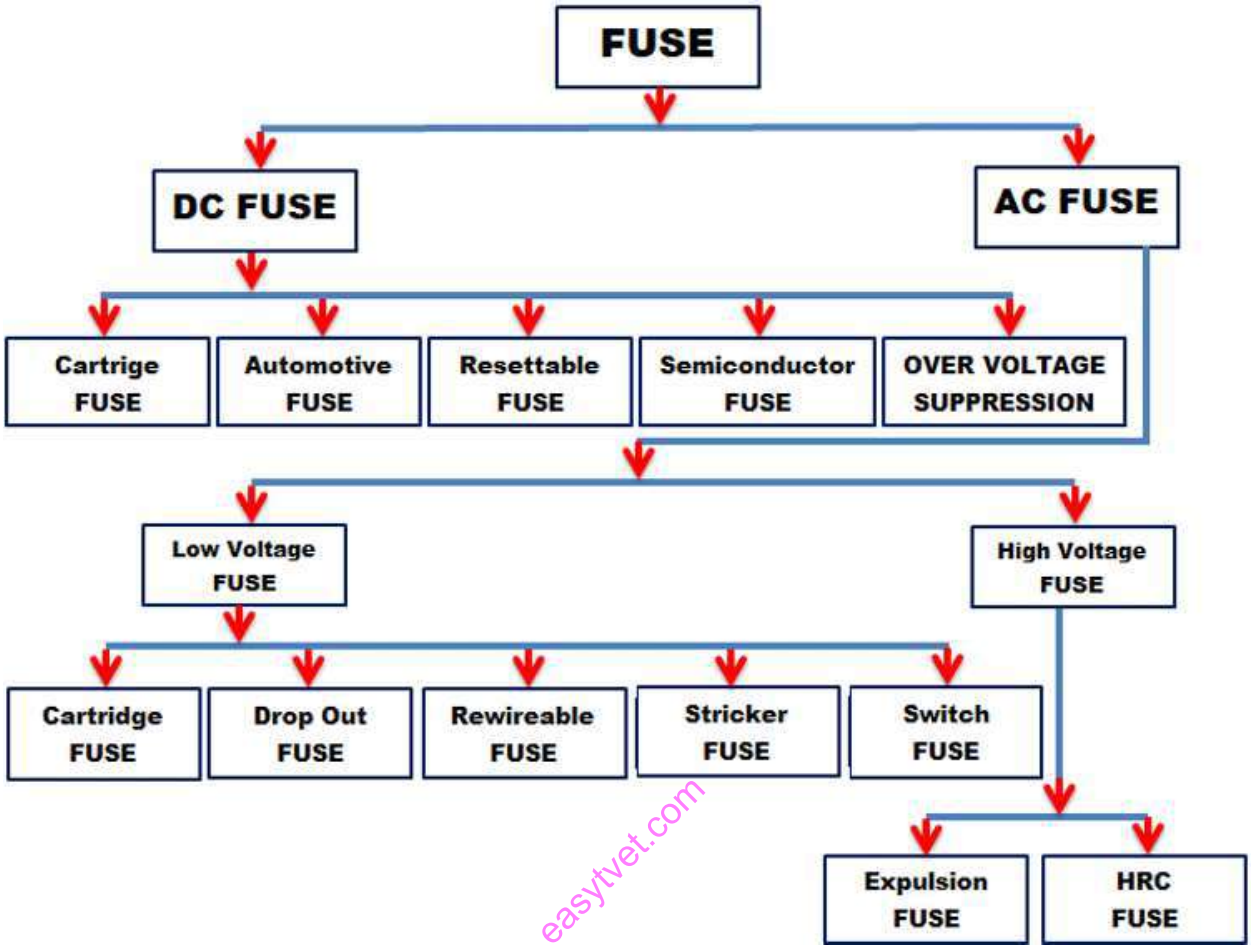


However, the IEC fuse is slightly different:

This is the most common type of fuse. The fuse element is encased in a glass envelope that is terminated by metal caps. The fuse is placed in an appropriate holder. Since the glass envelope is clear, it is easy to visually

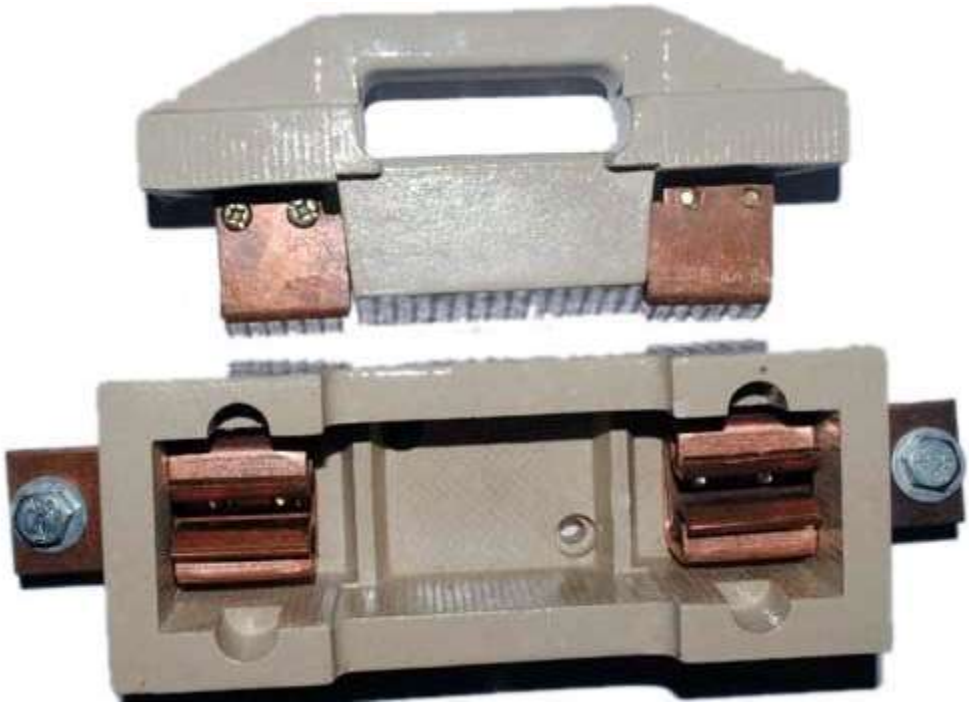
determine if the fuse is blown

classification of fuses



Cartridge fuse

This is the most common type of fuse. The fuse element is encased in a glass envelope that is terminated by metal caps. The fuse is placed in an appropriate holder. Since the glass envelope is clear, it is easy to visually determine if the fuse is blown.



Rewireable fuses: They are a simple reusable fuse used in homes and offices. They consist of a carrier and a socket. When the fuse is blown, the carrier is taken out, rewired and put back in the socket to resume normal operation. They are somewhat less reliable than HRC fuses.

Switch fuse: A handle that is manually operated can connect or disconnect high current fuses.

5.2.2.4 Learning Activities

Learning activity	Special instructions
Discuss the procedure of determining the load current for an installation given the system power input, voltage and power factor	Trainees to perform calculations of load current based on the parameters given
Discuss types of protective equipment and their rating fuses and circuit breakers	Trainees will draw labelled diagrams of the protective devices
Discuss factors that affect the rating and size of cables, illustrate how to interpret data from IEE reg tables	Trainees will practice how to determine or calculate the correct cable size for a given load based on available tables

5.2.2.5 Self-Assessment

1) Which four rating factors are necessary to consider while calculating for a cable? size
2) Complete the abbreviations MPVD as used in cable size calculation
3) A 230V single phase 20Kw load operates at a power factor of 0.7 lagging and is fed from a distribution board located 30m away by a 2 core PVC insulated and armored cable with aluminum conductors. The cable is clipped direct to a cable tray. The ambient temperature is 45^0C and close excess protection is provided.MPVD is 2.5% using table 25m in the IEE regulations 14^{th} edition calculate the correct cable size for the given load.

5.2.2.6 Tools, Equipment, Supplies and Materials

Stationery

IEE regulations 14 th edition

5.2.2.7 References

5.2.3 Learning Outcome 3: Prepare list of tools, equipment and materials

5.2.3.1 Introduction to the learning outcome

Modern electrical installations using new materials that are lasting for a longer duration than 50 years. Therefore, they must be properly installed. Good design, good workmanship by competent persons and the use of proper materials are essential if the installation is to comply with the relevant regulations, (IEE Regulation 134.1.1) so as to reliably and safely meet the requirements of the customer for over half a century. Electricians are not only in charge of making electrical installation but also have responsibilities of caring, storing and control of their tools, equipment and materials. Proper use, handling and storage of the tools, equipment and materials can protect them against loss, breakage and deterioration. In addition, the electrician has a responsibility of new purchase of tools, equipment and materials. Proper storage and timely maintenance can help the electrician's time in search of the available items in store, save a lot of money spent for maintenance and new purchase for replacement of lost or damaged electrical tools, equipment and materials

5.2.3.2 Performance Standard

5.2.3.2.1 The necessary tools and equipment needed for the work are determined and list prepared as per established procedure

5.2.3.2.2 Tools and equipment are checked for correct specifications and functionality and list prepared as per established procedure

5.2.3.2.3 Materials needed for the work are determined and list prepared as per established procedure

5.2.3.3 Information Sheet

The basic tools required by an electrician are those used in the stripping and connecting of conductors. These are pliers, side cutters, a knife and an assortment of screwdrivers. The tools required in addition to these basic implements will depend upon the type of installation work being undertaken. When wiring new houses or rewiring old ones, the additional tools required are those usually associated with a bricklayer and joiner. Tools should be cared for and maintained in good condition if they are to be used efficiently and remain serviceable. Screwdrivers should have a fl at squared off end and wood chisels should be very sharp. Access to a grindstone will help an electrician to maintain his tools in first-class condition. Additionally, wood chisels will require sharpening on an oilstone to give them a very sharp edge.

A list of necessary tools with correct specifications should be prepared for a given task as per the established procedures.

It is required that the tools and materials are stored in a convenient place so as to;

- Minimize the labour required to place the items in the store
- maintain items in good order
- issue items as quickly and orderly
- make easy inventory of the items
- inspect the quality and quantity of items available in store.

Items must be stored safely to prevent loss, breakage, spoilage and deterioration by heat, cold, sunlight, dampness, insects, rats and mice and spontaneous combustion. They must be stored as visible as possible to reduce duplication, prevent wastage, permit quick check and inspection as well as help in maintaining adequate stock (supplies).

For Storage of tools, equipment and materials, the electrician, should apply the practice of safe storage of working tools, equipment and materials in a

a separate kit which may be provided for use for each individual site worker. The type of the kit will vary from one designer to another.

Tools may be categorized in terms of use such as;

Special tools and equipment: Tools in limited numbers, which may be used by all workers, and are best stored in a centrally located tool crib. This arrangement provides for the proper care and control of these tools. This is particular to high precision instruments.

Machine accessories: can be stored in a Central tool room assigned to one particular site worker. Separate facilities convenient to a particular equipment e.g., closet, racks, drawer, boxes may also be used.

Tool cribs and panels may also be used for new or expansion of existing tools storage. while considering the location for the tools panels an electrician should consider the type of tool and each tool should be held in place by hooks against inclined tool board, in cupboard and on wall. The most frequently used tools should be located close to the distribution point.

The place of tools should be marked by:

- Assigning a symbol, letter or number for a particular tool
- Writing the name of a tool painted over or under the position.
- Having a painted outline of the tool in color contracted with the background, behind the place where it belongs.

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Upon Delivery the materials, tools and equipment must be checked to confirm whether the items received

i. Meet specifications required
ii. Are of the correct quantities
iii. Have any Defects
iv. have Breakages

The accounting procedures must be followed in receiving & checking items delivered ie

v. Signing a receipt or delivery order
vi. Posting the quantities received in the inventory sheet

The storekeeper must;

vii. Open all cases, boxes and inspect all items
viii. Sort goods accurately
ix. Place items in proper location

Safety precautions (care) in handling electrical tools

- Handle sharp edge tools with special care
- Never carry unshielded tools in pockets
- Never throw over tools to each other
- Avoid placing your fingers or hands in the path of motion of the cutting tools.
- Never leave tools on top of a step ladder or on any other place above your head.
- Never use tools for the purpose other than the designed.

Types and applications of Electrical hand tools

A. Wire strippers

The removal of insulation from wires and cables is one of the tasks which, is a major part of installation work. There are many techniques used within the industry, using tools ranging from the simple hand-operated strippers to automatic, motorized types. Hand-operated strippers fall into two main categories: those which are adjustable and those which are not. Within the non-adjustable types are some which have flexible jaws and will strip a range of wire sizes, while others have a series of cutting holes for each wire size.

B. **Adjustable wire strippers**

These have jaws with V-shaped notches to cut the insulation. The adjuster screw acts as a stop to allow for a range of wire diameters. To use the stripper: **i**. Adjust the screw to open or close the jaws so that the V cutting slots cut the insulation cleanly without tearing the insulation or damaging the conductor. **ii**. Use a test piece of wire to adjust the jaws to the correct position to cut the insulation but not the conductor. **iii**. Place the wire in the lower groove; squeeze the handles to cut the insulation, **iv**. Rotate the strippers half a turn and pull off the insulation stub. Check for damage to the conductor. **v.** When the adjustment is found to be correct, tighten the lock nut and test again. If OK, then the strippers are ready for use. **Vi**.

Always check the wire for damage each time you remove insulation with this type of wire stripper.

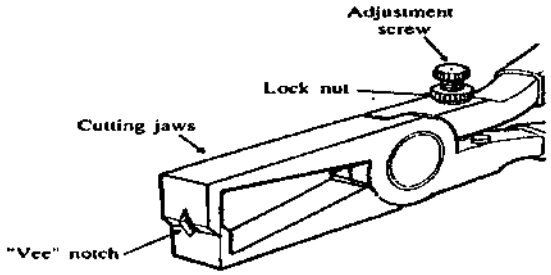


Fig Adjustable wire stripper

C. Hand-held automatic wire stripper

These are fully automatic in operation but it is essential that you use the correct size of cutting hole. There are two sets of jaws: one clamps the wire and holds it while the other cuts the insulation. Both jaws separate to pull the insulation stub away from the wire. The cutting blades can be changed to suit different sizes of conductor diameters. A 'length of strip' guide post can also be fitted.

Hand held automatic wire stripper works as: Place the wire between the jaws from the clamping jaw side into the correct size of cutting notch. If a 'length of strip' post is fitted, the end of the wire should be positioned so that the end is in line with the end of the post. Squeezing the handles will first cause the wire clamp jaw to close. Next the cutting jaws close; further squeezing will cause both sets of jaws to separate, pulling off the insulation stub. Continue to squeeze the handles and the jaws both open then snap together, releasing the wire. If you are going to twist the strands of flexible wire after stripping it is useful to arrange it so that the insulation stub is not completely removed from the conductor.

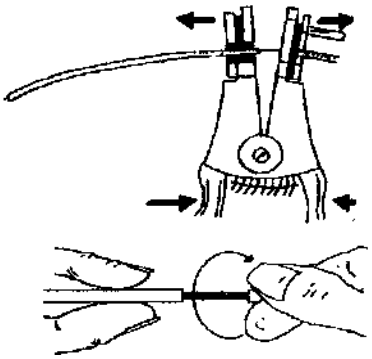


Fig Hand held automatic wire stripper

D. Cutting tools

The basic tools required by an electrician are those used in the cutting of conductors and other materials like the conduit, trunkings etc, that will be used in a given installation. These are pliers, side cutters, hacksaws, a knife among others. The tools required in addition to these basic implements will depend upon the type of installation work being undertaken. When wiring new houses or rewiring old ones, the additional tools required will be dependent on the

type of the work to be done. All tools must be used safely and sensibly. Cutting tools should be sharpened and screwdrivers ground to a sharp square end on a grindstone.

E. Pliers

Pliers are used for cutting and gripping wires.

a. **Side cutting plier**: used for cutting and gripping wires; it also pulls on snake wire through pipes.

b. **Diagonal cutting plier**: used to cut off wires close to connecting points such as switch and outlet terminals which are located close to the fitting so that the side cutting plier may not able to get close enough.

c. **Flat nose pliers**: used for bending, twisting and forming conductors and bus bashers.

d. **Long (sharp) nose pliers**: used for pulling wires and other materials through narrow holes or narrow areas.

e. **Round nose pliers**: used for looping conductors in order to connect them to the terminals.

f. **Slip joint pliers**

The slip joint permits the jaws to be extended to greater width than is possible with a cutting plier of the same size. **The slip joint pliers, are then** used to gripping wires, cutting wires and holding conduits while making up locknuts and bushings.

F. Electrician knife

Electrician knives are used for removing insulation in electrical wiring. The blade should be made of high grade, tempered steel. The knife should be strong, serviceable and, if possible, of the closing type.

G. **Hack saw**

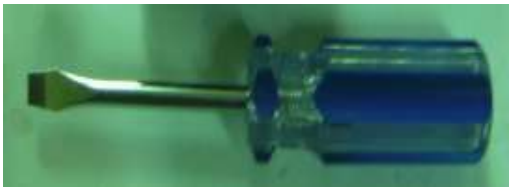
It is used for cutting metallic parts such as cable armor and conduit tubes. Hacksaw should be adjusted in the frame to prevent buckling and breaking, but not be tighten enough to break off the pins that support the blade. While installing the blade the teeth should point forward. When using hack saw, pressure is applied on the forward stroke not on the back stroke. **Caution:** If the blade is twisted or too much pressure is applied, the blade may break and cause injury to the hands or arms of the user.

Fig. Hacksaw

H. Screw drivers (sets)

Screw drivers are used to drive screws into and out of wood or some other materials.

a. **Standard/ Flat/ blade screw driver** is used for general purpose**.**



b. **Square blade screw driver:** is a strong screw driver used for turning **stubborn or heavy screws**. It has the possibility of increasing hand pressure and turning moment by means of a plier or a wrench.
c. **Thin blade screw driver:** is used for installing a screw past an obstacle or a nearby object (Inside a small holes).

d. Hammer

Hammers are used to drive chisels, straighten metals & pick out nails.

a. **Claw hammers** are of two types: Straight and curved claw hammers.

b. **Straight claw hammers** are inserted beneath, behind or between boards or timbers to be detached.
c. **Curved claw hammers** mainly used for picking out nails.
d. **Ball peen hammer:** provides greater striking power needed in such cases as driving a chisel or a stat drill into brick or concrete walls.
e. **Peen hammer** used for heavy duties since it provide for greater power.

Chisels

Chisels are used to cut metals as well as dig holes or grooves in brick or concrete walls. The following chisels are common in doing electrical works.

a. **Cold chisels** used to cut metals, bricks, concrete or any hard materials forged from alloy steel, hardened and tempered.
b. **Cape chisels** have sufficient sized striking heads and a narrower cutting edge which enables to penetrate hard surfaces, particularly metal, somewhat better than cold chisels.
c. **Wood chisel** used for performing soft operation such as grooves on wooden construction.

Cold chisel

Cape chisel

wood chisel

star/ start chisel

d. **Star chisel or start drill** used to make a circular hole through brickwork, concrete construction and other stone work

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Steel tape/ draw wire

Direct linear measurements of ordinary or more accurate precision require a steel tape. The most commonly used length is 100 feet, but tapes are also available in 50-, 200-, 300-, and 500-feet lengths. The 500-tape is usually a flat-wire type. Most steel tapes are graduated in feet and decimals of feet, but some are graduated in feet and inches, meters, and chains or other linear units. It is used for passing wire or cable through conduits, pipes or through spaces in the walls and under the floor of a house.

Some tapes, called engineers or direct reading tapes, are graduated in subdivisions of each foot. The tape most commonly used, however, is the so-called chain tape, on which only the first foot at the zero end of the tape is graduated in subdivisions; the main body of the tape is graduated only at every one foot mark. A steel tape is sometimes equipped with a reel on which the tape can be wound, although a tape can be, and often is, detached from the reel for convenience. There are various types of surveying tapes; metallic tape, steel tape on an open reel, steel tape on a closed reel, and special types of low-expansion steel tape, generally called an Invar tape or Lovar tape, used in high-order work.

Mallet is a wooden made hammer used to bend (give shape) of wire while working on the machines.

Equipment

Drill

Drills are of two types: hand drill and electric (hand) drill.

a. **Hand drill** is used to hold round shank drills during drilling operation to make holes on concrete, wooden and/ or metallic materials.

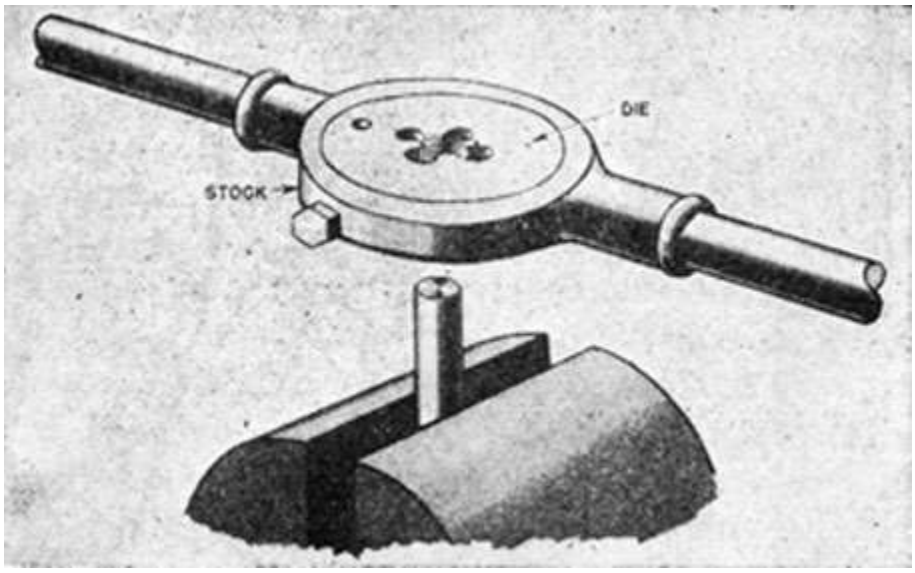
b. **Electric hand drill** is portable enough to be carried to places other than the workshop and connected to the power source by means of a long cord to drill holes on concrete, wooden and metallic bodies.

Fig Portable hand drills

Stocks and die

Dice are blocks of metal screw spiral cut inside them which are used for making external threads on conduits or pipes.

The most commonly types of vices likely to be used is the “bench” vise which can come with a fixed or swivel base. They are also available with or without pipe holding jaws. Bench vises are usually bolt mounted to a bench but clamp on models are also available for lighter duty. The blacksmith’s vise is useful for work which must be pounced; it is secured to a bench and braced by the long leg attached to a solid base on the floor. Pipe vises are also useful to various trades. The yoke type pipe vise usually has capacity up to about 8 cm. (3 in.). The chain-type vise has a larger diameter capability as well as being useful for irregular shape.



Procedures of Safe uses of vice are:

- Mount vice securely.
- Keep work close to jaws.
- Keep vice cleaned, oiled.
- Support extra-long work.
- Prop very heavy work in vice with wood blocks to prevent it from falling and causing injury.
- Don't open jaws beyond their capacity; the moveable jaw may fall, causing injury or damage.

Materials

Cables

For high voltage distribution services, cables having polymeric insulation, usually cross-linked polyethylene (XLPE), are finding favor over PILC types due mainly to the simplicity with which they may be terminated and jointed. The most usual construction is XLPE/SWA/PVC. For low voltage systems the universal PVC/SWA/PVC is generally satisfactory. Where cables are routed through buildings or in cable tunnels, safety requirements may in some cases dictate the use of low smoke/low fume cable types.

The choice between copper or aluminum conductors and, in the case of aluminium, solid or stranded construction, is influenced by cost and the practicalities of installation. Aluminium cables, where they are known to be such, are much less likely to be the subject of theft while waiting, or during, installation. As in any installation, conductor sizes must be chosen to meet the requirements of both current-carrying capacity and acceptable voltage drop. With regard to current-carrying capacity, decisions should be based on the usual factors and need not be discussed here. The question of cable size in relation to voltage drop is less clear. For low voltage systems the requirements of BS 7671 (IEE 16th edition) are deemed to be satisfied if the voltage drop between the origin of the installation and the fixed current-using equipment does not exceed 4% of the nominal voltage of the supply. This can be interpreted as being applicable to a 'site distribution system' operating at low voltage but there is at present no

equivalent standard for high voltage systems. Where a high voltage system is supplying power to be utilized entirely at low voltage, the voltage drop on the high voltage system may not be as important and can usually be compensated for by tap selection on the transformers at the load center substations. (Overvoltage under light load conditions must not then exceed a value that might be damaging to the connected equipment.) Where loads such as large motors are supplied directly at the high voltage system voltage, cable sizes should be selected to limit the voltage drop to a value acceptable to the manufacturers of the equipment in question.

Conduits

Definition of Conduit

A conduit is a tube, channel or pipe in which insulated conductors are contained. The conduit, in effect, replaces the PVC outer sheath of a cable, providing mechanical protection for the insulated conductors. A conduit installation can be rewired easily or altered at any time, and this flexibility, coupled with mechanical protection, makes conduit installations popular for commercial and industrial applications.

Types and applications of conduits

There are three types of conduit used in electrical installation work. Namely: steel, PVC and flexible.

Steel Conduit

Steel conduits are made to a specification defined by IEEE standards and are either heavy gauge welded or solid drawn. Heavy gauge is made from a sheet of steel welded along the seam to form a tube and is used for most electrical installation work. Solid drawn conduit is a seamless tube which is much more expensive and only used for special gas-tight, explosion-proof or flameproof installations. Steel conduit is supplied in 3.75 m lengths and typical sizes are 16, 20, 25 and 32 mm. Conduit tubing and fittings are supplied in a black enamel finish for internal use or hot galvanized finish for use on external or damp installations. A wide range of fittings is available and the conduit is fixed using Saddles or pipe hooks.

PVC Conduit

PVC conduit used on typical electrical installations is heavy gauge standard impact tube manufactured. The conduit size and range of fittings are the same as those available for metal conduit. PVC conduit is most often joined by placing the end of the conduit into the appropriate fitting and fixing with a PVC solvent adhesive.

PVC conduit can be bent by hand using a bending spring of the same diameter as the inside of the conduit. The spring is pushed into the conduit to the point of the intended bend and the conduit then bent over the knee. The spring ensures that the conduit keeps its circular shape. In

cold weather, a little warmth applied to the point of the intended bend often helps to achieve a more successful bend.

The advantages of a PVC conduit system are that it may be installed much more quickly than steel conduit and is non-corrosive, but it does not have the mechanical strength of steel conduit. Since PVC conduit is an insulator it cannot be used as the CPC and a separate earth conductor must be run to every outlet. It is not suitable for installations subjected to temperatures below 25°C or above 60°C. Where luminaires are suspended from PVC conduit boxes, precautions must be taken to ensure that the lamp does not raise the box temperature or that the mass of the luminaire supported by each box does not exceed the maximum recommended by the manufacturer (IEE Regulations. PVC conduit also expands much more than metal conduit and so long runs require an expansion coupling to allow for conduit movement and help to prevent distortion during temperature changes. All conduit installations must be erected first before any wiring is installed. The radius of all bends in conduit must not cause the cables to suffer damage, and therefore the minimum radius of bends as indicated in IEEE regulation. All conduits should terminate in a box or fitting and meet the boxes or fittings at right angles.

When drawing cables into conduit, they must first be run off the cable drum. That is, the drum must be rotated and not allowed to spiral off, which will cause the cable to twist. Cables should be fed into the conduit in a manner which prevents any cable crossing over and becoming twisted inside the conduit. The cable insulation must not be damaged on the metal edges of the draw-in box. Cables can be pulled in on a draw wire if the run is a long one. The draw wire itself may be drawn in on a fish tape, which is a thin spring steel or plastic tape. A limit must be placed on the number of bends between boxes in a conduit run and the number of cables which may be drawn into a conduit to prevent the cables being strained during wiring.

Flexible conduit

Flexible conduit is made of interlinked metal spirals often covered with a PVC sleeving. The tubing must not be relied upon to provide a continuous earth path and, consequently, a separate CPC must be run either inside or outside the flexible tube. Flexible conduit is used for the final connection to motors so that the vibrations of the motor are not transmitted throughout the electrical installation and to allow for modifications to be made to the final motor position and drive belt adjustments.

Trays/ duct

Cable tray is a sheet-steel channel with multiple holes. The most common finish is hot-dipped galvanized but PVC-coated tray is also available. It is used extensively on large industrial and commercial installations for supporting Mineral Insulated (MI) and SWA cables which are laid on the cable tray and secured with cable ties through the tray holes. Cable tray should be adequately supported during installation by brackets which are appropriate for the particular installation. The tray should be bolted to the brackets with round-headed bolts and nuts, with the round head inside the tray so that cables drawn along the tray are not damaged. The tray is supplied in standard widths from 50 to 900 mm, and a wide range of bends, tees and reducers is available. The tray can also be bent using a cable tray bending machine to create bends. The installed tray should be securely bolted with round-headed bolts where lengths or accessories are attached, so that there is a continuous earth path which may be bonded to an electrical earth. The whole tray should provide a firm support for the cables and therefore the tray fixings must be capable of supporting the weight of both the tray and cables.

Types and application of cable trays

Metallic cable Tray

The metallic (often slotted) construction of heavy-duty cable tray makes it appropriate for the support of heavy cables such as SWA mains or large numbers of MICC circuits in an industrial site. Other types and even categories of cables can use the same tray for support when appropriate. Cable ladders are a variation for vertical runs between horizontal trays, and find economic uses in power stations and factories with particularly dense cable populations. The overall technique allows excellent simple mechanical support with accessibility and little of the problem from grouping factors due to bunching of cables. Secondary trays may be installed alongside the main tray to house the final distribution

and/or data cables if segregation is a problem or specific EMC considerations prevail; otherwise the same tray can often house various cables.

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Plastic coated cable tray

Definition, types and installation of Trunking

A trunking is an enclosure provided for the protection of cables which is normally square or rectangular in cross-section, having one removable side. Trunking may be thought of as a more accessible conduit system and for industrial and commercial installations it is replacing the larger conduit sizes. A trunking system can have great flexibility when used in conjunction with conduit; the trunking forms the background or framework for the installation, with conduits running from the trunking to the point controlling the current-using apparatus. When an alteration or extension is required it is easy to drill a hole in the side of the trunking and run a conduit to the new point. The new wiring can then be drawn through the new conduit and the existing trunking to the supply point. Trunking is supplied in 3m lengths and various cross-sections measured in millimetres from 50 _50 up to 300_ 150. Most trunking is available in either steel or plastic.

Types of Trunking

Metallic Trunking

Metallic trunking is formed from mild steel sheet, coated with grey or silver enamel paint for internal use or a hot-dipped galvanized coating where damp conditions might be encountered and made to a

specification defined by BS EN 500 85. A wide range of accessories is available, such as 45° bends, 90° bends, tee and four-way junctions, for speedy on-site assembly. Alternatively, bends may be fabricated in lengths of trunking. This may be necessary or more convenient if a bend or set is non-standard, but it does take more time to fabricate bends than merely to bolt on standard accessories. When fabricating bends the trunking should be supported with wooden blocks for sawing and fi ling, in order to prevent the sheet-steel vibrating or becoming deformed. Fish plates must be made and riveted or bolted to the trunking to form a solid and secure bend. When manufactured bends are used, the continuity of the earth path must be ensured across the joint by making all fi xing screw connections very tight, or fi tting a separate copper strap between the trunking and the standard bend. If an earth continuity test on the trunking is found to be unsatisfactory, an insulated CPC must be installed inside the trunking. The size of the protective conductor will be determined by the largest cable contained in the trunking, as described by the IEE Regulations. If the circuit conductors are less than 16 mm^2, then a 16 mm^2 Circuit Protective Conductor will be required.

Non- metallic Trunking

Trunking and trunking accessories are also available in high-impact PVC.

The accessories are usually secured to the lengths of trunking with a PVC solvent adhesive. PVC trunking, like PVC conduit, is easy to install and is non-corrosive. A separate CPC will need to be installed and non-metallic trunking may require more frequent fixings because it is less rigid than metallic trunking. All trunking

fixings should use round-headed screws to prevent damage to cables since the thin sheet construction makes it impossible to countersink screw heads.

Mini-Trunking

Mini-trunking is very small PVC trunking, ideal for surface wiring in domestic and commercial installations such as offices. The trunking has a cross-section of 16 _ 16 mm, 25 _16 mm, 38 _16mm or 38 _ 25 mm and is ideal for switch drops or for housing auxiliary circuits such as telephone or audio equipment wiring. The modern square look in switches and sockets is complemented by the mini-trunking which is very easy to install.

Skirting Trunking

Skirting trunking is a trunking manufactured from PVC or steel and in the shape of a skirting board is frequently used in commercial buildings such as hospitals, laboratories and offices. The trunking is fitted around the walls of a room at either the skirting board level or at the working surface level and contains the wiring for socket outlets and telephone points which are mounted on the cover. Any trunking passes through walls, partitions, ceilings or floors, short lengths of lid should be fitted so that the remainder of the lid may be removed later without difficulty. Any damage to the structure of the buildings must be made good with mortar, plaster or concrete in order to prevent the spread of fire. Fire barriers must be fitted inside the trunking every 5m, or at every floor level or room dividing wall, if this is a shorter distance. Where trunking is installed vertically, the installed conductors must be supported so that the maximum unsupported length of non-sheathed cable does not exceed 5m. PVC insulated cables are usually drawn into an erected conduit installation or laid into an erected trunking installation.

Skirting trunking

Fittings

Fittings are joining materials. Plastic can be joined with an appropriate solvent. Metals may be welded, brazed or soldered, but the most popular method of on-site joining of metals on electrical installations is by nuts and bolts or rivets. A nut and bolt joint may be considered a temporary fastening since the parts can easily be separated if required by unscrewing the nut and removing the bolt. A rivet is a permanent fastening since the parts riveted together cannot be easily separated.

Two pieces of metal joined by a bolt and nut and by a machine screw and nut. The nut is tightened to secure the joint. When joining trunking or cable trays, a round head machine screw should be used with the head inside to reduce the risk of damage to cables being drawn into the trunking or tray.

Thin sheet material such as trunking is often joined using a pop riveter. Special rivets are used with a hand tool. Where possible, the parts to be riveted should be clamped and drilled together with a clearance hole for the rivet.

The stem of the rivet is pushed into the nose bush of the riveter until the alloy sleeve of the rivet is flush with the nose bush

(a) The rivet is then placed in the hole and the handles squeezed together

(b) The alloy sleeve is compressed and the rivet stem will break off when the rivet is set and the joint complete

(c) To release the broken off stem piece, the nose bush is turned upwards and the handles opened sharply. The stem will fall out and is discarded

Bracket supports

Conduit and trunking may be fixed directly to a surface such as a brick wall or concrete ceiling, but where cable runs are across girders or other steel framework, spring steel clips may be used but support brackets or clips often require manufacturing. The brackets are usually made from flat iron, which is painted after manufacturing to prevent corrosion. They may be made on-site by the electrician or, if many brackets are required, the electrical contractor may make a working sketch with dimensions and have the items manufactured by a blacksmith or metal fabricator. The type of bracket required will be determined by the installation, which may be modified to suit particular circumstances.

Fixings

Fixing methods

PVC insulated, and sheathed wiring systems are usually fixed with PVC clips in order to comply with IEEE Regulation 522.8.3 and 4. The clips are supplied in various sizes to hold the cable firmly, and the

fixing nail is a hardened masonry nail. The use of a masonry nail means that fixings to wood, plaster, brick or stone can be made with equal ease in which the screw can be secured.

a. Plastic plugs

A plastic plug is made of a hollow plastic tube split up to half its length to allow for expansion. Each size of plastic plug is color coded to match a wood screw size. A hole is drilled into the masonry, using a masonry drill of the same diameter, to the length of the plastic plug. The plastic plug is inserted into the hole and tapped home until it is level with the surface of the masonry. Finally, the fixing screw is driven into the plastic plug until it becomes tight and the fixture is secure.

Expansion bolts

The most well-known expansion bolt is made by raw bolt and consists of a split iron shell held together at one end by a steel ferrule and a spring wire clip at the other end. Tightening the bolt draws up an expanding bolt inside the split iron shell, forcing the iron to expand and grip the masonry. Raw bolts are for heavy-duty masonry fixings. A hole is drilled in the masonry to take the iron shell and ferrule. The iron shell is inserted with the spring wire clip end first so that the ferrule is at the outer surface. The bolt is passed through the fixture, located in the expanding nut and tightened until the fixing becomes secure.

Spring Toggle bolts

A spring toggle bolt provides one method of fixing to hollow partition walls which are usually faced with plasterboard and a plaster skimming.

Plasterboard and plaster wall or ceiling surfaces are not strong enough to support a load fixed directly into the plasterboard, but the spring toggle spreads the load over a larger area, making the fixing suitable for light loads. A hole is drilled through the plasterboard and into the cavity. The toggle bolt is passed through the fixture and the toggle wings screwed into the bolt. The toggle wings are compressed and passed through the hole in the plasterboard and into the cavity where they spring apart and rest on the cavity side of the plasterboard. The bolt is tightened until the fixing becomes firm. The bolt of the spring toggle cannot be removed after fixing without the loss of the toggle wings. If it becomes necessary to remove and re-fix the fixture a new toggle bolt will have to be used.

Measuring tools

The measuring tools that would be used to measure conductors that is required for a given installation may range from a steel rule to a tape measure.

Measuring equipment

The test instruments and test leads used by the electrician for testing an electrical installation must meet all the requirements of the relevant regulations. The HSE has published guidance note GS 38 for test equipment used by electricians. The IEE Regulations (BS 7671) also specify the test voltage or current required to carry out particular tests satisfactorily. All test equipment must be chosen to comply with the relevant parts of BS EN 61557. All testing must, therefore, be carried out using an ‘approved’ test instrument if the test results are to be valid. The test instrument must also carry a calibration certificate, otherwise the recorded results may be void. Calibration certificates usually last for a year. Test instruments must, therefore, be tested and recalibrated each year by an approved supplier. This will maintain the accuracy of the instrument to an acceptable level, usually within 2% of the true value. Modern digital test instruments are reasonably robust, but to maintain them in good working order they must be treated with care. An approved test instrument costs as much as a good-quality camera; it should, therefore, receive the same care and consideration.

Cables and conductors

Most cables can be considered to be constructed in three parts: the conductor, which must be of a suitable cross-section to carry the load current; the insulation, which has a colour or number code for identification; and the outer sheath, which may contain some means of providing protection from mechanical damage. The conductors of a cable are made of either copper or aluminum and may be stranded or solid. Solid conductors are only used in fixed wiring installations and may be shaped in larger cables. Stranded conductors are more flexible and conductor sizes from 4.0 to 25 mm 2 contain seven strands. A 10 mm 2 conductor, for example, has seven 1.35 mm diameter strands which collectively make up the 10 mm 2 cross-sectional area of the cable. Conductors above 25 mm 2 have more than seven strands, depending upon the size of the cable. Flexible cords have multiple strands of very fi ne wire, as fi ne as one strand of human hair. This gives the cable its very flexible quality. Rectangular conductors (usually called bus bars) are used in distribution boards or specially constructed bus bar chambers designed to allow many different circuits to be tapped from.

In many existing installations old cables can still be found insulated with rubber although they are no longer manufactured. A modern wiring material for cables is polyvinyl chloride (PVC). PVC insulated single core cables (singles) are used when the installation is to be run in a conduit or trunking.

Another type of fixed wiring cable is mineral insulated metal sheathed (MIMS)cable. They are strong and long lasting.

Armored cables are also an extension of the type of cables used in fixed wiring. Here the inner PVC sheath is in turn sheathed in strands of steel wire and an overall sheath fitted on the outer cover.

Crimping tool

This is a tool that is used to crimp lugs at the end of the conductor. Lug terminations is frequently used for connecting a conductor to the busbars.

accessible conduit system and for industrial and commercial installations it is replacing the larger conduit sizes.

A trunking system can have great flexibility when used in conjunction with conduit; the trunking forms the background or framework for the installation, with conduits running from the trunking to the point controlling the current-using apparatus. When an alteration or extension is required it is easy to drill a hole in the side of the trunking and run a conduit to the new point. The new wiring can then be drawn through the new conduit and the existing trunking to the supply point.

Trunking is supplied in 3 m lengths and various cross-sections measured in millimetres from 50 _ 50 up to 300 _ 150. Most trunking is available in either steel or plastic.

Joining materials

Plastic can be joined with an appropriate solvent. Metal may be welded, brazed or soldered, but the most popular method of on-site joining of metal on electrical installations is by nuts and bolts or rivets. A nut and bolt joint may be considered a temporary fastening since the parts can easily be separated if required by unscrewing the nut and removing the bolt. A rivet is a permanent fastening since the parts riveted together cannot be easily separated. The stem of the rivet is pushed into the nose bush of the riveter until the alloy sleeve of the rivet is flush with the nose bush (a). The rivet is then placed in the hole and the handles squeezed together (b). The alloy sleeve is compressed and the rivet stem will break off when the rivet is set and the joint complete (c). To release the broken-off stem piece, the nose bush is turned upwards and the handles opened sharply.

5.2.3.4 Learning Activities

Learning activity	Special instructions

Discuss the necessary types of tools and equipment required according to their purpose for an electrical installation project.	Trainees to identify tools from the tool racks or store and sketch them then list them on a table as guided
Demonstrate how to check on the specifications of tools and equipment required for the project from the manufacturers manual	Trainees will practice on how to list the equipment and their specifications
Discuss the materials required for a particular installation project	Identify the materials required at each stage of the installation project and list them according to size and purpose

5.2.3.5 Self-ssessment

1. Good housekeeping' at work is about:
a. cleaning up and putting waste in the skip
b. working safely
c. making the tea and collecting everyone's lunch
d. putting tools and equipment away after use.

2. Which hand tools would you use for terminating conductors in a junction box?
a. a pair of side cutters or knife
b. a screwdriver
c. a wood chisel and saw
d. a tenon saw.

3. Which hand tools would you use for removing cable insulation?
a. a pair of side cutters or knife
b. a screwdriver
c. a wood chisel and saw.
d. a tenon saw.

4. Which hand tools would you use to cut across a floorboard before lifting?
a. a pair of side cutters or knife
b. a screwdriver
c. a wood chisel and saw
d. a tenon saw.

5. Which hand tools would you use to cut and remove a notch in a floor joist?
a. a pair of side cutters or knife
b. a screwdriver
c. a wood chisel and saw
d. a tenon saw

5.2.3.6 Tools, Equipment, Supplies and Materials

- Screw driver
- Pliers different types
- Cable strippers
- Hammer
- Electrician knife
- Power drill

Measuring tools

- Voltage tester
- Clamp on ammeter

materials

- Steel conduit
- PVC conduit & Flexible conduit
- Hacksaw Taps & dies
- IEE Regulation and KEBS standards.
- Pieces of conduit with threads and without.
- Running coupler set, conduit boxes, bends
- Different types of cables
- Bolts and nuts
- Flip chart
- Equipment and tools Manufacturer's manuals
- Chalk board

5.2.3.7 References

Electrical installation principles and practice by J. Hyde Macmillan text for industrial vocational and technical education. pp 63-85

Basic Electrical installation works by Trevor Linsley, 5th edition pp 139- 159

Electrical installation work by Brian Scaddan 7th edition pp 253-283

5.2.4 **Learning Outcome 4:** Arrange for logistics

5.2.4.1 Introduction to the learning outcome

Logistics refers to the process of co ordinating and moving resources ie people, materials, inventory and equipment from one location to the storage at the work site

It is necessary to plan logistics efficiently in order to purchase raw materials transport them, and store them safely and securely until when they shall be used. Coordinating resources will allow for timely delivery and use of tools, materials ensuring a timely completion of electrical installation project work.

5.2.4.2 Performance Standard

5.2.4.2.1 Necessary logistics for the particular work and site is determined

5.2.4.2.2 Determined logistics are reported and arranged with the responsible party according to work schedule

5.2.4.3 Information Sheet

Logisticians should plan on how the acquired resources will be, stored and transported to their final destination. Logistics management will have to identify prospective distributors and suppliers and determine their effectiveness and accessibility.

There are five elements of logistics:

- Storage, warehousing and materials handling
- Packaging and unitization
- Inventory
- Transport
- Information and control

Only two functions are discussed here ie transport and Storage, warehousing and materials handling

Transport

Role of transport

Transport is the most recognizable role of logistics. This includes all modes of transport including road vehicles, freight trains, cargo shipping and air transport. Without transport, goods as well as human resource would be unable to move from one stage to another. Electrical equipment and material may consist of complex products that may need to be transported from all over the world and so plans must be put in place to ensure the materials arrival is timely. For imported goods, necessary licenses and trade goods certificate must be acquired well in advance to avoid clearance delay at the airport or other points of entry.

Storage and warehousing

This involves safe keeping of the materials, tools and equipment to be used in the project upon arrival on site. The amount of storage capacity required will depend on the type of storage required. The items and quantities to be stored are based on the projects needs within a given contract period. To determine the size of the warehouse required the volume and floor space needed, are considered rather than the weight of the items to be stored. Extra space is needed to load, unload and repack damaged goods, and will also help with ventilation. A good ratio is 30% of the space for access and 70% for storage of materials and equipment. Storage height depends on the type of items and packaging. A two-metre stacking height is appropriate for the majority of items.

Storage and warehouse selection

There are necessary factors to consider while selecting a storage facility for project materials and equipment. Such factors include;

Accessibility:

Access to warehouse should be easy for cars and trucks in all weathers.

Utilities:

There should be office space for the storekeeper, preferably with toilet and wash-up facilities, and regular garbage disposal. Lighting in the warehouse and surrounding area. The warehouse should be fenced and should have facilities present for security personnel

Size:

The warehouse should have sufficient capacity to meet forecast requirements for temporary storage.

Security: Area should not be likely to invite intrusion or vandalism.

Proximity: There should be good access to transport infrastructure.

Easy movement: The warehouse should have sufficient additional floor area to permit easy stock handling and access to all stocks for inspection, and insect and pest control.

Ventilation: The construction should be dry and well ventilated. The roof should be leak-proof. There should be no broken windows. Doors should close securely with no gaps. To reduce temperature inside the warehouse, you should paint the roof and walls outside, in white.

Maintenance: The floor should be flat and solid, preferably smooth and crack-free concrete. The walls should be as clean and smooth as possible.

Storage space management

Zones for activities and areas for storage must be defined inside the warehouse eg at the;

- arrival zone-during unloading, the storekeeper will inspect the delivery for quality and quantity. If this is correct, the storekeeper will accept and register the goods
- packing zone-for some for those items which need to be moved from the store so as to be delivered elsewhere eg generators used to supply temporary installation on site
- delivery zone-to save time during loading and to avoid disorder, items ready to be delivered are stored per destination
- storage zones-where stock is stored.

Human resource involved

Logistician is the person responsible of planning the entire logistics system and is also responsible of managing the store for a small organization. In case of a big enterprise, a store keeper must be employed to take charge of the store and warehouse

The main responsibilities and tasks of the storekeeper are to:

- ensure a correct physical and administrative stock management
- manage the team of loaders
- check the safety of the warehouse and goods.

The storekeeper is responsible for implementing all necessary measures related to the maintenance of the quality of items. If a problem cannot be solved at the storekeeper's level, the logistician has to be informed. The storekeeper is responsible for the items stored.

Annex 15.17 Storekeeper job description

loaders

Loaders are employees working under the responsibility of the storekeeper. They have to load, move and unload goods. They also undertake minor repair and repacking of damaged bags. The number of persons will depend on the volume and on the storage facilities. Loaders can be permanent employees, daily workers or a team paid per ton or unit carried depending on the frequency of activities. For electrical installation work loaders may be hired on a daily basis or for a specific task only

Communication in logistics

This involves the interaction between all the parties involved in a supply, distribution, storage of materials and equipment. If all people from different points of the logistics process are able give ideas for improvements based on firsthand experience, it will make for a much better managed process. If communication is limited, so is the ability of the timely supply and delivery of goods.

Modes of communication

Real-Time Communication through mobile phone softwares. this is a secure and safe communication transmission mode

Ways of improving Communications For efficient logistics

- make it a priority to liase with the suppliers and distributors of material and equipment to ensure that deliveries are on time and in the right quantities at considerable costs
- Regularly meet with stakeholders and suppliers. By getting together with them on a regular basis (weekly for instance) you can highlight and tackle their concerns and worries as they occur. make sure they are regularly updated even if it's just a quick summary email. With suppliers it's also important to regularly asses' relationships from both sides, and offer constructive feedback to the supplier as well as asking for it yourself.
- Always offer options. After negotiations, produce a list of options and relevant cases that back up each. This way, you are giving the stakeholders some influence and aren't taking the decision out of their hands, making them feel they have status.

Communication

When it comes to the communication method itself, one should assess which method best suits the situation that will deliver the optimum results for supply chain success. There are also some basic principles to consider when it comes to how one communicates with stakeholders and suppliers:

- Be clear**.** It's necessary to give clear instructions which are understandable to the team of people in the logistics department
- Be personal and pragmatic. Often with stakeholders, it's more beneficial to give them a call or pay a quick visit than to send less direct communication such as emails. A personal and pragmatic approach will get faster and better results when aiming to implement change.

5.2.4.4 Learning Activities

Learning activity	Special instructions
Discuss the necessary logistics required for particular work at an electrical installation site	Trainees will list all the necessary tasks to be performed with regard to transport and storage of materials required at site
Discuss on how to segregate logistics according to different departments	Trainees will role play different departments and prepare their logistics as per specific work schedule for each department

5.2.4.5 Self-Assessment

I. which two methods of communication may be used by a logistician?

II. how can a logistician endeavor to improve on his communication with the rest of the departments in an organization?
III. Which three factors may one need to consider when selecting a storage facility?
IV. who are the people most likely to be found working in the logistics department?

5.2.4.6 Tools, Equipment, Supplies and Materials

- Stationary
- Flipcharts
- Whiteboards
- Delivery note books
- Templates of material, tools, equipment checklists

5.2.4.7 References

Information sources should be quoted and presented as required in the APA format

5.2.4.8 Model answers to self-assessment

5.2.5 Learning Outcome 5: Prepare installation work

5.2.5.1 Introduction to the learning outcome

Work under this section shall include the supply, installation, testing and delivery in perfect running conditions of the electrical installations for subject project. Preparation of work schedules for the task involved is a major consideration where use of bar graphs, Gantt charts and in some cases critical path analysis. These methods are used to plan how the project will be executed.

5.2.5.2 Performance Standard

5.2.5.2.1 Official request is made for installation drawings
5.2.5.2.2 Installation drawing is acquired and deposited in a safe place as per established procedure
5.2.5.2.3 The scope of installation work is identified
5.2.5.2.4 All work is undertaken safely and as per workplace procedures, National/County regulations and legislative requirements
5.2.5.2.5 Working drawing is prepared in accordance with the design drawing
5.2.5.2.6 Work schedule is prepared based on the scope and the working drawing

5.2.5.3 Information Sheet

Identification of scope of installation work

These installations comprise, but are not limited to, the following: Main Distribution Boards (MDB) Complete electrical installations for all lighting, sockets, and power outlets lighting fixtures. The supply shall include all the equipment, accessories and other materials not enumerated in these specifications but found necessary for the completion and perfect functioning of the installations. Work shall be executed in a first-class work-manlike manner in accordance with these specifications, the drawings and notes indicated therein, the instructions of the Engineer, the provisions of the Bill of Quantities delivered in place and tested to the full satisfaction of the Engineer

Preparation of work schedules

Bar chart

Bar-chart (Gantt chart) Planning Technique. A Gantt chart, commonly used in project management, is one of the most popular and useful ways of showing activities (tasks) displayed against time. On the left of the chart is a list of the activities and along the top is a suitable time scale. Each activity is represented by a bar; the position and length of the bar reflects the start date, duration and end date of the activity. Benefits of Using Bar-chart (Gantt chart) Technique for Project Planning include, Clarity: Gantt chart has the ability to show and clarify multiple tasks and timelines. Communication: It is a visual method to help project team members understand task progress. Motivation: Gantt charts offer project teams the ability to focus work at the front of, or at the tail end of a task timeline. Coordination: project managers use these charts to break down projects into manageable sets of tasks. Creativity: The use of Gantt charts often encourages new partnerships that might not have evolved under traditional task assignment systems. Time Management: Time scheduling is considered as one of the major

benefits of Gantt charts. Flexibility: It offers a view of project which can help team members adjust changes. Manageability: By using Gantt charts, project managers can make more focused, effective decisions about resources and timetables. Efficiency: Visualizing resource usage during projects allows managers to make better use of people, places, and things. Accountability: Using Gantt charts during critical projects allows both project managers and participants to track team progress. Disadvantages of Using Bar-chart (Gantt chart) Technique for Project Planning include: They can become very complex, the length of the bar does not indicate the amount of work, they at all-time need to be updated and Difficult to see on one sheet of paper.

Critical path analysis

Critical path analysis identifies the sequence of crucial and interdependent steps that comprise a work plan from start to finish. The concept of a critical path recognizes that completion of some tasks in a project is dependent on the completion of other tasks. Some activities cannot start until others are finished. The essential technique for using CPM is to construct a model of the project that includes the following:

1. A list of all activities required to complete the project (typically categorized within a work breakdown structure) ,
2. The time (duration) that each activity will take to complete,
3. The dependencies between the activities and,
4. Logical end points such as milestones or deliverable items.

Using these values, CPM calculates the longest path of planned activities to logical end points or to the end of the project, and the earliest and latest that each activity can start and finish without making the project longer. This process determines which activities are "critical" (i.e., on the longest path) and which have "total float" (i.e., can be delayed without making the project longer). In project management, a critical path is the sequence of project network activities which add up to the longest overall duration, regardless if that longest duration has float or not. This determines the shortest time possible to complete the project.

The critical path determination:

After having computed various time estimates, we are now interested in finding the critical path of the network. A network will consist of a number of paths. A path is a continuous series of activities through the network that leads from the initial event (or node) of the network to its terminal event. For finding the critical path, we list out all possible paths through a network along with their duration. Assuming a network under consideration, has various paths have been listed below with Path Length (in days)

1–2–3–5–6 =36days

1–2–4–5–6 =52days

1–2–3–4–5–6 =50days

Critical path: A path in a project network is called critical if it is the longest path. The activities lying on the critical path are called the critical activities. In the above example, the path 1–2–4–5–6 with the longest duration of 52 days is the critical path and the activities 1–2, 2–4, 4–5 and 5–6 are the critical activities.

Calculation of Floats:

It may be observed that for every critical activity in a network, the earliest start and latest start time are the same. This is so since the critical activities cannot be scheduled later than their earliest schedule time without delaying the total project duration, they do not have any flexibility in scheduling. However, non-critical activities do have some flexibility i.e. these activities can be delayed for some time without affecting the project duration. This flexibility is termed as slack in case of an event and as float in case of an activity

5.2.5.4 Learning Activities

Learning activity	Special instructions

5.2.5.5 Self-Assessment

1 what is a critical path

2 Draw a critical path network diagram for the following data.

Task	Immediate Predecessor
A	—
B	—
C	B
D	B
E	B
F	E
G	A, D, C.

5.2.5.6 Tools, Equipment, Supplies and Materials

- This section should provide for the requirements of the learning outcome in terms of tools, equipment, supplies and materials
- The section should be adequate, relevant and comprehensive for the learning outcome.

5.2.5.7 References

5.2.6 **Learning Outcome 6** Establish installation team

5.2.6.1 Introduction to the learning outcome

Work teams and groups come in a variety of types and sizes, cutting across different contexts, functions, internal processes, and external linkages. However, several features provide a foundation for a basic definition. Work teams and groups: (a) are composed of two or more individuals, (b) who exist to perform organizationally relevant tasks, (c) share one or more common goals, (d) interact socially, (e) exhibit task interdependencies (i.e., workflow, goals, outcomes), (f) maintain and manage boundaries, and (g) are embedded in an organizational context that sets boundaries, constrains the team, and influences exchanges with other units in the broader entity. Teams are embedded in an open yet bounded system composed of multiple levels. This broader system sets top-down constraints on team functioning. Simultaneously, team responses are complex bottom-up phenomena that emerge over time from individual cognition, affect, behavior, and interactions among members within the team context. Based on this perspective, four conceptual issues are critical in efforts to investigate and understand work teams: (1) task or workflow interdependence, (2) contextual creation and constraint, (3) multilevel influences, and (4) temporal dynamics. The centrality of task interdependence is one issue that clearly distinguishes the work teams and small group literatures

5.2.6.2 Performance Standard

5.2.6.2.1 Team members are identified according to the task
5.2.6.2.2 Communication protocol is designed and distributed among the team members
5.2.6.2.3 Responsibilities are established and distributed among the team members
5.2.6.2.4 Team familiarization is done according to the established procedure

5.2.6.3 Information Sheet

Team building is a collective term for various types of activities used to enhance social relations and define roles within teams, often involving collaborative tasks. It is distinct from team training, which is designed by a combine of business managers, learning and development/OD (Internal or external) and an HR Business Partner (if the role exists) to improve the efficiency, rather than interpersonal relations.

Many team-building exercises aim to expose and address interpersonal problems within the group

Over time, these activities are intended to improve performance in a team-based environment Team building is one of the foundations of organizational development that can be applied to groups such as sports teams, school classes, military units or flight crews. The formal definition of team-building includes:

- aligning around goals
- building effective working relationships
- reducing team members' role ambiguity
- finding solutions to team problems

Team building is one of the most widely used group-development activities in organizations. A common strategy is to have a "team-building retreat" or "corporate love-in," where team members try to address underlying concerns and build trust by engaging in activities that are not part of what they ordinarily do as a team.

Of all organizational activities, one study found team-development to have the strongest effect (versus financial measures) for improving organizational performance. A 2008 meta-analysis found that team-development activities, including team building and team training, improve both a team's objective performance and that team's subjective supervisory ratings. Team building can also be achieved by targeted personal self-disclosure activities.

Team building describe four approaches to team building

Setting Goals

This emphasizes the importance of clear objectives and individual and team goals. Team members become involved in action planning to identify ways to define success and failure and achieve goals. This is intended to strengthen motivation and foster a sense of ownership. By identifying specific outcomes and tests of incremental success, teams can measure their progress. Many organizations negotiate a team charter with the team and (union leaders)

Role clarification

This emphasizes improving team members' understanding of their own and others' respective roles and duties. This is intended to reduce ambiguity and foster understanding of the importance of structure by activities aimed at defining and adjusting roles. It emphasizes the members' interdependence and the value of having each member focus on their own role in the team's success.

Problem solving

This emphasizes identifying major problems

Interpersonal relations

This emphasizes increasing teamwork skills such as giving and receiving support, communication and sharing. Teams with fewer interpersonal conflicts generally function more effectively than others. A facilitator guides the conversations to develop mutual trust and open communication between team members.

But sometimes, you get to create your own team. It can happen on special projects when you're pulling people from different departments, or when you are creating a new department. If you're in the situation where you get to create a team from scratch (or have the opportunity to add headcount to an existing group), here's how to create the best team possible.

1. Clearly Identify the Task at Hand

If your task is nebulous, you will have a tough time knowing what skills you need to find. You’re likely tempted to jump right in and hire people with the general skills that fit your overall department. (I need marketing people. I need creative people.)

2. Identify the Skills Needed

You need to identify the soft skills as well as the hard skills you need. Will the employee need to communicate results and progress to senior management? Are there skills you need that isn't going to be obvious without hard thought? For instance, if you're putting together a team to implement a new software system, you obviously need programmers.

3. Identify the People

If you want to build an internal team, you have advantages and disadvantages. The advantages are that you already know the people from whom you are choosing. You know their strengths and their weaknesses. You know who is good at technical work. You know who is creative. You know who is whiny. The disadvantages are that you've got to pull the team from your existing staff, so you can't fix any weaknesses that already exist in your potential team members. You have to deal with the politics of pulling someone from another group's staff. You can't ignore the fact that you can damage relationships if you steal too many of the best people from other departments.

4. Hire in the Right Order

Don't hire the administrative assistant first. You may think, “Okay, I'll get this out of the way.” But the administration's job is to help the rest of the team and support them. If you hire this person first, you need to find additional people with whom they can work, instead of the other way around. Start with your most senior person, or the person you want leading the team, and work down through the rest of the team members from this hire. You want your most senior person to help you with the additional hiring—either internally or externally.

5. Practice Honesty in Your Hiring

Don't just extol the virtues of working on this team. You need to state the challenges honestly to potential employees. For example, you might say: “We'll implement a new software system. You will work hard and put in long hours. We'll experience pushback from senior managers, and I will fight for the team, but it will be difficult.” This way, you'll get staff members who know what to expect. Don't lie and say the team’s task is a bed of roses unless you really think that is how the team's work will play out. You'll lose your best team members who will feel as if you fooled them.

6. Remember to Manage

Once you get your team together, you've got to run it. Great teams seldom run well without a great leader. That's your job. Make sure that you work to make the team cohesive and hard working. Don't ask more of them than you ask of yourself. If you are managing the team leader, the same applies. You need to check in on a pre-planned schedule to ensure that the team stays on track. If it's not, work with the team leader to regroup and move forward.

5.2.6.4 Learning Activities

Learning activity	Special instructions

5.2.6.5 Self-Assessment

1. If you're in the situation where you get to create a team from scratch (or have the opportunity to add headcount to an existing group), outline six steps to create the best team possible?

5.2.6.6 Tools, Equipment, Supplies and Materials

- This section should provide for the requirements of the learning outcome in terms of tools, equipment, supplies and materials
- The section should be adequate, relevant and comprehensive for the learning outcome.

5.2.6.7 References

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5.2.6.8 Model answers to self-assessment

5.2.7 **Learning Outcome 7** Obtain the necessary permit and licences

5.2.7.1 Introduction to the learning outcome

Permit to work (PTW) systems are formal procedures used to control activities that are considered high-risk. Permits only allow authorized personnel to perform those activities at specified times and in a way set out in the permit and referenced documents. A restricted electrical work license (a restricted license) authorizes the holder to perform electrical work only of a particular type stated in the license. An applicant for a restricted license must be able to demonstrate an occupational need to carry out restricted electrical work incidental to a particular trade or calling. For example, a mechanical fitter may be eligible for a restricted license to permit them to disconnect and reconnect an electric motor in order to realign a conveyor system. Similarly, a plumber may be eligible for a restricted license if in the course of their trade they need to disconnect and reconnect hot water systems.

5.2.7.2 Performance Standard

5.2.7.2.1 Type of permit to work is identified where applicable
5.2.7.2.2 Permit to work issuing body is identified
5.2.7.2.3 Permit to work form is filled and submitted to the responsible body

5.2.7.3 Information Sheet

Issuing permits to work can be a complicated and time-consuming process and so adequate notice should be given before a permit to work is required. Permit systems do not in themselves make activities safer, this is only possible through the implementation of the correct procedures. It is important therefore that systems not box-ticking exercises, that they are explained at site inductions and that they are continuously monitored, reviewed and kept up to date. A permit should: Describe the work and its location, Provide information about foreseeable risks, Provide information necessary for working safely, Set out requirements for personal protective equipment, Set out the time when the work can be carried out, Provide information about other permits.

A permit to work system should:

- Only allow permits to be issued by authorised, competent personnel.
- Prevent high-risk work being carried out without a risk assessment having been undertaken.
- Consider whether any other work will impact on, or be impacted by, the permitted work.
- Ensure control measures and supervision are in place.
- Ensure method statements and emergency procedures are prepared.
- Ensure work is checked and returned to a safe state.
- Provide information to other parties that might be affected by the work.
- Include a system for handing back and cancelling permits.

Types of permits

General

A written permit to work system provides formal written procedure and formal actions to ensure that

potentially hazardous activities are carried out as safely as possible. The work permit is a written document which authorizes persons to carry out the work concerned warns of possible dangers and clearly states the precautions to be taken for the job to be carried out safely.

The permit ensures that full consideration is given to the hazards and risks, and that these are properly dealt with, prior to commencement of the work. The permit to work has to be filled by the subcontractors for what concerns its activities and references. Contractor will give the necessary support as required.

The permit to work shall clearly specify the particular equipment and the construction area involved, the extent of work allowed, the conditions to be observed and the duration of the permit. Should any doubt exist as to the requirements for specific types of Permits, YOUR COMPANY NAME's Field HSE Coordinator and/or YOUR COMPANY NAME's Permit Coordinator should be consulted for advice.

Activities Requiring a Permit to Work

A Permit to Work will be required for the following activities:

- Any activity on live electrical equipment.
- Areas electrically classified.
- Closure of site roads to enable excavation and similar activities to be carried out.
- Confined space work (i.e. any work inside a vessel).
- Confined space work.
- Connection to the electrical supply.
- Connection to the water supply.
- Crane Lifts; lifting operations over living lines / equipment.
- Disconnecting or opening of any closed pipeline or vessel containing flammable or other hazardous material.
- Erection of site huts and lay down areas.
- Excavation and trenching.
- Facilities for the storage of cylinder gases, highly flammable liquids, paint or similar hazardous materials.
- Hot work of any type, where heat is used or generated.
- Hot work.
- Installation of pits for the storage of sealed radioactive sources.
- Isolation/lock-out/tag-out.
- Radiography (i.e. any work involving use of radioactive source, including the installation of pits for the storage of sealed radioactive sources).
- Working in hazardous zoned areas.

General Work Permit (cold)

- The general Work Permit shall be utilized for all activities requiring a Permit to Work, other than those capable of generating or using sources of ignition.
- The general Work Permit will facilitate all activities from scaffold erection to those controlling activities such as pressure testing.
- The general Work Permit has the facility to be validated for a period of 28 consecutive days.
- Revalidation of any Permit to Work shall remain at the discretion of YOUR COMPANY NAME's Construction Manager and only if all Permit Signatories are in agreement, that there is no significant change in condition, changes in work schedule or there is no significant changes in personnel.

- Permits to Work shall clearly specify the particular equipment and the construction area involved the extent of work allowed, the conditions to be observed and the duration of the permit.

Other Permits and Certificates

Should additional and/or other permits be required, they shall be created prior to commencement of work on definable features of work. The following Certificates shall be issued with the Work Permit (both general and hot) and they give details of the existing situation of the area.

Confined Space Certificate

- The Confined Space Certificate, shall be used in conjunction with the Permit to Work (both general and hot), and is required for any entry into a confined space as defined in this section.
- The Confined Space Certificate, once in place, only controls the entry of persons into a confined space. The actual task shall be controlled by the general Permit to Work. The Permit numbers shall be cross referenced to each other.
- Entry into confined spaces is subject to special requirements being put into place prior to the commencement of work. This will include but not be limited to:
    - Condition monitoring
    - Presence of a Safety Watch Person
    - PPE/RPE
    - Emergency Escape Plan

Electrical Work Certificate

This Certificate shall be used in conjunction with the Permit to Work (both general and hot), for any activity to be carried out on live electrical equipment or plant.

The Electrical Competent Person should complete this form and demonstrate that all necessary isolations have been made and that the system or plant is safe to be worked on. The electrical work certificate shall be utilized when an energization or de-energization operation should be carried out.

Lock out-tag out

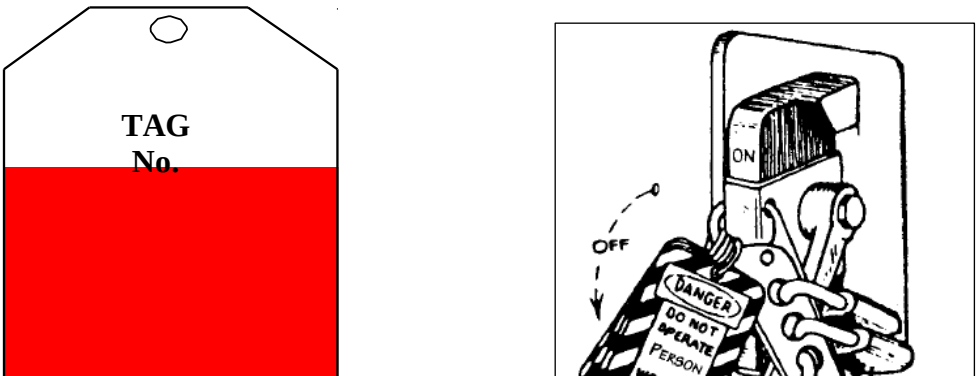
De-energization (Isolation) may be required prior to installation, inspection, repair, cleaning or dismantling. Where a job involves isolation of equipment, there shall be a work permit for the job and a lockout and tag-out procedure shall be followed. A lockout generally involves:

- Stopping all energy flows (for example, by tuning off switches or valves on supply lines).
- Locking switches and valves.
- Securing the machine, device or power transmission line in de-energizer state.

Electrical isolation may be required to immobilize machinery or to protect personnel working in electrical equipment. Situations involving electrical isolation including rotating machinery and machinery with moving parts and entry into vessel which contain stirrers or agitators. Electrical isolation should be performed only by a competent electrical engineer.

An example of a Warning Tag and Tag-out and lock-out are shown in Figure 3.

Figure 3. Example Warning Tag and Tag-out/Lock-out tags.



DO NOT
OPERATE

CAUTION

REM
DAT
SIG
COMMISSIONING TEAM

If other organizations or individuals working on equipment shall also install their locks and tags at locations have to be fit. In that case multiply lockout clips (Hasps) shall be used if necessary. When all padlocks will be removed energization will be possible. An example of Hasps is shown in Figure 4.

Figure 4. Example HASP

The Competent Electrical Engineer shall report all actions on the substation logbook for record purpose. As a general rule other discipline engineers cannot interfere with any electrical isolation work to be executed inside the substation for safety reasons and nobody (with the only exception of the Competent Electrical Engineer) can take or keep the padlock keys for their scopes.

Field HSE Coordinator should hold spare keys for all Lock Outs. This ensures no keys will go missing, if they are controlled by the Permit to Work Coordinator.

Execution of Energization, Removal of Tags, Padlock and Restoration of Power

After receiving the Electrical Certification in which the ENERGIZATION is required the Competent Electrical Engineer shall proceed to energize the equipment. The following procedure covers the energization for safe execution of the pre-commissioning electrical tests.

- If a padlock and a tag are installed (to show that the switchgear is isolated) the Competent Electrical
    - Engineer shall remove both of them.
- The Competent Electrical Engineer will give power to the equipment.
- As soon as the equipment is energized the Component Electrical Engineer shall hung a tag “IN SERVICE” close to the switchgear, as shown in Figure 5.

The Competent Electrical Engineer shall report all actions on the substation logbook for record purpose.

Figure 5. Example of "In Service" tag.

Excavation Work Certificate

This Certificate shall be used in conjunction with the Permit to Work, for Excavation activities. This Certificate should be submitted with the Permit to Work together with any supporting documentation such as sketches drawings and method statements. In this shall be reported all the underground services present in the area.

Accompanying Certification for Permit to Work

The more information there is to support a permit to work, the more safety factors can be considered or put
in place to make the job safer. Therefore it is important to submit supporting documents in the form of site layout drawings, equipment drawings, etc. with the certificate. This is especially important when trying to locate underground services and etc. Failure to provide these documents may result in an application being rejected.

Permit issuance and duration

The Permit to Work will involve the following steps shown below:

1. Conduct a thorough risk assessment and determine who is at risk, what control measures are necessary to eliminate the hazards, and the level of residual risk.

2. Prepare a written system of work identifying the following:
   - The level of competence of all operatives and any specialist skills
   - List Isolation / Pre-work precautions
   - List prohibited activities (communicate to others as necessary)
   - List Plant and Equipment required
   - List Personnel Protective Equipment to be used
   - List sequence of events as planned with identified hazards/residual risks and controls clearly defined
   - Emergency procedures for all foreseeable risks (ensure that procedures are conveyed to competent persons and fully understood)
3. Brief those who will be required to operate under the Permit to Work on the hazards and controls necessary to avoid them being realized (for example during Tool Box Talks).

4. Ensure that those conducting the task know that the safe system must be followed in full and that no other methods or sequence of work are allowed (i.e., work must stop, all persons withdrawn, and the safe system reviewed by the Authorized Person). If the safe system is found to be flawed, then the Permit must be cancelled, the system of work reassessed, a new Permit raised, and those conducting the task re-briefed.
5. Display the Permit at the work site/isolation point to ensure all that those who need to know, do so.
6. Ensure that the work area is clean, tidy, and that all safety devices have been replaced and are functioning correctly, prior to inspection by the Authorized Person. Please note the Authorized Person must not sign the "hand back" section of the form until the area is in fact clean and safe.

The validity of the Permit to Work will be evaluated according to the activity and operative patterns, shall be evaluated at Site by YOUR COMPANY NAME's Construction Manager (refer to Figure 6).

Figure 6 Permit Validity Period

DOCUME	VALIDITY PERIODS	ENDORSEMENT
Work Permit (cold)	28 consecutive (calendar)	7
Hot Work Permit	14 consecutive (calendar)	12
Confined Space Certificate *	28 consecutive (calendar)	12
Excavation Work Certificate *	28 consecutive (calendar)	12
Radiography Work Permit	Maximum 12 hours	N/
Electrical Work Certificate *	No validity period	N/

* Supporting documentation has to be required at the same time of the Work Permit (general and/or hot) for identifying particular hazards introduced by the work, which require further than formal controls.

Where such risks are identified, supporting Certificates are enclosed in the Work Permit.

Permit closure

The Permit to Work will be considered to be closed when YOUR COMPANY NAME's Issuing Authority signs the completion section of the Permit to Work (after receiving the subcontractor confirmation on the Permit to Work that the work is complete). Acceptance of this signature is conditioned to:

- Completion of the work according to the instructions;
- Cleanliness of work area, including the removal of all the work equipment;
- Re-installation of all safety conditions.

Layout and Color of Permits

The Permits to Work are in A4 format and for visibility purposes, to aid identification of documents, different colors are used on the border of Permits as per Figure 7.

Figure 7. Permit and Certificate Identification Color Codes

DOCUME	BORDER COLOUR	REFERENCE

Work Permit (cold)	**Blac**	Attachmen
Hot Work Permit	**Re**	Attachmen
Confined Space Certificate	**Dark**	Attachmen
Excavation Work Certificate	**Brow**	Attachmen
Radiography Work Permit	**Bright-Orange**	Attachmen
Electrical Work Certificate	**Blu**	Attachmen

2.2.64 *Attachment 1. Your Company Name Work Permit Forms*

Work Order No.:	**WORK PERMIT**	Work Permit No.:

TO BE FILLED BY

SUBCONTRACTOR _____AREA OF WORK _____

WORK STARTING DATE _____ TIME _____ WORK ENDING DATE _____ TIME _____ DESCRIPTION OF THE WORK _____

_____

_____

The above signing person is responsible to ensure the work is performed under all the mentioned and required safety precautions. Failure on this will be subject to disciplinary actions.

TO BE FILLED BY

INDIVIDUAL PROTECTION EQUIPMENT (CROSS WITH AN X):

□ Helmet	□ Hear Protectors	□ Gas Mask	□ Dielectric Gloves	□ Safety Gloves
□ Welder's Helmet		□ Emergency Respirator		□ Safety Shoes □ Rubber Safety Boots
		□ Safety Glasses		
□ Welder's Apron		□ Protective Goggles		□ Anti-Dust Overalls
	□ Welders Breeches	□ H2S Mask		
□ W work Clothes		□ Safety Belts	□ Dielectric Boots	□ Safety Harness
	□ Double Safety Harness			
□ Dust Mask	□ _____	□ _____	□ _____	□ _____

COMMON PROTECTION EQUIPMENT

_____

_____

_____

OTHER SAFETY MEASURES

_____

_____

_____

SANCTION AUTHORIZATION SIGNATURES			
DATE	TIME		
Contractor Issuing Authority			Date
_____	Time _____		

Is Electrical PTW required YES ___ NO ___ PTW Number ____	Is Confined Space PTW required YES ___ NO ___ PTW Number ____	In case Electrical or Confined Space PTW is required? YES ___ NO ___ If yes, attach a Copy.
Site Preparation completed and work can commence. Contractor Operating Authority	I understand the precaution to be taken as described above. Sub-Contractor Operating Authority	

CLOSURE		
	The Work is completed and working area cleared _____Subcontractor performing Authority	The Site has been checked and working Area accepted _____ Contractor Operating Authority

Electrical licenses

Energy regulatory commission offers licenses to qualified trained technicians and engineers under the following classes.

Class C-2

This class entitles the holder to carry out electrical installation work for connection to a single phase at low voltage, restricted to up to two storey residential and commercial buildings not used as factories or places of public entertainment.

Requirements:

Electrical wireman certificate 1 & 2 (copy)

or

Diploma in Electrical engineering (copy)
It can a Technical and Vocational Education and Training certificate, a Technical Education Programme certificate or an electrical engineering certificate from a recognized institution.

Bank deposit slip for kshs 250 (copy)

Identity card (copy)

Class C-1

The holder of this license is entitled to carry out electrical installation work in class C-2 and for connection to three phase supply at low voltage, restricted to up to four storey buildings not used as factories or places of public entertainment.

Requirements:

Bachelor of Science in Electrical Engineering certificate (copy)

or

Diploma in Electrical engineering (copy)

or

Electrical technician license- C2 (copy)
Must have held C2 certificate for more than 2 years.

Bank deposit slip for kshs 500 (copy)

Identity card (copy)

Class - B

Holder of this class can carry out electrical installation works as in C-1 but without limitation as to number of storeys in the buildings whether used as factories or places of public entertainment or for connection to supply metered at voltages not exceeding medium.

Requirements:

Bachelor of Science in Electrical Engineering certificate (copy)

or

Diploma in Electrical engineering

or

Electrical technician license - C1 (copy)
Must have held a C1 technician license for more than 2 years.

or

Registration with Kenya Engineering Technology Registration Board (copy)

Bank deposit slip for kshs 750 (copy)

Identity card (copy)

Class A-1

The holder of this license is entitled to carry out all kinds of electrical installation works.

Requirements:

Bachelor of Science in Electrical Engineering certificate (copy

2

Registration with Engineers Board of Kenya (copy)

or

Electrical technician license - B (copy)
Must have had an electrical technician license class B for more than 2 years.

Bank deposit slip for kshs 1,000 (copy)

Identity card (copy)

Class A-2

The holder of this license is entitled to carry out specialized electrical installation work.

Requirements:

Bachelor of Science in Electrical Engineering certificate (copy)

or

Diploma in Electrical engineering (copy)

Bank deposit slip for kshs 1,000 (copy)

Identity card (copy)

5.2.7.5 Learning Activities

5.2.7.4 Self-Assessment

1. What are the requirements for registering electrical technician license class C-1

5.2.7.5 Tools, Equipment, Supplies and Materials

5.2.7.6 References

PN12375 Last updated July 2020 - Electrical licensing eligibility guide (https://creativecommons.org/licenses).
Energy regulatory commission licensing (www.epra.go.ke)
HSSE 14.20.01 - BPWE JSEA Procedure
HSSE 13.40.01 - BPWE Confined Space Procedure

5.2.8 learning outcome 8: Prepare work site

5.2.8.1 Introduction to learning outcome

The promotion of health and safety measures is a mutual objective for the contractor and his employees at all levels. It is intended that the contractor will conduct his affairs at the work site in a manner which will not cause risk to the health and safety of employees or the general public. The contractor shall exercise his responsibility as an employer and make every effort to meet his legal obligations under the Health and Safety at Work Act to ensure the health and safety of his employees and that of the general public paying particular attention to the provision of the following;

Installation equipment and procedures of work that are safe.

Safe arrangements for the use, handling, storage and transport of tools, materials and equipment.

Sufficient information, instruction, training and supervision to enable all employees to contribute positively to their own safety and health at work and to avoid hazards.

- A safe place of work, and safe access to it.
- A healthy working environment.
- Adequate welfare services**.**

***Note*: Reference should be made to the appropriate safety etc. manuals**

5.2.8.2 Performance Standard

5.2.8.2.1 Special work, hazards and safety requirements are identified

5.2.8.2.2 Identified hazards and safety issues are mitigated according to OSHA

5.2.8.2.3 Work plan is confirmed in accordance with legislative and regulatory requirements and standard operating procedures

5.2.8.2.4 Work site is prepared for accessibility of utilities

5.2.8.3 Information Sheet

Safety hazards exist in every workplace, by identifying hazards at the workplace, one will be better prepared to control or eliminate them and prevent accidents, injuries, property damage, and downtime.

There are a number of factors that are most likely to contribute to potential hazard at the work site;

- Working heights
  Bureau of Labor Statistics data shows that falls to a lower level accounted for 14 percent of all fatalities in 2014, and OSHA standards related to scaffolding and ladders are regularly among the most frequently cited violations. Employers need to identify all locations where fall protection is necessary – as well as where the engineered anchor points are – and train employees and regularly audit the fall protection program, she said.

- Poor housekeeping This is where everything is cluttered all over with no clear pathways poor lighting system liquids poured on the floor and Workers shouldn't wait for housekeeping or sanitation crews to take care of these issue rather everyone should take it as a responsibility to maintain good house keeping
- Electrical – Extension cords

Inappropriate use of electrical cords is likely to pause a safety risk extension cords lying on the ground for extended periods of time are a trip hazard. They also can be subject to traffic abuse if run over by forklifts or feet, which can wear down insulation and create shock hazards. Employers should assess whether extension cords are truly being used for temporary measures. At the end of a task the cord should be gathered up at the end and stored. It is recommended to establish a system of periodical inspection of extension cords, as well as train employees safe use of extension cables

- Confined spaces

confined spaces have occurred because a contractor didn't issue a permit or failed to carry out a risk assessment.

The electrical installation shall comply with all regulations on safety aspects issued by the Kenyan Bureau of standards, National Environmental and Management Authority (NEMA) and other relevant authorities.

Occupational Safety and health act (OSHA)

OSHA focuses on the provision of all safety and protection equipment designed to be worn, or held, to protect against a risk to health and safety. This includes most types of protective clothing, and equipment such as eye, foot and head protection, safety harnesses, life jackets and high visibility clothing. Under the Health and Safety at Work Act, employers must provide free of charge any safety and protective equipment and employees must make full and proper use of it. Safety signs such as those shown at below are useful reminders of the type of safety and protection equipment to be used in a particular area. The vulnerable parts of the body which may need protection are the head, eyes, ears, lungs, torso, hands and feet and, in addition, protection from falls may need to be considered.

Objects falling from a height present the major hazard against which **head protection** is provided. Other hazards include striking the head against projections and hair and clothing becoming entangled in machinery.

Typical methods of protection include helmets, light duty scalp protectors

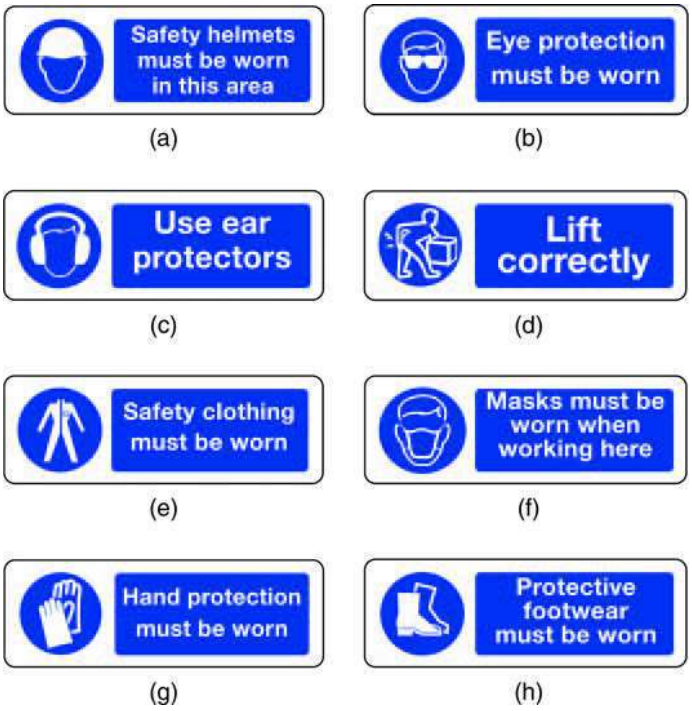


Fig. Safety sign showing protective equipment (Taken from BEIW, 5 th edition)

To assist electricians in their understanding of the Regulations, the work site manual should contain the safety requirements of doing: *Selection and Erection*; *Isolation and Switching; Inspection and Testing; Protection against Fire; Protection against Electric Shock; Protection against Overcurrent; Special Locations and Earthing and Bonding*. These safety guide manuals are intended to be read in conjunction with the Regulations.

5.2.8.4 Learning Activities

Learning activity	**Special instruction**
Discuss the possible hazards likely to occur on an electrical installation site	https://youtu.be/Yw0eI4oTX3Y https://youtu.be/M8-rYiVrm7g https://youtu.be/wpiSpt7YyPU trainees to click watch and listen to the videos on
Discuss the employers / workers responsibilities with regard to safety at the work site	trainees to practice using a hazard assessment guideline form https://safetylineloneworker.com/downloads/hazard-assessment
Discuss the steps to be followed in Confirming the legal documents regarding the building to be installed with electricity	Trainees to list the regulatory bodies alongside the certificate that they provide at a construction site
Discuss the accessibility of the site in terms of infrastructure, water and electricity	

5.2.8.5 Self-Assessment

1) which are two safety responsibilities of an;
   i) Employer
   ii) Employee at a work site
2) which are the five steps of hazard assessment at a work site
3) which three factors are most likely to cause an accident at a site
4) what are the recommendations of OSHA regarding safety at a site

5.2.8.6 Tools, Equipment, Supplies and Materials

Materials

Stationary
flipchart
whiteboards
hazard assessment forms
personal protective equipment