Trade of Electrician

Standards Based Apprenticeship

Cables and Cable Termination

Phase 2

Module No. 2.2

Unit No. 2.2.1

COURSE NOTES

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Introduction

Welcome to this section of your course which is designed to assist you the learner, familiarise yourself with the more common cables and tools used in basic electrical installation work. Also it will introduce the various electrical bodies and in particular the electrical rules that apply to the practical work involved in this section of the course

Objectives

By the end of this unit you will be able to:

- List common electrical conducting materials
- List common electrical insulating materials
- Describe the construction of PVC and PVC / PVC cables
- State the application of PVC and PVC / PVC cables
- List the sizes of PVC and PVC / PVC cables
- Describe the construction of flexible cords
- State the application of flexible cords
- List the sizes of flexible cords
- Select the correct tools and handle safely
- Accurately mark out positions for electrical accessories
- Select and use most suitable fixing device for job in hand
- Clip a selection of cables to required standard
- Terminate cables and flexible cords correctly
- State the effects of poor terminations
- Understand the roles of the main electrical bodies
- Understand the purpose of the ETCI rules

Reasons

One of the main causes of electrical problems is poor terminations. They can simply result in failure of equipment to function or even start a fire. The use of an inadequate size or type of cable or cord can also result in fire. Therefore it is most important that you understand and apply this information

Definitions

Electrical Equipment: Any item used for such purposes as generation, conversion, transmission, distribution or utilisation of electrical energy, such as machines transformers. apparatus, measuring instruments, protective devices, equipment for wiring systems and appliances.

Electrical Installation: An assembly of associated electrical equipment, to fulfil a specific purpose or purposes and having co-ordinated characteristics.

Accessory: A device, other than current-using equipment, associated with such equipment or with the wiring of an installation.

Ambient Temperature: The temperature of the air or other medium where the equipment is to be used.

Appliance: Any device that utilises electricity for a particular purpose, excluding a luminaire or an independent motor.

Insulation: Non-conducting material enclosing, surrounding or supporting a live part.

Insulated conductor: A conductor having only basic protection against shock, consisting of a covering of insulation.

Cable: An insulated conductor with an outer protective covering against external influences.

External Influences: Any influence external to an installation which affects the design or safety of the installation.

Fixed Wiring or Cable: Wiring or cable mounted on a fixed support so that its position does not change.

Flexible Wiring or Cable: Wiring or cable that may be moved in normal service between its points of termination.

Conduit: A system of tubing intended to enclose cables and wires in order to protect them from mechanical damage, and to allow them to be drawn-in and withdrawn.

Cable Trunking System: A factory-made system for enclosing cables and insulated wires, normally of rectangular cross-section, one side of which can be removed, and forming part of the wiring system.

Neutral Conductor (symbol N): A conductor connected to the neutral point of a system for the purpose of transmitting electrical energy.

Phase Conductor: A conductor of an AC system, other than a neutral conductor, intended for the transmission of electrical energy (also called "line conductor").

Cable Coupler: A means enabling the connection, at will, of two flexible cables. It consists of a connector and a plug.

Enclosure: A part providing an appropriate degree of protection of equipment against certain external influences and, a defined degree of protection against direct contact with live parts.

Building Void: A space within the structure or components of a building, which may be accessible at certain points.

Common Electrical Conducting Materials

MATERIAL	PROPERTIES	APPLICATIONS
Silver	Best conductor material. Expensive. Soft and easily shaped.	Used to plate contacts to ensure good electrical contact.
Copper	Very good conductor. Soft and easily drawn into wires. Easy to joint and solder. Good conductor of heat	Used extensively as a conductor material in cables and busbars.
Gold	Good conductor. Does not corrode. Expensive.	Used to plate contacts.
Aluminium	Good conductor. Low cost and weight. Soft and easily shaped. Not as flexible as copper. Corrodes.	Used to manufacture larger cables and busbars. Overhead cables with steel core.
Tungsten	Easily drawn into very fine wires. Very high melting point.	Lamp filaments.
Brass	An alloy of copper and zinc. Easily machined. Resists corrosion.	Used to manufacture cable glands, terminals, plug pins, some conduit fittings, nuts, bolts and washers.
Steel	Reasonably easy to shape.	Used to manufacture conduit, trunking, tray, enclosures and various fittings. May be galvanised.
Tin	Resists corrosion.	Used to manufacture solder. Coating on copper cables insulated with vulcanised rubber.
Lead	Does not corrode. Easily shaped.	Used to manufacture solder, sheaths of cables, plates in lead-acid cells.
Mercury	Liquid at normal temperature.	Used in tilt switches.
Nichrome	Nichrome is an alloy of nickel and chromium Hard and resists corrosion	Used to manufacture heating elements.
Carbon	Good conductor. Hard wearing - self lubricating - negative temperature co-efficient of resistance.	Brushes for electrical machines.

Common Electrical Insulating Materials

MATERIAL	PROPERTIES	APPLICATIONS
PVC (poly-vinyl -chloride)	Weather resistant. (Standard grade 0 to 70°C) Flexible (Arctic grade -20 to +70°C) Affected by contact with wet creosote or certain thermal insulating materials, such as expanded polystyrene. Emits smoke and fumes when burning.	Cable insulation. Cable sheaths.
Crosslinked Polyethylene (XLPE)	Emits little smoke or fumes when burning. Temp. range (-40 to +90°C)	Cable insulation and sheath.
Rubber	Flexible. Ages. Absorbs solvents and swells. Temp. range (-25 to +65°C). High temp. type up to 85°C.	Cable insulation and sheath. Moulded plug tops and extension sockets.
Silicone Rubber	Flexible. Conductor insulation for Temp. up to 145°C (Special type -60 to +260°C). (300°C for short durations).	High temp. areas, e.g. cooker internal wiring. Insulation sleeving.
Plastic	Relatively cheap. Not too brittle. Can be moulded into intricate shapes.	Plugs, sockets, switches, fuse carriers, fuse bases, conduits, trunking and enclosures.
Porcelain	Hard and brittle. Easily cleaned. High temp. range.	Fuse carriers and bases. Overhead line insulators. High temp. connectors.
Glass	Rigid and brittle. Easily cleaned.	Overhead line insulators.
Glass Fibre	Reasonably flexible. Temp. up to 170°C.	Conductor insulation in high temp. areas e.g. ovens.
Asbestos	Reasonably flexible.	Conductor insulation in high temp. areas. (Old types).
Mica	High temp. range. Brittle.	Toaster elements. Motor commutator insulation.
Magnesium Oxide	In powder form. Requires containing sheath High temp. range (145°C). Hygroscopic (absorbs moisture). Good conductor of heat	Insulation in mineral insulated cable (MIMS). (PYRO). Insulation in sheathed elements for kettles, cookers, immersion heaters.
Butyl Rubber	Tough. Remains flexible from -40°C to +85°C.	Extension leads in arduous conditions.

Cables and Flexible Cords

Cable Definition

One or more conductors provided with insulation. The insulated conductor (s) may be provided with an overall covering to give mechanical protection.

Construction: A cable consists of three parts. See Figure 1:

1. Conductor
2. Insulation
3. Sheath (Mechanical Protection)

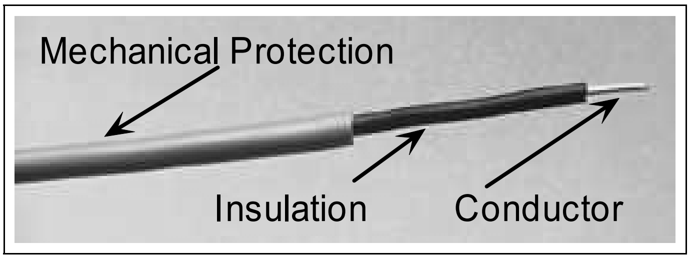


Figure 1

The most common conductor material used is copper. Aluminium is used for larger cables and its use is **not** permitted in domestic installations.

The most common insulation used is PVC. Other materials are used as insulation depending on what the cable is being used for and where it is being installed.

The most common mechanical protection used is PVC. Further protection is provided by installing cables in locations where they are unlikely to be damaged. Where this is not possible, cables must be installed in conduit, trunking or ducting. Otherwise a suitably armoured cable must be used. When cables are installed in conduit or trunking they need not have any other form of mechanical protection. The conduit or trunking is deemed to be its mechanical protection.

Cables are manufactured in a range of common sizes. These are decided by the **C**ross **S**ectional **A**rea (CSA) of the conductor, which is specified in square milli-metres (mm^2).

The following is a list of the standard sizes used in domestic installations.

Cross Sectional Area

Cross sectional area is the surface area of a section of conductor.

1.5 mm^2 – 2.5 mm^2 – 4 mm^2 – 6 mm^2 – 10 mm^2 – 16 mm^2

The cable insulation is colour coded as follows:

Phase (Live)	–	Brown
Neutral	–	Blue
Earth	–	Green / Yellow

In the cable most commonly used for domestic installations, there is a bare earth conductor and this **must** be terminated using Green / Yellow **sleeving**.

Cables are manufactured with solid, stranded or flexible cores.

Solid cores are used for the small cable sizes where the wiring is fixed.

Stranded cores are used for the larger cable sizes and where more flexibility is required, e.g. where cables are installed in conduit or trunking systems.
The number of strands is normally 7, 19 or 27 per core.

Flexible cores are used where extra flexibility is required,
e.g. pendants, immersion heaters and also leads for portable and hand held equipment. The number of strands is normally 16, 24, 32, 36, 40 or 50 per core.

These flexible cores when used as leads for portable and hand held equipment must be provided with an overall covering for mechanical protection. This unit is referred to as a **flexible cord**.

Flexible Cord Definition

"A flexible cable in which the CSA of the conductors does not exceed 4 mm^2."

Flexible cords are manufactured in standard sizes as follows:

0.5 mm^2 – 0.75 mm^2 – 1.0 mm^2 – 1.25 mm^2 – 1.5 mm^2 – 2.5 mm^2 – 4 mm^2

Larger flexible conductors are known as **flexible cables**.

Single Core Circular Cables

PVC Insulated - Unsheathed
Solid or stranded copper conductor with PVC insulation.
e.g. 1.5 mm^2 PVC Brown. See Figure 2.

APPLICATIONS: Installations where drawn into conduit or trunking.

Sizes: 1.5 2.5 4 6 10 16 mm^2

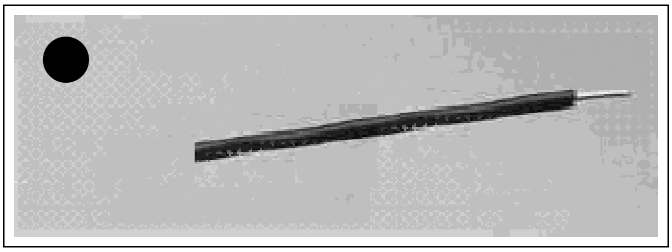


Figure 2.

PVC Insulated - PVC Sheathed
Solid or stranded copper conductor with PVC insulation surrounded by a PVC sheath.
e.g. 1.5 mm^2 PVC / PVC Blue. See Figure 3.

APPLICATIONS: Used in domestic installations and for clipping on the surface where little risk of mechanical damage exists.

Sizes: 1.5 2.5 4 6 10 16 mm^2

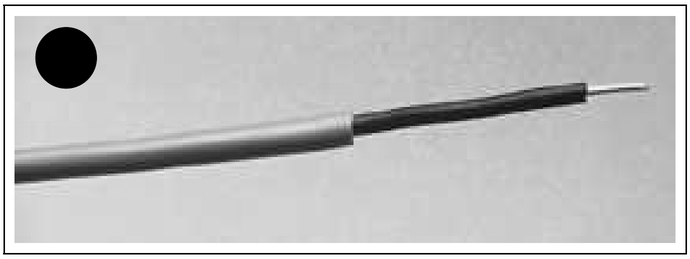


Figure 3

Single Core Cables

PVC Insulated – PVC Sheathed with Circuit Protective Conductor
Solid or stranded copper conductor with PVC insulation surrounded by a PVC sheath.
e.g. 1.5 mm^2 PVC / PVC Brown and Earth. See Figure 4.

Applications: Used for lighting circuits in domestic installations and for clipping on the surface where little risk of mechanical damage exists.

Size: 1.5 mm^2

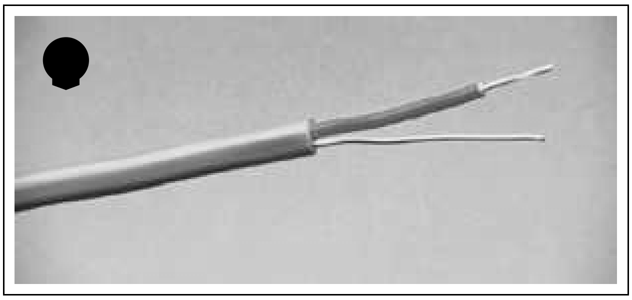


Figure 4

Multicore Flat Cables

Twin-Core with Circuit Protective Conductor PVC Insulated PVC Sheathed
Two copper conductors, PVC insulated, laid parallel and surrounded by PVC sheath to give a flat finish. An uninsulated protective conductor is laid in the centre.
e.g. 1.5 mm^2 Twin Brown / Blue and Earth. See Figure 5.

APPLICATIONS: As for single core PVC / PVC, especially suited to three-plate ceiling rose method of wiring. Also used for wiring socket outlets etc.

Sizes: 1.5 2.5 4 6 10 16 mm^2.

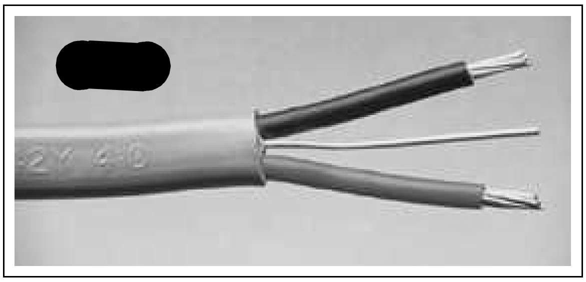


Figure 5

BELL WIRE – PVC INSULATED
Twin core, solid conductors, with PVC insulation. See Figure 6.

APPLICATIONS: Bell and indicator systems.

(Suitable for up to 50 Volts.)

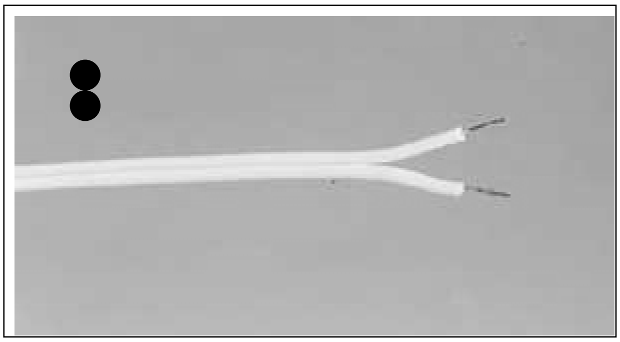


Figure 6.

Round Flexible Cords

PVC Insulated PVC Sheathed
PVC insulated flexible copper conductor with PVC sheath forming a round cord.
Available in two, three, four and five cores.
e.g. 2 x 0.75 mm^2, PVC circular flex. See Figure 7.

APPLICATIONS: General-purpose flexible cord for pendants, portable tools and appliances. Should not be used where sheath can come into contact with hot surfaces.

Sizes: 0.5 0.75 1.0 1.25 1.5 2.5 4 mm^2.

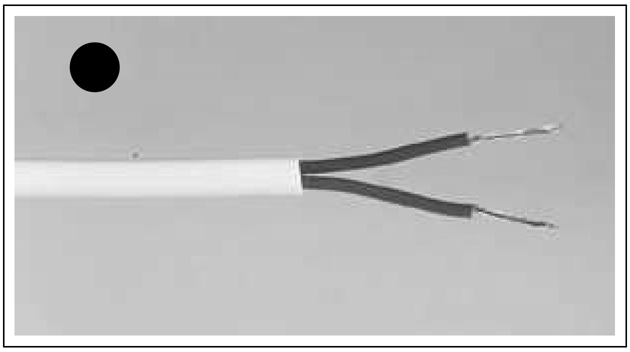


Figure 7

Heat Resistant - PVC Insulated PVC Sheathed
The insulation and sheathing is made from heat resistant PVC and is available in two, three and four cores, e.g. 3 x 1.5 mm^2, heat resistant flex. See Figure 8.

APPLICATIONS: Suitable for use in temperatures up to 85^{o}C. e.g. immersion heaters.

Sizes: 0.5 0.75 1.0 1.25 1.5 2.5 4 mm^2.

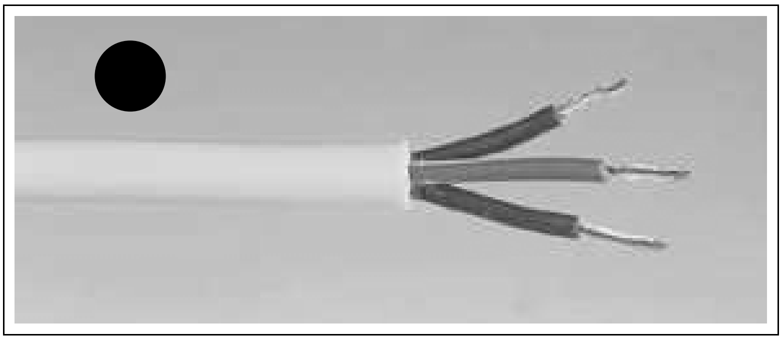
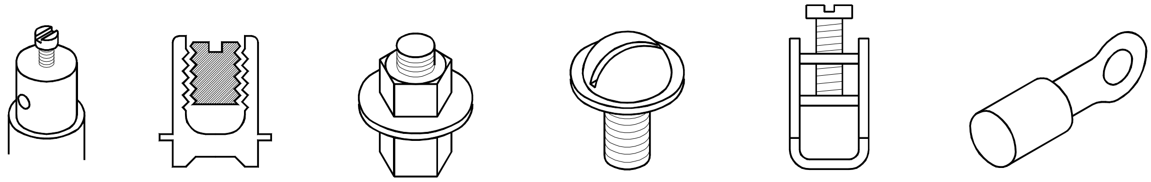


Figure 8

Terminals, Clamps and Lugs

There are a wide variety of conductor terminals. Typical types are as shown in Figure 9.



1 2 3 4 5 6

Figure 9

1. The screw terminal will be found in various accessories such as, lampholders, battenholders and plugtops used in domestic premises. A shrouded version of this terminal is probably the most commonly used type. It will be found in switches, sockets, ceiling roses and consumer units.

2. The split terminal will be used in joint boxes to enable joints to be made without having to cut conductors.

3. The post terminal will be used mainly to make connections to earth and also in such places as the mains connection to an electric cooker or an electric motor.

4. The screwhead terminal will also be mainly used to make connections to earth, and is also very popular in older fuseboards.

5. The clamp terminal is now in common use in main switches, MCB's, RCD's and RCBO's.

6. The lug terminal comes in an extremely wide variety of shapes and sizes. They may be bare or insulated. Methods of connecting to the cable vary as follows:

- Ferrules, which are used on flexible cables to prevent the strands from spreading out and are then connected using a screw or clamp terminal.
- Large power cables where the lug is compressed onto the cable using a hydraulic type crimptool. The lug is then connected to a post or screwhead terminal.

Use of Hand Tools

An electrician can often be judged by his appearance and by the tool kit with which he carries out his work. Clothing should be neat and tidy and kept in this manner by using an overall when necessary. Tool kit should contain all the necessary gear to do the work correctly and efficiently.

Electricians Pliers

These have serrated jaws and are used for gripping, twisting and bending conductors. They also have a curved section, serrated for gripping round metal items. A wire cutter is also provided. See Figure 10.

Figure 10

Long Nose Pliers

These are used for fine work where the electrician's pliers are too large and for guiding conductors into terminals etc. They are available with additional features such as small lug crimpers. See Figure 11.

Figure 11

Side Cutters

Commonly referred to as "snips", these are used to cut small cables and conductors, and to trim insulation. See Figure 12.

Figure 12

Wire Stripper

These are used to strip insulation from conductors. The adjusting screw should be used to prevent the cutting tips doing damage to the conductor. They may also be used to remove the sheath from single core PVC / PVC cable, $1.5mm^2$ and $2.5mm^2$, while leaving the insulation intact. See Figure 13.

Figure 13

Automatic Wire Stripper

Another form of wire stripper is the automatic wire stripper. See Figure 14. This tool is designed to remove insulation from a range of conductor sizes.

Figure 14

Junior Hacksaw

This is used to cut the larger size cables, cut mini trunking and cut out openings in surface boxes for cable entry.

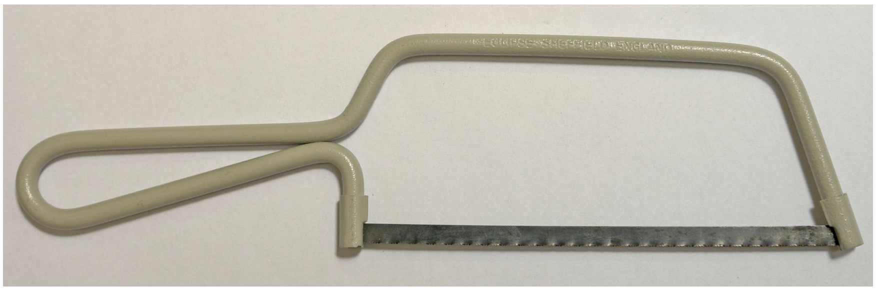


Figure 15a

Pad Saw

This is used to cut holes in plasterboard to enable the installation of drylining boxes.

Figure 15b

Bradawl

This is used to make holes in timber to aid accurate positioning and driving of woodscrews

Figure 16

Knife

A good quality electrician's penknife is mainly used to remove the sheath from the various types of cables and flexible cords.

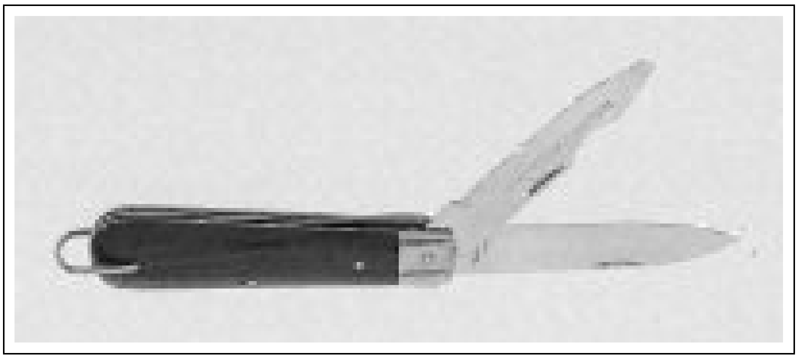


Figure 17

This is best done by scoring round the sheath at the point to which it must be removed. Be careful not to cut through the sheath, damaging the insulation. In some cases, the sheath can then be removed, by flexing gently at the scored point until it yields. Then pull while twisting to follow the lay of the cores. See Figure 18.

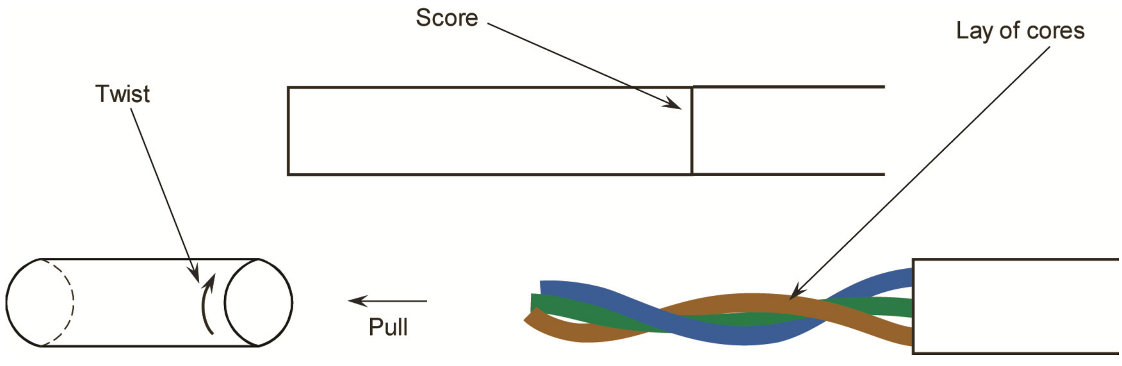


Figure 18

If the sheath is too long or too tough to be removed in this manner, it will have to be slit along its length to remove it.

Screwdrivers

There are a wide variety of types and sizes of screwdriver, some of which have very specialised uses, e.g. tamper proof fixings.

Flat blade screwdrivers are still in common use today in the electrical trade. They are specified in size, by the length of the blade and the width of the tip. A set consisting of at least five would be suitable for electrical work.

Screwdrivers should **not** be used as chisels. Larger sizes may be used to advantage for some levering operations, but great care must be taken to avoid damage to the shaft or tip.

The tip of the screwdriver should fit the screw head accurately, to achieve maximum drive and avoid damage to the screw head. See Figure 19.

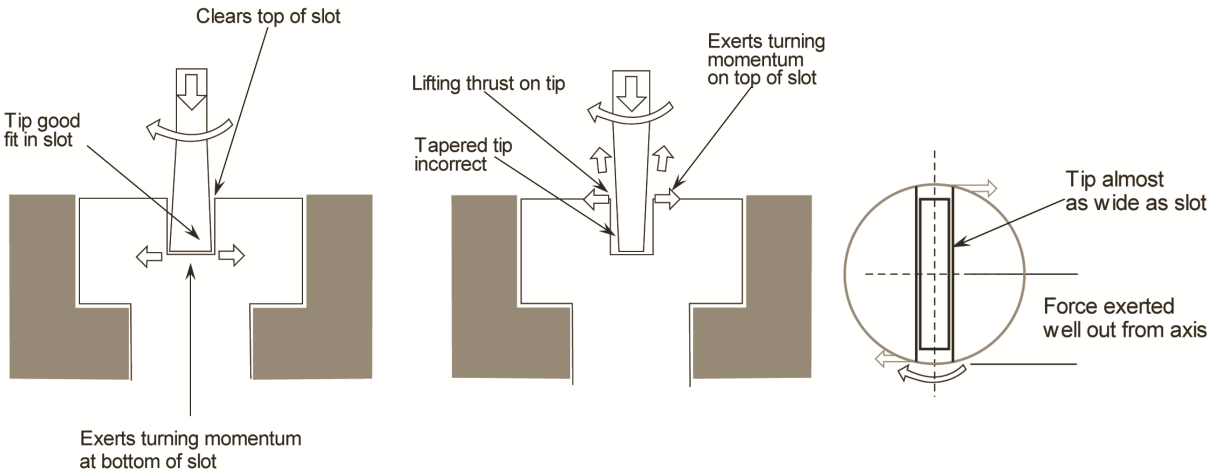


Figure 19

Philips and Pozidrive Screwdrivers

The Philips screwdriver has been in use for a long period of time. It has the advantage in that it can be very simply and quickly located in the screw head. Its main disadvantage is that it has wings, which are tapered. These tend to cause the tip of the screwdriver to be forced up out of the screw head, when a turning effort is applied.

A variation and indeed an improvement on the Philips screwdriver, is the Pozidrive type. These are very similar in appearance. The main difference between them is the fact that the Pozidrive has wings, which are parallel. These provide a better grip and do not cause the tip of the screwdriver to be forced up out of the screw head.

It is important to be able to identify which type of screw head is present and then choose the correct type of screwdriver to prevent damage to the screw head. See Figure 20.

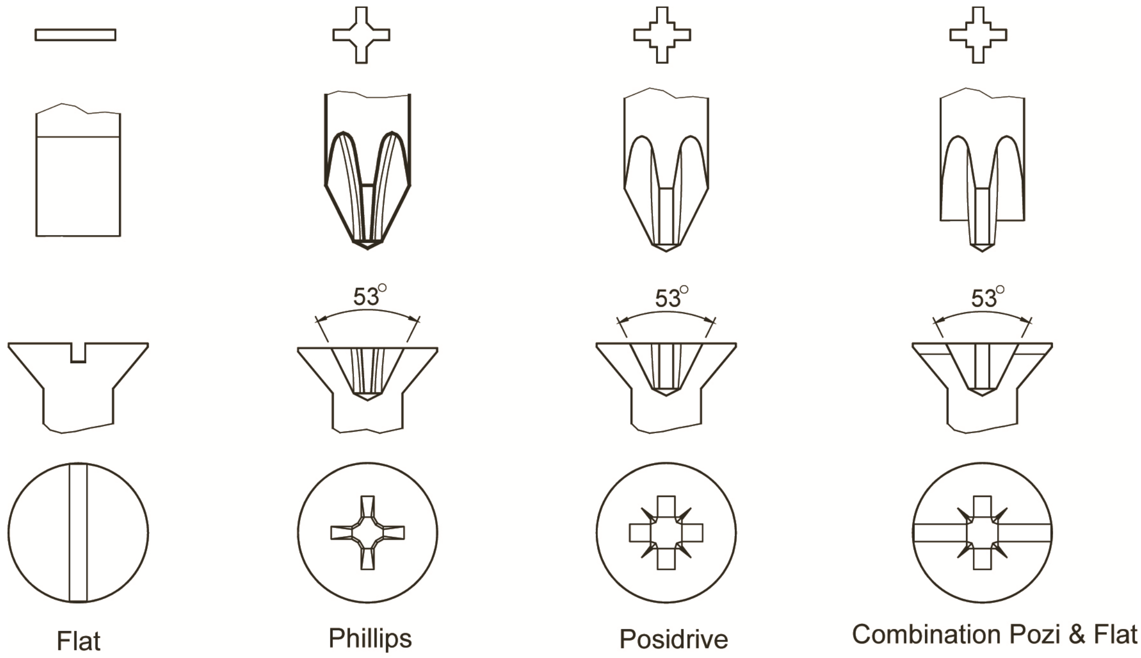


Figure 20

Both Philips and Pozidrive screwdrivers are available in three distinct tip or point sizes:

- Pt. 1 – Small size
- Pt. 2 – Medium size
- Pt. 3 – Large size

It is obviously very important to choose the correct tip size also.

Remember that terminal screws may be used several times due to maintenance work or alterations to circuits. The use of a screwdriver of the wrong size or type will damage the screw head and render the piece of equipment useless.

Flat Blade Screwdrivers

Figure 21 illustrates a set of terminal screwdrivers which are suitable for general electrical work. They have insulated shafts and tip sizes of 6, 5, 4 and 3 mm.

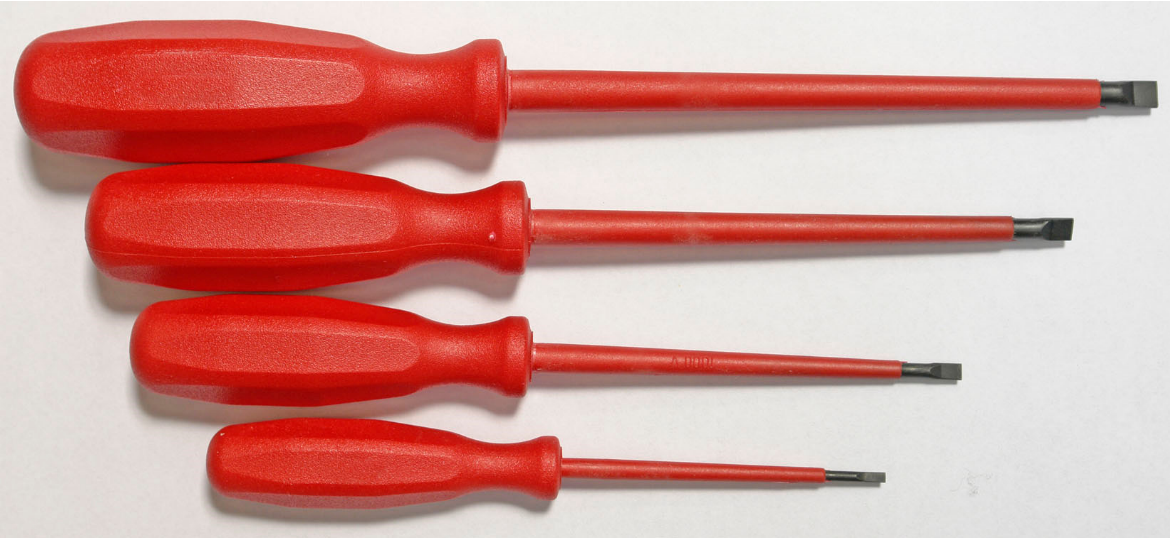


Figure 21

Phase Tester

Figure 22 illustrates a phase tester, which doubles as a small terminal screwdriver. It is a very useful tool when checking if a circuit is "live" or not. It is very important to ensure that it is not used in a damp or wet condition. When in use, current flows through the body of the user. Dampness may increase this operating current to a dangerous level.

Figure 22

Pozidrive Screwdrivers

Figure 23 illustrates a size 2 and size 1 Pozidrive screwdriver. Most woodscrews now in use are pozidrive type. A Philips screwdriver will simply slip causing damage to the screw head. The same information applies to terminal screws. The length of the shaft and the tip size are marked on the handle of most screwdrivers.

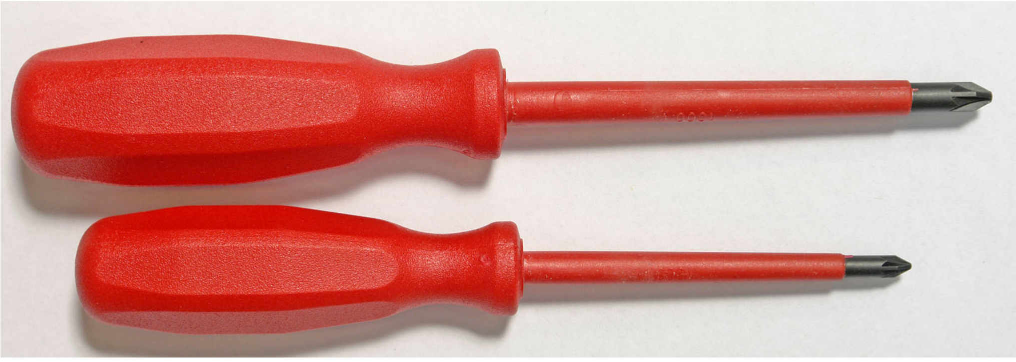


Figure 23

Combination Flat and Pozi Screwdrivers

Figure 24 illustrates a size 2 and a size 1 combination Flat and Pozi screwdriver. Most manufacturers of electrical protective devices are now using a screw head which will accept a Flat tip screwdriver or a Pozidrive type. This combination screwdriver provides an excellent grip and can be used numerous times without damage to the screw head.

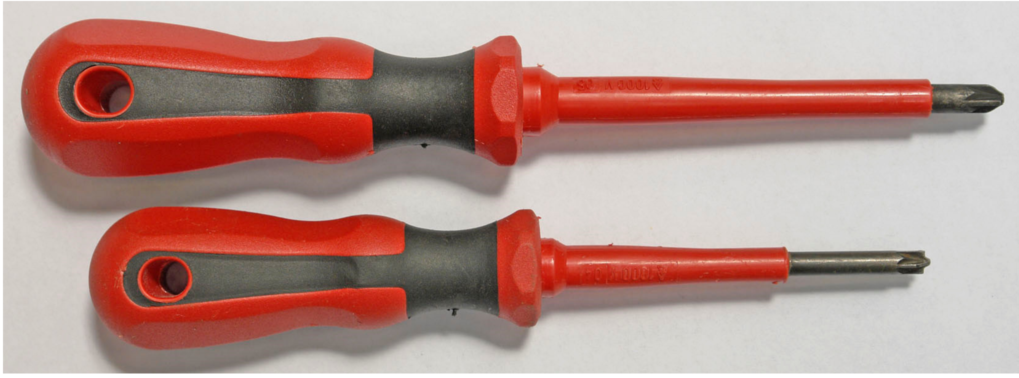


Figure 24

Marking Out

When installing electrical equipment and fittings into a building the electrician must decide where and how to fix to the floor, wall or ceiling.

The electrician may have working drawings available, indicating where the various fittings such as lights, switches, power points and / or appliances are to be installed. Symbols are used in the drawing legend to indicate the type of fixture and their exact location in the building.

Dimensions as to the height of switch drops and height of fixtures above the finished floor level are usually included.

With or without the information contained in working drawings the electrician has to translate installation plans into action. The first action is to mark out the exact location for the fixtures to be installed and also the route, which the cables will follow.

Marking a Vertical Line (Plumb Line)

Plumb lines, sometimes called "plumb bobs" are used to establish VERTICAL LINES.

The plumb bob consists of a balanced weight attached through its centre to one end of a piece of twine. It may be held or suspended from a point above. When stable, it will indicate a true vertical line.
See Figure 25.
Two pencil marks to correspond with the line of the twine are drawn, one at each end. Joining these two marks will provide a true vertical line.

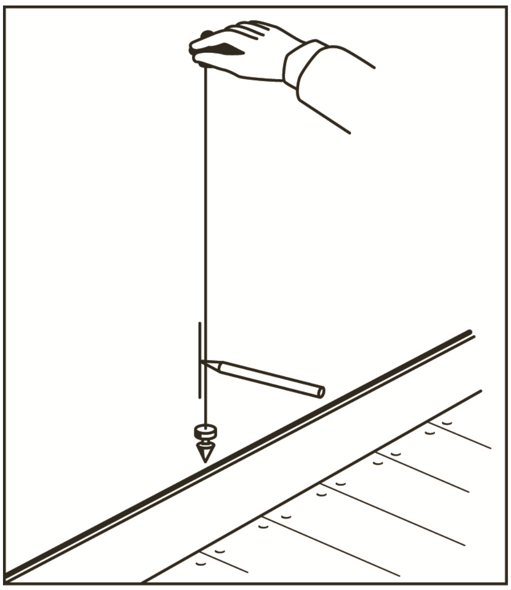


Figure 25.

Chalk Lines

Chalk lines are normally 3-5 metre lengths of twine impregnated with fine chalk powder. With purpose made chalk lines, chalk is applied to the twine as it is played out from the spool. A chalk line is so shaped that it can be used as a plumb bob.
See Figure 26.

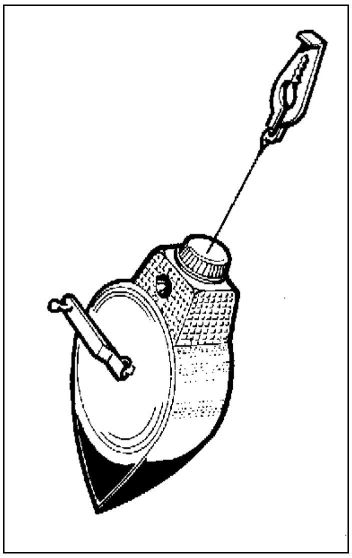


Figure 26

To mark a chalk line, use the free hand to lift the tautly held string away from the wall and then release it. The string will spring back and deposit a line of chalk on the surface of the wall. See Figure 27. For long runs, fix the line at both ends and pluck in a similar manner near the centre.

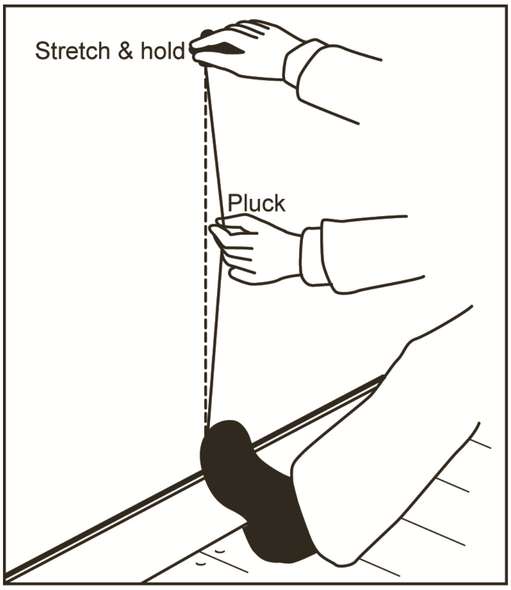


Figure 27.

Marking a Horizontal Line (Spirit Level)

The most common tool used to produce a horizontal line is a spirit level.

It consists of a straight edge, generally made of aluminium. A tough glass tube is fixed into the middle and both ends. These tubes are almost completely filled with liquid. Only a small air bubble remains. When the air bubble is located centrally between two markings on the centre tube, the spirit level is horizontal and a pencil line can be drawn. A spirit level may also be used to mark vertical lines. The tubes at either end are used for this purpose. Some models facilitate the marking of a 45° line using one end. Sizes vary from about 250mm to 2 metres long.
A level should be treated with care. For accurate marking, ensure that the bubble is equally spaced between the two lines on the glass tube.
See figure 28

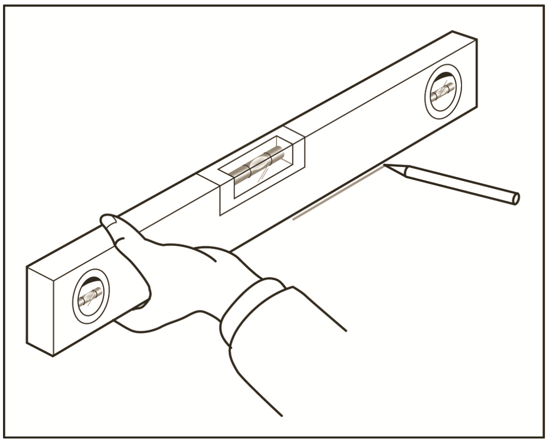


Figure 28.

Measuring Off

Horizontal lines can be drawn by measuring off from a common base. On walls this base could be either the floor, top of the skirting board or a ceiling surface provided these are reasonably level and even. Identical measurements are taken a short distance out from the corner of the wall, floor or ceiling and marked out. For long runs, intermediate points may also have to be marked out.

A chalk line is stretched over these marks for the required distance and 'plucked' to mark a line. Alternatively a long straight edge could be utilised.

The measuring off method is used in many situations where installations are made parallel to existing features, such as doorframes, architraves, skirting boards, ceiling cornices, rather than at the 'true' vertical or horizontal.

Never mark or draw, more lines than are absolutely necessary particularly on decorated surfaces. If you must mark the walls use chalk lines (white), which can be easily erased later.

Marking Out on a Ceiling

Marking out directly onto a ceiling is difficult without assistance. An alternative method is to mark out on the floor and transfer the points to the ceiling by use of a plumb line.
Figures 29 and 30 illustrate this process.

- Set out the fixing points and the direction of the fixtures on an unobstructed floor. The centres of these fixing points should be marked out with crosses that intersect exactly at right angles.
- Use a plumb line suspended from the ceiling so that the plumb bob is just clear of the floor.
- Move the plumb line until the point of the plumb bob rests exactly over the centre of the mark on the floor, then put a mark on the ceiling at the point of suspension.

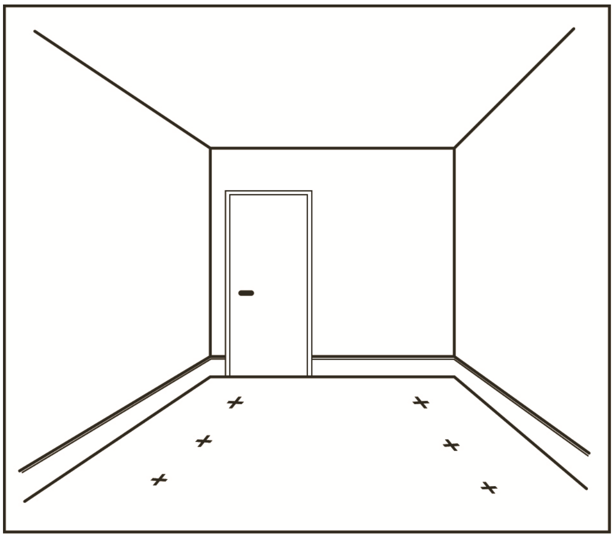


Figure 29.

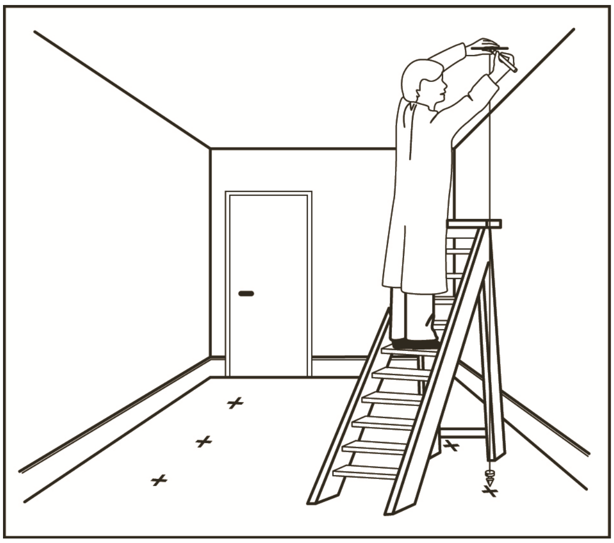


Figure 30.

Fixing Devices

There is a wide range of fixing devices in use in the electrical trade. They can be classified according to their use with particular building materials such as wood, concrete, metal, plasterboard etc. The following are examples of some types of woodscrews which are widely available.

Woodscrews

Figure 31 illustrates a slotted countersunk head woodscrew. This screw is used to fix items which have countersunk fixing holes. The screw head finishes flush with the surface of the work.

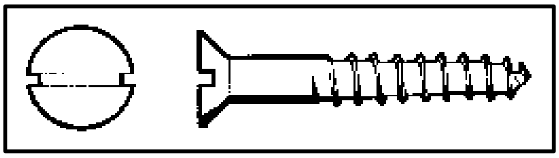


Figure 31.

Figure 32 illustrates a pozidrive countersunk head woodscrew. Its application is the same as the previous type but it has the advantage that the screwdriver used is easier to locate and less likely to slip while in use.

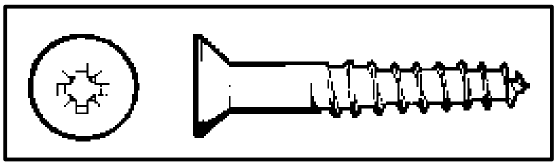


Figure 32.

Figure 33 illustrates a round head woodscrew which is used to fix items which do not have countersunk or counterbored holes, e.g. plastic or steel trunking. The reason for this is that the screw has no sharp edges which might damage cable insulation. This screw also provides a more decorative finish where fixing screws remain visible.

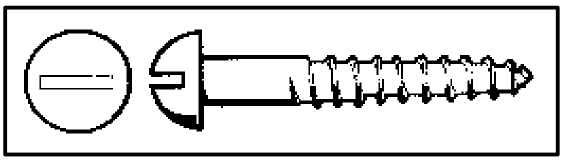


Figure 33.

All of these woodscrews are available in a range of sizes. They are sized according to their length, and diameter of the thread, in millimetres. A screw having a diameter of 4mm and a length of 25mm will be designated as an M4 x 25. The type of head incorporated will also be stated.

Machine Thread Screws

Machine thread screws are used to fix switches, sockets, ceiling roses etc., to their respective boxes. The following are examples of the more common types encountered in the electrical trade.

Figure 34 illustrates a slotted countersunk head machine thread screw. It is used to fix ceiling roses and battenholders to boxes which have machine thread inserts. The screw diameter in common use is 4mm. They are available in various length such as 6mm, 12mm, 16mm, 20mm, 25mm, 30mm and 40mm. They are manufactured from brass and have a thread pitch of 0.7mm.

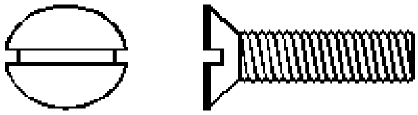


Figure 34.

Figure 35 illustrates a pan head screw. It is used to fix items similar to those mentioned previously which do not have countersunk fixing holes. Pan head screws provide a neat finish where fixing screws remain visible.

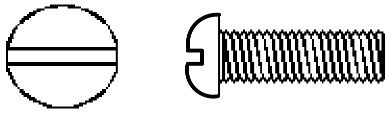


Figure 35.

Figure 36 illustrates a raised countersunk head screw. It is used to fix switches, sockets etc., to boxes which have machine thread inserts. The diameter in common use is 3.5mm. They are available in 20mm, 25mm, 60mm,75mm and 100mm lengths. They are generally brass with a nickel plated finish and have a thread pitch of 0.6mm.

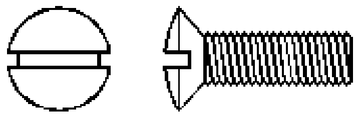


Figure 36.

Method of Fixing into Wood

First decide on the position of fixtures. Then take measurements off the walls, ceiling or floor. Use the same base line (datum line) each time. For repetitive fixing, a measuring rod may be more efficient. Using the fixture itself, or a template, clearly mark out the position of the holes using a pencil or a bradawl as shown in Figure 37.

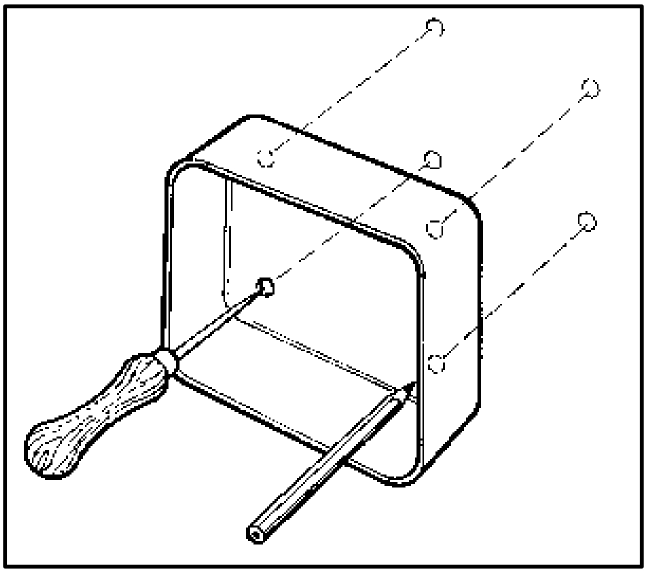


Figure 37.

Make a hole in the wood, for one woodscrew, using the bradawl. The hole should be about **half the depth** by which the woodscrew must enter the wood. As a general guide the woodscrew should enter the wood a distance **equal to 5 times its thread diameter**. Select the correct type and size of woodscrew. Note the surface finish on the fixture at the fixing point. Where a recess is provided, use a countersunk screw, if not use a round head screw. Check the diameter of the hole in the fixture and select a screw having a diameter equal to or slightly less than this. Drive the woodscrew into the prepared hole (preferably an uppermost hole) and allow the fixture to hang from this screw. The fixture can now be aligned accurately. Each remaining hole can be checked and started using the bradawl. The screws can be inserted and driven home. Finally tighten the first screw and check that the fixture is secure.

N.B. Do not overtighten screws particularly when securing hard plastics as these may crack easily.

When driving screws into hard woods it is advisable to drill a pilot hole which should be 2 mm less than the diameter of the screw thread.

Method of Fixing into Partition Walls

A fair proportion of electrical installation work involves fixing items to partition walls of various types. These may be plasterboard or timber walls for example. It is essential to know what fixing methods may be used.

Spring Toggle Fixings

The spring toggle consists of a plated steel, spring actuated toggle bar, pivoted on a swivel nut. When the nut has been run on to the end of the screw, the toggle is pushed through the fixing hole into the cavity whereupon it springs open and is then pulled back against the material to tighten the screw. The design of this fixing causes the load to be spread over a wide area.
See Figure 38.

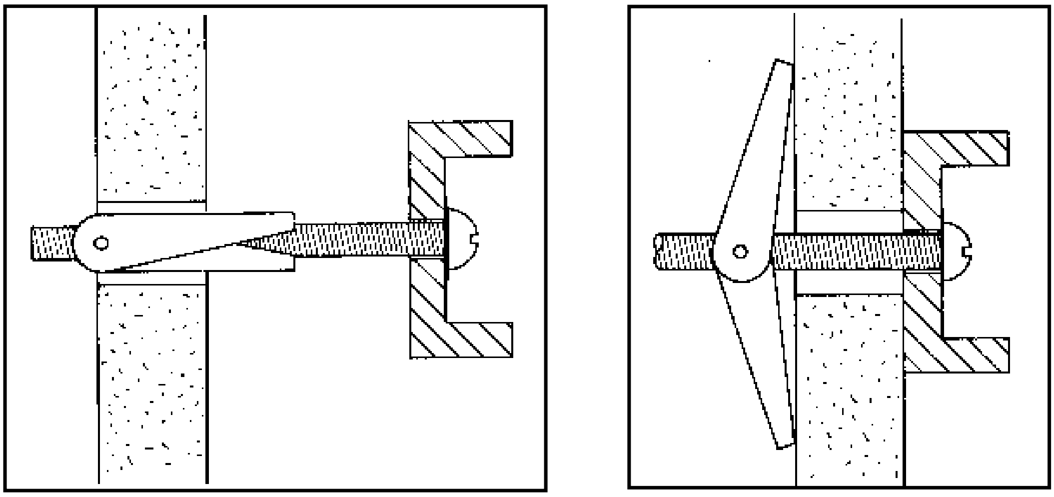


Figure 38.

The spring toggle is ideal for making fixings to cavity walls and ceilings where only one side of the material is accessible. It is especially effective when fixing to plasterboard and similar materials of low structural strength where, by embracing a comparatively wide area, reasonable loads can be supported.

N.B. If the screw of a spring toggle fixing is removed completely, the toggle will be lost inside the cavity.

Method of use:

- Drill a hole of suitable diameter through the partition into cavity
- Pass the fixing screw through the fixture and enter into nut.
- Pass the toggle through the hole in the partition and allow the toggle wings to spring apart.
- Pull on fixture while turning screw, to prevent toggle revolving inside cavity.
- Tighten screw until fixture is secure.

Rawlnut Multipurpose Fixing

The rawlnut fixing consists of a tough natural rubber sleeve with a non-ferrous nut bonded in one end, and a moulded external flange at the other. When the screw is tightened, the rubber sleeve compresses into a strong rivet fixing on the reverse side of the partition.
See Figure 39.

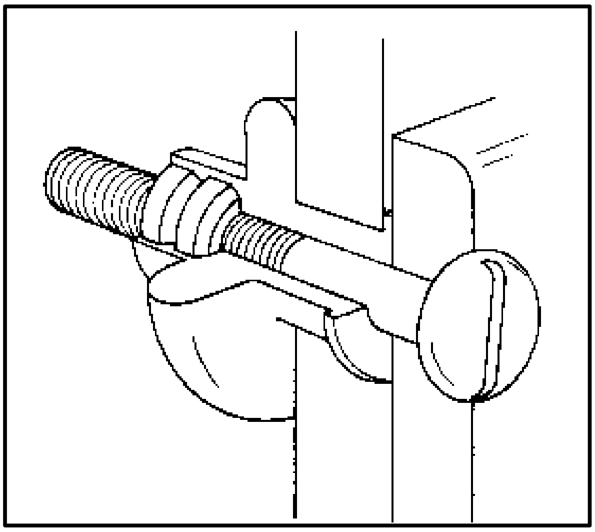


Figure 39.

The rawlnut is suitable for securing fixtures to plasterboard, plastics, sheet metal, concrete and glass, to name but a few. It provides a fixing which is corrosion resistant, waterproof, vibration proof and electrically insulated.

N.B. When the screw is removed, the sleeve will remain in position and can be re-used.

Method of Use.

- Drill a hole of a suitable diameter in material.
- Insert rawlnut in hole up to external flange.
- Pass fixing screw through fixture and enter into rawlnut.
- Tighten screw to compress rubber sleeve until fixture is secure.

Interset Cavity Fixing

The interset is a plated steel cavity fixing, having one end internally threaded to receive a fixing screw. The other end has an external flange which is provided with teeth. These teeth penetrate the material and so prevent rotation. Fixing is achieved by deforming the legs into a large load bearing surface against the sheet material.The interset is suitable for securing fixtures to plasterboard and other similar materials. It provides a solid fixing and can achieve the maximum load that the material can support. See Figures 40.

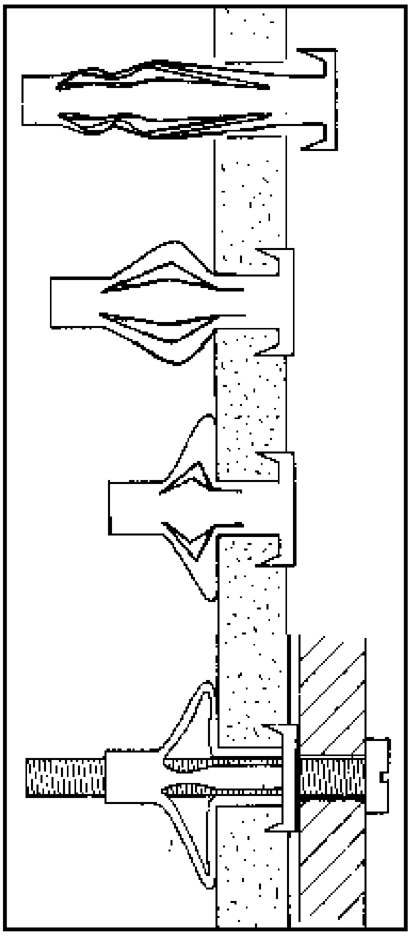


Figure 40.

N.B. If the screw is removed completely the interset will remain in position and can be reused.

Method of use.

- Drill a hole of a suitable diameter in material.
- Insert interset into hole and tap lightly to engage flange teeth in material.
- Pass fixing screw through fixture and enter into interset.
- Tighten screw to deform legs until fixture is secure.

N.B. A special interset fixing tool is available and would be an advantage in handling a large number of fixings.

Plasterboard Anchor

Figure 41 illustrates a zinc alloy plasterboard anchor which is quick and easy to install. One end is pointed to enable it to drill a pilot hole in the plasterboard. The other end consists of a flange which can be driven home using a pozidrive screwdriver. These are also available in plastic.

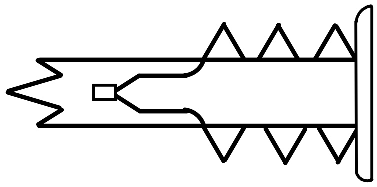


Figure 41.

The plasterboard anchor features a deep thread form which ensures a strong engagement in the plasterboard. See Figure 42.

This fixing is manufactured specifically for use on plasterboard surfaces. Each fixing is supplied with its own fixing screw. The fixing remains in place in the plasterboard if the fixing screw is removed.

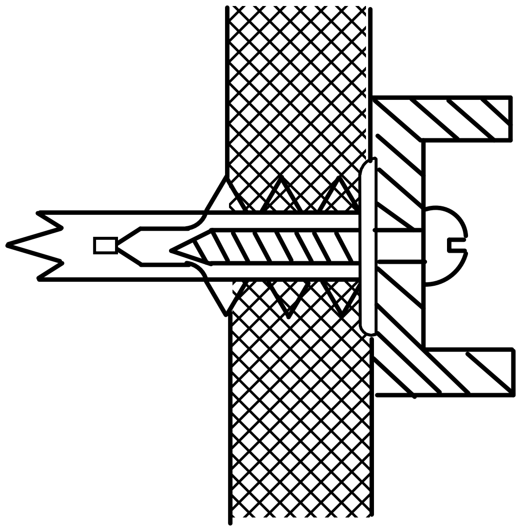


Figure 42.

Method of use.

- Using a screwdriver, self drill anchor at the required position.
- Drive anchor until flange is flush with plasterboard.
- Pass fixing screw through fixture and enter into anchor.
- Tighten screw until fixture is secure.

Surface Installation of PVC / PVC Cables

Cable Clips

Clips are manufactured to suit the size and shape of the various cables. Oval clips are sized according to the thickness and width of the cable for which they are suitable e.g. a 5 x 8 clip suits a 1.5 Twin or a Twin + Earth cable which measures approximately 5 mm x 8 mm. Clips are expandable to some degree. Circular clips are sized in a similar manner e.g. a 10 - 14 clip suits any cable having a diameter between 10 mm and 14mm.

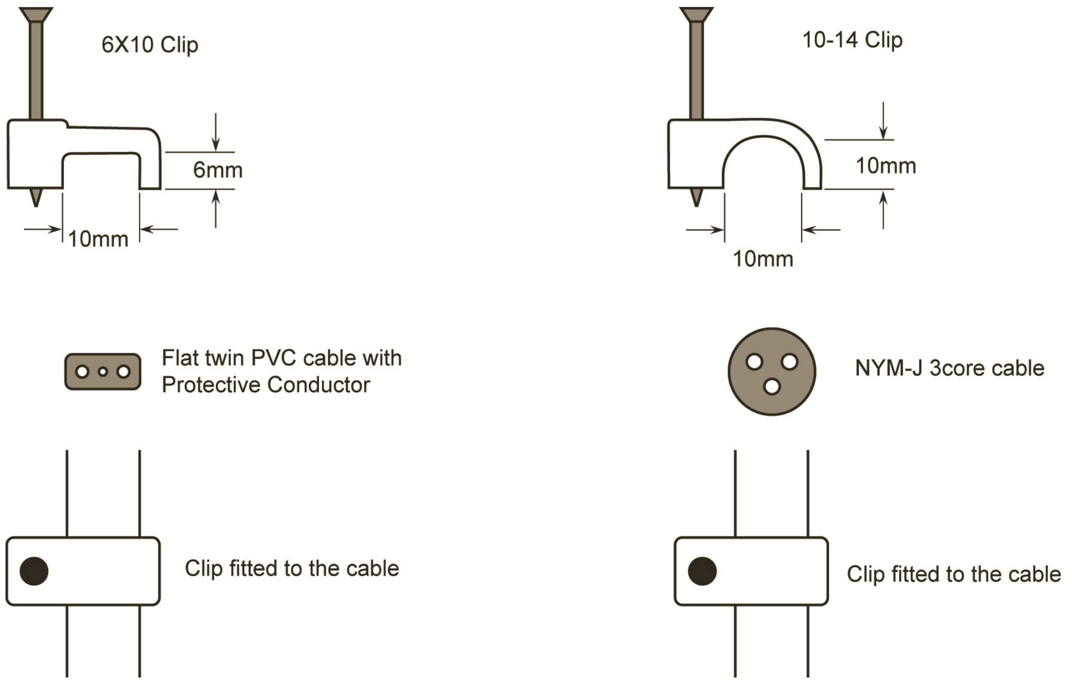


Figure 43.

Clipping of PVC / PVC Cables

PVC / PVC cables may be installed directly on a surface or in a void, where there is little risk of mechanical damage. The ambient temperature range in which they may be installed is from 0^oC to 60^oC. PVC / PVC cable is used in domestic and light commercial installations.

These cables are fixed in position using hardened PVC clips which incorporate a nail suitable for driving directly into most surfaces. If the surface is too hard (e.g. mass concrete) a hole should be made using a hammer action drill and a masonry drill bit. A clip plug is then inserted into the hole and the clip nail may then be driven home. The section of the clip incorporating the nail should be placed **underneath the cable to provide proper support.**

The spacing between clips should be such that the cable is adequately and neatly supported in a straight line. For horizontal runs, the cable should not sag between clips.

Where cable runs change in direction, it will be necessary to bend or offset the cable. This must be done in such a way as to avoid damaging any part of the cable. For PVC / PVC cables a suitable **minimum** internal radius for bends may be found by multiplying the cable external diameter by a **factor of 3**.

For appearance sake, clips should be equally spaced on either side of a bend or fixture. Clips should be equally spaced along a straight run.

Refer to Figure 44. Ensure a neat appearance by pressing the cable flat and stretching it, between clips. Straighten the cable by running the thumb along it as shown. It helps if you avoid kinking the cable when uncoiling.

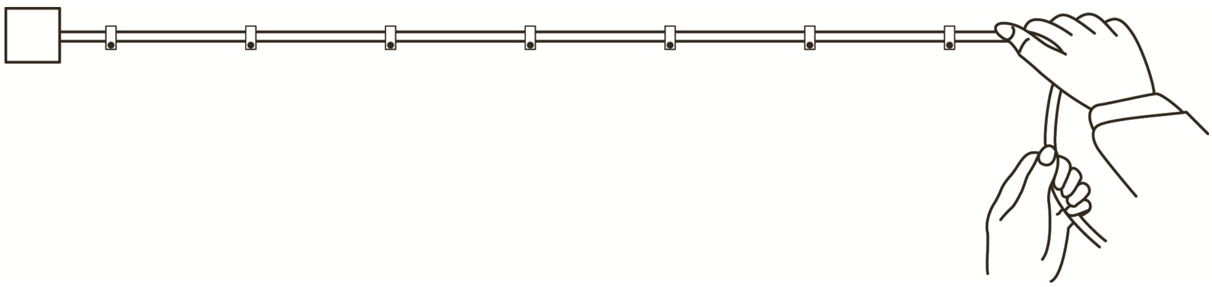


Figure 44.

Refer to Figure 45. Running the palm of the hand along the cable will also help in forming it.

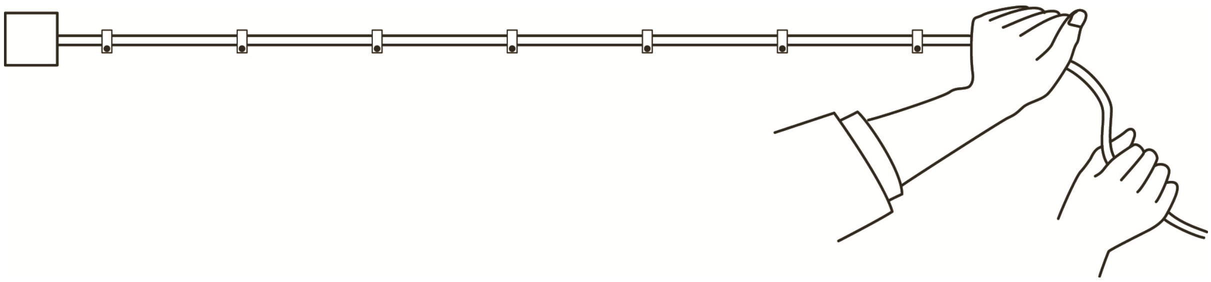


Figure 45.

Refer to Figure 46. The previous steps should be repeated after the fixing of each clip.

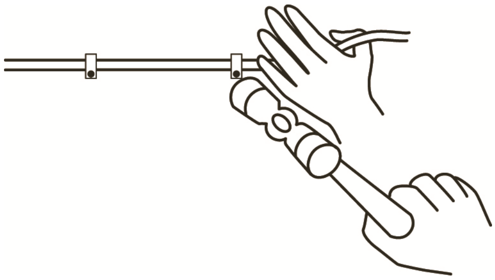


Figure 46.

Where a bend has to be formed, use the fingers and thumb as shown in Figure 47. Ensure that the bend is uniform and not too sharp and also that the clips are evenly spaced either side of the bend.

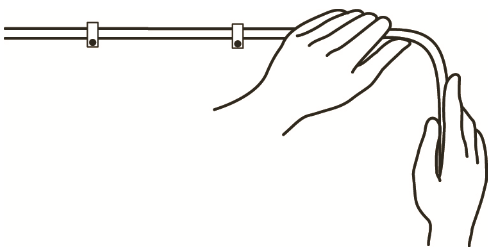


Figure 47.

<u>**Guidelines** for clipping **1.5mm^2 Twin and Earth Cable**</u>

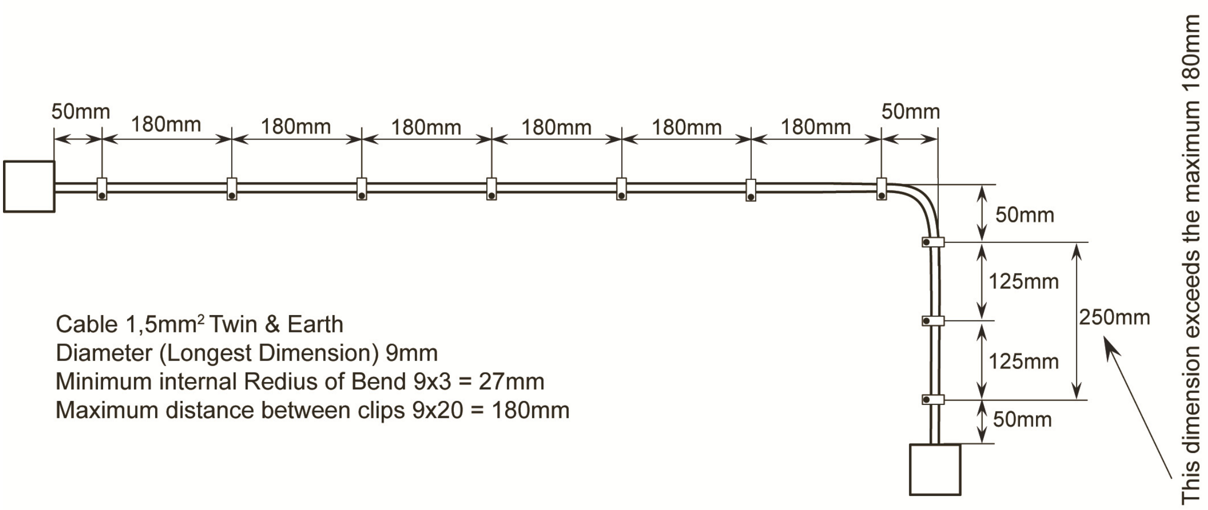


Figure 48.

Cable Mechanical Protection

The PVC sheath must enter into any enclosure to protect the conductor insulation from damage. Once inside the enclosure, the sheath can be removed because the enclosure now provides mechanical protection for the cable insulation.

There should be sufficient cable slack allowed in an enclosure to facilitate the termination and remaking of cables. This will also facilitate any alterations to the circuit or replacement of accessories. See Figure 49.

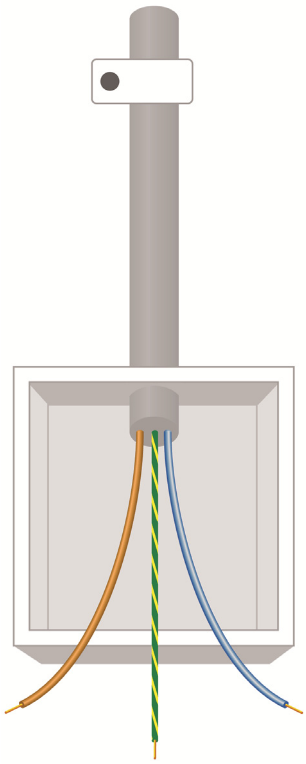


Figure 49.

Terminating Techniques

Screw Terminal

There are a variety of methods used to terminate conductors. One of the most common types is the screw terminal. Regardless of the type of terminal used it is important that the **joint between the conductor and the terminal is electrically and mechanically sound, without putting undue pressure on the conductor or the terminal.** In other words the terminal screw should be **sufficiently tight**. The conductor insulation should be removed far enough to allow the conductor enter the terminal. The conductor should be **insulated** right up to the **metal** of the terminal. **Stranded conductors** should be **twisted** to form a **solid mass**. The cable sheath should be removed a distance of **at least 20 mm.** This must be done to prevent **surface leakage current**, allow more **flexibility** at the termination and also to identify the **core colour**.

Figure 50 shows a termination made off **correctly**.

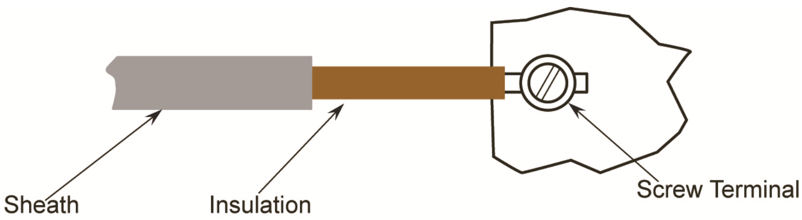


Figure 50

Figure 51 shows a termination made off **incorrectly.**

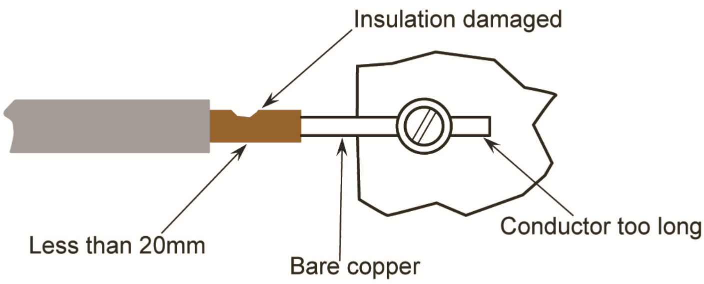


Figure 51

If the conductor is small in relation to the terminal, the conductor must be **doubled** back **fully**, **neatly** on itself. See Figure 52 for a **correct** termination.

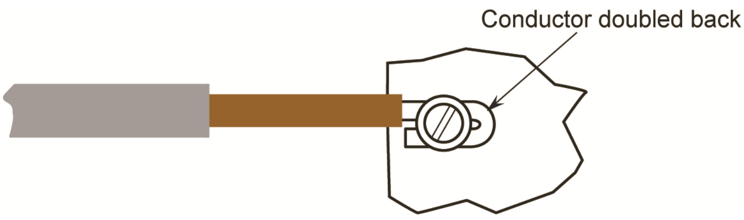


Figure 52

Figure 53 shows an **incorrect** termination.

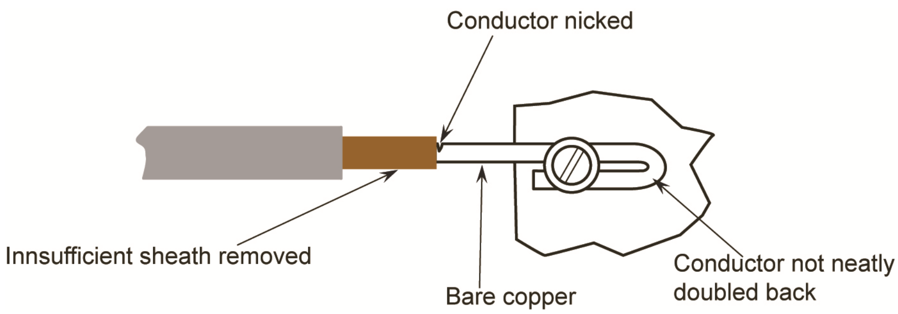


Figure 53

If two conductors are to be terminated together, they should be placed side by side in the terminal. The terminal screw must bear down on both of them. See Figure 54.

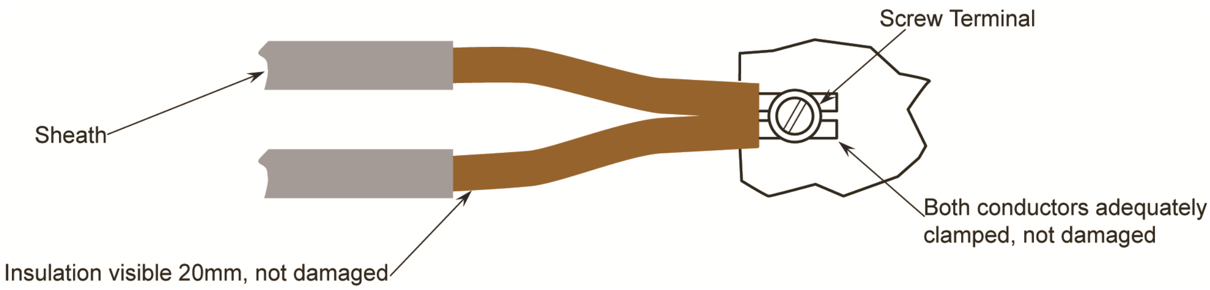


Figure 54

Screw Head and Nut and Washer Terminals

When terminating conductors under screw-heads or nuts, it is best to form the conductor into an eye, using round nose pliers. The eye should be slightly larger than the screw diameter, but smaller than the outside diameter of the screwhead, nut or washer.

The eye should be placed in such a way that rotation of the screw head or nut tends to close the joint in the eye. If the eye is put the opposite way round, the motion of the screw or nut will tend to untwist the eye, and will probably result in poor contact. The conductor should be wound **at least three quarter way** round the screw. See Figure 55.

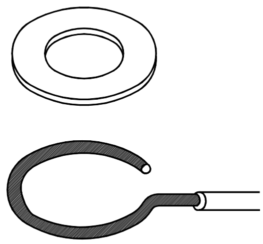


Figure 55

Clamp Type Terminal

These terminals are used in a similar manner to the screw type terminal. They provide heavier clamping, generally for terminating larger conductors. The clamping plate may be ribbed in order to put small indents into the conductor to provide better electrical and mechanical contact.

Criteria for Good Terminations

Every cable termination should be completed and checked using the following headings.

- Solid Conductors – doubled back where possible.
- Stranded and Flexible Conductors – **all** strands twisted neatly together in the right direction, and doubled back where possible. – **all** strands present and clamped.
- No damage to conductor e.g. nicked while stripping insulation.
- No damage to insulation e.g. nicked while stripping sheath or pulling in cables.
- Insulation not clamped.
- Conductor insulated right up to the metal of the terminal (no bare copper).
- Sufficient slack available on cable.
- Cable arranged neatly and not fouling moving parts or covers.
- No makeshift terminals used.
- Terminal screw tightened sufficiently.

Wherever possible, conductors should be doubled back in order to fill the terminal and allow two lengths of conductor share the stress imposed by the tightening of the terminal screw. If a single solid conductor is clamped under a terminal screw, the screw tends to create a reasonable indent in the conductor, thereby weakening the conductor at that point. If the terminal is large in relation to the conductor, it is also possible for the conductor to move under the screw, giving rise to a loose termination.

Stranded conductors should be terminated in such a way that all strands are twisted neatly together in the direction of the lay of the cable, and again, neatly doubled back where possible. If this is **not** done some of the strands will not be clamped under the screw, giving rise to a bad termination.

If a conductor is nicked or a strand is accidentally cut away, the cross sectional area of the cable is thereby reduced at that point. This results in increased resistance and overheating.

The insulation should remain in good condition right up to the metal of the terminal. Most electrical terminals are now shrouded to prevent accidental contact by even a fingertip. If too much insulation is removed when terminating conductors, leaving bare copper exposed to touch, then what is the point in shrouding terminals in the first place.

There should be a sufficient amount of slack available on every conductor and this slack should be arranged neatly and not allowed foul any moving parts or prevent any cover / lid being fitted properly.

Use of makeshift terminals particularly applies to earthing of equipment. It is not unusual to find an earth conductor, terminated under a woodscrew used to fix a metallic enclosure in position. This is entirely **wrong** and should **NEVER** be done.

Terminal screws should be tightened **sufficiently**. This means that they should not be too loose or too tight. The best way to ensure this is to use the correct size screwdriver. As the tip of a screwdriver changes in size, so also does the handle.

Small tip	–	Small handle	Low torque
Medium tip	–	Medium handle	Medium torque
Large tip	–	Large handle	High torque

A small handle allows a low torque to be applied to a screw and a large handle allows a high torque to be applied to a screw.

It is only through practice and repeated checking of one’s own work that one can become competent in making good terminations.

Dangers of Loose Connections

(Poor electrical terminations)

- Loose connections give rise to heat.
- This heat travels from its point of origin, along the conductor in both directions.
- The insulation becomes brittle, delicate and disintegrates.
- The result is a high resistance joint.
- Possible damage to equipment.
- Possible electric shock.
- Possible fire hazard.

Role of Electrical Bodies

International Electro-technical Commission (IEC)

The IEC was founded in 1906 and is the authority for world standards for electrical and electronic engineering. Its standards are the basis of the national standards of its member-bodies, and are also the basis of standards of the Regional standards Bodies such as those in Europe (CENELEC), the Pacific Area (PASC), the Arab Countries (ASMO) and the Americas (COPANT).

The IEC, which is a non-governmental organisation based in Geneva, is composed of National Committees from over 40 countries. These countries comprise 80% of the world's population and consume 95% of the world's electrical energy. Each National Committee is expected to be representative of all the major electrical and electronics interests in its country including manufacturers, specifiers, sellers and users of equipment, government, public services, the engineering profession, and research organisations.

The IEC works in close co-operation with many international organisations including the International Standards Organisation (ISO), which is responsible for international standards in non electrical fields.

European Committee for Electro-technical Standardisation
(CENELEC)

CENELEC was set up in 1973 and is comprised of the National Electro-technical Committees of 18 West European Countries (12 EC & 6 EFTA). Its aims are to harmonise the electro-technical standards of its member countries and to assist in removing trade barriers arising from conflicting national electrical safety requirements.

CENELEC produces three types of documents, European Standards (EN), Harmonisation Documents (HD) and European Pre-Standards (ENV's). European Standards are intended to be published or endorsed, in all Member Countries, as identical national standards. For Harmonisation Documents, the technical content is intended to be incorporated into the national standard, but not necessarily identically. The HD allows national deviations for a specified period. ENV's are European Pre-Standards published by CENELEC to gain experience in newly developed areas of electro-technology and are intended to be converted into EN's within a few years.

EN's and HD's are based on IEC standards, or in the rare case that a suitable one does not exist, CENELEC may initiate the work

The Electro-Technical Council of Ireland (ETCI)

The ETCI, is a voluntary body of twenty two organisations representative of all aspects of electro-technology in this country. Formally constituted in 1972, the Council is the national body responsible for the harmonisation of standards in the electrotechnical field, in collaboration with the National Standards Authority of Ireland (NSAI).

ETCI is the Irish Member of the International Electro-technical Commission (IEC) and the European Committee for Electro-Technical Standardisation (CENELEC).

The objectives of the ETCI are:

- To promote and co-ordinate standardisation in all branches of electrotechnology in harmony with international agreements, and in collaboration with the National Standards Authority of Ireland (NSAI).
- To establish liaison with similar bodies in other countries and with international bodies.
- To promote safety in electrical equipment and installations and to encourage an awareness of electrical safety among the general public.
- To advise and make recommendations on any matter pertaining to electro-technology, subject to the statutory powers, duties and functions of other bodies.

Register of Electrical Contractors of Ireland (RECI)

RECI was founded in 1992 to promote and protect the interests of the public as users of electrical service so that they will obtain an acceptable standard of workmanship and technical competence within the electrical contracting industry, and to provide a high level of assistance to the industry to achieve this standard

- To ensure that the standards required by the Register of Electrical Contractors of Ireland are relevant, realistic and reflect public expectations and are appropriate to current and evolving electrical technology, regulations, standards, rules and codes of practice.
- To promote safety and encourage an awareness of electrical safety among electrical contractors.
- To complement the role of industry and other organisations in their endeavours to ensure that there are sufficient numbers of registered electrical contractors practising within the industry who are properly qualified to meet the standards set by RECI and who will maintain appropriate levels of technical competency.
- To ensure that persons conducting a business within the industry are appropriately registered and to encourage competence and ethical business behaviour for the benefit of the public.
- To improve registered contractor’s ability to deal effectively from initial negotiations of a contract through to satisfactory completion of the project.
- To resolve disputes between contractors and consumers promptly and fairly by mediation, direction or referral to an appropriate authority or other body if necessary.

Electrical Contractors Safety and Standards Association Ltd

(ECSSA)

The ECSSA is one of only two regulatory bodies for electrical contractors currently recognised by the ESB and ETCI.

- Members of both bodies enjoy equal status in regard to self-certification of installations and connections to the national grid.
- All ECSSA registered members undertake to carry out their work in strict accordance with ETCI wiring regulations.
- Members are required to carry Public Liability, Product Liability and, where appropriate, employers Liability insurance.
- To the customer, the ECSSA offers the assurance of quality work by qualified and insured contractors and an immediate response and investigation by ECSSA inspectors of every complaint received regarding work carried out by an ECSSA member.
- To the contractor we offer the right to self certification, equal status in tendering for all public contracts, an excellent insurance deal with selected brokers, and a fair and unbiased disciplinary and appeals procedure. We aim to make ECSSA membership an asset rather than an evil in the lives of contractors

Electricity Supply Board (ESB)

The ESB was established in 1927 with a mandate to generate, transmit and distribute electricity to the homes, businesses and industry of Ireland.

There are 16 Generating Stations located in different parts of the country, the biggest being Moneypoint in County Clare. The Generating Stations use a mix of fuels including coal, gas, oil, peat and also hydroelectric power from some of our larger rivers.

The transmission and distribution business is organised into four Regions with Headquarters in Dublin, Sligo, Limerick and Cork. The High Voltage Transmission system extends the electricity from the Generating Stations to the main population and industrial centres and the distribution system then brings electricity to the Customers.

The ESB also operates an extensive international consultancy business and is currently working in almost 40 countries around the world.

Health and Safety Authority (HSA)

The HSA is a state-sponsored body, under the Department of Enterprise and Employment. It has overall responsibility for the administration and enforcement of Health and Safety at Work Act in Ireland. The HSA regulations on electricity are the law of the land.

These regulations are concerned with general electrical safety requirements rather than with detailed specifications and they will be backed up by approved codes of practice (although used by the HSA the ETCI Rules are not yet approved.) The regulations apply to all electrical equipment and installations in all workplaces, except mines and quarries, and to all work activities related to the use of electricity.

National Standards Authority of Ireland (NSAI)

The National Standards Authority of Ireland - NSAI, an autonomous body reporting to FORFAS, and acts on behalf of the Minister for Enterprise & Employment for the publication of national standards and the provision of a comprehensive product and quality system certification service.

The Board of Directors of NSAI represents a cross section of industrial and government interests.

NSAI develops and publishes standards to meet international demands for quality, design, performance and safety of products and services. These standards are quoted extensively by specifiers in public and private purchasing requirements.

NSAI certification service, operates in accordance with the stringent European Standards series EN 45000, and global ISO Conformity Assessment Procedures, recognised and accepted worldwide as a mark of assured quality and conformity to recognised performance requirements.

As the national certification body, NSAI has been designated by the Irish Government as a “Notified Body” in connection with EC procedures leading to the issue of certificates for use of the ‘CE’ Mark of Conformity.

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