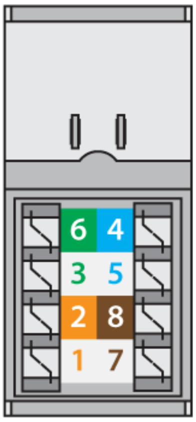
Level 3 Diploma
in
Installing Electrotechnical Systems & Equipment

C&G 2357

Unit 306 - Principles, practicies and legislation for the termination and connection of conductors and cables



T568B

EIA/TIA 568B WIRING STANDARD	
Pin No.	**Wire colour**
1	White with **Orange** stripe
2	**Orange**
3	White with **Green** stripe
4	**Blue**
5	White with **Blue** stripe
6	**Green**
7	White with **Brown** stripe
8	**Brown**

EIA Electronics Industry Association
TIA Telecommunications Industry Association

B&B Training Associates Ltd
Learning Materials for the Electrical Industry

Produced by

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Aims and objectives

Outcome 1

- State the implications of carrying out safe isolation to other personnel, clients, members of the public and on building systems.
- State the implications of not carrying out safe isolation to self, other personnel, clients, members of the public and on building systems.
- Specify and undertake the correct procedure for completing safe isolation.

Outcome 2

- Identify and interpret appropriate sources of relevant information for the termination and connection of conductors, cables and flexible cords in electrical wiring systems and equipment.
- Specify organisational procedures for reporting variations in the installation specification.
- Describe methods and procedures appropriate to the installation environment to ensure the safe and effective termination and connection of conductors, cables and flexible cords in electrical wiring systems and equipment.

Outcome 3

- Explain the advantages, limitations and applications of making connections by screwing, crimping, soldering and non-screw compression.
- Describe the procedures for proving that terminations and connections are electrically and mechanically sound.
- Explain the consequences of terminations not being electrically and mechanically sound.
- Specify the health and safety requirements appropriate to terminating and connecting conductors, cables and flexible cords in electrical wiring systems and equipment.
- Interpret and apply the techniques and methods for the safe and effective termination and connection of a variety of cable types.

1: Why do we need to isolate?

In this session the student will:

- State the implications of carrying out safe isolation.
- State the implications of not carry out safe isolation.

Legislation

The Health and Safety at Work etc. Act 1974 sets out the general health and safety duties of employers, employees and the self-employed. The Electricity at Work Regulations 1989, which were made under the Act, requires precautions to be taken against the risk of death or personal injury from electricity in work activities.

Duties are placed on employers to ensure, amongst other things that employees engaged in such work activities on or near electrical equipment implement safe systems of work, have the technical knowledge, training or experience to carry out the work safely, and are provided with suitable tools, test equipment and personal protective equipment.

Every year, people working on construction sites suffer electric shock and burn injuries some of which, tragically, are fatal. Some of these accidents are a direct consequence of electrical contractors not implementing safe isolation procedures.

The Management of Health and Safety at Work Regulations 1999 require employers to make a suitable and sufficient assessment of the risks to the health and safety both of their employees and of other persons arising out of, or in connection with, the conduct of their undertakings.

Employees are required to co-operate with their employer to enable the requirements of the Regulations to be met; this includes complying with any instructions given on matters such as safe systems of work.

Safe isolation

Safe isolation, amongst other things, is done to prevent people receiving electric shocks

Here is a definition of an electric shock.

> An unpleasant sensation produced by the nerves response to a passage of electric current through a part of the body.

To receive a shock you must form part of a circuit. If no circuit is present then there can be no shock.

The severity of a shock depends on a number of factors, such as age, sex, state of health, excitement, and environmental factors, particularly where there is an increase in moisture.

To help prevent shocks, before working on or near electrical circuits and equipment, we isolate.

Isolation is defined in BS 7671 as:

> "A function intended to cut off for reasons of safety the supply from all, or a discrete section, of the installation by separating the installation from every source of electrical energy."

The Electricity at Work Regulations gives information on the requirements of safe isolation. The regulation we are concerned with are;

Regulation 12

Where necessary to prevent danger, suitable means must be available to cut off supplies of electrical energy to equipment and the equipment must be isolated, defined as the secure disconnection of the electrical equipment from every source of electrical energy.

Regulation 13

The means of disconnection of the electrical must be secured in the OFF position, with a warning notice or label at the point of disconnection, and proving dead at the point of work with an approved voltage indicator.

Regulation 14

Dead working should be seen as the normal method of carrying out work on electrical equipment or circuits. Live work should only be carried out in particular circumstances where it is unreasonable to work dead.

Regulation 16

Requires that no one shall engage in work with electricity unless they are competent to do so.

Safe isolation

Before you even begin to isolate there are procedures which must be undertaken.

There are people to consider such as your fellow workers, your customers/client, the public and the effect on the building and its users if power is cut off.

You should ensure that when isolating the circuit that others who are working around you are warned that the supply will be turned off and you should allow ample time for them to finish what they are doing. You are not going to be very popular if you cut of the power to drills, leave everyone in the dark etc.

Customer / Clients

Every effort should be made to notify the client well in advance of any loss of supply and for commercial installations, effort should be made to try to arrange any shut down during hours when the impact will be minimised. There are certain types of machinery and plant which could be damaged if suddenly switched off, the impact of going from full power to none could rip bolts from fixings, send potentially dangerous goods and equipment flying. Machinery using magnetic clamps would lose grip of the objects.

In domestic situations, there may be vulnerable people such as the elderly and very young children who need light and heat.

Public

Any area that the general public may occupy and the effect an interruption in the electrical supply will have on them needs to be considered. Lighting in areas such as shopping centres, underpasses, car parks and other public access points need to be maintained so that the public are able to move around in or exit the buildings safely. The working area must be maintained in a safe condition with no danger to the public. Before removing power to lifts, escalators or any public area, the area must be checked and warning notices positioned first.

Building systems

Prior warning needs to be given to users of buildings as loss of power to lighting, power, air conditioning, building management systems, security, fire alarms, lifts and escalators, computers and IT systems can have serious consequences. They all need to be maintained, as far as possible, to keep a building operating. Some systems can continue operating by using back up supplies provided by generators or other UPS arrangements. Sudden loss of power could lead to critical data loss on computers, potentially lethal effects to medical premises and panic if lifts or lighting suddenly fail. UPS systems can cause problems, as isolating the mains will bring the UPS system back on line.

Remember that Photovoltaic supplies are live all the time, so special precautions are necessary when dealing with these.

Possible effects from failing to isolate

The implication to yourself, others around you, the public and the buildings supply are great, ranging from a mild tingle, death from an electric shock to the building catching fire.

To receive a shock you must be part of a circuit. If no circuit is present then there can be no shock.

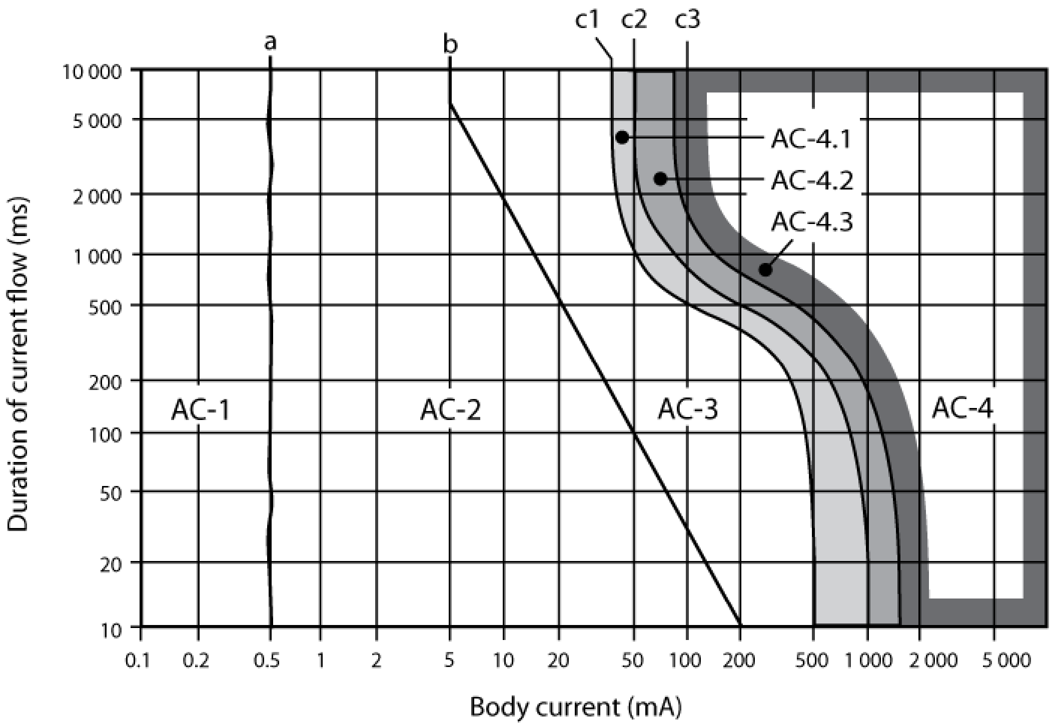
The severity of a shock depends on a number of factors, such as age, sex, state of health, excitement, and environmental factors, particularly where there is an increase in moisture.

The effects on the body vary, what is known however is that the heart can be seriously affected when a person comes into contact with electricity and this can cause the heart to beat irregularly leading to death. Furthermore, a person in contact with electricity can receive very severe burns to the body. This occurs because a person’s body acts as a resistor.

Below is a table showing the levels at which current can be perceived and the possible damage done.

Current in mA	Effect
0.5-2	Threshold of perception.
2-10	Painful sensation, increasing with current.
10-25	Cramp and inability to let go. Increase in blood pressure. Breathing difficulties caused by muscular contraction of the lungs.
10 mA is taken as the current value, above which, were there to be hand to foot contact there would be a significant risk of fibrillation (irregular heartbeat) and death. A current of 25 mA hand to hand has the equivalent effect to a 10 mA hand to foot shock.	
25-80	Severe muscular contraction sometimes with bone fractures. Increased blood pressure. Loss of consciousness from heart or breathing failure.
80+	Burns at point of contact. Deep seated burns causing the internal cells to die from the effects of very high current leading to the destruction of flesh. Death from heart failure

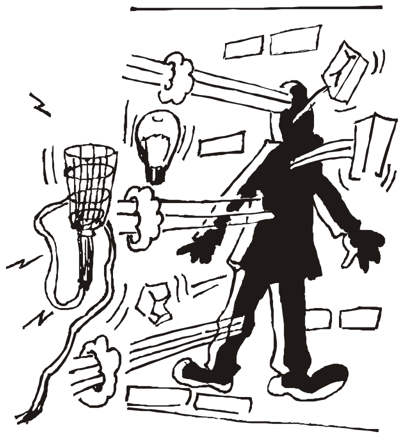
You can see just how dangerous electricity can be. The table below is a more technical way of showing similar information.



Zone label	Zone limits	Physiological effects
*AC-1	Up to 0.5 mA – to line a	Usually no reaction.
AC-2	0.5 mA – to line b	Usually no harmful effects.
AC-3	Line b to line c_1	Usually no organic damage. Cramp-like muscular contractions and difficulty in breathing for current flows greater than 2 s.
AC-4	Beyond c_1	Above c_1 there is greater danger of cardiac arrest, breathing arrest and severe burns. c_1-c_2 – Probability of ventricular fibrillation increases by 5% c_2-c_3 – Probability of ventricular fibrillation increases by 50% Beyond c_3 – Above 50% probability of ventricular fibrillation.

Below and over the next few pages are a series of drawings highlighting what the different levels of current can do!

Sensation and effect	**Diagram**
Threshold of perception Current is usually 0.5 mA to 2 mA.	
Let go level Current ranges up to approximately 10 mA. This level of current is likely to hurt. This pain increases with an increase in current.	

Sensation and effect	Diagram
Hold on level The point at which you are likely to find it difficult to let go of the object ranges from 10 mA to 25 mA. Blood pressure will rise and a person may experience difficulty breathing.	
Throwing level At currents in excess of 25 mA you are at risk from being physically thrown by the effects of the electric current on the muscles in a body. Bones may be broken, blood pressure rises and there may be a loss of consciousness.	

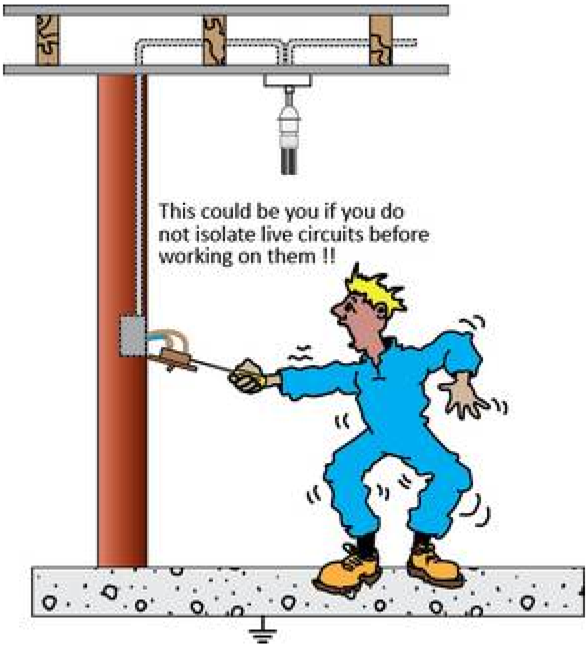
There are differences between alternating current (a.c.) and direct current (d.c.) in the effects felt by a person. Direct current usually delivers a small shock, usually when making or breaking the connection, although it does burn. Alternating current, particularly at a frequency of 50/60 Hz, delivers the shock sensation; although at different frequencies the shock sensation is reduced. This does not make the flow of current through a person any less dangerous however.

Causes of electric shock

This may seem an obvious point, after all we all know what causes an electric shock; being in contact with a conductor which is live! There are however two ways of receiving a shock.

1. Failure of basic protection

This is through coming into contact with a live part that is expected to be live

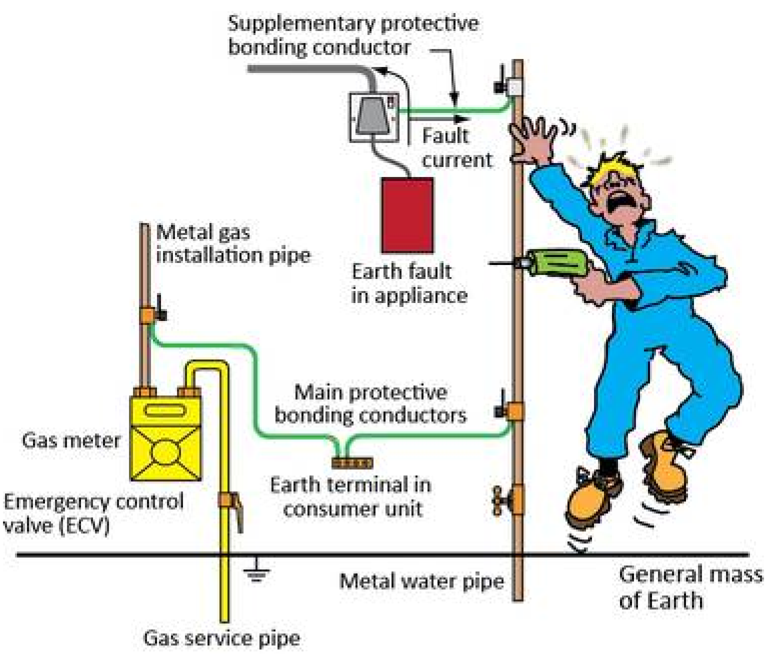


Notice from the picture, that the person makes up a circuit. The circuit comprises the source, through the person, to Earth and then back to the source. No circuit means there can be no shock.

Depending on which part of your body makes contact with source there will be a variety of ways in which a person or animal could be affected by it. This type of shock usually occurs at the mains voltage: in the UK this stands at 230 V.

2. Coming into contact with a conductive part that has become live due to a fault existing.

Fault protection



This type of source is rarely at the mains voltage, usually 230 V for a single-phase supply; although it is not any less dangerous for that.

Consequences
Two electricians suffered life-threatening injuries when they were engulfed by a fireball at a factory as they were about to clean debris from a damaged fuse box. One of the electricians is still undergoing treatment for his burns, nearly five years on, and will never be able to return to work. There had been a fire in the fuse box during the previous afternoon but live cables had been routed through it so that the cooling equipment at the factory could continue to operate. This meant the company avoided having to shut down the plant for 36 hours. A suitable risk assessment had not been carried out for the work and management at the company had allowed the work to go ahead without the electricity supply being isolated, even though this went against their own work procedures.
A subcontractor fell more than five metres from a ladder after suffering an electric shock when he made contact with a live three-phase 415v conductor that was the main power channel to the overhead crane that he had been about to repair. The company had not marked it or isolated it prior to the subcontractor starting his work.
A young electrician was holding two ends of an open flex thinking they were dead. He touched the neutral held in one hand and at the same time touched the line conductor in the other. Fortunately, a trainee, who was with him, was alert enough to hit him repeatedly with a wooden brush handle to get him to let go. The electrician was hospitalised and off work for a time.
An employee lost an arm at a giant industrial auger as he was carrying out repairs. He initially attempted a repair with the electrical power to the auger incorrectly isolated and without completing the permits for work required by company policy. The repair failed, so he attempted another repair the following day. However, both he and his supervisor failed to check that the power had been isolated, in breach of company procedures. When the supervisor accidentally activated the machine, his colleague's arm was removed above the elbow. Although the facilities to correctly isolate the machines were available, and the worker's employer had trained its workforce in safety, it failed to provide the injured man with initial training or any additional information about the equipment he was working on or about company procedures. In addition, the plant manager did not supervise work correctly, which meant company permits to work were frequently not completed.
A worker cleaning a large baling machine was crushed to death when it re-activated. He had received no proper training in how to clean the machine but had tackled the task when asked to do the job. The machine had not been shut down completely as there was a common misunderstanding at the company that isolation and lock-off at the mains were not required.
A worker came into contact with exposed live electrical conductors and suffered a 33,000 volt shock whilst carrying out electrical maintenance work. He had been cleaning the conductors and circuit breaker units in a control room that had not been isolated.

A man received a fatal electric shock in front of his young child when he touched his kitchen sink. He had reported that at times they were receiving a shock from the metal work of the sink. The electrician who went to investigate missed the fact that there were two faults, a faulty circuit breaker and a loose wire in the central heating system. Even though the electrician did not cause the faults he was convicted of manslaughter and received an 18-month prison sentence: the new Electricity at Work Regulations had come into force.
A maintenance electrician at a minerals processing plant received severe burns when changing fuses on the live part of a control panel.
On 11 June, a safety manager for a Chelmsford-based firm, lost his appeal at Southwark Crown Court against his conviction for breaching s2(1) of the HSWA 1974 (by virtue of s37), reg. 3 of the MHSWR 1999, and reg. 14 of the Electricity at Work Regulations 1989. The manager was fined £2500 and ordered to pay £5500 in costs. He was initially convicted of the charges following a trial at Westminster Magistrates' Court in November 2009. The charges related to a flashover incident at an office building in Shoe Lane, central London on 1 February 2007. Two technicians were installing a capacitor to help reduce energy consumption at the site. One of the workers was fitting cables in the back of the capacitor, which was positioned above a number of live conductors. The cables came into contact with one of the conductors and caused a flashover. The worker suffered burns to his face and upper body, injuries that have prevented him from returning to work.

There are, as can be seen, a wide range of consequences where safe isolation is not carried out.

Exercise 1

1. Give two reasons why you should isolate equipment?
2. What is meant by the term ‘basic protection’?
3. What is meant by the term ‘fault protection’?
4. Explain how not giving sufficient warning that you are going to remove the power supply could affect your fellow workers. Briefly give at least two examples of what the effect might be.
5. Describe how the loss of power might affect your clients.
6. Describe how the loss of power might affect the general public

2: Safe isolation

In this session the student will:

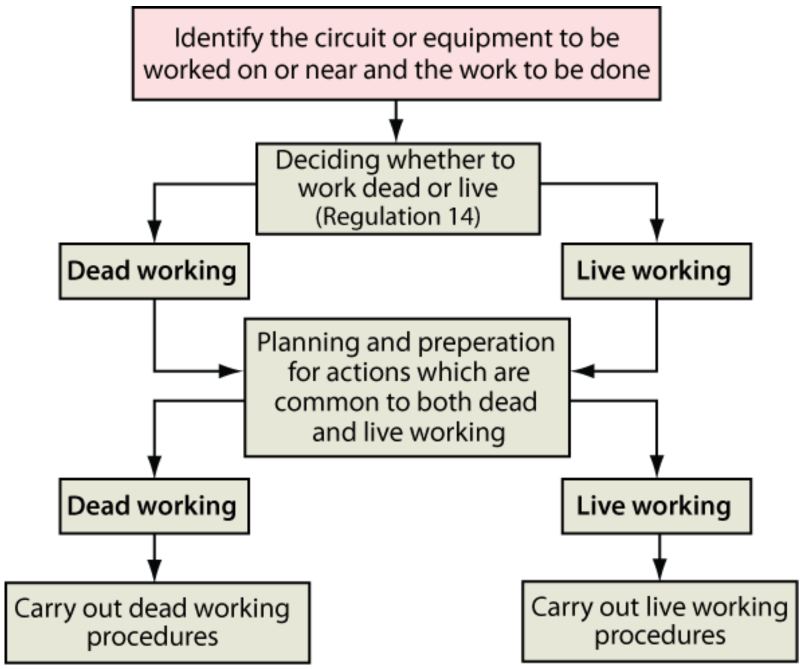
- Be able to specify and undertake the correct procedure for completing safe isolation.

The correct procedure for completing safe isolation

The HSE produce a booklet HSG85 which gives guidance on the key elements that need to be considered when devising safe working practices for people who carry out work on or near electrical equipment.

The figure below illustrates the sequence of the planning steps. The procedure can be divided into stages as follows:

- deciding whether to work dead or work live
- planning and preparation for actions which are common to both dead and live working



Actions common to both dead and live working

- Identify the circuit or equipment to be worked on or near and the work to be done
- Plan the work
- Specify correct system of work (preferably written)
- Specify level of supervision and whether accompaniment is necessary
- Select and instruct competent workers
- Ensure correct working methods
- Provide and ensure use of appropriate protective equipment
- Provide appropriate information and suitable tools and instruments for workers. Ensure they are fully instructed
- Make arrangements for management checks and supervision of work

Implement DEAD or LIVE working procedures

Dead working procedures

- Identify circuit or equipment to be worked on
- Cut off supply, isolate and secure isolation
- Retain keys. Post 'caution' and 'danger' notices
- Prove circuit or equipment dead
- Apply circuit main earth(s) where necessary
- Take precautions against adjacent live parts where necessary
- Issue permit-to-work where necessary
- Apply local earth(s) where necessary

Work on or near live conductors should rarely be permitted (regulation 14). Many accidents to electricians, technicians and electrical engineers occur when they are working on equipment that could have been isolated.

Regulation 14 requires that three conditions are met for live working to be permitted where danger may arise. It is stressed that if just one of those conditions cannot be met, live working cannot be permitted and dead working is necessary.

- it is unreasonable in all the circumstances for the conductor to be dead; and
- it is reasonable in all the circumstances for the person to be at work on or near that conductor while it is live; and
- suitable precautions (including, where necessary, the provision of personal protective equipment) have been taken to prevent injury.

It is unreasonable for the work to be done dead

There are some circumstances where it is unreasonable to make equipment dead because of the difficulties it would cause (regulation 14). For example, it may be difficult, if not impossible, to commission a complex control cabinet without having it energised at some time with parts live (but not exposed so that they may be easily touched). Also it may not be realistic to monitor the operation and performance of a control system or to trace a malfunction of such equipment with it dead, i.e. fault-finding.

Justifying live working

Providing the other requirements of regulation 14 have been met, live working can still only be justified if suitable precautions are taken to prevent injury arising from risks identified in the assessment (regulation 14(c)).

The possibility of anyone touching parts at dangerously different potentials at the same time should be avoided by installing temporary insulation or protective barriers. This may mean putting temporary insulating screens over live parts and/or applying insulation to parts that are at earth potential. Temporary screens etc can also help to prevent the risk of accidental short circuit from tools, components, conductors etc.

When work is to be carried out ‘near’ rather than ‘on’ live equipment (eg near an overhead line), the essential precautions will often be directed towards ensuring that appropriate and adequate safety clearances are established and maintained.

The people doing the work must be adequately trained and experienced in the type of live work being undertaken (regulation 16).

Live working procedures

- Identify the circuit or equipment to be worked on or near and the work to be done
- Ensure suitable precautions are taken and that suitable protective equipment is used
- Ensure adequate working space, access and lighting. Restrict access to area of live work
- Ensure accompaniment is provided if necessary. Accompaniment to be trained to give assistance

Identification of circuits to be isolated

In many cases actual physical identification will be necessary and this may be aided by the use of appropriate drawings, diagrams and other written information. You should never assume that the labelling or drawings are correct without having proved that the circuit is dead.

Suitable points of isolation

For work on LV electrical equipment or circuits, it is important to ensure that the correct point of isolation is identified, an appropriate means of isolation is used and the supply cannot inadvertently be reinstated while the work is in progress. Caution notices should also be applied at the point(s) of isolation, and the conductors must be proved to be dead at the point of work before they are touched.

The means of isolation can be an adjacent local isolation device such as a plug and socket, switch-disconnector, circuit breaker, fuse etc, as appropriate, which is under the direct control of the competent person carrying out the work. These devices can be used without further precautions provided there is no foreseeable risk that the supply could be reinstated by others.

When there is no such local means of isolation or there is a risk of reinstatement of the supply as above, the circuit or equipment to be worked on should be securely isolated by one of the following methods.

Isolation using a main switch or distribution board (DB) switch-disconnector

Isolation of equipment or circuits using the main switch or DB switch-disconnector is the preferred method. The point of isolation should be locked off using a unique key or combination retained by the person carrying out the work. In the case of multiple isolations on a DB, a multi-lock hasp can be used to prevent access to a main isolator until such time that all persons working on a system have completed their work and removed their padlocks from the hasp.

If locking-off facilities are not provided on the relevant switch then a locked DB door or locked switch-room door is acceptable provided the key or combination is unique, and is retained by the person doing the work. Again, multi-lock hasps can be used to control multiple isolations, although a key box or similar system may be needed to retain and control access to the main door key.

Safe Isolation Practice

Where it is intended that more than one person will be working on circuits supplied from a DB, (i.e. multiple isolations) and a multi-lock hasp cannot be used to secure the main point of isolation, individual isolation of each circuit is recommended, to prevent inadvertent reinstatement of the supply. The principle is that each person carrying out such work should have control of their own point(s) of isolation and not rely on others to prevent inadvertent switching on.

Neutral conductors

All live conductors must be isolated before work can carried out including the neutral conductor as this is a live conductor. The practice of 'borrowing' neutrals is not permitted by the BS 7671 but it is not uncommon.

Lighting and control circuits are the most common example, the neutral conductor can become live if an energised load on another circuit is added to it.

Isolation of individual circuits

Where it is not practical to isolate a distribution board, individual circuits supplied from it can be isolated by one of the methods described below, depending on the type of protective device used.

It should be remembered that work carried out inside a live DB is regarded as live working when there is access to exposed live conductors. In this case the appropriate precautions should be taken.

Isolation of individual circuits protected by circuit breakers

Where circuit breakers are used the relevant device should be locked-off using an appropriate locking-off clip with a padlock which can only be opened by a unique key or combination. The key or combination should be retained by the person carrying out the work.

Isolation of individual circuits protected by fuses

Where fuses are used, the simple removal of the fuse is an acceptable means of disconnection. Where removal of the fuse exposes live terminals that can be touched, the incoming supply to the fuse will need to be isolated. To prevent the fuse being replaced by others, the fuse should be retained by the person carrying out the work, and a lockable fuse insert with a padlock should be fitted as above. A caution notice should also be used to deter inadvertent replacement of a spare fuse.

Safe isolation

For the testing of a potentially live source, two pieces of test equipment are required. These are:

Approved voltage tester

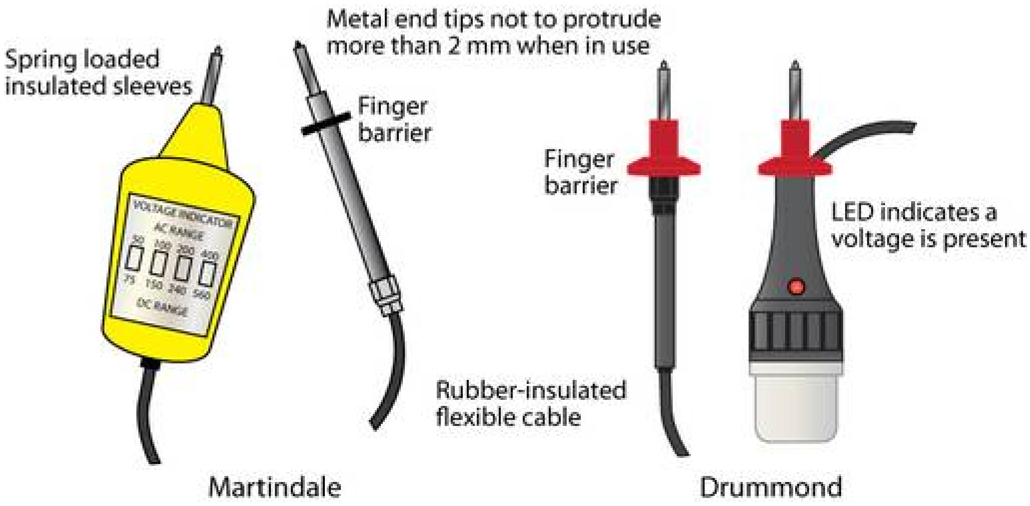
Voltage proving unit.

Guidance is provided by the HSE in the form of Guidance Note GS 38 'Electrical test equipment for use by electricians'.

GS 38 reminds electricians of current legislation and their responsibilities relating to the equipment used the requirements for live working and the nature of the work practices. GS 38 also provides a set of values that should be followed for test leads. In this instance, it is reasonable to assume that an approved voltage tester falls into this criterion. Many of the following will apply to an approved voltage tester, although not necessarily all. Remember that GS 38 applies to all test leads.

- Adequate insulation. This may depend on the environmental conditions present.
- Have coloured leads to distinguish one lead from another.
- Have finger barriers to stop accidental slipping of hand.
- Be insulated so that the tip of the probe shows no more than 4 mm of bare metal; it is strongly recommended that this is kept to less than 2 mm.
- Be flexible and robust enough for their use.
- Be sheathed to prevent mechanical damage.
- Be long enough for their purpose.
- No part accessible to fingers, even if a lead becomes loose.
- Have fused leads.

There are many varieties of voltage tester and as long as they meet the requirements of GS 38 then you will be fine.

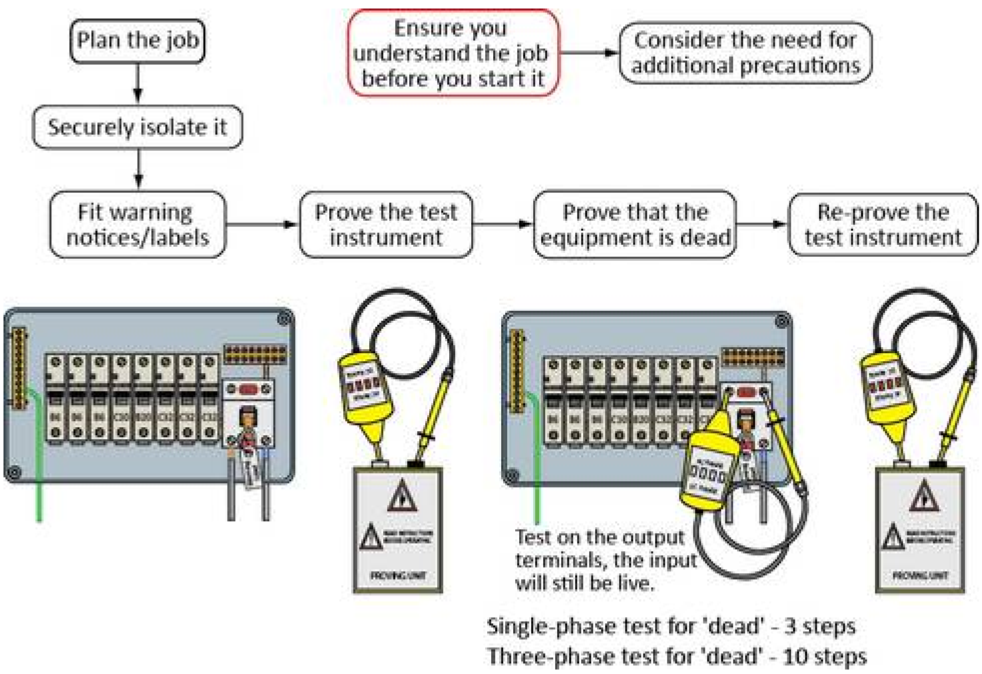


A tester is no use if we cannot guarantee its effectiveness. This is where the proving unit comes into its own. All equipment should be regularly checked to make sure it is good safe working order.

A proving unit is a d.c. voltage source that checks its own status and is then a known reference voltage against which the voltage tester can test itself. Without this, we cannot guarantee the voltage tester, at which point it is useless.

The process of safe isolation

The process for safe isolation of a complete isolation is to find the point to be isolated, decide on the means of isolation, then check that it is safe to isolate, if necessary get permission to isolate.



The process for safe isolation on individual circuits is similar, but you may need permission to remove any loads.

The diagram here shows the procedure you should use for the safe isolation of a piece of equipment or plant.

Warning notices and locking devices for secure isolation

Re-energising equipment or a circuit

Before re-energising equipment or a circuit you should Inspect and test the work that has been carried out and then inform others.

Exercise 2

1. Briefly describe of the process of carrying out safe isolation.
2. Name two items used to make sure an isolated circuit cannot be accidently switched back on.
3. What item of equipment would be used to make sure your voltmeter or similar device is operating correctly before carry out a test?
4. GS 38 gives guidance on the safety features of test leads. Name at least three features that apply.
5. What are the three conditions that Regulation 14 states must be met for live working to be permitted where danger may arise?
6. What two conditions where ‘live working’, with due care, is permitted?
7. What actions would you take if a circuit you thought was ‘dead’ was in fact live?

3: Sourcing information for the safe termination and connection of conductors, cables and flexible cords

In this session the student will:

- Specify organisational procedures for reporting variations to the installation specification.
- Identify and interpret appropriate sources of information for the termination and connections of conductors, cables and flexible cords.

Before we look at the connection and termination of cables we will quickly look at variation orders.

What is a 'Variation Order'?

We are all aware that for everyone's good when working on a contract, it is important to stick to the terms and conditions.

If you find you cannot comply with the specification, for any reason, this should be reported to your supervisor who can request a **variation order**.

Any change must be agreed with the client and written permission must be obtained before any work which is not on the original contract/specification is carried out.

Most companies have their 'variation orders', if you don't know what your companies look like ask to see one and practice filling one out.

Sourcing information

Electricians have to be able to find information about a wide range of items. The type of cabling to install, any special requirement in the installation of equipment, the size of fuse, the position of the switch on a wall, the list is endless. There is no way that you can have all this information in your head.

The risks from terminating or connecting cables and conductors incorrectly could result in fatal electric shock, burns or the fabric of the building being damaged by fire.

To safely terminate and connection of conductors, cables and flexible cords means that they have to be done to recognised standards. The information can be sourced in documents such as those listed below;

- Statutory documents
- Codes of Practice
- British Standards
- IEE Wiring Regulations
- Manufacturer's instructions
- Installation specifications
- site drawings
- wiring diagrams
- Guidance Note 1: Selection and Erection of Equipment

Statutory documents would include:

Electricity at Work Regulations1989 which states amongst other things;

'All systems shall at all times be of such construction as to prevent, so far as is reasonably practicable, danger'

Regulation 10 states that;

'Every joint and connection shall be mechanically and electrically suitable for use. In this respect the joint or connection should be of proper construction as regards conductivity, insulation, mechanical strength and protection'

The main source of information for electrotechnical information is the current edition of the BS: 7671 Wiring Requirements which will tell you most things that you need to know to comply with the law and electrical safety. Along with that you need the current edition of the on-site guidance notes which will help you work out what the regulations mean in practice.

Requirement 134.1.4 generalises the rules for connecting and terminating cables by stating;

'Every electrical joint and connection shall be properly constructed as regard to conductance, insulation, mechanical strength and protection'.

Section 526 covers electrical connections in more detail.

526.1 states, ‘every connection between conductors or between a conductor and other equipment shall provide durable electrical and adequate mechanical strength and protection’.

The selection of the means of connection shall take into account, (as appropriate)

- The material of the conductor
- The number and shape of the wires forming the conductor
- The cross sectional area of the conductor
- The number of conductors to be connected together
- The temperature attained at the terminals in normal service, making sure that the insulation connecting them is not impaired
- The provision of adequate locking arrangements in situation where there is vibration or thermal cycling.

526.2 requires every connection where possible, to be accessible for inspection, testing and maintenance.
526.6 states there shall be no appreciable strain on connections of conductors.

The ‘means of connection’ could include the termination of a socket, junction box, distribution board or compression lugs.
The ‘termination’ is the entry of the cable into the accessory.

Good electrical connections are essential in avoiding fire or other harmful effects due to excessive temperature developed at high resistance joints, or from arcing. When current is flowing in a conductor, a certain amount of heat is made; this heat can lead to expansion and contraction. This in turn can lead to the cables disconnecting under the stress

Poor electrical connections may also lead to electric shock where a high resistance joint causes the protective device to operate too slowly to remove the shock risk when a fault exists.

Every connection must be electrically and mechanically sound (Regulation 526.1 refers). How this is achieved will depend on a number of factors, including, type of connector, nature of equipment etc.

Common Connectors

Crimped connectors

Crimped connectors are fastened onto the conductor, usually by a crimping tool.


Lug

Here we have a lug termination.

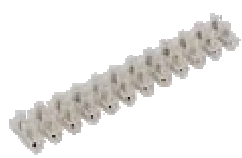
The most common method of connecting lugs is via the use of a crimping tool. The pinhole is there to make sure that you know that the cable has been pushed right up to the end of the lug.

Grub-screw or pillar screw

This is the most common type of termination method. You will find grub screws in strip connectors, ceiling roses, switches, socket outlets; the list is almost endless.

Strip connectors

The connectors come in blocks sometimes referred to as ‘chocolate blocks’.



Porcelain connectors

These are used where high heat is expected in appliances such as water heaters, and some luminaries.

Junction boxes

Junction boxes are chosen according to the current rating and the number of terminals. They are used for lighting or socket outlet circuits. They are some council's who do not like their use at all.

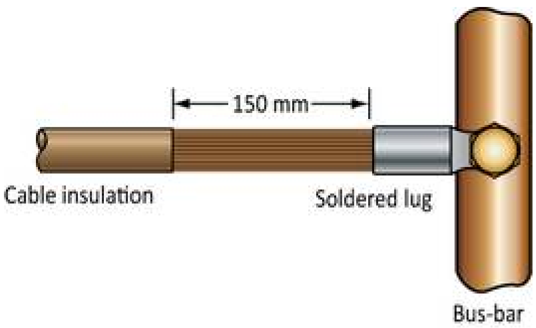
			
3-Terminal 30 A Used on socket-outlet circuits	4-Terminal 20 A Used mainly on lighting cuits	6-Terminal 20 A Used mainly on lighting cuits	Terminal number depends upon the size of the box. Used where needed

Conductor and insulation material

The safe and effective termination of conductors, cables and flexible cords depends on many external factors. The nature of a conductor's material will influence the selection of the means of connection, as will the type of insulation surrounding the conductor.

For example, an aluminium conductor must not be placed in direct contact with a terminal having a high copper content, such as brass or copper, unless the terminal is suitably coated with a substance such as zinc or cadmium, or protected via some other means.

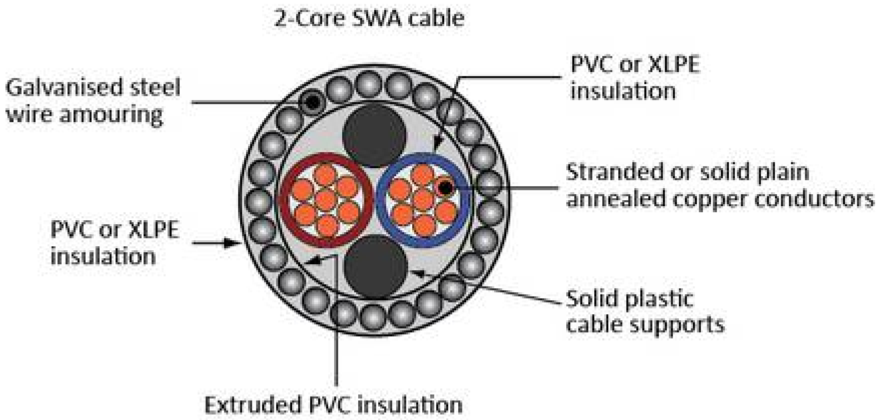
When making connections it is also important that the temperature rating is considered, particularly where the insulating material is considered. For example, general purpose PVC can operate safely at a temperature of 70 °C. Temperatures above this value significantly reduce the ability of the PVC to adequately function as an insulator.



Where busbars are rated at a higher temperature than a conductor surrounded by a lower temperature rated insulator, the conductor should be stripped back for a distance of at least 150 mm from the point of connection and replaced with an appropriate heat-resisting insulator.

Number and shape of wires

Conductors come in a variety of shapes and sizes. Some are solid, others stranded; some are circular, whilst others are shaped, often in a triangular formation.



Circular conductors may be either solid or stranded, but generally, copper conductors are stranded when their size reaches a cross-sectional area of 4.0 mm^2.

Aluminium conductors are rarely stranded and are usually used for larger cable types and are commonly triangular in shape. This has the benefit of reducing the overall diameter of the cable.

Other types of conductors can be circular rods, or even rectangular bus bars.

Conductor cross-sectional area

Any connection must be adequate for the size of the conductor. It is not acceptable to cut strands out of a stranded conductor to enable it to fit into a connection. Any connection must provide good electrical continuity and adequate mechanical strength.

Technical specification

Electrical

Voltage rating:
230V/400V a.c.

Operating frequency:
50Hz

Rated short circuit capacity Icn:
6000A

Service short circuit capacity Ics:
6000A

When backed up by a BS 1361, 100A fuse, then the breaking capacity of the MCB is increased to 16,000A.

Energy limiting class: 3

Physical

Ambient operating temperature:
−5°C to +40°C

Calibration temperature:
+30°C

IP rating:
Front face IP4X, screw IP2X

Terminal capacity:
35mm²

Tightening torque:
3Nm Max.

Max. installation altitude:
2000 metres

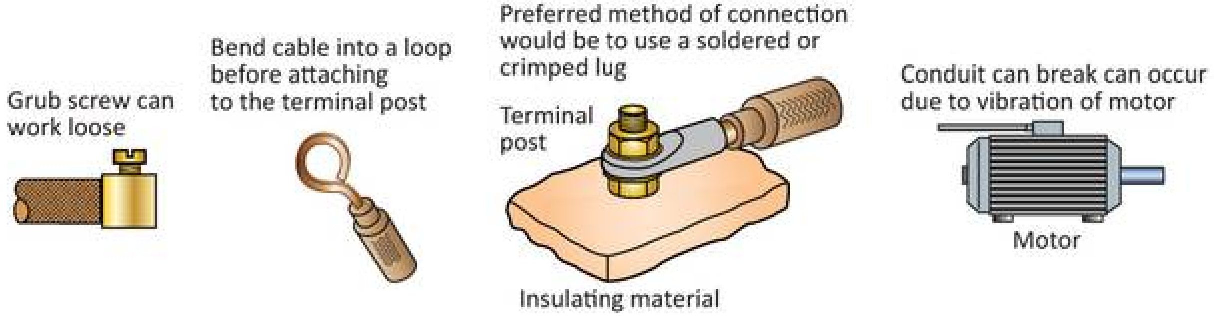
Manufacturers will often detail a specific torque for the final connections to equipment such as main switches or consumer units. To the left is an example of the data provided by MK for one of their product ranges. Notice that the torque requirements are 3 Nm. Over time connections may work loose and manufacturer's guidance should be complied with (Regulation 510.3 refers).

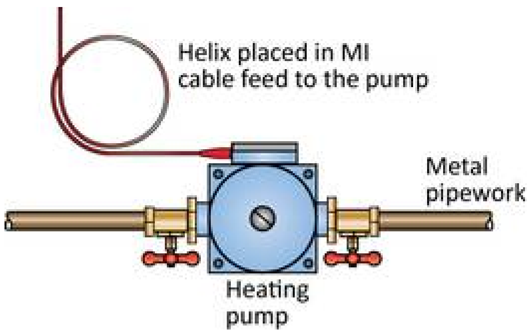
Number of conductors

There is no specific limit on the number of conductors entering an individual terminal. However connections should be electrically and mechanically sound and conductors accessible for inspection, testing and maintenance and properly identified where appropriate (refer Regulations 514.1.2 and 513.1).

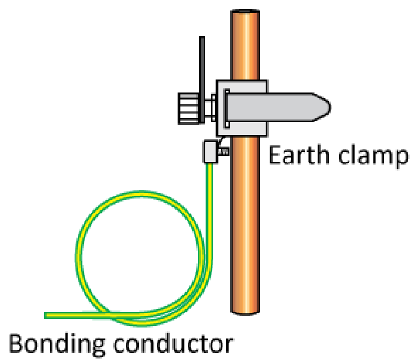
Locking arrangements

Where a connection is liable to vibration or thermal cycling, suitable precautions should be taken to stop such a connection working loose. Such an arrangement may take the form of a locking ring, putting a helix into a cable using flexible conduit or other such arrangement as is appropriate.





Helix placed in MI to protect cable in case of vibration.



Helix placed in a bonding conductor, not because of vibration, but to create some spare in case cable needs to be re-terminated.

Soldered connections

Soldered connections are relatively rare today, but generally, where no other information is available, such joints are limited to a maximum temperature of 160 °C under fault conditions.

Where joints are incorrectly made off they may create a high resistance joint leading to an increase in temperature and a potential failure of fault protection arrangements.

These could be found with the aid of a thermal imaging camera.

External influences

All electrical connections should be suitable for the environmental conditions in which they are required to operate. Section 522 of BS 7671 details the specific environmental conditions that should be managed, and include:

- Ambient temperature.
- External heat sources.
- Presence of water, high humidity and/or solid foreign bodies.
- Presence of corrosive or polluting substances.
- Impact.
- Other mechanical stresses including pulling, vibration and the like.
- Presence of flora (plants/mould/fungus) and fauna (animals).
- Radiation.
- Building design, which includes structural movement.

Protection against electric shock

A connection in a live conductor must be provided with both basic protection (insulations etc.) and fault protection in accordance with Chapter 41 of BS 7671.

Basic protection may be provided by an enclosure, such as a consumer unit, a joint box or similar. Where the enclosure does not provide basic protection, the live parts should be either insulated or placed behind a barrier. Insulating tape does not meet the requirements of basic protection.

Fault protection measures must be maintained. This requires the reliable continuity of protective conductors, such as circuit protective conductors and protective bonding conductors.

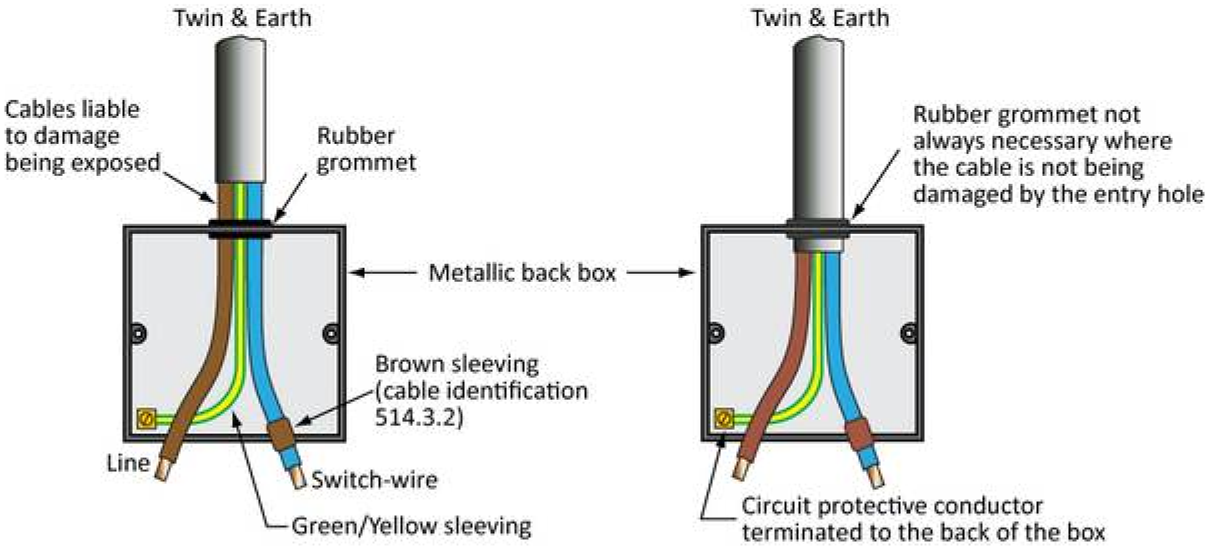
Protection against contact with live parts

All connection should by installed to take into account there environmental surroundings.

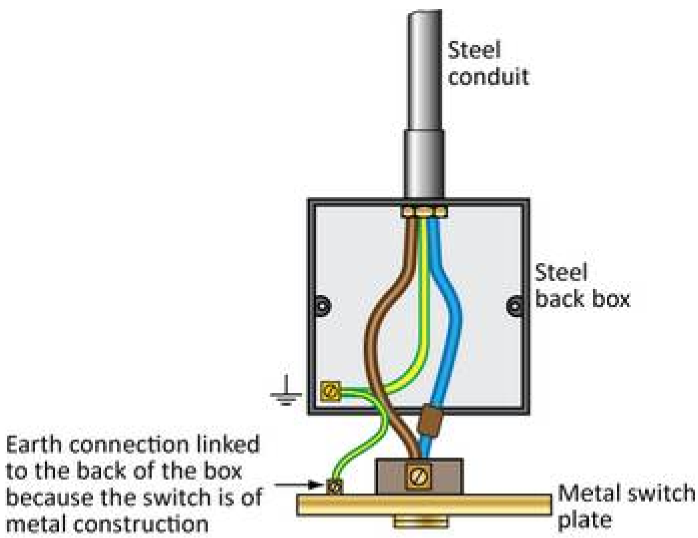
Requirement 416.2.1 states all live parts shall be completely covered with insulation which can only be removed by destruction. Live parts inside enclosures should be to at least IPXXB or IP2X

Enclosure of connections

All terminations and joints in a live or PEN conductor must be contained within an enclosure. According to Requirement 526.5, such an enclosure is permitted to be one of/or a combination of the list. The installer can use either an appropriate accessory, equipment enclosure or an enclosure formed by the fabric of the building complying with the non-combustibility tests of BS 476-4. This will include brick and block work and the like.



Practically, this will require cable sheaths to enter accessory boxes without showing insulation outside of the accessory. Where, for example, PVC insulated and sheathed cable is used, a good habit would for at least 10 mm of sheath to show inside the accessory box before the sheath is stripped from the cable.



Where conduit, trunking or ducting provides the protective conductor for a circuit, Regulation 543.2.7 requires that a link is made between the earthing terminal of the accessory box and the accessory's earth terminal.

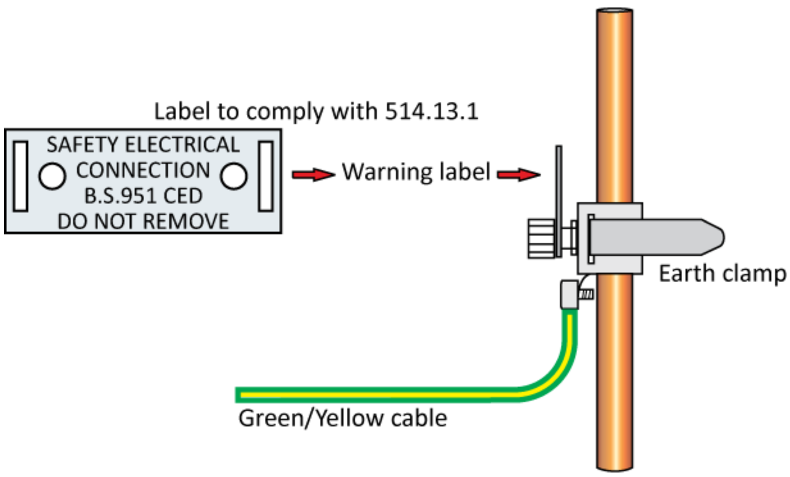
Accessibility of connections

Regulation 526.3 requires that all connections are accessible for inspection, testing and maintenance. This limits the use of certain means of connection. For example, a joint box positioned under a floor may only be accessible when carpets are lifted and floorboards are taken up. This is not accessible as recognised within BS 7671.

There are some exceptions listed in Regulation 526.3 and, for example, where a joint is designed to be buried in the ground, or where the joint is encased in a compound, it is not necessary for it to be readily accessible.

Protective conductors

A protective conductor does not have to be a recognised cable. Regulation 543.2.1 recognises seven ways in which a protective conductor might be provided. These include conductors and armouring, but also metal conduit and trunking and even extraneous-conductive-parts where the requirements of Regulation 526.2.6 are complied with.



It should also be noted that protective bonding conductor connections to extraneous-conductive-parts, such as gas a water pipes, should also be accessible.

Siting such connections under floors and in difficult to locate positions is a failure to comply with Regulation 526.3.

Typical earth clamp

Exercise 3

1. What is the purpose of a 'variation order'?
2. Name two possible consequences of not having a variation order
3. Name 6 different sources that you might need to look up information on safe termination and connection of cables and equipment.
4. What does The Electricity at Work Regulations 1989- Regulation 10 state?
5. What section of the current BS 7671 deals with electrical connections?

6 Name some external factors that influence the type of connector you used.

7. Why should enclosures be installed to the correct IP index.

4: Connection methods

In this session the student will:

- Understand the advantages, limitations and application of common connection methods.
- Describe the procedures for proving that termination and connections are electrically and mechanically sound.
- Understand Health and safety requirements appropriate to terminating and connecting cables
- Know how to terminate different types of connectors

In the previous session we looked how to safely terminate conductors; we now look at the advantages and limitations of some of the more common types.

Screw connections




Advantage

- Relatively easy to use,
- No special tools needed only the correct size of screwdriver or allen key

Disadvantage

- A risk of under or over tightening them;
- A risk of a high resistance joint,
- A risk of breaking the screw head,
- Cables may be cut through by too much pressure from the terminal screw
- Coming loose over time

Crimped connections

These provide an efficient means of connecting two conductors together or providing a lug connection to the end of a cable.

Advantage

- Relatively easy to connect
- On small cables only a hand held crimping tool is needed

Disadvantage

- Cannot be removed once in place
- If the joint is not tight a high resistance can build up eventually causing a fire risk

Soldered joints

Soldered joints have largely been replaced by crimping cables or by insulation-displacement connector (IDC) systems.

Insulation displacement

Soldered joints are still used on mains cables.

Where joints are to be soldered a soldering iron should be used. Larger joints will need a hotter heat source such as LPG.

To make a clean connection the metal should be cleaned and flux used. The solders is Tinmans solder which has approximately 40% lead and 60% tin

The metal must be clean, and flux used to aid solder flow, and to prevent surface oxidisation.

If the heat damages the insulation the insulation must be replaced. Heat sinks should be used to prevent damage to equipment.

Disadvantages

- Soldered joints require a soldering iron and a heat source for larger joints
- Heat from solder can damage the cable insulation or accessory
- On large cables short circuit currents may damage the joint or even melt it.

Non screw compression

	Insulation displacement type	• No need to strip wires • The cables are placed alongside each other and then the top is positioned over the cables before squeezing with a pair of pliers.
	Push in type	• The conductor needs to be prepared before pushing into screwless connector. • To remove, twist the conductor whilst pulling at the same time.

Proving that terminations and connections are sound both mechanically and electrically.

BS 7671 526.1 tells us: 'Every connection between conductor and between conductor and other equipment shall provide durable electrical continuity and adequate mechanical strength'.

BS 7671 526.2 tells us: the means of connection should take in to account the material of the conductor and its insulation. The number shape and cross sectional area of the conductor, the number of conductors to be connected together, the temperature and the locking arrangements.

BS 7671 526.6 tells us:

'There shall be no appreciable strain on the connection of the conductors'.

BS 7671 526.7 tells us:

'Where a connection is made in an enclosure, the enclosure shall provide adequate mechanical protection and protection against relevant external influences'

BS 7671 526.9.1 tells us:

To avoid the separation or spreading of individual wire of multiwire, fine wire or very fine wire, suitable terminals shall be used or the conductor ends suitably treated.

BS 7671 526.9.2 tells us:

'Soldering of multi-wire, fine wire or very fine wire, is not permitted if screw terminal are used'

BS 7671 526.9.3 tells us:

'Soldering of multiwire, fine wire or very fine wire, is not permitted at connection and junction joints which are in service to a relative movement between soldered and non soldered parts of the conductor'.

Consequences of the connection not being sound

The consequences of the connections or termination not being sound, is that they could lead to a risk of fire or electric shock.

If a current flows through a resistance, heat is developed, in a terminal this heat can cause expansion and contraction and the conductor can come loose. This would become a high resistance joint. High resistance joints will lead to heat, causing insulation failure with the possibility of arcing and fire.

The heating can also cause the cable to oxidise and discolour, which in turn increases the resistance.

Corrosion

Corrosion causes the materials surface to breakdown, joints must be made and kept dry to prevent moisture and oxygen mixing and allowing corrosion to take place. Rust will quickly form on materials which have iron in them such as copper. Corroded terminals may lead to voltage drop and possible high resistance

Erosion

This is caused where water or other fluids wear away or erode the material.

Electrolytic action

Copper based materials should not be terminated with aluminium, as the two material react with each other.

Contacts

The action of the surface rubbing against each other as they open and close can eventually cause wear. The breaking of the contact causes some arcing this will also lead to the surface becoming uneven and pitted. The terminals can be protected by an application of silicon lubricant. The terminals will need replacing eventually.

Proving that terminations and connections are electrically sound

There are several ways of proving that terminations and connections are electrically and mechanically sound.

- checking that sufficient insulation has been removed and the conductor is/are securely gripped
- checking that all strands of a multi wire conductor have been successfully terminated with no loose strands
- The terminal screws are tight
- Any crimped connectors are secure and of the correct size
- Check for any signs of erosion or corrosion
- Check for any sign of moisture or dampness
- Using an insulation resistance tester

High resistance

High resistance is caused when the two metals in the conductor or connector are not tightly connected. If the metals are tight together the current flows freely and there is no problem. If there is a gap the current will struggle to get from one side to the other.

Using a Low-resistance tester you can test whether the joint or terminal is acceptable.

As with any work in an electrotechnical environment, health and safety is important.

- Always use the correct tools for the terminal or connector. A pair of pliers is not a crimper.
- Always use the PPE. Goggles and gloves are needed, particularly when terminating fibre optic cable, because the glass shards can cut skin or blind if they get in your eyes.
- Always carry out a risk assessment before carrying out a task. Is the environment safe? Has the cable been isolated?
- Any unsafe situations must be reported to your supervisor
- At all times your work must be carried out in accordance to any relevant statutory or non statutory regulations.

Exercise 4

1. Name four common types of terminations which are used on power cables
2. Why should aluminium and copper or brass not be connected together?
3. Name a disadvantage of using screw connectors.
4. What are two possible consequences of connections not being sound?
5. How can you check that joints are sound?
6. What health and safety checks should be carried out before terminating or connecting cables?
7 How is high resistance in a joint or termination caused?

5: Techniques and methods for safe and effective termination of cables.

In this session the student will:

- Understand and be able to interpret and apply the techniques and methods for safe and effective termination of a variety of cables.

Cable colours

Since April 2004, throughout the UK and the EU the colours and numbering of cables and conductors have to comply with Table 51 of BS: 7671. Which means all new cable must be installed using the internationally recognized colours Before that UK used other colours, so when joining or terminating conductors you may come across conductors with the old colours; if you are not removing all the old cables, a warning notice should be attached to state that there are two types of cable colouring. Be careful that you don't get confused with the colours!

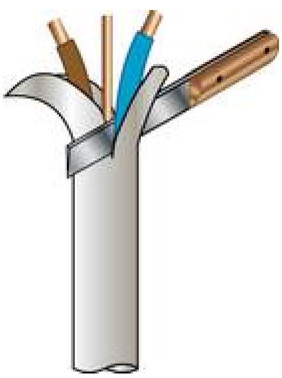
Cables can be identified by the use of coloured sleeves, discs or tape. Letters or numbers may be used.

Methods for the safe termination and connection of cables and flexes.

Thermosetting insulated cables, single and multicore PVC cables including flat profile cable**.**

Preparing the cable

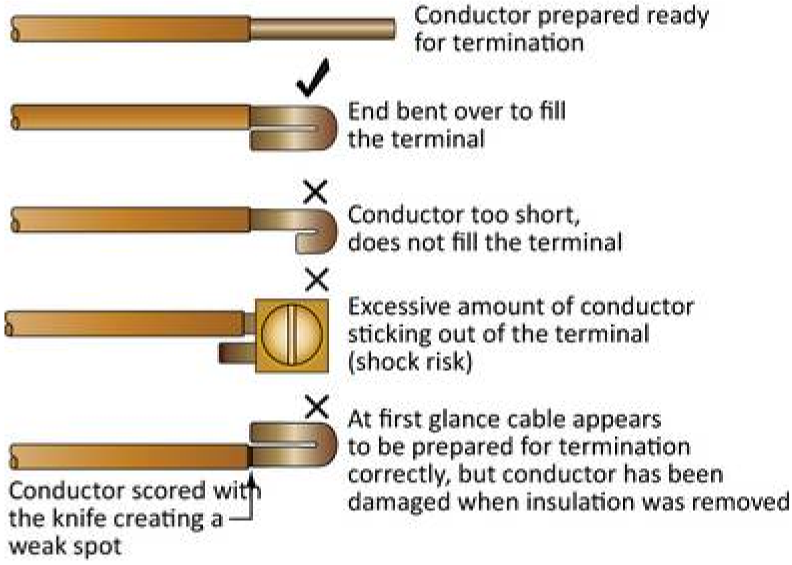
When stripping pvc-insulated and sheathed cables, remember that the cable can be easily damaged, take care and don't hack at it



Notice that the blade is angled in towards the bare cpc (circuit protective conductor). If you are not careful, you will remove insulation. This will lead to the conductor having an area of increased resistance, leading to a heat rise in the cable. To remove insulation using the rip-cord method is frowned upon by the NICEIC.

Take care to tidy up the ends. Use your knife or purpose made strippers to strip back the conductors to a reasonable length and then double the ends of the conductor over. This is to ensure that the grub screw has a large enough area to grip. The general rule is that the conductor should fill the hole/termination. Don't get lazy!

Don't forget to sleeve the CPC with greensleeving.



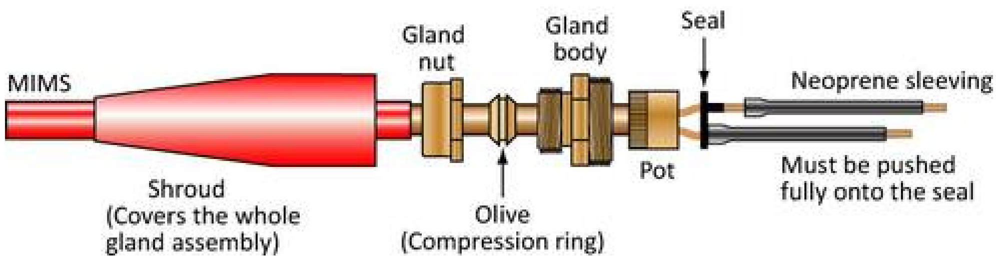
Mineral insulated cable

Terminating

Mineral insulated cable must be sealed at each end, to prevent the magnesium oxide insulation from absorbing moisture; this will give a low insulation resistance reading.

There is a particular way in which MI should be terminated.

The tools that might be needed for this are a Ringing tool, rotary stripping tool and crimping tool.

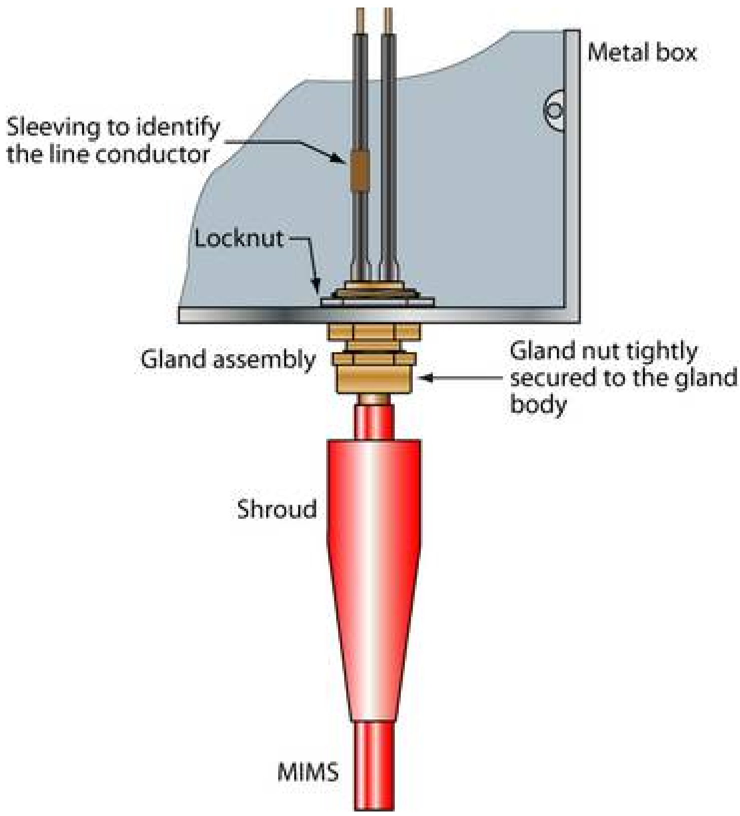


The termination is made up of, the gland body, the gland nut, the shroud and the '***olive***'. The '***olive***' is a brass sleeve that is shaped like an olive.

The gland is to connect the cable to the equipment; the seal is to stop any moisture getting into the cable. The pot is filled with a special powder and is screwed on to the gland body. The seal is slotted over the conductors and compressed onto the pot. Neoprene rubber sleeves are fitted to insulate the conductors.

When the gland nut and the gland body are screwed together, the olive is forced out of shape and onto the sheath of the cable. This forms a good connection, and the outer sheath can be used as the cpc.

Great care must be taken not only when making the connection. You must make sure that everything is tight, especially as you trust the connections to provide you with a good cpc.



Terminating MI.

This process will be shown at work or at college, once you get familiar with it terminating MI will not seem so daunting.

1) Strip off outer sheath to an appropriate length

2) Using either a pair of side-cutters (snips) or the appropriate rotary strippers strip the outer sheath

3) a). If you using the side-cutters, when you get near to where you want to finish, take the ringing tool and mark the armouring-not too deeply though. Using a pair of pliers '*work*' the copper sheath until it snaps off, leaving a nice neat edge

   b). If you are using the stripping tool, when you get near to where you want to finish, hold the cable tightly with the pliers and keep turning the stripper. The straight edge is formed automatically when the strippers come up against the pliers

4) Put the shroud on. If you forget it is very difficult to slice it with a knife long ways and try and glue it back together once it is in place!

5) Put on the gland nut and the olive (compression ring)

6) The pot has an internal thread. Using either your pliers or the pot-wrench, tighten the pot onto the cable armouring, making sure that you don't go too far. The armouring should not be proud of the pot on the inside

7) Wipe the conductors with a dry cloth; this removes any spare magnesium oxide, which could lead to damp getting into the cable. Also, check that no thin sliver of brass has come off the pot and is resting on the conductors. Do not blow into the pot as you may spit into it as the same time.

8) Put the seal onto the conductors and try it in the pot to make sure that it fits. Pull the seal back about 75 mm and start to put in the compound. The compound should be fed in from mainly one side. Make sure that there are no air gaps, and that the compound is slightly proud of the pot. Prior to this put the compound in your pocket to warm it, this helps it become softer and more manageable.

9) Using the butterfly crimp tighten the seal down onto the pot, making sure that the seal is square to the pot, and remove any excess compound

10) Put the insulation onto the conductors then test

11) Pull the shroud back over the completed gland.

Testing

It is very difficult to determine the faulty end if a fault is found when both ends are made off so the testing is usually carried out before the other end of the cable is terminated. Repeat the test at other end, remembering to fit the shroud first if required.

Carry out an insulation resistance test on the completed cable.

Identification

As the conductors in MI cable have no self identification they need to be tested to determine which conductor is which.

Use a low range ohmmeter set to 2Ω range. Connect one conductor to the metal sheath at one end and at the other end test between the sheath and conductors.

The conductor which gives a very low reading is the same conductor as the one connected to the sheath at the other end. Identify each end of the conductors as required. If the cable is multicore, then continue until all cores are identified.

Terminating to metal boards or boxes

Remove the appropriate knock out and paint from around the hole. Pass the gland thread through the hole and tightened the locknut to hold the gland in place. Where space is restricted, first fix a coupler and male bush into the box and then terminate the gland into the coupler. When the cable has been dressed, tighten the back nut compressing the olive onto the sheath ensuring earth continuity. Pull the shroud (if fitted) up over the gland.

Terminating to insulated boxes

The procedure is the same but earth continuity needs to be maintained by using a pot with an earth tag similar to that used with SWA cables.

Faulty terminations

If a cable is found to have a low insulation resistance after termination then this could be caused by damp or moisture. To check this, connect an insulation resistance tester to the cable and apply heat to the cable end/pot. If the insulation resistance drops then the fault is due to dampness. If nothing changes then it is probably due to the conductors touching or other debris in the pot.

If this happens the pot should be removed and dried out at the cable end by progressively applying heat towards the cable end until a satisfactory reading is obtained. The termination will need re-making.

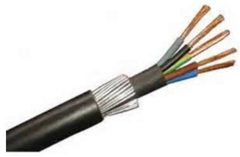
Limiting factors to consider when terminating MI cable

MI cable is capable of withstanding heat up to about 1083°C when the copper will melt. Most terminations will only withstand temperatures up to around 70^0 C if they contain PVC or 105^0 C if the sheath is bare.

Magnesium oxide is hygroscopic, which means that can soak up moisture from the air unless a compound has been added in order to prevent this. If the cable has been left out in bad weather for a long time then stripping back the cable to remove the damaged section containing the solid powder, should mean that the whole reel is not wasted.

An electrolytic action may also be caused by installing bare-sheath MICC cables on new oak. The reaction causes the copper to be eaten away, making a hole in the side of the cable and letting in water, causing a short-circuit between live, neutral and earth

SWA cable



Steel wire armoured cable comes in many forms and are generally terminated in the same way. The only thing to remember is that aluminium conductors must be connected to aluminium glands as brass connectors will react with the aluminium.

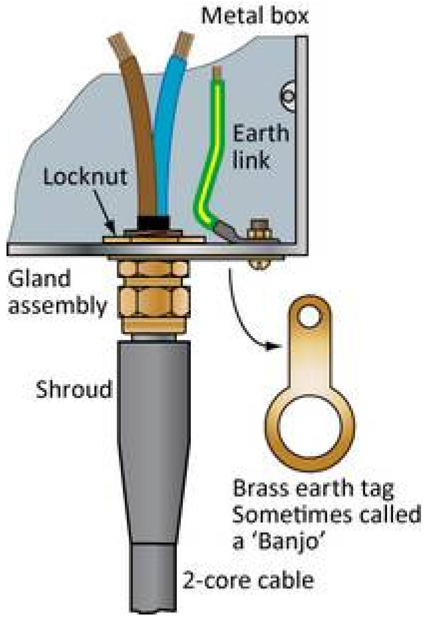
The armouring is used as a circuit protective conductor so special glands are used to make sure the continuity between the conductor and the metal work of the equipment that it is to be connected to.

An earth tag sometimes referred to as a 'banjo' provide the earth continuity between the armour of the cable, and the box or panel.

If the cable is to be connected directly to an electric motor, which is mounted on a slide rail, a loop (helix) should be left to allow for any movement or vibration.

Although glands are all fitted in basically the same way, the glands should be chosen according to their use. Some are flameproof and others for industrial use. The flameproof gland has seals in the inner and outer case of the sheath. This is to prevent a spark from the equipment igniting gas or similar substances.

Terminating SWA cable



1. Strip off outer sheath to an appropriate length-this depends on what you are connecting to.
2. Mark the cable so that there is a straight edge to work to.
3. Score the armouring using a junior hacksaw. Don't go all the way through, about half way is enough.
4. Pull off the steel wire you have just scored around.
5. Put on the shroud.
6. Put on the gland nut.
7. Strip back a little bit more of the outer XLPE sheath-not too much.
8. Work the conductors around in a circular motion. This opens up the steel armouring.
9. Put on the main part of the gland, keeping the steel armouring on the outside of the nut.
10. Tighten the gland nut onto the main part of the gland, making sure that the main part of the gland doesn't move.
11. Pull the shroud over the whole of the completed gland.
12. If required slide the earth tag of the threaded part of the gland and clean any paint work from the area of contact before tightening up the lock nut.
13. Fit the CPC between the bolt securing the earth tag and the earth terminal of the equipment

Data networking

There are five main types of cable available for data networking:

- unshielded twisted pair – UTP
- shielded twisted pair – STP
- screened twisted pair – ScTP
- coaxial
- fibre optic.

Twisted wiring is cheap to buy and install. The tools necessary for terminating the cables are also less costly than that used for fibre-optic cables.

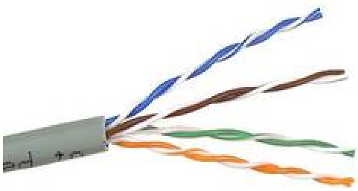
There are a number of types of UTP. These are split into categories and are defined by the amount of data they can handle.

- **Category 1** – usually supplies frequencies less than 1 MHz and are used for phone lines
- **Category 5** – supports frequencies up to 100 MHz and is the common type of cable in use today.

Data Cables

Unshielded twisted pair cables obtain interference protection from the twisting of the paired conductors. 4 is the normal number of pairs.

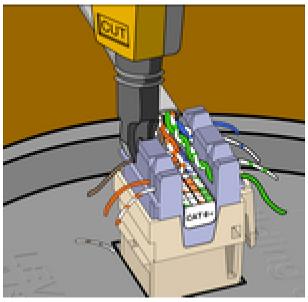
The cable is terminated by patch connectors. The wires are placed in position and a special tool pushes the conductors down onto the contacts where pressure holds them in place.



Prepare the cable

Identify the correct pins

Locate the punch down tool



Using the tool press the cable onto the connections and trim

Practice this in the college workshop or at work under supervision.

Fibre optic cables

Fibre optic cables are mainly used for high speed data transmission. They are also used for decorative lighting; transmitting light from a master lamp to slave lamp outlets.

The main difference between fibre optic cables and other cables is that they use glass to transmit data in the form of rapid flashes of light and do not carry any current. As there is no metal in them they are not affected by electromagnetic interference (EMI).

There are several different ways of terminating Fibre Optic cables and each process is quite complicated.

They can be done using Fusion splice kits or Epoxy splice kits.

Risks

Candidate should never look down the end of a fibre optic cable as the light emitted from the end of the cable can damage the eyes.

When cutting the glass fibre, the glass can shatter into sharp glass shards which can penetrate the skin. Extreme care should be taken.

Fire resistant cables

FP cables

This type of cable is simple to strip. However, what you cannot do is simply tear at it with a pair of side cutters (snips). The inner insulation is very easy to damage; it only takes a thumbnail to tear the inner insulation off.

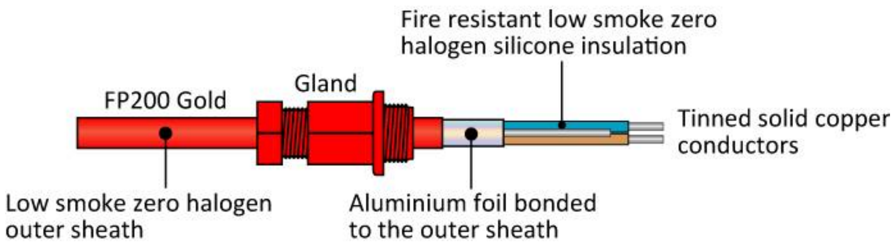
FP 200

FP 600

Glands for FP 600

Terminating FP 200 cable

1. Using a knife ring the outer sheath down to the inner metal sheath.
2. Bend the cable at the cut until it breaks open.
3. Gently pull the outer sheath off leaving the inner insulation intact.
4. Put the shroud (where used) and gland on the cable.
5. There is no need to over tighten the rear nut.



This type of cable must be bent slowly i.e. have a large radius; too tight a bend and the inner conductors can be damaged.

Exercise 5

1. Name two risks associated with using very sharp knives when terminating cables.
2. List three methods of identifying cables
3. Why is it important that the conductor completely fills the termination?
4. Why should mineral insulated cable be sealed at each end?
5. How would you identify conductors in MI cable?
6. What particular risks are there when working with fibre optic cables?
7. Why should you place a label on installations which use both new and old coloured cables?

End of unit questions

1. Why do we need to isolate cables and equipment?

2. Briefly describe the safe isolation process for safely isolating a three-phase circuit.

3. What two pieces of equipment do you need to safely isolate?

4. Once you have isolated the equipment and securely locked it, what should you do with the key?

5. Name three requirement that leads should have according to GS38

6. What is a variation order and why is it needed?

7. If you found that you could not install any equipment or cables according to the specification sheet, what should you do?

8. What is the most important source of information for finding out how to safely terminate or join conductors?

9. Name two advantages and three disadvantages of using screw connectors.

10. Why should you carry out a risk assessment before terminating or joining cables?

11. What PPE would you use when terminating or joining cables?

12. Name three methods of identifying cables.

13. Name two causes of a high resistance joint

14. What is the advantage of using ratchet crimps over hand crimps?

15. Give two reasons why a helix might be placed in a cable.

16. You have been asked to find out why a motor has stopped working. When you go to the motor it has been switched off. What should you do next?