CHAPTER TWO: SINGLE PHASE ELECTRICAL INSTALLATION AND MAINTENANCE

Unit Code: ENG/LG/EI/CR/02/3/A

Relationship to Occupational Standards

This unit addresses the Unit of Competency: Perform single phase electrical installation and maintenance

Introduction

Current legal frameworks prescribed that all electrical wiring, testing, preventive and corrective maintenance shall be performed by Competent Persons. Therefore, the demand for Competent Persons is always there in tandem with the growth of construction industry. Hence, this course was especially being accredited to equip the trainees with relevant set of theoretical and practical skills for them in becoming Competent Persons that are recognized by Energy Commission once they are working on the fields near the future

Summary of Learning Outcomes

1. Apply workplace safety
2. Interpret electrical drawings
3. Select correct types and sizes of cables
4. Install cables for lighting and power points
5. Install power intake point
6. Install consumer's control unit
7. Inspect and test the complete installation
8. Repair and maintain the installation

2.0.Interpret electrical drawings

Introduction

Electrical drawings are a formal and precise way of communicating information about the layout, the dimensions, features and precision of Electrical installations. Drawing is the universal language of engineering. To understand how to "read and interpret" a drawing it is necessary to be familiar with the standard conventions, rules, and symbols used on the various types of electrical drawings.

The purpose of this course is to prepare electrical personnel with the ability to read and understand the electrical diagrams, various standards and practices used for reading and Interpreting electrical drawings and schematics. Participants will be introduced to electrical symbols, one-line and three-line electrical schematics and their content, including basic layout

and legends. The course will help the attendees understand the symbols and the language used in electrical drawings in line with the international standards and practices, giving a detailed insight into the various types of electrical drawings used in the industry, their purpose and applications

Performance Standard

i. Identification of intake points and equipment
ii. Identification of installation equipment and accessories e.g., switches, lamp holders
iii. Identification of electrical symbols and abbreviations
iv. Types of drawings
v. Schematic/layout
vi. Circuits and wiring

Information Sheet

Power Intake Point

Identification of electrical wiring should be clear and accurate so that the risk of injury or damage is minimized. This article looks at requirements relating to the identification of conductors contained in Section 514 of BS 7671.

As required by Regulation 514.1.2, wiring should be arranged and/or marked so that it is readily identified for the purposes of inspection, testing, repair or alteration, and each circuit protective device (circuit breaker, fuse or RCD) should be arranged and identified so that the circuit protected may be easily recognized (Regulation 514.8.1).

Where it is impracticable to individually label protective devices, the protective devices may be identified by means of a durable chart or schedule fitted inside the cover of, or adjacent to, the consumer unit or distribution board. Regulation 514.9.1 requires that the form of information provided is legible and durable, and indicates:

i. The type, and composition of each circuit (number of points served, number and size of conductors, type of wiring) and,
ii. The method for providing shock protection (which protective measure (such as ADS) has been provided), and
iii. The information necessary for the identification of each device performing the functions of protection, isolation and switching, and its location, and
iv. Any circuit or equipment vulnerable to a typical test.

For a typical domestic premises and other simple types of installations, a copy of the combined ‘Schedule of Circuit Details and Test Results’, which forms part of a NICEIC Domestic Electrical Installation Certificate, fixed within or adjacent to the consumer unit

is likely to achieve compliance with Regulation 514.9.1. For more complex installations, however, more comprehensive information will be required.

Requirements for conductors

Except where identification is not required, the cores of cables should be identified by colour, letters or numbers. Every core of a cable must be identifiable at its terminations and preferably throughout its length.

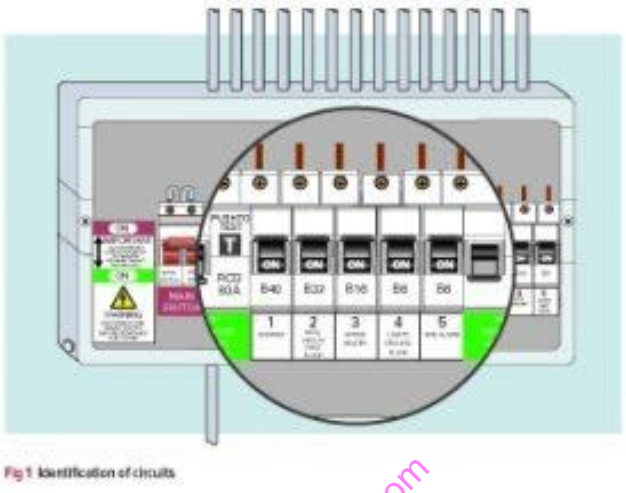


Figure 54; Identification of Circuits

Omissions

Identification is not required for concentric conductors of cables, metal sheath or armored cables were used as a protective conductor, certain bare conductors where identification is not practicable, extraneous-conductive-parts used as a protective conductor and exposed-conductive-parts used as a protective conductor (Regulation 514.6.1).

Identification of conductors by colour

For a single-phase installation, the line conductors should be identified by the colour brown and for a three-phase installation the line conductors should be identified by the colours of brown, black and grey. In either case, the neutral conductor must be identified by the colour blue (Regulation 514.4.1). A PEN conductor shall be identified in accordance with Regulation 514.4.3.

Where a conductor identified with the colour blue is used as a switch line, as is common for wiring in domestic premises, the correct identification must be applied at the terminations (both the switch and the ceiling rose). This is achieved, as shown in Fig 2.2, by sleeving the (blue)

switch line conductor with brown sleeving. In addition, the protective conductors should be identified using green-and-yellow sleeving only (Regulation 514.4.2).

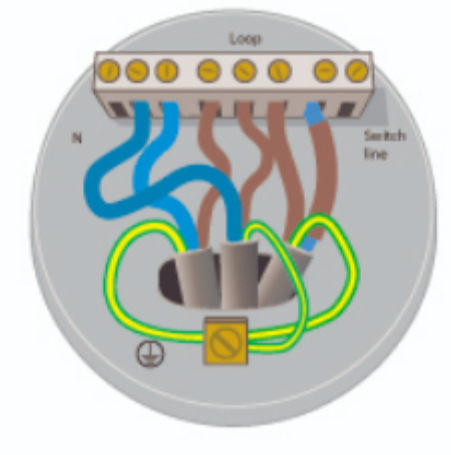


Figure 55: Identification of Switch lines and ceiling rose

Identification by lettering and/or numbering

Where lettering and/or numbering is used it should be clear, legible and durable. in order to avoid confusion, unattached numerals 6 and 9 must be underlined (see Regulation 514.5.1). Where identification is by numbers, the number 0 (zero) is reserved for the neutral conductor (Regulation 514.5.4).

Bare conductors

By the application of tape, sleeve or disc (or by painting) a bare conductor should be identified in accordance with Table 51 of BS 7671 (Regulation 514.4.6). Where a bare conductor or busbar is used as a protective conductor it must be identified, where necessary, by equal green-and yellow stripes, each not less than 15 mm and not more than 100 mm wide, close together, either throughout the length of the conductor or in each compartment and unit and at each accessible position.

Colours to previous versions of BS 7671:

Except where there is no possibility of confusion, unambiguous marking must be provided at the interface between conductors identified in accordance with BS 7671 and wiring to previous versions of the Regulations. Where newly installed cables interface with conductors identified to a previous version (older colours), the guidance given in Appendix 7 of BS 7671 should be followed.

As shown in Fig 2.4, where an addition is made to an existing installation that is wired using the ‘older’ colours a ‘Caution’ notice in accordance with Regulation 514.14.1 must be provided at the appropriate consumer unit or distribution board.

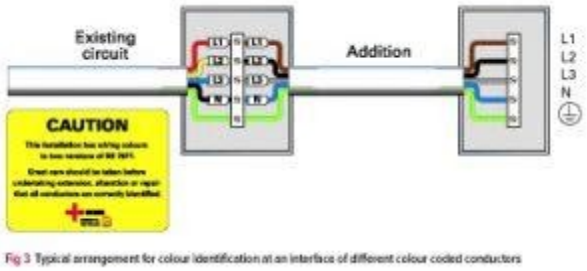


Fig 3 Typical arrangement for colour identification at an interface of different colour coded conductors

Fig. Typical arrangement for color identification at an interface of different color-coded conductors.

Switchgear and control gear

Labels or other means of identification should be provided, where necessary, to indicate the purpose of switchgear and control gear.

Other notices and labeling required

For safety reasons, BS 7671 requires a number of labels and notices to be provided, including the following:

i. An RCD test notice should be provided at (or near) the origin of an installation which incorporates one or more residual current devices (Regulation 514.12.2).
ii. An inspection recommendation label should be fitted on completion of installation work (including additions and alterations) and on each completion of periodic inspection, in a prominent position at or near the origin, giving the recommended date within which, the installation should be re-inspected (Regulation 514.12.1).
iii. A voltage warning should be visible before gaining access to live parts in an enclosure where a nominal voltage exceeding 230 V to earth exists but would not normally be expected (Regulation 514.10.1).
iv. Where a circuit is likely to have a high protective conductor current, information should be provided at the distribution board or consumer unit indicating the circuit(s) likely to have a high protective conductor current. The information should be positioned so it is visible to a person modifying or extending the circuit (Regulation 543.7.1.205).

Point equipment

Identification of installation equipment and accessories e.g., switches, lamp holders

Switch:
A switch is used to make or break the electric circuit. Or it is used to switch "ON or OFF" the electric supply. The switches may be one-way switch and two-way switch. The one-way switch is used to control single circuit or lamp, whereas the two-way switch issued to divert the flow of current to either of two directions. The two-way switch can also be used to control one lamp from two different places (As in case of stair case wiring).

Figure 56: Switch

Surface Switch:
The switches are mounted on wooden board, fixed over the surface of the wall. These switches are also known as "Tumbler switches".

Flush/Piano type switch:
The switches are used where good appearance is required. The switches are fixed in flush with the wall and do not project out. These switches are also known as "Piano Type Switches".

Bed switch:
As the name indicates, it is used to switch "ON or OFF" the light from the place, other than switch-board or from near the bed, while going to sleep or getting up. This switch is connected through flexible wire.

Figure 57: Bed Switch

Rotary switch: This switch is used to control different lamps from one place one by one or as selector switch, to select different voltage tapping of transformer in voltage stabilizer

Figure 58: Rotary Switch

Push Button switch:

These switches are used to control the electric bell and indicating lamps etc. When the push button is pressed, the circuit is completed and the bell or lamp is switched on. The supply to bell or lamp is switched off as the push button is released.

Figure 59: Push Button Switch

Pull switch: These switches are operated with a single pull of the cord, for the on and off position. These are also used in bedroom and bathroom. These switches are fixed near the ceiling and hence these are also known as “Ceiling Switches”.

Intermediate switch: This switch has four terminals and four different connection position. The main function of this switch is to control a lamp from three or more different places, along with ordinary two-way switch. Generally, this switch is used in double stair case wiring or corridor wiring. This switch is also known as four-way switch.

Lamp Holder: As the name indicates, a lamp holder is used to hold the lamp, and connect it electrically to supply terminals, required for lighting purposes. The lamp holders may be bayonet cap and screw type. Depending upon our requirement, these lamp holders are also manufactured in different designs

Some important types of lamp holders are detailed below: -
Batten Lamp Holder: These lamp holders may be of brass or Bakelite, with brass plunger. The holders are fixed on either on round block or wooden board with the help of wooden screws.

Figure 60:Batten Lamp Holder

Pendant Lamp Holder: This lamp holder is used to hang the lamp from ceiling rose, with flexible wire. Sometime these holders are provided with lampshades, to divert the upward light to down ward. These may be of brass or Bakelite, with brass plunger.

Figure 61:Pendant Holder

Angle Lamp Holder: The angle holder is used to focus the light at an angle and is fixed directly on wall or round block with the help of gutties and wooden screws. These may be of brass or Bakelite with brass plunger.

Figure 62: Angle Lamp Holder

Swivel Lamp Holder: These lamp holders are used for lighting of shop windows, show case etc. It consists of ball and socket joint fitted between back plate and lamp holder, for the purpose to move the light to a wide angle.

Figure 63: Swivel Lamp holder

Bracket Lamp Holder: These lamp holders are used to focus the light on the floor or at some angle, slightly away from the walls. Light shades can also be used for diverting all light on floor. Such lamps are provided with such fittings which make them water tight so that these can be used outside the houses or for street lighting. The bracket may be of wood, aluminum and brass. The lamp holder is simply a pendant holder made of brass or Bakelite.

Figure 64: Bracket Lamp Holder

Fluorescent Lamp (Tube) Holder

Figure 65:Fluorescent Lamp (Tube) Holder

These are used to hold the fluorescent tube and pin type holders are generally used.

Ceiling Rose

These are fixed on walls near the ceiling. Normally these are used to provide tapping to the pendent lamp holder, ceiling fan and fluorescent tube etc through the flexible wire.

Figure 66: Ceiling rose

Socket

The sockets have insulated base with moulded base having three terminal sleeves. The two terminal sleeves having same cross-section are used to connect phase and neural wire whereas the third having greater cross-section is used to connect with earth wire. These are made for 5 amps and 15 amps load. Two-pin sockets are also available, in which only phase and neutral wires are connected. These are available in 5-amp capacity.

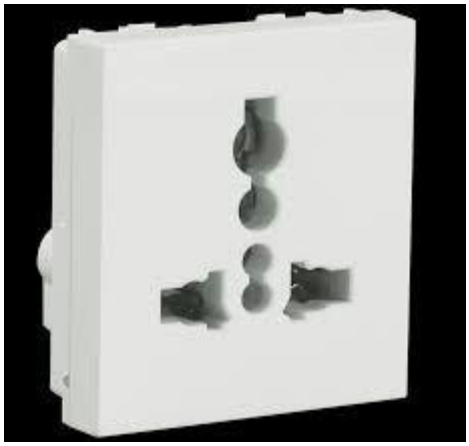


Figure 67: Socket

Plug

The plugs are also having moulded three pins of brass or any electrically conducting material. These are also made of 5 amp and 15-amp rating. These are used for taking power from socket.

Figure 68: Pin Switch

Main Switch

As the name indicates that this switch is used to switch "on or off" the main supply. In other words these switches are used to control the whole supply for a house, office and machine. In single-phase circuit I.C.D.P. main switches are used, whereas in three-phase circuits I.C.T.P. main switches are used to control the supply. The main switches are of the following type: **a) I.C.D.P. Switch:** Iron Clad Double Pole main switch is used in single-phase supply circuits. These are available in 15 Amp, 30 Amp, 60 Amps and 100 amperes current rating.

Figure 69: Main Switch

In these switches, either two numbers of fuse links are provided or a fuse link and a neutral link is provided. The neutral wire is directly connected with the neutral link and phase wire is connected with the fuse link. Normally 15 Amp current rating main switches are made of plastic moulding instead of iron.

I.C.T.P Switch: Iron Clad Triple Pole main switches are used to control the three phase supply circuit. These are available in 15 Amp, 30 Amp, 60 Amp,100 Amp, 150 Amp and 250 Amps current rating.

Figure 70: I.C.T.P Switch

Generally, these switches are also known as 3 phase 4 wires main switches. In these switches, three fuses and a neutral link is available. The neutral wire is directly connected with the neutral link and phase wires are connected with these fuse links.

Fuse

It is the most common and important type of safety device used for domestic and commercial installations. These fuses are of kit-Kat type and are also known as cut-out.

Figure 71: Cut Out Fuse

These cut-outs are made of porcelain in current rating of 15 to 300 amperes. The material used as a fuse wire is tin, lead, silver, antimony, copper and aluminum etc. Copper or lead, tin alloy is mostly used in ordinary fuse wire.

Miniature Circuit Breaker (M.C.B.)

A miniature circuit breaker is an electro-mechanical safety device which operate and disconnect the circuit supply, when the current drawn from the circuit increases to a pre-determined value. These are used in lieu of fuses and can be fitted in consumer's distribution board. An MCB will normally operates at 1.25 times its rated current value. It can be reset, by simply lifting its operational knob, whereas the fuse has to replace its fuse wire. Hence the miniature circuit breakers are replacing the rewirable fuses now a day.

Figure 72: Miniature Circuit Braker

Identification of electrical symbols and abbreviations

Symbols are a shorthand way of showing the locations, types, and sizes or ratings of **electrical** wiring and equipment, and the interrelationships between these items. It should be emphasized that **drawings** need to be supplemented with specifications in order to establish the details of the **electrical** systems.

TYPICAL ELECTRICAL DRAWING SYMBOLS AND CONVENTIONS

ELECTRICAL SYMBOLS

CONTACTS, SWITCHES, CONTACTORS AND RELAYS

SYMBOL	DESCRIPTION
X1 N.O. X1 N.C.	Relay contact - Shown with relay in de-energized or in reset position. (Show relay coil designation near contact.)
T1 TDC T1 TDO	Timing Relay Contact - TDC indicates contact closes at end of timing period. TDO contact opens at end of timing period.
X1	Coil - Relay, contactors, circuit breaker, solenoid etc. (Show device designation, X1)
T1 TDPU (TDDO)	Coil - Timing Relay - TDPU indicates timing period starts when coil is energized. TDDO indicates timing period starts when coil is de-energized.
R1 O R	Latching Relay or Mechanically-Held Contactor O=operate; R=reset; TC=trip coil; CC=closing coil. (Coils may be separated on diagram)
	Knife Switch, general. (If shown closed, terminals must be added.)
	Switch - General, single pole, single throw.
	Switch - One pole of multi-pole switch shown. Other poles shown elsewhere.
	Pushbutton - Momentary or spring return. Single Circuit (make)
	Pushbutton - Momentary or spring return. Single Circuit (break)
	Pushbutton - Momentary or spring return. Two Circuit
	Pushbutton - Maintained, two circuit
	Pushbutton - Maintained, single circuit
A	Selector Switch - Two position, maintained (designate position shown; i.e. A=Auto; H=Hand)
T C SR SR	Selector Switch - Three position, SR indicates spring return from position so labeled. ("TRIP-(NORMAL)-CLOSE" position shown)
	Limit Switch - Normally oper - Not applicable for Motor Operated Valves and Solenoid Valves.
	Limit Switch - Normally closed - Not applicable for Motor Operated Valves and Solenoid Valves.

Figure 73: Electrical Installation Drawing symbols

Types of drawings

One of the best ways to communicate one's ideas is through some form of picture or drawing. This is especially true for the engineer. The purpose of this guide is to give you the basics of engineering sketching and drawing.

We hope you like the object in Figure 1, because you'll be seeing a lot of it. Before we get started on any technical drawings, let's get a good look at this strange block from several angles.

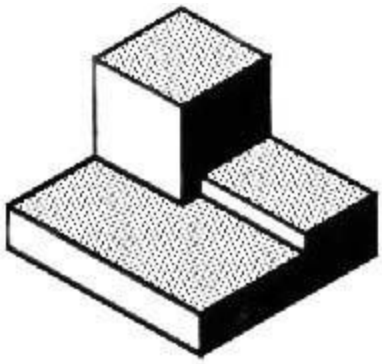


Figure 74: Machined Block

Isometric Drawing

The representation of the object in figure 1.22 is called an isometric drawing. This is one of a family of three-dimensional views called pictorial drawings. In an isometric drawing, the object's vertical lines are drawn vertically, and the horizontal lines in the width and depth planes are shown at 30 degrees to the horizontal. When drawn under these guidelines, the lines parallel to these three axes are at their true (scale) lengths. Lines that are not parallel to these axes will not be of their true length.

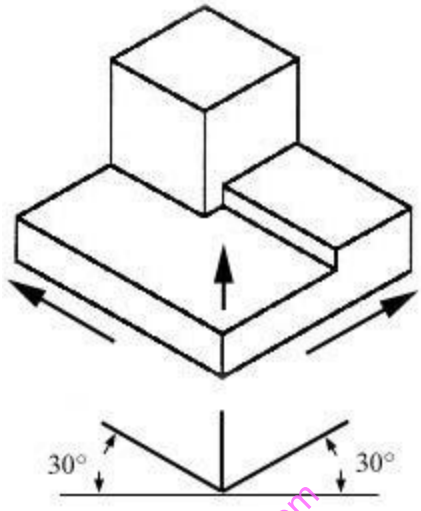
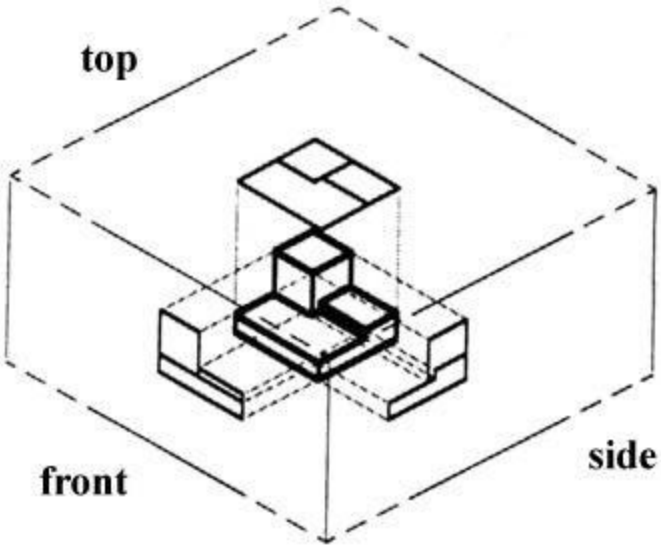


Figure 75: Isometric Drawing

Any engineering drawing should show everything: a complete understanding of the object should be possible from the drawing. If the isometric drawing can show all details and all dimensions on one drawing, it is ideal. One can pack a great deal of information into an isometric drawing. However, if the object in figure 2.22 had a hole on the back side, it would not be visible using a single isometric drawing. In order to get a more complete view of the object, an orthographic projection may be used.

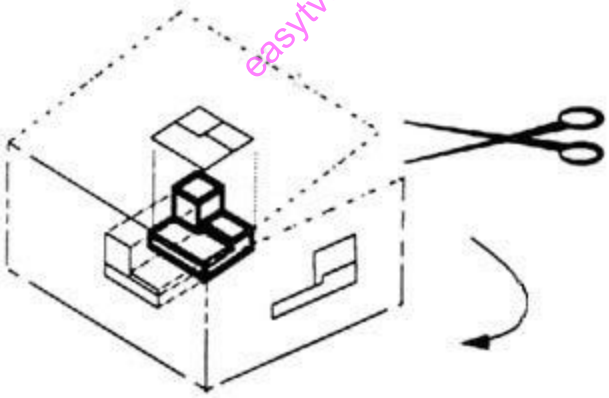
Orthographic or Multiview Drawing

Imagine that you have an object suspended by transparent threads inside a glass box, as in figure 2.23

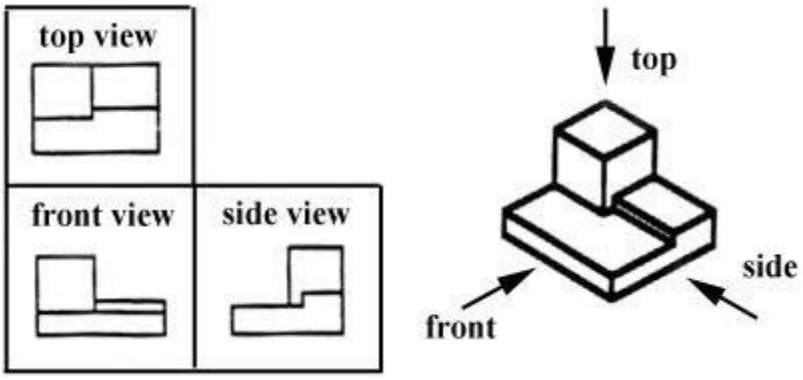


The block suspended in a glass box.

Then draw the object on each of three faces as seen from that direction. Unfold the box (figure 4) and you have the three views. We call this an "orthographic" or "multiview" drawing.

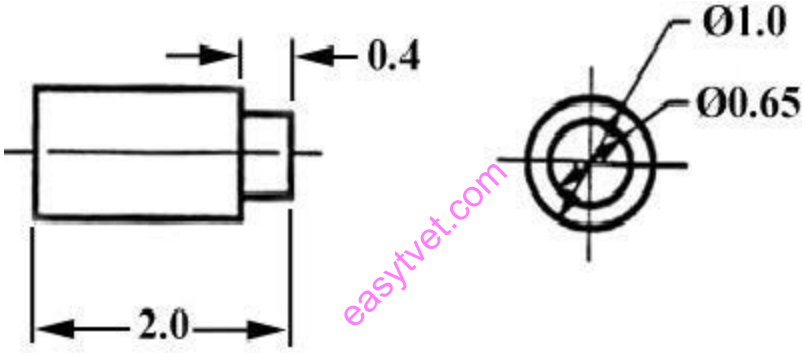


The creation of an orthographic Multiview drawing.

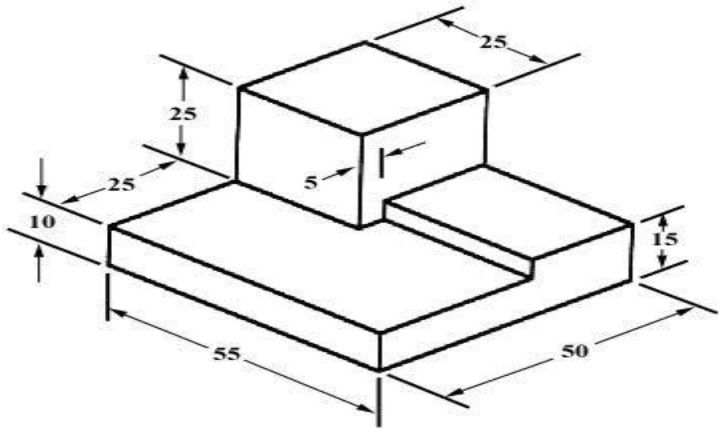


A Multiview drawing

Which views should one choose for a multiview drawing? The views that reveal every detail about the object. Three views are not always necessary; we need only as many views as are required to describe the object fully. For example, some objects need only two views, while others need four. The circular object in figure 6 requires only two views.



Two orthogonal views.

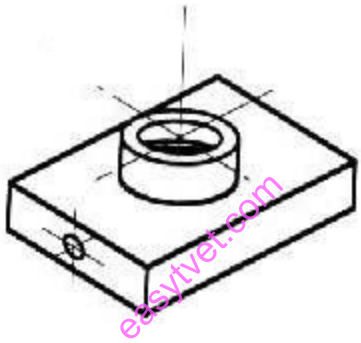


We have "dimensioned" the object in the isometric drawing in figure 2.27. As a general guideline to dimensioning, try to think that you would make an object and dimension it in the most useful way. Put in exactly as many dimensions as are necessary for the craftsperson to make it -no more, no less. Do not put in redundant dimensions. Not only will these clutter the drawing, but if "tolerances" or accuracy levels have been included, the redundant dimensions often lead to conflicts when the tolerance allowances can be added in different ways.

Repeatedly measuring from one point to another will lead to inaccuracies. It is often better to measure from one end to various points. This gives the dimensions a reference standard. It is helpful to choose the placement of the dimension in the order in which a machinist would create the part. This convention may take some experience.

Sectioning

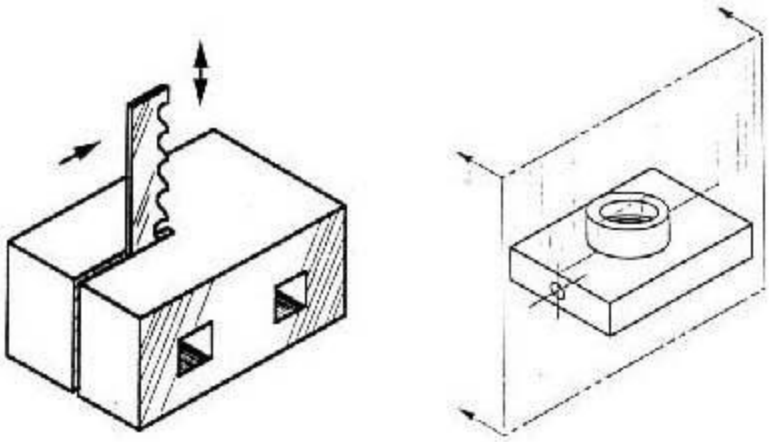
There are many times when the interior details of an object cannot be seen from the outside (figure 8).



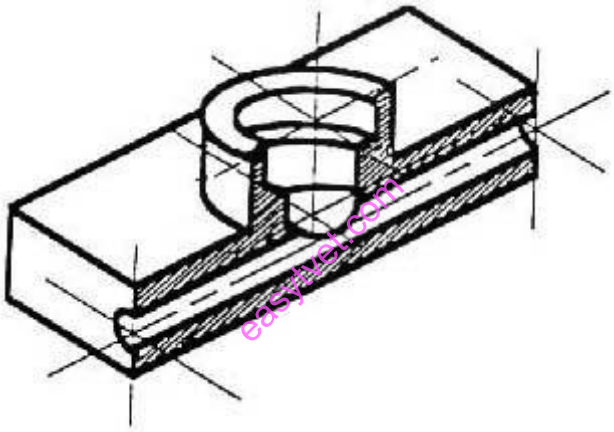
An isometric drawing without all details.

We can get around this by pretending to cut the object on a plane and showing the "sectional view". The sectional view is applicable to objects like engine blocks, where the interior details are intricate and would be very difficult to understand through the use of "hidden" lines (hidden lines are, by convention, dotted) on an orthographic or isometric drawing.

Imagine slicing the object in the middle (figure 9):

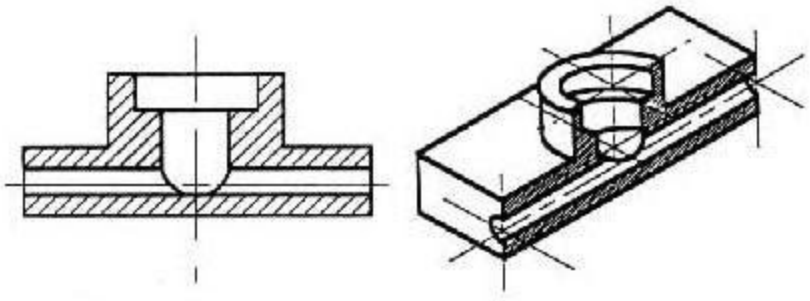


"Sectioning" an object.



Sectioning the object in figure 2.28.

Take away the front half (figure 2.30) and what you have is a full section view (figure 2.31).



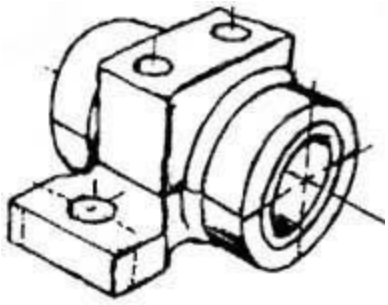
Sectioned isometric and orthogonal views.

The cross-section looks like figure 2.31 when it is viewed from straight ahead.

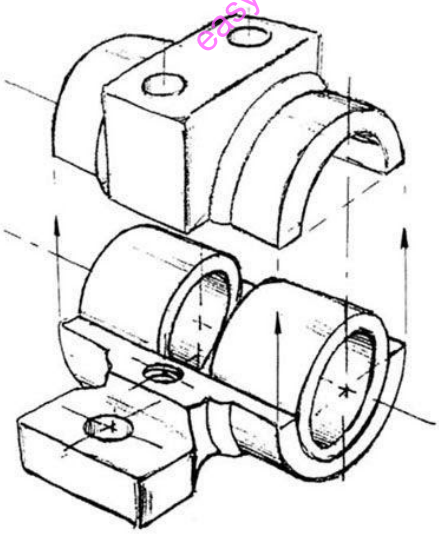
"Assembly" Drawings

An isometric view of an "assembled" pillow-block bearing system is shown in figure 13. It corresponds closely to what you actually see when viewing the object from a particular angle. We cannot tell what the inside of the part looks like from this view.

We can also show isometric views of the pillow-block being taken apart or "disassembled" (figure 14). This allows you to see the inner components of the bearing system. Isometric drawings can show overall arrangement clearly, but not the details and the dimensions.



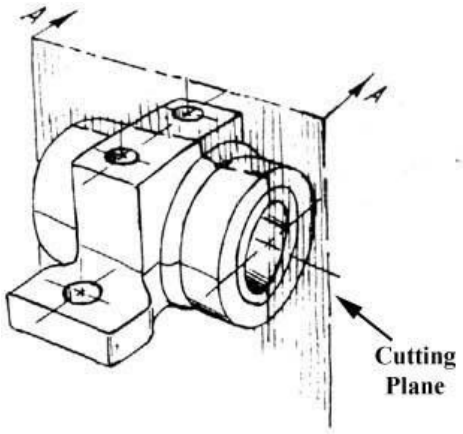
Pillow-block (Freehand sketch).



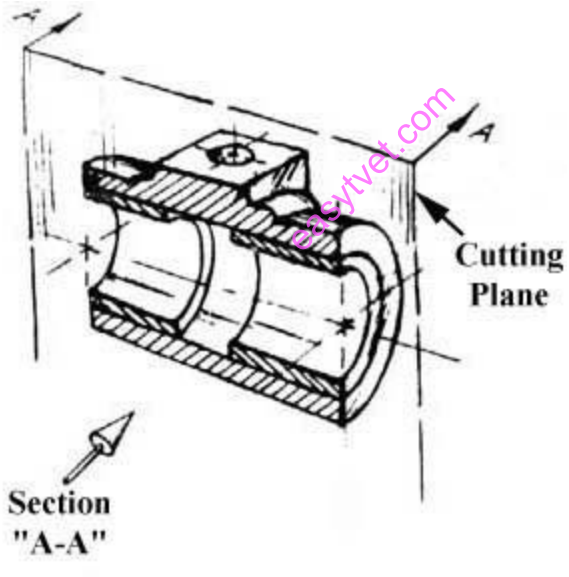
Disassembled Pillow-block.

Cross-Sectional Views

A cross-sectional view portrays a cut-away portion of the object and is another way to show hidden components in a device.
Imagine a plane that cuts vertically through the center of the pillow block as shown in figure 15. Then imagine removing the material from the front of this plane, as shown in figure 2.35

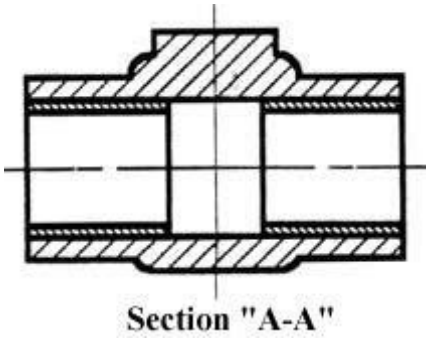


Pillow Block.



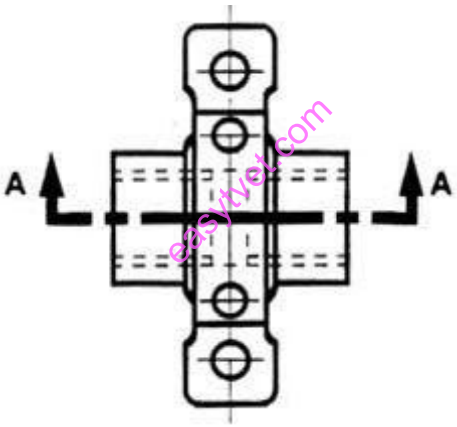
Pillow Block.

This is how the remaining rear section would look. Diagonal lines (cross-hatches) show regions where materials have been cut by the cutting plane.



Section "A-A".

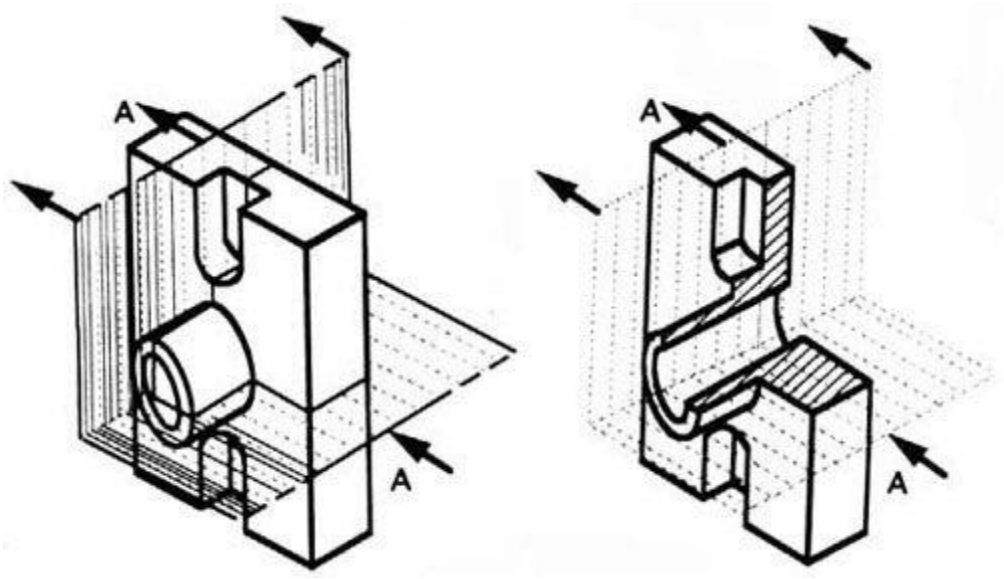
This cross-sectional view (section A-A, figure 2.36), one that is orthogonal to the viewing direction, shows the relationships of lengths and diameters better. These drawings are easier to make than isometric drawings. Seasoned engineers can interpret orthogonal drawings without needing an isometric drawing, but this takes a bit of practice.
The top "outside" view of the bearing is shown in figure 2.37. It is an orthogonal (perpendicular) projection. Notice the direction of the arrows for the "A-A" cutting plane.



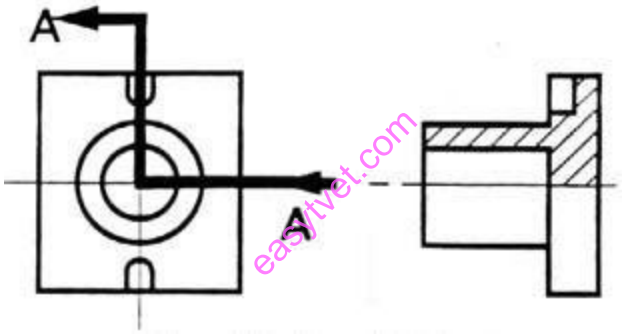
The top "outside" view of the bearing.

Half-Sections

A half-section is a view of an object showing one-half of the view in section, as in figure 2.35 and 2.36



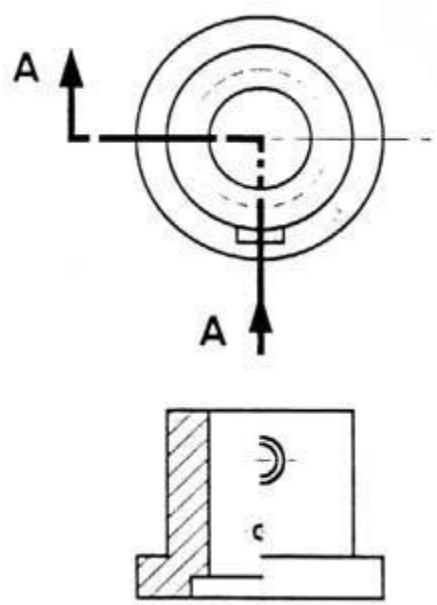
Full and sectioned isometric views.



Front view and half section.

The diagonal lines on the section drawing are used to indicate the area that has been theoretically cut. These lines are called section lining or cross-hatching. The lines are thin and are usually drawn at a 45-degree angle to the major outline of the object. The spacing between lines should be uniform.

A second, rarer, use of cross-hatching is to indicate the material of the object. One form of cross-hatching may be used for cast iron, another for bronze, and so forth. More usually, the type of material is indicated elsewhere on the drawing, making the use of different types of cross-hatching unnecessary.

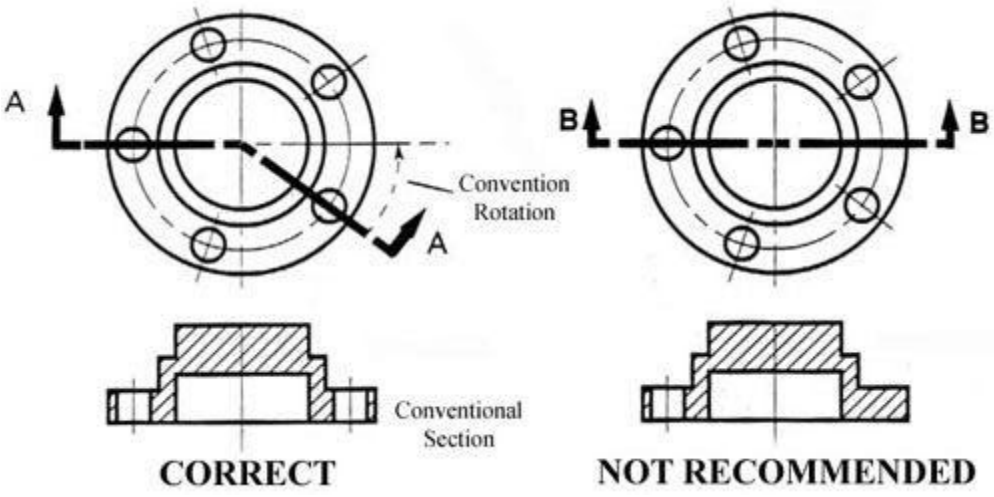


Half section without hidden lines.

Usually hidden (dotted) lines are not used on the cross-section unless they are needed for dimensioning purposes. Also, some hidden lines on the non-sectioned part of the drawings are not needed (figure 2.22) since they become redundant information and may clutter the drawing.

Sectioning Objects with Holes, Ribs, Etc.

The cross-section on the right of figure 2.41 is technically correct. However, the convention in a drawing is to show the view on the left as the preferred method for sectioning this type of object.

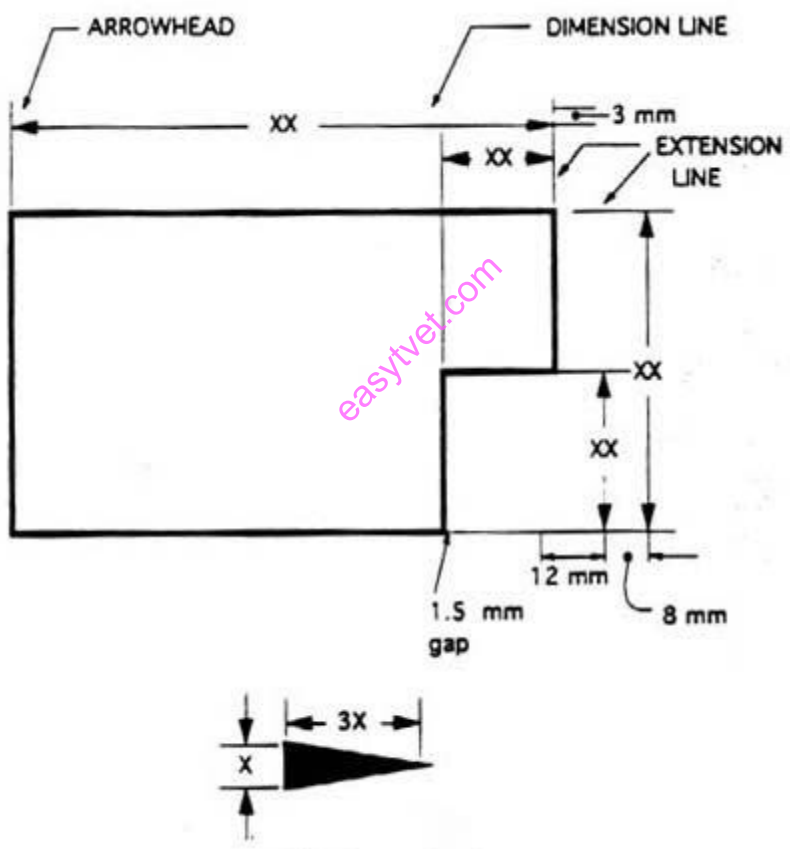


Cross section

Dimensioning

The purpose of dimensioning is to provide a clear and complete description of an object. A complete set of dimensions will permit only one interpretation needed to construct the part. Dimensioning should follow these guidelines.

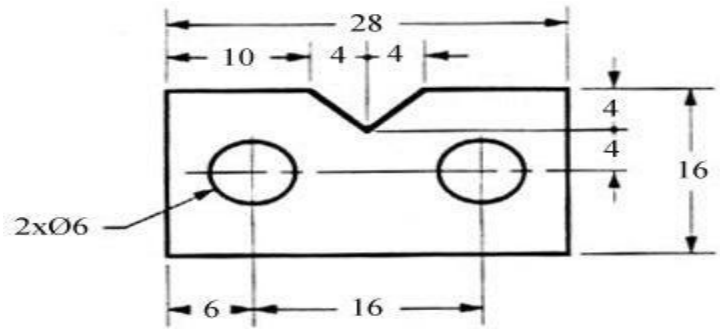
i. Accuracy: correct values must be given.
ii. Clearness: dimensions must be placed in appropriate positions.
iii. Completeness: nothing must be left out, and nothing duplicated.
iv. Readability: the appropriate line quality must be used for legibility.



Dimensioned Drawing.

An **arrowhead** is approximately 3 mm long and 1 mm wide. That is, the length is roughly three times the width. An **extension line** extends a line on the object to the dimension line. The first-dimension line should be approximately 12 mm (0.6 in) from the object. Extension lines begin 1.5 mm from the object and extend 3 mm from the last dimension line.

A leader is a thin line used to connect a dimension with a particular area.

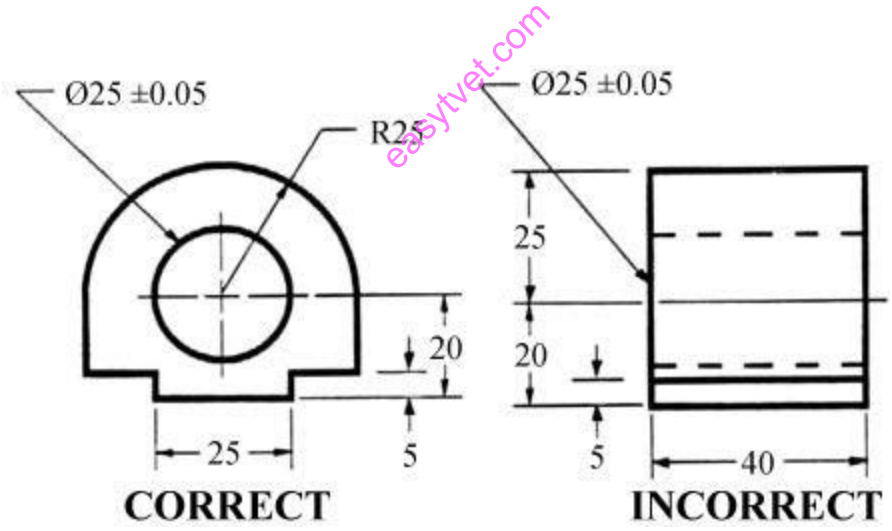


Drawing with a leader.

A leader may also be used to indicate a note or comment about a specific area. When there is limited space, a heavy black dot may be substituted for the arrows. Also in this drawing, two holes are identical, allowing the "2x" notation to be used and the dimension to point to only one of the circles.

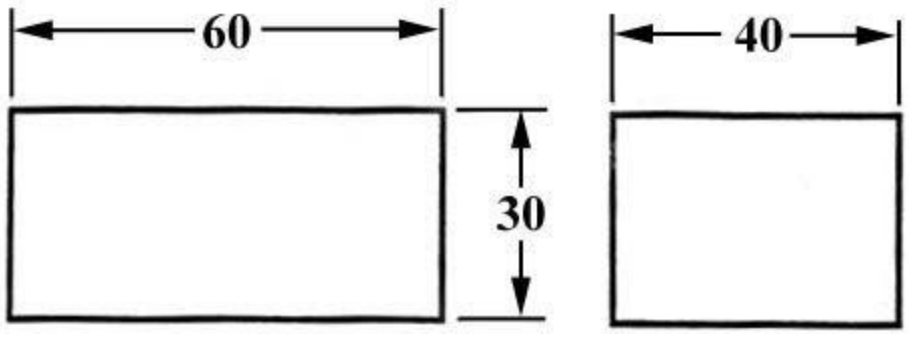
Where to Put Dimensions

The dimensions should be placed on the face that describes the feature most clearly.



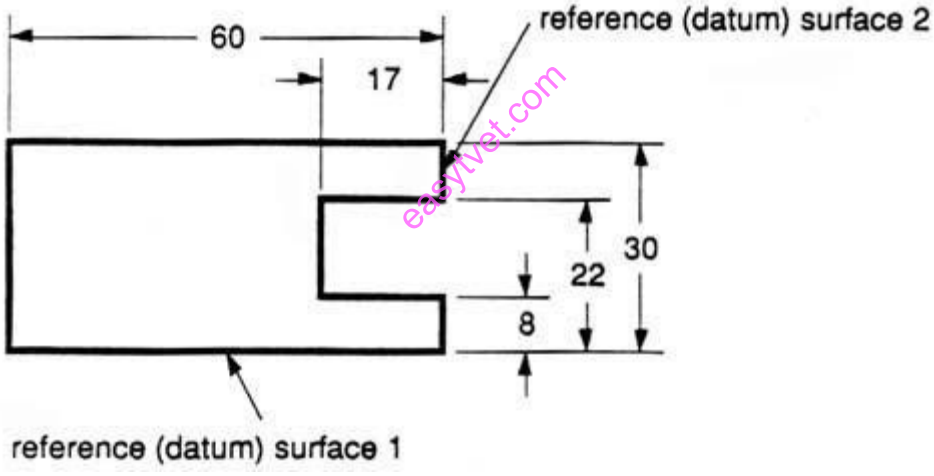
Appropriate and inappropriate dimensioning.

In order to get the feel of what dimensioning is all about, we can start with a simple rectangular block. With this simple object, only three dimensions are needed to describe it completely (figure 2.45). There is little choice on where to put its dimensions.

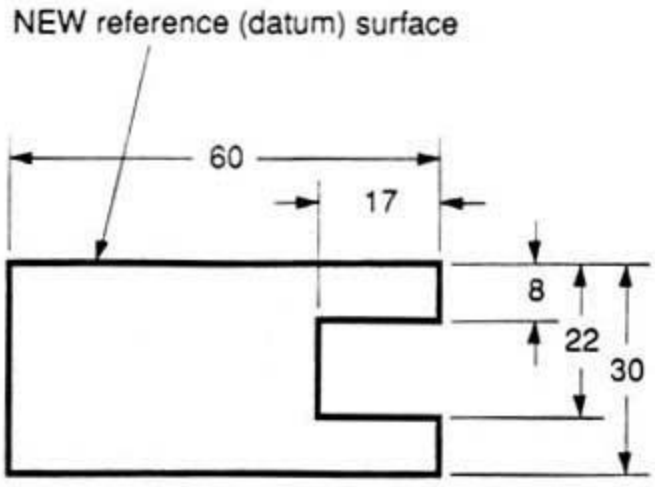


Simple Object.

We have to make some choices when we dimension a block with a notch or cutout (figure 2.46). It is usually best to dimension from a common line or surface. This can be called the datum line of surface. This eliminates the addition of measurement or machining inaccuracies that would come from "chain" or "series" dimensioning. Notice how the dimensions originate on the datum surfaces. We chose one datum surface in figure 2.46, and another in figure 2.47. As long as we are consistent, it makes no difference. (We are just showing the top view).

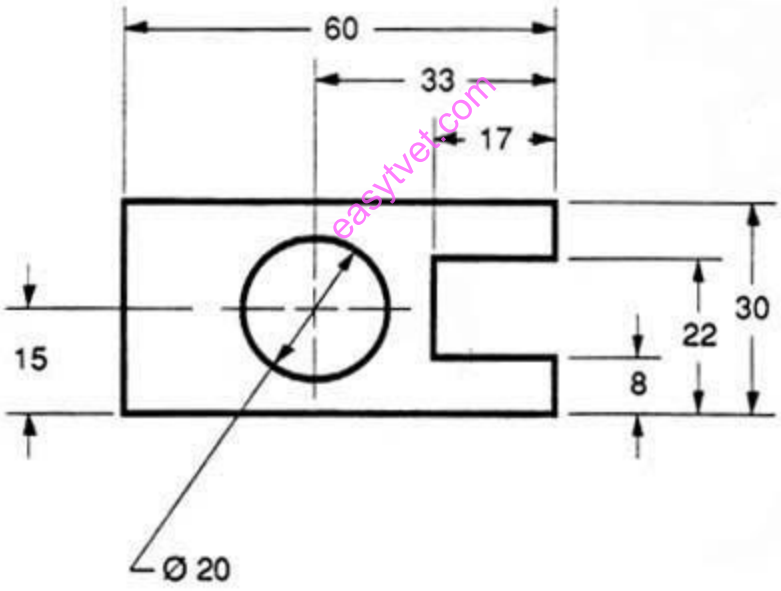


Surface datum



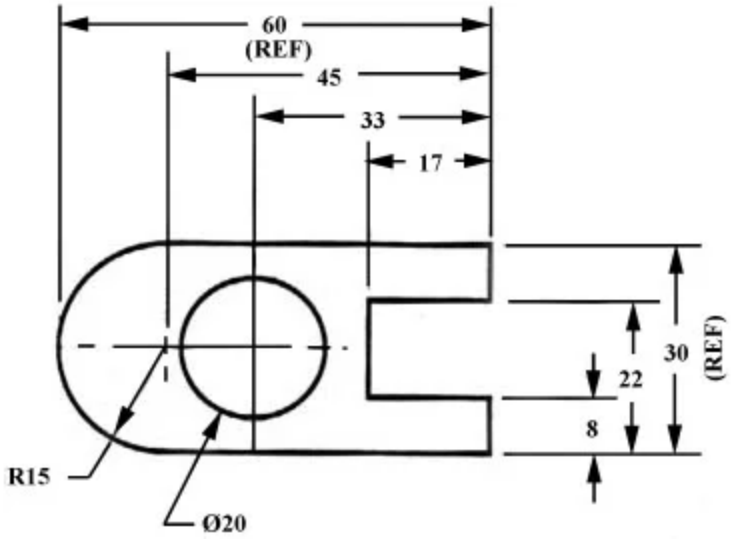
Surface datum example.

In figure 2.48 we have shown a hole that we have chosen to dimension on the left side of the object. The Ø stands for "diameter".



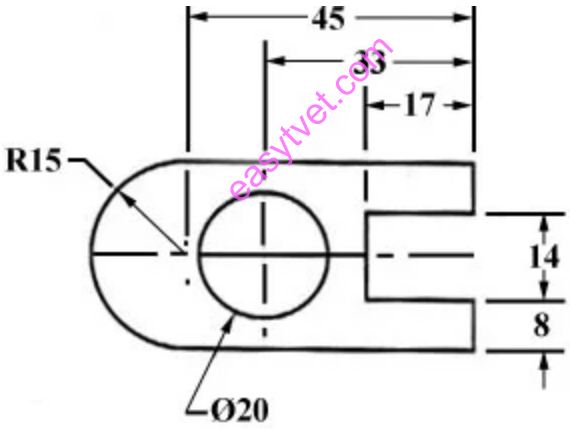
Dimensioned hole.

When the left side of the block is "radiuses" as in figure 2.49, we break our rule that we should not duplicate dimensions. The total length is known because the radius of the curve on the left side is given. Then, for clarity, we add the overall length of 60 and we note that it is a reference (REF) dimension. This means that it is not really required.



Directly dimensioned hole.

Somewhere on the paper, usually the bottom, there should be placed information on what measuring system is being used (e.g. inches and millimeters) and also the scale of the drawing.



Example of a directly dimensioned hole.

This drawing is symmetric about the horizontal centreline. Centrelines (chain-dotted) are used for symmetric objects, and also for the centre of circles and holes. We can dimension directly to the centreline. In some cases this method can be clearer than just dimensioning between surfaces.

Schematic/layout

A schematic, or schematic diagram, is a representation of the elements of a system using abstract, graphic symbols rather than realistic pictures.

Circuit

Electric **circuit** is a path for transmitting electric current. An electric **circuit** includes a device that gives energy to the charged particles constituting the current, such as a battery or a generator; devices that use current, such as lamps, electric motors, or computers; and the connecting wires or transmission lines.

Types of Circuits

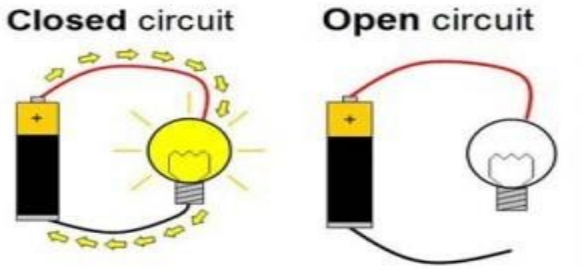


Figure 76:Closed and Open Circuit

Closed Circuits & Open Circuits

A **closed circuit** has a complete path. An **open circuit** does not. In order for a circuit to work, it must be closed; thus, open circuits aren't functional. That may be a hard idea to grasp at first, but circuits are very different from open restaurants or open doors. When a circuit is open, the current can't flow through.

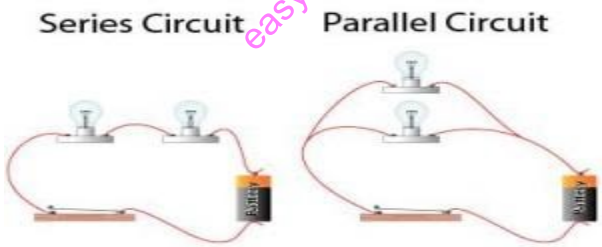


Figure 77: Series and Parallel Circuits

Series Circuits and Parallel Circuits

A **series circuit** is a circuit in which the same current flows through all components of the circuit. The current only has one path to take. If you've ever had trouble with Christmas lights, you might know a little about series circuits. If the lights are constructed in a series circuit (as many holiday lights are), when one bulb is missing or burnt out, the current cannot flow and the lights won't turn on. Series circuits can be very frustrating because if they don't work, you have to figure out which piece is responsible for the whole.

A **parallel circuit is** a circuit in which the components are arranged so that the current must break up (with bits flowing across each parallel branch) before meeting and combining again.

Because the current divides, each component is assured a charge. And if one path breaks, the other paths will still work because they aren't reliant on each other. (So if you're looking for new Christmas lights, check that they're in a parallel circuit arrangement to avoid a lot of hassle.) Houses are always built with parallel circuits so that if one light burns out, your entire house won't lose power.

Short circuit is a circuit that allows the current to travel along an unintended path. In this way, it encounters little (or no) resistance. The piece of the circuit bypassed by the short circuit may cease to function and a large amount of current may begin flowing. This causes the wires to heat up and can potentially cause a fire. As we've already discussed, circuit breakers and fuse boxes are put in place to cut off circuits as a safety measure when a short circuit occurs. A short circuit is not, as some believe, just any electrical malfunction.

Circuit diagram

A circuit diagram is a visual display of an electrical circuit using either basic images of parts or industry standard symbols. Symbol usage depends on the audience viewing the diagram. These two different types of circuit diagrams are called pictorial (using basic images) or schematic style (using industry standard symbols). A schematic style circuit diagram is used to give a visual representation of an electrical circuit to an electrician. The pictorial style circuit diagram would be used for a broader, less technical audience.

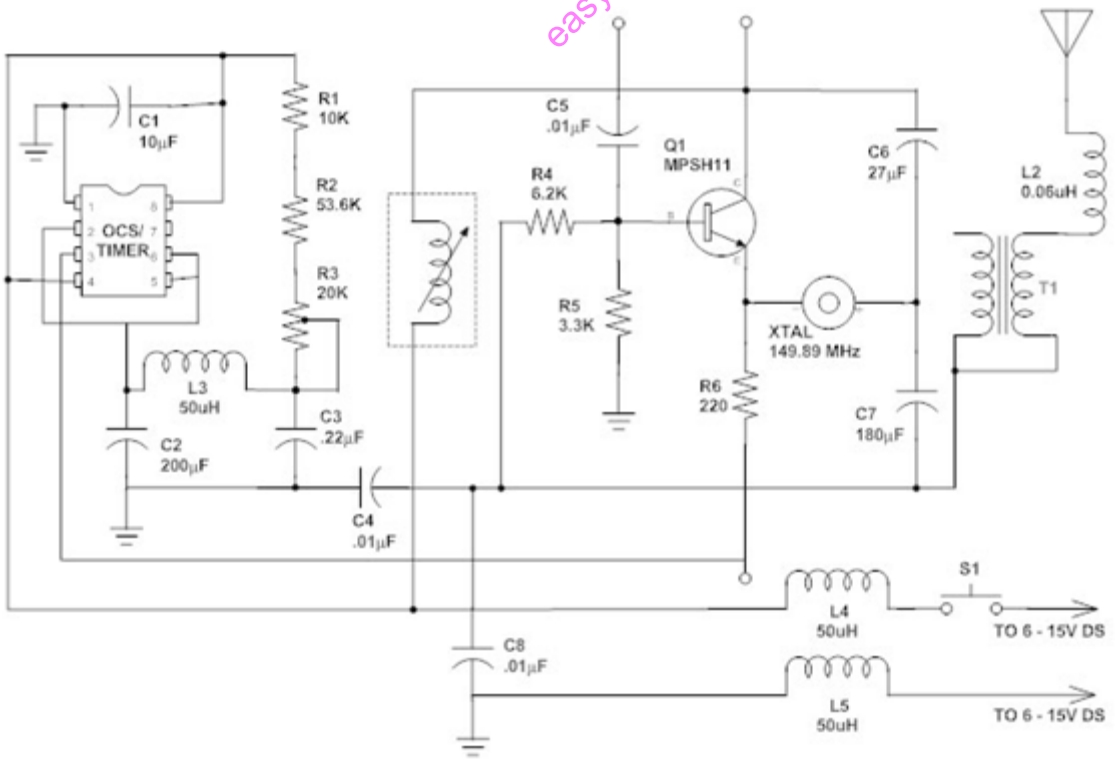


Figure 78: Circuit Diagram

Circuit Diagram Symbols

There are hundreds of different symbols that can be used in a circuit diagram. These include simple images of objects such as a battery or a resistor for a pictorial style circuit diagram, or industry-standard symbols for objects such as capacitors or inductors.

How to Create a Circuit Diagram

There are many different ways to create a circuit diagram. They can be created manually, but the more efficient way is to use diagramming software such as Smart Draw, which is designed for this purpose. Diagramming software that is specifically designed for creating a circuit diagram offers several advantages.

i. It is fast and allows for simple construction.
ii. It provides access to thousands of symbols.
iii. It is easy to share electronically.
iv. It provides precise placement of objects.
v. It is easy to edit.

Smart Draw allows you to quickly, accurately, and easily create a circuit diagram. It also allows you to create personal custom libraries of symbols you commonly use.

Electrical Wiring

Electrical Wiring is a process of connecting cables and wires to the related devices such as fuse, switches, sockets, lights, fans etc. to the main distribution board is a specific structure to the utility pole for continues power supply.

Wiring Diagram

A wiring diagram is a simple visual representation of the physical connections and physical layout of an electrical system or circuit. It shows how the electrical wires are interconnected and can also show where fixtures and components may be connected to the system.

When and How to Use a Wiring Diagram

Use wiring diagrams to assist in building or manufacturing the circuit or electronic device. They are also useful for making repairs.

DIY enthusiasts use wiring diagrams but they are also common in-home building and auto repair.

For example, a home builder will want to confirm the physical location of electrical outlets and light fixtures using a wiring diagram to avoid costly mistakes and building code violations.

How a Wiring Diagram Different from a Schematic

A schematic shows the plan and function for an electrical circuit, but is not concerned with the physical layout of the wires. Wiring diagrams show how the wires are connected and where they should/are located in the actual device, as well as the physical connections between all the components.

How a Wiring Diagram Different from a Pictorial Diagram

Unlike a pictorial diagram, a wiring diagram uses abstract or simplified shapes and lines to show components. Pictorial diagrams are often photos with labels or highly-detailed drawings of the physical components.

Standard Wiring Diagram Symbols

Most symbols used on a wiring diagram look like abstract versions of the real objects they represent. For example, a switch will be a break in the line with a line at an angle to the wire, much like a light switch you can flip on and off. A resistor will be represented with a series of squiggles symbolizing the restriction of current flow. An antenna is a straight line with three small lines branching off at its end, much like a real antenna.

Learning Activities

Figure below shows a part of a machine. Draw full size, in 3rd angle projection, the following views:

i. Front elevation viewed from arrow X,
ii. End elevation viewed from arrow Y
iii. Plan

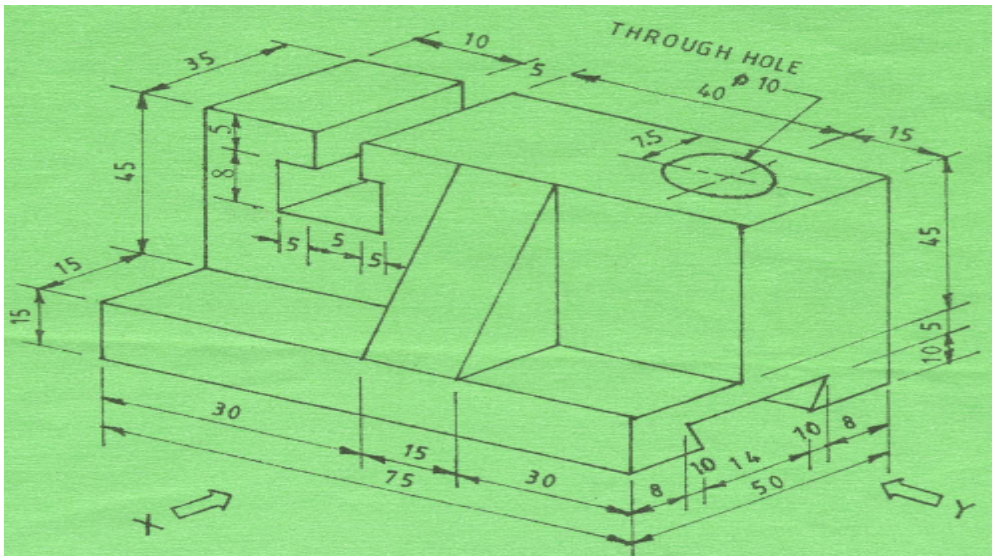


Figure 79: Parts of a Machine

Self-Assessment

1. What is drawing in technology? (4 Marks)
2. What are the types of drawing? (5 Marks)
3. How sketching and technical drawing are related? (4 Marks)
4. What is outline in drawing? (2 Marks)
5. How can I improve my technical drawing skills? (5 Marks)

2.1.2.5: Tools, Equipment and Materials

i. Mechanical pencil and clutch pencil.
ii. Technical pens.
iii. Rulers. .
iv. Compass.
v. Drawing boards.
vi. Erasers.
vii. Sharpeners
viii. T-Square.
ix. Technical Drawing Set

References

i. https://professional-electrician.com/technical/identification-electrical-wiring/
ii. https://girishsab.wordpress.com/identification-of-various-types-of-electrical-accessories-and-components/

iii. https://ocw.mit.edu/courses/mechanical-engineering/2-007-design-and-manufacturing-i-spring-2009/related-resources/drawing_and_sketching/

Model answers to Self-assessment Questions

1. **Technical drawing, drafting or drawing** (4 Marks)

This is the act and discipline of composing drawings that visually communicate how something functions or is constructed.

2. Types of Drawing (5 Marks)

i. Illustration Drawing.
ii. Life Drawing.
iii. Emotive Drawing.
iv. Analytic Drawing.
v. Perspective Drawing.
vi. Diagrammatic Drawing.
vii. Geometric Drawing.

3. **Technical sketching Visas technical drawing:** (4 Marks)

Technical sketches are made with a pencil, paper, and an idea, while technical drawing advances a sketch to follow specific technical drawing guidelines that employ the use of tools, such as isometric graph paper and the aid of a computer.

4. **Outline in drawing**: (2 Marks)

The line by which a figure or object is defined or bounded; contour.
A drawing or sketch restricted to line without shading or modeling of form.

5. **Tips For Improving Your Drawing Skills**
(5Marks)

i. Go draw something. Repeat.
ii. Look at **drawings**. Whether simple line **drawings** or meticulously detailed renderings, you can learn a lot from looking at the work of others.
iii. Draw from **drawings**.
iv. Draw from photographs.

v. Draw from life.

vi. Take a class.

2.1.Select Correct Types and Sizes of Cables

Introduction

A **cable** is a thick wire, or a group of wires inside a rubber or plastic covering, which is used to carry electricity or electronic signals. **Cable** is used to refer to television systems in which the signals are sent along underground wires rather than by radio waves.

For selection of proper cable, the following conditions should be satisfied:

i. **Cable** derating amp should be higher than full load current of load.

ii. **Cable** voltage drop should be less than defined voltage drop.

iii. **Cable** short circuit capacity should be higher than system short circuit capacity at that point.

Performance Standard

i. Reading and interpretation of drawings

ii. Determination of correct type, size and quantity of cables and related consumables.

iii. Selection of tools and equipment.

iv. Identification and selection of correct PPE

Information Sheet

Insulators, Conductors and Cables Conductors

Conductors are the materials or substances which allow electricity to flow through them. They conduct electricity because they allow electrons to flow easily inside them from atom to atom. Also, conductors allow the transmission of heat or light from one source to another.

Insulator

An insulator is a material which is a poor conductor of electricity or heat. Some common insulators include wood, plastic, glass, porcelain and Styrofoam; Styrofoam and plastic see wide use in household applications.

Cable

A cable is a thick wire, or a group of wires inside a rubber or plastic covering, which is used to carry electricity or electronic signals. ... Cable is used to refer to television systems in which the signals are sent along underground wires rather than by radio waves.

Types of conductors (e.g., copper, aluminium) and their applications

Many materials are used to transmit electrical energy, but those most frequently specified for types of conductors are copper, copper-covered steel, high strength copper alloys, and aluminum.

Copper conductor

Copper is the electrical **conductor** in many categories of electrical wiring. **Copper wire** is used in power generation, power transmission, power distribution, telecommunications, electronics circuitry, and countless types of electrical equipment. **Copper** and its alloys are also used to make electrical contacts.

Aluminum conductor

Aluminium conductor steel-reinforced cable (ACSR) is a type of high-capacity, high-strength stranded conductor typically used in overhead power lines. The outer strands are high-purity aluminium, chosen for its good conductivity, low weight, low cost, resistance to corrosion and decent mechanical stress resistance.

Application of conductors in daily life

i. Mercury is used in thermometers to absorb heat
ii. Aluminium is used for making frying pans to absorb heat quickly.
iii. Motor vehicle engines are made of iron to conduct away heat- car radiators are made of iron to conduct away heat- refrigerators have copper pipes at the back for conducting away heat from coolant.
iv. Wire gauze conducts heat quickly to the container placed on it for heating.
v. The iron plate of an electric iron is made of steel to absorb heat quickly- the head of a soldering iron is made of copper to be heated quickly.

Properties of conductors e.g. conductivity, temperature, weight, strength

The basic properties of conductors allow us to describe many physical phenomena. Consider the following man standing inside a thin metal wire frame.

Conductivity of conductors

Conductivity is the measure of the ease at which an electric charge or heat can pass through a material. A conductor is a material which gives very little resistance to the flow of an electric current or thermal energy. ... Electrical conductivity tells us how well a material will allow electricity to travel through it.

Temperature effects to conductors

The electrical conductivity of a **conductor** will decrease with an increase in **temperature**!
where rho room temp is the room **temperature** resistivity and alpha is
the **temperature** coefficient of resistivity.

Consider the effect of increasing the temperature on the conductivity of conductors.
Let's look at the factors that go into conductivity and consider how each of these are affected:

Sigma (Σ) = = n q m

i. First consider what will happen to n as temperature increases. The electrons that are
ii. Charge carriers in a conductor will gain energy and go into higher energy levels. However, these energy levels are all still in the valance band. So, the number of charge carriers will not change for a conductor with an increase in temperature.
iii. Now consider q. As temperature increases, the charge on each carrier will not change.
iv. Finally, what happens to the mobility? Recall that mobility is the drift velocity divided by the electric field strength. Temperature won't affect the electric field strength. But it will decrease the drift velocity because as the temperature increases, the atomic vibrations will increase, which will cause more collisions of the electrons with the crystal lattice. Hence the drift velocity will decrease.

Conclusion:
The electrical conductivity of a conductor will decrease with an increase in temperature!
The relationship is not linear; however, if we consider the resistivity, which is the reciprocal of conductivity, we do get a linear relationship:

rho (ρ ρ) = rho $_{roomTemp}$ [1 + alpha (T - T_{room})]
where rho $_{roomTemp}$ is the room temperature resistivity and alpha is the temperature coefficient of resistivity.

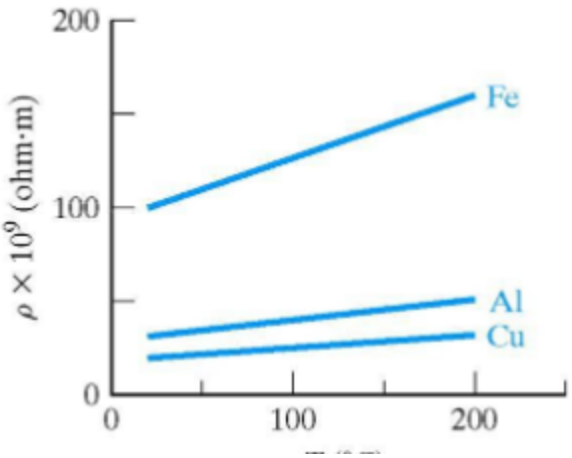


Figure 80: Effects of Temperature to Conductors

Weight of Conductors

To determine the weight of a conductor,

Multiply the mass per centimeter value from Step 13 by the planned length of the wire (in centimeters). This will give you the total mass of the wire, expressed in grams. Multiply the wire's total mass by 0.0022 to convert it to pounds.

Strength of Conductor

Copper: Copper has a high conductivity and greater tensile strength.

Aluminium: Aluminium has about 60% of the conductivity of copper; that means, for the same resistance, the diameter of an aluminium conductor is about 1.26 times than that of a copper conductor.

Types of insulators (e.g. PVC, rubber, porcelain, fibre)

PVC insulators

PVC is a polymer with good insulation properties, but because of its higher polar nature the electrical insulating property is inferior to non-polar polymers such as polyethylene and polypropylene.

Rubber insulator

In either its natural or synthetic form, rubber has been used as an insulator since 1870. The tightly bound electrons are not free to be shared by neighbouring atoms. The properties of rubber also cause the electrons to slow down and eventually prevent them from moving at all. Electrical cords are a good example of rubber being used as an insulator. If a cord is frayed and has damaged the outer rubber lining, the rubber will not be an effective insulator. If the conductors (wires) are exposed, it is necessary to replace the cord.

Porcelain insulators

Porcelain is made from a refined, white clay called kaolin and is fired at temperatures as high as 2,600° Fahrenheit. It is sometimes referred to as “China,” because the manufacturing process was developed centuries ago in that country.

Porcelain also has a solid color throughout, usually white. Porcelain is denser and less absorbent than ceramic, so it can easily withstand moisture and harsher weather conditions. Because of the cost of materials and an intensive manufacturing process, porcelain is more expensive to produce.

Fibre insulator

Natural **Fiber**: Some natural **fibers** including cotton, wool, straw, and hemp are used as **insulation** materials. ... Wool has a similar R-value as other more common types of **insulation**. Hemp **insulation** is relatively unknown and not used widely, but has a similar R-value to other types of fibrous **insulation**.

Properties of insulators e.g. resistivity

Property 1: In an insulator, the valence electrons are tightly held together. They do not have free electrons to conduct electricity.

Property 2: The ability of the material to not allow the electric current to pass through it is called electrical resistance. The resistance of an insulator per unit cross-sectional area per unit length is called resistivity. Insulators have very high resistivity. For example, insulators like glass have a resistivity value as high as 1012 Ωm. The resistance of the insulator is considerably reduced in the presence of moisture and when there is an increase in temperature.

Property 3: Insulators have large dielectric strength. The dielectric strength is the maximum electric field that the insulator can withstand without undergoing electrical breakdown and becoming electrically conductive.

Property 4: Good insulators have a high air permeability (the ability of the material to allow air to flow through its pores) since air itself is an insulator.

Factors to consider when selecting cables e.g. load, length

The key to the successful operation of a cable system is to select the most suitable cable for the application, make a correct installation, and perform the required maintenance. In this technical article, discussion is based on the correct cable selection and application for power distribution and utilization.

Cable selection can be based upon the following five key factors:

The key to the successful operation of a cable system is to select the most suitable cable for the application, make a correct installation, and perform the required maintenance.

In this technical article, discussion is based on the correct cable selection and application for power distribution and utilization.

i. Cable installation
ii. Cable construction
iii. Cable operation (voltage and current)
iv. Cable size

v. Shielding requirements

Cable installation

Cables can be used for outdoor or indoor installations depending upon the distribution system and the load served.

A good understanding of local conditions, installation crews, and maintenance personnel is essential to assure that the selected cable system will operate satisfactorily! Many times cable insulation is damaged or weakened during installation by applying the incorrect pulling tensions.

Designs of conduit systems not only should minimize the number of conduit bends and distances between manholes but also should specify the pulling tensions.

Cable construction

Selection and application of cable involves the type of cable construction needed for a particular installation. Cable construction involves conductors, cable arrangement, and insulation and finish covering.

Conductors

Conductor materials such as copper and aluminum should be given consideration with regard to workmanship, environmental conditions, and maintenance. The requirements for aluminum conductors with regard to these factors are more critical than for copper conductors.

Cable arrangement

Conductors can be arranged to form single-conductor or three-conductor cable. There are certain advantages and disadvantages to both types of arrangements. Single conductors are easier to install, easier to splice, and allow the formation of multiple-cable circuits.

On the other hand, they have higher reactance than three-conductor cable. Shielded single conductors carry high shield currents, and consideration must be given to preventing overheating of the cable.

Single-conductor cables are subject to considerable movement owing to the mechanical stresses produced by the short circuit currents or high inrush currents. Three-conductor cable with an overall jacket has the lowest reactance, and voltage stress distribution is balanced owing to equivalent spacing between conductors.

The availability of ground wire in three-conductor cable or a separate ground wire with single-conductor cable is an important consideration. Since the ground conductor in three-conductor cable construction provides the lowest impedance path, it offers a good system ground.

Similarly, a separate ground in the same conduit as the power conductors provides a better ground return path than a ground path via the equipment or building steel.

The selection and application of a cable system should be based on correct selection of the type of cable arrangement required for the purpose.

Insulation and finish covering

The selection of cable insulation and finish covering is normally based on the type of installation, ambient operating temperature, service conditions, type of load served, and other criteria as applicable. In many installations unusual conditions may be prevalent, such as corrosive atmosphere, high ambient temperature, insect and rodent hazard, presence of oil and solvents, presence of ozone, and extreme cold.

In certain applications, two or more of these unusual conditions may be present, in which case the selection of suitable cables becomes much more difficult.

Cable operation

The insulation of the cable must be able to withstand the voltage stresses experienced during normal and abnormal operating conditions. Therefore, the selection of the cable insulation should be made on the basis of the applicable phase-to-phase voltage and the general system category which are classified as either 100%, 133%, or 173% insulation levels.

These insulation levels are discussed as follows:

100% level:

Cables in this category may be applied where the system is provided with relay protection which normally clears ground faults within 1 minute This category is usually referred to as the grounded systems.

133% level:

Cables in this category may be applied where the system is provided with relay protection which normally clears ground faults within 1 hour. This category is usually referred to as the low resistance grounded, or ungrounded systems.

173% level:

Cables in this category may be applied where the time needed to de-energize the ground fault is indefinite. This level is recommended for ungrounded and for resonant grounded systems.

The current capacity that the cable needs to carry is determined by the load it serves.

In cases where cables may be load cycled, the current carrying capacity may be calculated by the following formula:

$$I_{eq}\, I_{eq} == \frac{EI^2t}{T}\frac{EI^2t}{T}$$

Where:

$I_{eq}\, I_{eq}$ is the equivalent current carrying capacity

I is the constant current for a particular time period

t is the time period of constant current

T is the total time of duty cycle

E is the voltage of the cable

The equivalent current carrying capacity should be used for selecting the conductor sizes for thermal withstand.

Cable size

The selection of cable size is based upon the following factors:

i. Current carrying capacity
ii. Voltage regulation
iii. Short circuit rating

These factors should be evaluated before selecting a cable size! In many instances voltage regulation and short circuit rating factors are overlooked. This oversight can result in danger to property and personnel, as well as destruction of the cable itself.

Current carrying capacity

The current carrying capacity of a cable is based upon its thermal heating. The NEC publishes tables listing the current capacity for various-sized cables. The ICEA publishes current ratings for various types of insulation and installation conditions.

The current rating of cable is based upon certain spacing to permit thermal dissipation. If this spacing is smaller where the cable is to be installed, then derating of cable is required.

Home / Technical Articles / Five key factors to the correct cable selection and application

Voltage regulation

In correctly designed electrical power systems, voltage regulation is usually not a problem. Voltage drops for excessively long runs at low voltage should be checked to ensure correct load voltage. In rotating loads, checks should be made both on steady-state voltage regulation and during starting.

Short circuit rating

The cable size selected should be checked for short circuit withstand capability, which should be based upon the circuit opening time for short circuit condition. In other words, the cable should hold without any thermal damage to it until such time as the fault can be removed by the switching device, such as a circuit breaker or fuse.

Shielding

In selecting and applying cables at medium voltage, a major consideration involves whether the cable should be shielded or non-shielded. The condition under which shielded cable is to be selected and applied is explained in the following discussion.

The application of shielded cable involves the following considerations:

i. Type of insulation system
ii. Whether the system neutral is grounded or ungrounded
iii. Safety and reliability requirements of the system

In power systems where there is no shield or metallic covering, the electric field is partly in the air and partly in the insulation system! If the electric field is intense, such as in the case of high and medium voltage, surface discharges will take place and cause ionization of the air particles. The ionization of air causes ozone generation, which can deteriorate certain insulations and finish coverings.

Shielding should be considered for nonmetallic cable operating in excess of 2kV where any of the following conditions exist:

Damp conduits

i. Connection to aerial wires
ii. Transition from a conducting to a nonconducting environment (such as from moist to dry earth)
iii. Dry soil
iv. Dirty environment containing soot, salt, and other contaminants
v. Where safety to personnel is required
vi. Where radio interference is expected

Identification of sub- circuits

Sub-circuits are self-contained circuits that appear as "black boxes" in other circuits. A given sub-circuit may be used any number of times at multiple levels just as long as it does not become a sub-circuit of itself. Cards and chips both begin as circuits designed on the circuit board.

Sub-circuits are self-contained circuits that appear as "black boxes" in other circuits. A given sub-circuit may be used any number of times at multiple levels just as long as it does not become a sub-circuit of itself.

There are three types of sub-circuits: cards, chips and plug-ins. Plug-ins will be discussed in a separate section.

Cards and chips both begin as circuits designed on the circuit board. The difference between a card and a chip is that the internal structure of a card remains visible and editable while a chip is closed and opaque.

Types and sizes of cables
Cables may be classified into the following types depending upon their purpose:

Ribbon Electric Cables
It consists of multiple insulated wires running parallel with one another and is used for transmission of multiple data simultaneously. For example, this is used to connect the CPU with the motherboard and is generally used for interconnection of networking devices.

Shielded Cables
It consists of 1 or 2 insulated wires which are covered by a woven braided shield or aluminium Mylar foil for better signal transmission and removing irregularities in the frequency of power and external interference in radio. These cables transmit high voltage electric current and are protected by a shield.

Twisted Pair Cables
It has two or more insulated copper wires which are twisted with each other and are colour-coded. These types of wires are usually used in telephone cables and the resistance to external interference can be measured by the number of wires.

Coaxial Cables
This consists of solid copper or steel conductor plated with copper which is enclosed in the metallic braid and metallic tape. This is entirely covered with an insulated protective outer jacket. These types of cables are used for computer networking and audio-video networking.

Fibre Optics Cable
There are these types of cables which transport optical data signals from an attached light source to the receiving device. We are pretty much aware of what is an optical fibre and its uses in a wide variety of applications.

Measurements and estimations of cable lengths and sizes
Thicker cables offer less resistance to electric flow. They offer more electrons to carry a charge and a greater number of paths through which the electrons can travel. As a result, given the same voltage, a thicker cable carries more current. Choose a cable's exact thickness to meet a

target level of resistance. The other relevant factors are the length of the cable, which external needs usually dictate and the resistivity of the cable's material.

Divide the voltage running through the cable by your target current. If, for instance, 120 volts will act on the cable, and you want 30 amps to run through it: 120 / 30 = 4. This is your target resistance, measured in ohms.

Multiply the cable's length by its material's resistivity. Copper, for instance, has a resistivity of 1.724×10^{-8} ohm meters at room temperature. If your cable must measure 30,000 meters in length:

$30{,}000 \times 1.724 \times 10^{-8} = 0.0005172$-ohm sq. m.
Divide the answer by your target resistance:
0.0005172 / 4 = 0.0001293.

This is the cable's necessary cross-sectional area.
Divide the cable's area by pi: (0.0001293) / 3.142 = 4.1152×10^{-5}.
Find the square root of this answer: $(4.1152 \times 10^{-5})^{0.5} = 0.006415$. This is the cable's radius, measured in meters.

Multiply your answer by 39.37 to convert it to inches: 0.006415 x 39.37 = 0.2526.
Multiply the answer by 2: 0.2526 x 2 = 0.5052 inches. This is the cable's necessary thickness. It approximately corresponds with the standard 16-gauge cable.

Relevant IEE regulations

i. The cable must be of complete chemical and physical stability.
ii. The cable must be provided with suitable mechanical protection.
iii. The cable must have a proper thickness of insulation.
iv. The conductors used in cables must be tinned and stranded copper or aluminum of high conductivity.

Learning Activities

Three most commonly used cable sizes of 1, 1.5 and 2.5mm twin and earth there are in fact several other larger sizes of cable that include 4mm, 6mm, 10mm and 16mm. Identify these cables according to their size and state where they are used.

Self-Assessment

1. What is the meaning of IEE in electrical? (2 Marks)
2. What are the factors to be considered when selecting cable size? (2 Marks)
   What are the factors on which the insulation layer thickness of the conductor is decided in the cables? (1Mark)

3. How do you protect a cable from mechanical injury? (3 Marks)
What is a cable? (2 Marks)

Tools, Equipment and Materials

i. Tape Measure.
ii. Hammer.
iii. Spirit Level.
iv. Flashlight.
v. Utility Knife.
vi. Screwdrivers.
vii. Straight-Blade Screwdrivers

References

i. https://sciencing.com/how-8093550-calculate-size-cable.html
ii. https://www.zarebasystems.com/articles/ceramic-vs-porcelain-insulators
iii. https://electrical-engineering-portal.com/cable-selection-application
iv. https://byjus.com/physics/types-of-cables/

Model Answers to the self-assessment

1. IEE (Institution of Electrical Engineers) (2 Marks)

The Institution of Electrical Engineers (IEE) was a British professional organization of electronics, electrical, manufacturing, and information Technology professionals, especially electrical engineers. It began in 1871 as the Society of Telegraph Engineers.

2. **Factor to consider when selecting size of a Cable** (4 Marks)

i. Current carrying capacity
ii. Voltage regulation
iii. Short circuit rating
iv. Length of the cable run.

3. **The factors on which the insulation layer thickness of the conductor is decided in the cables**

It depends on the voltage. (1 Mark)

4. **Cable Protection from mechanical injury** (3 Marks)

By using the process of armouring, the cable can be protected from mechanical injury.

5. **Cable** (2 Marks)

A cable is a thick wire, or a group of wires inside a rubber or plastic covering, which is used to carry electricity or electronic signals. Cable is used to refer to television systems in which the signals are sent along underground wires rather than by radio waves.

2.2.Install Cables for Lighting and Power Points

Introduction

Homes typically have several kinds of home **wiring**, including electrical **wiring for lighting and power** distribution, permanently **installed** and **Power points** (wall outlets); **Light** fixtures and switches; Telephone; Internet; Television, *etc etc* .

Performance Standard

1. Safety procedures and regulations installation of lighting and power points
2. Wiring of lighting and power points
3. Grounding of Lighting and power points
4. Installation quality checking

Information Sheet

Cable joint and termination

The cable joints and terminations provide a means of making reliable electrical connections between different cables or between the electrical cable and the terminals of equipment.

Types of cable joints and termination

Cable joints

A joint is a connection of two lengths of conductors by a method which ensures a continuous path for the unimpeded flow of an electrical current. This connection is applied to the end of a conductor prepared in such a way that it is suitable for connection to the terminal to which it is to be connected by mechanical means.

In making a joint, care must be taken to ensure that there must be sufficient contact area between the two current carrying surfaces. This is to ensure that heat is not generated on such surfaces on account of increased resistance. They are used to join cables in order to complete the circuit.

There are three main types of electrical joints, also known as splices: The Western Union splice, the tap splice and the fixture splice.

i. Bell hangers joint/ The Western Union splice/ Married joint
ii. Telegraph joint
iii. A tap splice (Tee Joint)
iv. A fixture splice

Bell hangers joint

This joint at times is also called straight twist joint it is not a strong type and so it is used where more tensile stress is placed on the conductors which are usually solid core and insulated.

Figure 81: Bell hangers joint

The Western Union splices

Connects two conductors together and is particularly useful in repairing a broken wire. The two wires are trimmed of insulation, and then each is wrapped around the other around six times.

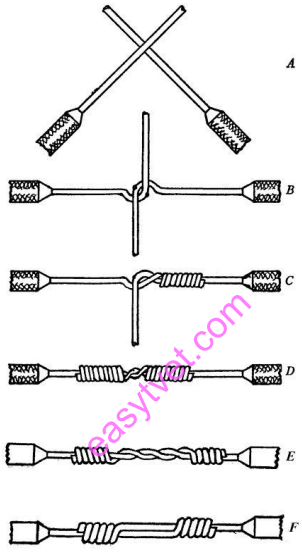
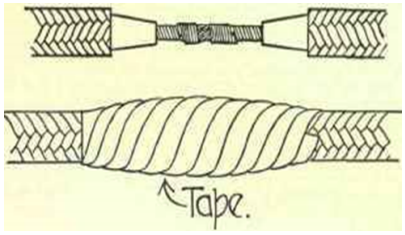


Figure 82: Western Union Splice cable joint

Married joint

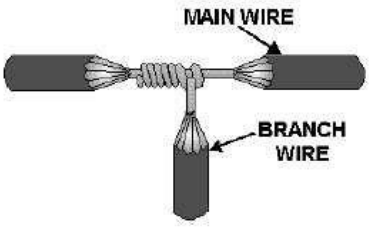
When made correctly it forms a very strong and satisfactory joint



Tap splice (Tee Joint)

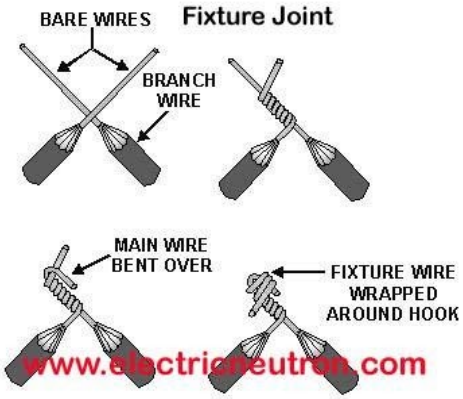
This connects a loose wire to the conductor at an angle, typically resembling a "T" shape. They are named tap splices because the loose wire can then "tap" the flow of the conductor. The wires of the loose wire are wrapped around the conductor, first with one-on-one side and then with five or more on the other.

It is a branch or TEE joint made with single core conductors



Tap splice cable joint

A fixture splice connects two different conductors and can be called a rat tail splice. The two exposed wires must be twisted together with a plier, then bent into place.



Fixture splice cable joint

Purpose and application of cable joints and termination

The cable joints and terminations provide a means of making reliable electrical connections between different cables or between the electrical cable and the terminals of equipment.

Relevant IEE regulations

The normal installation has many joints, and it follows that these must all remain safe and effective throughout the life of the system. With this in mind, regulations on joints include the following:

i. All joints must be durable, adequate for their purpose, and mechanically strong.
ii. They must be constructed to take account of the conductor material and insulation, as well as temperature: e.g., a soldered joint must not be used where the temperature may cause the solder to melt or to weaken. Very large expansion forces are not uncommon in terminal boxes situated at the end of straight runs of large cables when subjected to overload or to fault currents.
iii. All joints and connections must be made in an enclosure complying with the appropriate British Standard.
iv. Where sheathed cables are used, the sheath must be continuous into the joint enclosure.
v. All joints must be accessible for inspection and testing unless they are buried in compound or encapsulated, are between the cold tail and element of a heater such as a pipe tracer or underfloor heating system, or are made by soldering, welding, brazing or compression.

Cable terminations

The electrical cable termination is the physical and electrical connection of a cable end that connects to another cable, or to the terminal of the equipment. The cable terminations are often designed to enable the physical and electrical interconnecting of two cable ends, or a cable end and a terminal on the equipment. Remember the cable connection is not complete until all terminations are properly identified and labelled.

The methods used to terminate the cables vary according to the type of cable, type of connectors and application. The common types of terminations are crimp connection, soldered connection, compression termination and wire-wrapping connection, direct connection, loops or eye connection.

Some of the factors that determine the type are:

i. Outdoor or indoor use
ii. Voltage
iii. Current
iv. Overhead or underground
v. Type of connector on the equipment where the cable will be connected

Learning Activities

Figure below shows a 12 V solar home system layout.

i. Draw a wiring diagram of the layout
ii. Carry out the wiring of the control gear of the solar unit in correct sequence

iii. Using PVC mini trunking system, install the circuits such that:
iv. The lamps are controlled from two positions
v. Socket outlets are wired in ring.

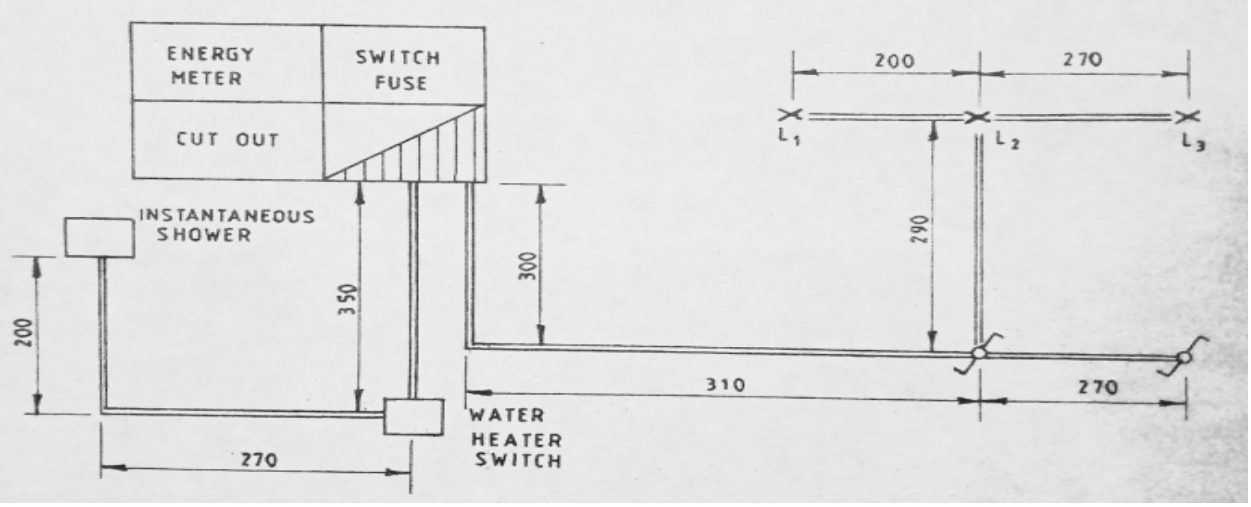


Figure 83: Solar home system layout

Self-Assessment

1. Why are cable termination kits used? (2 Marks)
2. What are the types of cable joints? (2 Marks)
3. What are the main types of electrical terminations? (2 Marks)
4. How do you terminate electrical cables? (2 Marks)
5. Can you leave unused wire in wall? (2 Marks)

Tools, Equipment, Supplies and Materials

i. Needle nose crimping pliers.
ii. Connector crimper.
iii. Wire stripper hole for 22- to 24-gauge wire.
iv. Built-in side cutter.
v. Rubber coated handles for non-slip grip.
vi. Pliers
vii. Screw drivers
viii. Tester
ix. Hammer
x. Draw wire

References

i. **https://kvcable.com/cable-accessories/cable-termination/**
ii. **https://www.tlc-direct.co.uk/Book/4.4.3.htm**

Model Answers to the self-assessment Questions

1. **Reason for using cable termination kits** **(2 Marks)**
   For connection of Cable to Switchgear Terminal, Transformer Terminal, Poles etc. termination kits are required. It can also be single core or 3 core / 3.5 core based on cable configuration. Termination can be for XLPE & strong PILC Cable and can be used in extreme hazardous atmosphere conditions.

2. **Types Of Cable Joints** **(2 Marks)**
   i. The Western Union splice, The Western Union splice connects two conductors together and is particularly useful in repairing a broken wire.
   ii. The tap splice and the
   iii. Fixture splice.

3. **Types of electrical terminations:** **(2 Marks)**
   Chip, coaxial, SCSI, and waveguide. Chip terminations have a form factor of an integrated circuit (IC) chip. They are manufactured using thin-film technology. Coaxial terminations terminate coaxial ports.

4. Electrical tape is the simplest method of making electric wires safe. You also use tape on capped live electric wires as an extra precaution. Tapes can be used on loose live wires that do not fit the cap. You can simply use tape over the live wire to fit into the cap.

5. It's acceptable to leave wire in the walls. The only thing you need to do is leave the ends exposed in boxes and wire nut and tape the two legs together. That will indicate to an electrician what's going on, and if someone does try to tie into them in the future it will just pop the breaker. **(2 Marks)**

Install Power Intake Point

Introduction

The main control or intake point.

main equipment at power intake for domestic consumer. main equipment at the power intake points of domestic consumers. mains electricity intake point.

Performance Standard

1. Safety procedures and regulations
2. Selection of, tools, equipment and materials
3. Identification and selection of correct PPE
4. Meter box and components wiring
5. Installation of lead-in pipe
6. Installation of consumer main earthing terminal bonding

Information Sheet

Identification of tools and equipment

Tools and equipment mean all hand tools, implements, camp equipment, drawing office and survey instruments, medical and surgical instruments and all articles of similar nature, whether or not they are of an expendable nature, which are not normally issued to officers personally for use in carrying out their official.

Basic electrical tools, equipment, and their uses include:

Pliers

Pliers are available in different types, shape, and sizes. They are also available in both insulated and uninsulated handles. An insulated handle should be used when working on or near hot wires. It is also used for cutting big and small wires.

Figure 84: Pliers

Screw Drivers:

A screwdriver comes in various sizes and with several tip shapes. Screwdrivers used by electricians should have insulated handles. Using a screwdriver for a particular job, the width of the screw slot.

screw drivers

Drilling Equipment

Drilling equipment is needed to make holes in building structure passages of conduits and wires.

Driller

Sawing and Cutting

Saws commonly used by electricians include the crosscut, keyhole, and hacksaw.

Hark saw

Soldering Equipment

In doing electric wiring splices and taps (connections made to wire) should be soldered, unless you use solderless connectors. Typical equipment available for soldering are shown below.

Soldering equipment

Hammers

Hammers are used with chisels and for nailing and fitting. Below are examples of carpenter's claw hammer, lineman's hammer, and machinist's ball-peen hammer

Hammers

Measuring Tools

To measure wire length and other items, the electrician finds considerable use for measuring tools such as the extension or zigzag rule, push-pull rule and a steel tape as shown below.

Measuring tools

Assembling of Working Tools and Equipment

The identified tools are assembled accordingly.

Preparation of cables

Cable stripping

You have to be careful when removing the insulation from a cable with a cable knife. If strands are cut off, this can lead to contact resistances or even to a cable fire. On top of that, there‘s the very real risk of injury with fixed-blade cable knives. A safe alternative would be a cable stripper or cable knife with adjusting screws.

A cable stripper is great for hard-to-reach places when circular cutting. The stripper is easy to close and maneuver and allows material to be removed cleanly. We recommend using a cable stripper for longer sections like the distributor. The adjusting screw helps to set the correct blade depth.

Stripping pliers make stripping wires and strands even easier. Universal pliers with an integrated knife are brilliant for round or flat cables because you can adjust the cutting length and depth.

Cable pairing

Twisted pair cabling is a type of wiring in which two conductors of a single circuit are twisted together for the purposes of improving electromagnetic compatibility. Compared to a single conductor or an untwisted balanced pair, a twisted pair reduces electromagnetic radiation from the pair and crosstalk between neighboring pairs and improves rejection of external electromagnetic interference

Drawing in of cables

Pulling NM Cable Through Conduit

Most wire that is installed in conduit is insulated wire (usually THHN or THWN) rather than sheathed cable, such as non-metallic (NM), or Romex, cable. Running NM cable inside conduit is not a standard practice and may not be allowed in all jurisdictions.

The National Electrical Code (NEC) does not prohibit running NM cable inside conduit, but this installation is subject to conduit fill limits, just like insulated wire in conduit. Because NM cable takes up more space than individual wires, it's easier to exceed the fill limit with cable. Also, cable is difficult to pull through conduit, due to the cable's size and the sheathing, so running cable in conduit typically is limited to very short runs that do not require standard wire pulling techniques.

Pulling Wire with a Mouse

A conduit mouse, also called a conduit piston, is a small cylinder of foam that is slightly smaller than the interior diameter of the conduit. You use it with a shop vacuum.

Tie Pull String to Wire

Tie a strong string, called a pull string, to the loop on the wire running through the mouse**.**

Insert Mouse into Conduit

Insert the mouse into the conduit on the end that is opposite to the end you will pull from. The mouse goes in first, followed by the string.

Fit Shop V_{ac} V_{ac} Hose Over Conduit

Fit the hose of a shop vac over the other end of the conduit, and turn on the vacuum until the mouse is sucked all the way to that end, then turn off the vacuum.

Pull Mouse Out of Conduit

Pull the mouse out of the conduit and untie the string from the wire loop.

Secure String

Secure the string to the wires, and lubricate the wires, as needed.

Feed Wires into Conduit

Feed the wires into the conduit while your partner pulls them from the other end, using the string.

Pulling Wire with a Fish Tape

The most commonly used tool for pulling wire through conduit is fish tape, an electrician's tool with a long, flat metal wire wound inside a wheel-shaped spool. Fish tapes are widely available in a range of lengths starting at 25 feet. There are also nylon tapes that don't include a spool; these may be the most economical option for when you need a fish tape only for small jobs.

Feed End of Tape into Conduit

Feed the end of the tape, which has a hook on it, into the same end of the conduit that you will pull from.

Push Tape Through Conduit

Push the tape through the conduit, unwinding from the spool as you go. Stop feeding when the hook end emerges from the opposite end of the conduit.

Strip Insulation

Strip insulation from the end of each wire, using wire strippers. Strip each wire a different amount. For example, if there are three wires, strip one about six inches, one about four inches, and one about two inches.

Hold Wires Together

Hold the three wires together so their insulation is aligned. Grab all three with linesman's pliers and twist their bare ends together.

Bend Wire and Loop Through Fish Tape

Bend the longest wire into a hook and loop it through the hook of the fish tape, then wrap the loop closed.

Wrap Fish Tape Hook

Wrap the fish tape hook and the bare wire ends with electrical tape.

Apply Lubricant

Apply lubricant to the tape, if desired. Feed the wires into the conduit while your partner pulls them through from the other end by pulling on the fish tape.

Cable joints

The **cable joints** are used to connect low, medium or high voltage **cables**. The type of **cable joint** sizes, shapes and configurations vary according to the voltage, structure, insulation and the number of cores of the **cable** to be jointed.

Labeling of circuits

The Basic Procedure for Circuit Labeling

Step 1 – Number Every **Circuit**. Assign a number to each **circuit** breaker inside the breaker panel.

Step 2 – Locate all the Devices on the **Circuit**.

Step 3 – List down the Results.

Step 4 – Test all the Appliance **Circuits**.

Step 5 – Make an Index.

Conducting final checks for workmanship, conformity with instructions and job requirements

Inspection and testing are investigative process that verifies the essential safety of electrical installations. In Great Britain, this is normally achieved by ensuring the installation complies with a British Standard known as BS7671, otherwise known as “The Wiring Regulations” or “the regs” as it is often referred to within the electrical industry.

Why should it be considered?

Generally, the older electrical installation’s get and the more they are used, the more likely they will become defective due to neglect, wear and tear or poorly executed additions and alterations.

Who is responsible for instigating electrical testing?

Duty holders (landlords, premises managers and company directors etc.) have the legal responsibility for the safety of their electrical installations. They should ensure suitable proactive action is completed as a matter of course rather than by intervention. Unfortunately, all to often electrical inspections are instigated by Local Authorities, Insurance Companies and the HSE, whereby duty holders have some demanding time frames placed on them to complete an inspection, only to find that defects are then identified which require immediate rectification, often at significant inconvenience and cost within short time frames.

How often should testing be carried out?

It varies from installation to installation. Recommended intervals advise that academic, commercial and industrial ones are tested every five years* and domestic ones up to every ten years*. Although, on very large installations, it can be advantageous to carry out an annual rolling test whereby twenty per cent per year is tested over five years.

What does electrical testing involve?

Initially, varied site-specific factors need to be identified, accounted for and agreed prior to the examination commencing. This is due to the variations that exist between electrical installations within different buildings, their many uses and the physical and operational restrictions that may exist.

Good housekeeping

Effective housekeeping can help control or eliminate workplace hazards. Poor housekeeping practices frequently contribute to incidents. If the sight of waste-paper, debris, clutter and spills is accepted as normal, then other more serious hazards may be taken for granted.

Housekeeping is not just cleanliness. It includes keeping work areas neat and orderly, maintaining halls and floors free of slip and trip hazards, and removing of waste materials (e.g.,

paper, cardboard) and other fire hazards from work areas. It also requires paying attention to important details such as the layout of the whole workplace, aisle marking, the adequacy of storage facilities, and maintenance. Good housekeeping is also a basic part of incident and fire prevention.

Effective housekeeping is an on-going operation: it is not a one-time or hit-and-miss clean-up done occasionally. Periodic "panic" clean-ups are costly and ineffective in reducing incidents.

Purpose of workplace housekeeping
Poor housekeeping can be a cause of incidents, such as:

i. Tripping over loose objects on floors, stairs and platforms
ii. Being hit by falling objects
iii. Slipping on greasy, wet or dirty surfaces
iv. Striking against projecting, poorly stacked items or misplaced material
v. Cutting, puncturing, or tearing the skin of hands or other parts of the body on projecting nails, wire or steel strapping

To avoid these hazards, a workplace must "maintain" order throughout a workday. Although this effort requires a great deal of management and planning, the benefits are many.

Benefits of good housekeeping practices
Effective housekeeping results in:

i. Reduced handling to ease the flow of materials
ii. Fewer tripping and slipping incidents in clutter-free and spill-free work areas
iii. Decreased fire hazards
iv. Lower worker exposures to hazardous products (e.g. Dusts, vapours)
v. Better control of tools and materials, including inventory and supplies
vi. More efficient equipment clean-up and maintenance
vii. Better hygienic conditions leading to improved health
viii. More effective use of space
ix. Reduced property damage by improving preventive maintenance
x. Less janitorial work
xi. Improved morale
xii. Improved productivity (tools and materials will be easy to find)

Good housekeeping program
A good housekeeping program plans and manages the orderly storage and movement of materials from point of entry to exit. It includes a material flow plan to ensure minimal handling. The plan also makes sure that work areas are not used as storage areas by having

workers move materials to and from work areas as needed. Part of the plan could include investing in extra bins and more frequent disposal.

The costs of this investment could be offset by the elimination of repeated handling of the same material and more effective use of the workers' time. Often, ineffective or insufficient storage planning results in materials being handled many times and being stored in hazardous ways. Knowing the workplace layout and the movement of materials throughout it will help when planning work procedures.

Worker training is an essential part of any good housekeeping program. Workers need to know how to work safely with the products they use. They also need to know how to protect other workers such as by posting signs (e.g., "Wet - Slippery Floor") and reporting any unusual conditions.

Housekeeping order is "maintained" not "achieved." Cleaning and organization must be done regularly, not just at the end of the shift. Integrating housekeeping into jobs can help ensure this is done. A good housekeeping program identifies and assigns responsibilities for the following:

i. Clean up during the shift
ii. Day-to-day cleanup
iii. Waste disposal
iv. Removal of unused materials
v. Inspection to ensure cleanup is complete

Do not forget out-of-the-way places such as shelves, basements, sheds, and boiler rooms that would otherwise be overlooked.

The final step to any housekeeping program is inspection. It is the only way to check for deficiencies in the program so that changes can be made. Examples of checklists include inspecting offices and manufacturing facilities.

Documentation and reporting

Documentation is about documents, which communicate information. Those documents provide information for and about a certain object, process or topic. Documentation can be published in digital (CD, DVD, disc, memory stick, download, as a web site,) or in analogue (book, paper, poster, photo.) form. Furthermore, digital documentation can be presented in an interactive manner, which increases ease of use. Examples for interactive features are, among others, cross references, search, tip-of-the-day features, contextual information, wizards or knowledge-based help systems.

Another important characteristic of documentation is the level of detail. There may exist several documents describing the same aspect, but are intended for a different audience (with varying domain knowledge) and thus serve a different purpose. Software system underlies continuous

changes throughout their whole life cycle. As a consequence, also the amount of information grows continually. For international software systems, the documentation has to be available in multiple languages. All these aspects contribute to the problems of documentation: Keeping up with changes during the development, propagating changes in requirements documents, design documents to the development and keeping documents on the desired level of quality

Maintenance of tools

When it comes to home improvement tools, regular maintenance tools are mandatory. Only a high-quality tool ensures excellent results and longevity.

As a passionate craftsman, you should know the essential tips about the maintenance of tools and equipment. Machine *maintenance tools* suffer a lot of wear and tear due to regular use.

If you don't do proper maintenance, it may result in machine breakdown and damage. With the proper handling and maintenance, you may reduce any risks. That is why you should do a regular check-up of your machine tools.

Basic Tips about Maintenance Tools and Equipment

Clean the Tools Regularly.

Whenever you use any tools for your projects, make sure to clean them immediately. The next day, you'll notice there is a layer of dirt that may lead to rust.

That's why you should clean the tools after use. You don't need to use chemicals every time, sometimes wiping is good enough.

Lubricate the Tools.

Machine tools include moving parts that require lubrication to work smoothly. Check the details daily, whether they are properly lubricated.

Please read the instruction in case of power tools as it requires an adequate level of oil

Sharpen the Essential Parts.

Some equipment is used for cutting and slicing, such as blade, drill bits, and lathe tools. You'll need to check whether it is sharp or not.

If these tools are not sharp enough, it may result in serious injuries.

Check the Function of the Tools.

You should check the functions of the tools for any damage or fault. Scrutinize each part.

If any faulty functioning is found, then immediately repair them.

Check Machines Tools, Alignments.

Most of the time, the machine works with fault due to improper alignment. Improper alignment also affects the tools in a negative way.

So, you should check the arrangement every time you intend to use the tool.

To ensure proper alignment, you may want to perform a few test tasks. If it is working well, that means the machine is all set.

Store with Care.
Proper storing also enhances the lifetime of any machine tools. Moisture and air is the reason for rust over the metal surface of the devices.

You will need to keep the tools in a place that is dry and clean.
If the tools are extensive, keep it in a tight closing garage or dry basement or insulated rooms.
Conversely, store the small tools in an air-tight box. Make sure to cover the device and inspect them regularly.

Care for Electrical Cords and Batteries.
The cable wires in some tools are prone to damage. Power tools like circular saw or drill may cut the wires accidentally.
That's why you should keep them protected. You may want to use purpose-built ramps or industrial-strength casing.
If the tool is battery operated, inspect the battery from time to time. Don't let sit it for long.
Also, recharge it if needed.

Require Decent care of Parts and Accessories.

It truly is crucial to carry out regular maintenance checks. On each one of your accessories and components. A vitally significant part of perfect maintenance.
It is always to need to take specific most care of your tool's accessories.
And parts have been managed and kept sensibly. You really don't desire to be more careless using almost any component of one's system application.
Good awareness plays a significant role. Use each one you sense to find prospective issues.
A strange noise, an odd scent or unordinary vibration may indicate a problem.
All items which may be easily cared for if discovered early.
Keeping a checklist and logging all of the upkeep completed will maximize the procedure.

Storage of tools
The proper care and storage of tools and equipment are not only the concern of the management but of the workers who use the equipment.
Importance of proper storage of tools and equipment

i. It is an important factor for safety and health as well as good business.
ii. Improves appearance of general-shop and construction areas.
iii. Reduces overall tool cost through maintenance.
iv. This also ensures that tools are in good repair at hand.
v. Teaches workers principles of (tool) accountability.

Points to consider in storing tools and equipment:

i. Have a designated place for each kind of tools.
ii. Label the storage cabinet or place correctly for immediate finding.
iii. Store them near the point of use.
iv. Wash and dry properly before storing.
v. Store knives properly when not in use with sharp edge down.
vi. Put frequently used items in conveniently accessible locations.
vii. Gather and secure electrical cords to prevent entanglement or snagging.
viii. Cutting boards should be stored vertically to avoid moisture collection.
ix. Metal equipment can be stacked on one another after drying such as storage dishes and bowls.
x. Make sure the areas where you are storing the equipment are clean, dry and not overcrowded.

Documentation and reporting

Documentation is about documents, which communicate information. Those documents provide information for and about a certain object, process or topic. Documentation can be published in digital (CD, DVD, disc, memory stick, download, as a web site,) or in analogue (book, paper, poster, photo.) form. Furthermore, digital documentation can be presented in an interactive manner, which increases ease of use. Examples for interactive features are, among others, cross references, search, tip-of-the-day features, contextual information, wizards or knowledge-based help systems.

Another important characteristic of documentation is the level of detail. There may exist several documents describing the same aspect, but are intended for a different audience (with varying domain knowledge) and thus serve a different purpose. Software system underlies continuous changes throughout their whole life cycle. As a consequence, also the amount of information grows continually. For international software systems, the documentation has to be available in multiple languages. All these aspects contribute to the problems of documentation: Keeping up with changes during the development, propagating changes in requirements documents, design documents to the development and keeping documents on the desired level of quality

Relevant IEE regulations

i. **Connection of conductors:**

Are terminations electrically and mechanically sound? Is insulation and sheathing removed only to a minimum to allow satisfactory termination?

ii. **Identification of conductors:**

Are conductors correctly identified in accordance with the Regulations?

iii. **Routing of cables:**

Are cables installed such that account is taken of external influences such as mechanical damage, corrosion, heat, etc.?

iv. **Conductor selection:**
Are conductors selected for current carrying capacity and voltage drop in accordance with the design?

v. **Connection of single pole devices:**
Are single pole protective and switching devices connected in the line conductor only?

vi. **Accessories and equipment:**
Are all accessories and items of equipment correctly connected?

vii. **Thermal effects:**
Are fire barriers present where required and protection against thermal effects provided?

viii. **Protection against shock:**
What methods have been used to attain both basic protection and fault protection?

ix. **Mutual detrimental influence:**
Are wiring systems installed such that they can have no harmful effect on non-electrical systems, or those systems of different currents or voltages are segregated where necessary?

x. **Isolation and switching:**
Are there appropriate devices for isolation and switching correctly located and installed?

xi. **Under voltage:**
Where under voltage may give rise for concern, are there protective devices present?

xii. **Labeling:**
Are all protective devices, switches (where necessary) and terminals correctly labeled?

xiii. **External influences:**

Have all items of equipment and protective measures been selected in accordance with the appropriate external influences?

xiv. **Access:**
Are all means of access to switchgear and equipment adequate?

xv. **Notices and signs:**
Are danger notices and warning signs present?

xvi. **Diagrams:**

xvii. Are diagrams, instructions and similar information relating to the installation available?

xviii. **Erection methods:**

Have all wiring systems, accessories and equipment been selected and installed in accordance with the requirements of the Regulations, and are fixings for equipment adequate for the environment?

So, now that we have inspected all relevant items, and provided that there are no defects that may lead to a dangerous situation when testing, we can start the actual testing procedure.

Learning Activities

Figure below shows the layout of a consumer intake point and two final circuits.

i. Draw the wiring diagram and carry out the wiring

ii. Using PVC mini trunking wiring system install the

a) Lighting circuit such that the lamps L1, L2 and L3 are controlled from two different positions.

b) Water heater switch to operate the instantaneous shower unit

c) Carry out the polarity test

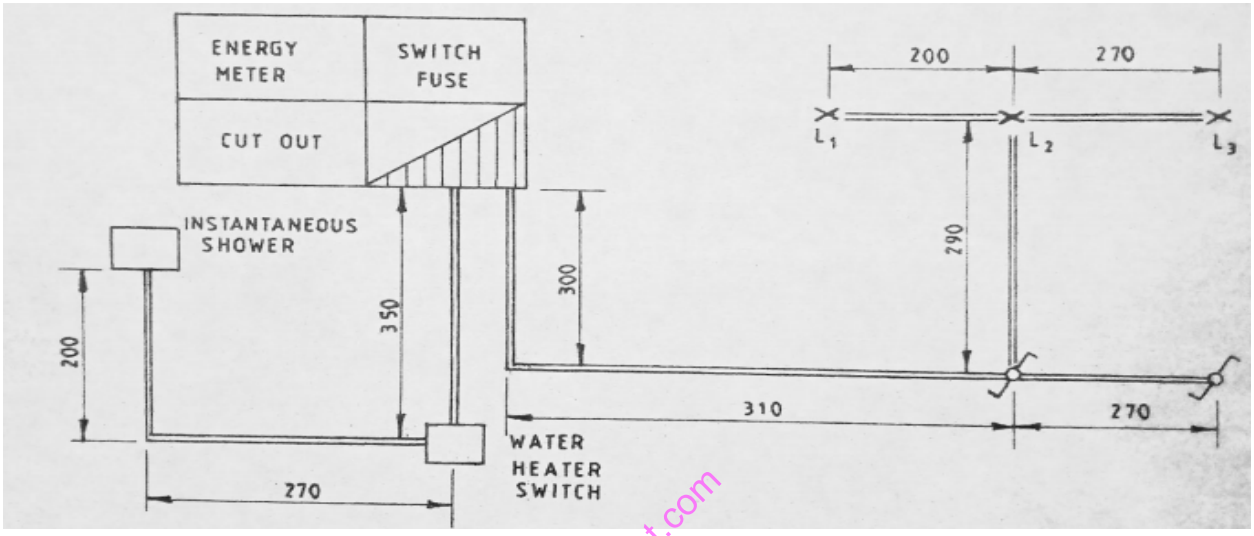


Figure 85: Layout of a Consumer intake point and two final circuits

Self-Assessment Questions

1. What are the difference between materials and equipment? (1 Mark)
2. What are the examples of equipment? (5 Marks)
3. How do you define equipment? (2 Marks)

Tools, Equipment, Supplies and Materials

i. Pliers
ii. Screwdrivers
ii. Hammers
iii. Wire splicers
iv. Electrician knives
v. Phase Testers
vi. Wire gauge
vii. Wire cutters and strippers
viii. Steel tapes (draw wire)
ix. Tape measures

x. Crimping and clamping tools

References

a) https://drexel.edu/goodwin/professional-studies-blog/overview/2018/July/Five-types-of-communication/
b) https://www.thespruce.com/pull-wire-through-conduit-3969936
c) http://www.btme.co.uk/electricalservices/inspection-testing-of-electrical-installations/
d) Brian Scaddan, IEE Wiring Regulations: Inspection, Testing and Certification, Sixth edition, 2008 Elsevier Ltd.

Model Answers to the self-assessment Questions

1. **The difference between equipment and materials** **(1 Mark)**

The key difference between equipment and materials is that materials form the actual product and are the parts, components, ingredients and raw materials that become a part of the product whereas equipment refers to the tools, machinery, devices that help create the product.

2. Examples of professional equipment **(5 Marks)**

i. Personal computers.
ii. Telefax equipment.
iii. Typewriters.
iv. Cameras of all kinds (film and electronic cameras)
v. Sound or image transmitting, recording or reproducing apparatus (tape and video recorders and video reproducers, microphones, mixing consoles, loudspeakers)
vi. Sound or image recording media, blank or recorded.

3. Equipment **(2 Marks)**

The set of articles or physical resources serving to equip a person or thing: such as the implements used in an operation or activity: apparatus sports equipment.

All the fixed assets other than land and buildings of a business enterprise can be referred to as equipment.

2.3.Install consumer's control unit

Introduction

The modern consumer unit is the centre, or heart, of the wiring system in the home. The unit distributes the electricity, via fuses of one kind or another, to the different circuits in the house. The older fuse wires are being replaced gradually by their modern equivalent, the MCB or miniature circuit breaker.

Performance Standard

1. Safety procedures and regulations in installation of Customer's Control Unit
2. Selection of installation tools, equipment and materials
3. Identification and selection of correct PPE for safety in the installation work
4. Identification and selection of consumer's control unit
5. Wiring of consumer's control unit
6. Cleaning up of workplace and OSH regulations

Information Sheet

Meaning of power intake point

The electricity supply to a domestic installation begins at the meter cabinet which houses the DSO service fuse, DSO meter and an isolator. This is the Main Supply Point.

The DSO supply cable is referred to as the service cable. The DSO service fuse and meter are sealed to prevent any interference with this part of the installation. The Nominal Voltage of the supply to domestic premises is 230 Volts. This is known as Low Voltage.

Identification of sequence of control equipment

The control and distribution of the electricity supply to the installation is contained within one enclosure. It is referred to as a Distribution Board. This unit has its own main switch fuse, or a separate main switch and main fuse, or main MCB. This is followed by individual circuit fuses or more commonly nowadays, Miniature Circuit Breakers (MCB's), to protect and isolate each circuit. There will also be neutral and earth terminals provided.

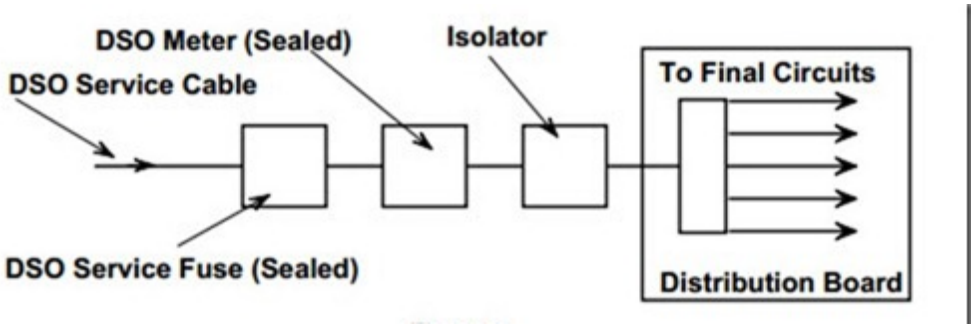


Figure 86: Neutral and Earth terminals

Distribution Board

The distribution board may also house other protective or control devices such as Residual Current Devices (RCD's), bell transformers, time-switches and contactors.

Figure below represents the sequence of control for a very basic distribution board. Depending on the installation requirements, a second or third RCD may be required and of course, more MCB's, one for each circuit.

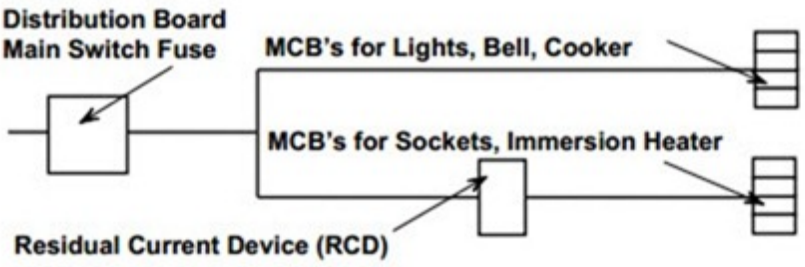


Figure 87: Sequence of Control for a very basic distribution board

As can be seen, an RCD is not provided for the lighting and cooker circuits, although there are exceptions to this situation.

Mounting of components

i. An assemblage comprising an electrical component mounting panel of sheet metal having a plurality of teeth struck therefrom to extend in a generally normal direction to one side of the plate and leaving a plurality of slots in said plate from which said teeth are struck, an electrical component, and means for securing said electrical component to said plate including a screw engaging said component and threadedly received in one of the slots in said plate, a backing panel, said plate being disposed against said backing panel with the tips of said teeth bearing against said backing panel, and means for securing said plate to said backing panel including screws threadedly engageable in said slots.

ii. An assemblage comprising a mounting panel according to claim 1 wherein the latter screws engage through said plate from a side thereof opposite the side from which the first mentioned screw engages through the plate.

iii. An assemblage including a mounting panel according to claim 1 including an enclosure for said electrical components, said backing panel comprising one wall of said enclosure.

iv. An assemblage including a mounting panel according to claim 1 including a plurality of electrical components, means for securing each component to said plate including screws engaging said components and threadedly received in the slots of said plate, the screws securing said plate to said backing panel engaging through said plate from a side thereof remote from said electrical components.

Wiring of intake point

Main Distribution Board or Fuse Boards (Consumer Unit) usually contains on the following three main units to control and distribute electric supply to the different connected appliances and devices through electrical wiring cables and wires.

Earth lead and earth electrode installation

The quality of an earth electrode (resistance as low as possible) depends essentially on two factors:

i. Installation method
ii. Type of soil

Three common types of installation will be discussed:

Buried ring

This solution is strongly recommended, particularly in the case of a new building.

The electrode should be buried around the perimeter of the excavation made for the foundations. It is important that the bare conductor be in intimate contact with the soil (and not placed in the gravel or aggregate hard-core, often forming a base for concrete). At least four (widely-spaced) vertically arranged conductors from the electrode should be provided for the installation connections and, where possible, any reinforcing rods in concrete work should be connected to the electrode.

The conductor forming the earth electrode, particularly when it is laid in an excavation for foundations, must be in the earth, at least 50 cm below the hard-core or aggregate base for the concrete foundation. Neither the electrode nor the vertical rising conductors to the ground floor, should ever be in contact with the foundation concrete.

For existing buildings, the electrode conductor should be buried around the outside wall of the premises to a depth of at least 1 metre. As a general rule, all vertical connections from an electrode to above-ground level should be insulated for the nominal LV voltage (600-1,000 V).

The conductors may be:

i. Copper: Bare cable (≥ 25 mm2) or multiple-strip (≥ 25 mm2) and (≥ 2 mm thick)

ii. Aluminium with lead jacket: Cable (≥ 35 mm2)
iii. Galvanised-steel cable: Bare cable (≥ 95 mm2) or multiple-strip (≥ 100 mm2 and ≥ 3 mm thick)

The approximate resistance R of the electrode in ohms:

$$R\,R = = \frac{2\rho}{L}\,\frac{2\rho}{L}$$

Were,

$\boldsymbol{L\,L}$
= length of conductor in meters

$\boldsymbol{\rho\,\rho} = =$
resistivity of the soil in ohm-metres (see Influence of the type of soil)

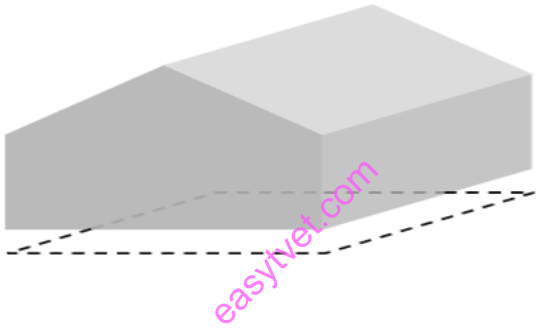


Figure 88:Conductor buried below the level of the foundation

Earthing rods

$$\text{For n rods: } \mathrm{R} = \frac{1}{\mathrm{n}}\,\frac{\rho}{\mathrm{L}}$$

ally driven earthing rods are often used for existing buildings, and for improving (i.e., reducing the resistance of) existing earth electrodes.

The rods may be:

i. Copper or (more commonly) copper-clad steel. The latter are generally 1 or 2 meters long and provided with screwed ends and sockets in order to reach considerable depths, if necessary (for instance, the water-table level in areas of high soil resistivity)
ii. Galvanized steel pipe ≥ 25 mm diameter or rod ≥ 15 mm diameter, ≥ 2 meters long in each case.

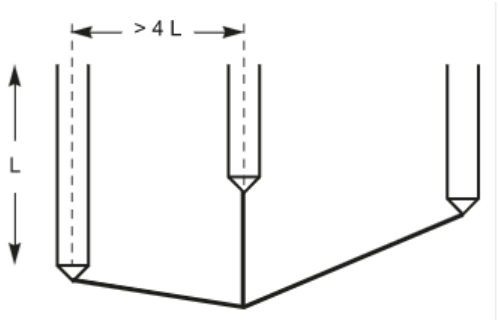


Figure 89:Earthing rods connected in parallel

It is often necessary to use more than one rod, in which case the spacing between them should exceed the depth to which they are driven, by a factor of 2 to 3.

The total resistance (in homogeneous soil) is then equal to the resistance of one rod, divided by the number of rods in question.

The approximate resistance R obtained is:

$$R = \frac{1}{n}\frac{\rho}{L}$$

If the distance separating the rods > 4L

Where,

L = the length of the rod in meters
ρ = resistivity of the soil in ohm-metres (see Influence of the type of soil)

Vertical plates

For a vertical plate electrode: $R = \frac{0.8\,\rho}{L}$

Rectangular plates, each side of which must be ≥ 0.5 metres, are commonly used as earth electrodes, being buried in a vertical plane such that the centre of the plate is at least 1 metre below the surface of the soil.

The plates may be:

i. Copper of 2 mm thickness

ii. Galvanized steel of 3 mm thickness

The resistance R in ohms is given (approximately), by: $R = \frac{0.8\,\rho}{L}$

Where

L = the perimeter of the plate in metres
ρ = resistivity of the soil in ohm-metres (see Influence of the type of soil)

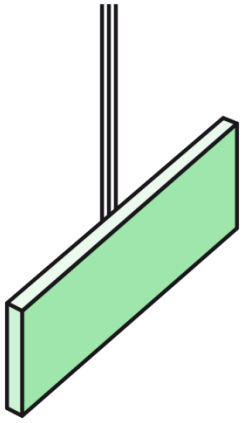


Figure 90:Vertical plate

Bonding of all metal parts

a) Extraneous-conductive-part: A conductive part liable to introduce a potential, generally earth potential, and not forming part of the electrical installation.
For example:

i. Non-insulated floors or walls, metal framework of buildings
ii. Metal conduits and pipework (not part of the electrical installation) for water, gas, heating, compressed-air, etc. and metal materials associated with them

Bonding conductor: A protective conductor providing equipotential bonding

Main earthing terminal: The terminal or bar provided for the connection of protective conductors, including equipotential bonding conductors, and conductors for functional earthing, if any, to the means of earthing.

The main equipotential bonding system
The bonding is carried out by protective conductors and the aim is to ensure that, in the event of an incoming extraneous conductor (such as a gas pipe, etc.) being raised to some potential due to a fault external to the building, no difference of potential can occur between extraneous-conductive-parts within the installation.

The bonding must be affected as close as possible to the point(s) of entry into the building, and be connected to the main earthing terminal (6).
However, connections to earth of metallic sheaths of communications cables require the authorization of the owners of the cables.

Supplementary equipotential connections

These connections are intended to connect all exposed-conductive-parts and all extraneous-conductive-parts simultaneously accessible, when correct conditions for protection have not been met, i.e., the original bonding conductors present an unacceptably high resistance.

Connection of exposed-conductive-parts to the earth electrode(s)

The connection is made by protective conductors with the object of providing a low-resistance path for fault currents flowing to earth.

Provision of draw wire for power authority

A **fish tape** (also known as a *draw wire* or *draw tape* or an "electricians snake") is a tool used by electricians to route new wiring through walls and electrical conduit.

Conducting final checks for workmanship, conformity with instructions and job requirements

In general terms we are inspecting the installation with regard to personal safety, equipment age, deterioration, equipment corrosion and overload.
Suitability and external influence to the power system should also be included. At this point it is a good idea to get from the client any documentation that is relevant to the installation (like plans, drawings, previous test results and certification/if any, fuse charts and so on.

You should also make it clear that you will require access to all parts of the building and that the electricity supply will need to be turned off at some point. It is also a good idea to ask the client if they are aware of any alterations that have been carried out, as this information may be useful to you during inspection.

Good housekeeping

The elements of an effective housekeeping program

i. Maintenance. The maintenance of buildings and equipment may be the most important element of good housekeeping.
ii. Dust and Dirt Removal.
iii. Maintain Light Fixtures.
iv. Aisles and Stairways.

v. Spill Control.
vi. Tools and Equipment.

Maintenance of tools

The following are some helpful tips on how to clean and properly store your tools.

i. Keep Power Tools Clean. **Dust** and grime can bring your power tools to a grinding halt if left unchecked over time
ii. Store Power Tools Correctly.
iii. Inspect for Wear or Damage.
iv. Lubricate Moving Parts.
v. Keep Batteries in Shape.

Storage of tools

Zip those home projects out in no time with well-organized and properly stored tools and other home maintenance equipment. Garden supplies, vehicle implements and liquids and home tools such as hammers, saws, nails and power equipment all benefit from proper care and storage. These items organized efficiently make home projects easy, and make clean up even easier.

Documentation and reporting

Documentation is anything written or printed on which you rely as record or proof of patient actions and activities. A record or chart or client record, is a formal, legal document that provides evidence of a client's care and can be written or computer based.

Learning Activities

Figure below shows the layout of the equipment at consumer's intake point and two final circuits.

a) Draw the wiring diagram of the installation
b) Carry out the wiring at the consumer intake point
c) Using PVC sheathed wiring system install the
   i. Lighting circuit such that switch S1 controls lamp L1 and L2 and switch S2 controls L2
   ii. Cooker control unit and the cooker terminal box.
d) Carry out the insulation test

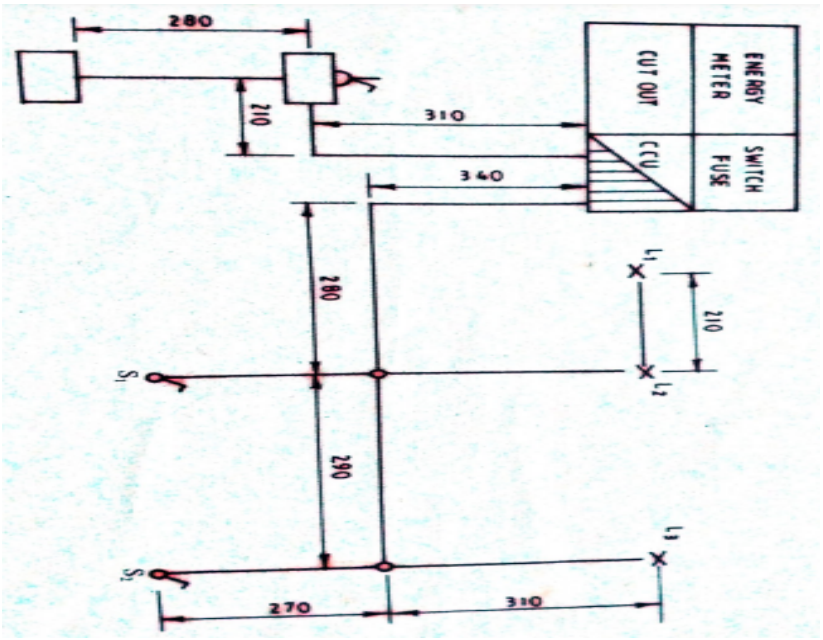


Figure 91: Consumer's Intake Point

Self-Assessment

1. Is an earth wire dangerous?
2. How is earthing connected?
3. What happens if there is no earthing?
4. What is the purpose of earthing?
5. How would you fix surface mount components?

Tools, Equipment, and Materials

i. Tape Measure.
ii. Hammer.
iii. Torpedo Level.
iv. Flashlight.
v. Utility Knife.
vi. Screwdrivers.

References

i. http://machineryequipmentonline.com/electric-equipment/lighting-circuitssequence-of-control/
ii. https://www.electrical-installation.org/enwiki/Installation_and_measurements_of_earth_electrodes
iii. https://www.youtube.com/watch?v=o6M7769TymU&feature=emb_title

Model Answers to self-assessment Questions **(2 Marks)**

1. Earthing. Without the earth wire, if a fault occurs and the live wire becomes loose, there is a danger that it will touch the case. The next person who uses the appliance could get electrocuted. As the wire is made of copper, the earth wire provides a low resistance path to the ground.
2. Connectors for earthing installation are a means of communication between the various components of the earthing and lightning protection installations **(2 Marks)** (earthing rods, earthing conductors, current leads, busbars, etc.). For high voltage installations, exothermic welding is used for underground connections. **(1 Mark)**
3. If the house is not earthed, people could get electrocuted. Without an earth connection, the safety switches will not work and an electrical fault could cause a house or appliances to become 'live' as the current flows to earth.
4. Earthing is used to protect you from an electric shock. It does this by providing a path (a protective conductor) for a fault current to flow to earth. It also causes the protective device (either a circuit-breaker or fuse) to switch off the electric current to the circuit that has the fault.
5. Steps: **(5 Marks)**

   Step 1: Preparing the PCB. Check to be sure the pad size of the PCB lines up with the pins on the SMD.

   Step 2: Use Tweezers to Position the Component.

   Step 3: Tack Down One Corner.

   Step 4: Flux.

   Step 5: Solder.

   Step 6: Heat Up Desoldering Wick to Fix Tack.

   Step 7: Solder.

   Step 8: Fix Any Remaining Solder Bridges.

2.4.Inspect and test the complete installation

Introduction

It is a vital part of every electrical job and is completely separate to Part. An inspection and test is carried out to verify, so far as is reasonably practicable, that the requirements of BS 7671 (Wiring Regulations) and other relevant regulations have been met, during the job itself and after completion before handing over to the client. Inspection and testing should also be carried out for all electrical installations at regular intervals. For example, an EICR (Electrical Installation Condition Report) for existing installations.

Performance Standard

1. The process of electrical inspection and testing
2. Visual and physical checks
3. Verification of polarity test on an electrical installation
4. Types of electrical installation tests
5. Testing equipment and tools
6. Good housekeeping
7. Maintenance of tools and equipment
8. Documentation and reporting

Information Sheet

Meaning of inspection and testing

Inspection and Testing is the testing procedures that electricians use to ensure that a circuit is working correctly and safe for use before being energised. Inspection and testing should also be carried out for all electrical installations at regular intervals.

Sections of the installation to be inspected

The following items must be checked concerning protection against direct contact:

i. Insulation of live parts
ii. Enclosures have a suitable degree of protection appropriate to external influences
iii. Enclosures have cable entries correctly sealed
iv. Enclosures have unused entries blanked off where necessary

Types of visual and physical checks

A visual electrical inspection is a survey of your electrical wiring system. It is used to identify defects, damage or deterioration of the electrical installation and to determine whether it complies with the current BS7671 electrical safety standard. This type of inspection does not involve any circuit testing, therefore, on its own.

Completion installation tests

It is through this certification system that Safe Electric, can monitor and validate that the electrical works completed meet the required safety standards (National Rules for Electrical Installations).

To facilitate the wide range of electrical works undertaken by RECs, the different types of Completion Certificates are outlined below:

Certificate No. 1 (paper based) (<50 kVA): Completion Certificate for the connection of new electrical installations (less than 50kVA) to the Distribution System Operator (DSO) Network. A sample for an Electronic Certificate No. 1 is available here.

Certificate No. 2 (paper based) (≥50 kVA): Completion Certificate for the connection of new electrical installations (greater than or equal to 50kVA) to the DSO Network. A sample for an Electronic Certificate No. 2 is available here.

Certificate No. 3: Covers alterations (including additions and extensions) to existing installations. Certificate No. 3 cannot be used to obtain a connection or a re-connection of the electrical supply from the DSO.

Agricultural Certificate: All electrical works in agricultural locations must comply with the National Rules for Electrical Installations. A copy of the Agricultural Completion Certificate may be required by the Department of Agriculture for agricultural buildings grant-aid.

Interim electrical installations (≥50kVA): Interim Certificates are validated by Safe Electric to enable the main distribution board in an industrial or commercial installation to be energised so that a completed subsystem e.g. a lift system, or a standalone module, can be tested or commissioned.

Verification of polarity test

This test will verify that all the switches installed in the system are connected in current carrying conductor and not in neutral. For example, if you isolate or switch the neutral of a circuit via a single-pole circuit breaker or switch, it would appear that the circuit is dead where in fact it is still live.

Insulation

A Quality Insulation Inspection (QII) is performed by a certified HERS (Home Energy Rating System) technician. This inspection ensures that the insulation in a home is installed to a particular standard set by the California Energy Commission.

Resistance test

The Insulation Resistance Test is the second test required by the electrical safety testing standards. The Insulation Resistance Test consists in measuring the Insulation resistance of a device under test, while phase and neutral are short circuited together. This is the simplest of the tests.

After the required connections are made, you apply the test voltage for a period of one min. (The one-min interval is an industry practice that allows everyone to take the reading at the same time. In this way, comparison of readings will be of value because, although taken by different people, the test methods are consistent.) During this interval, the resistance should drop or remain relatively steady.

Larger insulation systems will show a steady decrease, while smaller systems will remain steady because the capacitive and absorption currents drop to zero faster on smaller insulation systems. After one min, read and record the resistance value.

Note that IR is temperature sensitive. When the temperature goes up, IR goes down, and vice versa. Therefore, to compare new readings with previous readings, you need to correct the readings to some base temperature. Usually, 20°C or 40°C are used as comparison temperatures; tables are available for any correction. However, a common rule of thumb is that IR changes by a factor of two for each 10°C change.

Earth continuity tests

The earth continuity test is a designed to test the resistance of the protective earth of an appliance and/or the supply lead. It is measured between any accessible earthed parts and the earth pin of the plug. The test is based on the principles of Ohm's Law.

Ring circuit continuous test

It is very important that each of the three rings associated with each circuit (phase, neutral and protective conductors) should be continuous and not broken. In simple terms, current is then shared between the conductors, so that each could have a minimum current carrying capacity of 15 A.

Learning Activities

In a construction site, a team of electrician carries out electrical installation for both lighting and power circuits. During inspection it noticed that the lighting circuit is not working. As an electrician, inspect and test the whole lighting circuit.

Self-Assessment Questions

1. Which instrument is used to test the new wiring installation? **(2 Marks)**
2. How many types of electrical measuring instruments are there? **(4 Marks)**
3. What is inspection in electrical installation? **(2 Marks)**
4. How do you test electrical equipment? **(5 Marks)**
5. How often should electrical testing be done? **(2 Marks)**

Tools, Equipment, and Materials

i. Continuity **tester**.
ii. Insulation resistance **tester**.
iii. Earth fault loop impedance **tester**.
iv. RCD **tester**.

References

i. https://safeelectric.ie/help-advice/completion-certificates/
ii. https://www.ecmweb.com/maintenance-repair-operations/test measurement/article/20898954/understanding-insulation-resistance-testing

Model Answers to self-assessment Question

1. Instruments used to test the new wiring installation
   a) Meg ohmmeters **(2 Marks)**

   Megohmmeters assess high electrical resistance and are used to test motor winding, cable assemblies, and insulation, wiring installations, motors, transformers generators, and more.

2. **List of electrical and electronic measuring equipment**: **(4 Marks)**
   (i) Ammeter (Amperermeter):- Measures current
   (ii) Capacitance meter:- Measures the capacitance of a component
   (iii) Current clamp:- Measures current without physical connection
   (iv) Curve tracer:- Applies swept signals to a device and allows display of the response

3. **Inspection** **(2 Marks)**

   This is an examination of an electrical installation using all available means to ascertain correct selection and proper erection of electrical equipment.

   Note: the word 'inspection' has replaced 'visual inspection', indicating that all of the senses (touch, hearing, and smell, as well as sight) must be used.

4. The correct tests need to be carried out on your Class I or Class II appliance in the following order: **(5 Marks)**
   (i) Visual Inspection.
   (ii) Earth Continuity Test.
   (iii) Insulation Resistance Test.
   (iv) Leakage Test.

   Further tests have to be performed on leads, RCDs etc.

5. For many commercial businesses, an EICR, which used to be called a periodic testing report, will be required at the lowest frequency interval – every 5 Years. However, higher risk environments will require 3 Yearly or even more frequent testing. It should be noted that all stated periods are maximum intervals. **(2 Marks)**

2.5.Repair and maintain the installation

Introduction

The technical meaning of **maintenance** involves functional checks, servicing, repairing or replacing of necessary devices, equipment, machinery, building infrastructure, and supporting

utilities in industrial, business, governmental, and residential installations. Over time, this has come to include multiple wordings that describe various cost-effective practices to keep equipment operational; these activities occur either before or after a failure.

Performance Standard

1. Safety procedures and regulation in the repair and maintenance of electrical systems
2. Tools, equipment and materials used in repair and maintenance
3. Identification and replacement of faulty components
4. Routine checks on an electrical installation
5. Repair and replacements of faulty components

Information Sheet

Meaning of repair and maintenance

Repairs are restoration work for when something gets broken, damaged or stops working. Maintenance are routine activities meant to prevent damage and prolong the life of appliances, fixtures, and the property itself. Examples include regular cleaning of air-conditioning units, grease traps, repainting, and the likes.

Types of maintenance

i. Routine
ii. Breakdown
iii. Periodic
iv. Overhaul

Maintenance procedures

i. Conducting final checks for workmanship, conformity with instructions and job requirements
ii. Good housekeeping
iii. Maintenance of tools
iv. Storage of tools
v. Documentation and reporting
vi. Relevant IEE regulations

Routine maintenance

Routine maintenance refers to any maintenance task that is done on a planned and ongoing basis to identify and prevent problems before they result in equipment failure. Some common routine maintenance includes regular inspections or service work.

Breakdown maintenance

Breakdown maintenance is maintenance performed on a piece of equipment that has broken down, faulted, or otherwise cannot be operated.

Periodic maintenance

Periodic maintenance refers to activities performed on equipment based on a set time interval. The purpose of periodic maintenance, or time-based maintenance, is to maintain smooth operation of a machine or other asset.

Overhauling maintenance

Overhauling of a machine is defined as a process of general maintenance performed on a machine or other industrial equipment. The goal of overhauling is to keep the system in serviceable condition.

Repair and replacements of faulty components

When equipment breaks down, everything from your productivity to your bottom line is disrupted. Your team needs a quick and effective solution. The difficult question arises- should you try for a repair, or replace the asset outright?

Replacing equipment is the larger investment; so many technicians choose to repair the equipment instead of replacing it. But the costs that go along with frequent breakdowns — lower productivity, defective output, rising labour costs, and unmet production schedules — can sometimes be greater than the cost of replacing the equipment outright.

In addition to the obvious replacement cost for a new piece of equipment, there are several other factors to take into consideration when deciding whether to repair or replace a piece of equipment:

i. Ongoing maintenance costs over the remaining life of the equipment
ii. The impact any repair would have on productivity and quality
iii. Costs incurred from the equipment downtime
iv. Health, safety, and environmental costs that come with equipment breakdown
v. Training costs for a new piece of equipment
vi. Disposal costs
vii. Installation costs

Maintenance procedures

Maintenance procedures are written instructions that, when followed by the maintenance personnel, will ensure that equipment operates as designed within safe operating limits.

a) Maintenance procedures that should be considered when preparing the planned maintenance program include:

b) Carrying out repairs needed when plant or equipment breaks down;

c) Predicting, from a history of breakdowns, the life expectancy of parts, bearings, etc., the tasks to be carried out and the frequency to be established;

d) Checking the condition throughout the plant of equipment, its running hours, readings of different responses (e.g. vibration, temperatures, current, etc.);

e) Monitoring the operating cycle and, where appropriate, seasonal shutdowns of plant, equipment (e.g. production process, 24-hour duty, etc.).

Learning Activities

Assume you are the lead technician in a production a company where one of the production machine stops working. As a qualified electrician perform the following maintenance:

i. Routine
ii. Breakdown
iii. Periodic
iv. Overhaul

Self-Assessment

1. What are the four types of maintenance? (3 Marks)
2. What is a maintenance checklist? (2 Marks)
3. What is difference between maintenance and repair? (4 Marks)
4. What is the purpose of machine overhauling? (3 Marks)
5. Which process comes under the periodical maintenance? (3 Marks)

Tools, Equipment and Materials

i. Pliers. Pliers—often referred to as cutting pliers or lineman pliers—are a staple on any **electrical tools** list.
ii. Screwdrivers.
iii. **Electrical** Contractor Software.
iv. Tape Measure.
v. **Electrical** Tape.
vi. Cable Ties.
vii. **Electric** Drill.

References

i. https://www.micromain.com/asset-repair-or-replace/

ii. https://www.sciencedirect.com/topics/engineering/maintenance-procedure#:~:text=Maintenance%20procedures%20are%20written%20instructions,designed%20within%20safe%20operating%20limits.

Model Answers to Self-Assessment Questions

1. **Types of maintenance** (3 Marks)

Four general types of maintenance philosophies can be identified, namely:

i. Corrective,
ii. Preventive,
iii. Risk-based and
iv. Condition-based maintenance.

2. Maintenance Checklist. (2 Marks)

An itemized list of discrete maintenance tasks that have been prepared by the manufacturers of the asset and/or other subject matter experts such as consultants. Checklists are the basic building blocks of a maintenance program. Organization of the Checklist.

3. **Difference between Maintenance and Repair** (4 Marks)

Maintenance is regular service that will help prolong the life of your vehicle, while auto repair is when a part or fluid is not performing and needs to be fixed. Without proper maintenance, pricey repairs might be needed.

4. **Purpose of machine overhauling** (3 Marks)

When a machine is overhauled, it is disassembled, cleaned, inspected, and repaired as necessary. Depending on what the issue is with your engine, sometimes an overhaul is better than if you would fully replace it. This can also save you money and you will not need a brand new machine for your vehicle.

5. Periodic maintenance schedule (3 Marks)

Periodic maintenance schedule is a time-based series of activities performed on equipment to maintain the smooth operation of the vehicle. Wear and tear is unavoidable and motor vehicles would usually have a long life span before eventually being unoperational.