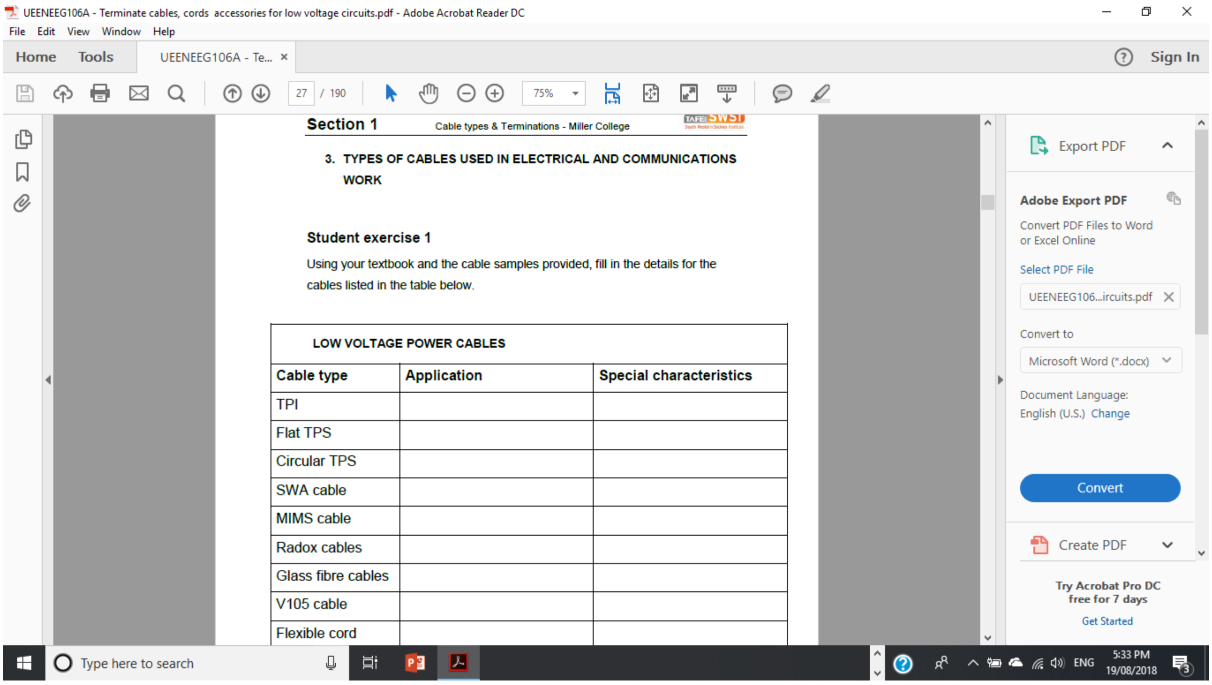
Page 26

1. CONDUCTORS

Conductors are defined as materials that easily allow the flow of _________. Metals are _______ conductors while insulators are ______ .
The 2 common metals used for conductors in the electrical trade are:
___________ and ______________.
Aluminium has become more prevalent for larger C.S.A. conductors as it is cheaper and lighter but more brittle than copper.

Current/ Copper/ Aluminium



Section 1 Cable types & Terminations - Miller College

3. TYPES OF CABLES USED IN ELECTRICAL AND COMMUNICATIONS WORK

Student exercise 1

Using your textbook and the cable samples provided, fill in the details for the cables listed in the table below.

LOW VOLTAGE POWER CABLES		
Cable type	**Application**	**Special characteristics**
TPI		
Flat TPS		
Circular TPS		
SWA cable		
MIMS cable		
Radox cables		
Glass fibre cables		
V105 cable		
Flexible cord		

Thermoplastic-sheathed cable (TPS) consists of an outer toughened sheath of polyvinyl chloride (PVC) (the thermoplastic element) covering one or more individual cables which are PVC insulated annealed copper conductors. It is a commonly used type of wiring for residential and light commercial construction in many countries. The flat version of the cable with two insulated conductors and an uninsulated earth conductor all within the outer sheath is referred to as twin and earth. In mainland Europe, a round equivalent is more common.

Flat cables (or festoon cables) are made in PVC and Neoprene and are used as trailing cables for cranes, open filed conveyors and shelve service devices.

Flat cables offer the advantages of extremely small bending radius’s, high flexibility and minimum wastage of space.

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The **SWA Cable** is designed to have mechanical protection, which is why the **cable**is often **used** for external **use**. The armour is **used** to reduce any risk of the **cable**getting pinched or damaged; the steel is **used** to protect the **armoured cable**.

Steel wire armoured cable, commonly abbreviated as SWA, is a hard-wearing power cable designed for the supply of mains electricity. It is one of a number of armoured electrical cables – which include 11 kV Cable and 33 kV Cable – and is found in underground systems, power networks and cable ducting.[1]

Contents

Construction[edit]

Example of steel wire armoured cables in a UK installation. Blue sheathed cable is normally instrumentation signal, black is power

The typical construction of an SWA cable can be broken down as follows:

- Conductor: consists of plain stranded copper (cables are classified to indicate the degree of flexibility. Class 2 refers to rigid stranded copper conductors as stipulated by British Standard BS EN 60228:2005[2])
- Insulation: Cross-linked polyethylene (XLPE) is used in a number of power cables because it has good water resistance and excellent electrical properties. Insulation in cables ensures that conductors and other metal substances do not come into contact with each other.[3]
- Bedding: Polyvinyl chloride (PVC) bedding is used to provide a protective boundary between inner and outer layers of the cable.

- Armour: Steel wire armour provides mechanical protection, which means the cable can withstand higher stresses, be buried directly and used in external or underground projects.[4] The armouring is normally connected to earth and can sometimes be used as the circuit protective conductor ("earth wire") for the equipment supplied by cable.
- Sheath: a black PVC sheath holds all components of the cable together and provides additional protection from external stresses.

The PVC version of SWA cable,[5] described above, meets the requirements of both British Standard BS 5467 and International Electrotechnical Commission standard IEC 60502.[6] It is known as SWA BS 5467 Cable and it has a voltage rating of 600/1000 V.[7]

SWA cable can be referred to more generally as mains cable, armoured cable, power cable and booklet armoured cable. The name power cable, however, applies to a wide range of cables including 6381Y, NYCY, NYY-J and 6491X Cable.

Aluminium wire armoured cable[edit]

Steel wire armour is only used on multicore versions of the cable. A multicore cable, as the name suggests, is one where there are a number of different cores. When cable has only one core, aluminium wire armour (AWA) is used instead of steel wire. This is because the aluminium is non-magnetic. A magnetic field is produced by the current in a single core cable. This would induce an electric current in the steel wire, which could cause overheating.

Use of armour for earthing[edit]

cable with light armouring

The use of the armour as the means of providing earthing to the equipment supplied by the cable (a function technically known as the circuit protective conductor or CPC) is a matter of debate within the electrical installation industry. It is sometimes the case that an additional core within the cable is specified as the CPC (for instance, instead of using a two core cable for line and neutral and the armouring as the CPC, a three core cable is used) or an external earth wire is run alongside the cable to serve as the CPC. Primary concerns are the relative conductivity of the armouring compared to the cores (which reduces as the cable size increases) and reliability issues. Recent articles by authoritative sources have analysed the practice in detail and concluded that, for the majority of situations, the armouring is adequate to serve as the CPC under UK wiring regulations.[8][9]

SWA BS 6724 cable[edit]

The construction of an SWA cable depends on the intended use. When the power cable needs to be installed in a public area, for example, a Low Smoke Zero Halogen (LSZH) equivalent, called SWA BS 6724 Cable must be used. After the King’s Cross fire in London in 1987 it became mandatory to use LSZH sheathing on all London Underground cables – a number of the fatalities were due to toxic gas and smoke inhalation. As a result, LSZH cables are now recommended for use in highly populated enclosed public areas. This is because they emit non-toxic levels of Halogen and low levels of smoke when exposed to fire. SWA Cable BS 6724 – which meets the requirements of British standard BS 6724 – has LSZH bedding and a black LSZH sheath.

- t
- e

PVC-sheathed MICC cable. Conductor cross section area is 1.5 mm^2; overall diameter is 7.2 mm

Mineral insulated cables at a panel board

Mineral-insulated copper-clad cable is a variety of electrical cable made from copper conductors inside a copper sheath, insulated by inorganic magnesium oxide powder. The name is often abbreviated to MICC or MI cable, and colloquially known as **pyro** (because the original manufacturer and vendor for this product in the UK was a company called Pyrotenax). A similar product sheathed with metals other than copper is called *mineral insulated metal sheathed* (MIMS) cable.

Contents

Construction[edit]

MI cable is made by placing copper rods inside a circular copper tube and filling the intervening spaces with dry magnesium oxide powder. The overall assembly is then pressed between rollers to reduce its diameter (and increase its length). Up to seven conductors are often found in an MI cable, with up to 19 available from some manufacturers.

Since MI cables use no organic material as insulation (except at the ends), they are more resistant to fires than plastic-insulated cables. MI cables are used in critical fire protection applications such as alarm circuits, fire pumps, and smoke control systems. In process industries handling flammable fluids MI cable is used where small fires would otherwise cause damage to control or power cables. MI cable is also highly resistant to ionizing radiation and so finds applications in instrumentation for nuclear reactors and nuclear physics apparatus.

MI cables may be covered with a plastic sheath, coloured for identification purposes. The plastic sheath also provides additional corrosion protection for the copper sheath.

The metal tube shields the conductors from electromagnetic interference. The metal sheath also physically protects the conductors, most importantly from accidental contact with other energised conductors.

History[edit]

The first patent for MI cable was issued to the Swiss inventor Arnold Francois Borel in 1896. Initially the insulating mineral was described in the patent application as pulverised glass, silicious stones, or asbestos, in powdered form. Much development ensued by the French company Société Alsacienne de Construction Mécanique.[1] Commercial production began in 1932 and much mineral-insulated cable was used on ships such as the Normandie and oil tankers, and in such critical applications as the Louvre museum. In 1937 a British company *Pyrotenax*, having purchased patent rights to the product from the French company, began production. During the Second World War much of the company's product was used in military equipment.

About 1947 the British Cable Maker's Association investigated the option of manufacturing a mineral-insulated cable that would compete with the Pyrotenax product. The manufacturers of the products "Bicalmin" and "Glomin" eventually merged with the Pyrotenax company.

The Pyrotenax company introduced an aluminum sheathed version of its product in 1964. MI cable is now manufactured in several countries. Pyrotenax is now a brand name under nVent (formerly known as Pentair Thermal Management).

Purpose and use[edit]

MI cables are used for power and control circuits of critical equipment, such as the following examples:

- Nuclear reactors
- Exposure to dangerous gasses
- Air pressurisation systems for stairwells to enable building egress during a fire
- Hospital operating rooms
- Fire alarm systems
- Emergency power systems
- Emergency lighting systems
- Temperature measurement devices; RTDs and Thermocouples.
- Critical process valves in the petrochemical industry
- Public buildings such as theatres, cinemas, hotels
- Transport hubs (railway stations, airports etc.)
- Mains supply cables within residential apartment blocks

- Tunnels and mines
- Electrical equipment in hazardous areas where flammable gases may be present e.g. oil refineries, petrol stations
- Areas where corrosive chemicals may be present e.g. factories
- Building plant rooms
- Hot areas e.g. power stations, foundries, and close to or even inside industrial furnaces, kilns and ovens

MI cable fulfills the passive fire protection called circuit integrity, which is intended to provide operability of critical electrical circuits during a fire. It is subject to strict listing and approval use and compliance

Heating cable[edit]

A similar appearing product is mineral-insulated trace heating cable, in which the conductors are made of a high-resistance alloy. A heating cable is used to protect pipes from freezing, or to maintain temperature of process piping and vessels. An MI resistance heating cable may not be repairable if damaged. Most electric stove and oven heating elements are constructed in a similar manner.

Typical specifications[edit]

maximum voltage	600 or 1000 volts
current rating	18 - 450 amperes
conductor area	1.0 – 240 mm^2
copper sheath area	5 – 70 mm^2 effective
number of cores	1,2,3,4,7,12,19
overall diameter	5 – 26 mm
minimum bend radius	6 x diameter (3 x diameter if bent once only)
weight	100 – 3300 kg/km, 355 - 11708.4 lbs/mi
twists per metre	0, 20 (in many applications NO twist is preferred)
finish	bare copper, standard PVC sheath, low smoke and fume (LSF) polymer sheath, various stainless steels, Inconel, titanium, and some

	super alloys.
colour	natural (bare stainless, bare copper), white, black, red, orange
maximum operating temperature	continuous - exposed to touch 70 °C continuous - not exposed to touch; PVC-sheathed 90 °C continuous - not exposed to touch; not PVC-sheathed 250 °C intermittent >1000 °C (melting point of copper is 1083 °C)

Advantages[edit]

The metal sheath and solid filling of MI cable makes it mechanically robust and resistant to impact; an MI cable may be struck repeatedly with a hammer and still provide adequate insulation resistance for a circuit.[2] Copper sheathing is waterproof and resistant to ultraviolet light and many corrosive elements. MI cable is approved by electrical codes for use in areas with hazardous concentrations of flammable gas in air; an MI cable will not allow propagation of an explosion inside the copper tube, and the cable is unlikely to initiate an explosion even during circuit fault conditions. Metal sheathing will not contribute fuel or hazardous combustion products to a fire, and cannot propagate a fire along a cable tray or within a building. The cable is inherently fire-rated without additional coatings, and will survive designated fire tests representative of actual fire conditions longer than the enclosing structure.

When used within a tenanted area, carrying electricity supplied and billed to the landlord, for example for a communal extract system or antenna booster, it provides a supply cable that cannot easily be 'tapped' into to obtain free energy.

Although made from solid copper elements, the finished cable assembly is still pliable due to the malleability of copper. The cable can be bent to follow shapes of buildings or bent around obstacles, allowing for a neat appearance when exposed.

Since the inorganic insulation does not degrade with (moderate) heating, the finished cable assembly can be allowed to rise to higher temperatures than plastic-insulated cables; the limits to temperature rise may be only due to possible contact of the sheath with people or structures. This may also allow a smaller cross-section cable to be used in particular applications.

Due to oxidation, the copper cladding darkens with age and MICC is therefore often used in historic buildings such as castles where it blends in with stonework. However, where MICC cables with a bare copper sheath are installed in damp locations, particularly where lime mortar has been used, the water and lime combine to create an electrolytic action with the bare copper. Similarly, 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. The appearance of green verdigris on the bare copper sheath may be a sign this has occurred.

Disadvantages[edit]

- *The termination points:* While the length of the MI cable is very tough, at some point, each run of cabling terminates at a splice or within electrical equipment. These terminations are vulnerable to fire, moisture, or mechanical impact.
- *Vibration:* MICC is not suitable for use where it will be subject to vibration or flexing, for example connection to heavy or movable machinery. Vibration will crack the cladding and cores, leading to failure.

- *Labour Cost:* During installation MI cable must not be bent repeatedly as this will cause work hardening and cracks in the cladding and cores. A minimum bend radius must be observed and the cable must be supported at regular intervals. The magnesium oxide insulation is hygroscopic so MICC cable must be protected from moisture until it has been terminated. Termination requires stripping back the copper cladding and attaching a compression gland fitting. Individual conductors are insulated with plastic sleeves. A sealing tape, insulating putty or an epoxy resin is then poured into the compression gland fitting to provide a watertight seal. If a termination is faulty due to workmanship or damage then the magnesium oxide will absorb moisture and lose its insulating properties. Depending on the size and number of conductors, a single termination can take between 1 and 2 hours of labour (an electrician should be able to make a termination in 10 to 15 minutes on up to 4 core smaller sizes). Installation of a three-conductor MI cable (size No. 10 AWG — about 5 square mm) takes about 65% more time than installation of a PVC-sheathed armoured cable of the same conductor size.[3] Installation of MICC is therefore a costly task.
  Certain PTFE, silicone or other polymer-insulated cables have been substituted in applications which require similar properties in terms of flame spread, which use less labour to terminate. MICC is still used in applications which are particularly suited to its combination of properties.
- *Voltage rating:* MI cable is only manufactured with ratings up to 1000 volts.
- *Moisture absorption:* The magnesium oxide insulation has a high affinity for moisture. Moisture introduced into the cable can cause electrical leakage from the internal conductors to the metal sheath. Moisture absorbed at a cut end of the cable may be driven off by heating the cable.
- *Corrosion:* The copper sheath material is resistant to most chemicals but can be severely damaged by ammonia-bearing compounds and urine. A pinhole in the copper sheathing will allow moisture into the insulation, and eventual failure of the circuit. A PVC over jacket or sheaths of other metals may be required where such chemical damage is expected. When MI cable is embedded in concrete as snow melting cable it is subject to physical damage by concrete workers working the concrete into the pour. If the 3-5mil coating is damaged pin holes in the copper jacket develop causing premature failure of the snow melting system.
- *Repair:* If the MI cable jacket has been damaged the magnesium oxide will wick moisture into the cable and it will lose its insulating properties causing shorts to the copper cladding, and thence to earth. It is often necessary to remove 0.5 to 2 metres (1.6 to 6.6 ft) of the MI cable and splice in a new section to accomplish the repair. Depending on the size and number of conductors, a single termination can take between one and two hours of labour.[3]

Alternatives[edit]

Circuit integrity for conventional plastic-insulated cables requires additional measures to obtain a fire-resistance rating or to lower the flammability and smoke contributions to a minimum degree acceptable for certain types of construction. Sprayed-on coatings or flexible wraps cover the plastic insulation to protect it from flame and reduce its flame spreading ability. However, since these coatings reduce the heat dissipation of the cables, often they must be rated for less current after application of fire-resistant coatings. This is called current capacity derating. It can be tested through the use of IEEE 848 Standard Procedure for the Determination of the Ampacity Derating of Fire-Protected Cables.

Supplier news

Radox 125 single core and Radox 125 RW types of Radox Cables

15/05/08 - Radox Cables represents a brand of wiring and cabling products that have been offered by HUBER + SUHNER Australia. These cabling products include Radox 125 and Radox 155 series of cables.

Read more at http://www.ferret.com.au/c/Radox-Cables#OvD5YomFaOV8VjRW.99

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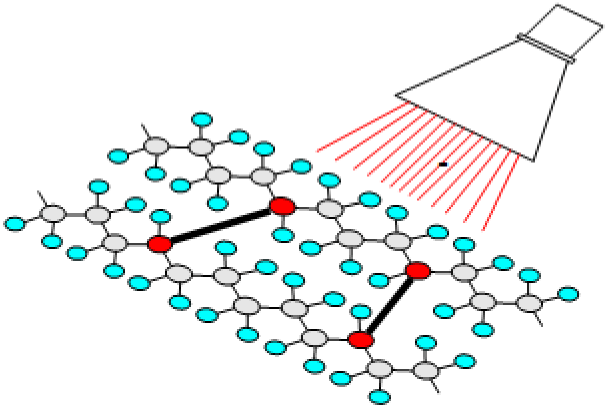

Cross Linking with high energy electrons
changes the chemical structure of the polymers.
A melting material, becomes a non melting material

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RADOX® GKW are compact single core power and signal cables. They are halogen free, flame retardant, low smoke and have a low toxicity index. Demands for temperature, weathering, ozone and oil resistance are fulfilled easily.	**Catalogues on Huber & Su** Inter-vehicle Systems Radox Railway Cables acc. to Railway Cable Systems Railway Products Railway Cable Systems Refe Train-Ground Communicatio Databus Cables

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High performance wires according to MIL-W-22759/32 and MIL-W-81044/12 meet the most demanding requirements for airframe wiring, defence and other applications, where low weight and compact design are required.	**RADOX® 2275** **RADOX® 8104**

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See our separate webpage	**Sola**

Wind Power Solutions

Wind Power System Solutions	**Solutions fo**

The most expensive, and the most efficient cable type, Glass Fibre cable suffers very little distance-related energy loss. It tolerates currents up to **Insane Voltage** (8192 EU/t).

Due to latest quality standards of Glass Fibre Cable, only the highest quality materials can be utilized, resulting in reduced cable lengths from the same materials.

Cable Efficiency

Cable type	Max packet	Energy loss/block	Energy loss
Glass Fibre Cable	8192 EU/t	0.025	1 EU/40 blocks

Insulation

There is no need to insulate glass fiber cable as it will not shock you. It also has the same energy loss as tin cable so it's best to use it whenever you can afford to, even on lower voltages.

Optical fiber

From Wikipedia, the free encyclopedia

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A bundle of optical fibers

Fiber crew installing a 432-count fiber cable underneath the streets of Midtown Manhattan, New York City

A TOSLINK fiber optic audio cable with red light being shone in one end transmits the light to the other end

A wall-mount cabinet containing optical fiber interconnects. The yellow cables are single mode fibers; the orange and aqua cables are multi-mode fibers: 50/125 µm OM2 and 50/125 µm OM3 fibers respectively.

An **optical fiber** or **optical fibre** is a flexible, transparent fiber made by drawing glass (silica) or plastic to a diameter slightly thicker than that of a human hair.[1] Optical fibers are used most often as a means to transmit light between the two ends of the fiber and find wide usage in fiber-optic communications, where they permit transmission over longer distances and at higher bandwidths (data rates) than electrical cables. Fibers are used instead of metal wires because signals travel along them with less loss; in addition, fibers are immune to electromagnetic interference, a problem from which metal wires suffer excessively.[2] Fibers are also used for illumination and imaging, and are often wrapped in bundles so they may be used to carry light into, or images out of confined spaces, as in the case of a fiberscope.[3]Specially designed fibers are also used for a variety of other applications, some of them being fiber optic sensors and fiber lasers.[4]

Optical fibers typically include a core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by the phenomenon of total internal reflection which causes the fiber to act as a waveguide.[5] Fibers that support many propagation paths or transverse modes are called multi-mode fibers, while those that support a single mode are called single-mode fibers (SMF). Multi-mode fibers generally have a wider core diameter[6] and are used for short-distance communication links and for applications where high power must be transmitted.[citation needed] Single-mode fibers are used for most communication links longer than 1,000 meters (3,300 ft).[citation needed]

Being able to join optical fibers with low loss is important in fiber optic communication.[7] This is more complex than joining electrical wire or cable and involves careful cleaving of the fibers, precise alignment of the fiber cores, and the coupling of these aligned cores. For applications that demand a permanent connection a fusion splice is common. In this technique, an electric arc is used to melt the ends of the fibers together. Another common technique is a mechanical splice, where the ends of the fibers are held in contact by mechanical force. Temporary or semi-permanent connections are made by means of specialized optical fiber connectors.[8]

The field of applied science and engineering concerned with the design and application of optical fibers is known as **fiber optics**. The term was coined by Indian physicist Narinder Singh Kapany, who is widely acknowledged as the father of fiber optics.

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Specification Sheet

Lake Cable Part #: V105

Description: 10 AWG 5 conductor 7 strand bare copper with polyvinylchloride and nylon insulation, unshielded with an overall PVC jacket 600V control tray cable, approved for use in SUN RES DIR BUR OIL RES I 90°C applications.

1. Conductor

1.1. AWG Size & Stranding: 10 AWG 7 Strands Class B

1.2. Material: Annealed Bare Copper

1.3. Conductor Count: 5 Conductors

2. Insulation

2.1. Material: Polyvinylchloride & Nylon

2.2. Wall Thickness: 0.020” PVC & 0.005” Nylon

2.3. Color Code: Method 1, Table E-2
Single Core V90 HT (V105) 250/440 Volt
PVC Insulated
APPLICATIONS: Wiring of communication, electronic equipment and switchboards.
CONDUCTOR: Tinned copper wire.
INSULATION: V90HT (105°C) PVC to AS3808

COLOUR: Red, blue, green, yellow, white, black, brown, violet, orange.
PACK: 100, 500, 1000 metres.

For example, **V105** PVC **cable** has a maximum temperature rating of 105 °C. ... for low frequency **applications** such as those used in CCTV and sound systems.

Every electrical cable has particular characteristics that distinguish it from other types of cable, for example, the type of conducting material that it's made of, the type of insulation that surrounds it and of course, the size of the actual cable.

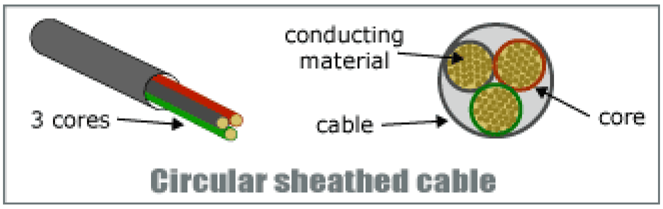
Each type of cable also has a rating. These ratings are specified by the manufacturer or an authority such as the Australian Communications Industry Forum.

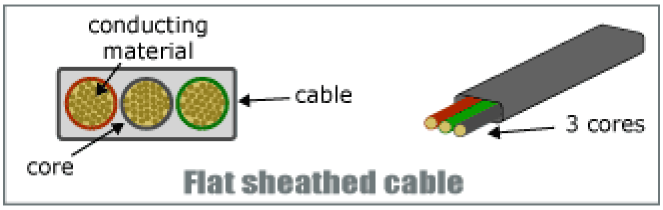
A rating is a value that **must not be exceeded** during normal service. The following terms are used to describe the most common characteristics or ratings of electrical cables:

- Cores and strands
- Size
- Current rating
- Voltage rating
- Temperature rating
- Cable colours
- Insulation
- Sheathing
- Shielding

Cores and strands

The core of a cable is the conducting material that carries the current, and includes the surrounding insulation. A cable can be single core or it can have two or more cores (multi-core cable). Each core consists of one or more strands of conducting material.





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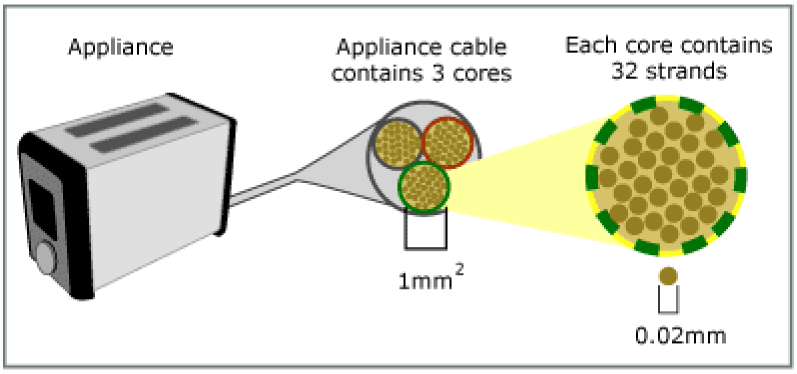
Size

The size of a cable is usually known as the total **cross sectional area** (CSA) of the conducting material in each core and is expressed in square millimetres.

The size of the cable can **also** be referred to as the number of strands followed by the diameter of each strand (i.e. number of strands/diameter of each strand (in mm)).

A typical three core flexible cord used in portable appliances (such as a kettle or toaster) has three insulated cores.



The total nominal cross sectional area of each core is 1 square mm, so the 'size' of the cable is 1 square mm.
Each core consists of 32 strands of 0.02 mm diameter copper wire. Therefore the size of the cable could also be written as (32/0.02).

top

Current rating

The current rating of a cable refers to the **maximum** current it is permitted to have flowing through it under normal operating conditions. This rating is usually expressed in amps.

The Electrical Wiring Rule AS/NZS 3008.1.1 states the current rating of a specific cable under defined installation conditions.

If the current rating of a cable is exceeded, the cable may overheat and burn out.

top

Voltage rating

The voltage rating of a cable refers to the maximum voltage to which it may be connected (and have running through it).
If the voltage rating is exceeded, the insulation between cable cores, or between a cable core and earth, may break down and cause a short circuit or a fire.

Circular Sheathed Power Cable	
Current rating:	1.4 amps
Voltage rating:	0.6/1 kV (600 volts rms)
Temperature rating:	75 °C

A typical voltage rating is 0.6/1 kV. This means that a cable with this rating is capable of withstanding a voltage of 0.6 kV (600 volts rms) between the conductor and earth, and 1 kV (1000 V rms) between adjacent conductors.

The voltage rating of a particular cable can usually be found on the cable reel or drum.

top

Temperature rating

The temperature rating of a cable is the maximum temperature at which it may be operated without damaging the insulation.
A typical temperature rating for general wiring in a domestic installation is 75 °C.
There are special cables available that have insulation capable of withstanding higher temperatures. For example, V105 PVC cable has a maximum temperature rating of 105 °C.

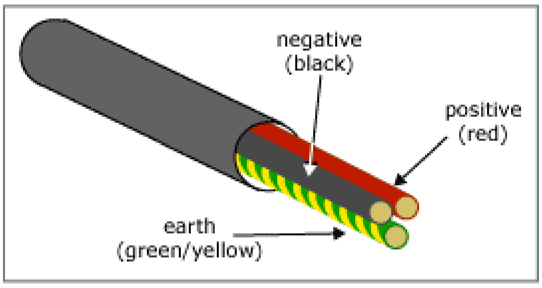
top

Cable colours

The colour of a cable is the colour of the insulation. Where colours are required to be used to identify different cables such as positive, negative and earth, there are specific colours for specific purposes.

Cables used for typical installations are available in a variety of different colours. For example,

- **black** for negative
- **red** for positive and
- **green/yellow** for earth.



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Electrical cable should not be coloured green or yellow as this is the colour of the earthing cable.

However, the colour code used for fixed wiring in Australia is **NOT** the same as the international colour code for flexible cords (see AS/NZS 3000 Clause 3.8.1), nor is the same fixed wiring colour code used in all countries.

Insulation

All cable wiring, including the earth wire, is required to be insulated.

The type of insulation usually determines the maximum temperature and voltage rating of the cable. The insulation on typical domestic building wire (V75) is made of PVC and has a temperature rating of 75 °C with a voltage rating of 0.6/1kV.

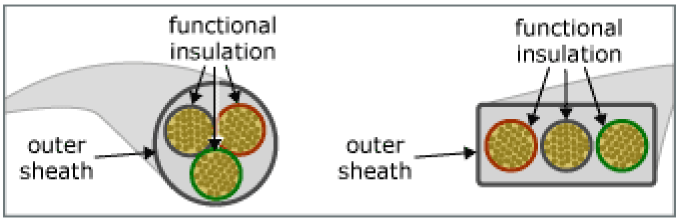
You can determine the voltage rating of a cable by examining the drum or reel that the cable comes on. Some PVC insulated cables are designed for extra low voltages.

top

Sheathing

The primary layer of insulation on a cable core is known as the functional insulation. Some types of cable have an additional layer of protective insulation over the functional insulation, to provide double insulation and additional mechanical strength.

The outer protective insulation is known as sheathing. The sheathing is usually provided in a form that results in either a **flat** or **circular** sheathed cable.



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Shielding

Single or multi-core cables are required to be protected against electronic noise or interference and have an outer layer of braided tinned or bare copper known as the **shielding** or **screening**.

Shielding from the effects of electrical interference is achieved by earthing the outer metallic braiding. Shielded cables have a particular value of voltage per unit length and are designed for low frequency applications such as those used in CCTV and sound systems.

For more information on cabling requirements and ratings, take a look at the Installation requirements for customer cabling (Wiring Rules) at the ACIF website.

What are flexible cords used for?

One such listed **use** is in (C), for connection of portable lamps. Therefore, under these sections, **flexible cords** and cables are permitted to be run through walls, ceilings, or floors when **used** to power portable lamps. Another listed **use** in (C) is for connection of "appliances."

What is flex wire?

Flex Wires is a California **wire** manufacturing company, and full line source for **wire**,**cable** and tubing products.Jun 1, 2016

What is flex cable made of?

FFC is a miniaturized form of ribbon cable, which is also flat and flexible. The cable usually consists of a flat and flexible plastic film base, with multiple **metallic**conductors bonded to one surface. Often, each end of the cable is reinforced with a stiffener to make insertion easier or to provide strain relief

A **data cable** is any media that allows baseband transmissions (binary 1,0s) from a transmitter to a receiver. Examples Are: Networking Media. Ethernet **Cables** (Cat5, Cat5e, Cat6, Cat6a)

A **data cable** is any media that allows baseband transmissions (binary 1,0s) from a transmitter to a receiver.

Examples Are:

- Networking Media
  - Ethernet Cables (Cat5, Cat5e, Cat6, Cat6a)
  - Token Ring Cables (Cat4)
  - Coaxial cable is sometimes used as a baseband digital data cable, such as in serial digital interface and thicknet and thinnet.
  - Optical fiber cable; see fiber-optic communication
  - Serial cable
- Telecommunications Cable (Cat2 or telephone cord)

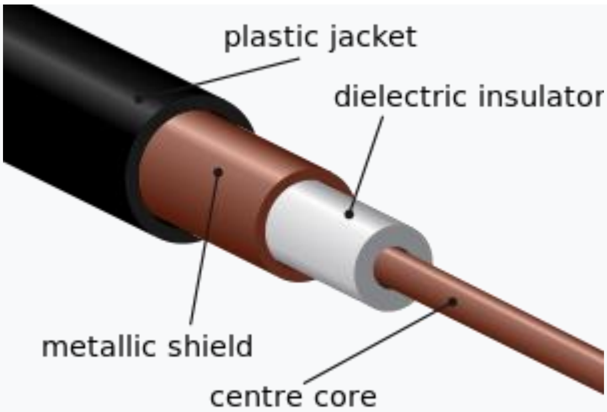
Cable. ... A **data cable** is a **cable** that provides communication between devices. For example, the **data cable** (i.e., DVI, HDMI, or VGA) that connects your monitor to your computer and allows your computer to display a picture on the monitor

Coaxial cable, or **coax** (pronounced /ˈkoʊ.æks/), is a type of electrical cable that has an inner conductor surrounded by a tubular insulating layer, surrounded by a tubular conducting shield. Many coaxial cables also have an insulating outer sheath or jacket. The term coaxial comes from the inner conductor and the outer shield sharing a geometric axis. Coaxial cable was invented by English engineer and mathematician Oliver Heaviside, who patented the design in 1880.[1] Coaxial cable differs from other shielded cables because the dimensions of the cable are controlled to give a precise, constant conductor spacing, which is needed for it to function efficiently as a transmission line.

Applications[edit]

Coaxial cable is used as a transmission line for radio frequency signals. Its applications include feedlines connecting radio transmitters and receivers to their antennas, computer network (Internet) connections, digital audio (S/PDIF), and distributing cable television signals. One advantage of coaxial over other types of radio transmission line is that in an ideal coaxial cable the electromagnetic field carrying the signal exists only in the space between the inner and outer conductors. This allows coaxial cable runs to be installed next to metal objects such as gutters without the power losses that occur in other types of transmission lines. Coaxial cable also provides protection of the signal from external electromagnetic interference.

Description[edit]



Coaxial cable cutaway (not to scale)

Coaxial cable conducts electrical signal using an inner conductor (usually a solid copper, stranded copper or copper plated steel wire) surrounded by an insulating layer and all enclosed by a shield, typically one to four layers of woven metallic braid and metallic tape. The cable is protected by an outer insulating jacket. Normally, the shield is kept at ground potential and a signal carrying voltage is applied to the center conductor. The advantage of coaxial design is that electric and magnetic fields are restricted to the dielectric with little leakage outside the shield. Conversely, electric and magnetic fields outside the cable are largely kept from interfering with signals inside the cable. Larger diameter cables and cables with multiple shields have less leakage. This property makes coaxial cable a good choice for carrying weak signals that cannot tolerate interference from the environment or for stronger electrical signals that must not be allowed to radiate or couple into adjacent structures or circuits.[2]

Common applications of coaxial cable include video and CATV distribution, RF and microwave transmission, and computer and instrumentation data connections.[3]

The characteristic impedance of the cable ( ) is determined by the dielectric constant of the inner insulator and the radii of the inner and outer conductors. A controlled cable characteristic impedance is important because the source and load impedance should be matched to ensure maximum power transfer and minimum standing wave ratio. Other important properties of coaxial cable include attenuation as a function of frequency, voltage handling capability, and shield quality.[2]

Construction[edit]

Coaxial cable design choices affect physical size, frequency performance, attenuation, power handling capabilities, flexibility, strength, and cost. The inner conductor might be solid or stranded; stranded is more flexible. To get better high-frequency performance, the inner conductor may be silver-plated. Copper-plated steel wire is often used as an inner conductor for cable used in the cable TV industry.[4]

The insulator surrounding the inner conductor may be solid plastic, a foam plastic, or air with spacers supporting the inner wire. The properties of the dielectric insulator determine some of the electrical properties of the cable. A common choice is a solid polyethylene (PE) insulator, used in lower-loss cables. Solid Teflon (PTFE) is also used as an insulator. Some coaxial lines use air (or some other gas) and have spacers to keep the inner conductor from touching the shield.

Many conventional coaxial cables use braided copper wire forming the shield. This allows the cable to be flexible, but it also means there are gaps in the shield layer, and the inner dimension of the shield varies slightly because the braid cannot be flat. Sometimes the braid is silver-plated. For better shield performance, some cables have a double-layer shield.[4] The shield might be just two braids, but it is more common now to have a thin foil shield covered by a wire braid. Some cables may invest in more than two shield layers, such as "quad-shield", which uses four alternating layers of foil and braid. Other shield designs sacrifice flexibility for better performance; some shields are a solid metal tube. Those cables cannot be bent sharply, as the shield will kink, causing losses in the cable. When a foil shield is used a small wire conductor incorporated into the foil makes soldering the shield termination easier.

For high-power radio-frequency transmission up to about 1 GHz, coaxial cable with a solid copper outer conductor is available in sizes of 0.25 inch upward. The outer conductor is corrugated like a bellows to permit flexibility and the inner conductor is held in position by a plastic spiral to approximate an air dielectric.[4] One brand name for such cable is *Heliax*.[5]

Coaxial cables require an internal structure of an insulating (dielectric) material to maintain the spacing between the center conductor and shield. The dielectric losses increase in this order: Ideal dielectric (no loss), vacuum, air, polytetrafluoroethylene (PTFE), polyethylene foam, and solid polyethylene. A low relative permittivity allows for higher-frequency usage. An inhomogeneous dielectric needs to be compensated by a non-circular conductor to avoid current hot-spots.

While many cables have a solid dielectric, many others have a foam dielectric that contains as much air or other gas as possible to reduce the losses by allowing the use of a larger diameter center conductor. Foam coax will have about 15% less attenuation but some types of foam dielectric can absorb moisture—especially at its many surfaces — in humid environments, significantly increasing the loss. Supports shaped like stars or spokes are even better but more expensive and very susceptible to moisture infiltration. Still more expensive were the air-spaced coaxials used for some inter-city communications in the mid-20th century. The center conductor was suspended by polyethylene discs every few centimeters. In some low-loss coaxial cables such as the RG-62 type, the inner conductor is supported by a spiral strand of polyethylene, so that an air space exists between most of the conductor and the inside of the jacket. The lower dielectric constant of air allows for a greater inner diameter at the same impedance and a greater outer diameter at the same cutoff frequency, lowering ohmic losses. Inner conductors are sometimes silver-plated to smooth the surface and reduce losses due to skin effect.[4] A rough surface extends the current path and concentrates the current at peaks, thus increasing ohmic loss.

The insulating jacket can be made from many materials. A common choice is PVC, but some applications may require fire-resistant materials. Outdoor applications may require the jacket to resist ultraviolet light, oxidation, rodent damage, or direct burial. Flooded coaxial cables use a water blocking gel to protect the cable from water infiltration through minor cuts in the jacket. For internal chassis connections the insulating jacket may be omitted.

Signal propagation[edit]

This section **needs additional citations for verification**. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed. *(March 2016)* *(Learn how and when to remove this template message)*

Twin-lead transmission lines have the property that the electromagnetic wave propagating down the line extends into the space surrounding the parallel wires. These lines have low loss, but also have undesirable characteristics. They cannot be bent, tightly twisted, or otherwise shaped without changing their characteristic impedance, causing reflection of the signal back toward the source. They also cannot be buried or run along or attached to anything conductive, as the extended fields will induce currents in the nearby conductors causing unwanted radiation and detuning of the line. Coaxial lines largely solve this problem by confining virtually all of the electromagnetic wave to the area inside the cable. Coaxial lines can therefore be bent and moderately twisted without negative effects, and they can be strapped to conductive supports without inducing unwanted currents in them.

In radio-frequency applications up to a few gigahertz, the wave propagates primarily in the transverse electric magnetic (TEM) mode, which means that the electric and magnetic fields are both perpendicular to the direction of propagation. However, above a certain cutoff frequency, transverse electric (TE) or transverse magnetic (TM) modes can also propagate, as they do in a waveguide. It is usually undesirable to transmit signals above the cutoff frequency, since it may cause multiple modes with different phase velocities to propagate, interfering with each other. The outer diameter is roughly inversely proportional to the cutoff frequency. A propagating surface-wave mode that does not involve or require the outer shield but only a single central conductor also exists in coax but this mode is effectively suppressed in coax of conventional geometry and common impedance. Electric field lines for this [TM] mode have a longitudinal component and require line lengths of a half-wavelength or longer.

Coaxial cable may be viewed as a type of waveguide. Power is transmitted through the radial electric field and the circumferential magnetic field in the TEM00 transverse mode. This is the dominant mode from zero frequency (DC) to an upper limit determined by the electrical dimensions of the cable.[6]

Connectors[edit]

Main article: RF connector

A male F-type connector used with common RG-6 cable

A male N-type connector

The ends of coaxial cables usually terminate with connectors. Coaxial connectors are designed to maintain a coaxial form across the connection and have the same impedance as the attached cable.[4] Connectors are usually plated with high-conductivity metals such as silver or tarnish-resistant gold. Due to the skin effect, the RF signal is only carried by the plating at higher frequencies and does not penetrate to the connector body. Silver however tarnishes quickly and the silver sulfide that is produced is poorly conductive, degrading connector performance, making silver a poor choice for this application.[citation needed]

A **fiber optic cable** consists of a bundle of glass threads, each of which is capable of transmitting messages modulated onto light waves. **Fiber optics** has several advantages over traditional metal communications lines: **Fiber optic cables** have a much greater bandwidth than metal **cables**.

What is Fiber Optics? Webopedia Definition

https://www.webopedia.com/TERM/F/fiber_optics.html

What are the different types of fiber optic cables?

Where is fiber optic cable most commonly used?

Optical fibers are **used most** often as a means to transmit light between the two ends of the **fiber** and find wide usage in **fiber**-**optic** communications, where they permit transmission over longer distances and at higher bandwidths (data rates) than electrical **cables**.

What are the advantages of fiber optic cable?

Network fiber cables have some definite advantages over copper cables.

- Greater Bandwidth. Copper cables were originally designed for voice transmission and have a limited bandwidth. ...
- Faster Speeds. ...
- Longer Distances. ...
- Better Reliability. ...
- Thinner and Sturdier. ...
- More Flexibility for the Future. ...
- Lower Total Cost of Ownership.

What are the advantages of optical fiber?

Fiber optic cables have a much greater bandwidth than metal cables. The amount of information that can be transmitted per unit time of fiber over other transmission media is its most significant advantage. An optical fiber offers **low** power loss, which allows for longer transmission distances.Jul 12, 2017

Stranding: the ____________ and ________________ of the wires use to make the core of the conductor:
Conductors used for electrical wiring can be single core or stranded. Most conductors used for electrical wiring are stranded copper which has been annealed to make it more flexible. *See Figure 10.2 on Page 296 of your*

The required processability is achieved by using stranded conductors inside the **cable** which are produced on **stranding** machines. **Stranding** is the process where a particular number of **stranding** elements are joined together while winding them round a common axis. **Stranding** is a result of rotating and forward movement.

What is stranding in wire?

A **wire** is a single, usually cylindrical, flexible strand or rod of metal. ... The term **wire**is also used more loosely to refer to a bundle of such strands, as in "multistranded**wire**", which is more correctly termed a **wire** rope in mechanics, or a cable in electricity. **Wire** comes in solid core, stranded, or braided forms.

Screening: This cable has a light weight metal layer which is not for mechanical protection but for ____________________-_______________________ protection if earthed correctly.
Screening on electrical cables is designed to stop the magnetic field surrounding a conductor or cable interfering with signal conductors which are installed near the power cables. Screens can be either 'foil wrapped', 'braided' or 'spiral' wound.

What is screening in cable?

Screened cables. **Screening** is used to reduce the effects of electromagnetic interference (EMI) or electrical noise which can disrupt the transmission performance in some environments.

What is a screened cable?

A **shielded cable** is an electrical **cable** of one or more insulated conductors enclosed by a common conductive layer. The shield may be composed of braided strands of copper (or other metal, such as aluminium), a non-braided spiral winding of copper tape, or a layer of conducting polymer.

Temperature rating: this is the __________________ temperature the cable can operate up to. V75, V90, V105 are examples of available insulation temperature ratings for PVC (Poly Vinyl Chloride) insulation.
The number after the prefix refers to the maximum cable operating temperature permissible.

Operation

Serving: This is a layer of electrical insulation on the very outside of the cable, it can also act a ____________________ barrier.
Serving is a protective layer on the outside of a cable and is used to protect cables from mechanical, chemical and water damage. It is often used with armour and sheathing and can also be used an extra layer of insulation.

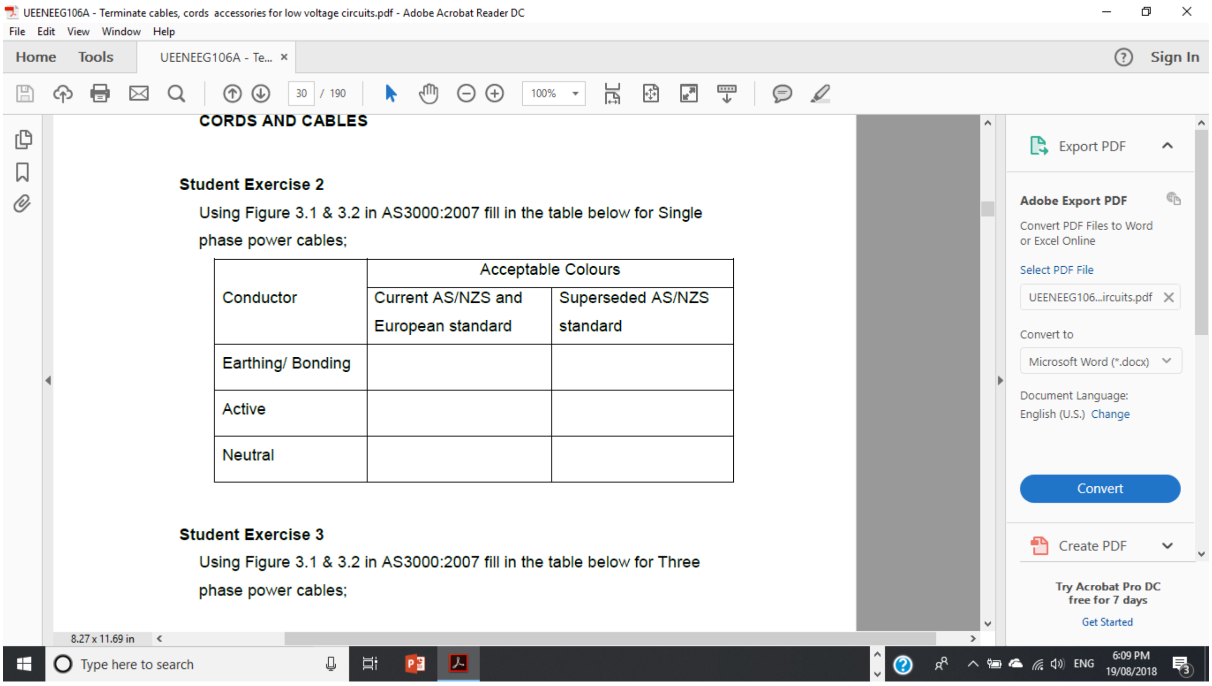
cable serving

what is "serving " of a cable? i mean something which covers the utmost exterior part of it....
also there are some other definitions used in xlpe cables
1- binder
2-"extruded" pvc sheath (what is exactly extrusion with regards to cables)
3- semiconductor XLPE screen (what good will make a semiconductor in a cable?)

Serving[edit]

The outer layer of protection is formed of twine wrapped as tightly as possible around the line, each progressive turn of the twine laid as close as possible against the last, covering the line completely. Following the rhyme above, it should have course run *against* the lay of the rope; this alternation helps prevent sideways chafe from opening up the protection. Traditionally hemp "marline" was and still is used for service; on modern small craft three-strand nylon "seine twine" is often used.

A serving board or serving mallet can be used to help get the outer twine as tight as possible. Despite the name (arising from its shape) the serving mallet is not used to hit anything; it forms a kind of guide and tensioning lever for applying the twine to the rope.



CORDS AND CABLES

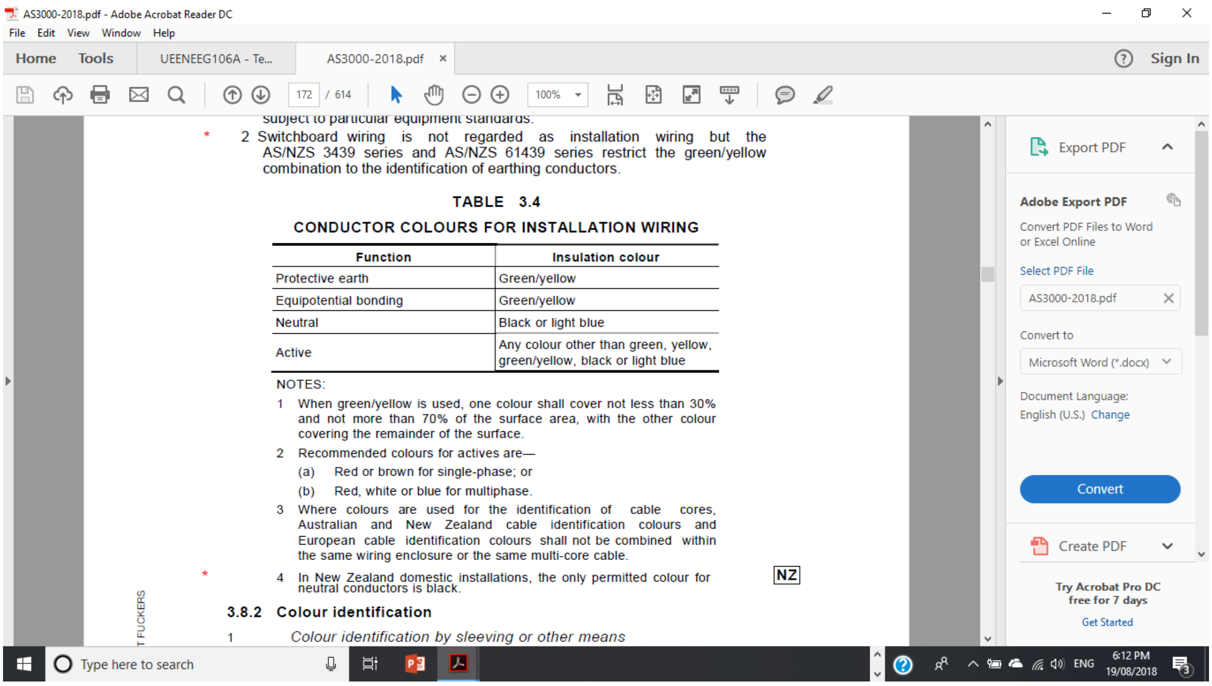
Student Exercise 2

Using Figure 3.1 & 3.2 in AS3000:2007 fill in the table below for Single phase power cables;

Conductor	Acceptable Colours	
	Current AS/NZS and European standard	Superseded AS/NZS standard
Earthing/ Bonding		
Active		
Neutral		

Student Exercise 3

Using Figure 3.1 & 3.2 in AS3000:2007 fill in the table below for Three phase power cables;



2 Switchboard wiring is not regarded as installation wiring but the AS/NZS 3439 series and AS/NZS 61439 series restrict the green/yellow combination to the identification of earthing conductors.

TABLE 3.4

CONDUCTOR COLOURS FOR INSTALLATION WIRING

Function	Insulation colour
Protective earth	Green/yellow
Equipotential bonding	Green/yellow
Neutral	Black or light blue
Active	Any colour other than green, yellow, green/yellow, black or light blue

NOTES:

1 When green/yellow is used, one colour shall cover not less than 30% and not more than 70% of the surface area, with the other colour covering the remainder of the surface.

2 Recommended colours for actives are—

(a) Red or brown for single-phase; or

(b) Red, white or blue for multiphase.

3 Where colours are used for the identification of cable cores, Australian and New Zealand cable identification colours and European cable identification colours shall not be combined within the same wiring enclosure or the same multi-core cable.

4 In New Zealand domestic installations, the only permitted colour for neutral conductors is black. NZ

3.8.2 Colour identification

1 *Colour identification by sleeving or other means*

3.8.2 Colour identification

1 Colour identification by sleeving or other means

Colour identification by sleeving or other means, using colours corresponding to those listed in Table 3.4 at each termination, may be used as a means of identification for the following purposes:

(a) Conductors with black or light blue insulation used as active

conductors.

or

(b) Conductors with other than green, yellow, green/yellow, black or light blue insulation used as neutral conductors.

or

(c) Conductors within multi-core cables with other than green, yellow or green/yellow insulation used as earthing conductors.

Colour identification shall be of colour-fast, non-conductive material that is compatible with the cable and its location.

Single-core cables with other than green, yellow or green/yellow insulation, used as earthing conductors, shall be identified continuously along their entire length.

Colour identification shall not be used at terminations or along the entire length, to identify a green, yellow or green/yellow colour-insulated conductor as an active or neutral conductor.

2 Sleeving of existing earthing and bonding conductors

* In electrical installations where earthing or bonding conductors have been previously installed using bare or green conductors, complying with previous editions of this Standard, such earthing or bonding conductors may remain.

* When alterations or repairs are carried out that result in new terminations or junctions to those existing bare or green conductors, such bare or green coloured conductors shall be sleeved with green/yellow sleeving within each of those new cable junctions or terminations.

3 Sleeving of existing live conductors

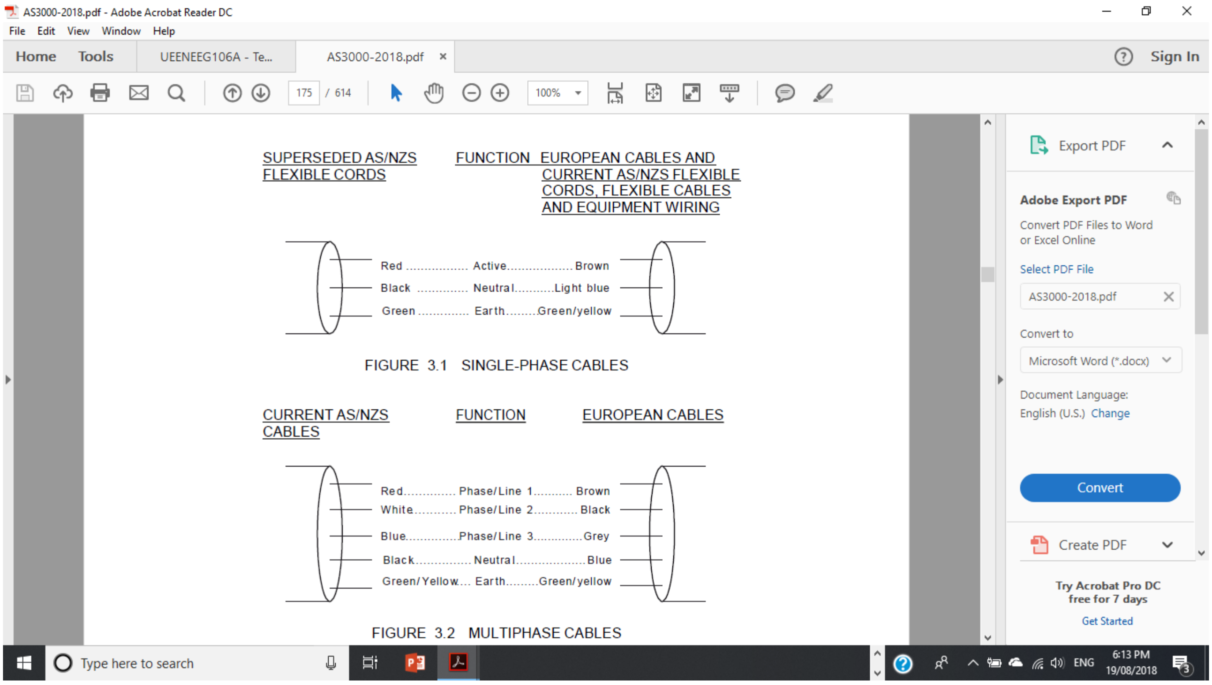
* In electrical installations where conductors with yellow insulation have been previously installed as live conductors, complying with previous editions of this Standard, such conductors with yellow insulation may remain.

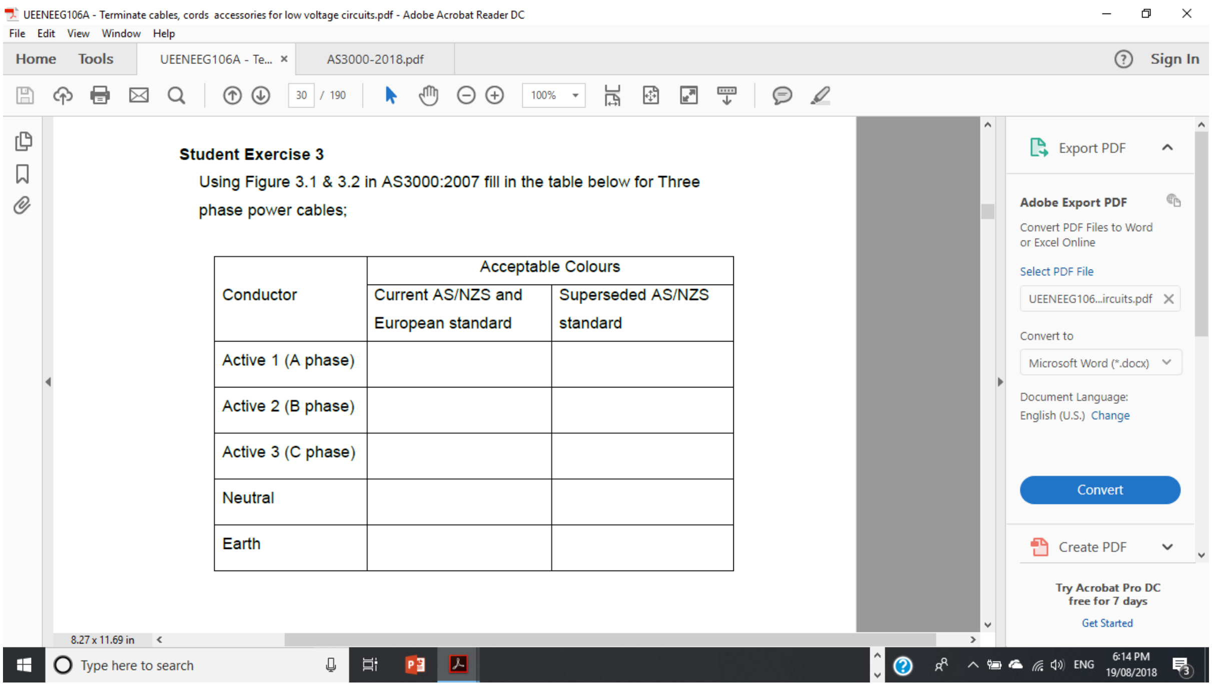
* When alterations or repairs are carried out that result in new terminations or junctions to those existing live conductors with yellow insulation, such live conductors with yellow insulation shall be sleeved with white sleeving within

each of those new cable junctions or terminations.

3.8.3.4 Alternative and European cable identification colours

Figure 3.1 demonstrates the coordination of conductor insulation colours of single-phase cables manufactured to current and superseded Australian and New Zealand Standards and typical European practices. Figures 3.2 demonstrates the coordination of conductor insulation colours of multiphase cables manufactured to current Australian and New Zealand Standards and typical European practices.





Student Exercise 3

Using Figure 3.1 & 3.2 in AS3000:2007 fill in the table below for Three phase power cables;

Conductor	Acceptable Colours	
	Current AS/NZS and European standard	Superseded AS/NZS standard
Active 1 (A phase)		
Active 2 (B phase)		
Active 3 (C phase)		
Neutral		
Earth		

Do it yourself

8. FLEXIBLE CORDS

A flexible cord is a cable whose conductors have many strands of fine wire which makes the cable more flexible. Cords are used to supply appliances like kettles, toasters and electronic equipment. AS 3000 defines a cord as:

____

____

_______________________ Clause No:________

3.9.7.4 Flexible cords used as installation wiring

Flexible cords used as installation wiring shall be of the heavy-duty sheathed type and installed in the same manner as insulated and sheathed cables.

Exception: Flexible cords need not be of the heavy-duty type if—

(a) used for the connection of pendant socket-outlets;

(b) installed in a suitable wiring enclosure; or

NOTE: See Clause 3.10.1 for requirements for enclosure of cables.

(c) installed for the connection of equipment, in accordance with the equipment wiring provisions of Clause 4.3.

Flexible cords installed as follows shall be regarded as installation wiring and shall comply with this Clause (3.9.7.4):

(a) Permanently connected flexible cords, including flexible cords used as pendants for socket-outlets and those connected to an installation coupler.

(b) Flexible cords not open to view.

C.S.A. AND NUMBER OF CORES

Single strand conductors have limited _________________ as their size increases. Stranding of cable makes it more flexible. This is important for extension cords because they are often moving while in use, but it is equally important for permanent installations. A certain amount of flexibility allows the cable to be "____________ _____" more easily.

Solid **conductors** are more likely to break if subjected to frequent flexing than**stranded conductors**. **Stranded conductors** are made of multiple small **strands**, which group together to make up a **single conductor**. It is more flexible than a solid **conductor**, but less durable.

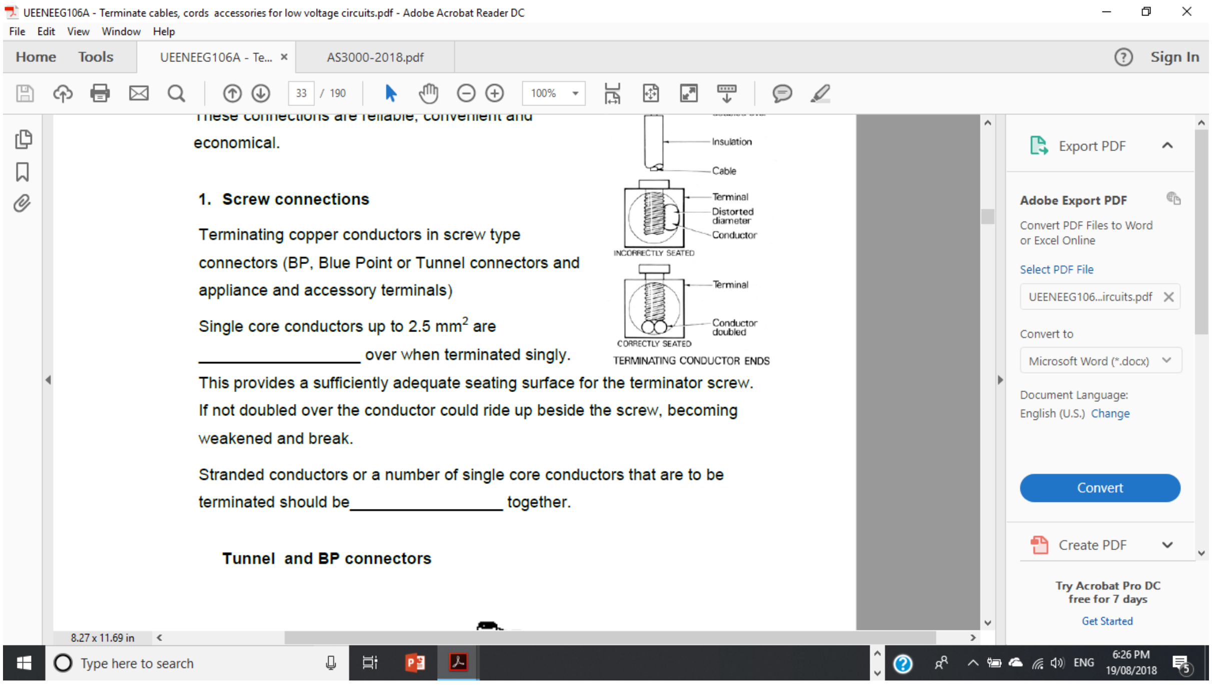
What does single conductor mean?

A **single**-**wire** transmission line (or **single wire** method) **is a** method of transmitting electrical power or signals using only a **single** electrical **conductor**. ... In a **single-wire** transmission line there is no second **conductor** of any form.

There are two broad categories of connection methods:
1. Fusion: soldering, welding and brazing.
2. Pressure: clamping, compression

These methods ________ ________ be used together. That is, two conductors can not be soldered together and then compressed in a crimp connector, or terminated into the terminal of a switch, socket-outlet or circuit breaker etc.

Can be


These connections are reliable, convenient and economical.

1. Screw connections

Terminating copper conductors in screw type connectors (BP, Blue Point or Tunnel connectors and appliance and accessory terminals)

Single core conductors up to 2.5 mm^2 are ________________ over when terminated singly.

This provides a sufficiently adequate seating surface for the terminator screw. If not doubled over the conductor could ride up beside the screw, becoming weakened and break.

Stranded conductors or a number of single core conductors that are to be terminated should be _______________ together.

Tunnel and BP connectors

SCREWED/ TWISTED

JOINTING AND TERMINATING CABLES

BY GEORGE GEORGEVITS

26/03/2012

Jointing and terminating cables is an exacting business, writes George Georgevits. Following the requirements will ensure performance, safety and long service life.

Compression and mechanical jointing connectors rely on pressure to make an electrical connection with the cable.

They play a crucial role in service, are expected to have a long service life and may be required to handle high currents. Therefore correct product design, proper termination technique and product quality are essential for long-term reliability.

Connectors for insulated power cables

In general, such connectors are used for terminating or jointing cables. The type and size of connector is a function of the type and size of the cable and the amount of current the circuit is required to carry.

For power cables, there are additional performance requirements and limitations, including whether:

- the conductor material is copper or aluminium;
- the connector uses a mechanical clamp (eg: screw type) or a compression fitting (eg: crimp type) termination; and
- whether the connector is required to withstand a prolonged high intensity short-circuit current , such as may be encountered in electricity distribution networks where distribution circuits are protected by slow-acting protection relays rather than fast acting fuses.

The discussion here is limited to fixed jointing connectors intended for termination of insulated power cables.

Aerial cables, as used in overhead power reticulation networks, have additional special mechanical requirements. Similarly, separable connectors are another subject, although some of the test techniques may apply.

Standards

The applicable Australian Standard for connectors used with copper cables of cross-section area greater than 10mm2 and aluminium cables of cross-section area greater than 16mm2, is AS/NZS 4325.1:1995, Compression and mechanical connectors for power cables with copper or aluminium conductors, Part 1: Test methods and requirements.

This is based primarily on International Electrotechnical Commission Standard IEC 1238-1.

The Standard specifies testing of joint resistance after heat cycling, short-circuit testing (if applicable – depending on intended use) and mechanical ‘pull withstand’ strength testing.

A low and stable joint resistance is essential for good connector performance in the long term. The heat dissipated in the connector due to cable joint resistance may be calculated by multiplying the joint resistance by the square of the current passing through the connector.

If the connector is passing a current at – or more than – its rated current, a poorly terminated connector could easily have to dissipate much more heat than it is designed to do. This applies to the joint where the cable terminates inside the connector and also to the joint where the connector terminates on the equipment.

Extreme temperature rise may occur, causing connector oxidation and eventual failure – or worse.

High termination resistance at a joint is a common cause of switchboard fires.

A poor cable termination in a connector may be caused by:

- not using the correct tool or die for a compression connector (the die should be wide enough to properly crimp the connector over the required barrel length with a single compression);
- not applying enough pressure to perform the crimp action completely over the required barrel length – multiple short crimps along the barrel do not work as well as a single full-length crimp;
- not applying the specified tightening torque to a mechanical connector bolt;
- using the wrong size of connector for a given size and type of cable;
- using an aluminium cable crimp connector on a copper cable, and vice versa;
- not having the cable inserted along the full length of the barrel before terminating; and
- not ensuring that the cable conductor and the connector barrel are clean and free from oxidation and corrosion.

Testing to the Australian Standard

If a particular connector has been type tested and found to comply with the Standard, it can be implied that under normal operating conditions:

1. the resistance of the connection will remain stable;
2. the temperature of the connector will be of the same order or less than that of the cable conductor when in service;
3. the mechanical strength will be fit for the purpose; and
4. application of short-circuit currents, if the intended use demands it, will not affect the first three aspects.

The Standard defines an optional short-circuit testing regime. Only connectors that have been tested for compliance with the short-circuit performance requirements of the Standard (known as Class A connectors) are suitable for use in unfused applications, such as in power distribution and industrial networks.

Connectors that are not required to be tested for short-circuit performance are known as Class B.

Although the above is reassuring, it does not mean that a compliant connector will perform satisfactorily for all applications or under all conditions.

Prolonged elevated temperature, excessive vibration, shock or corrosion can have a detrimental effect on connector performance and shorten the service life. If connectors are exposed to such adverse conditions, appropriate additional testing may be required, as the circumstances dictate.

The range of connectors covered by the Standard includes both compression and mechanical jointing types. The realisations of both types include barrel or through connectors (for joining two cables), palm lugs (for terminating a cable on a busbar on terminating plant) and branch connectors (where one cable run is split into two).

Electrical compliance testing

In brief, the Standard calls for six terminated connectors to be tested.

The required connectors are terminated on stipulated lengths of appropriately sized bare cables, which are bolted together to form a test loop.

The test loop is subjected to heat cycling by passing a large AC current through it for a predetermined time, during which the conductor temperature is monitored.

For each cycle, the loop temperature is raised from room temperature to about 120oC, maintained at that temperature for 10 minutes then allowed to cool to room temperature.

The joint resistance of each connector is measured at the beginning of heat-cycle testing, then after specific numbers of heat cycles. Twelve sets of measurements are required during the stipulated 1,000 heat cycles.

Because the joint resistance for large connectors can be of the order of micro-ohms, accurate measurement of connector joint resistance is not straightforward.

To determine the joint resistance accurately, the AC heating circuit is disconnected and a much smaller but accurately controlled constant DC test current is injected into the test loop.

A high-precision DC voltmeter is used for measuring the voltage drop across each connector under test plus a predetermined and accurately measured length of test conductor immediately following each connector.

The DC voltage drop is also measured along a second separate but known length of test conductor (known as the reference conductor).

The resistance for each connector is then calculated by factoring out the voltage drops due to the relevant cable resistances.

The ambient temperature is also measured and is used for calculating the test results referenced back to 20oC.

For a connector to comply with the Standard, it must meet the performance parameters in Table 1.

The specific meaning and derivation of each of the above test parameters are complex and beyond the scope of this article. Readers should refer to the Standard. However, in simple terms, the requirements imply that the:

E.3 – spread for connection resistance of the six connectors under test must be within strict bounds at the start of testing.
E.4 – average values of the connector resistances for the duration of testing must be within strict bounds.
E.5 – variation in connector resistance during testing must be within strict bounds.
E.6 – maximum change in connector resistance as a result of heat cycling must be within strict bounds.
E.7 – maximum temperature reached by any connector during testing must be recorded.

Conclusion

Jointing connectors play a crucial role in long-term circuit reliability.

Testing of jointing connectors is a complex and involved procedure, and the Standard requirements are very demanding. Consequently, any connector which has been found to pass those requirements should provide reliable long-term performance.

Connectors used in critical applications should be type tested against the Standard.

12. PREPARING A CONDUCTOR FOR TERMINATION OR CONNECTION
When preparing stranded conductors for termination or connection the following points should be observed:
1. TPS cable should not have any more than __________mm of sheathing removed.
2. The conductor insulation should be removed without causing damage to the conductor, either by "nicking" the copper or removing strands. Either of these two faults will reduce the current carrying capacity of the conductor. They are illustrated in the photographs.

Strip 25mm of insulation off each cable

3.7.2.2 Preparation for connection
The insulation on a conductor shall not be removed any further than is necessary to make the connection.
For connections between insulated conductors, the connection shall be insulated to provide a degree of insulation not inferior to that of the conductors. Any damaged insulation shall be reinstated.

Next Project

Learn special tools and techniques for stripping any kind of wire. Different types of electrical cable and cords, coaxial cable, communication wires and thin phone and bell wire are all covered.

By the DIY experts of The Family Handyman Magazine

How to Strip Wire Overview

Safe, durable electrical connections begin with clean, accurate wire stripping. You have to remove the outer layer of plastic without nicking or slicing the insulation or wires underneath; otherwise, your connection might break or an electrical short might occur.

In a pinch, you can strip almost any wire or cable with nothing more than a sharp pocket knife or utility knife. We'll show you how to strip wire safely and carefully. But for fast, accurate stripping, we recommend the specialized stripping tools we demonstrate in this article. They're affordable and easy to use, and they produce high-quality results.

All the tools we show are available at home centers and electrical supply stores. Buy each as you need it, and you'll soon have exactly what you need for any home wiring task.

How to Strip Wire: Electrical cords

1.
2.
3.
4.

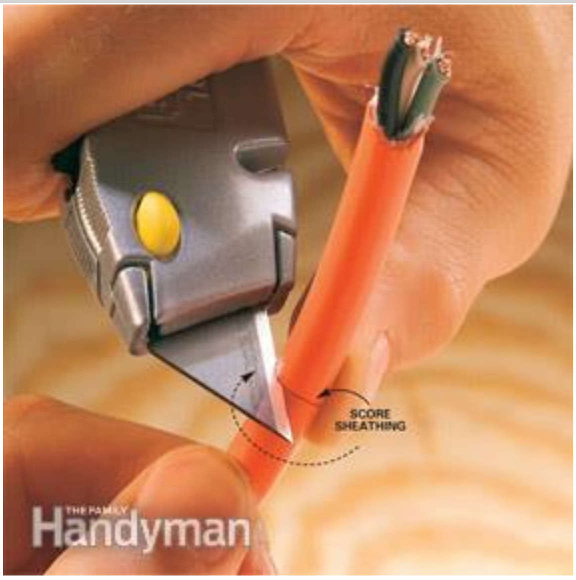


Photo 1: Score the jacket

Score a circle around the cable jacket, but don't cut all the way through the plastic. This technique may look dangerous, but it's safe as long as you apply very light pressure with the knife and keep your thumb on the opposite side of the cord. Carefully guide the knife around the cable until you reach your starting point.

A knife works best for stripping sheathing from cords. It takes a sharp blade, a steady hand and concentration to control the depth of the cut precisely. But once you master the technique, you'll be surprised how quickly and accurately you can remove cord sheathing.

We're showing the technique on a cord, but it also works on plastic-sheathed cable. Practice with the blade extended (Photo 1) or barely visible to see which technique works best for you.

When it comes to stripping individual wires, a wire stripping tool (Photo 3) is faster and more accurate, but in a pinch you can use a knife (Photo 4). With all of these techniques, the key is to control the depth of the cut to avoid cutting or gouging the conductor.

Plastic-sheathed cable

1.
2.
3.

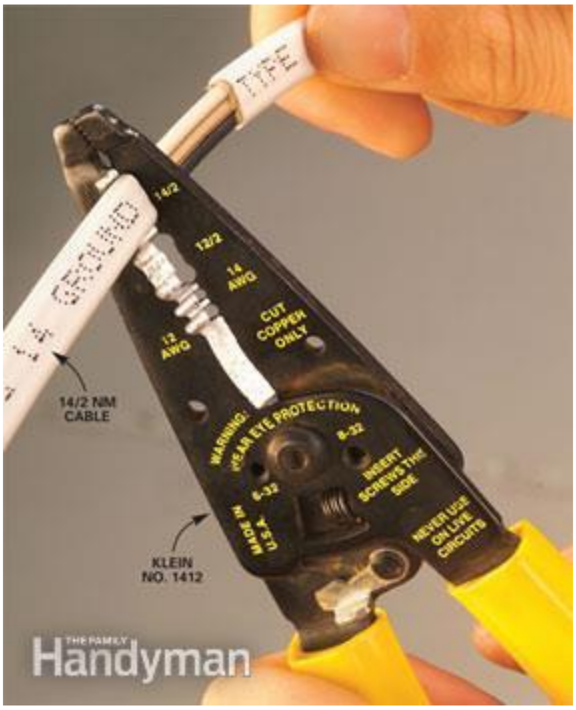


Photo 1: Strip sheathing

Align the plastic-sheathed cable with the notch that matches the wire gauge you're using—either 14/2 or 12/2—and squeeze down to cut the sheathing. Slide the sheathing off to expose the wires underneath.

Stripping plastic-sheathed (NM, for nonmetallic) type cable is a two-step process. First you remove the outer plastic sheathing. Then you strip the individual conductors. There are many methods to remove the plastic sheath, ranging from a simple knife technique (Photo 2) to special tools. The stripping tool we're using is unique because it combines both sheathing removal and wiring stripping in one tool (Photo 1) and works perfectly for both tasks. It's well worth the price if you do any amount of home wiring. Otherwise, buy a less expensive, general purpose stripper, and use a knife (Photo 2) or other method to remove the outer sheathing.

Underground cable

1.
2.
3.

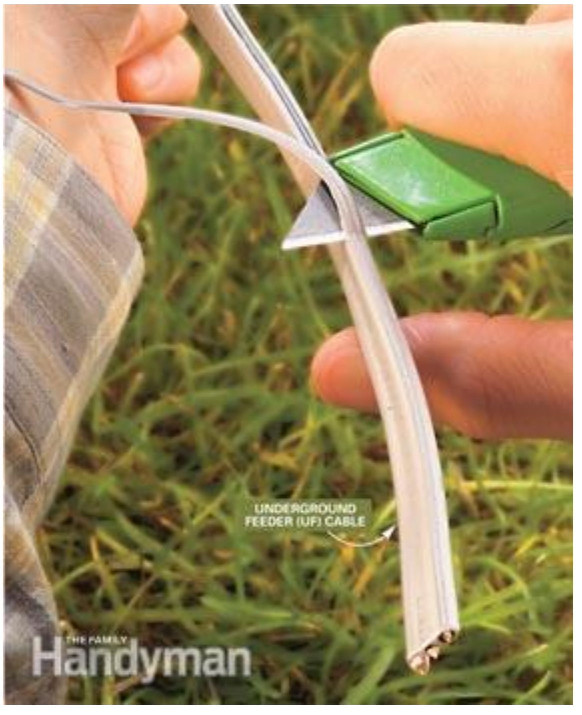


Photo 1: Peel an edge

Peel the plastic sheathing from the wires underneath with a sharp utility knife. Slide your thumb along the underside of the wire while you pull the knife along the top to remove a thin slice of plastic. This technique takes practice. If you cut through the insulation on the wire underneath, cut off that segment of cable and try again.

A special type of plastic-sheathed cable called UF (underground feeder) requires a slightly different technique. Since the sheathing surrounds each conductor, you can't just score it and slide it off. Photos 1 – 3 show how to strip UF cable.

This technique on how to strip wire requires practice to master. Develop your skill before trying it on a real project. The key to success on how to strip wire is controlling the depth of the cut by keeping the angle of the blade low, almost parallel with the cable. When you get it right, you'll be able to feel the blade riding along the top of the insulation of the wire underneath. Remember, if you gouge the insulation or nick the wires inside, cut off the cable at that point and try again.

Coaxial cable

1.
2.
3.

Photo 1: Adjust cutter depth

Test cutter depth on a cable scrap. Adjust the two cutting blades one at a time to fine-tune the depth of the cut. Turn the adjusting screws clockwise with the Allen wrench (included with the tool) to make a deeper cut.

Adding F-type connectors to coaxial cable requires a two- or three-step strip on the end of the cable, depending on the connector. With care, you can make the strip with a utility knife, using the technique shown in Photo 1 and a regular wire stripper. But the dedicated tool we show here makes the job quick and accurate. Read the packaging to match the stripper to the type of coaxial cable you're using. The strippers you find in home centers work on common household coaxial cables.

Read the lettering on the sheathing to determine whether your coaxial cable is RG-58, RG-59 or RG-6, and adjust the slide on top of the cutter to match your cable type. Make a practice cut and adjust the blades if necessary (Photo 1).

Sheathed communication wires

1.
2.
3.

Cable stripper

Use a cable stripper tool to remove the sheathing from communication wires.

With high-speed Internet lines and household computer networking becoming more common, you may soon find yourself installing new communication cables that can handle the greater bandwidths. Here’s an inexpensive tool that makes short work of removing the outer sheath from these small cables without nicking the conductors inside. The cable size notches aren’t labeled, so you’ll have to experiment to find the one that works.

Thin wires

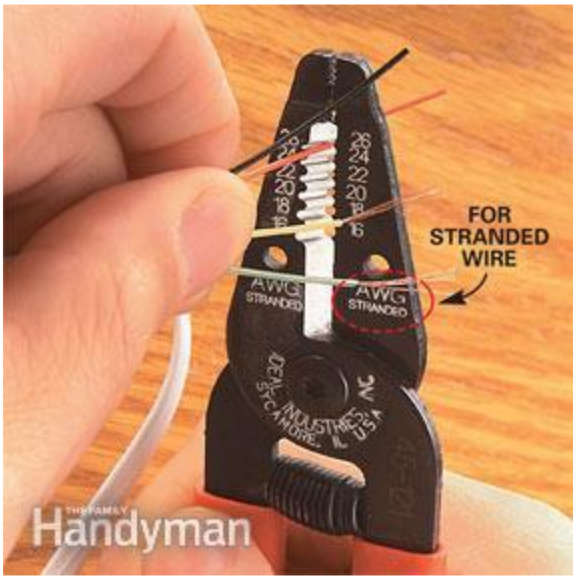


Photo 1: Stranded wire stripper

This stripper removes the insulation from 16- to 26-gauge stranded wires. Similar tools strip larger-gauge stranded wires and solid wires.

Tiny communication wires are tough to strip without nicking and weakening them. The key is to match the stripper to the wire you're using. For example, you may be surprised to discover that there's a special stripper for stranded wire (Photo 1) that's just slightly larger than the same size solid wire. There are also strippers for those tiny little wires you find on doorbells and telephone lines. Read the packaging before you buy to find the stripper that's right for your job.

Required Tools for this How to Strip Wire Project

Have the necessary tools for this DIY how to strip wire project lined up before you start—you'll save time and frustration.

- Select the wire stripper labeled for the type of wire you're working with.

Termination of Cables - Are going to bring the cable to an end?

Believe it or not the term "termination" is not defined in the Wiring Rules. The dictionary defines termination as "bring to an end", or to "put an end to", so one could argue that we are going to bring the cable to an end, to put an end to it being a cable, or even just end its employment.

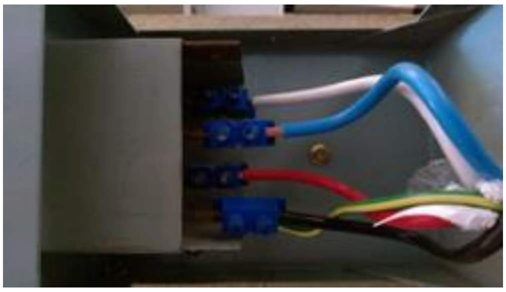
Fortunately, the Wiring Rules are clear when a term is used within the Wiring Rules that is not specifically defined. In that situation, the commonly understood meaning shall apply as used in the electrical field.

We, in the electrical industry, have been guilty for years of using incorrect terminology, and this is just another case of such. The correct terminology is connection, and for our trade "electrical is connections". This is defined under clause 3.7 in AS/NZS3000: 2007 as the connection between conductors and other electrical equipment, or as per the dictionary, a joint between two electrical conductors.
Now that we have established what we are on about, let's look at the requirements to complete a compliant electrical connection.

Back in "the good old days" when the Wiring Rules were more prescriptive, there were a lot of rules in relation to connections of conductors to electrical equipment. These included but were not limited to:

- No more than four conductors in a fixed tunnel terminal at the rear of an electrical accessory.
- All earthing conductors 2.5mm2 or smaller shall be twisted together prior to termination.
- All earthing conductors up to and including 16mm2 shall be terminated by soldering.

These current Wiring Rules are not as prescriptive as they were, but no less, they in general still exist. The fundamental principle must be achieved. The fundamental principle is the provision of electrical continuity, thus ensuring that the connection is not less in continuity than the original conductors, along with an appropriate level of insulation and adequate mechanical strength.



It is not my intention to repeat the Wiring Rules as you can go and read them at your leisure, however, I will point out some of the more interesting rules and also some of those that appear to be regularly breached.

There is no restriction on the number of conductors being connected together. All that is required is that you take into account the number of conductors to be joined and select an appropriate method of connection for that number of conductors being joined, to ensure that the fundamental principle is complied with.

One connection requirement that I constantly see breached is in relation to the retention of stranded conductors. Many electricians simply strip the outer sheath and the insulation off the conductor, then push it into a tunnel type connector.

They do not consider that the screw pushes some of the strands to the side and that only 3-4 strands are retained under the screw.
This does not meet the requirement of a proper connection.
However if they considered twisting the conductors together, prior to connecting into the tunnel type connector, this should of itself ensure a proper connection.
Or, better still the use of bootlaces or ferrules that are crimped onto the conductor prior to connecting the conductor into the tunnel terminal provides a better option.

Following on from this example is the cutting down of crimp lugs, redrilling of the crimp lug or connecting a crimp lug to a terminal or bar that is smaller in surface area to that of the crimp lug.

Remember that one of the fundamental principles is to ensure that the conductivity and current carrying capacity of the joint or connection is not less than that of the conductor.

Therefore the modification of any crimp lug for any reason renders the connection as non-compliant.

The Wiring Rules require conductors joined or terminated by means of a crimp connection to be securely retained within a suitable crimping device. This connection shall be made using a tool designed for the purpose and techniques specified by the manufacturer. Please note that this does not include pliers.

There is no longer a requirement to use two screws to connect an earth conductor in either a fixed or floating connection, providing that the earth conductor is connected into a tunnel type connection with one screw with an outside diameter not less than 80% of the tunnel diameter into which the earthing conductor is to be installed.

Unsupported conductors that create stress on conductor terminals is another example that comes to mind. All cables regardless of their size, from 1mm2 up to 500mm2, require supporting to remove the stress of the connection.
Distances of large cables in excess of 100mm between the cable support and the termination point may cause undue stress on the connection. Remember to always support cables prior to the termination point.

And finally, with the preparation of conductors it should be remembered that the insulation on a conductor shall not be removed any further than is necessary to make the connection.
And when the connection is between insulated conductors, the connection shall be insulated to provide a degree of insulation not inferior to that of the original conductors being joined.

Any damaged insulation shall be reinstated and remember the Energy Safe Victoria ruling that insulating tape is only acceptable if contained within an enclosure. The acceptable enclosures are switchboards and J Boxes or similar.

1. Name 2 advantages of stranded conductor over single core solid conductor?

___

___

Stranded wire is more flexible than solid wire of the same total cross-sectional area.**Stranded** wire tends to be a better **conductor** than solid wire because the individual wires collectively comprise a greater surface area. **Stranded** wire is used when higher resistance to metal fatigue is required.

2. What is meant by the term *temperature rating*?

___

When a bag is described as a "20-degree bag," it means that most users should remain comfortable if the air **temperature** drops no lower than 20°F. These **ratings** assume that the sleeper is wearing a layer of long underwear and using a sleeping pad under the bag.

3. What is the purpose of *serving* on a cable?

___

___

Serving definition, the act of a person or thing that serves. ... that is applied to the core or the exterior of a lead-covered **cable** and acts as a protective covering. ... definite use: This cup will **serve** as a sugar bowl. to answer the **purpose**:

4. Why, if possible do we double over the ends of a conductor before it is inserted into a tunnel type connector?

   ____

   To grip the conductor

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AS/NZS 3000 defines a flexible cable as:
Clause 1.4.20

1.4.24 Cable, flexible

A cable, the conductors, insulation and covering of which afford

Flexibility

AS/NZS 3000 also defines a flexible cord as:
Clause 1.4.36

1.4.40 Cord, flexible

A flexible cable, no wire of which exceeds 0.31 mm diameter and no

conductor of which exceeds 4 mm^2 cross-sectional area, and having

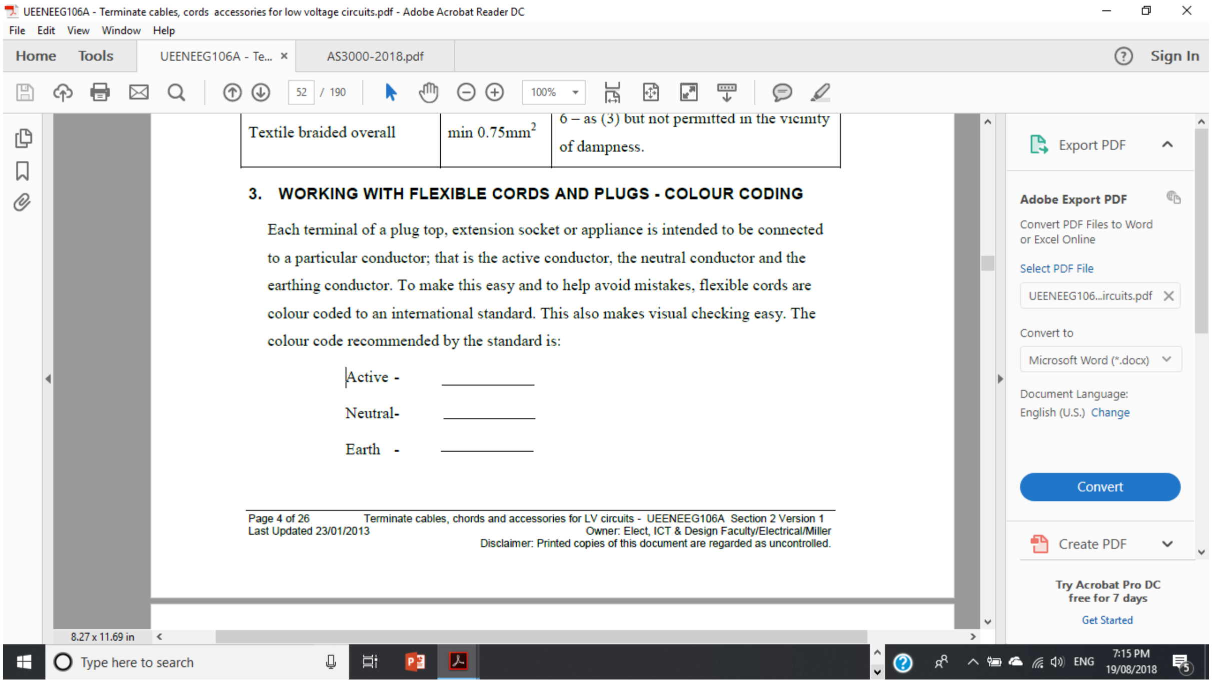
not more than five cores.

Special cables which are constructed to afford flexibility similar to that of a cord and which have conductors greater than 4mm^2 or more than five cores are known simply as _________________

1.4.40 Cord, flexible

Flexible cords must have the capacity to carry a current not less than the rating of the _________ to which they are connected.

Equipment



Textile braided overall	min 0.75mm²	6 – as (3) but not permitted in the vicinity of dampness.

3. WORKING WITH FLEXIBLE CORDS AND PLUGS - COLOUR CODING

Each terminal of a plug top, extension socket or appliance is intended to be connected to a particular conductor; that is the active conductor, the neutral conductor and the earthing conductor. To make this easy and to help avoid mistakes, flexible cords are colour coded to an international standard. This also makes visual checking easy. The colour code recommended by the standard is:

Active - ________

Neutral- ________

Earth - ________

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Red (Brown)/ Black (Blue)/ Green-Yellow

SECURING THE CORD

Flexible cords must be fitted to devices so that any pull on the cord does not exert any strain on the terminal connections. This is usually done by a '**tortuous path'** that the cord or cores must follow to the terminals in the device to be connected. The strain of pulling on the cord is taken up in the curves formed in the cord path and not the terminals. Another method is by a.
______________________________ All of these methods are generally built into the device intended to be cord connected

Clamp

How do you secure wires to the wall?

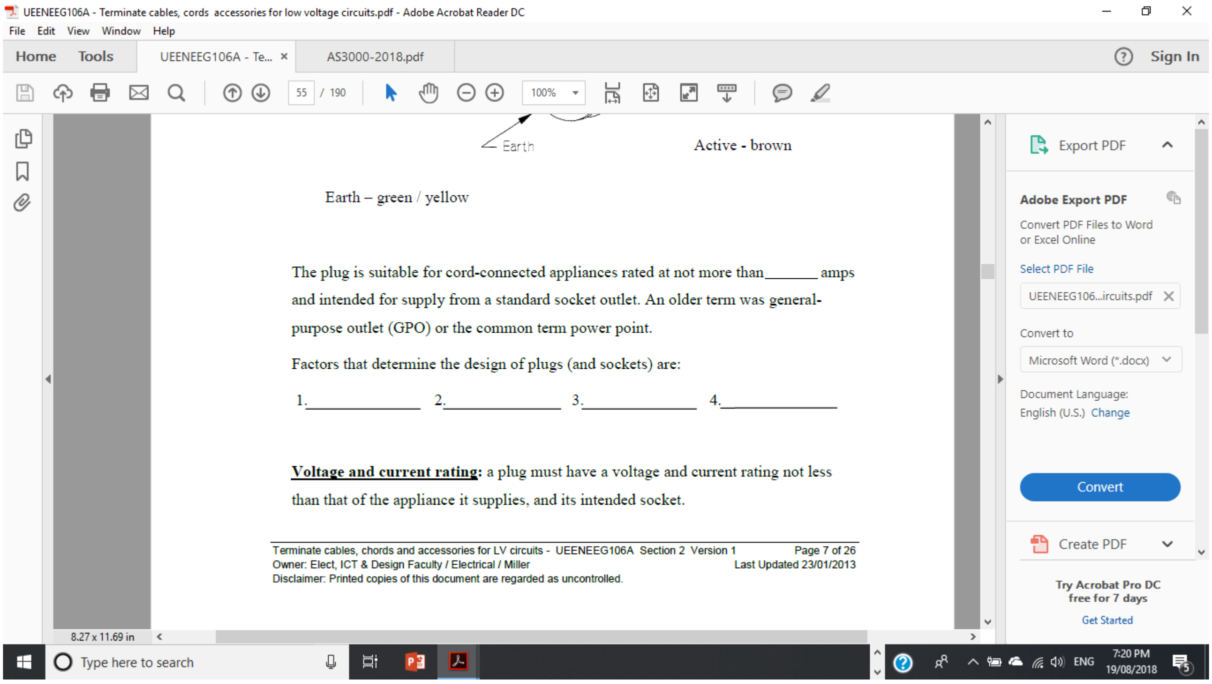
Clean the baseboard surface with isopropyl alcohol, wipe gently and let dry. 2. Remove the Command™ Clear Round **Cord** Clips and adhesive strips from the packaging, and separate the strips from one another. Remove black "**wall** side" liner and apply strip to desired location.

What is a cable clamp?

Wire rope **clamps** or **cable clamps** are commonly used throughout the construction industry. ... They are used for rigging, temporary guardrail systems, securing loads, and basically anything that involves **cables**. If these **clamps** are not used properly, they can lead to the failure of any application.

Appliances not classified as double insulated **must be earthed** and are provided with a terminal specifically for this purpose. The earthing system, (that is conductors and connections), must have a _________ resistance to ensure the fuse or circuit breaker protecting the appliance circuit _______________ quickly in the event of a fault.

Low/ trip



Earth

Active - brown

Earth – green / yellow

The plug is suitable for cord-connected appliances rated at not more than______ amps and intended for supply from a standard socket outlet. An older term was general-purpose outlet (GPO) or the common term power point.

Factors that determine the design of plugs (and sockets) are:

1.____________ 2.____________ 3.____________ 4.____________

Voltage and current rating: a plug must have a voltage and current rating not less than that of the appliance it supplies, and its intended socket.

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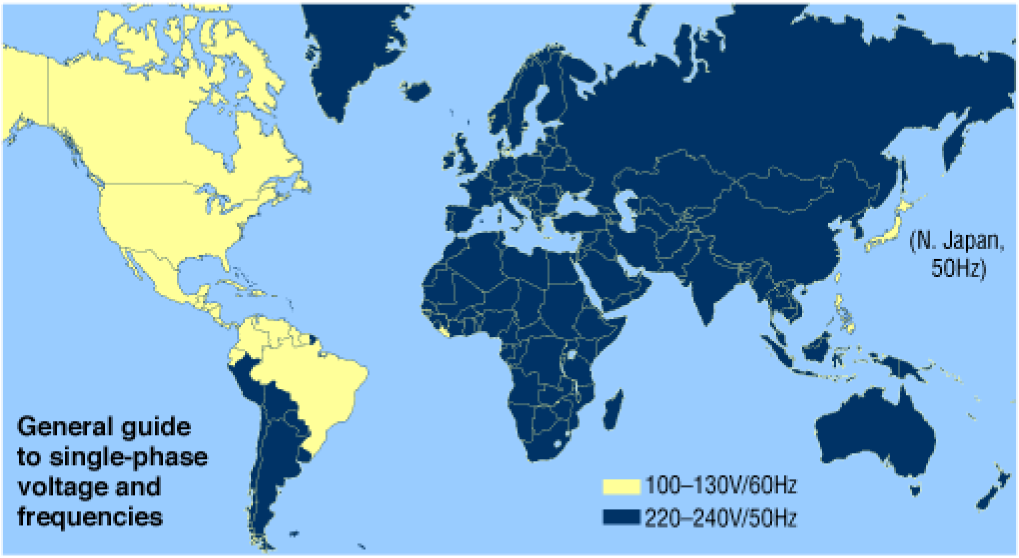
Convenient/ Protection/ Plariizatiomn/

Voltages and Frequencies

In addition to different plug patterns being available, there are also different voltages and frequencies that come into play, varying in different areas of the world.

In many industrialized countries, voltages run on 120V or 230V (except for Japan which uses 100 volts), but voltages can run between 100-250V. Some countries use multiple voltages.

North America, part of South America, part of Japan, and a few other countries run on 60Hz. Most of the rest of the world runs on 50Hz. There are some countries that run on both, such as Japan.



Ratings

A plug and socket have a maximum voltage and amperage rating. The ratings are determined by national and/or international standards. They are set for safety purposes and are often higher than the actual voltage measurement at use. For example, if a Continental European plug is rated for 16 amps at 250 volts, it is unlikely that there will be a constant current of 16A at 250V flowing through the electrical connection. European voltage is standardized at 230V. In the United States, the National Electrical Code sets the standard for the common household use to be 120VAC.

Class I and Class II

Plugs and sockets can be rated for Class I or Class II applications. In a Class I application, the component must have the ability to provide grounding. In a Class II application, there is no grounding required.

Even though some electrical systems in developing countries may be ungrounded, it is not recommended to cut off the ground pin of a Class I plug so that it can fit into a two-pole, ungrounded socket. This eliminates the safety ground connection and will cause the plug or socket to lose its approval. It is better to use a Class II plug on a power cord or cord set, than alter a Class I assembly.

Polarized and Non-Polarized

Polarized can have two meanings: electrical or pin. Electrical polarization means there is a standardized method of wiring the plug or socket to circuit wires. The circuit wires need to connect correctly to the line, neutral, and ground contact points on the plug and socket. The components mirror the electrical circuit. Pin polarization means there is a dedicated alignment of the pins—there is only one way of the plug fitting into the socket. Note: Even though a plug is pin polarized, it doesn't necessarily mean it is also electrically polarized.

All polarized and non-polarized plugs will fit into a polarized socket, but polarized plugs will not fit into a non-polarized socket. The need for one or the other is equipment specific—what is required within the equipment internal circuitry. It depends on if the requirements of the end product need a defined electrical path of the line current, or whether it doesn't matter which leg of the power is connected to the internal circuitry.

Approvals

It's also essential to include the correct plug and socket in the product design in order to follow the specific standard of the country of export. In most countries, approval documentation is needed in order for the final product to be accepted into that country.

1. What is the difference between a 10A 250V socket and 15A 250V socket?

Size of pin hole is bigger in 15A 250V socket

2. What is thence between a 10A 250V socket and 20A 250V socket?

Size of pin hole is bigger in 15A 250V socket

3. Would a 15A 250V plug fit into a 10A 250V socket? (explain your answer)

No Size of pin hole is bigger in 15A 250V socket

4. Would a 15A 250V plug fit into a 25A 250V socket? (explain your answer)

No

5. How would the switch mechanism that controls a 10A socket vary from a switch mechanism that controls a 25A socket?

CLI10MDPLGY

SWITCHED SOCKET MECHANISM 10A LT P/MNT. range of product: Standard Series - product brand: Clipsal - quantity per set: set of 1 - cover type: complete housing. Benefits: .. Applications: ..

Product Attributes

Colour	Grey
Cover	Complete housing
Depth of device	33 mm
Height of device	43 mm
Imprint/indication	Without imprint
Label space/information surface	No
Model	Earthing pin
Mounting method	Flush mounted (plaster)

Nominal current	10 A
Nominal voltage	250 V
Number of socket outlets switchable	1
Number of units	1
Type of fastening	Mounting with screw
Width of device	42 mm
With function lighting	No
With hinged lid	Yes
With orientation lighting	No
UOM	Each

25A

it is designed for hardwired installation

Male 3 pin **plug 25 Amps**. 3 flat pins with a bent top on the earth pin

Discuss and list 3 possible hazards that may occur as a result of a plug-top being rotated or inserted into the wrong socket.

(1)It will **overload** an extension lead by plugging in appliances that together will exceed the maximum current rating stated for the extension lead. This could cause the **plug** in the wall **socket** to overheat and possibly cause a fire.

(2)Equipment will be over voltaged and damaged

(3)Wrong polarity can happen

1. The international colour code for three core flexible cords for use with single-phase appliances is:
(a) Blue active; Black neutral; Green/yellow earth
(b) Brown active, Black neutral; Green earth
(c) Red active; Black neutral; Green earth
(d) Brown active; Blue neutral; Green/yellow earth
2. The international protection rating (IP) of a plug or socket indicates the level of protection against:

(a) Fault currents
(b) Over voltage
(c) The ingress of moisture and foreign bodies
(d) Earth faults

3. A 230V double insulated portable electric drill must:

(a) Have a minimum earth resistance of 1ohm
(b) Have a resistance between active and neutral terminals greater than 1 M ohms (1,000,000 ohms).
(c) Not be earthed
(d) have an insulation resistance not exceeding 1M ohms

4. The continuity of a flexible cord is best tested using:

(a) An ohmmeter
(b) Test lamps
(c) A voltmeter
(d) A test pencil

5. Before working on a cord-connected appliance it is important to first:
(a) Remove the appliance terminal cover
(b) Test the appliance with an insulation tester
(c) Test the supply at the appliance terminals
(d) Isolate the appliance by removing the plug from the socket

6. The resistance between the active and neutral pin of the plug top used to connect an appliance, should be:

(a) Less than 2 ohms
(b) Greater than 2 ohms
(c) Greater than 1 M ohms
(d) Determined by the wattage rating of the appliance

7. “Figure eight” type flexible cords may be used for:

(a) Double insulated appliances
(b) Hand held appliances only
(c) Double and single insulated appliances
(d) Appliances fitted with robust metal jackets, to provide mechanical protection

Figure 8 cable is most commonly used with telephone **cables** because it is often run overhead into residential and commercial areas. The messenger wire in a **Figure 8 cable** is made of extra strength galvanized steel with a zinc coating that prevents the steel from rust and increases the lifespan of the messenger.J

8. The CSA of the conductors in a flexible cord used to supply an appliance is determined by the:

(a) Mechanical stresses that the cord will be subjected to
(b) Load current required by the machine
(c) Amount of flexing that the cord will be subjected to
(d) Insulating ability of the cable covering material

9. Why is the earth pin of a three-pin plug longer than the other two?

___

Earthing is applied before electrical current flows into the equipment to protect the leakage of electrical current into the body

10. Why is the earth pin of a three-pin plug sometimes wider than the other two?

___

To reduce earth resistance

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The main reasons for use of TPS wiring systems include:

- It is quickly and easily ___ for surface work
- It is even more ___ for concealed systems
- If used with all ___ accessories it forms a complete double insulated system. (*1.4.60c*)
- Available with or without an ___ conductor (earth conductor will simplify some installations)

Wired/ flexible /Electrical/earthing

The disadvantages to using TPS wiring include:

- It is prone to ___ damage during installation and in use.
- It can be damaged by rodents.
- The presence of excessive ___ can damage or degrade it.
- The PVC sheath is chemically inert in most environments, but there is a likelihood of solvents affecting cable insulation *(Organic solvents (acetone and ketone) and oxidising acids (nitric and sulphuric acids))*

Mechanical/ temperature

Applications

- Commercial and domestic ___ and ___ circuits
- Underground wiring, if suitably ___ – Clause 3.11 & Table 3.6

- Certain external situations (preferably UV protected)

Applications/ wiring

Protected

TPS *cables* are categorised as either ______________ or _______________.

Flat/ Circular

The sheath of flat TPS cables is normally white, black or grey. Red sheathed cable is usually for ______________________ systems. Circular TPS usually has an orange sheath.
Red electrical wire indicates the secondary live **wires** in a 220-volt circuit, used in some types of switch legs and in the interconnection between smoke detectors that are hard-wired into the power system.

2. TPS CABLES USED IN TRUNKING SYSTEMS

What is trunking?
Read the definitions in AS/NZS 3000:2007 *Clause* _____________ (trunking) and *Clause* _____________ (duct) to answer the question.

1.4.127 Trunking, cable

A trunk or trough for housing and protecting electrical cables and conductors.

Restrictions for use
AS/NZS 3000, *Clause* ___________ outlines requirements for trunking systems.
General requirements on use of wiring enclosures are in AS/NZS 3000 *Clause* ___________ – Enclosure of cables
The maximum number of cables in a trunking system is only limited by the space available for the cables. Furthermore, it should permit installation of the cables without _______________.
The cable rating ________________ if more than one circuit is in the trunking.

Is derated

3.10.3.9 Cable trunking

Cable trunking installations shall be installed as follows:

(a) Covers shall be able to be opened, where practicable.

(b) Covers shall be continuous when passing through walls or floors.

(c) Cable trunking shall be accessible through its entire length.

(d) Cables installed in a trunking shall not rely on any readily removable cover for support.

(e) Non-hygroscopic trunking shall be used to enclose insulated, unsheathed conductors

.

(f) Live parts of accessories mounted on cable trunking shall be arranged so that basic protection is provided, in accordance with Clause 1.5.4.

NOTE: See Clause 3.9.9.3 for requirements for penetration of fire-rated constructions.

H4.4 Enclosed wiring systems

The following recommendations apply to enclosed wiring systems:

(a) If mechanical protection of the wiring system is achieved by an additional enclosure, the protection may be in the form of—

(i) a complete enclosure, such as a conduit, pipe, trunking or other housing; or

(ii) a barrier that is interposed between the wiring system and the possible source of impact.

In both cases, the protection needs to be capable of resisting the impact load.

(b) If cables are contained in conduit or piping, such enclosure should be type tested for the impact energy and ambient temperature range of the location in which it is installed.

(c) If cables are installed in a cable trunking, on a cable tray with covers, or in a similar manner, the enclosure should be type tested

Segregation

The Australian Communications Authority (ACA) Regulations and AS/NZS 3000 *Clauses* 3.9.8.3 and 3.9.8.4 require low voltage cables to be segregated from cables of other systems, particularly ______________________________ services.

Telecommunication

Where it is possible to remove the cover of cable trunking without the use of tools, you should install _________ cables in the trunking. Refer to AS/NZS 3000 *Clause 3.10.2.1c.*

3.10.2 Wiring enclosures

3.10.2.1 Types

The following types of wiring enclosures may be used for the protection of cables requiring enclosure as specified in Clause 3.10.1:

* (a) Conduits in accordance with AS/NZS 2053 series or the AS/NZS 61386 series, including—

(i) steel conduits or other metal tubing or conduit;
(ii) flexible metal conduit;
(iii) rigid and flexible insulating conduit; and
(iv) corrugated insulating conduit.

* NOTE: Refer to Appendix N for information on compatibility of conduit classifications in the AS/NZS 2053 series and AS/NZS 61386 series.

b) Cable trunking systems in accordance with AS/NZS 4296, with or without compound filling.
(c) Other wiring enclosures providing mechanical protection at least equivalent to those listed in Items (a) and (b).
Covers of wiring enclosures containing unsheathed cables shall be effectively retained in position and, where installed in a readily accessible position, shall not be removable without the use of tools.

Sheathed cable

Page 79

Cable duct is a ____________ passage for cables, so they must be drawn in after the installation of the duct. (i.e. no access apart from either end or at joins) If the duct is in the form of a pipe, it will be classified as a duct only if it has a diameter 75 mm or greater (otherwise it is known as ____________).

Wiring Duct **Wiring ducts** are rigid trays typically used as raceways for **cables** and wires within electrical enclosures. **Wiring ducts**, along with **conduit**, wireways,

Cable duct is made from sheet steel, and can be formed into a range of combinations of widths and heights so it is easy to find a size to fit your installation's needs.

Mutual heating of bunched cables will lead to cable current '_____________'.
Derating

The cables are in a position ______________________________________, (suspended ceilings – 3.9.3.2) so you do not need any further *enclosure* or protection.
Loom wiring is a system in which ____________ cables are installed in the space between the underside of a concrete slab or roof structure and a false ceiling, for the supply of plug in lighting units.
o. A **wiring loom**, also known as a harness, wire harness, cable assembly, wiring assembly or wiring harness, is an assembly of wires which transmit signals or electrical power. The wire looms are bound together by braiding, straps, cable ties, cable lacing,
sleeves, electrical tape, conduit, a weave of extruded string, or a combination thereof. So,

the word wiring harness and wire loom are interchangeable. In the dictionary it says that the word loom means: “An apparatus for making thread or yarn into cloth by weaving strands together at right angles.”

3.9.3.2 Suspended ceilings

The following conditions apply to the installation of wiring systems in suspended ceilings:

(a) Wiring systems may be supported by the suspended ceiling system unless this is not permitted by the suspended ceiling manufacturer.

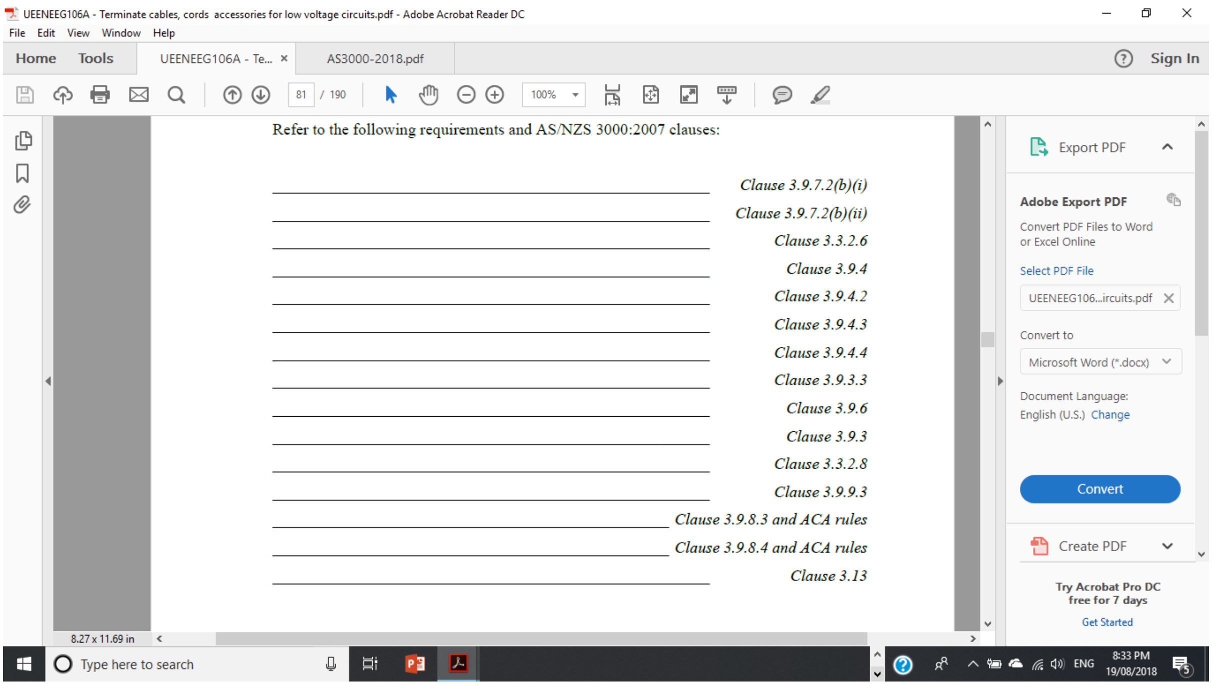
(b) Cables shall be provided with additional protection against mechanical damage where in contact with conductive ceiling support runners.

(c) Wiring systems installed above suspended ceilings shall be fixed at suitable intervals to prevent undue sagging of cables.

NOTES:

1 Suspended ceilings referred to in this Clause do not include timber systems to AS/NZS 2589.1 and timber building Standards.

2 National building codes may restrict the use of suspended ceilings to support services.



Refer to the following requirements and AS/NZS 3000:2007 clauses:

______________________ *Clause 3.9.7.2(b)(i)*

______________________ *Clause 3.9.7.2(b)(ii)*

______________________ *Clause 3.3.2.6*

______________________ *Clause 3.9.4*

______________________ *Clause 3.9.4.2*

______________________ *Clause 3.9.4.3*

______________________ *Clause 3.9.4.4*

______________________ *Clause 3.9.3.3*

______________________ *Clause 3.9.6*

______________________ *Clause 3.9.3*

______________________ *Clause 3.3.2.8*

______________________ *Clause 3.9.9.3*

______________________ *Clause 3.9.8.3 and ACA rules*

______________________ *Clause 3.9.8.4 and ACA rules*

______________________ *Clause 3.13*

Read them in AS3000:2018 Do yourself

7. INSULATION RESISTANCE (MEGGER TEST) (CLAUSE 8.3.6)

________ DC is used to ‘stress’ the insulation to ensure resistance between all live conductors & EARTH exceeds _______ (1 million ohms) or _________ (10,000 ohms) for appliances with heating elements

8.3.6.2 Method

The integrity of the insulation is stressed by applying a direct current at 500 V for low voltage circuits.

Exceptions:

1 Where equipment, such as electromagnetic compatibility (EMC) filters, equipment containing surge protective devices connected to earth, or electronic equipment, is likely to be damaged by the test—

・ such equipment may be disconnected or switched off before carrying out the insulation resistance test on the circuit; or

・ the test voltage for the particular circuit may be reduced to 250 V d.c.

2 Where connected equipment, such as sheathed heating elements of appliances or an RCD with an FE connection, is likely to influence the verification test, the equipment may be disconnected before carrying out the insulation resistance test on the circuit and the equipment tested separately.

The insulation resistance tester used shall be able to maintain its terminal voltage within +20% and ・10% of the nominal open circuit terminal voltage, when measuring a resistance of 1 M・ ・ on the 500 V range or 10 M・ ・ on the 1000 V range.

8.3.6.3 Results

The insulation resistance between—

(a) the conductors of consumer mains and submains; and

(b) live and earthed parts of an electrical installation, or parts thereof, including consumer mains and submains,

shall be not less than 1 M・.

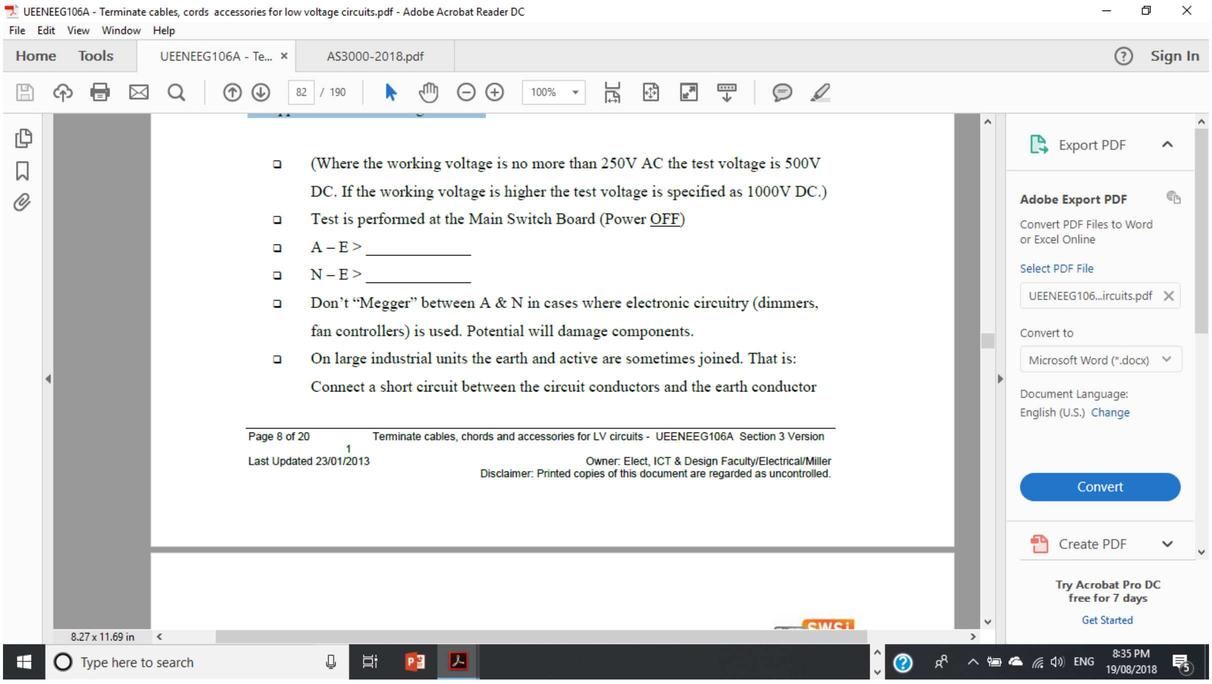
* Exceptions:

Acceptable insulation resistance values for items likely to adversely affect test results are as follows:

1 For sheathed heating elements of appliances; not less than 0.01 M・ .

2 A value permitted in the Standard applicable to the electrical equipment.

3 For functional earth connections of RCDs; not less than 0.05 M・ , or as prescribed by the manufacturer.


UEENEEG106A - Terminate cables, cords accessories for low voltage circuits.pdf - Adobe Acrobat Reader DC

- (Where the working voltage is no more than 250V AC the test voltage is 500V DC. If the working voltage is higher the test voltage is specified as 1000V DC.)
- Test is performed at the Main Switch Board (Power OFF)
- A – E > ___________
- N – E > ___________
- Don't "Megger" between A & N in cases where electronic circuitry (dimmers, fan controllers) is used. Potential will damage components.
- On large industrial units the earth and active are sometimes joined. That is: Connect a short circuit between the circuit conductors and the earth conductor

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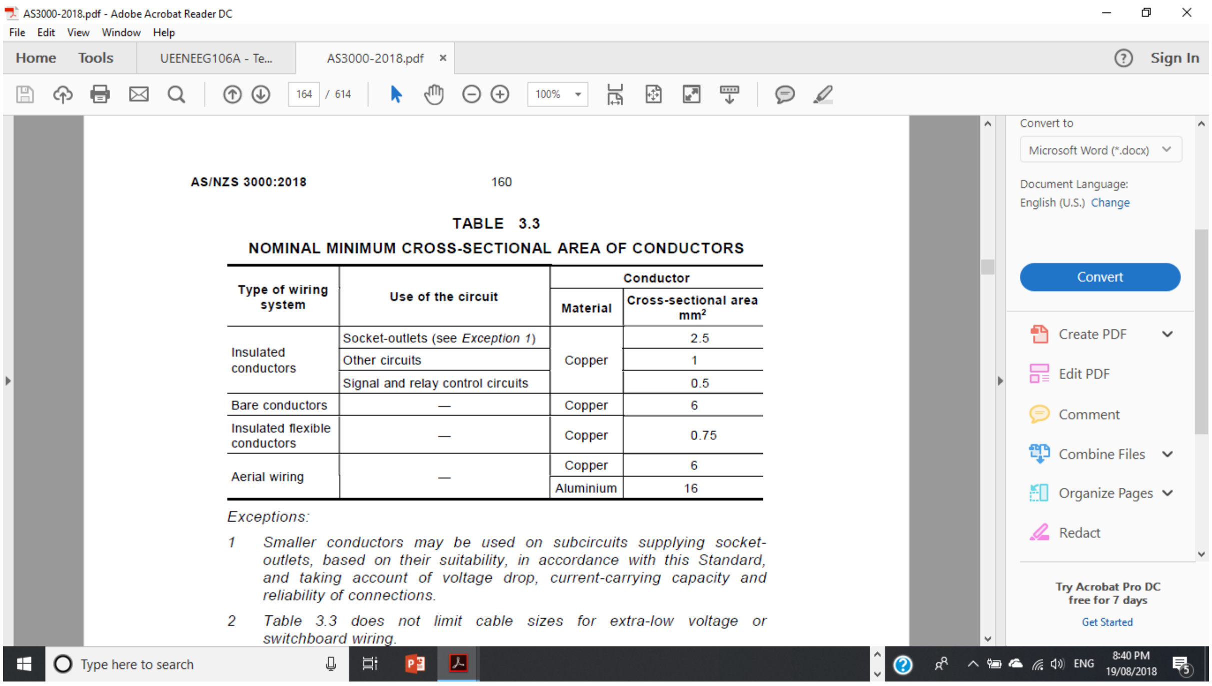
Tutorial 3

1. Determine the minimum size of cable required for the two socket outlets, wired in TPS cable and enclosed in skirting duct ____**AS/NZS3000** T3.3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AS/NZS 3000:2018 160

TABLE 3.3
NOMINAL MINIMUM CROSS-SECTIONAL AREA OF CONDUCTORS

Type of wiring system	Use of the circuit	Conductor: Material	Conductor: Cross-sectional area mm²
Insulated conductors	Socket-outlets (see *Exception 1*)	Copper	2.5
	Other circuits		1
	Signal and relay control circuits		0.5
Bare conductors	—	Copper	6
Insulated flexible conductors	—	Copper	0.75
Aerial wiring	—	Copper	6
		Aluminium	16

Exceptions:

1 *Smaller conductors may be used on subcircuits supplying socket-outlets, based on their suitability, in accordance with this Standard, and taking account of voltage drop, current-carrying capacity and reliability of connections.*

2 *Table 3.3 does not limit cable sizes for extra-low voltage or switchboard wiring.*

2.5 sqmm

2. Determine the minimum conductor size required for the lighting circuit, wired in TPS cable and enclosed in PVC duct ____**AS/NZS3000** T3.3 1 sqmm

3. What segregation is required when installing telephone and low voltage cables in skirting duct?

____

____

____________________ **AS/NZS3000** 3.9.8.4.c

(c) Telecommunication services Requirements for the separation of telecommunications cables from low voltage and high voltage systems are provided—

(i) for Australia, in AS/CA S009; and

(ii) for New Zealand in the NZ Telecommunications Forum (TCF) Premises Wiring Guidelines.

Separation from telecommunications services shall be as shown in Figures 3.8 and 3.9.

NOTE: The documents listed in Item (c) contain distances and other measures for the separation of telecommunications cables from low voltage cables as follows:

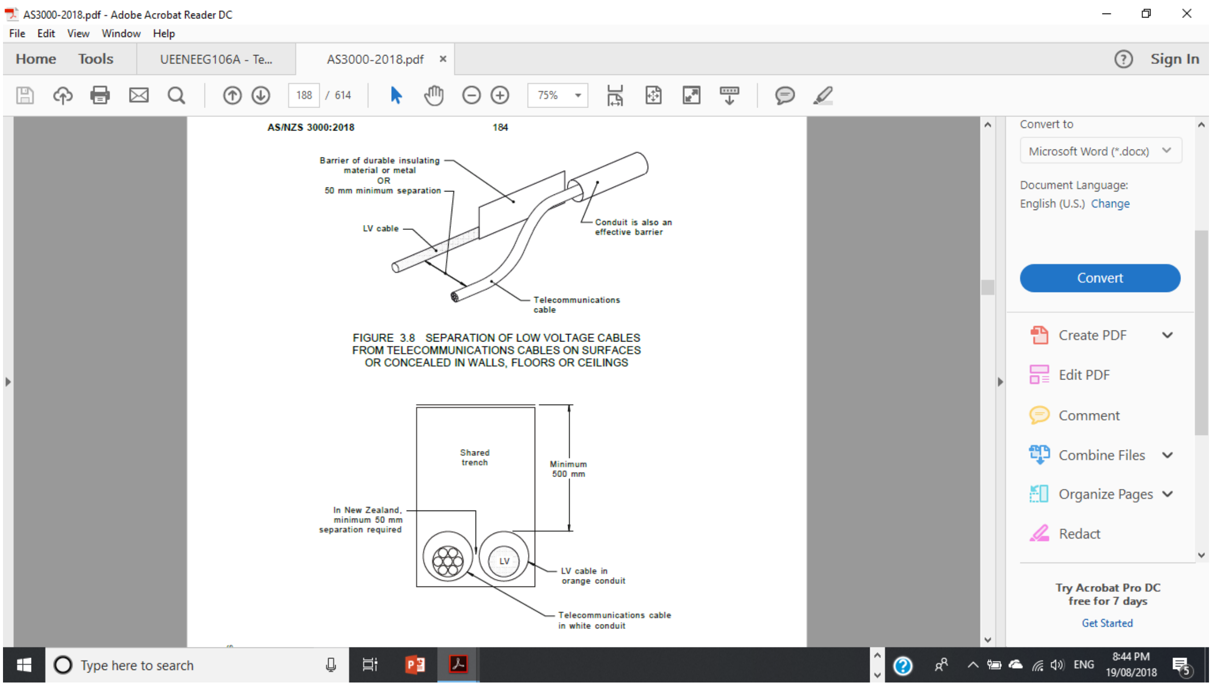
(a) On surfaces or concealed in walls, floors or ceilings, such as depicted in Figure 3.8.

(b) Cables in common ducting.

(c) In underground trenches, such as depicted in Figure 3.9.

(d) Under-carpet wiring.

(e) Aerial cables.



50mm

4. What is the definition of cable trunking

____

__________________________________**AS/NZS3000** 1.4.97

1.4.127 Trunking, cable
A trunk or trough for housing and protecting electrical cables and conductors.

5. What is the polarisation (polarity) of a single phase three pin socket outlet?

____

____

_____________________**AS/NZS3000** 4.4.5

4.4.5 Polarization and phase sequence
Where socket-outlets of the same type form part of an electrical installation, the order of connection of the socket-outlets shall be the same.
All socket-outlets that accommodate three-pin/flat-pin plugs shall be connected so that, when viewed from the front of the socket-outlet, the order of connection commencing from the slot on the radial line shall be earth, active, neutral in a clockwise direction.

6. What is the definition for Cable duct

____

__________________________________**AS/NZS3000** 1.4.42

1.4.42 Duct
A pipe of 75 mm diameter or greater, or a closed passage formed underground or in any structure and intended to receive one or more cables that may be drawn in.

7. Is it permissible to use single insulated cable in PVC trunking?
____**AS/NZS3000** 3.10.2.1
Yes

8. In an area that is likely to be disturbed, what is necessary for the removal of the covers of cable trunking? ____**AS/NZS3000** 3.10.2.1

Covers of wiring enclosures containing unsheathed cables shall be effectively retained in position and, where installed in a readily accessible position, shall not be removable without the use of tools.

9. Describe the maximum spacing for supports for cables installed in positions considered as `likely to be disturbed'.

____

____

_____________________**AS/NZS3000** 3.9.3.3

Exceptions:
1 Where a wiring system is resting on an immovable continuous surface no further support is required.

2 Any specific methods of fixing outlined in this Standard shall not prohibit the use of alternative methods, provided that an equivalent degree of support and strength is maintained.

3.9.3.2 Suspended ceilings

The following conditions apply to the installation of wiring systems in suspended ceilings—

(a) wiring systems may be supported by the suspended ceiling system unless this is not permitted by the suspended ceiling manufacturer; and

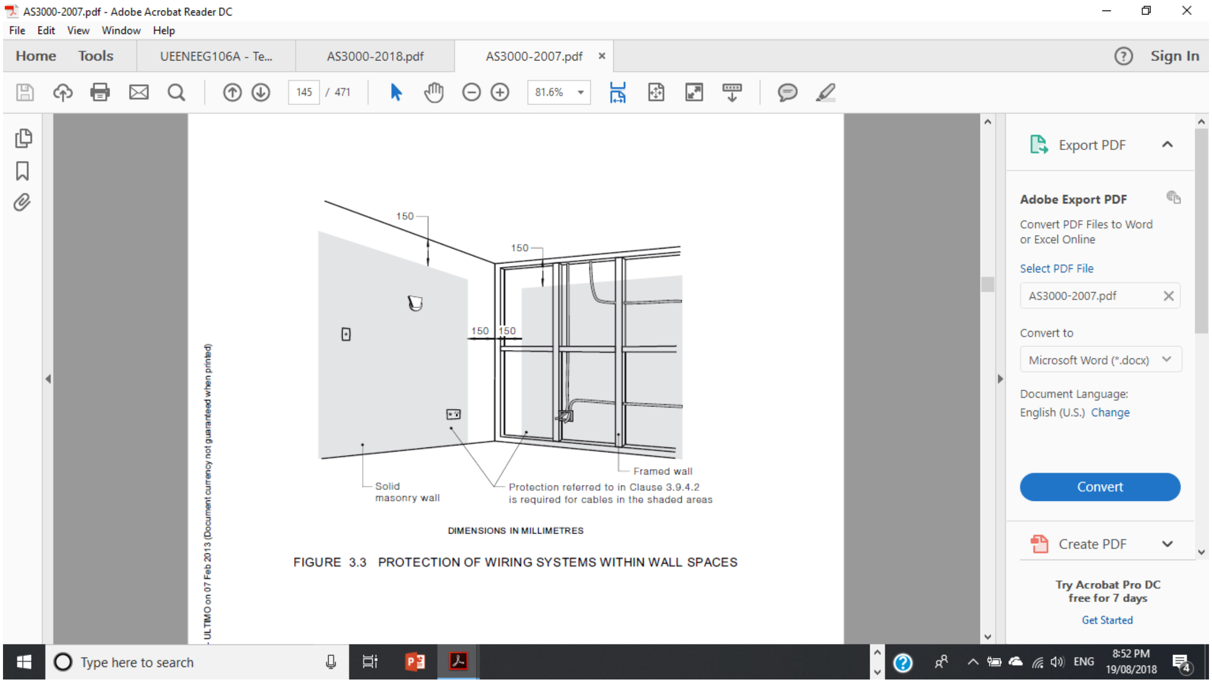
(b) cables shall be provided with additional protection against mechanical injury where in contact with conductive ceiling support runners; and

(c) wiring systems installed above suspended ceilings shall be fixed at suitable intervals to prevent undue sagging of cables.

NOTES:

1 Suspended ceilings referred to in this Clause do not include timber systems to AS/NZS 2589.1 and timber building Standards.

2 National Building Codes may restrict the use of suspended ceilings to support services.



150mm

10. When can the earthing conductor be less than 2.5mm2?

____

________________________________**AS/NZS3000** T5.1

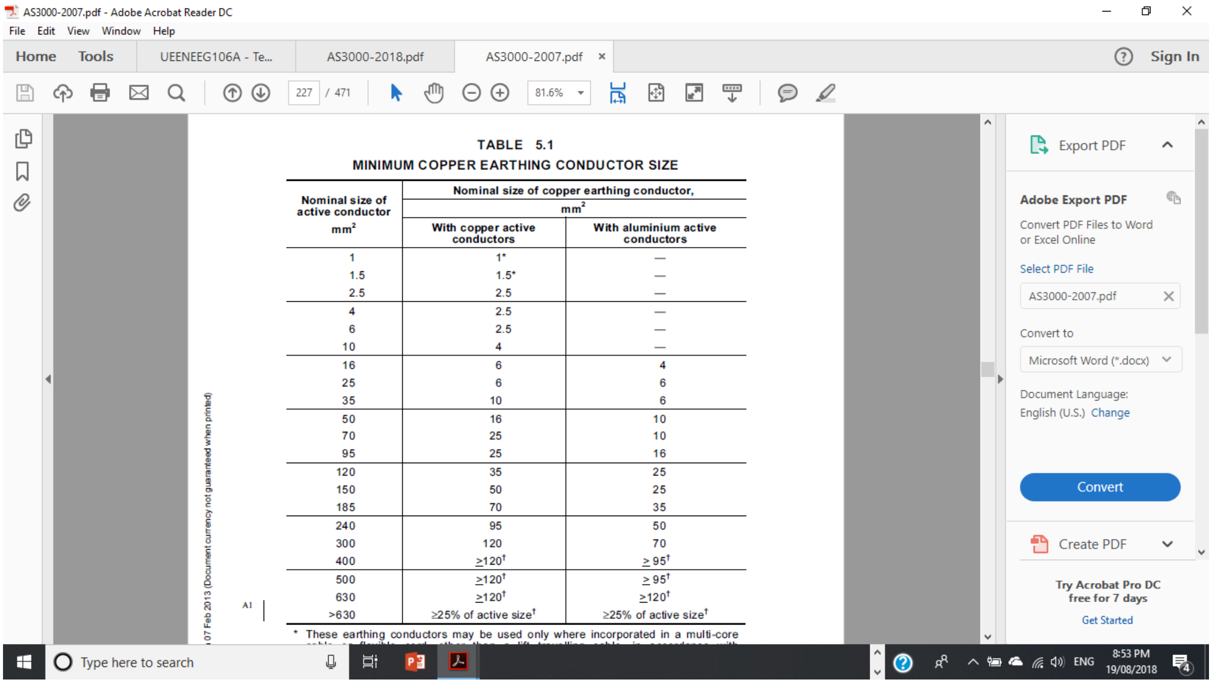


TABLE 5.1

MINIMUM COPPER EARTHING CONDUCTOR SIZE

Nominal size of active conductor mm²	Nominal size of copper earthing conductor, mm²	
	With copper active conductors	With aluminium active conductors
1	1*	—
1.5	1.5*	—
2.5	2.5	—
4	2.5	—
6	2.5	—
10	4	—
16	6	4
25	6	6
35	10	6
50	16	10
70	25	10
95	25	16
120	35	25
150	50	25
185	70	35
240	95	50
300	120	70
400	≥120†	≥ 95†
500	≥120†	≥ 95†
630	≥120†	≥120†
>630	≥25% of active size†	≥25% of active size†

* These earthing conductors may be used only where incorporated in a multi-core

Exception: The size of the main earthing conductor need not be determined in relation to the size of the largest active conductor of the consumers mains under the following conditions:

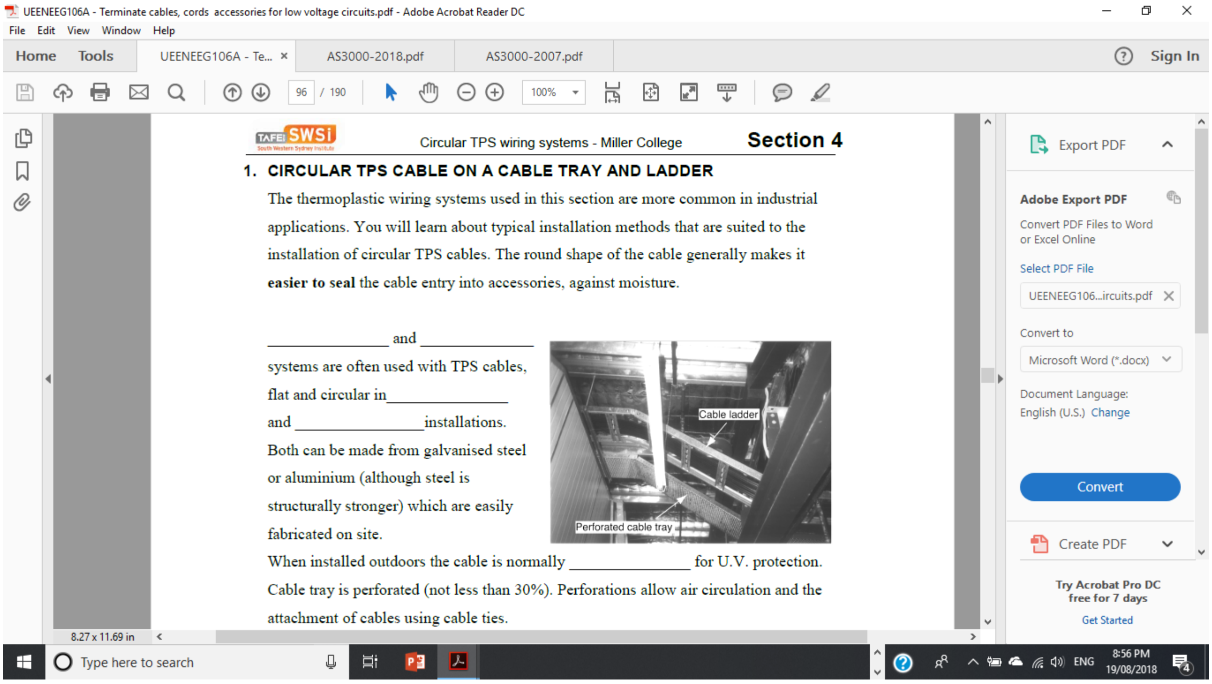
(a) Where double insulation is maintained between the point of supply and the load terminals of the protective devices for the submains and final subcircuits outgoing from the main switchboard. The minimum size of the main earthing conductor may be determined in relation to the cross-sectional area of the largest active conductor of the largest outgoing submain or final subcircuit.

(b) Where the cross-sectional area of the consumers mains is larger than that required to carry the maximum demand of the installation because of voltage-drop limitations. The minimum size of the main earthing conductor may be determined in relation to the cross-sectional area of the minimum cable size required to carry the maximum demand.

11. Answer review questions 1, 2 & 24 from page 343 and questions 1 -8 on page 364 in your textbook.

____

____



Circular TPS wiring systems - Miller College **Section 4**

1. CIRCULAR TPS CABLE ON A CABLE TRAY AND LADDER

The thermoplastic wiring systems used in this section are more common in industrial applications. You will learn about typical installation methods that are suited to the installation of circular TPS cables. The round shape of the cable generally makes it **easier to seal** the cable entry into accessories, against moisture.

_____________ and _____________ systems are often used with TPS cables, flat and circular in_____________ and _____________installations. Both can be made from galvanised steel or aluminium (although steel is structurally stronger) which are easily fabricated on site.

When installed outdoors the cable is normally _____________ for U.V. protection. Cable tray is perforated (not less than 30%). Perforations allow air circulation and the attachment of cables using cable ties.

________________ and _______________ systems are often used with TPS cables, flat and circular in________________ and _________________installations.

Electrical/ Telecommunication

Thermoplastic-sheathed cable (TPS) consists of an outer toughened sheath of polyvinyl chloride (PVC) (the thermoplastic element) covering one or more individual cables which are PVC insulated annealed copper conductors. It is a commonly used type of wiring for residential and light commercial construction in many countries. The flat version of the cable with two insulated conductors and an uninsulated earth conductor all within the outer sheath is referred to as twin and earth. In mainland Europe, a round equivalent is more common

When installed outdoors the cable is normally ________________ for U.V. protection.
Cable tray is perforated (not less than 30%). Perforations allow air circulation and the attachment of cables using cable ties.

Sheathed

2. CABLE DERATING

If not enough space is allowed between cables of other circuits, the amount of cooling air will be restricted possibly causing the cables to _________________. It is necessary to ______________ the maximum current the cable can carry to limit the heat produced in the cable. In other words, the current-carrying capacity of the cable is reduced. This is called

_________________________________.

Figure 1, page 26, in AS/NZS 3008.1.1:2009 shows the **minimum clearance** between cables so they **do not require derating**. This table is shown below.

Overheat / reduce/ derating

5. IP (INTERNATIONAL PROTECTION) RATING OF ACCESSORIES

The degree of protection provided by enclosures of electrical equipment can be determined by the tests of AS 60529. The standard considers the protection of persons against access to hazardous parts ______________ the enclosure, against ____________of solid foreign objects and the ____________________of the equipment inside the enclosure against harmful effects due to the ingress of water.

IP Ratings for Electrical Enclosures

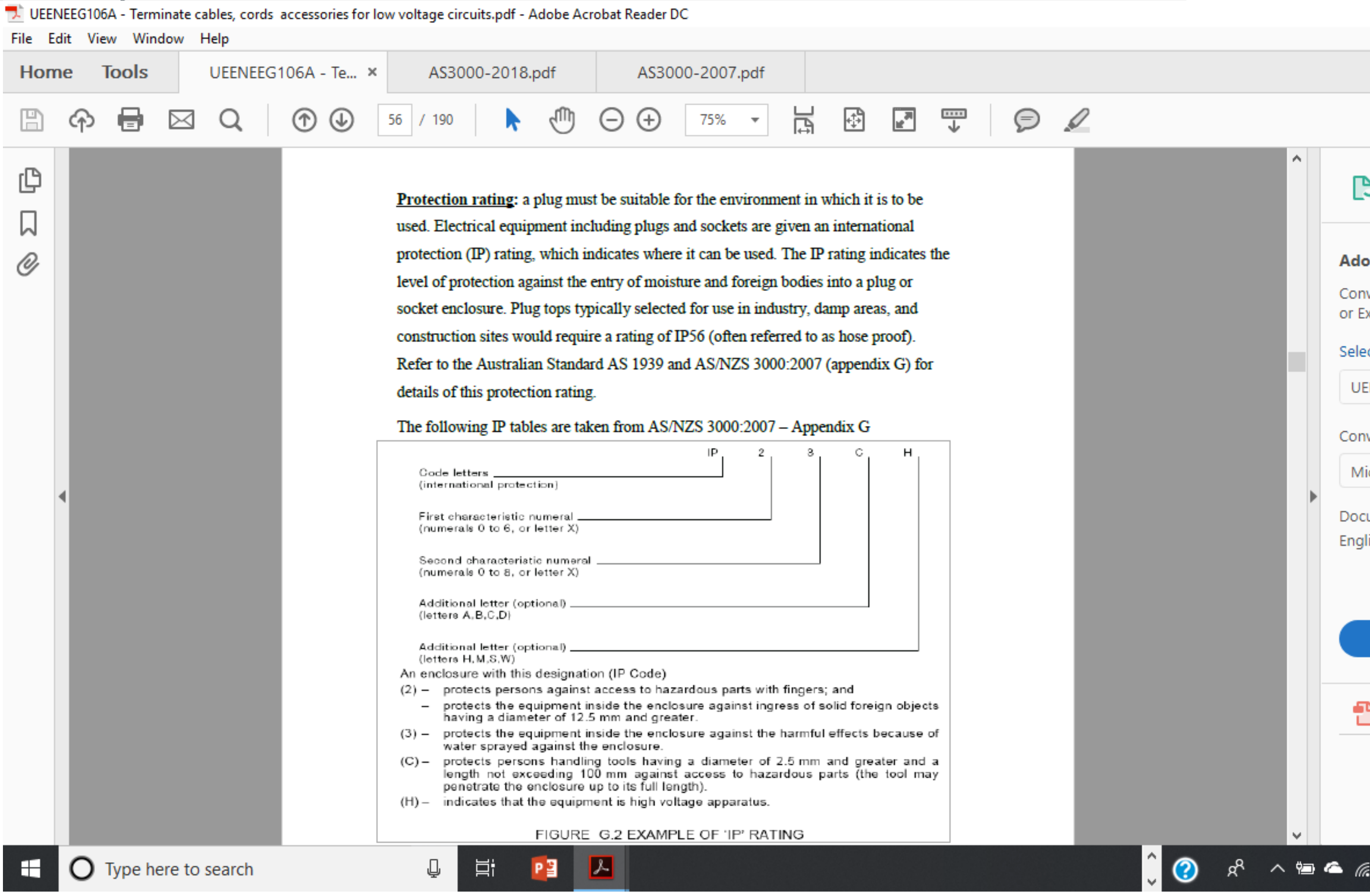
The IP rating (or International Protection Rating, also referred to as Ingress Protection Rating) consists of the letters IP followed by two digits. It is defined by IEC 60529 and classifies the degree of protection against the intrusion of a solid object (e.g. hands, fingers, screwdriver and dust) as the first numeral and protection against water as the second numeral.
IP ratings are often specified for projects and it is important to know that generally any IP rating higher than the one specified will be sufficient for the application. For example, if IP56 is specified you could use IP66, but not IP65 (as the 2nd numeral indicating water protection is too low).

For a full description of what each numeral means, see our **IP Rating Chart** (pdf).

B&R Enclosures industrial products are rated at the following: –

- **IP30** – An access probe of 2.5mm diameter shall not penetrate but no protection against water damage.
- **IP34** – An access probe of 2.5mm diameter shall not penetrate and protected against water splashed from all directions. Limited ingress permitted.
- **IP42** – An access probe of 1.0mm diameter shall not penetrate and protected against sprays to 60°. Limited ingress permitted.
- **IP54** – Limited ingress of dust permitted (no harmful deposit) and protected against water splashed from all directions. Limited ingress permitted.
- **IP55** – Limited ingress of dust permitted (no harmful deposit) and protected against jets of water. Limited ingress permitted.
- **IP56** – Limited ingress of dust permitted (no harmful deposit) and protected against strong jets of water. Limited ingress permitted.
- **IP65** – Totally protected against the ingress of dust and protected against jets of water. Limited ingress permitted.
- **IP66** – Totally protected against the ingress of dust and protected against strong jets of water. Limited ingress permitted.
- **IP67** – Totally protected against the ingress of dust and protected against the effects of temporary immersion between 15cm and 1m.

Search by Material



Protection rating: a plug must be suitable for the environment in which it is to be used. Electrical equipment including plugs and sockets are given an international protection (IP) rating, which indicates where it can be used. The IP rating indicates the level of protection against the entry of moisture and foreign bodies into a plug or socket enclosure. Plug tops typically selected for use in industry, damp areas, and construction sites would require a rating of IP56 (often referred to as hose proof). Refer to the Australian Standard AS 1939 and AS/NZS 3000:2007 (appendix G) for details of this protection rating.

The following IP tables are taken from AS/NZS 3000:2007 – Appendix G

IP 2 3 C H

Code letters (international protection)

First characteristic numeral (numerals 0 to 6, or letter X)

Second characteristic numeral (numerals 0 to 8, or letter X)

Additional letter (optional) (letters A,B,C,D)

Additional letter (optional) (letters H,M,S,W)

An enclosure with this designation (IP Code)

(2) – protects persons against access to hazardous parts with fingers; and
– protects the equipment inside the enclosure against ingress of solid foreign objects having a diameter of 12.5 mm and greater.

(3) – protects the equipment inside the enclosure against the harmful effects because of water sprayed against the enclosure.

(C) – protects persons handling tools having a diameter of 2.5 mm and greater and a length not exceeding 100 mm against access to hazardous parts (the tool may penetrate the enclosure up to its full length).

(H) – indicates that the equipment is high voltage apparatus.

FIGURE G.2 EXAMPLE OF 'IP' RATING

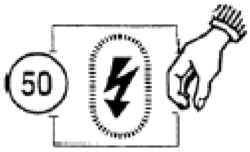
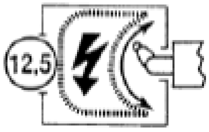
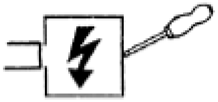
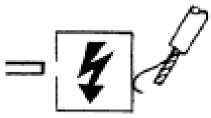
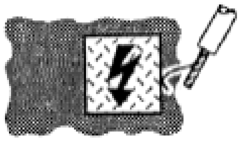
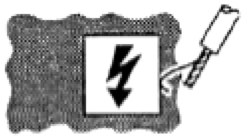
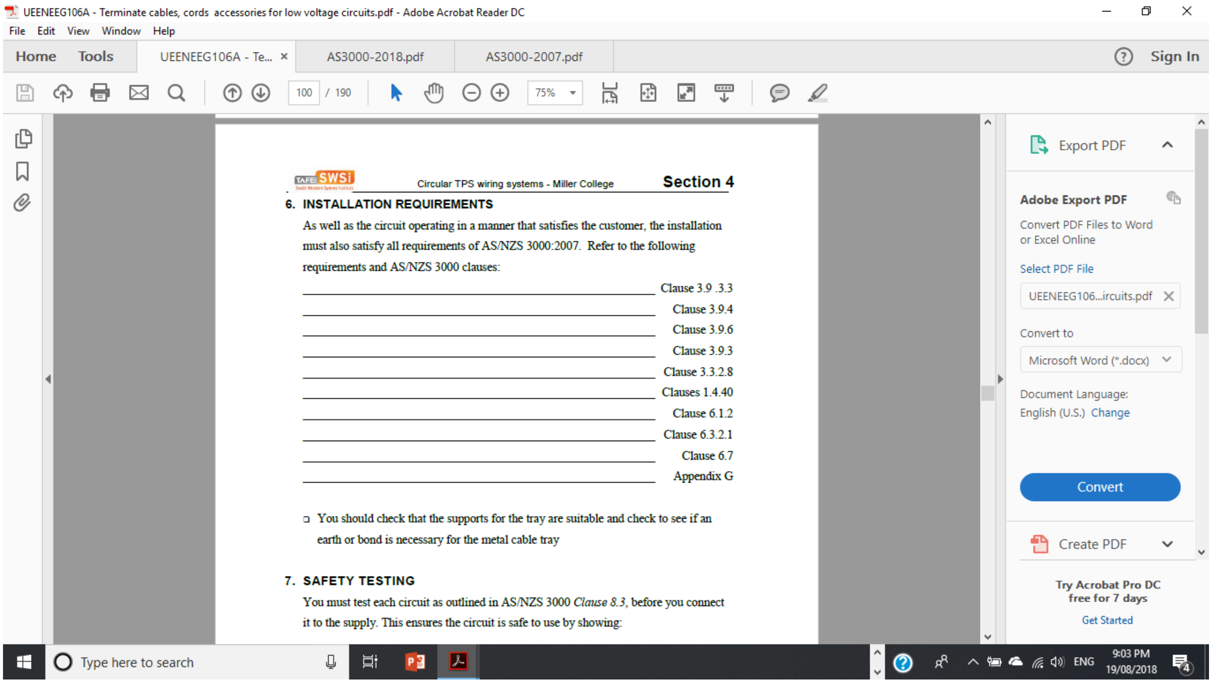
G1a—First numeral—Protection against ingress of solid objects			Protection of persons against access to hazardous parts with:
IP	Requirements	Example	
0	No protection		Non-protected
1	Full penetration of 50 mm diameter sphere not allowed. Contact with hazardous parts not permitted		Back of hand
2	Full penetration of 12.5 mm diameter sphere not allowed. The jointed test finger shall have adequate clearance from hazardous parts		Finger
3	The access probe of 2.5 mm diameter shall not penetrate		Tool
4	The access probe of 1.0 mm diameter shall not penetrate		Wire
5	Limited ingress of dust permitted (no harmful deposit)		Wire
6	Totally protected against ingress of dust		Wire

FIGURE G1 (in part) IP CODES

Do yourself to fill the blanks



Circular TPS wiring systems - Miller College **Section 4**

6. INSTALLATION REQUIREMENTS

As well as the circuit operating in a manner that satisfies the customer, the installation must also satisfy all requirements of AS/NZS 3000:2007. Refer to the following requirements and AS/NZS 3000 clauses:

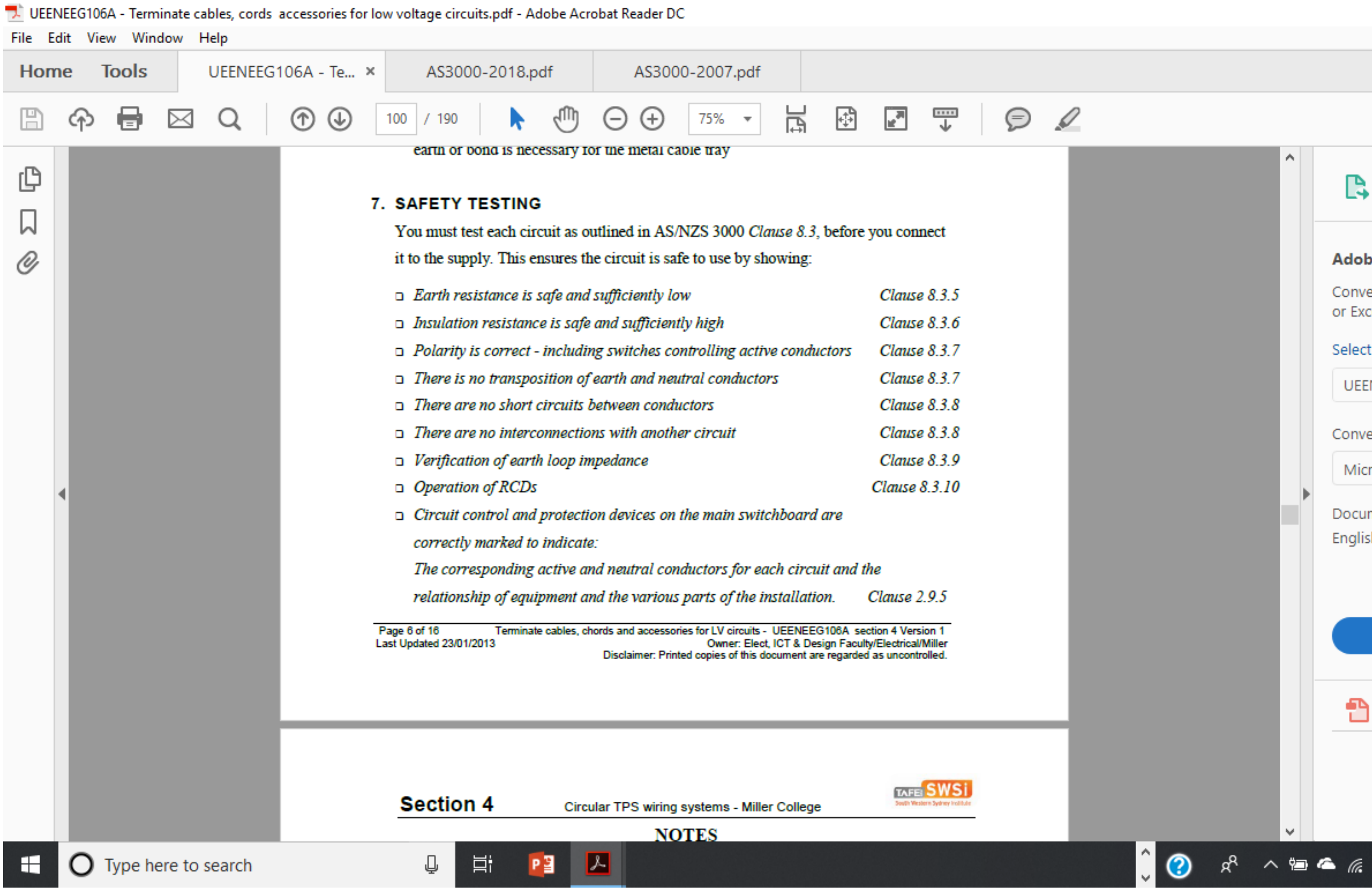
______________________________	Clause 3.9 .3.3
______________________________	Clause 3.9.4
______________________________	Clause 3.9.6
______________________________	Clause 3.9.3
______________________________	Clause 3.3.2.8
______________________________	Clauses 1.4.40
______________________________	Clause 6.1.2
______________________________	Clause 6.3.2.1
______________________________	Clause 6.7
______________________________	Appendix G

- You should check that the supports for the tray are suitable and check to see if an earth or bond is necessary for the metal cable tray

7. SAFETY TESTING

You must test each circuit as outlined in AS/NZS 3000 *Clause 8.3*, before you connect it to the supply. This ensures the circuit is safe to use by showing:

See AS3000:2018



earth or bond is necessary for the metal cable tray

7. SAFETY TESTING

You must test each circuit as outlined in AS/NZS 3000 *Clause 8.3*, before you connect it to the supply. This ensures the circuit is safe to use by showing:

- *Earth resistance is safe and sufficiently low* — *Clause 8.3.5*
- *Insulation resistance is safe and sufficiently high* — *Clause 8.3.6*
- *Polarity is correct - including switches controlling active conductors* — *Clause 8.3.7*
- *There is no transposition of earth and neutral conductors* — *Clause 8.3.7*
- *There are no short circuits between conductors* — *Clause 8.3.8*
- *There are no interconnections with another circuit* — *Clause 8.3.8*
- *Verification of earth loop impedance* — *Clause 8.3.9*
- *Operation of RCDs* — *Clause 8.3.10*
- *Circuit control and protection devices on the main switchboard are correctly marked to indicate:*
  The corresponding active and neutral conductors for each circuit and the relationship of equipment and the various parts of the installation. — *Clause 2.9.5*

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Section 4 Circular TPS wiring systems - Miller College

NOTES

See AS3000:2018

Q1 Where circuits are wired in TPS cable and fixed to metal cable tray, must the cable tray be earthed?

____
____________________________________**AS/NZS3000** __________________

5.4.1.2 Conductive building materials

Conductive building materials shall be earthed in accordance with

Clause 5.4.6.

5.4.1.3 Connection of electrical equipment to earth

Equipment required to be earthed shall be arranged for connection to—

(a) protective earthing conductors in the form of cables, cords, busbars or

similar forms of current-carrying material; or

b) another earthing medium, such as conductive parts of cables, wiring

enclosures, switchboard framework or the like, in accordance with

Clause 5.3.2.

Q2 Which conductor is wired into the circuit breaker?
____**AS/NZS3000** __________________

Active

Clause 2.5.1 requires active conductors to be protected by one or more

protective devices in the event of overload or short-circuit

Q3 What is the minimum insulation resistance acceptable for live parts of cables to earth?
____**AS/NZS3000** __________________

1 Mega Ohm

8.3.6.3 Results

The insulation resistance between—

(a) the conductors of consumer mains and submains; and

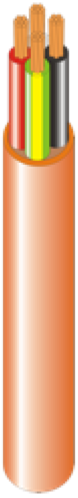
(b) live and earthed parts of an electrical installation, or parts thereof,

including consumer mains and submains,

shall be not less than 1 M · .

Q4 Is the orange circular TPS cable used in the exercises regarded as armoured cable?
____

Yes



Orange Circular Power Cable (0.6/1kV)

Application:	For mains, sub mains and sub circuits unenclosed, enclosed in conduit buried direct or underground ducts for buildings and industrial plants where not subject to mechanical damage. Suitable for glanding.
Conductor:	Plain annealed copper (AS/NZS 1125)
Insulation:	PVC V90
Sheath:	PVC 5V-90
Standards:	AS/NZS 5000.1
Packing Length:	100m, 500m
Normal Operating Temperature:	90°C
Core Colours:	2 Core+ Earth Core Color: Red, Black, Green/Yellow

Q5 To measure the insulation resistance of the circuits, what DC voltage setting on the megger should be used?
____**AS/NZS3000** __________________

8.3.6.2 Method

The integrity of the insulation is stressed by applying a direct current at

500 V for low voltage circuits

Q7 What colours or combination of colours must be used to identify an earthing conductor?
____**AS/NZS3000**__________________

Green/Yellow

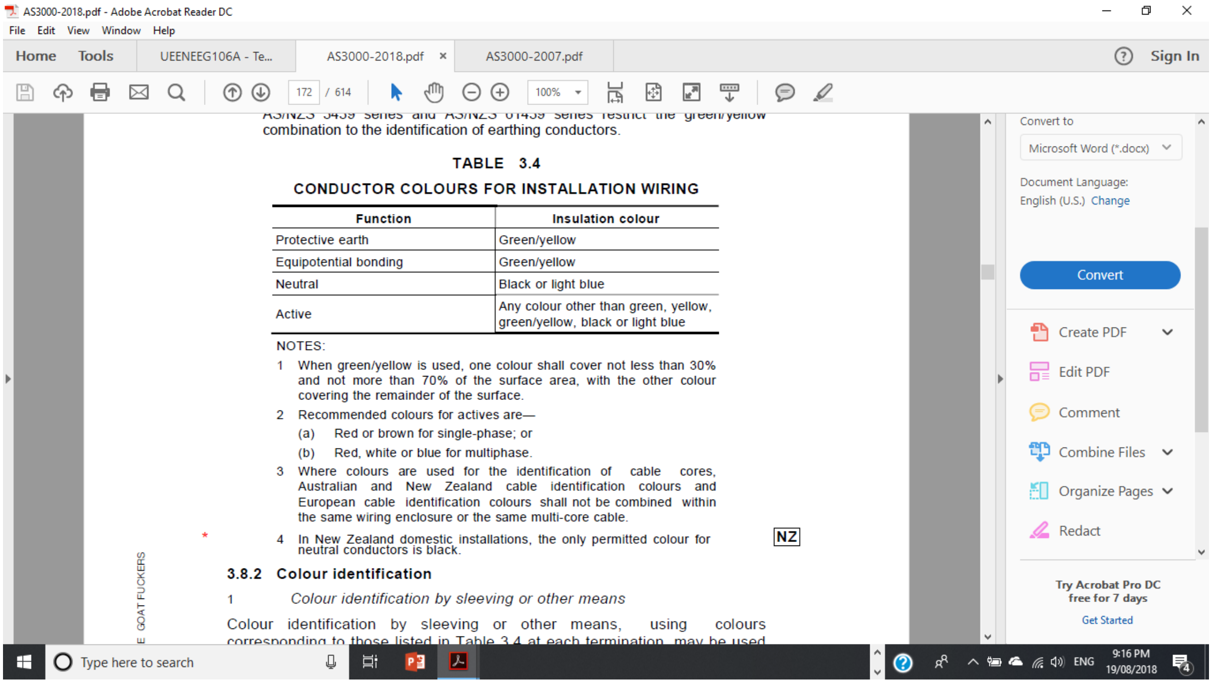

combination to the identification of earthing conductors.

TABLE 3.4

CONDUCTOR COLOURS FOR INSTALLATION WIRING

Function	Insulation colour
Protective earth	Green/yellow
Equipotential bonding	Green/yellow
Neutral	Black or light blue
Active	Any colour other than green, yellow, green/yellow, black or light blue

NOTES:

1 When green/yellow is used, one colour shall cover not less than 30% and not more than 70% of the surface area, with the other colour covering the remainder of the surface.

2 Recommended colours for actives are—

(a) Red or brown for single-phase; or

(b) Red, white or blue for multiphase.

3 Where colours are used for the identification of cable cores, Australian and New Zealand cable identification colours and European cable identification colours shall not be combined within the same wiring enclosure or the same multi-core cable.

* 4 In New Zealand domestic installations, the only permitted colour for neutral conductors is black. NZ

3.8.2 Colour identification

1 *Colour identification by sleeving or other means*

Colour identification by sleeving or other means, using colours corresponding to those listed in Table 3.4 at each termination, may be used

Q8 Can black cable be used for the switch wire of a fixed lighting circuit ____**AS/NZS3000** ______________________

No

3.8 IDENTIFICATION

3.8.1 General

Installation wiring conductors shall be clearly identified to indicate their intended function as active, neutral, earthing or equipotential bonding conductors.

Where identification is achieved using the colour of the conductor insulation, the colours specified in Table 3.4 shall be used.

Q9 How much insulation should be removed when terminating a cable? ____**AS/NZS3000** ______________________

3.7.2.2 Preparation for connection

The insulation on a conductor shall not be removed any further than is necessary to make the connection.

Q10 Electrical connections between conductors and equipment shall provide _____________ continuity, appropriate ______________ and ______________ strength. **AS/NZS3000**___________________

Rating/ Mechanical

4.3.3 Installation wiring connected by an installation coupler(s)

* 4.3.3.1 General

Cords or cables connected by an installation coupler shall be—

(a) of heavy-duty sheathed type complying with AS/NZS 3191 and the requirements of Clause 3.9.7.4 or AS/NZS 5000;
(b) selected to suit the protection device;
Exception: For sections of installation wiring that terminate within a single piece of electrical equipment, such as a luminaire, single socket-outlet or SELV socket-outlet, the cable may be reduced to suit the rating of that single piece of electrical equipment.
(c) adequately protected and installed to minimize the risk of mechanical damage in accordance with Clause 3.3.2.6;
(d) supported and fixed in position in accordance with Clause 3.3.2.8 and Clause 3.9.3.1; and
(e) as short as practicable

4.3 CONNECTION OF ELECTRICAL EQUIPMENT
4.3.1 General
Electrical equipment may be connected to the installation wiring by one of the methods detailed in Clauses 4.3.2 to 4.3.5.

4.3.6 Equipment wiring
Equipment wiring shall comply with the following:
(a) Be as short as practicable.
NOTE: A maximum flexible cord or cable length of 2.5 m is recommended.
(b) Have a current-carrying capacity not less than the maximum load of the connected appliance or luminaire.
NOTE: The minimum cross-sectional area of 0.75 mm^2 for flexible cords is recommended, other than those specified for portable or hand-held appliances and luminaires.
(c) Be protected against short-circuit, in accordance with Clause 2.5.4.
(d) Where earthing is required, be provided with a protective earthing conductor of suitable cross-sectional area that will ensure operation of the circuit protective device, in the event of a fault to earth, without damage to the protective earthing conductor.
* (e) Installation wiring connected within a luminaire or passing through a luminaire shall be so selected and erected that the wiring and any associated connections within the luminaire will not suffer damage or deterioration due to heat or UV radiation generated by the luminaire or its lamps.

OF WIRING ENCLOSURES – 3.10.2.1 (See pge 324 in your textbook)

• The protection offered by the sheath of the cable will be inadequate for some conditions.

• Cables will sometimes need the added ______________ of conduit or other types of ________________.

• It is usual to use single insulated unsheathed *(_______)* cables in these situations to save space in the enclosure and reduce costs.

3.10.2 Wiring enclosures

3.10.2.1 Types

The following types of wiring enclosures may be used for the protection of cables requiring enclosure as specified in Clause 3.10.1:

* (a) Conduits in accordance with AS/NZS 2053 series or the AS/NZS 61386 series, including—

(i) steel conduits or other metal tubing or conduit;

(ii) flexible metal conduit;

(iii) rigid and flexible insulating conduit; and

(iv) corrugated insulating conduit.

* NOTE: Refer to Appendix N for information on compatibility of conduit classifications in the AS/NZS 2053 series and AS/NZS 61386 series.

AS/NZS 3000:2007 has some requirements you must follow when installing electrical equipment. These specifications generally refer to the following _________________ wiring enclosures:

- Rigid PVC conduit *(UPVC – unplasticised polyvinyl chloride)*
- HFT conduit *(Halogen free, fire resistant, temperature stable)*
- Flexible non-metallic (PVC) conduit
- Corrugated PVC conduit
- Non-metallic trunking

NOTE: Refer to Appendix N for information on compatibility of conduit classifications in the AS/NZS 2053 series and AS/NZS 61386 series.

RIGID PVC CONDUIT

A complete conduit installation is considered to be ___________________________, that is, there can't be any short circuits to earth

RIGID PVC CONDUIT

A complete conduit installation is considered to be ___________________________, that is, there can't be any short circuits to earth.

Manufacturers of PVC conduit produce a standard range of pipes and tubes from 16 mm *outside diameter* to 63 mm *outside diameter* for the medium duty (MD) range. Medium duty conduit is _________________ in colour.

HFT conduit is ________________ while for telecommunication installations ________________conduit is used.
The heavy-duty range starts at 16 mm outside diameter to 150 mm outside diameter. Heavy duty conduit is __________________ in colour.
Note: *Clause 1.4.42* of AS/NZS 3000:2007 defines conduit having a diameter of 75 mm or more as a _______________.

Medium duty conduit – Medium duty conduit is **coloured** grey. Heavy **duty conduit –** Heavy **duty conduit** is **coloured** orange.

www2.schneider-electric.com/resources/sites/SCHNEIDER.../content/.../HFT.pdf

1.
2.

features of our rigid **HFT conduits**. In addition, FLEXIBLE. ELECTRICAL HOSE extends the **use** of halogen free **conduits** into petrochemical areas, an avenue of.

1.4.42 Duct
A pipe of 75 mm diameter or greater, or a closed passage formed underground or in any structure and intended to receive one or more cables that may be drawn in.

TYPICAL APPLICATIONS

Generally medium duty conduit is used ______________________ in places where there is little chance the conduit will be damaged, while the main use for heavy-duty conduit is for the enclosure of cable _____________________

This Electrical **Conduit** is used for commercial and industry **applications**. ... Our PVC Electrical **Conduit** is four metres long and comes in two specifications – grey**medium duty** (MD) which is used for aboveground **applications** and orange heavy**duty** (HD) which is used for underground **applications**

An **electrical conduit** is a tube **used to** protect and route **electrical** wiring in a building or structure. **Electrical conduit** may be made of metal, plastic, fiber, or fired clay.
Most **conduit** is rigid, but flexible **conduit** is **used for** some purposes.

Electrical conduit - Wikipedia

https://en.wikipedia.org/wiki/Electrical_conduit

Search for: What is PVC conduit used for?

What is orange conduit used for?

Iplex PVC-U electrical **conduits** are designed to protect cables in a range of buried and aboveground installations. PVC-U is the most commonly **used** material for electrical **conduits** due to its lightweight, ease of assembly and non-conductivity. Heavy Duty **conduit** is **orange** in colour and is intended for buried cables.

4. PROHIBITED USE

The usefulness of PVC conduit reduces in hot or very cold places. Certain chemical solvents will also reduce the protection offered by the conduit.

- PVC conduit _______________ when hot, becomes ______________ when cold.
- It is prohibited or limited in use by other standards and codes for ________, ______________________ and ____________________ areas.
- PVC conduit is "*notch sensitive*" – scratches and nicks on the surface can become a point of failure during bending operations.

Elongate/ contract

_. Certain Green Building Certification programs **prohibit** the **use** of specific materials including **PVC** and products containing halogenated flame retardants, under ...

INSTALLATION (See page 332-323 in your textbook)

You need to make allowances for the physical properties of PVC conduit when you shape and fix it in position. In particular you must consider **support** and the high rate of **expansion** of the conduit.

- Cut the conduit to length using a hacksaw or conduit cutters. All sharp edges must be __________________ to avoid cable insulation damage.

filed

- Support (saddle) spacing should not exceed approximately ________________.

What is the recommended maximum spacing between fixings when installing **20mm**or **25mm** conduit? Conduit is installed using saddles, spacer bar saddles or quick clip fixings. The recommended maximum spacing between fixings is **1m**. It is advisable to saddle **approximately 150mm** on either side of a ben

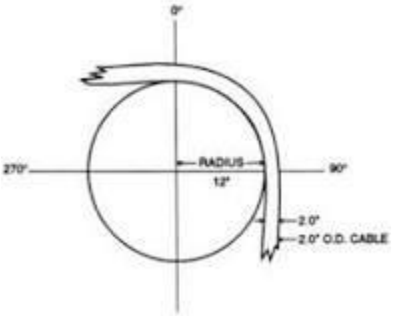
- Rigid conduit has an expansion rate of 1 mm per metre for each 10° increase in temperature. Expansion joints are recommended every 4 metres where temperature variations occur. Saddles should allow for movement due to expansion. *See Figure 10.76 &10.77on page 333 in your textbook.*

- Some types of conduit are not suitable for use in direct sunlight without further protection. Ultra violet light leads to a degradation of the conduits' impact strength of up to 10%. If conduit is subject to direct sunlight a conduit made to AS/NZS 2053.1 and marked with a "____" must be used, or the exposed conduit painted with a light coloured ____________________________ paint.

enamel

❑ Joins should be made using an adhesive supplied or recommended by the manufacturer.

❑ Sets and bends must be made so as not to ____________ the passage for the ____________. *(3.10.3.4.)* Bends are made with an internal spring. (*See Figure 10.73 page 332 in your textbook).* The minimum bend radius for the cable is _______ times the cable diameter. *(3.9.6)*
Right angle / wire



According to Table 1, the minimum bend radius is found to be six times the cable's overall diameter. The overall diameter of the cable is given as **2.08 inches** in the product catalog. Multiplying **2.08 inches** by six, we get**12.48 inches**. The minimum bending radius for this SHD-GC cable is approximately **12.5 inches**

Connection to accessories should be done using the correct conduit adaptors. ________________________ adaptors are available to join to threaded parts

coupling

); **Conduit Adapter** (8); Conduit Bend (34); Conduit Bush (10); Conduit Coupling (11); Conduit End Cap (8); Conduit .

HFT conduit _________________ be bent therefore bends, elbows and tees should be used to change direction.
Must not be

Corrugated conduit is ______ a replacement for flexible conduit and is ______ suitable if continuous flexing is required

Corrugated Conduit is a **flexible conduit** which can be used in a host of different applications. Medium duty (Grey) **corrugated conduit** is typically used above ground, and Heavy Duty (Orange) is used for underground installations.Conduit & Conduit Acces

Support
The same rules that cover the support of flexible conduit apply to corrugated conduit. Generally, you must have enough supports to prevent excessive _______ and ______.

Sagging and moving

Page 116

Flexible PVC conduit is manufactured in a range of sizes from 16 mm *inside diameter* to 63 mm *inside diameter*. Flexible conduit is measured across the __________ diameter and rigid PVC conduit is measured across the ___________ diameter.

Inside/ Outside

If you prefer to measure the outside diameter of PVC pipe:

1. Take your OD measurement and look in the second or third column (Actual OD) of each table below.
2. Once you find your pipe OD, look to the left-most column (Pipe Size). This will be the nominal pipe size, or the size of fittings you want to order.

PVC Pipe sizes are so named by the **measurement** of the **inside** diameter (also called the bore) of the **PVC** pipe, and not the **outside** diameter. If you **measure** the **outside** diameter it will give you a larger reading than the actual **PVC** Pipe Size.

Measure Twice; Buy Once

One of the most frequent questions we get, and the reason for almost every product return to our site, is because the “common sense method” of measuring does not really apply when it comes to Schedule 40 flexible PVC pipe. The “Pipe Schedules” were constructed by someone undoubtedly in a bureaucratic position, not one using common sense measuring techniques. It is quite easy to measure across your pipe, but that is where the “easy” ends. So we say, Measure twice, buy once” and you’ll get what you need the first time.

Someone once sent us the following email about bureaucracy and specifications (source unknown):

RFQ SPECIFICATION WAP-007

PAGE 1 OF 1

PIPING SPECIFICATIONS

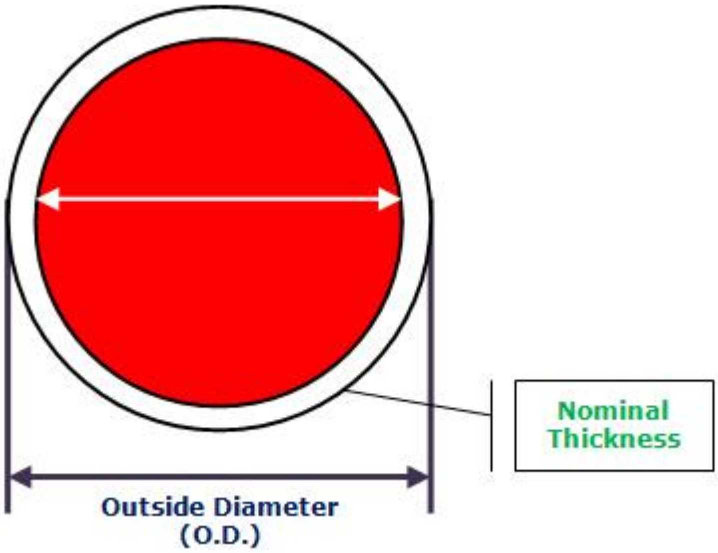
- *All pipe is to be made of a long hole, surrounded by metal centered around the hole.*
- *All pipe is to be hollow throughout the entire length.*
- *All pipe is to be constructed of the very best quality, preferably tubular in nature.*
- *All pipe specified as “acid-free” must be constructed of acid-free metal.*
- *Outer diameter of all pipes must exceed inner diameter.*
- *All pipe is to be supplied without rust regardless of material.*
- *All pipe over 500 feet in length must have the words “Long Pipe: clearly painted on each end so that the pipe fitter will know that it is a long pipe.*

The above proves why bureaucracies don’t do a good job of creating specifications, but unfortunately, flexible pipe sizes are made in accordance with and to the tolerances of the Schedule 40 pipe specifications.

The standards or “schedules” and sizes work like this. The outside diameter of a single “nominal” pipe size is kept constant. So when you are buying a fitting for a Schedule 40 pipe, the outside diameter of the pipe and the fitting size will always be the same. This is the reason for the “schedules” – so that fittings and pipe can easily match across a broad spectrum of manufacturing, and within “acceptable” tolerance and standards. So the outside diameter remains constant, and as a result the inside diameter of a pipe will depend on the "schedule" or the thickness of the pipe. The schedule and the actual thickness of a pipe varies with the size of the pipe.

WHAT DOES THAT ALL MEAN?

OK, let’s cut through the fog here. It means that you need always need to measure the OUTSIDE (O.D.) diameter of your flexible PVC Schedule 40 pipe…



…and then compare that measurement to the following chart in order to order/receive the correct size. We know, this does not pass the “common sense test”, but it’s the way the industry works…and it will keep you from ordering the wrong size flexible PVC pipe! We know this is confusing, if you have questions on what size flexible PVC pipe or fittings to use, call or email us any time!

PLEASE NOTE – Flexible PVC pipe is NOT meant to be used with fittings that fit INSIDE the pipe, sometimes called barbed fittings, friction fittings or insert fittings.While these fittings MAY fit and MAY work, we do not recommend their use, nor do we guarantee that our flexible PVC pipe will fit these fittings.

FLEX PVC PIPE ORDERING DIMENSION CHART			
Outside Diameter (O.D.) Measures (in inches)	Order FLEX PVC Pipe size	Approx. Inside (I.D.) Diameter	Nominal Pipe Thickness
0.540	1/4"	0.364	0.088
0.840	1/2"	0.622	0.109
1.050	3/4"	0.824	0.113
1.315	1"	1.049	0.133
1.660	1-1/4"	1.380	0.140
1.900	1-1/2"	1.610	0.145
2.375	2"	2.067	0.154
2.875	2-1/2"	2.469	0.203
3.500	3"	3.068	0.216
4.000	3-1/2	3.548	0.226
4.500	4"	4.026	0.237
6.625	6"	6.065	0.280

PLEASE NOTE – the sizes listed in the chart above are for reference only, and tolerances in the standard allow for deviations in size and diameter of +/- 10%.

Flexible PVC (Polyvinyl Chloride)

Unmodified polyvinylchloride is a very rigid thermoplastic. Flexibility can be increased over a wide range by adding varying amounts of several plasticizers such as dioctyl phthalate. A frequent method of processing PVC involves the suspension of solid particles of the polymer in an appropriate plasticizer. This suspension, a "plastisol," is then heated resulting in a homogenous system which becomes a flexible solid upon cooling. Usage of PVC has grown steadily since its introduction in the early 1930s to become a very widely used plastic in a myriad of uses from films and mouldings to extruded pipe. PVC has excellent resistance to water and aqueous solutions, but it is attacked severely by stronger solvents such as aromatic hydrocarbons, ketones, esters and chlorinated solvents. Recently discovered health hazards due to extended exposure to the vinyl chloride monomer have resulted in strict production controls. Several alloys and copolymers are possible with PVC, including styrene and acrylonitrile. See also polyvinyl chloride/vinylidene chloride.

ADVANTAGES:

- Processed by thermoplastic methods
- Wide range of flexibility possible with varying levels of plasticizer
- Plastisol processing possible
- Non-flammable
- Dimensional stability
- Comparatively low cost
- Good resistance to weathering

DISADVANTAGES AND LIMITATIONS:

- Attacked by several solvent types
- Limited thermal capability
- Thermal decomposition evolves HCI
- Stained by sulphur compounds
- Higher density than many plastics

TYPICAL APPLICATIONS:

Pipe, extruded wire covering, toys, bottles, door and window components, film and fabric coatings.

Visit the IDES database for detailed specifications.

Restricted use

Generally, you may use flexible non-metallic conduit in similar situations to rigid PVC conduit or where continuous flexibility is required. It is best used where a connection is to be made between a __________ point and an _____________, such as a stove, or a machine that is subject to ___________ or ______________.

Power point and an equipment, Vibrate, move

PVC electrical conduit is always used in construction. General there are two kinds of PVC electrical conduit: rigid PVC electrical conduit and flexible PVC conduit.

1. rigid PVC electrical conduit is used under concrete during the building construction. It is smooth outsides and insides, and easy to through the wire or cables in it. rigid PVC electrical conduit is also stronger to support themselves to keep shape.

1. flexible PVC conduit always used to connect rigid conduit because is easy to be bending in terrible situation.

If you have any ideas about flexible pvc conduit or other flexible plastic conduit, please visit http://www.flexconduit.com/

. There are a few other types of PVC flex pipes, one typically called Smurf tube, due to the blue color that may be used in some interesting applications. As for the rigid pipe, there are a few rare exposed applications for it and even a bending process for it, like EMT (electrical matalic tubing conduit) that involves filling the pipe with sand to not collapse it during the bend, yet that is very high end, and rare use of this type of pipe.

Fittings (*See pictures and samples provided by your teacher)*
The fittings for flexible conduit must not collapse or distort the tube.
The fittings for terminating flexible conduit are called _______________.

Terminator

Trunking comes in _____________ or ________________ sections with removable covers. Trunking also comes in a variety of materials, however in this section we will only cover the regulations that apply to non-metallic systems.
PVC trunking is available in sizes from 10 mm x 6 mm to l00 mm x 100 mm

Square or round

Covers ***(3.10.2.1c)***
Cable trunking containing ________________ cables must have covers. If the trunking is in a readily accessible position, then the covers must need __________ to remove them. The cover can not be used as support for the cable nor can the cable be attached to the cover.

3.10.2 Wiring enclosures

3.10.2.1 Types

The following types of wiring enclosures may be used for the protection of cables requiring enclosure as specified in Clause 3.10.1:

* (a) Conduits in accordance with AS/NZS 2053 series or the AS/NZS 61386 series, including—

(i) steel conduits or other metal tubing or conduit;

(ii) flexible metal conduit;

(iii) rigid and flexible insulating conduit; and

(iv) corrugated insulating conduit.

* NOTE: Refer to Appendix N for information on compatibility of conduit classifications in the AS/NZS 2053 series and AS/NZS 61386 series

(b) Cable trunking systems in accordance with AS/NZS 4296, with or without compound filling.

(c) Other wiring enclosures providing mechanical protection at least equivalent to those listed in Items (a) and (b).

Covers of wiring enclosures containing unsheathed cables shall be effectively retained in position and, where installed in a readily accessible position, shall not be removable without the use of tools.

Installation of cables
Generally, the same rules apply to trunking that apply to other wiring systems. You can fit as many cables into the enclosure as you can without ______________ the cables during installation.
The practical limit is determined by:

- ________________ requirements for the current carrying capacity of the cables.

- The cables having to stay in place when the lid is ____________.

Damaging,

Load /Open

Cables of some systems should not be enclosed with low voltage systems. For example; Telecommunication cables must be __________________ from low voltage systems. Cables in a trunking system should be arranged to allow for the circulation of _______ to help remove any _________.

Segregated/ air/ heat

Passage through walls and floors

When the trunking system passes through a fixed barrier like a wall or floor, it **must be a complete section.** Any **gaps** around the trunking or around the cables in the trunking must be **filled with a suitable barrier** to inhibit the spread of _________.

Extra care needs to be used when enclosures must pass through **fire barriers**. In general the size of the opening is limited and the fire rating of the barrier must be _________________ after installation. More information is found in clause *3.9.9.3* of AS/NZS 3000.

Fire/ determined

3.9.9.3 Penetration of fire barriers

(a) Where a wiring system passes through elements of building construction, such as floors, walls, roofs, ceilings, partitions or cavity barriers that are required to be fire-rated—

(i) the opening shall be close-fitting to the wiring system and at least 50 mm from any other service opening;

(ii) the cross-sectional area of the opening shall be not greater than 500 mm^2, i.e. if circular, 25 mm diameter; and

Exception: The cross-sectional area of the opening may be increased up to a maximum of 2000 mm^2 (50 mm diameter) for a single cable that leaves a gap of not more than 15 mm between the cable and the opening.

(iii) the fire-rating of structures shall be reinstated where openings remain after passage of the wiring system, in accordance with the relevant provisions of national building codes.

NOTE: Guidance on materials suitable for restoring fire-rated constructions is given in national building codes.

4. INSTALLATION REQUIREMENTS

As well as the circuit operating in a manner that satisfies the customer, the installation must also satisfy all requirements of AS/NZS 3000:2007. Refer to the following requirements and AS/NZS 3000:2007 clauses:

______________________	*General Clause 3.10*
______________________	*Clause 3.10.3.9*
______________________	*Clause 3.9.9.3*
______________________	*Clause 3.10.3.5*
______________________	*Clause 3.9.8.3*
______________________	*Clause 3.9.8.4*

5. SAFETY TESTING

You must test each circuit as outlined in AS/NZS 3000 *Clause 8.3*, before you connect it to the supply. This ensures the circuit is safe to use by showing:

- *Earth resistance is safe and sufficiently low* — *Clause 8.3.5*
- *Insulation resistance is safe and sufficiently high* — *Clause 8.3.6*

See AS3000 Rule book

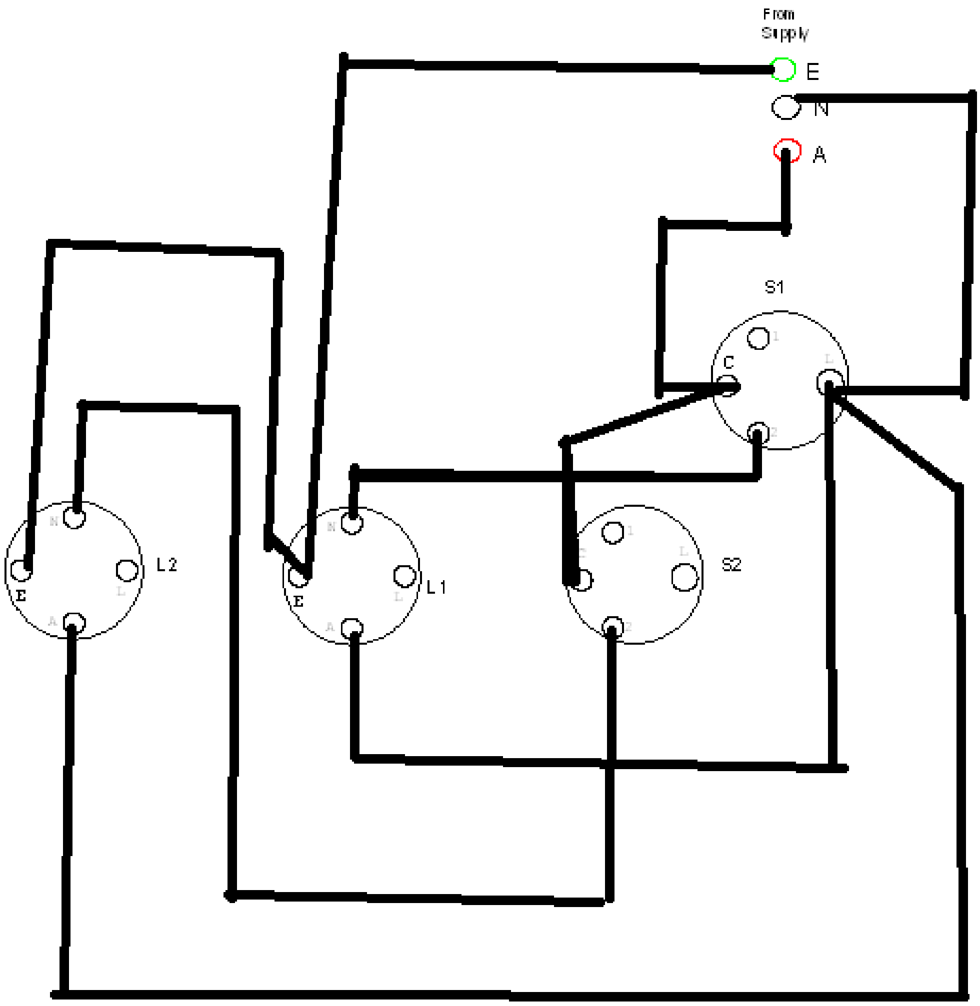
UEENEEG106A - Terminate cables, cords accessories for low voltage circuits.pdf - Adobe Acrobat Reader DC

5. SAFETY TESTING

You must test each circuit as outlined in AS/NZS 3000 *Clause 8.3*, before you connect it to the supply. This ensures the circuit is safe to use by showing:

- *Earth resistance is safe and sufficiently low* — *Clause 8.3.5*
- *Insulation resistance is safe and sufficiently high* — *Clause 8.3.6*
- *Polarity is correct - including switches controlling active conductors* — *Clause 8.3.7*
- *There is no transposition of earth and neutral conductors* — *Clause 8.3.7*
- *There are no short circuits between conductors* — *Clause 8.3.8*
- *There are no interconnections with another circuit* — *Clause 8.3.8*
- *Verification of earth loop impedance* — *Clause 8.3.9*
- *Operation of RCDs* — *Clause 8.3.10*
- *Circuit control and protection devices on the main switchboard are correctly marked to indicate:* — *Clause 2.9.5*
  - *corresponding active and neutral conductors for each circuit*
  - *relationship of equipment and the various parts of the installation*
- IP rating of the accessories is maintained. — Appendix G
- The earthing conductor included in the conduit only connects to earth of equipment supplied by active conductors contained in the conduit.

See AS3000 Rule book



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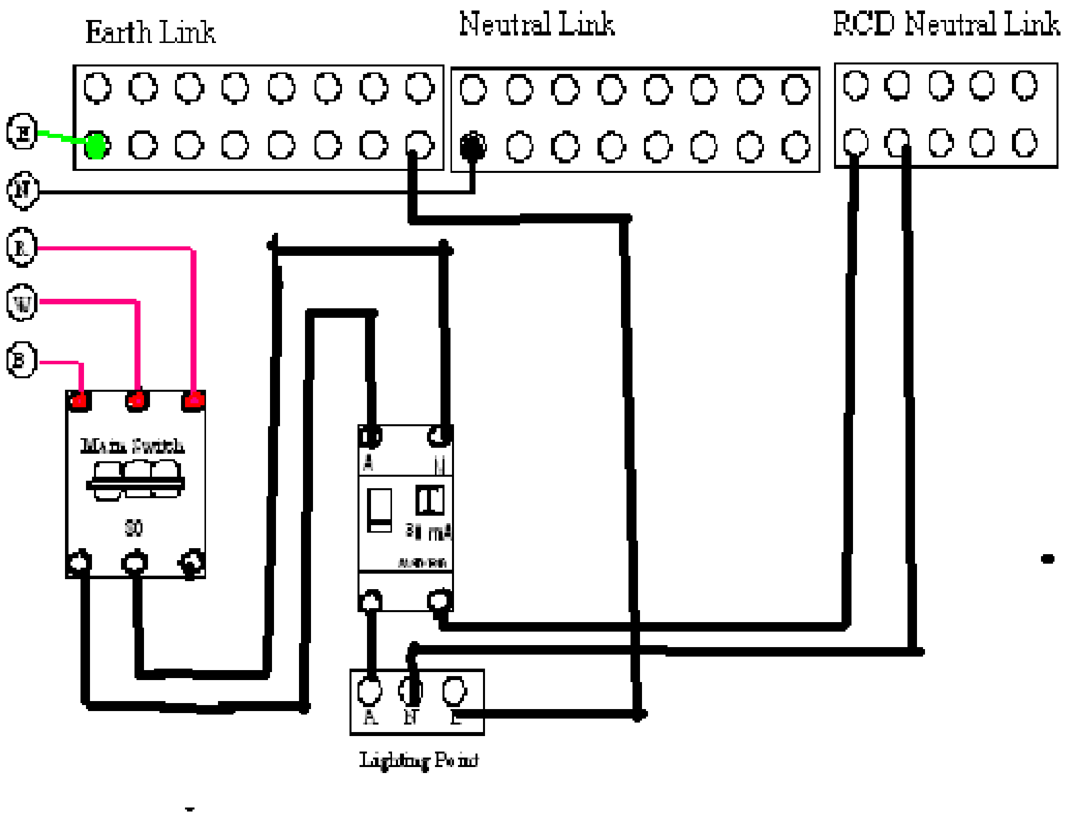
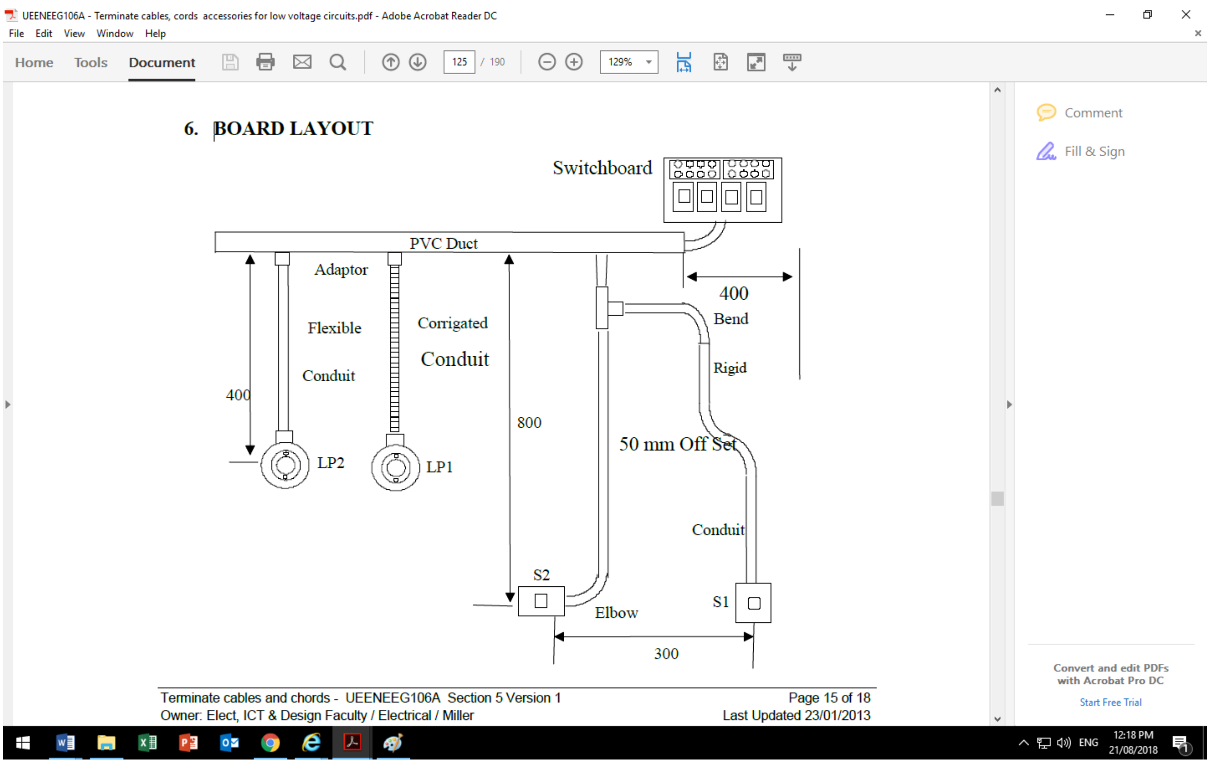
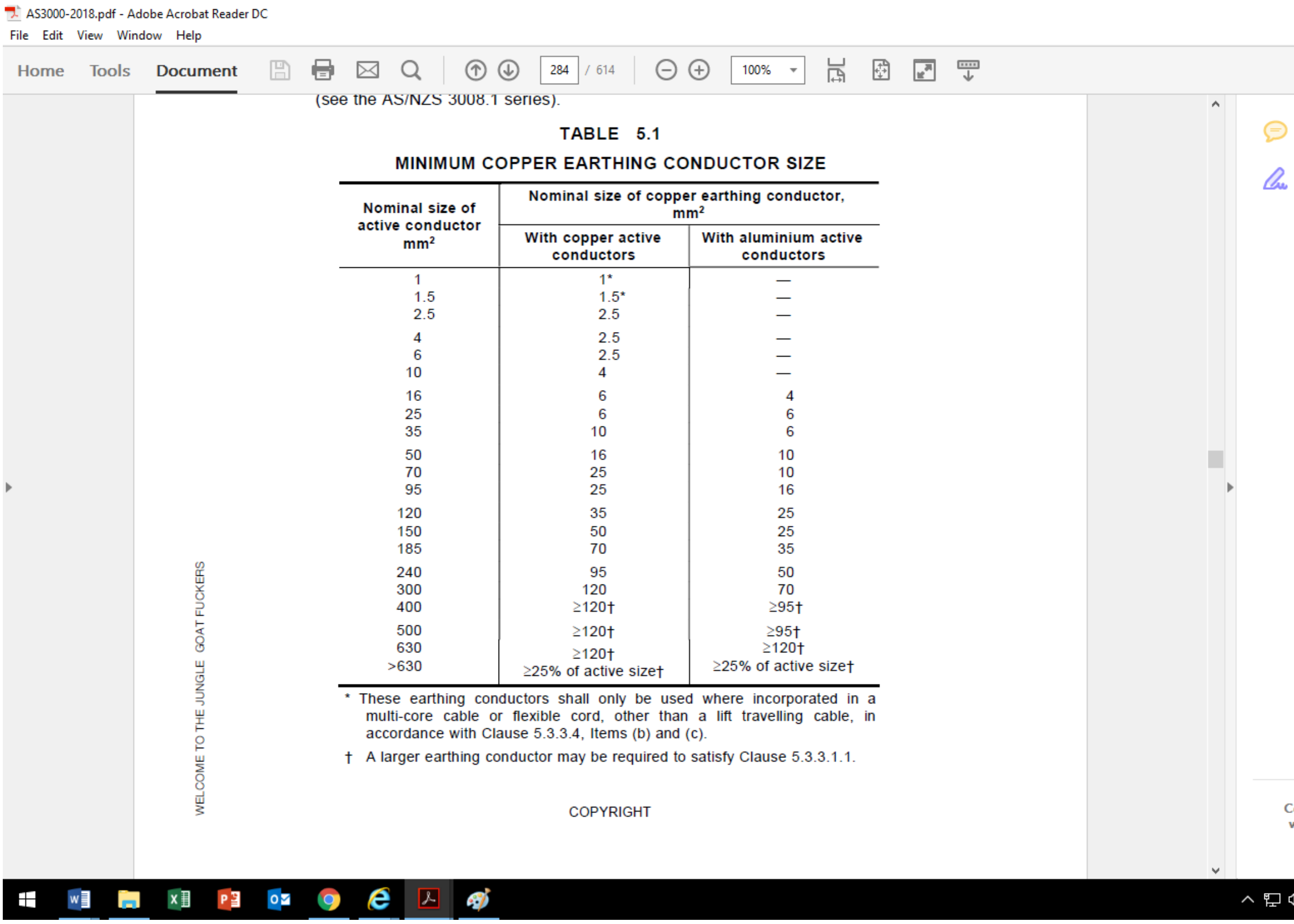




6. BOARD LAYOUT

Page 127

1. What is the minimum size earth conductor which can be used when using 1 mm2 single insulated active and neutral (TPI) cable in conduit or duct? ____**AS3000**____________



(see the AS/NZS 3008.1 series).

TABLE 5.1

MINIMUM COPPER EARTHING CONDUCTOR SIZE

Nominal size of active conductor mm²	Nominal size of copper earthing conductor, mm²	
	With copper active conductors	With aluminium active conductors
1	1*	—
1.5	1.5*	—
2.5	2.5	—
4	2.5	—
6	2.5	—
10	4	—
16	6	4
25	6	6
35	10	6
50	16	10
70	25	10
95	25	16
120	35	25
150	50	25
185	70	35
240	95	50
300	120	70
400	≥120†	≥95†
500	≥120†	≥95†
630	≥120†	≥120†
>630	≥25% of active size†	≥25% of active size†

* These earthing conductors shall only be used where incorporated in a multi-core cable or flexible cord, other than a lift travelling cable, in accordance with Clause 5.3.3.4, Items (b) and (c).

† A larger earthing conductor may be required to satisfy Clause 5.3.3.1.1.

1 sqmm

2. When bending Light duty rigid PVC conduit, what precautions should be observed? ____**_AS3000___________**

3.10.3.4 Bending

The radius of every bend in a wiring system shall be such that conductors and cables will not suffer damage.

Bends in rigid conduit shall be such that the internal diameter is not significantly reduced.

Changes of direction in trunking, ducts or similar applications shall permit the bending of cables laid therein, so as to comply with the requirements of this Clause.

NOTE: See Clause 3.9.6 for cable-bending requirements.

3. By what marking or identification are PVC conduits labelled when the PVC conduit material is suitable for installation in exposed direct sunlight?
____**AS3000**____________

3.10.3.7 Installation in direct sunlight

Rigid insulating conduit, conduit fittings and cable trunking systems installed in direct sunlight shall be—

(a) of a type designed for such use; or

(b) painted with a light-coloured water-based acrylic paint.

NOTES:

1 AS/NZS 2053.1 and AS/NZS 61386.1 requires that conduits suitable for use in direct sunlight be marked with the letter 'T'.

2 AS/NZS 4296 recommends that cable trunking systems suitable for use in direct sunlight be marked with the letter 'T'.

4. If rigid non-metallic conduit is installed in a roof space of a factory:

a. PVC jointing cement must be used

b. provision must be made for expansion

c. the conduit must have the rating 'T'

d. the maximum size is 40 mm

AS/NZS 3000 reference ___________________

3.9.4.3.2 Protection required

Wiring systems shall be protected by one of the methods outlined in Clause 3.9.4.4 if they pass through a structural member, or are fixed in position, within 50 mm from the face of the supporting member to which the lining or roofing material is attached (see Figure 3.7).

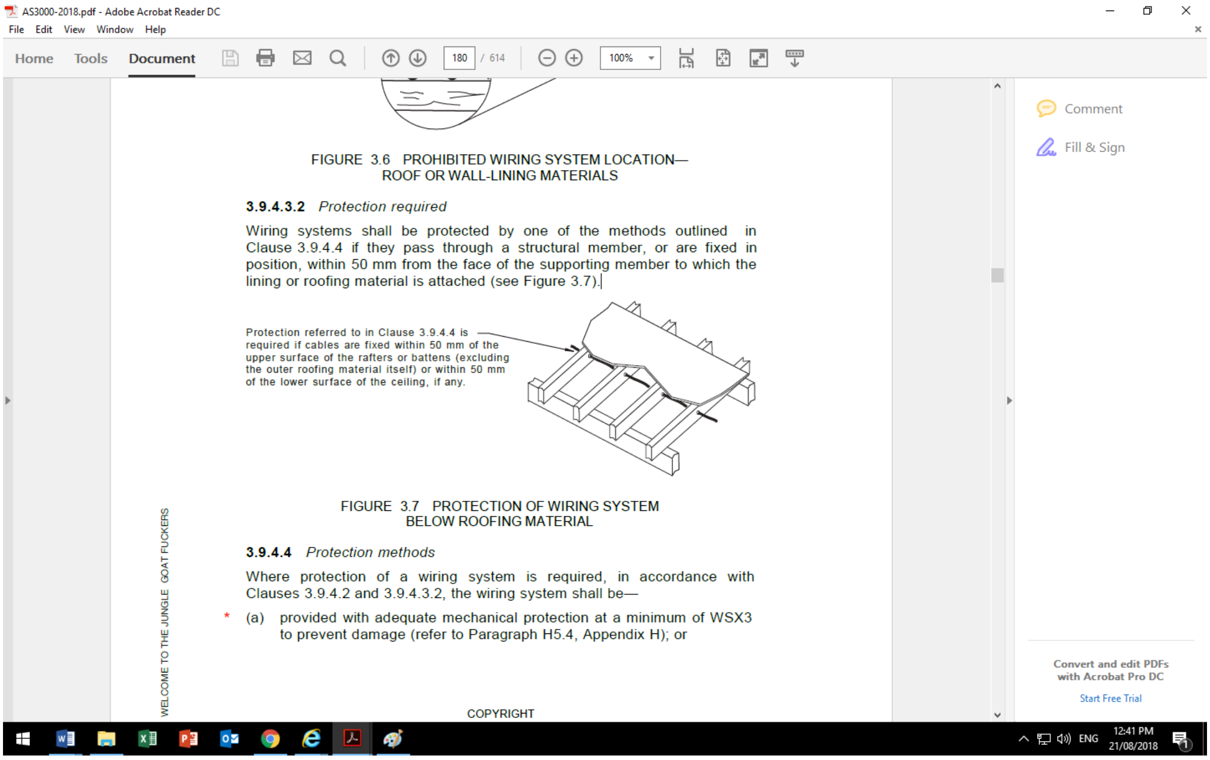

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FIGURE 3.6 PROHIBITED WIRING SYSTEM LOCATION—ROOF OR WALL-LINING MATERIALS

3.9.4.3.2 *Protection required*

Wiring systems shall be protected by one of the methods outlined in Clause 3.9.4.4 if they pass through a structural member, or are fixed in position, within 50 mm from the face of the supporting member to which the lining or roofing material is attached (see Figure 3.7).

Protection referred to in Clause 3.9.4.4 is required if cables are fixed within 50 mm of the upper surface of the rafters or battens (excluding the outer roofing material itself) or within 50 mm of the lower surface of the ceiling, if any.

FIGURE 3.7 PROTECTION OF WIRING SYSTEM BELOW ROOFING MATERIAL

3.9.4.4 *Protection methods*

Where protection of a wiring system is required, in accordance with Clauses 3.9.4.2 and 3.9.4.3.2, the wiring system shall be—

* (a) provided with adequate mechanical protection at a minimum of WSX3 to prevent damage (refer to Paragraph H5.4, Appendix H); or

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5. To connect medium duty rigid PVC conduit to an accessory or appliance that has threaded conduit entries, you should:

a. cut a thread on the PVC conduit with a suitable stock and die

b. file away the thread until you can fit the conduit into the access hole and glue it in place

c. fit the conduit through the hole and seal the hole with silicon or similar sealing compound

d. attach a plain to screw adaptor to the conduit with a thread that is the same as the accessory

6. List the most common colour for the following conduits. a. Medium duty rigid PVC ____________________ Grey

b. Heavy duty rigid PVC ____________________ Orange

c. Underground telecommunications ____________________ white

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When installation conditions require extra protection from _______________ damage, it is normal to use ____________ enclosures. Electricians working in the **lift industry** or working on plant that require **explosion proof installations** use steel conduit extensively.
This section will deal with the basic skills needed to install a basic steel conduit or other metallic wiring system.
Metallic enclosures provide cable protection from _______ and ________. They are also suitable where the ambient temperature exceeds the limits for ______ enclosures.
It should be noted that the cable being enclosed in Metallic enclosures has insulation generally made from ________ and thus still liable to damage from _________________ heat.

Sprayed. The third major type of insulation is spray foam. Just as there are two types of **blown** insulation (fiberglass and cellulose) and two types of people (those who divide everything into two groups and those who don't), there are two types of spray foam - open cell and **closed** cell

Mechanical/ wiring/ stress and abrasion
/extreme

Metallic cable trunking is unsuitable in ___________ situations, because of its removable lid or in areas exposed to the possibility of ________________ damage. It is generally made from light gauge sheet metal.

3.10.3.9 Cable trunking

Cable trunking installations shall be installed as follows:

(a) Covers shall be able to be opened, where practicable.

(b) Covers shall be continuous when passing through walls or floors.

(c) Cable trunking shall be accessible through its entire length.

(d) Cables installed in a trunking shall not rely on any readily removable cover for support.

(e) Non-hygroscopic trunking shall be used to enclose insulated, unsheathed conductors.

Mechanical

(f) Live parts of accessories mounted on cable trunking shall be arranged so that basic protection is provided, in accordance with Clause 1.5.4.

Cable trunking is a hollow enclosure through which cables can be run to keep them protected and organised, with a removable or hinged side allowing quick and convenient access for routine inspections or wire changes.You'll see cable trunking used most conspicuously in office buildings, usually as a white plastic outcropping that runs along walls adjacent to computer terminals and other electrical appliances. This widespread use has given rise to the common assumption that cable trunking is for commercial rather than residential use. In reality, it can perform an instrumental role in keeping your cables protected while safeguarding you and your family from harm and your property from damage. Without cable trunking, water hazards pose a greater risk, electrical fires are more likely, and the chance of suffering a serious electric shock rises.

What Types of Cable Trunking Are Available?

There are several different materials used for cable trunking, with the most popular being:

- **PVC**: By far the lightest and most affordable material, PCV cable trunking can be made in various thicknesses to suit varying applications, and it resists moisture and corrosion extremely well. It is also non-conductive and possesses a high thermal coefficient of expansion to allow for expansion and contraction – both qualities are clearly useful in conjunction with electric wiring. The downside is that it isn't particularly tough, but it still works well in most residential settings.
- **Steel**: Often used where durability is paramount, steel trunking is remarkably strong and yet heavy and inflexible. The price is relatively low, but steel's weight and its ability to rust make it little used for residential cable trunking.
- **Glass Reinforced Polyester**: Still cost-effective, glass reinforced polyester is fire retardant and self-extinguishing, making it excellent in hazardous areas. It even boasts anti-corrosive properties.
- **Galvanized Rigid Conduit (or RMC):** Made using galvanized steel tubing to resist corrosion, this is a thick and tough metal often used in commercial and industrial applications. Recent cost reduction and a spreading awareness of its longevity have seen it used more widely in residential construction, though the price still puts some people off.

Regardless of the cable trunking you use, you'll chiefly be using it to protect yourself against water-damage, fire, and electric shocks. Before this article comes to an end, we'll have covered each risk factor, detailing the dangers involved and how cable trunking can make a difference.

Risk Areas

Steel conduit is available from **16 mm up to 50 mm diameter**. Most steel conduit from suppliers is **galvanised** to protect against corrosion. Other metallic piping can be used in place of steel conduit providing it affords adequate ________________ and _________________ continuity. Steel conduit provides up to **10 times the (tensile) strength of PVC conduit**
Electrical/ Mechanical

3. INSTALLATION OF METALLIC CONDUITS

❑ Conduit must be free from internal __________ and ______________. *(3.10.3.5b)* This means it is best to cut conduit to length using a **hacksaw** as the **burr** produced is easily **removed by filing** or with a **de-burring tool**. *See figure 10.100 on page 345 in your textbook)*

❑ Any sets or bends in the conduit must not _________- the walls or open any joints or welds. Unlike PVC conduit, which may be set by hand or across the knee, **steel conduit requires** the use of **commercial or automatic bending machines**
(See Pictures on page 343-356 in your textbook)

3.10.3.5 Passage for conductors

Where conductors or cables, including flexible cables and flexible cords, are to be threaded through conduits, tubes or channels, or passed through openings formed in metalwork, such tubes, channels, conduit ends or openings shall be of adequate size and shall—

(a) be provided with bushes that are securely fixed in position; or

(b) if not bushed, have no sharp angles or projecting edges that would be likely to damage a conductor or the insulation, braiding or sheathing of a cable.

Contact

You must cut a __________ to join metallic conduits or terminate the pipe at an appliance or accessory. Any damage to the protective coating on the pipe means you must replace the pipe. Damage can occur while gripping the conduit for threading, as well as when cutting the thread itself.
Fixed stocks and block dies are the most common way of **hand threading steel conduit.**
The ends of the conduit must be **de-burred to prevent cable damage**.

Thread

4. SUPPORT (Saddles)
The supports for the rigid metallic systems can be **further apart than for PVC** conduit. Supports for metallic conduits must be placed to prevent damage to _________ or and any associated _________. Linear expansion is also less of a problem.
Flexible metallic conduit, on the other hand, needs **supports more closely spaced** than flexible PVC conduit.

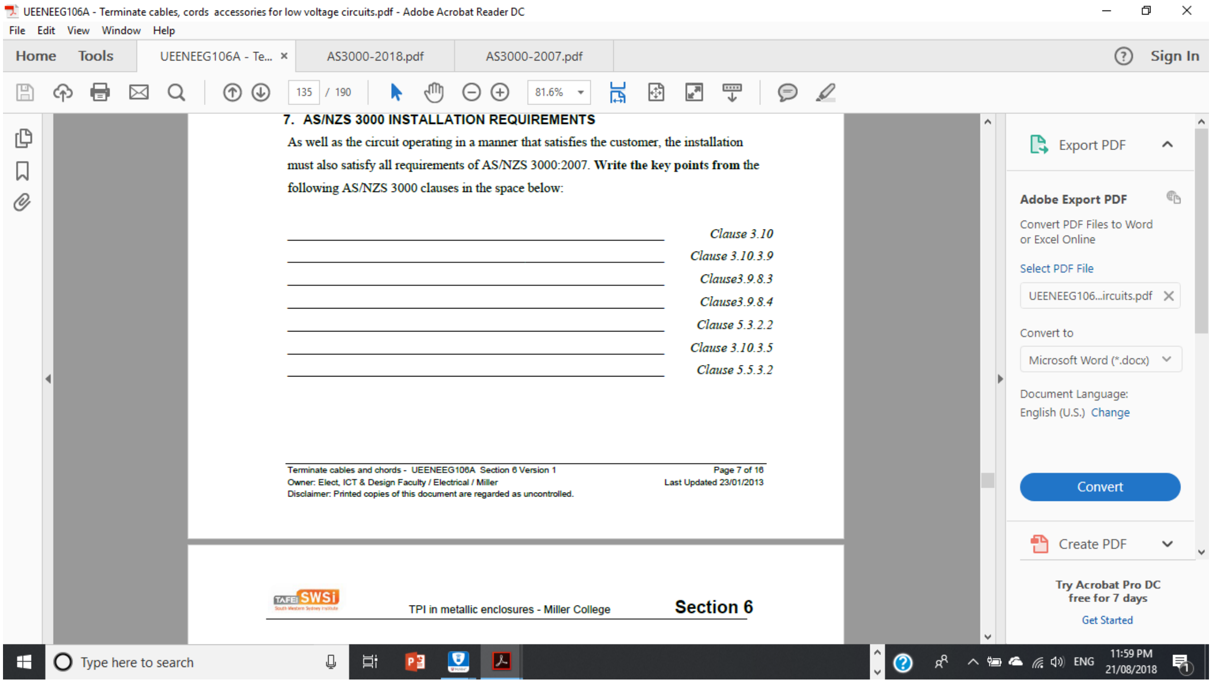
Conduit/ wires

5. FITTINGS
All fittings for conduit should be of the _____________ type except in certain cases. The inspection cavity makes it easier to _________ in the cable. The fitting must maintain electrical _______________ and hold the conduit without distorting

Coupling /Check / continuity

Non- metallic fittings.
At any point where the metal enclosure is not mechanically and electrically continuous, the parts must be electrically joined by installing an earthing connection between them.
You must be careful to maintain ______________ and _____________ continuity when using metallic wiring enclosures. If a _____________________ housing or junction box interrupts the continuity of the wiring enclosure, **you must bond the two parts of the metallic enclosure to ensure electrical continuity.**

Electrical/ Mechanical
Conduit



7. AS/NZS 3000 INSTALLATION REQUIREMENTS

As well as the circuit operating in a manner that satisfies the customer, the installation must also satisfy all requirements of AS/NZS 3000:2007. **Write the key points from the** following AS/NZS 3000 clauses in the space below:

______________________________ *Clause 3.10*
______________________________ *Clause 3.10.3.9*
______________________________ *Clause3.9.8.3*
______________________________ *Clause3.9.8.4*
______________________________ *Clause 5.3.2.2*
______________________________ *Clause 3.10.3.5*
______________________________ *Clause 5.5.3.2*

Terminate cables and chords - UEENEEG106A Section 6 Version 1 Page 7 of 16
Owner: Elect, ICT & Design Faculty / Electrical / Miller Last Updated 23/01/2013
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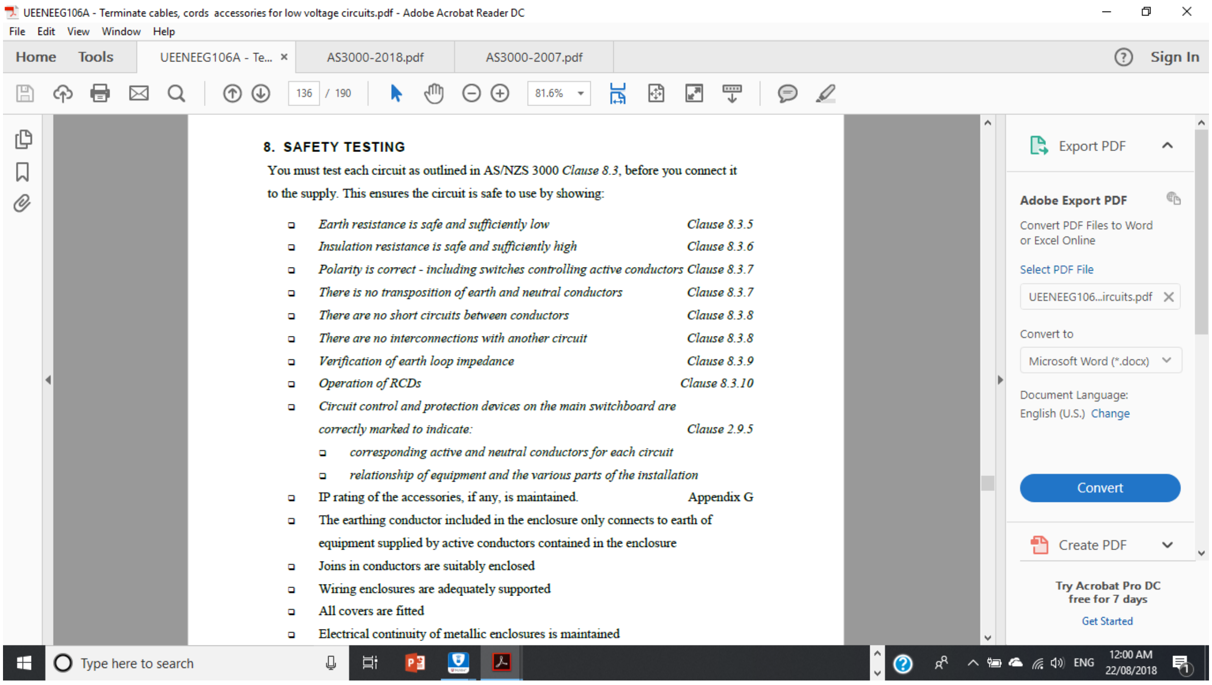
TPI in metallic enclosures - Miller College **Section 6**

Read them



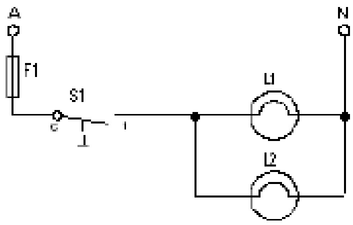
8. SAFETY TESTING

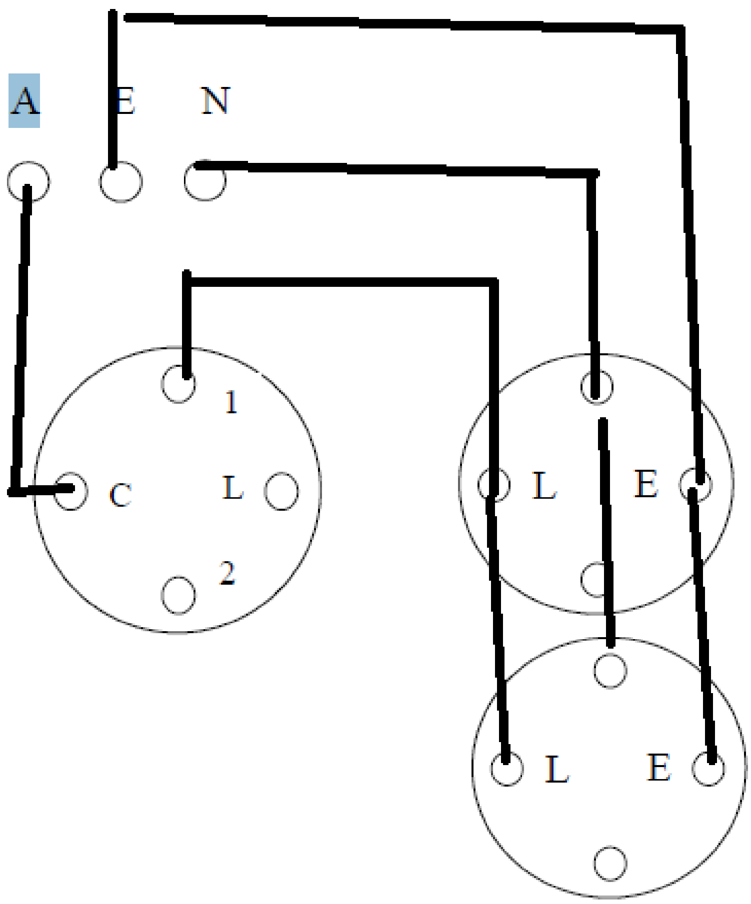
You must test each circuit as outlined in AS/NZS 3000 *Clause 8.3*, before you connect it to the supply. This ensures the circuit is safe to use by showing:

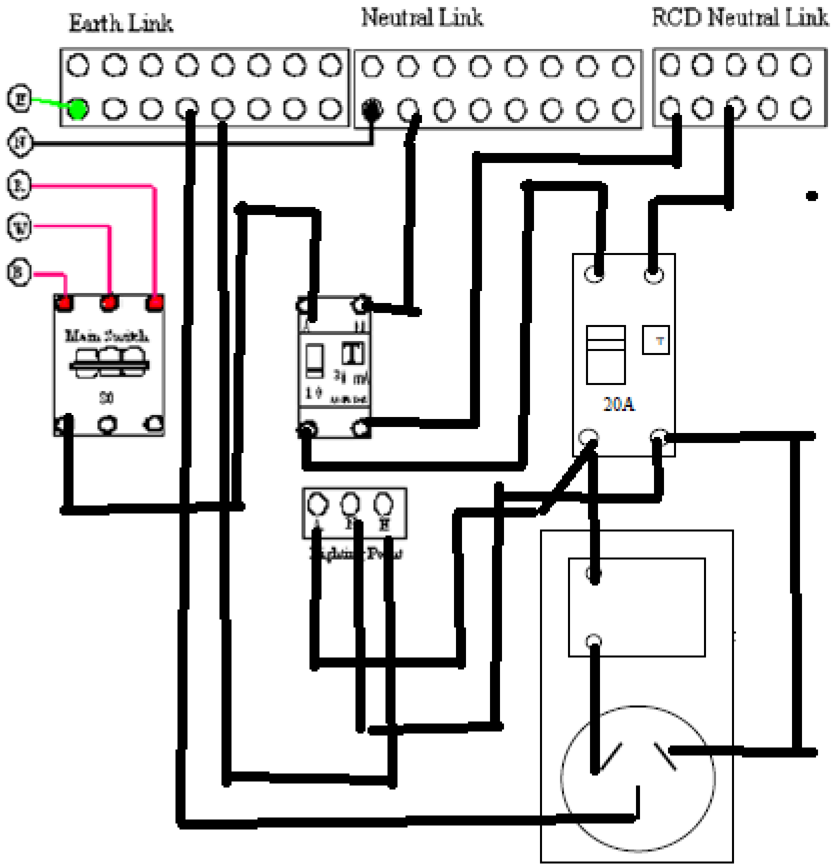
- *Earth resistance is safe and sufficiently low* *Clause 8.3.5*
- *Insulation resistance is safe and sufficiently high* *Clause 8.3.6*
- *Polarity is correct - including switches controlling active conductors* *Clause 8.3.7*
- *There is no transposition of earth and neutral conductors* *Clause 8.3.7*
- *There are no short circuits between conductors* *Clause 8.3.8*
- *There are no interconnections with another circuit* *Clause 8.3.8*
- *Verification of earth loop impedance* *Clause 8.3.9*
- *Operation of RCDs* *Clause 8.3.10*
- *Circuit control and protection devices on the main switchboard are correctly marked to indicate:* *Clause 2.9.5*
  - *corresponding active and neutral conductors for each circuit*
  - *relationship of equipment and the various parts of the installation*
- IP rating of the accessories, if any, is maintained. Appendix G
- The earthing conductor included in the enclosure only connects to earth of equipment supplied by active conductors contained in the enclosure
- Joins in conductors are suitably enclosed
- Wiring enclosures are adequately supported
- All covers are fitted
- Electrical continuity of metallic enclosures is maintained

3. LIGHTING CIRCUIT

1. Complete the wiring diagram for the light controlled by an individual switch







These questions will help you revise what you have learnt in Section]. Write down the AS/NZS 3000:2007 reference with each answer when it is used.
1. Galvanised steel conduit is commonly available in what size ranges?

____

ube and Pipe Size Overview | Allied Tube & Conduit | Mechanical ...
www.atc-mechanical.com › Resources › Tube & Pipe 101

1.
2.

Discussion of OD and Nominal **Pipe** Size as well as Wall Thickness and **Pipe** ... You can see by the chart at the right, not all 12 **Gauge** allows a thickness .

2. What is the standard measurement for a length of steel conduit?

____

RIGID **METAL CONDUIT** WEIGHTS AND **DIMENSIONS** (10O **LENGTHS**) ... manufactured to produce a 10O (3.05 m) **length** of conduit when a **standard** coupling ...
3. The size of steel conduit is measured by its internal or external diameter?

____

[Electrical Conduit Gauge - Solus Group](https://solusgrp.com/electrical-conduit-gauge.html)
https://solusgrp.com/electrical-conduit-gauge.html

1.

Electrical **Conduit Gauge** used to measure the inside diameter of steel and aluminum conduit ranging in size from 0.5” (13 mm) up to 4” (102 mm) diameter.

4. When bending steel conduit, what precautions should be observed?

____
______________________________ AS/ NZS3000________________

3.10.3.4 Bending

The radius of every bend in a wiring system shall be such that conductors and cables will not suffer damage.

Bends in rigid conduit shall be such that the internal diameter is not significantly reduced.

5. Where must a run of steel conduit be earthed?

____
______________________________AS/ NZS3000 ________________

5.3.2.3 Special conditions

The following conditions apply where the components in Clause 5.3.2.2(i), (ii), (iii) or (iv) are used for protective earthing:

(a) Conductive conduit, tube, pipe, trunking and similar wiring enclosures May be regarded as a protective earthing conductor, provided that—

(i) the electrical equipment to be earthed is supplied by live conductors contained within the wiring enclosure; and

(ii) for screwed conductive wiring enclosures, the wiring enclosure is directly connected by conductive threads or locknuts to the electrical equipment to be earthed.

6. After threading steel conduit what should be removed?

___________________________________AS/ NZS3000 __________________

Remove metallic pieces

3.10.3.6 Terminations

Terminations shall be arranged so that wiring enclosures terminate in, and are supported on, electrical equipment in such a manner as to fully protect the enclosed cables as they pass into the electrical equipment.

Each end of flexible conduit shall be securely anchored to the fixed conduit, structure or electrical equipment where it terminates.

7. If a run of steel conduit is interrupted by a PVC switch, what precautions should be observed?

____
_____________________________ AS/ NZS3000_________________

3.10.2.2 Change of wiring enclosures

Any change from one type of wiring enclosure to another shall be made—

(a) at a switchboard; or

(b) by means of a suitable device that provides for the complete protection of the conductor insulation and for continuity of conductive wiring enclosures.

8. If you are required to change wiring enclosures, is the switchboard a suitable place to change enclosures?

___________________________________AS/ NZS3000__________________

Yes

3.10.2.2 Change of wiring enclosures

Any change from one type of wiring enclosure to another shall be made—

(a) at a switchboard; or

(b) by means of a suitable device that provides for the complete protection of the conductor insulation and for continuity of conductive wiring enclosures

9. When running steel conduit vertically how far apart are the supports by installed?

____
_____________________________AS/ NZS3000__________________

3.9.5 Wiring systems installed vertically

Where wiring systems are installed vertically, they shall be installed in accordance with the requirements of Clauses 3.9.2 and 3.9.3 and in such a manner as to avoid damage to any part of the wiring system that may be caused by its own weight or method of support or fixing.

Adequate provision shall be made for the support of cables enclosed in a wiring enclosure installed vertically. Cable supports shall be provided at intervals not exceeding 8 m or as recommended by the cable manufacturer

10. When installing single insulated cables in steel conduit, care should be taken not to:

____
____

3.9.7.1.2 Unprotected

Insulated, unsheathed cables enclosed in conductive wiring enclosures shall not be installed without short-circuit protection.

NOTE: Sheathing of cables is not required within conductive switchboard surrounds.

* Consumer mains not provided with short-circuit protection on the supply side, shall comply with the installation requirements of this Section relevant to the type of wiring system and shall be—

(a) constructed in such a manner as to reduce the risk of short-circuit to a minimum; and

(b) installed in accordance with the relevant additional requirements of the electricity distributor.

The following wiring systems are deemed to reduce the risk of short-circuit to a minimum:

(i) Insulated and sheathed cables enclosed in heavy-duty insulating conduit in accordance with either the AS/NZS 2053 series or the AS/NZS 61386 series.

(ii) Insulated and sheathed cables installed in underground wiring enclosures.

(iii) Aerial conductors consisting of XLPE cables type X-90UV in accordance with the AS/NZS 3560 series.

(iv) Busways and busbar systems, including joints and switchboard busbars, having insulation up to the first protective device in accordance with the AS/NZS 3439 series or the AS/NZS 61439 series.

3.9.7.2 Insulated and sheathed cables

The following applies to insulated and sheathed cables:

(a) Armoured sheathed cables Armoured sheathed cables may be installed in concrete, plaster or cement render without protection of a wiring enclosure.

(b) Unarmoured sheathed cables:

(i) In concrete Unarmoured sheathed cables installed in concrete shall be contained within an appropriate wiring enclosure installed in accordance with Clauses 3.3.2.6 and 3.9.4.

(ii) In plaster or cement render Unarmoured sheathed cables may be installed in plaster or cement render without protection of a wiring enclosure, provided that the cables are installed and protected in accordance with Clauses 3.3.2.6 and 3.9.4.

3.9.8.4 Proximity to non-electrical services

(v) Cables without sheathing or further enclosure shall not be installed in enclosures where they are accessible to personal contact or where they may contact other services, such as water, gas, hydraulic or communications systems.

NOTE: Metal parts of other services may require bonding to the earthing system in order to provide protection against earth faults, in accordance with Clause 5.6.2.3.

3.10.1 General

3.10.1.1 Insulated, unsheathed cables

Insulated, unsheathed cables shall be enclosed in a wiring enclosure throughout their entire length.

Exceptions: Wiring enclosures need not be provided for insulated, unsheathed cables installed as follows:

1 As aerial conductors, in accordance with Clause 3.12.

2 In an enclosed wall cavity between an accessory and a wiring enclosure or sheathing terminated within 100 mm of the hole over or within which the accessory is mounted.

NOTE: This exception does not apply within a roof space.

3 Within switchboards, metering and similar enclosures, provided that such cables are not exposed to touch during normal switching or meter-reading operations.

4 As earthing or equipotential bonding conductors installed in accordance with Section 5.

5 As an extra-low voltage circuit, in accordance with Clause 7.5.

3.10.1.2 Insulated and sheathed cables

Cables of a sheathed type need not be installed in a wiring enclosure.

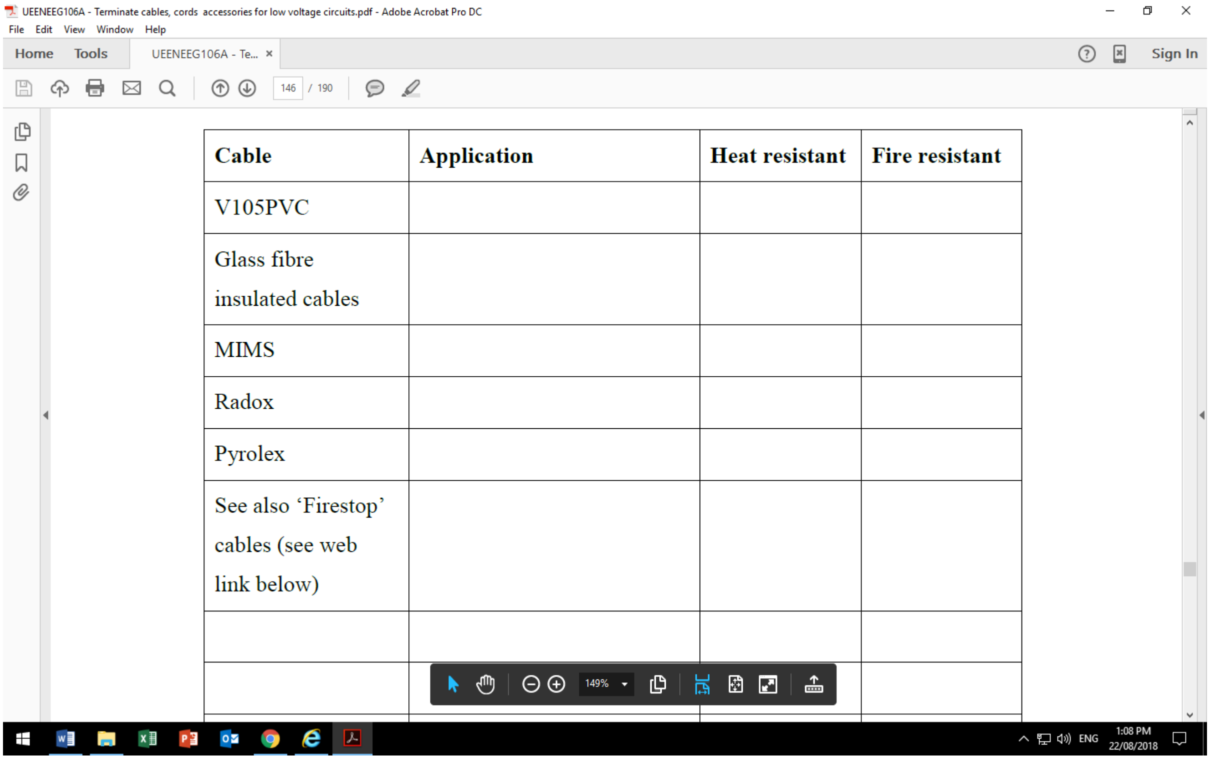
Exception: Cables having insulation or sheath that does not meet the combustion propagation requirements of the AS/NZS 5000 series, e.g. polyethylene-insulated unsheathed cables, shall be installed in fire rated enclosures.

Where the sheath of a cable is removed, the exposed cores of the cable shall be enclosed in accordance with Clause 3.10.1.1.

Page 145

TPS (PVC) insulation is typically rated to operate within 75° (________) or 90° (________) maximum temperatures. **PVC** burns easily (but is **self extinguishing**). The problem is PVC produces smoke containing hazardous chemicals and toxic gases when burnt (hydrogen chloride gas, hydrochloric acid and halogens). So TPS cable is not suitable for heat or fire resistant applications

V75, V90



Cable	Application	Heat resistant	Fire resistant
V105PVC			
Glass fibre insulated cables			
MIMS			
Radox			
Pyrolex			
See also 'Firestop' cables (see web link below)			

V105PVC

Does the change of V105 to V90-HT mean that this grade of PVC has been down rated?

Some contractors interpreted the V105 rating as a continuous operating temperature of 105°C, which is incorrect. The V105 grade should only be operated at this temperature for limited periods under certain conditions. In order to avoid this confusion, the name has been changed to V90-HT, ie indicating that the cable can operate at high temperatures for limited times. The actual composition of the PVC has not change

Fire Resistant The property of cables to continue to function while under the influence of fire. Olex cables that are Fire Resistant provide circuit integrity even when burned and maintains integrity after the fire has extinguished. In most cases, the cables will withstand a water spray and still provide circuit integrity.

Flame Retardant The property of cables to retard or slow the progress of fire and flame along the cable. This is achieved through the use of materials that do not readily burn and will tend to self-extinguish.

Glass Fibre Insulated Cable

Suitable for high ambient temperature environments up to 350°C

Benefits	
High Temperature Rating	Glass insulated pure nickel conductors are suitable for use in very high temperature environments
Pure Nickel Conductors	Nickel conductors offer high strength and corrosion resistance at elevated temperatures where copper and tinned copper degrade
Flexible Stranding	Class 5 flexible conductor stranding
Abrasion Resistant	Silicone varnish impregnated, glass braided insulation provides excellent abrasion resistance
Reduced Diameter	Double fine and super fine options are available to fit specific inserts
Wide Choice Available	A variety of colours available ex-stock

Features
Pure nickel conductors are suitable for operation up to 350°C
Class 5 stranding allows increased flexibility
Double glass braid for high insulation resistance
Silicone varnish and double glass braid for 100% coverage

Construction	
Conductor	Pure nickel wire, class 5 stranding
Insulation	Double glass fibre braid impregnated with silicone varnish
Colours	Blue, black, green, natural, red and white

Ratings	
Temperature	0°C to + 350°C
Voltage	0.6/1kV*
Applicable Standards	AS/NZ

MIMS Cable

MI cable is made by placing copper rods inside a circular copper tube and filling the intervening spaces with dry magnesium oxide powder. The overall assembly is then pressed between rollers to reduce its diameter (and increase its length). Up to seven conductors are often found in an MI cable, with up to 19 available from some manufacturers.

Since MI cables use no organic material as insulation (except at the ends), they are more resistant to fires than plastic-insulated cables. MI cables are used in critical fire protection applications such as alarm circuits, fire pumps, and smoke control systems. In process industries handling flammable fluids MI cable is used where small fires would otherwise cause damage to control or power cables. MI cable is also highly resistant to ionizing radiation and so finds applications in instrumentation for nuclear reactors and nuclear physics apparatus.

MI cables may be covered with a plastic sheath, coloured for identification purposes. The plastic sheath also provides additional corrosion protection for the copper sheath.

The metal tube shields the conductors from electromagnetic interference. The metal sheath also physically protects the conductors, most importantly from accidental contact with other energised conductors.

Heating cable[edit]

A similar appearing product is mineral-insulated trace heating cable, in which the conductors are made of a high-resistance alloy. A heating cable is used to protect pipes from freezing, or to maintain temperature of process piping and vessels. An MI resistance heating cable may not be repairable if damaged. Most electric stove and oven heating elements are constructed in a similar manner.

Typical specifications[edit]

maximum voltage	600 or 1000 volts
current rating	18 - 450 amperes
conductor area	1.0 – 240 mm^2
copper sheath area	5 – 70 mm^2 effective
number of cores	1,2,3,4,7,12,19
overall diameter	5 – 26 mm
minimum bend radius	6 x diameter (3 x diameter if bent once only)
weight	100 – 3300 kg/km, 355 - 11708.4 lbs/mi
twists per metre	0, 20 (in many applications NO twist is preferred)
finish	bare copper, standard PVC sheath, low smoke and fume (LSF) polymer sheath, various stainless steels, Inconel, titanium, and some super alloys.

colour	natural (bare stainless, bare copper), white, black, red, orange
maximum operating temperature	continuous - exposed to touch 70 °C continuous - not exposed to touch; PVC-sheathed 90 °C continuous - not exposed to touch; not PVC-sheathed 250 °C intermittent >1000 °C (melting point of copper is 1083 °C)

Advantages[edit]

The metal sheath and solid filling of MI cable makes it mechanically robust and resistant to impact; an MI cable may be struck repeatedly with a hammer and still provide adequate insulation resistance for a circuit.[2] Copper sheathing is waterproof and resistant to ultraviolet light and many corrosive elements. MI cable is approved by electrical codes for use in areas with hazardous concentrations of flammable gas in air; an MI cable will not allow propagation of an explosion inside the copper tube, and the cable is unlikely to initiate an explosion even during circuit fault conditions. Metal sheathing will not contribute fuel or hazardous combustion products to a fire, and cannot propagate a fire along a cable tray or within a building. The cable is inherently fire-rated without additional coatings, and will survive designated fire tests representative of actual fire conditions longer than the enclosing structure.

When used within a tenanted area, carrying electricity supplied and billed to the landlord, for example for a communal extract system or antenna booster, it provides a supply cable that cannot easily be 'tapped' into to obtain free energy.

Although made from solid copper elements, the finished cable assembly is still pliable due to the malleability of copper. The cable can be bent to follow shapes of buildings or bent around obstacles, allowing for a neat appearance when exposed.

Since the inorganic insulation does not degrade with (moderate) heating, the finished cable assembly can be allowed to rise to higher temperatures than plastic-insulated cables; the limits to temperature rise may be only due to possible contact of the sheath with people or structures. This may also allow a smaller cross-section cable to be used in particular applications.

Due to oxidation, the copper cladding darkens with age and MICC is therefore often used in historic buildings such as castles where it blends in with stonework. However, where MICC cables with a bare copper sheath are installed in damp locations, particularly where lime mortar has been used, the water and lime combine to create an electrolytic action with the bare copper. Similarly, 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. The appearance of green verdigris on the bare copper sheath may be a sign this has occurred.

Disadvantages[edit]

- *The termination points:* While the length of the MI cable is very tough, at some point, each run of cabling terminates at a splice or within electrical equipment. These terminations are vulnerable to fire, moisture, or mechanical impact.
- *Vibration:* MICC is not suitable for use where it will be subject to vibration or flexing, for example connection to heavy or movable machinery. Vibration will crack the cladding and cores, leading to failure.
- *Labour Cost:* During installation MI cable must not be bent repeatedly as this will cause work hardening and cracks in the cladding and cores. A minimum bend radius must be observed and the cable must be supported at regular intervals. The magnesium oxide insulation is hygroscopic so MICC cable must be protected from moisture until it has been

terminated. Termination requires stripping back the copper cladding and attaching a compression gland fitting. Individual conductors are insulated with plastic sleeves. A sealing tape, insulating putty or an epoxy resin is then poured into the compression gland fitting to provide a watertight seal. If a termination is faulty due to workmanship or damage then the magnesium oxide will absorb moisture and lose its insulating properties. Depending on the size and number of conductors, a single termination can take between 1 and 2 hours of labour (an electrician should be able to make a termination in 10 to 15 minutes on up to 4 core smaller sizes). Installation of a three-conductor MI cable (size No. 10 AWG — about 5 square mm) takes about 65% more time than installation of a PVC-sheathed armoured cable of the same conductor size.[3] Installation of MICC is therefore a costly task.
Certain PTFE, silicone or other polymer-insulated cables have been substituted in applications which require similar properties in terms of flame spread, which use less labour to terminate. MICC is still used in applications which are particularly suited to its combination of properties.

- *Voltage rating:* MI cable is only manufactured with ratings up to 1000 volts.
- *Moisture absorption:* The magnesium oxide insulation has a high affinity for moisture. Moisture introduced into the cable can cause electrical leakage from the internal conductors to the metal sheath. Moisture absorbed at a cut end of the cable may be driven off by heating the cable.
- *Corrosion:* The copper sheath material is resistant to most chemicals but can be severely damaged by ammonia-bearing compounds and urine. A pinhole in the copper sheathing will allow moisture into the insulation, and eventual failure of the circuit. A PVC over jacket or sheaths of other metals may be required where such chemical damage is expected. When MI cable is embedded in concrete as snow melting cable it is subject to physical damage by concrete workers working the concrete into the pour. If the 3-5mil coating is damaged pin holes in the copper jacket develop causing premature failure of the snow melting system.
- *Repair:* If the MI cable jacket has been damaged the magnesium oxide will wick moisture into the cable and it will lose its insulating properties causing shorts to the copper cladding, and thence to earth. It is often necessary to remove 0.5 to 2 metres (1.6 to 6.6 ft) of the MI cable and splice in a new section to accomplish the repair. Depending on the size and number of conductors, a single termination can take between one and two hours of labour.[3]

Mineral-insulated (MI) **cable** is a specially constructed **cable** that can survive a fire. It is well known as Fire Survival **Cable** or Fire Rated **Cable**. Capable of carrying current at temperatures in excess of 1000˚C, MI **cable** has unsurpassed fire survival properties.

Radox Cable

RADOX® Power cables

Main characteristics of the cables include excellent resistance to heat, a high current capacity, a robust composition, a compact design, outstanding flexibility and a long service life.

RADOX® 4GKW

Halogen free, compact power cables for flexible applications.

RADOX® 9GKW

Halogen free, compact, dual wall power cables

Fire-rated cable

Sunday, 16 October, 2005 | **Supplied by:**http://www.olexcables.com.au/

- - - -

Click2Contact

Developed in conjunction with the Cooperative Research Centre for Polymers, Pyrolex ceramifiable cable uses the latest in polymer technology.

Unlike conventional polymers that typically break down in a fire emergency, the ceramifiable polymer transforms into a protective ceramic barrier, providing added protection to building occupiers and emergency crew at the outbreak of fire. The cable is also designed without stiff mica glass tape, ensuring greater flexibility at installation and high performance in emergency situations. The cables are tested and certified to AS/NZS 3013: 1995 - category WS52W, IEC 60331 and BS 6387, and Olex manufactures the complete single core range from 10 to 630 mm2.

PVC is available at various temperature ratings, ie 75°C, 90°C and 90°C-HT. As XLPE is rated at 90°C what's the difference between that and the higher rated PVC?
All grades of PVC are nominally rated at a 75°C operating temperature for normal installations however the higher PVC rated cables can operate at higher temperatures under certain conditions. These conditions are outlined in AS/NZ 3000:2000, but generally limit the time at which they can operate at those temperatures and restrict their usage where there is no potential for mechanical damage (PVC softens considerably at these temperatures). XLPE does not soften at 90°C and hence does not have the installation and operation restrictions of PVC.

Does the change of V105 to V90-HT mean that this grade of PVC has been down rated?

Some contractors interpreted the V105 rating as a continuous operating temperature of 105°C, which is incorrect. The V105 grade should only be operated at this temperature for limited periods under certain conditions. In order to avoid this confusion, the name has been changed to V90-HT, ie indicating that the cable can operate at high temperatures for limited times. The actual composition of the PVC has not changed.

And then from the same cable manufacturer here.

Question from Voltimum user: PVC is available in various temperature ratings, ie 75°C, 90°C and 90°C-HT. As XLPE is rated at 90°C what's the difference between that and the higher rated PVC?

Answer provided by Martin Muxworthy, Senior Cable Design Engineer at Nexans Olex.
The standard designations of PVC insulation used in Australia are V-75, V-90, and V-90HT. Regardless of their designation all grades of PVC are rated at 75°C operating temperature for continuous use.

Therefore the current carrying capacity of PVC insulated low voltage cables, as documented in Australian Standards AS/NZS 3000:2007 and AS/NZS 3008.1.1:2009,.are based on a maximum operating temperature of 75°C.

The intent of the higher rated PVC cables, with V-90 and V-90HT insulation, is to allow these cables to operate at their higher rated temperature only under certain special conditions. These conditions are outlined in AS/NZ 3000:2007 and in AS/NZS 3008.1.1:2009, and they generally restrict their usage to only those installations where the risk of mechanical damage is low. This is because PVC softens considerably at higher temperatures and therefore is more vulnerable to mechanical damage. Examples of these special conditions might include cables that are enclosed in a manner that affords mechanical protection, ie installations in conduit, or in situations where the cable is installed within thermal insulation that restricts the dissipation of heat from the cable.

Other cable insulation materials exist that do not exhibit the same thermal properties as PVC, include Cross Linked Polyethylene (XLPE). Being a Cross Linked material XLPE (designation X-90 within AS/NZS 3008.1.1) has the property of maintaining its shape and does not flow at the higher operating temperatures and hence does not have the same installation and operation restrictions of PVC.
- See more at: Difference between XLPE & higher rated PVC | Voltimum Australia
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AS/NZS 3008.1.1) has the property of maintaining its shape and does not flow at the higher operating temperatures and hence does not have the same installation and operation restrictions of PVC.

Polyvinyl Chloride (PVC)

Polyvinyl chloride is a thermoplastics material which consists of PVC resin compounded with varying proportions of stabilisers, lubricants, fillers, pigments, plasticisers and processing aids. Different compounds of these ingredients have been developed to obtain specific groups of properties for different applications. However, the major part of each compound is PVC resin.

The technical terminology for PVC in organic chemistry is poly (vinyl chloride): a polymer, i.e. chained molecules, of vinyl chloride. The brackets are not used in common literature and the name is commonly abbreviated to PVC. Where the discussion refers to a specific type of PVC pipe, that type will be explicitly identified as detailed below. Where the discussion is general, the term "PVC pipes" will be used to cover the range of PVC pipe pressure materials supplied by Vinidex.

Different Types of Polyvinyl Chloride

The PVC compounds with the greatest short-term and long-term strengths are those that contain no plasticisers and the minimum of compounding ingredients. This type of PVC is known as UPVC or PVC-U. Other resins or modifiers (such as ABS, CPE or acrylics) may be added to UPVC to produce compounds with improved impact resistance. These compounds are known as modified PVC (PVC-M). Flexible or plasticised PVC compounds, with a wide range of properties, can also be produced by the addition of plasticisers. Other types of PVC are called CPVC (PVC-C) (chlorinated PVC), which has a higher chlorine content and oriented PVC (PVC-O) which is PVC-U where the molecules are preferentially aligned in a particular direction.

PVC-U (unplasticised) is hard and rigid with an ultimate tensile stress of approximately 52 MPa at 20°C and is resistant to most chemicals. Generally PVC-U can be used at temperatures up to 60°C, although the actual temperature limit is dependent on stress and environmental conditions.

PVC-M (modified) is rigid and has improved toughness, particularly in impact. The elastic modulus, yield stress and ultimate tensile strength are generally lower than PVC-U. These properties depend on the type and amount of modifier used.

PVC (plasticised) is less rigid; has high impact strength; is easier to extrude or mould; has lower temperature resistance; is less resistant to chemicals, and usually has lower ultimate tensile strength. The variability from compound to compound in plasticised PVC is greater than that in PVC-U. Vinidex does not manufacture pressure pipes using plasticised PVC.

PVC-C (chlorinated) is similar to PVC-U in most of its properties but it has a higher temperature resistance, being able to function up to 95°C. It has a similar ultimate stress at 20°C and an ultimate tensile stress of about 15 MPa at 80°C.

PVC-O (Oriented PVC) is sometimes called HSPVC (high strength PVC). PVC-O pipes represent a major advancement in the technology of the PVC pipe industry.

PVC-O is manufactured by a process which results in a preferential orientation of the long chain PVC molecules in the circumferential or hoop direction. This provides a marked enhancement of properties in this direction. In addition to other benefits, ultimate tensile strength up to double that of PVC-U can be obtained for PVC-O. In applications such as pressure pipes, where well defined stress directionality is present, very significant gains in strength and/or savings in materials can be made.

Typical properties of PVC-O in the hoop direction are:

Tensile Strength of PVC-O – 90 MPa

Elastic Modulus of PVC-O – 4000 MPa

Property enhancement by molecular orientation is well known and some industrial examples have been produced for over thirty years. In more recent times, it has been applied to consumer products such as films, high strength garbage bags, carbonated beverage bottles and the like.

The technique for applying molecular orientation to PVC pipes was pioneered during the 1970′s by Yorkshire Imperial Plastics and in fact the earliest trial installations were made in 1974 with 100 mm pipe by the Yorkshire Water Authority, United Kingdom. Vinidex commenced production in a pilot PVC-O pipe plant in early 1982 and PVC-O pipes were first installed in Australia in 1986. Since that time, Vinidex have continued to develop and expand the PVC-O product range in commercial production under the trade name Supermain.

Comparison between PVC-O, PVC-M and Standard PVC-U

PVC-O is identical in composition to PVC-U and their general properties are correspondingly similar. The major difference lies in the mechanical properties in the direction of orientation. The composition of PVC-M differs by the addition of an

impact modifier and the properties deviate from standard PVC-U depending on the type and amount of modifier used. The following comparison is general in nature and serves to highlight typical differences between pipe grade materials.
Tensile Strength – The tensile strength of PVC-O is up to twice that of normal PVC-U. The tensile strength of PVC-M is slightly lower than standard PVC-U.
Toughness – Both PVC-O and PVC-M behave in a consistently ductile manner under all practical circumstances. Under some adverse conditions, in the presence of a notch or flaw, standard PVC-U can exhibit brittle characteristics.
Safety Factors – Design of PVC pipes for pressure applications involves prediction of long term properties and application of a safety factor. As in all engineering design, the magnitude of the safety factor reflects the level of confidence in the prediction of performance. The greater confidence in predictable behaviour for the new generation materials PVC-M and PVC-O has the benefit of allowing a lower factor of safety to be used in design.
Design Stress – PVC-O and PVC-M pipes operate at a higher design stress than standard PVC-U pipes as a result of their reduced safety factor and in the case of PVC-O, higher strength in the hoop direction.
Elasticity and Creep – PVC-O has a modulus of elasticity up to 24% higher than normal PVC-U in the oriented direction and a similar modulus to standard PVC-U in other directions. The elastic modulus of PVC-M is marginally lower than standard PVC-U.
Impact Characteristics – PVC-O exceeds standard PVC-U by a factor of at least 2 and up to 5. PVC-M also has greater impact resistance than standard PVC-U. Impact performance tests for PVC-M pipes focus on obtaining a ductile failure characteristic.
Weathering – There are no significant differences in the weathering characteristics of PVC-U, PVC-M and PVC-O.
Jointing – PVC-U and PVC-M pipes can be jointed by either rubber ring or solvent cement joints. PVC-O is available in rubber-ring jointed pipes only. PVC-O cannot be solvent-cement jointed.

Properties OF PVC

General properties of PVC compounds used in pipe manufacture are given in the Table below. Unless otherwise noted, the values given are for standard unmodified formulations using K67 PVC resin. Some comparative values are shown for other pipe materials. Properties of thermoplastics are subject to significant changes with temperature, and the applicable range is noted where appropriate. Mechanical properties are subject to duration of stress application, and are more properly defined by creep functions. More detailed data pertinent to pipe applications are given in the design section of this manual. For data outside of the range of conditions listed, users are advised to contact our Technical Department.

Typical Properties of PVC pipe material

Property	Value	Conditions and Remarks
Physical properties		
Molecular weight (resin)	140000	cf: K57 PVC 70,000
Relative density	1.42 – 1.48	cf: PE 0.95 – 0.96, GRP 1.4 – 2.1, CI 7.2, Clay 1.8 – 2.6
Water absorption	0.0012	23°C, 24 hours cf: AC 18 – 20% AS1711
Hardness	80	Shore D Durometer, Brinell 15, Rockwell R 114, cf: PE Shore D 60
Impact strength – 20°C	20 kJ/m^2	Charpy 250 µm notch tip radius
Impact strength – 0°C	8 kJ/m^2	Charpy 250 µm notch tip radius
Coefficient of friction	0.4	PVC to PVC cf: PE 0.25, PA 0.3
Mechanical properties		

Property	Value	Conditions and Remarks
Ultimate tensile strength	52 MPa	AS 1175 Tensometer at constant strain rate cf: PE 30
Elongation at break	50 – 80%	AS 1175 Tensometer at constant strain rate cf: PE 600-900
Short term creep rupture	44 MPa	Constant load 1 hour value cf: PE 14, ABS 25
Long term creep rupture	28 MPa	Constant load extrapolated 50 year value cf: PE 8-12
Elastic tensile modulus	3.0 – 3.3 GPa	1% strain at 100 seconds cf: PE 0.9-1.2
Elastic flexural modulus	2.7 – 3.0 GPa	1% strain at 100 seconds cf: PE 0.7-0.9
Long term creep modulus	0.9 – 1.2 GPa	Constant load extrapolated 50 year secant value cf: PE 0.2 – 0.3
Shear modulus	1.0 GPa	1% strain at 100 seconds $G=E/2/(1+\mu)$ cf: PE 0.2
Bulk modulus	4.7 GPa	1% strain at 100 seconds $K=E/3/(1-2\mu)$ cf: PE 2.0
Poisson's ratio	0.4	Increases marginally with time under load. cf: PE 0.45
Electrical properties		
Dielectric strength (breakdown)	14 – 20 kV/mm	Short term, 3 mm specimen cf PE 70 – 85
Volume resistivity	2×10^{14} Ω.m	AS 1255.1 PE > 10^{16}
Surface resistivity	$10^{13} – 10^{14}$ Ω	AS 1255.1 PE > 10^{13}
Dielectric constant (permittivity)	3.9 (3.3)	50 Hz (106 Hz) AS 1255.4 cf PE 2.3 – 2.5
Dissipation factor (power factor)	0.01 (0.02)	50 Hz (106 Hz) AS 1255.4
Thermal properties		
Softening point	80 – 84°C	Vicat method AS 1462.5 (min. 75°C for pipes)
Max. continuous service temp.	60°C	cf: PE 80*, PP 110* not under pressure
Coefficient of thermal expansion	7×10^{-5} K	7 mm per 10 m per 10°C cf: PE 18 – 20 x 10^{-5}, DI 1.2 x 10^{-5}

Property	Value	Conditions and Remarks
Thermal conductivity	0.16 W/(m.K)	0 – 50°C PE 0.4
Specific heat	1,000 J/(kg.K)	0 – 50°C
Thermal diffusivity	1.1 x 10^{-7} m^2/s	0 – 50°C
Fire performance		
Flammability (oxygen index)	0.45	ASTM D2863 Fennimore Martin test, cf: PE 17.5, PP 17.5
Ignitability index	10 – 12 (/20)	cf: 9 – 10 when tested as pipe AS 1530 Early Fire Hazard Test
Smoke produced index	6 – 8 (/l0)	cf: 4 – 6 when tested as pipe AS 1530 Early Fire Hazard Test
Heat evolved index	0	
Spread of flame index	0	Will not support combustion. AS 1530 Early Fire Hazard Test

Abbreviations
PE Polyethylene
PP Polypropylene
PA Polyamide (nylon)
CI Cast Iron
AC Asbestos Cement
GRP Glass Reinforced Pipe
Conversion of Units
1 MPa = 10 bar = 9.81 kg/cm2 = 145 lbf/in^2
1 Joule = 4.186 calories = 0.948 x 10-3 BTU = 0.737 ft.lbf
1 Kelvin = 1°C = 1.8°F temperature differential

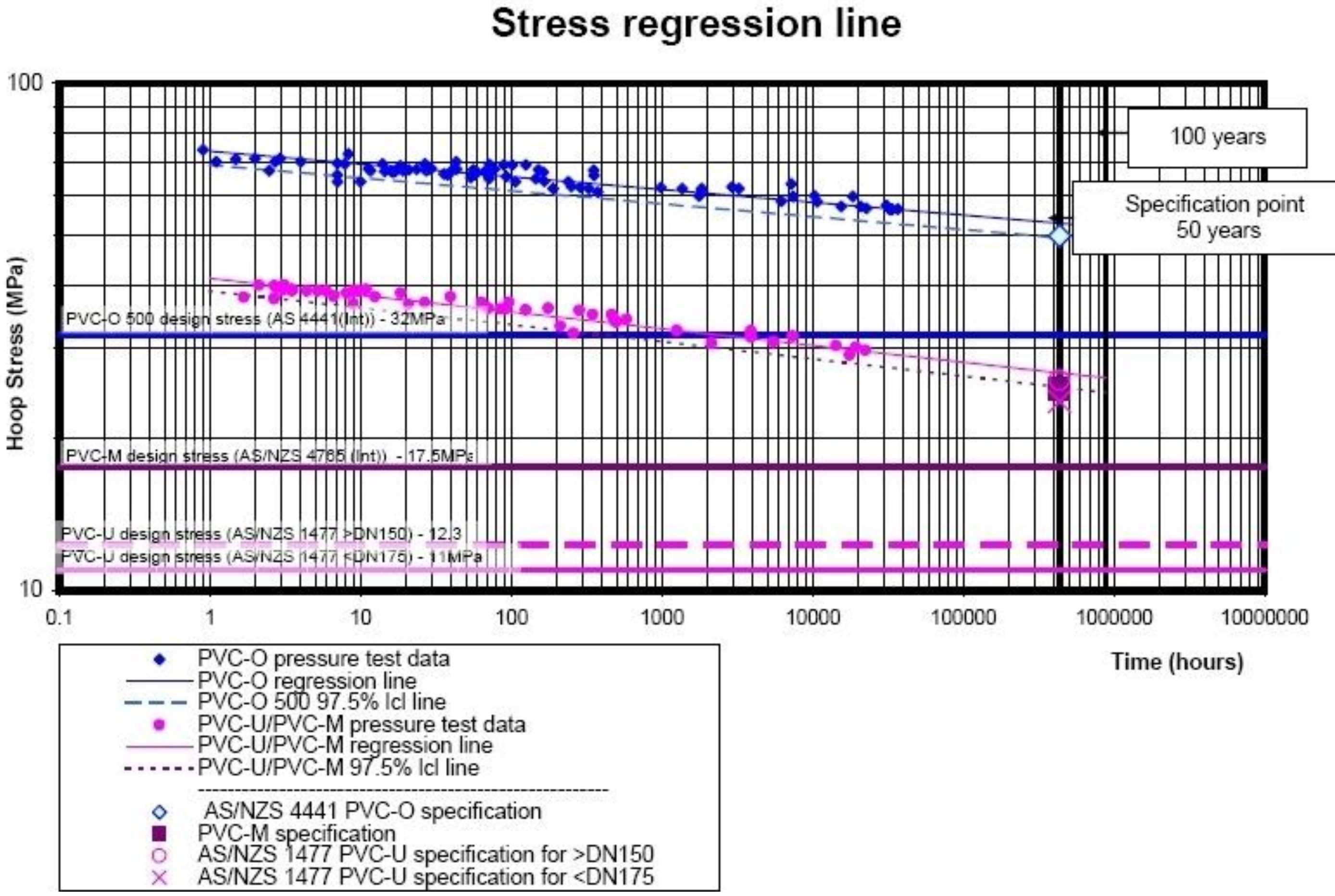
Mechanical Properties

For PVC, like other thermoplastics materials, the stress /strain response is dependent on both time and temperature. When a constant static load is applied to a plastics material, the resultant strain behaviour is rather complex. There is an immediate elastic response, which is fully recovered as soon as the load is removed. In addition there is a slower deformation, which continues indefinitely while the load is applied until rupture occurs. This is known as creep. If the load is removed before failure, the recovery of the original dimensions occurs gradually over time. The rate of creep and recovery is also influenced by temperature. At higher temperatures, creep rates tend to increase. Because of this type of response, plastics are known as viscoelastic materials.

The Stress Regression Line

The consequence of creep is that pipes subjected to higher stresses will fail in a shorter time than those subjected to lower stresses. For pressure pipe applications, long life is an essential requirement. Therefore, it is important that pipes are designed to operate at wall stresses which will ensure that long service lives can be achieved. To establish the long term properties, a large number of test specimens, in pipe form, are tested until rupture. All of these separate data points are then plotted on a graph and a regression analysis performed. The linear regression analysis is extrapolated to obtain the 97.5% lower prediction limit failure stress at the design point which must exceed a minimum required stress (MRS).

A safety factor is then applied to the MRS to obtain a maximum operating stress for the pipe material which is used to dimension pipes for a range of pressure ratings. In Europe and Australasia, the ISO design point of 50 years, or 438,000 hours, is adopted. In North America, the design point of 100,000 hours has historically been used. This design point is quite arbitrary and should not be interpreted as an indication of the expected service life of a PVC pipe. The stress regression line is traditionally plotted on logarithmic axes showing the circumferential or hoop stress versus time to rupture.



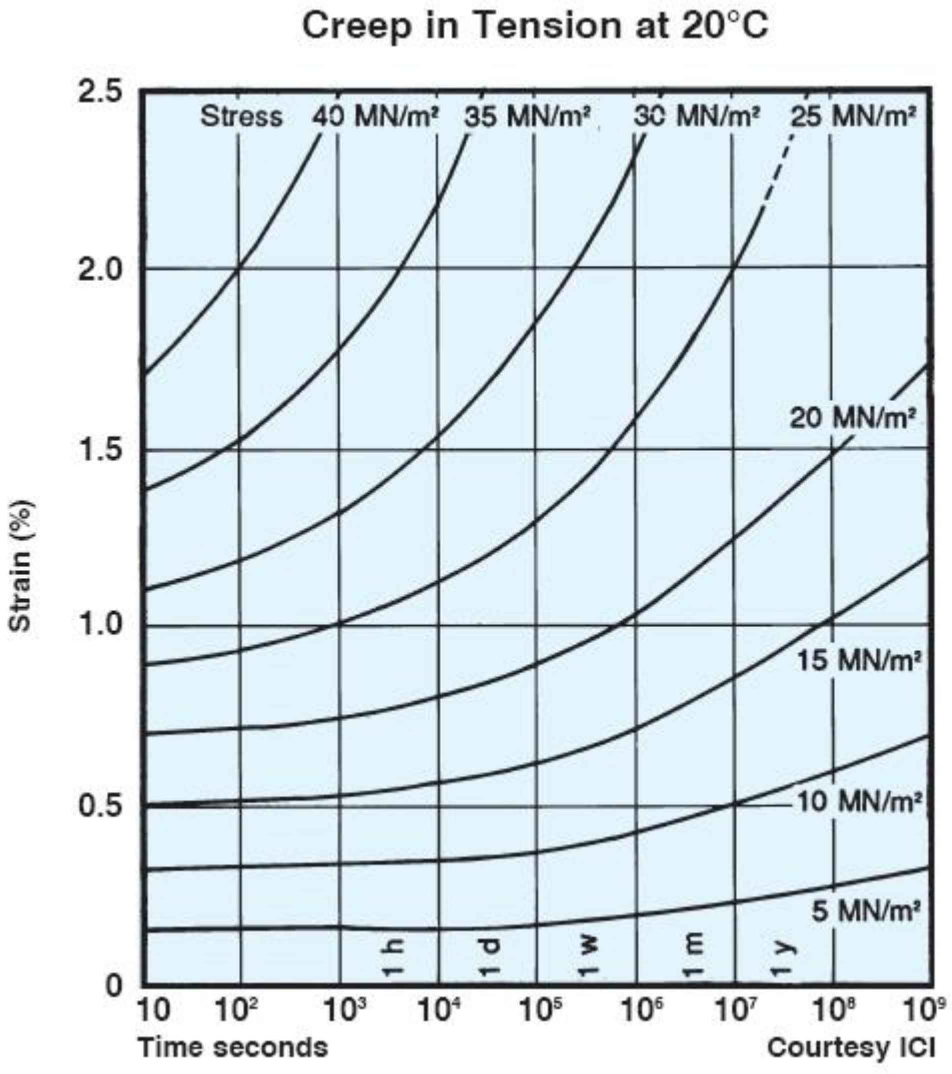
*For PVC-M and PVC-O, the 50 year specification point is a 97.5% lower confidence limit point to ensure that the minimum factor of safety is obtained.

Creep Modulus

For PVC, the modulus or stress/strain relationship must be considered in the context of the rate or duration of loading and the temperature.

A universal method of data presentation is a curve of strain versus time at constant stress. At a given temperature, a series of curves is required at different stress levels to represent the complete picture. A modulus can be computed for any stress/strain/ time combination, and this is normally referred to as the creep modulus.

Such curves are useful, for example, in designing for short and long term transverse loadings of pipes.



Tests conducted in both England and Australia have shown that PVC-O is stiffer, i.e. it has a higher modulus, than standard PVC-U by some 24% for equivalent conditions in the oriented direction. From other work, there appears to be no significant change in the axial direction.

Elevated Temperatures

Pressure Ratings at Elevated Temperatures

The mechanical properties of PVC are referenced at 20°C. Thermoplastics generally decrease in strength and increase in ductility as the temperature rises and design stresses must be adjusted accordingly.

Reversion

The term “reversion” refers to dimensional change in plastics products as a consequence of “material memory”. Plastics products “memorise” their original formed shape and if they are subsequently distorted, they will return to their original shape under heat.

In reality, reversion proceeds at all temperatures, but with high quality extrusion it is of no practical significance in plain pipe at temperatures below 60°C and in PVC-O pipe at temperatures below 50°C.

Weathering and Solar Degradation

The effect of “weathering” or surface degradation by radiant energy, in conjunction with the elements, on plastics has been well researched and documented. Solar radiation causes changes in the molecular structure of polymeric materials, including PVC. Inhibitors and reflectants are normally incorporated in the material which limits the process to a surface effect. Loss of gloss and discolouration under severe weathering will be observed. The processes require input of energy and cannot proceed if the material is shielded, e.g. under-ground pipes. From a practical point of view, the bulk material is unaffected and performance under primary tests will show no change, i.e. tensile strength and modulus. However, microscopic disruptions on a weathered surface can initiate fracture under conditions of extreme local stress, e.g. impact on the outside surface. Impact strength will therefore show a decrease under test.

Protection against Solar Degradation

All PVC pipes manufactured by Vinidex contain protective systems that will ensure against detrimental effects for normal periods of storage and installation. For periods of storage longer than one year, and to the extent that impact resistance is important to the particular installation, additional protection may be considered advisable. This may be provided by under-cover storage, or by covering pipe stacks with an appropriate material such as hessian. Heat entrapment should be avoided and ventilation provided. Black plastic sheeting should not be used. Above-ground pressure pipe systems may be protected by a coat of white or pastel-shade PVA paint. Good adhesion will be achieved with simply a detergent wash to remove any grease and dirt.

Material Ageing

The ultimate strength of PVC does not alter markedly with age. Its short-term ultimate tensile strength generally shows a slight increase. It is important to appreciate that the stress regression line does not represent a weakening of the material with time, i.e. a pipe held under continuous pressure for many years will still show the same short-term ultimate burst pressure as a new pipe. The material does, however, undergo a change in morphology with time, in that the “free volume” in the matrix reduces, with an increasing number of cross-links between molecules. This results in some changes in mechanical properties:

• A marginal increase in ultimate tensile strength.
• A significant increase in yield stress.
• An increase in modulus at high strain levels.

In general, these changes would appear to be beneficial. However, the response of the material at high stress levels is altered in that local yielding at stress concentrators is inhibited, and strain capability of the article is decreased. Brittle-type fracture is more likely to occur, and a general reduction in impact resistance may be observed.

These changes occur exponentially with time, rapidly immediately following forming, and more and more slowly as time proceeds. By the time the article is put into service, they are barely measurable, except in the very long term. Artificial ageing can be achieved by heat treatment at 60°C for 18 hours. PVC-O undergoes such ageing in the orientation process and its characteristics are similar to a fully aged material, but with greatly enhanced ultimate strength.

Abrasion Resistance

Plastics generally show excellent performance under abrasive conditions. The main properties contributing to this are the low elastic modulus and coefficient of friction. This enables the material to “give” and particles tend to skid rather than abrade the surface.

Well known low friction materials such as Teflon, Nylon and Polyurethanes show outstanding characteristics. Economics, however, are a major factor and PVC’s performance in the context of wear rate/unit cost is excellent. Factors affecting abrasion are complex and it is difficult to relate test data to practical conditions.

The Institute for Hydromechanic and Hydraulic Structures of the Technical University of Darmstadt in West Germany tested the abrasion resistance of several pipe products. Gravel and river sand were the abrasive materials used in concrete pipe, glazed vitrified clay pipe and PVC piping, with the following results:

Concrete (unlined)	Measurable wear at 150,000 cycles
Vitrified Clay (glazed lining)	Minimal wear at 260,000 cycles. Accelerated wear after glazing wore off at 260,000 cycles.
PVC	Minimal wear at 260,000 cycles (about equal to glazed vitrified clay, but less accelerated than vitrified clay after 260,000 cycles)

Microbiological Effects

PVC is immune to attack by microbiological organisms normally encountered in under-ground water supply and sewerage systems.

Macrobiological Attack

PVC does not constitute a food source and is highly resistant to damage by termites and rodents.

Effect of Soil Sulphides

Grey discolouration of under-ground PVC pipes may be observed in the presence of sulphides commonly found in soils containing organic materials. This is due to a reaction with the stabiliser systems used in processing. It is a surface effect, and in no way impairs performance.

Radox and Pyrolex are prone to _______________ damage and provide less integrity in case of fire. **Mineral Insulated Metal Sheathed** (_________) cable is less flexible and more difficult to install however when there is a need to maintain circuits (fire pumps, emergency lighting, passenger lifts etc) during a fire it is a suitable choice

In considering the degree of cable performance required in fire, the properties of the cable ________________ are established by controlled laboratory tests.

WHAT ARE CABLE FIRE PERFORMANCE TESTS?

There are several different fire performance tests for cables. The purpose of the test is to verify that the cable will continue to maintain electrical continuity or functionality for a defined period of time in a simulated fire condition. These cables are used to provide power to fire survival equipment, fire alarms and emergency lighting etc.

BS6387 - BRITISH FIRE PERFORMANCE TEST

One of the longest established British Standards for fire performance testing is BS 6387. This covers cables with a diameter of up to 20mm. The standard describes three which the cable must pass, C, W and Z. The tests are conducted on a special fire test rig and the cable is energised to 600V. The cables electrical continuity is indicated by a series of light bulbs which are connected through fuses. A failure will be indicating by the fuse blowing and the light failing on one or more of the bulbs.

The test parameters are as follows and each test is conducted separately.

Test	Description	Temperature of Attack	Duration
C test	Fire alone test at the highest temperature for the longest time	950°C ±4°C	3 hours
W test	Fire and water test simulating a sprinkler system	650°C ±4°C	15 minutes fire plus 15 minutes sprinkler
Z test	Fire test with indirect mechanical shock	950°C ±4°C	15 minutes fire plus impact every 30 seconds

BS EN 50200 - HARMONISED FIRE PERFORMANCE STANDARD

The harmonised standard covering test requirements for fire performance for these smaller cables is BS EN 50200.

The test to BS EN 50200 includes direct flame at a notional temperature of 842°C with mechanical shock to the back board on which the test cables are mounted. There is also a separate test for the cable included in Annex E which includes a water, fire and mechanical shock element.

BS EN 50200 FIRE PERFORMANCE CABLE CLASSIFICATIONS

The cables are classified under the following classifications:

PH15 - 15 minutes duration

PH30 - 30 minutes duration

PH60 - 60 minutes duration

PH120 - 120 minutes duration

BS8491 - FIRE PERFORMANCE STANDARD FOR LARGER CABLES

The British Standard which caters for cables with a diameter greater than 20mm is BS8491.

The test method in BS8491:2008 involves subjecting the cable under test to radiation via direct impingement, corresponding to a constant temperature attack of 842°C; to direct mechanical impacts corresponding to a force of approximately 10N; and to direct application of a water jet simulating a firefighting water jet.
The test method given in this standard includes three different test durations to allow testing of cables intended for different applications:

F30 - for 30 minutes duration

F60 - for 60 minutes duration

F120 - for 120 minutes duration.

IEC 60331 - INTERNATIONAL FIRE PERFORMANCE STANDARD

An International standard for Fire Performance tests is IEC 60331 consists of the following parts under the general title: Tests for electric cables under fire conditions – Circuit integrity:

Part 1: Test method for fire with shock at a temperature of at least 830°C for cables of rated voltage up to and including 0.6/1kV and with an overall diameter exceeding 20mm.

Part 2: Test method for fire with shock at a temperature of at least 830°C for cables of rated voltage up to and including 0.6/1kV and with an overall diameter not exceeding 20mm.

Part 3: Test method for fire with shock at a temperature of at least 830°C for cables of rated voltage up to and including 0.6/1kV tested in a metal enclosure.

Part 11: Apparatus – Fire alone at a flame temperature of at least 750°C

Part 21: Procedures and requirements – Cables of rated voltage up to and including 0.6/1kV

Part 23: Procedures and requirements – Electric data cables

Part 25: Procedures and requirements – Optical fibre cables

NOTE Parts 21, 23 and 25 relate to fire-only conditions at a flame temperature of at least 750 °C.

3. MINERAL INSULATED METAL SHEATHED CABLE (MIMS)
(See Figure 10.30 on page 310 in your textbook) and
http://www.pyrosales.com.au/files/grabdoc.php?type=doc&id=746
This type of cable consists of an annealed seamless **metal sheath**, housing a highly compressed mineral oxide powder (**magnesium oxide**), which surrounds and insulates between 1 to 7

_________ conductors. The most common material used for the outer sheath of MIMS cables is ___________. The melting point of copper (1080°C approximately) and magnesium oxide (2800°C) means MIMS cable is virtually

Strands/ any malleable metal

Copper and Magnesium Oxide are both________________ and won't produce any toxic smoke or gas.

inert

Copper, although mostly inert, is affected by agents in concrete and plaster so if the cable is to be buried in concrete or plaster it should have a **protective _____________serving**. Similar restrictions apply to MIMS cables installed underground to avoid ________________ on the metallic sheath of the cable.

Compressed **magnesium oxide powder** insulation is **Hygroscopic**, that is, it will _____________ moisture readily.

Mineral insulated metal sheathed cable provides an **alternative to wiring systems in metallic conduit.** This method may be more expensive than TPI cables and conduit but is generally quicker to install.

The annealed seamless **copper sheath**_______ be **used as an earth conductor**, saving money on larger systems.

Current can be carried up to a cable temperature of 1000°, the melting point of the copper sheath.

The cable is most likely to fail at its _________________

Layer/ damage/release/ to/melting temperature

CONDUCTOR SIZE

The smallest conductor size used for fixed wiring is 1 mm^2 and this applies to most wiring systems. The largest **solid** conductor for fixed wiring is 2.5 mm^2 except for MIMS cables and a few other cases. MIMS cables __________ have any stranded conductors and the maximum number of cores in the cable is __________. MIMS cable is available from 1mm^2 up to very large single core cables e.g. 400mm^2.

Clause 5.3.2.1.1(c) of AS/NZS 3000:2007 precludes you from using a solid conductor less than ___________ as an earthing conductor. However, the sheath of the cable is suitable for use as the earthing conductor

core

1, 2, 3, 4, or 7 standard (Contact Pentair Industrial Heat Tracing Solutions for custom configurations)

7

5.3.2 Earthing conductor material and type

5.3.2.1 Conductor material

5.3.2.1.1 Copper conductors

Copper earthing conductors shall be of high conductivity copper and shall be in the form of—

(a) stranded conductors;

(b) circular braided conductors; or

(c) solid conductors having a cross-sectional area not less than 10 mm^2 and a thickness not less than 1.5 mm.

EARTH SHEATH RETURN SYSTEM (ESR)

In installations using the MEN system of earthing, it is possible to **combine the *neutral* and the *earthing* conductors** - ________________________. This is an economical system often used in multi-storey construction; Clause 3.16 of AS/NZS 3000:2007 provides information about the **Earth Sheath Return system** (ESR).

3.16 EARTH SHEATH RETURN (ESR) SYSTEM

The earth sheath return (ESR) system is one where the copper sheath of a MIMS cable forms a single conductor that is used as both a protective earthing (PE) conductor and a neutral (N) conductor simultaneously.

Only a copper sheath may be used as a combined protective earthing and neutral (PEN) conductor.

These cables shall be installed in accordance with Clause 3.9.7.3 and the following:

(a) The sheath shall be of adequate cross-sectional area and conductivity.

(b) The ESR system shall be used only in electrical installations where the MEN earthing system is used. It shall commence at the location where the neutral and earthing conductors are connected to form the MEN connection.

(c) Where the combined protective earthing and neutral (PEN) conductor is changed to provide a separate neutral and protective earth to electrical equipment, then the neutral and protective earth shall not be combined again to form a combined protective earthing and neutral (PEN) conductor.

(d) The ESR system shall not be installed in hazardous areas.

(e) Conductors used in an ESR system shall not be smaller than 2.5 mm^2.

(f) At every joint in the sheathing, and at terminations, the continuity of the combined protective earthing and neutral (PEN) conductor shall be ensured by a bonding conductor in addition to the means used for sealing and clamping the external conductor.

The resistance of the bonding conductor at joints shall not exceed that of the cable sheath.

(g) Two conductors, one for protective earthing and one for the neutral, shall be used at terminations. The minimum size for the protective earthing conductor shall be in accordance with Clause 5.3.3 and Table 5.1, and the minimum size for the neutral conductor shall be 6 mm^2, or in accordance with Clause 3.5.2.

(h) Where several cables are associated, e.g. single-core cables used in a multiphase circuit, the cables shall be arranged in accordance with Clause 3.9.10.3.

(i) The circuit shall be clearly identified on the switchboard at which the circuit originates to indicate that the circuit is using the ESR system.

(j) No switch shall operate in the combined protective earthing and neutral (PEN) conductor of an ESR system.

(k) Only electrical fittings identified as suitable for use in conjunction with an ESR system shall be used.

NOTE: Circuits employing ESR systems are unable to be protected by RCDs.

6. SUPPORT AND FIXING

Spacings between fixings and supports for MIMS cables should be such to protect the cable from ______________.

Sagging

One feature of MIMS cables in operation is the relatively high surface temperature of the metallic sheath under some conditions. You should install the cable in such a way as to avoid _____________to other sections of the electrical installation that may suffer damage at these higher temperatures.

touching

Separation Separate MIMS cables from tough plastic sheathed (TPS) cables and UPVC conduits by at least 25 mm.

TERMINATIONS

Terminating MIMS cables is a specialised job that requires **specialised tools** and equipment. The main purpose of the termination accessories is to prevent _____________ from entering the cable insulation and the _______ of the powdery magnesium oxide insulation.

*Before starting it is best to straighten the cable for the length to be stripped.

Moisture/mixture

10. INSULATION RESISTANCE

The insulation resistance should be checked **after stripping and before termination**. It should be greater than ____________. This will prevent a lowering of the total circuit resistance when a number of cables are to be installed

Insulation Resistance XACTPAK mineral insulated, metal-sheathed cable should have a minimum room temperature insulation resistance of **100 megohms** when tested at 50VDC for both wires to sheath and wire to wire. All ceramics used in XACTPAK cable decrease in resistance as temperature increases.

11. MOISTURE REMOVAL

Moisture is ____________ when the cable is open to the environment through a chemical reaction between the Magnesium oxide and water. Typically it won't penetrate much further than 400 to 600 mm. The first 25 mm becomes moist quickly. Any moisture **must** be removed before the cable is sealed as this will affect the insulation resistance.

Present

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1. Mineral Insulated Metal Sheathed cable consists of a seamless copper sheath, with what powder as the insulator?

Magnesium Oxide

2. How is MIMS cable defined as per the AS3000 wiring rules?

____

____

_________________________ AS/ NZS 3000 __________

3.9.7.3 Mineral insulated metal sheathed (MIMS) cable

MIMS cable shall comply with the following:

3. What is the maximum operating temperature of MIMS cable?

____ AS/ NZS 3000 __________

3.4.2 Operating temperature limits

The operating temperatures of conductors shall not exceed the limits given in Table 3.2.

Polymeric cables with normal use temperatures below 75° C (see Notes to Table 3.2) are deemed not suitable for Australian or New Zealand conditions.

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TABLE 3.2

LIMITING TEMPERATURES FOR INSULATED CABLES

Type of cable insulation[1]	Operating temperature of conductor, °C		
	Normal use[2]	Maximum permissible[7]	Minimum ambient[3]
Thermoplastic[4]			
V-75	75	75	0
HFI-75-TP, TPE-75	75	75	−20
V-90	75	90	0
HFI-90-TP, TP-90	75	90	−20
V-90HT	75	105	0
Elastomeric			
R-EP-90	90	90	−40
R-CPE-90, R-HF-90, R-CSP-90	90	90	−20
R-HF-110, R-E-110	110	110	*
R-S-150	150	150	−50
Cross-linked polyethylene			
X-90, X-90UV, X-HF-90	90	90	*
X-HF-110	110	110	*
MIMS[5]	100	250	[6]
Other types			
PE, LLDPE	70	70	*

* Refer to manufacturer's information.

NOTES:

1 The types of cable insulation given in Table 3.2 are included in relevant specifications, i.e. the AS/NZS 5000 series, AS/NZS 3191, AS/NZS 3808 and AS/NZS 60702.1.

2 Lower maximum temperatures will apply where materials used in the construction of the cables or in association therewith, such as coverings, sheathings, insulating sleeving on connections and sealing compounds, have maximum operating temperatures lower than the cable proper. However, the allowable operating temperatures for such materials shall not be exceeded.

3 If manufacturer's recommendations permit, cables may be installed in locations

4. How should MIMS cable be supported?

____ AS/ NZS 3000 __________

3.3.2.8 Other mechanical stresses

Wiring systems shall be selected and installed so as to minimize damage to the cable insulation, sheathing and connections during installation, operation and maintenance.

Measures undertaken to minimize damage may include the following:

(a) Provision of supports, continuous or at appropriate intervals suitable for the mass of the cable.

(b) Use of suitable fixings for the cable size and type that hold the cable in position without damage.

(c) Use of suitable connections for the cable size and type that reduce mechanical strain at joints and terminations.

(d) Attention to minimum bending radius limits of cables.

(e) Provision of flexibility to accommodate any movement or tension stresses.

5. Is it permissible to use plastic saddles to fix MIMS cable?
____ AS/ NZS 3000 __________

No

3.9.7.3 Mineral insulated metal sheathed (MIMS) cable
MIMS cable shall comply with the following:
(a) Protection against corrosion The type of MIMS cable shall be selected to suit the environmental conditions it is installed in where the cable is—
(i) buried in concrete or plaster containing corrosive agents;
(ii) installed underground, in accordance with Clause 3.11; or
(iii) in other locations where corrosion is likely to occur.
(b) Protection against vibration Movement caused by vibration shall be provided for by introducing a loop in the cable immediately before the termination.
The size of the loop shall be determined by the cable size and severity of the vibration.
(c) Support and fixing MIMS cable shall be supported and, if necessary, fixed in position so as to provide adequate protection against damage.
The supports and fixings shall be suitable for use at the highest temperature attained by the cable according to the circumstances of its use.
NOTE: See Clause 4.2.2.3 for requirements concerning the effect of elevated temperatures on adjacent materials.

3.9.3 Support and fixing
3.9.3.1 General
Wiring systems shall be supported by suitable means to comply with Clause 3.3.2.8.
Wiring systems shall be fixed in position by suitable clips, saddles or clamps or by means that will not damage the wiring system and that will not be affected by the wiring system material or any external influences.
For wiring systems installed in building elements, the positioning and size

of openings and checks shall not reduce the structural strength of those building elements below the levels required by national building codes.

6. When terminating MIMS cable to a motor, what should be provided to stop vibration?
____AS/ NZS 3000 __________

3.9.7.3 Mineral insulated metal sheathed (MIMS) cable
MIMS cable shall comply with the following:

(b) Protection against vibration Movement caused by vibration shall be provided for by introducing a loop in the cable immediately before the termination.
The size of the loop shall be determined by the cable size and severity of the vibration.

7. Is it permissible to install orange served MIMS cable buried directly in the concrete without any further protection?
____ AS/ NZS 3000 __________
No

3.9.7.3 Mineral insulated metal sheathed (MIMS) cable
MIMS cable shall comply with the following:
(a) Protection against corrosion The type of MIMS cable shall be selected to suit the environmental conditions it is installed in where the cable is—
(i) buried in concrete or plaster containing corrosive agents;
(ii) installed underground, in accordance with Clause 3.11; or

3.11 UNDERGROUND WIRING SYSTEMS
3.11.1 Suitability and protection
Cables installed underground shall be—
(a) suitable for the environment in which they are placed;
(b) provided with protection against inadvertent damage likely to be caused by manual or mechanical excavation work; and
(c) provided with suitable warnings, marking or other means to minimize the risk of inadvertent damage likely to be caused by

manual or mechanical excavation works.

3.11.2 Classification of wiring systems

Underground wiring systems are classified as one of three categories.

The type of cable and form of enclosure determine the category assigned to the underground wiring system.

Category A system—where the wiring system is inherently suitable for installation below ground and no further mechanical protection is required.

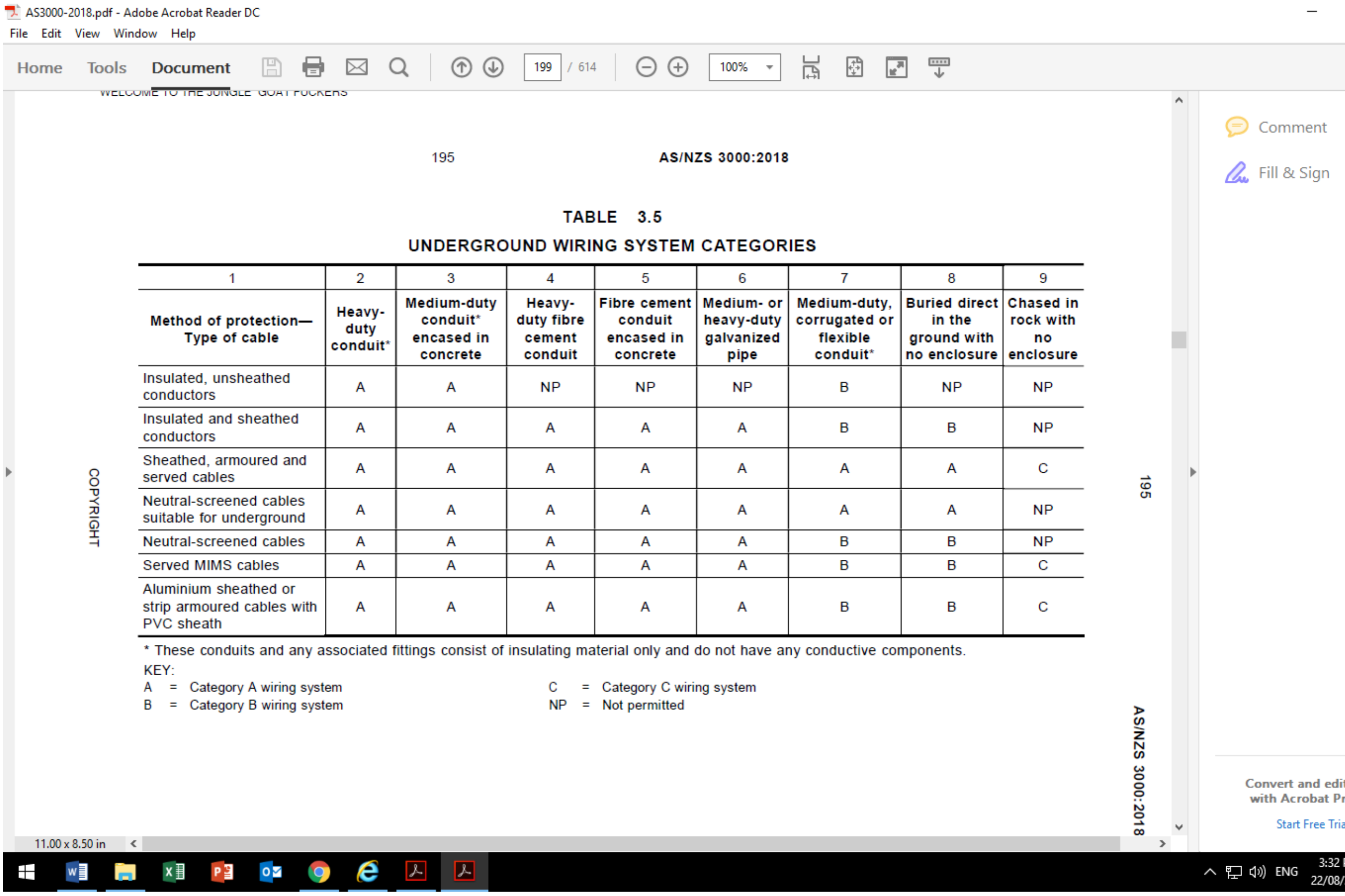

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TABLE 3.5

UNDERGROUND WIRING SYSTEM CATEGORIES

1	2	3	4	5	6	7	8	9
Method of protection—Type of cable	**Heavy-duty conduit***	**Medium-duty conduit* encased in concrete**	**Heavy-duty fibre cement conduit**	**Fibre cement conduit encased in concrete**	**Medium- or heavy-duty galvanized pipe**	**Medium-duty, corrugated or flexible conduit***	**Buried direct in the ground with no enclosure**	**Chased in rock with no enclosure**
Insulated, unsheathed conductors	A	A	NP	NP	NP	B	NP	NP
Insulated and sheathed conductors	A	A	A	A	A	B	B	NP
Sheathed, armoured and served cables	A	A	A	A	A	A	A	C
Neutral-screened cables suitable for underground	A	A	A	A	A	A	A	NP
Neutral-screened cables	A	A	A	A	A	B	B	NP
Served MIMS cables	A	A	A	A	A	B	B	C
Aluminium sheathed or strip armoured cables with PVC sheath	A	A	A	A	A	B	B	C

* These conduits and any associated fittings consist of insulating material only and do not have any conductive components.

KEY:

A = Category A wiring system

B = Category B wiring system

C = Category C wiring system

NP = Not permitted

3.11.3.1 Category A underground wiring systems

Category A underground wiring systems recognized by this Standard comprise one of the following arrangements:

(a) A system where cables are enclosed in heavy-duty insulating conduit without further mechanical protection.

(b) A system where cables are enclosed in insulating wiring enclosures encased in concrete.

(c) A system where sheathed cables are enclosed in galvanized steel pipe without further mechanical protection.

NOTE: Metal conduits are not suitable for this purpose.

(d) A system where armoured sheathed cables or neutral-screened cables are buried direct in the ground without mechanical protection.

NOTE: Examples of Category A underground wiring systems are given in Figures 3.10 to 3.12.

3.11.3.2 Category B underground wiring systems

Category B underground wiring systems recognized by this Standard comprise one of the following arrangements:

(a) A system where cables are enclosed in medium-duty insulating conduit with additional mechanical protection.

(b) A system where sheathed cables are buried direct in the ground with mechanical protection.

8. Are you permitted to use orange served MIMS cable in a refrigeration room? ____ AS/ NZS 3000 _________

Yes

6.6.3.2.2 Types permitted

The following wiring systems are permitted:

(a) Unenclosed sheathed cables including served MIMS cables.

(b) Insulated, unsheathed or sheathed cables enclosed in a wiring enclosure that has adequate draining facilities.

9. Can MIMS cable be used as an Earth Sheathed Return system? ____ AS/ NZS 3000 _________

Yes

3.16 EARTH SHEATH RETURN (ESR) SYSTEM

The earth sheath return (ESR) system is one where the copper sheath of a MIMS cable forms a single conductor that is used as both a protective earthing (PE) conductor and a neutral (N) conductor simultaneously.

Only a copper sheath may be used as a combined protective earthing and neutral (PEN) conductor.

These cables shall be installed in accordance with Clause 3.9.7.3 and the following:

(a) The sheath shall be of adequate cross-sectional area and conductivity.

(b) The ESR system shall be used only in electrical installations where the MEN earthing system is used. It shall commence at the location where the neutral and earthing conductors are connected to form the MEN connection.

(c) Where the combined protective earthing and neutral (PEN) conductor is changed to provide a separate neutral and protective earth to electrical equipment, then the neutral and protective earth shall not be combined again to form a combined protective earthing and neutral (PEN) conductor.

(d) The ESR system shall not be installed in hazardous areas.

(e) Conductors used in an ESR system shall not be smaller than 2.5 mm^2.

(f) At every joint in the sheathing, and at terminations, the continuity of the combined protective earthing and neutral (PEN) conductor shall be ensured by a bonding conductor in addition to the means used for sealing and clamping the external conductor.

The resistance of the bonding conductor at joints shall not exceed that of the cable sheath.

(g) Two conductors, one for protective earthing and one for the neutral, shall be used at terminations. The minimum size for the protective earthing conductor shall be in accordance with Clause 5.3.3 and Table 5.1, and the minimum size for the neutral conductor shall be 6 mm^2, or in accordance with Clause 3.5.2.

10. What type of MIMS cable is suitable for underground wiring?
____ AS/ NZS 3000 __________

3.9.7.3 Mineral insulated metal sheathed (MIMS) cable

MIMS cable shall comply with the following:

(a) Protection against corrosion The type of MIMS cable shall be selected to suit the environmental conditions it is installed in where the cable is—

(i) buried in concrete or plaster containing corrosive agents;

(ii) installed underground, in accordance with Clause 3.11; or

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Steel wire armoured cables (_______) are sometimes used as alternatives to wiring systems in __________ conduit, that is, where ______________ protection is required. These methods are generally more expensive than TPI cables in conduit but they are generally quicker to install.

SWA, PVC, mechanical

1. STEEL WIRE ARMOURED CABLE
Armoured cables have the advantage of a _________ wrapping that surrounds the cores of the cable with the wrapping itself being protected by a PVC sheath.
The metallic armour is for **mechanical protection** and is not a __________________.
Do not confuse this cable with neutral screened cables. You can use the armour of the cable for ________________.
The fittings or cable glands used with this type of cable must be capable of making an ____________ electrical connection to the steel armour. Some glands will also make a weatherproof seal with the sheath of the cable.
The extra protection offered by the steel armour lets you install this cable _____________ in situations that might otherwise need the protection of conduit.

Metallic, conductor, earthing , optional, especially

CABLE GLANDS

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APPLICATIONS OVERVIEW

We supply a comprehensive range of industrial and hazardous area cable glands (also known as cable fittings) for the smooth interconnection of cables and equipment. This covers the full spectrum of cable, with applications from general industrial types through to safety, deluge, flameproof and explosion proof cable glands.

Our cable glands are designed to provide optimal systems integrity when used alongside our cables and form an integral part of our cable solutions. Depending on the application, we offer brass cable glands as well as stainless steel, aluminium, nylon, nickel, plastic and other materials. Our cable glands are generally supplied with other cable gland accessories including locknuts, O-rings, sealing washers, earthing washers, earth tags, shrouds, clamping modules, adaptors, reducers, and blanking plugs. These are available in both metric and PG threads, as well as for armoured and non-armoured cable applications.

Our cable glands adhere to the strictest national and international specifications including NEC, CEC, ATEX and IECEx.

CABLE GLANDS PORTFOLIO

Some of our most popular cable glands include:

Brass Gland	A2	A2 brass cable glands are suitable for use with unarmoured cables. Their outer seal grips the sheath of the cable to achieve a weatherproof seal, hence their IP68 rating.
	BW	AWA and SWA cable requires armoured cable glands. BW brass cable glands are suitable for use with steel wire armoured cables on indoor applications. These SWA cable glands have no loose parts in their construction which allow for easy installation.
	CX	CX brass cable glands are suitable for use with braided cables providing electrical

		continuity for the cables' wire braid.
	CXT	CXT brass cable glands are suitable for use with all types of screened flexible wire braid and wire braid armoured cables. These glands provide mechanical cable retention and electrical continuity
	CW	CW brass cable glands are suitable for use with steel wire armoured cables on outdoor applications. Their outer seal grips the cable sheath to achieve weatherproof seal. A separate armour lock ring ensures armour clamping.
Nickel plated glands	Hummel MS	A standard grade nickel-plated brass gland which is IP68 rated. This waterproof cable gland's seal prevents ingress of dust and water, suitable for immersion. The Hummel MS Gland is suitable for use in environments demanding high levels of chemical and mechanical stability including measurement and control applications.
	Hummel EMC	Nickel plated Hummel EMC glands are ideal for watertight applications. Their high quality finish makes them suitable for plant machinery and control equipment. These are known as SY cable glands and CY cable glands, and should only be used for applications with these control cables.
Nylon glands	Hummel PA	A standard grade polyamide metric gland (plastic cable gland) manufactured with IP68 watertight and dust-tight rating. They are supplied with a neoprene seal to reduce the gland diameter where applied to smaller size cables.

For more information on cables for specific applications or industries, such as rail cable glands, contact our technical team.

CABLE GLANDS PG SIZE CONVERSION TABLE

Nominal thread size	Outer diameter	Threads per inch (TPI)	Pitch	Inner diameter	Cable diameter
PG7	12.5mm / 0.492in	20	1.270mm / 0.05in	11.28mm / 0.444in	3- 6.5mm / 0.118 - 0.256in
PG9	15.5mm / 0.610in	18	1.4112mm / 0.05556in	13.86mm / 0.546in	4 - 8mm / 0.157 - 0.315in
PG11	18.6mm / 0.732in	18	1.4112mm / 0.05556in	17.26mm / 0.680in	5 - 10mm / 0.197 - 0.394in
PG13.5	20.4mm / 0.803in	18	1.4112mm / 0.05556in	19.06mm / 0.750in	6 - 12mm / 0.236 - 0.472in
PG16	22.5mm / 0.886in	18	1.4112mm / 0.05556in	21.16mm / 0.833in	10 - 14mm / 0.394 - 0.551in
PG21	28.3mm / 1.114in	16	1.5875mm / 0.0625in	26.78mm / 1.054in	13 - 18mm / 0.512 - 0.709in
PG29	37.0mm / 1.457in	16	1.5875mm / 0.0625in	35.48mm / 1.397in	18 - 25mm / 0.709 - 0.984in
PG36	47.0mm / 1.850in	16	1.5875mm / 0.0625in	45.48mm / 1.791in	22 - 32mm / 0.866 - 1.26in

PG42	54.0mm / 2.126in	16	1.5875mm / 0.0625in	52.48mm / 2.066in	30 - 38mm / 1.18 - 1.50in
PG48	59.3mm / 2.335in	16	1.5875mm / 0.0625in	57.78mm / 2.275in	34 - 44mm / 1.34 - 1.73in

CABLE GLANDS SELECTION

As cable experts, Eland Cables' technical team is ideally positioned to provide technical support with the selection of the ideal gland solution to use alongside our cables. Our cable solutions include one of the most comprehensive selections of cable accessories in the industry, including custom designed glands on large-scale projects.

RANGE OF CABLES

Hummel PA Nylon Gland

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Hummel MS Brass Gland

Download PDF FastQuote

Hummel EMC Earthing Gland

Download PDF FastQuote

Cable Gland CX

Download PDF FastQuote

Cable Gland CXT

Download PDF FastQuote

Cable Gland BW

Download PDF FastQuote

Cable Gland CW

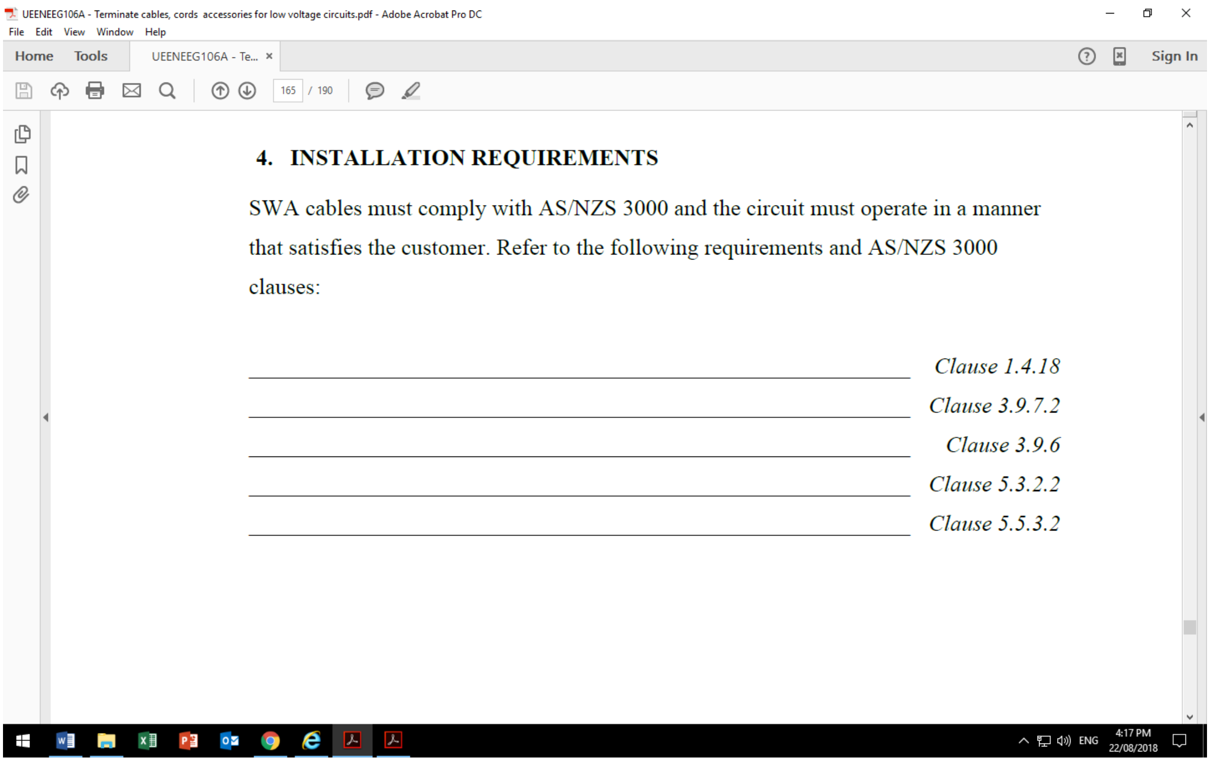
Download PDF FastQuote

Cable Gland A2

2. SUPPORT OF SWA CABLES

The same regulations for the support of unarmoured cables apply to armoured cables. The cables must have sufficient support to **prevent undue** ____________. When SWA cable is run vertically, the supports need to be closer together than for unarmoured cables. The **extra support** is necessary because the armoured cable is much _________ than the unarmoured cable of similar size.

Stress, heavier



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4. INSTALLATION REQUIREMENTS

SWA cables must comply with AS/NZS 3000 and the circuit must operate in a manner that satisfies the customer. Refer to the following requirements and AS/NZS 3000 clauses:

____ *Clause 1.4.18*

____ *Clause 3.9.7.2*

____ *Clause 3.9.6*

____ *Clause 5.3.2.2*

____ *Clause 5.5.3.2*

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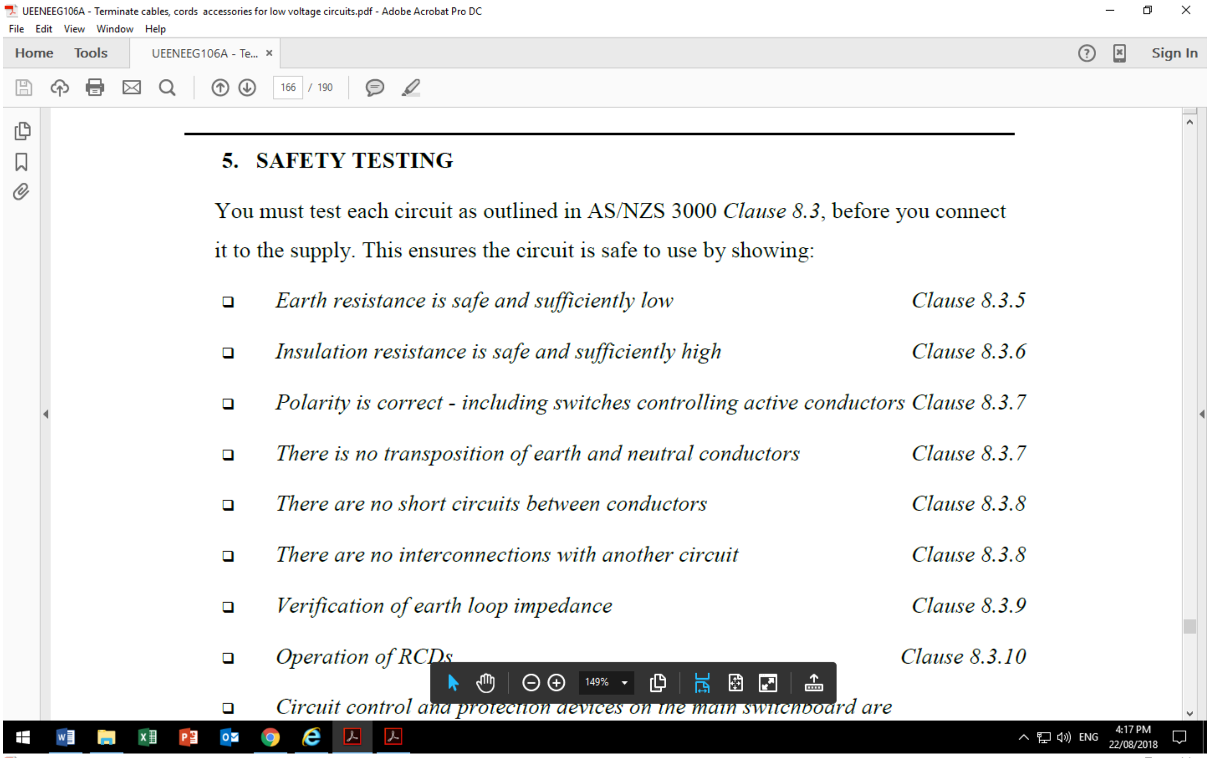
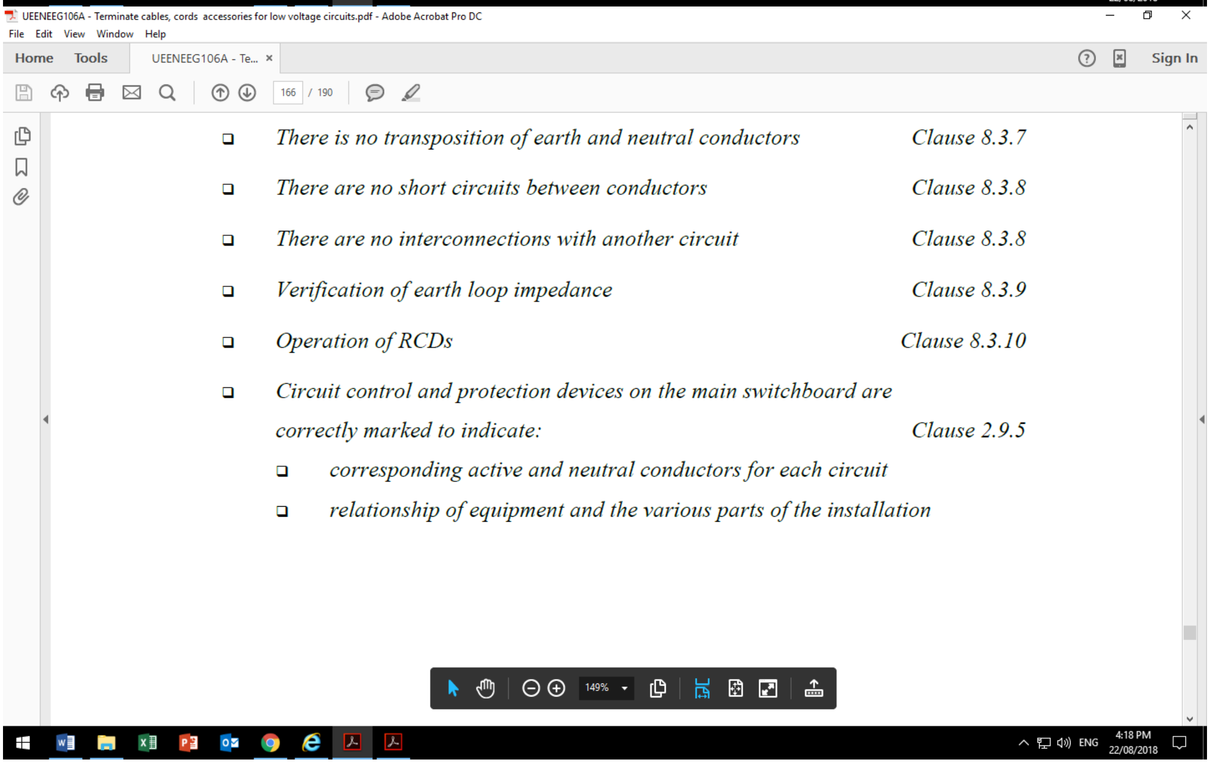


5. SAFETY TESTING

You must test each circuit as outlined in AS/NZS 3000 *Clause 8.3*, before you connect it to the supply. This ensures the circuit is safe to use by showing:

- *Earth resistance is safe and sufficiently low* — *Clause 8.3.5*
- *Insulation resistance is safe and sufficiently high* — *Clause 8.3.6*
- *Polarity is correct - including switches controlling active conductors* — *Clause 8.3.7*
- *There is no transposition of earth and neutral conductors* — *Clause 8.3.7*
- *There are no short circuits between conductors* — *Clause 8.3.8*
- *There are no interconnections with another circuit* — *Clause 8.3.8*
- *Verification of earth loop impedance* — *Clause 8.3.9*
- *Operation of RCDs* — *Clause 8.3.10*
- *Circuit control and protection devices on the main switchboard are*



- *There is no transposition of earth and neutral conductors* — *Clause 8.3.7*
- *There are no short circuits between conductors* — *Clause 8.3.8*
- *There are no interconnections with another circuit* — *Clause 8.3.8*
- *Verification of earth loop impedance* — *Clause 8.3.9*
- *Operation of RCDs* — *Clause 8.3.10*

- *Circuit control and protection devices on the main switchboard are correctly marked to indicate:* — *Clause 2.9.5*
  - *corresponding active and neutral conductors for each circuit*
  - *relationship of equipment and the various parts of the installation*

1. How is Steel Wired Armoured cable defined?

____

____ **AS / NZS3000** __________

1.4.22 Cable, armoured

A cable provided with a wrapping of metal, usually tapes or wires, primarily for the purpose of mechanical protection.

2. If the steel armouring of steel wired armoured cable, needs to be earthed where should it be earthed?

____ **AS / NZS3000** __________

Protective earthing conductors may include the following:

(a) Earthing conductors that comply with Clause 5.3.2.1, separately installed.

b) Earthing conductors that comply with Clause 5.3.2.1, in a common enclosure with live conductors.

(c) Earthing conductors in multi-core cables.

(d) Busbars.

In addition, and subject to the special conditions of Clause 5.3.2.3, the following media may be regarded as a protective earthing conductor:

(i) Conductive conduit, tube, pipe, trunking and similar wiring enclosures.

(ii) Conductive sheaths, armours and screens of cables.

(iii) Conductive framework used for mounting electrical equipment.

(iv) Catenary wires for the support of cables.

3. Can SWA cable be installed directly in a concrete slab, without any further protection?

____ **AS / NZS3000** __________

Yes

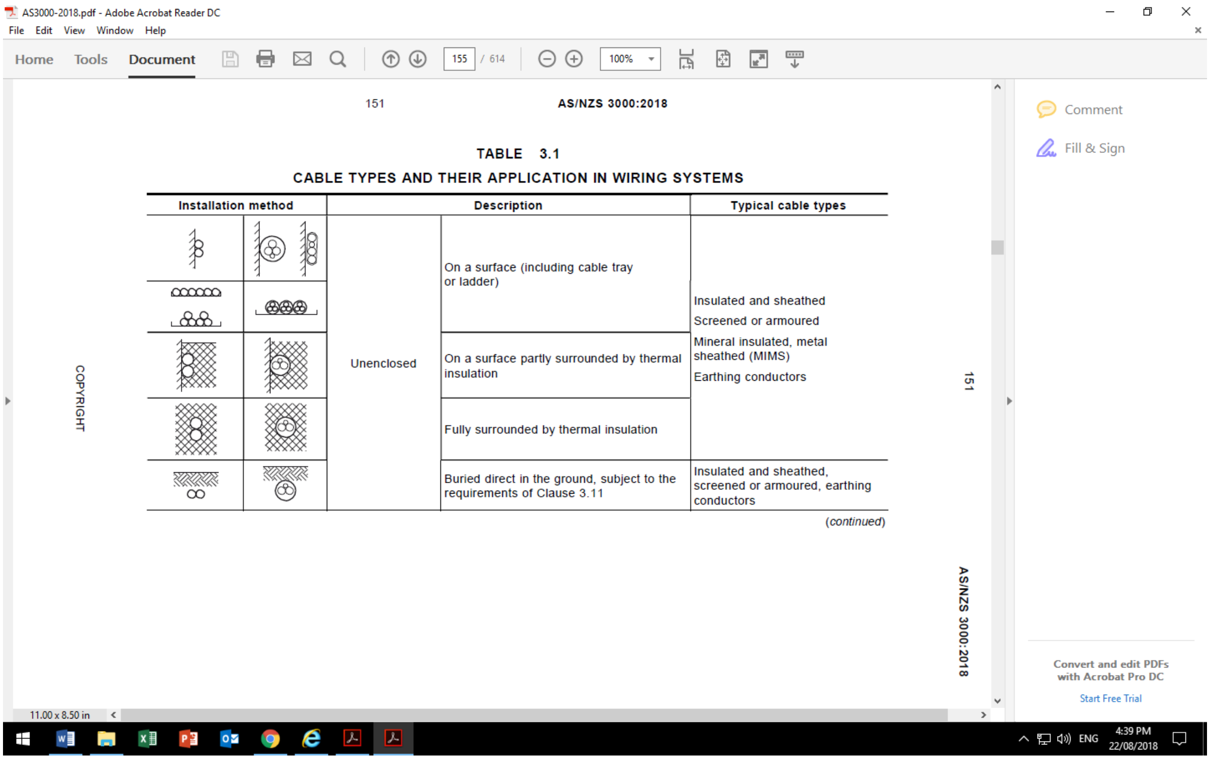


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TABLE 3.1

CABLE TYPES AND THEIR APPLICATION IN WIRING SYSTEMS

Installation method		Description		Typical cable types
		Unenclosed	On a surface (including cable tray or ladder)	Insulated and sheathed Screened or armoured Mineral insulated, metal sheathed (MIMS) Earthing conductors
			On a surface partly surrounded by thermal insulation	
			Fully surrounded by thermal insulation	
			Buried direct in the ground, subject to the requirements of Clause 3.11	Insulated and sheathed, screened or armoured, earthing conductors

(continued)

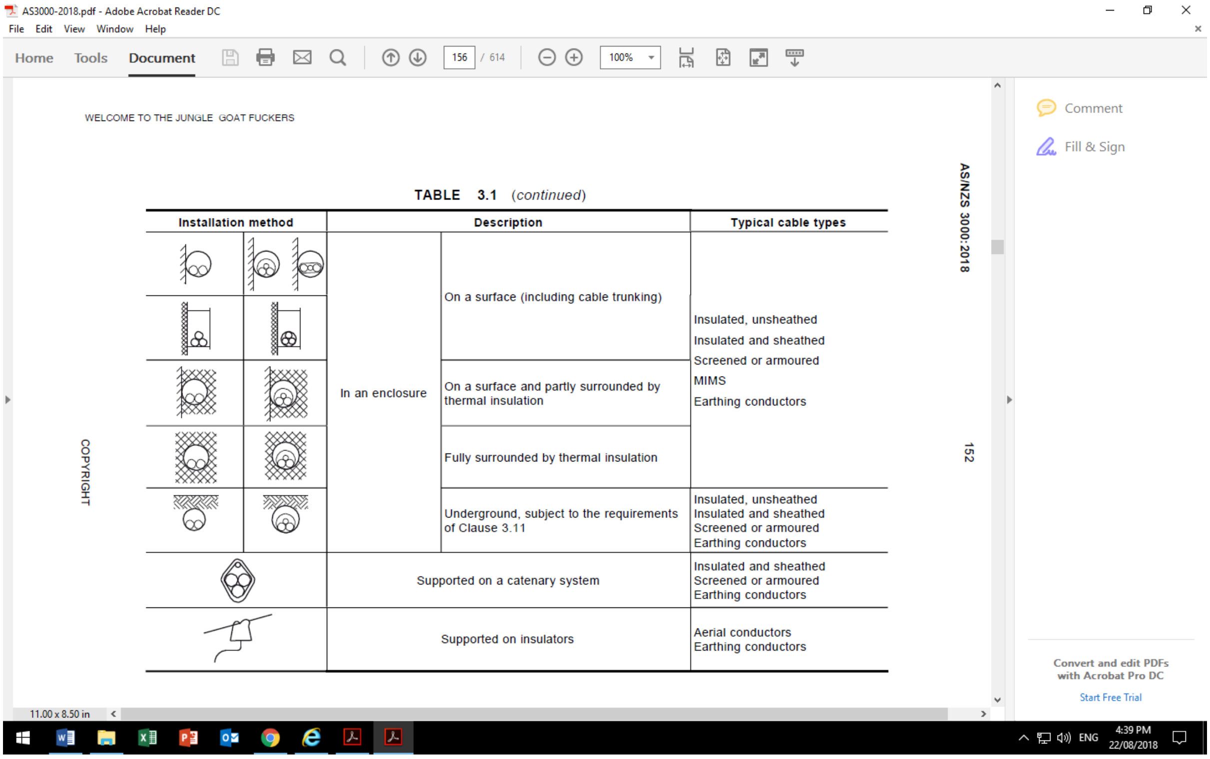

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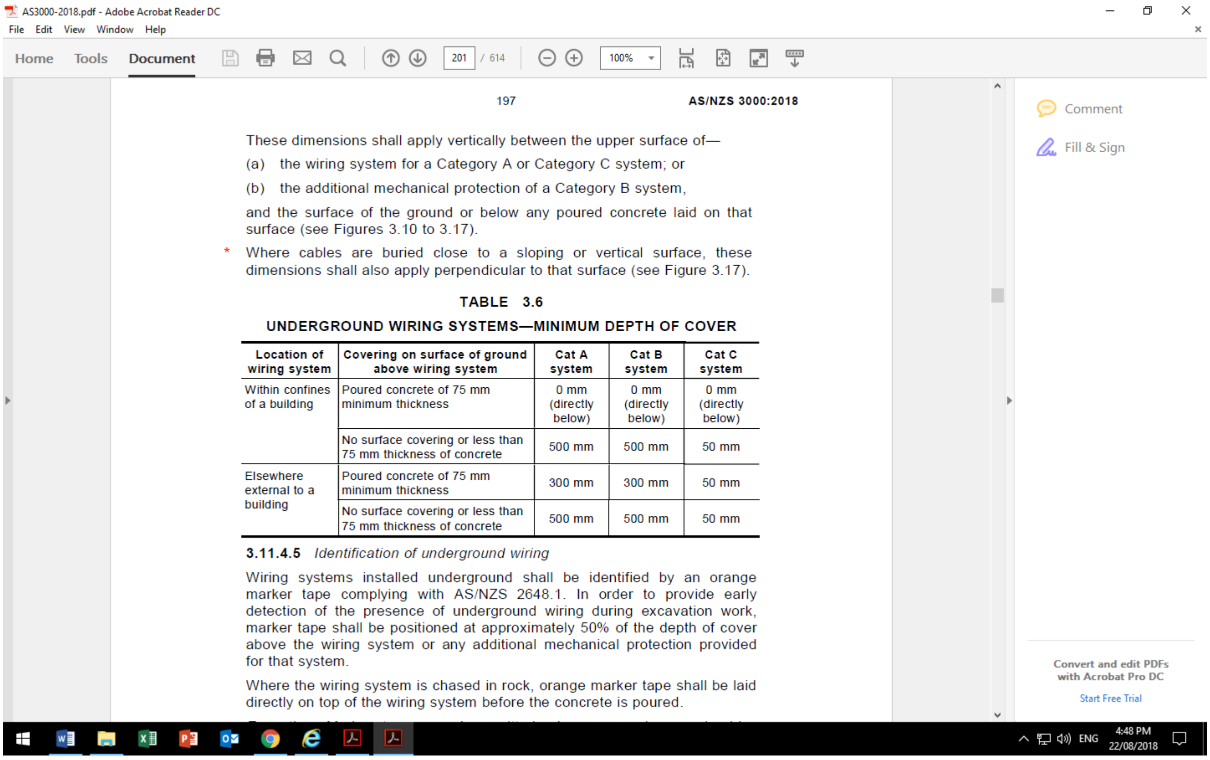
TABLE 3.1 *(continued)*

Installation method		Description	Typical cable types
In an enclosure		On a surface (including cable trunking)	Insulated, unsheathed Insulated and sheathed Screened or armoured MIMS Earthing conductors
		On a surface and partly surrounded by thermal insulation	
		Fully surrounded by thermal insulation	
		Underground, subject to the requirements of Clause 3.11	Insulated, unsheathed Insulated and sheathed Screened or armoured Earthing conductors
	Supported on a catenary system		Insulated and sheathed Screened or armoured Earthing conductors
	Supported on insulators		Aerial conductors Earthing conductors

4. What is the minimum depth in the ground of steel wired armoured cable installed underground in a category A system?

______________________________________ **AS / NZS3000** __________

300mm



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These dimensions shall apply vertically between the upper surface of—

(a) the wiring system for a Category A or Category C system; or

(b) the additional mechanical protection of a Category B system,

and the surface of the ground or below any poured concrete laid on that surface (see Figures 3.10 to 3.17).

* Where cables are buried close to a sloping or vertical surface, these dimensions shall also apply perpendicular to that surface (see Figure 3.17).

TABLE 3.6

UNDERGROUND WIRING SYSTEMS—MINIMUM DEPTH OF COVER

Location of wiring system	Covering on surface of ground above wiring system	Cat A system	Cat B system	Cat C system
Within confines of a building	Poured concrete of 75 mm minimum thickness	0 mm (directly below)	0 mm (directly below)	0 mm (directly below)
	No surface covering or less than 75 mm thickness of concrete	500 mm	500 mm	50 mm
Elsewhere external to a building	Poured concrete of 75 mm minimum thickness	300 mm	300 mm	50 mm
	No surface covering or less than 75 mm thickness of concrete	500 mm	500 mm	50 mm

3.11.4.5 *Identification of underground wiring*

Wiring systems installed underground shall be identified by an orange marker tape complying with AS/NZS 2648.1. In order to provide early detection of the presence of underground wiring during excavation work, marker tape shall be positioned at approximately 50% of the depth of cover above the wiring system or any additional mechanical protection provided for that system.

Where the wiring system is chased in rock, orange marker tape shall be laid directly on top of the wiring system before the concrete is poured.

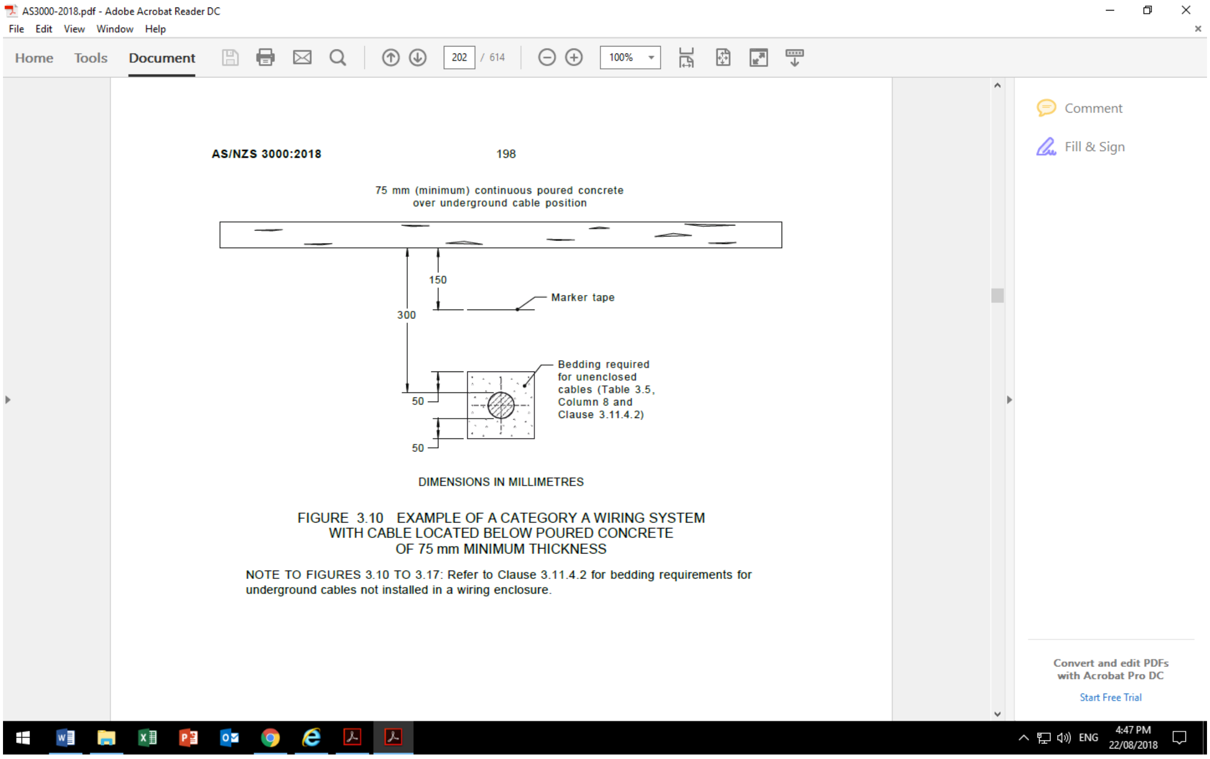

FIGURE 3.10 EXAMPLE OF A CATEGORY A WIRING SYSTEM WITH CABLE LOCATED BELOW POURED CONCRETE OF 75 mm MINIMUM THICKNESS

NOTE TO FIGURES 3.10 TO 3.17: Refer to Clause 3.11.4.2 for bedding requirements for underground cables not installed in a wiring enclosure.

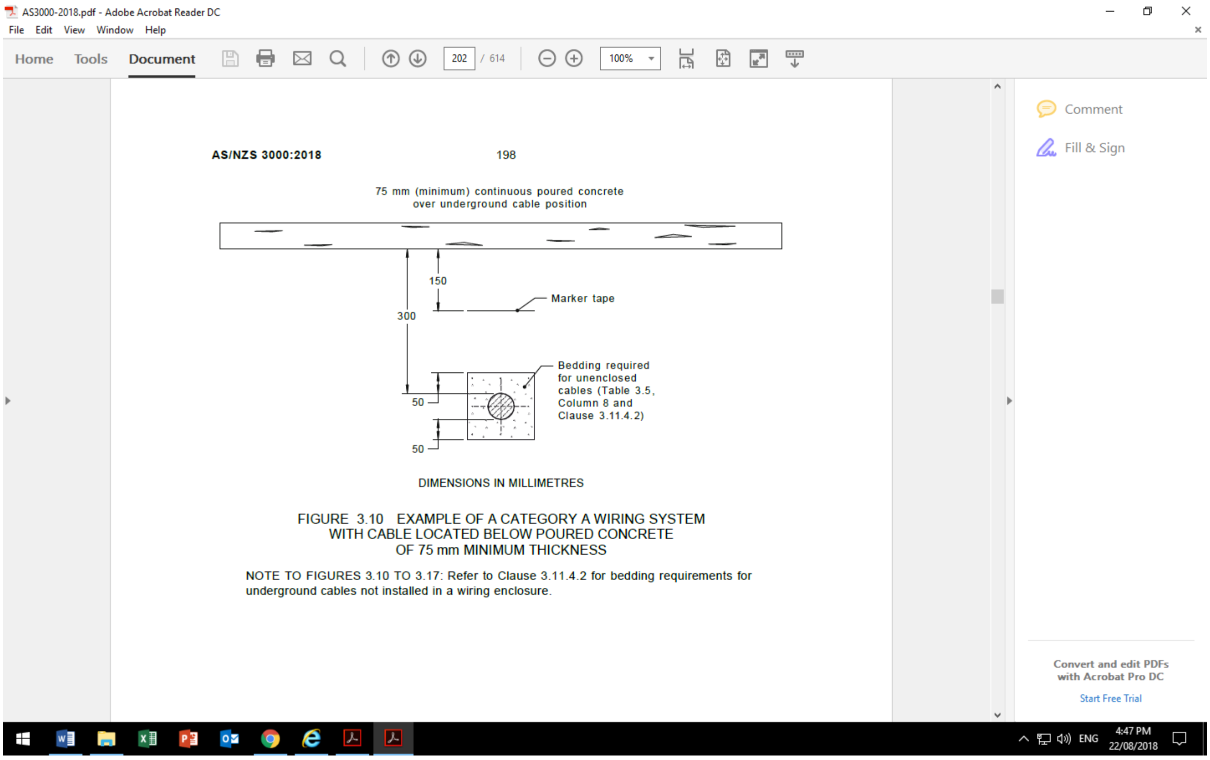
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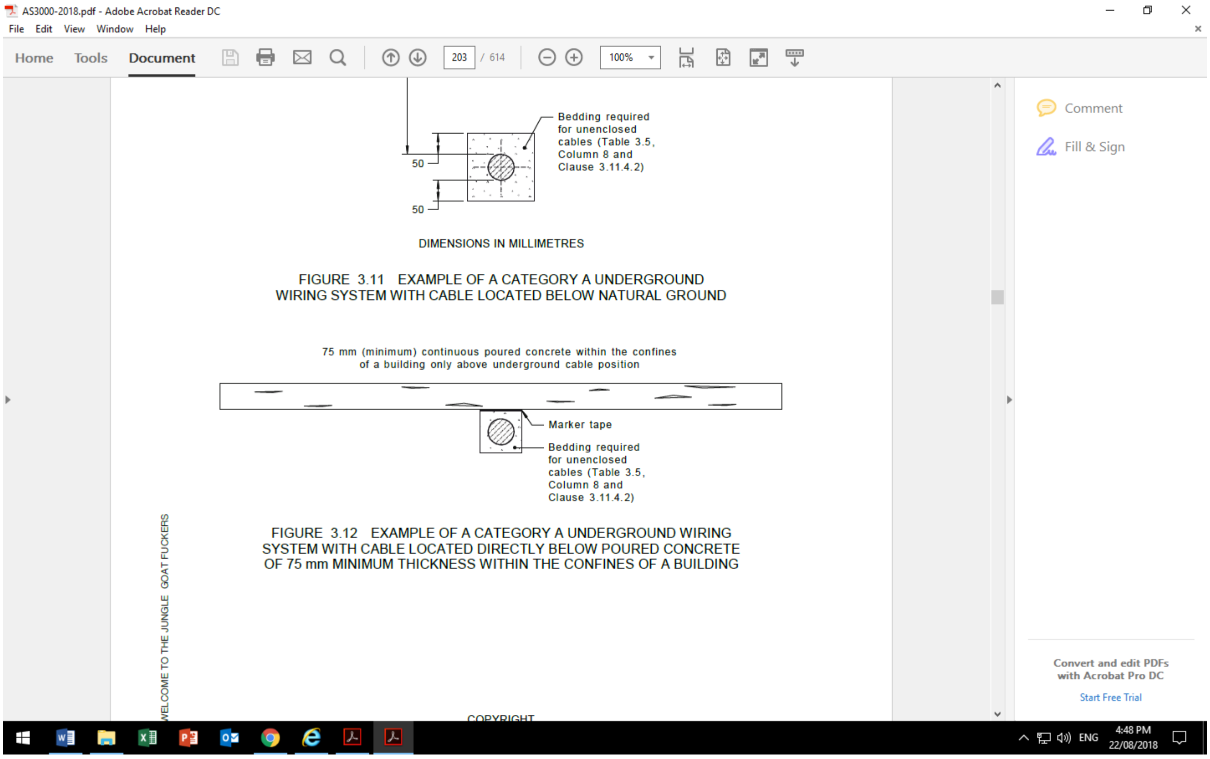
FIGURE 3.10 EXAMPLE OF A CATEGORY A WIRING SYSTEM WITH CABLE LOCATED BELOW POURED CONCRETE OF 75 mm MINIMUM THICKNESS

NOTE TO FIGURES 3.10 TO 3.17: Refer to Clause 3.11.4.2 for bedding requirements for underground cables not installed in a wiring enclosure.



5. Is it permissible to install SWA cable buried directly in the ground without any further protection?

____ **AS / NZS3000** __________

Yes

3.11.2 Classification of wiring systems

Underground wiring systems are classified as one of three categories. The type of cable and form of enclosure determine the category assigned to the underground wiring system.

Category A system—where the wiring system is inherently suitable for installation below ground and no further mechanical protection is required.

Category B system—where the wiring system is suitable for installation below ground only with additional mechanical protection provided for the cable or cable enclosure.

Category C system—where the wiring system is laid within a channel chased in the surface of rock.

3.11.3 Arrangements

3.11.3.1 Category A underground wiring systems

Category A underground wiring systems recognized by this Standard comprise one of the following arrangements:

(a) A system where cables are enclosed in heavy-duty insulating conduit without further mechanical protection.

(b) A system where cables are enclosed in insulating wiring enclosures encased in concrete.

(c) A system where sheathed cables are enclosed in galvanized steel pipe without further mechanical protection.

NOTE: Metal conduits are not suitable for this purpose.

(d) A system where armoured sheathed cables or neutral-screened cables are buried direct in the ground without mechanical protection.

6. What is the minimum bending radius for 25 sq mm, 4 core, SWA cable? (the overall diameter of the cable is 30 mm)

____ **AS / NZS3000** __________

3.10.3.4 Bending

The radius of every bend in a wiring system shall be such that conductors and cables will not suffer damage.

Bends in rigid conduit shall be such that the internal diameter is not significantly reduced.

Changes of direction in trunking, ducts or similar applications shall permit the bending of cables laid therein, so as to comply with the requirements of this Clause.

NOTE: See Clause 3.9.6 for cable-bending requirements.

3.9.6 Change of direction

Where wiring systems change direction, the following requirements apply:

(a) Bends shall not cause damage, or place undue stress on their sheathing, insulation or terminations.

(b) The bending radius recommended by the cable manufacturer shall be observed.

Where manufacturer's information is not available, the following minimum internal radii may be considered suitable:

(i) Unarmoured sheathed cables............ 6 times the cable diameter.

or

(ii) Armoured sheathed cables............... 12 times the cable diameter.

(c) Supports in contact with cables under pressure from changes in

direction shall not have sharp edges.
Exception: These requirements need not apply where the cable has been otherwise protected at the pressure point.

12x30 mm = 360mm

7. When joining SWA cables the steel armouring what are the requirements for the armouring?
____ **AS / NZS3000** __________

3.10.3.3 Continuity
Mechanical and electrical continuity of conductive enclosures shall be maintained.
Exception: Continuity of conductive enclosures need not be maintained where, in accordance with this Standard, the enclosure is not required to be earthed, e.g. the enclosure contains insulated and sheathed cables only

8. When installing SWA cable on a vertical wall, what can be used to fix the cable to the wall?
____ **AS / NZS3000** __________

3.9.5 Wiring systems installed vertically
Where wiring systems are installed vertically, they shall be installed in accordance with the requirements of Clauses 3.9.2 and 3.9.3 and in such a manner as to avoid damage to any part of the wiring system that may be caused by its own weight or method of support or fixing.
Adequate provision shall be made for the support of cables enclosed in a wiring enclosure installed vertically. Cable supports shall be provided at intervals not exceeding 8 m or as recommended by the cable manufacturer.
3.9.2 Methods of installation
Installation methods for typical types of wiring systems are depicted in Table 3.1.
The effect of external influences at the installation shall be considered in accordance with Clause 3.3 and manufacturer's instructions.
Installation methods and wiring systems that are not depicted in Table 3.1 may be used provided that compliance is maintained with the general requirements of this Section.
3.9.3 Support and fixing
3.9.3.1 General
Wiring systems shall be supported by suitable means to comply with Clause 3.3.2.8.

Wiring systems shall be fixed in position by suitable clips, saddles or clamps or by means that will not damage the wiring system and that will not be affected by the wiring system material or any external influences.
For wiring systems installed in building elements, the positioning and size of openings and checks shall not reduce the structural strength of those building elements below the levels required by national building codes.

9. What is maximum operating temperature of V75 PVC sheathed SWA cable?

____ **AS / NZS3000** __________

75 degree C

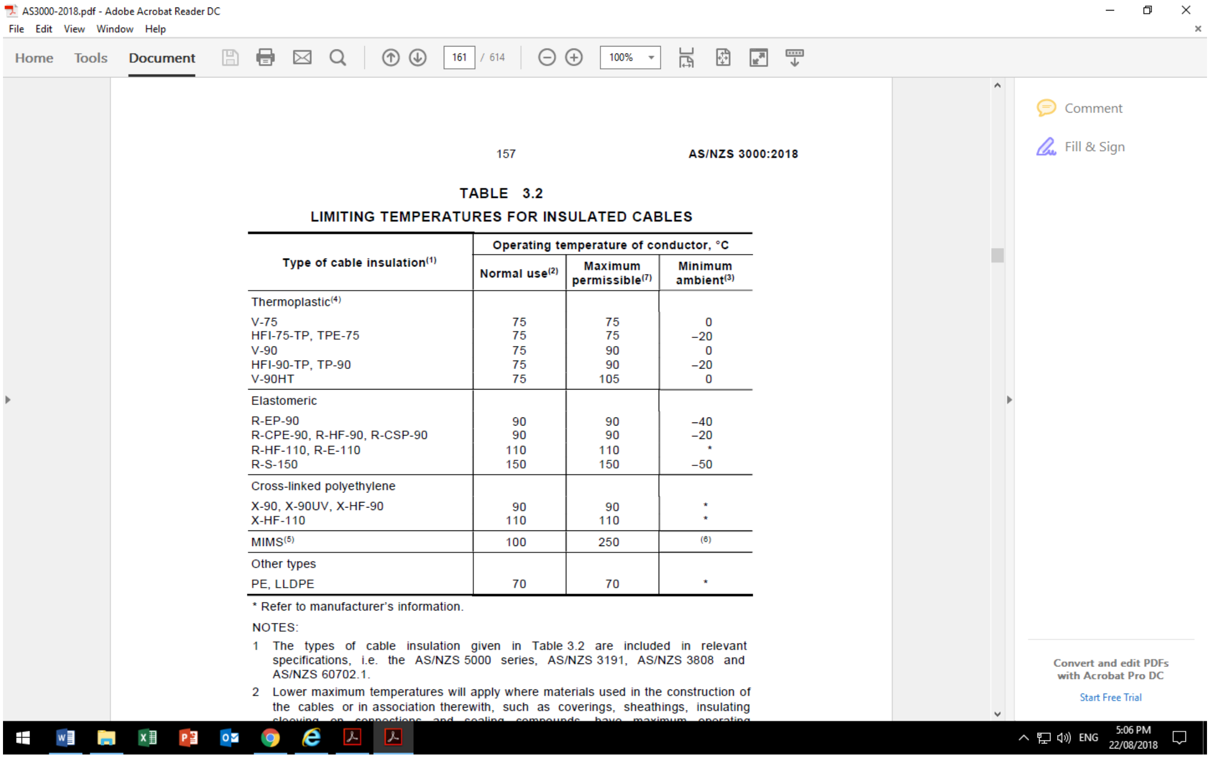


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TABLE 3.2

LIMITING TEMPERATURES FOR INSULATED CABLES

Type of cable insulation(1)	Operating temperature of conductor, °C		
	Normal use(2)	Maximum permissible(7)	Minimum ambient(3)
Thermoplastic(4)			
V-75	75	75	0
HFI-75-TP, TPE-75	75	75	−20
V-90	75	90	0
HFI-90-TP, TP-90	75	90	−20
V-90HT	75	105	0
Elastomeric			
R-EP-90	90	90	−40
R-CPE-90, R-HF-90, R-CSP-90	90	90	−20
R-HF-110, R-E-110	110	110	*
R-S-150	150	150	−50
Cross-linked polyethylene			
X-90, X-90UV, X-HF-90	90	90	*
X-HF-110	110	110	*
MIMS(5)	100	250	(6)
Other types			
PE, LLDPE	70	70	*

* Refer to manufacturer's information.

NOTES:

1 The types of cable insulation given in Table 3.2 are included in relevant specifications, i.e. the AS/NZS 5000 series, AS/NZS 3191, AS/NZS 3808 and AS/NZS 60702.1.

2 Lower maximum temperatures will apply where materials used in the construction of the cables or in association therewith, such as coverings, sheathings, insulating

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1. CATENARY SYSTEMS

Catenary support systems for TPS cables and other **aerial support systems** find use in a variety of installations from building sites to supermarkets and factories. These systems are often used where cables have to ________ an area that is in ____________ use but still maintain high levels of _______________________________. One typical application for a catenary support system is for the _________________ power to a **site shed** on a construction site.

Supply ,less ,readiness electrical

1.4.129 Wiring, catenary

A system of wiring consisting of a cable or cables attached at intervals to a suitable support that is suspended between two points.

A catenary is a wire, usually ________________________________ used to support a TPS cable. The TPS cable must also have ______________conductors and be attached to the catenary support in a way that does not _____________ the thermoplastic sheath. __________________ or clips can be used with tape wrapped around the catenary wire to prevent chafing between the strands of the catenary and the power cable sheath. The **attachment points** should be around __________ apart, to avoid undue sag.

Attached , 7 strands, damage, 0.3m

3.13.1 Types of cables

Cables supported by means of a catenary shall be stranded cables affording double insulation or the equivalent of double insulation.

Cables and catenary supports installed out of doors shall be suitable for exposure to direct sunlight.

NOTE: Cables are considered to be adequately supported if supported by a catenary and thereby relieved from excessive mechanical stresses.

3.13.2 Catenary supports

A catenary shall—

(a) provide uniform support;

(b) consist of material equally resistant to corrosion or deterioration;

(c) be effectively fixed at each end;

(d) be capable of withstanding mechanical stresses likely to occur, in particular, those because of wind or ice; and

(e) be mounted at a sufficient height above the ground to prevent danger to persons or livestock, or damage to the cable being supported.

NOTE: A catenary may form part of a cable, in which case it should be installed in accordance with the manufacturer's instructions.

When placing the cable on the catenary you need to **provide some slack** in it to **prevent strain on the cable**. To prevent water from travelling along the cable and entering a building a _________ loop is normally provided.

Drip

Excessive tension on the catenary may cause the wire to stretch and ultimately ___________. broken

An allowance for wind and other extra loads, for example rain water, ice, birds etc, may be necessary because these will cause strain on the catenary that may be significant in some locations. Stranded catenary wire is used to allow ____________ under these circumstances.

tension

3.12.5.4 *Spacing between conductors*

Conductors shall be adequately spaced to prevent contact with each other under all conditions of sag and sway.

The spacing between conductors at supports, measured in any direction, shall be not less than that shown in Table 3.10.

Exception: The spacing between conductors of a multi-core cable or cables operated in parallel may be less than that shown in Table 3.10.

NOTE: The electricity distributor may require a minimum clearance between consumer aerial lines and any electricity distributor aerial lines.

TABLE 3.10

SPACING BETWEEN AERIAL CONDUCTORS AT SUPPORTS

Span	Spacing m	
	Insulated conductors	Bare conductors
≤10	0.2	0.4
>10 ≤25	0.3	0.5
>25 ≤45	0.4	0.6
>45 ≤60	0.5	0.7

3.12.6 Poles and posts (including supports, struts and extensions to structures)

Poles and posts shall be constructed of materials suitable for the conditions of use, taking account of the following:

(a) Size.

(b) Depth in ground.

NOTES:

1 Guidance on the size of a typical range of poles and posts is given in Appendix D.

2 Guidance on the depth in ground for a typical range of poles and posts of lengths up to 7 m above the ground is given in Appendix D.

The depth in ground may be reduced if the pole or post is set in solid rock, provided that the arrangement is not inferior to installation in accordance

5. TRAILING CABLES

One of the main differences between a trailing cable system and a catenary support system is the relative **movement** between the supporting system and the attached cable. The trailing cable system generally supports _________________ cables and provides a method for controlling ______________ when the supplied load _____________.

Electrical/ position

The support for the power cable may be a tightly strained steel wire, a rolled or extruded section of steel or aluminium. The attachments between the support system and the power cable are manufactured ___________ and ________________ systems

to meet the load capacity and type of

Section 9 Trailing cables and Catenary systems – Miller College

6. INSTALLATION REQUIREMENTS

________________________________ *Clause 3.13*

________________________________ *Clause3.13.3 and Table3.8*

________________________________ *Clause 1.4.20, 3.9.7.4*

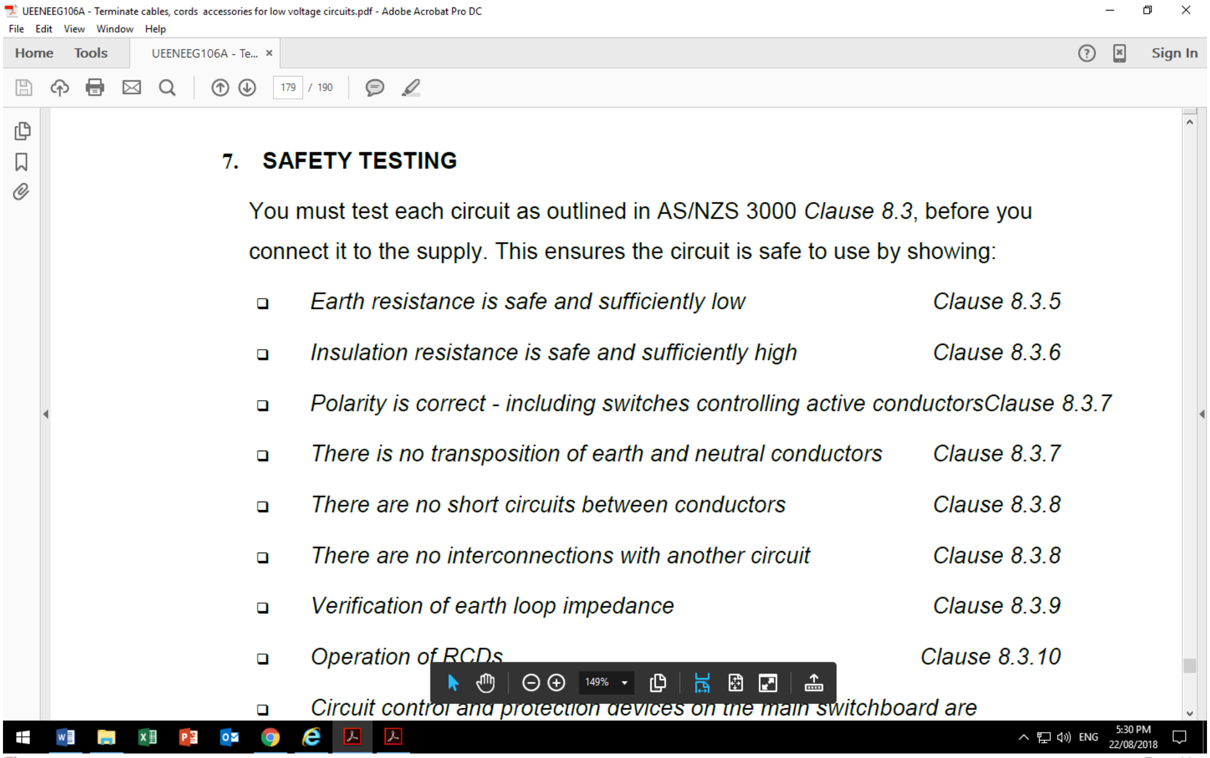
________________________________ *Clause 3.7.2.8*

________________________________ *Clause 4.4.4.4*

7. SAFETY TESTING

You must test each circuit as outlined in AS/NZS 3000 *Clause 8.3*, before you connect it to the supply. This ensures the circuit is safe to use by showing:

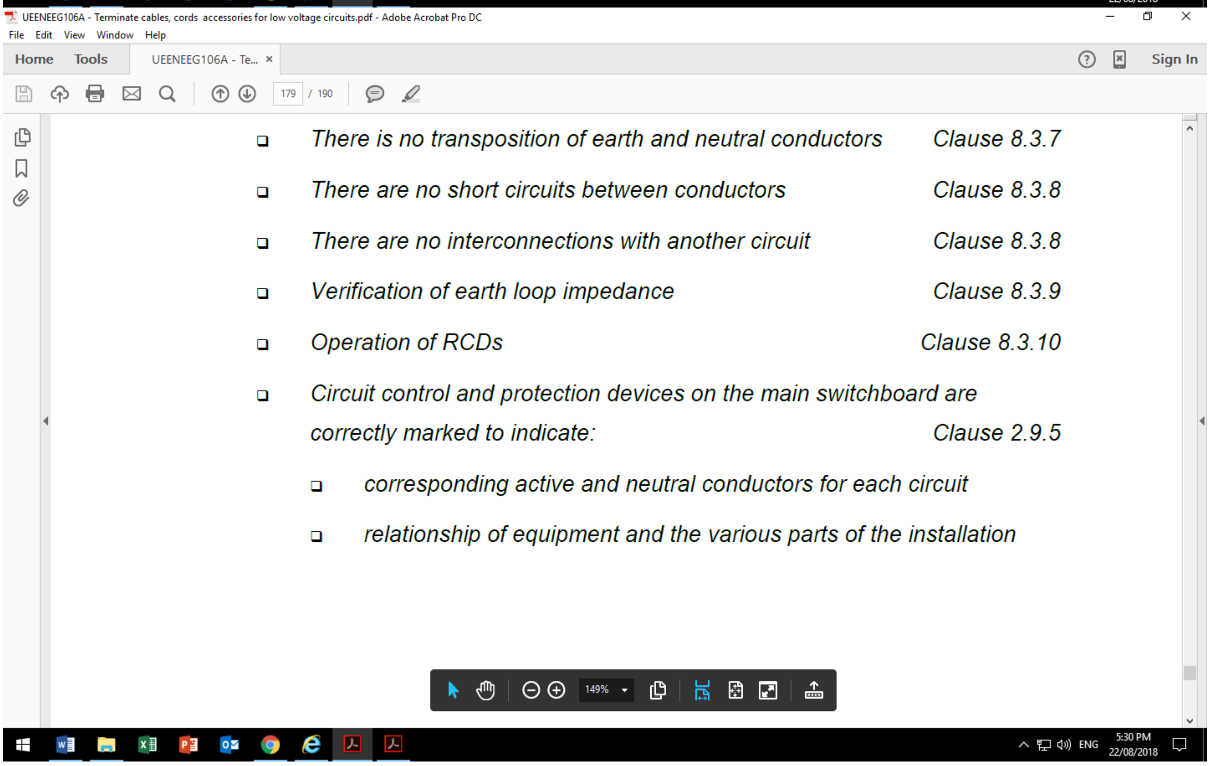
- *Earth resistance is safe and sufficiently low* *Clause 8.3.5*



7. **SAFETY TESTING**

You must test each circuit as outlined in AS/NZS 3000 *Clause 8.3*, before you connect it to the supply. This ensures the circuit is safe to use by showing:

- *Earth resistance is safe and sufficiently low* — *Clause 8.3.5*
- *Insulation resistance is safe and sufficiently high* — *Clause 8.3.6*
- *Polarity is correct - including switches controlling active conductorsClause 8.3.7*
- *There is no transposition of earth and neutral conductors* — *Clause 8.3.7*
- *There are no short circuits between conductors* — *Clause 8.3.8*
- *There are no interconnections with another circuit* — *Clause 8.3.8*
- *Verification of earth loop impedance* — *Clause 8.3.9*
- *Operation of RCDs* — *Clause 8.3.10*
- *Circuit control and protection devices on the main switchboard are*



- *There is no transposition of earth and neutral conductors* — *Clause 8.3.7*
- *There are no short circuits between conductors* — *Clause 8.3.8*
- *There are no interconnections with another circuit* — *Clause 8.3.8*
- *Verification of earth loop impedance* — *Clause 8.3.9*
- *Operation of RCDs* — *Clause 8.3.10*

- *Circuit control and protection devices on the main switchboard are correctly marked to indicate:* — *Clause 2.9.5*
  - *corresponding active and neutral conductors for each circuit*
  - *relationship of equipment and the various parts of the installation*

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How is a catenary wiring system defined?

____

____

_____ AS / NZS3000 __________

1.4.129 Wiring, catenary

A system of wiring consisting of a cable or cables attached at intervals to a suitable support that is suspended between two points.

2. Is it necessary to use galvanised bolts a catenary wiring system?
____________________________________ AS / NZS30000 __________
Yes

Catenary Wire and Accessories from Armafix

Catenary wire is for appliccations where you do not have a suitable place from which to suspend your lighting or cable management accessories. Frequently, it's not possible to hang straight down from a purlin or directly drill into a soffit, but catenary wire allows you to overcome these challenges. Manufactures Zip and Gripple offer extensive product ranges and we will help you find the accessories you need.

Catenary Wire


Catenary wire is available in 2mm, 3mm and 6mm thicknesses. Each roll contains 100m.

Zip Clips


Zip clips are releaseable catenary wire rope grips which are used to form loops of wire around girders etc. for hanging services and fittings. The release clip enables easy, accurate height adjustments. We stock clips for 2mm and 3mm wire. For maximum load capacities and other advice, please call our sales team on 0113 256 7211.

Catenary Wire Grips


Catenary wire grips are for gripping and securing catenary wire once a loop has been formed by bending the wire back on itself. We stock two sizes; one to suit 2-3mm wire and the other to suit 6mm wire.

Catenary Wire Tensioners

 Catenary wire tensioners are used to tension the wire which minimises unwanted movement. Our stock consists of two sizes; one to suit 2-3mm wire and the other to suit 6mm wire.

Galvanised D-Shackles

 Galavanised D-shackles are suitable for all anchoring uses when installing catenary wire but are not to be used for lifting. The width between the legs is 18mm.

Eye Bolts

 Eye bolts are fully threaded bolts for anchoring catenary wire into concrete or other solid materials. We stock M6, M8, M10 and M12 threads.

Vine Eyes

 BZP vine eyes are for anchoring catenary wire into timber or other solid materials. We stock 5.5 x 75mm with a 12mm eye diameter.

Wire Hangers

Wire hangers are used in concrete soffits and similar materials for wire suspension applications. The hanger requires a 6mm hole with a minium depth of 40mm.

---

3. Is it permissible to use single pole switch to control a suspended socket outlet?

_______________________________________ AS / NZS3000 __________

No

4.4.4.4 Pendant-type socket-outlet

A switch incorporated in a pendant-type socket-outlet attached to a flexible cord shall interrupt all live (active and neutral) conductors.

Exception: Pendant-type multiphase outlets with switching only in the active conductors may be used where—

(a) the outlet is not dependent on the supply cable for support; and

(b) additional mechanical protection is provided where necessary; and

(c) the supply cable or cord is selected to take into account any likelihood of vibration and movement expected during operation.

4. Is it permissible to use single insulated cable on a catenary wiring system?

_______________________________________ AS / NZS3000 __________

No

3.13.1 Types of cables

Cables supported by means of a catenary shall be stranded cables affording double insulation or the equivalent of double insulation.

Cables and catenary supports installed out of doors shall be suitable for exposure to direct sunlight.

NOTE: Cables are considered to be adequately supported if supported by a catenary and thereby relieved from excessive mechanical stresses.

5. What height above the ground, in an outdoor situation, frequented by vehicles, should a catenary wiring system be installed?

____ AS / NZS3000 __________

3.13.3 Clearances

Cables supported by a catenary wire shall maintain the following clearances:

(a) In an outdoor location, as specified in Clause 3.12.3 for a neutral screened cable.

(b) In an indoor location, not less than 100 mm from any moving parts or

parts of equipment operating at an elevated temperature.

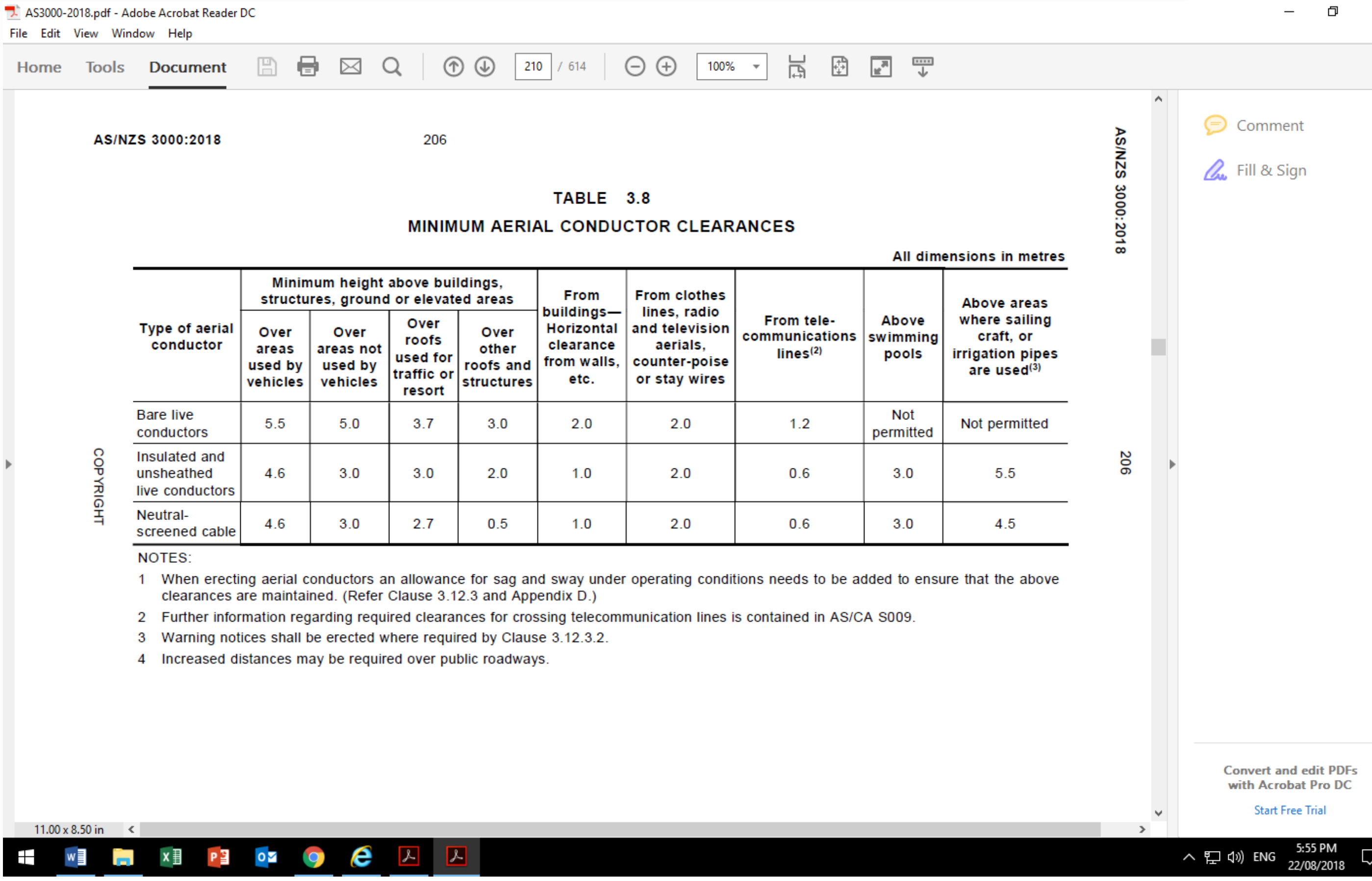

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TABLE 3.8

MINIMUM AERIAL CONDUCTOR CLEARANCES

All dimensions in metres

Type of aerial conductor	Minimum height above buildings, structures, ground or elevated areas: Over areas used by vehicles	Over areas not used by vehicles	Over roofs used for traffic or resort	Over other roofs and structures	From buildings—Horizontal clearance from walls, etc.	From clothes lines, radio and television aerials, counter-poise or stay wires	From tele-communications lines(2)	Above swimming pools	Above areas where sailing craft, or irrigation pipes are used(3)
Bare live conductors	5.5	5.0	3.7	3.0	2.0	2.0	1.2	Not permitted	Not permitted
Insulated and unsheathed live conductors	4.6	3.0	3.0	2.0	1.0	2.0	0.6	3.0	5.5
Neutral-screened cable	4.6	3.0	2.7	0.5	1.0	2.0	0.6	3.0	4.5

NOTES:

1 When erecting aerial conductors an allowance for sag and sway under operating conditions needs to be added to ensure that the above clearances are maintained. (Refer Clause 3.12.3 and Appendix D.)

2 Further information regarding required clearances for crossing telecommunication lines is contained in AS/CA S009.

3 Warning notices shall be erected where required by Clause 3.12.3.2.

4 Increased distances may be required over public roadways.

AS/NZS 3000:2018 206

6. Is it permissible to use a TPS cable in a catenary system?

____ AS / NZS3000 __________

No

3.12.1 Types of conductor

Conductors used as aerial conductors shall be—

(a) hard-drawn bare conductors;

(b) polymeric insulated cables;

(c) neutral-screened cables; or

(d) parallel-webbed, twisted or bundled insulated cables.

7. Is a flexible cord attached to a pendant socket classed as fixed wiring?

____ AS / NZS3000 __________

No

3.9.7.4 Flexible cords used as installation wiring
Flexible cords used as installation wiring shall be of the heavy-duty sheathed type and installed in the same manner as insulated and sheathed cables.
Exception: Flexible cords need not be of the heavy-duty type if—
(a) used for the connection of pendant socket-outlets;
(b) installed in a suitable wiring enclosure; or
NOTE: See Clause 3.10.1 for requirements for enclosure of cables.
(c) installed for the connection of equipment, in accordance with the equipment wiring provisions of Clause 4.3.
Flexible cords installed as follows shall be regarded as installation wiring and shall comply with this Clause (3.9.7.4):
(a) Permanently connected flexible cords, including flexible cords used as pendants for socket-outlets and those connected to an installation coupler.

(b) Flexible cords not open to view.

Exceptions:
1 Flexible cords used as pendants for lamps, luminaires or provided with, and permanently connected to, an appliance shall not be regarded as installation wiring.
2 Flexible cords installed for the connection of a single appliance or luminaire shall not be regarded as installation wiring, provided that they—

- do not exceed 2.5 m in length; and

· have a current-carrying capacity of not less than—
— the current rating or setting of the circuit protective device;
or
— the actual load of the appliance or luminaire, subject to the
minimum cross-sectional area of any conductor being not

less than 0.75 mm^2.

8. What is required to terminate each end of a catenary wire system?
____ AS / NZS3000 ___________

3.13.2 Catenary supports
A catenary shall—
(a) provide uniform support;
(b) consist of material equally resistant to corrosion or deterioration;
(c) be effectively fixed at each end;
(d) be capable of withstanding mechanical stresses likely to occur, in
particular, those because of wind or ice; and
(e) be mounted at a sufficient height above the ground to prevent danger
to persons or livestock, or damage to the cable being supported.
NOTE: A catenary may form part of a cable, in which case it should be installed
in accordance with the manufacturer's instructions. Provide the loop

(b) Protection against vibration Movement caused by vibration shall be
provided for by introducing a loop in the cable immediately before the
termination.
The size of the loop shall be determined by the cable size and severity
of the vibration
3.9.7.3 Mineral insulated metal sheathed (MIMS) cable

9. Is it permissible to use a knot in a flexible cord to secure a pendant socket outlet?

_______________________________________ AS / NZS3000 __________

No

4.4.4.4 Pendant-type socket-outlet

A switch incorporated in a pendant-type socket-outlet attached to a flexible cord shall interrupt all live (active and neutral) conductors.
Exception: Pendant-type multiphase outlets with switching only in the active conductors may be used where—
(a) the outlet is not dependent on the supply cable for support; and
(b) additional mechanical protection is provided where necessary; and
(c) the supply cable or cord is selected to take into account any likelihood

of vibration and movement expected during operation.