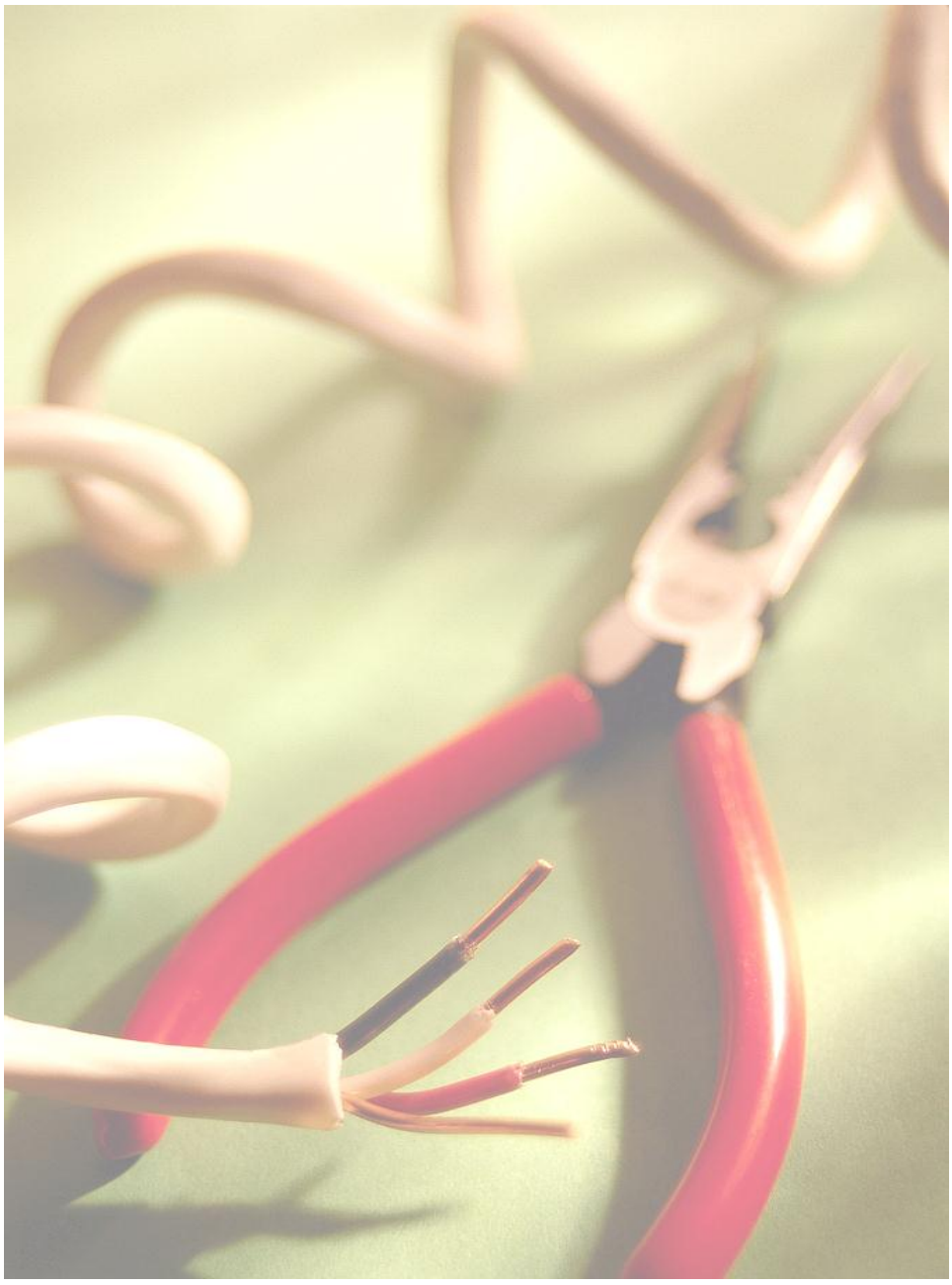
Terminate & Connect Electrical Wiring

Stage 1 Electrical



Cable Terminology

Every cable has many characteristics which distinguish them from other types of cable, these may be, conductor material, insulation type, reinforcing, size & so on. All cables have ratings which can be specified by the “Wiring Rules” or cable manufacturer. A rating refers to a limit that must not be exceeded during normal operation, this could be “voltage or current”. The following are the most common characteristics of cables.

Cores & Strands

The core of a cable is the conducting material, usually copper or aluminum, & it’s surrounding, usually an insulating material. A cable can be single or multi-core, referring to whether it is an individual cable (single core) or a cable that has more than one core (multi-core). An example of multi-core cable is Flat TPS cable, “Twin & Earth”, it has two conductors (active & neutral) plus an earth conductor, it is commonly used for power & lighting circuits.

Each core will consist of one or more strands, one being referred to as “solid” & multi-stranded cable being referred to as “stranded”. Stranded cable is commonly used because it has better flexing characteristics.

Size

The size of cables are expressed in a “total cross sectional area” (CSA) of the conducting material or strands & is measured in square millimeters. The sizing of cable, in particular multi-core cables, refers to the size of one of the cores conducting material. A 2.5mm2 Twin & Earth, TPS cable has three cores each with 2.5mm2 current carrying conductors.

Current Rating

The current rating is the maximum permissible current that a particular cable can carry under normal operating conditions, & is expressed in amps. The current carrying capacity can be found in the “Wiring Rules” using the size of the conductors as a guide. A cables current carrying capacity must never be exceeded, it may fail & cause electrical hazards or fires.

Voltage Rating

The voltage rating is the maximum permissible voltage which the insulation of the cable can resist. If the voltage rating is exceeded it may cause equipment to malfunction or create electrical hazards. The voltage rating of cables can be found on the manufacturers specifications. A typical voltage rating is 0.6/1 Kv, this means

the cable can withstand 0.6kv (600 V) between the live conductors (active or neutral) & earth, & 1 Kv (1000 V) between adjacent conductors.

Temperature Rating

The temperature rating is the maximum permissible temperature the cable can operate at without damaging it's insulation. A typical rating is "V – 75" which means the cable can operate up to & at 75 degrees Celsius. There are other specialized types of cable which have a much higher rating.

Cable Colours

The colour of a cable is the colour of it's insulation, where colours are used to identify different cables (such as active, neutral & earth) there are specific colours for each. The colour coding for fixed wiring in Australia is not the same as the International colour coding for flexible cords (AS/NZS 3000:2000 3.8.1), nor is the same fixed wiring colour coding used in other countries.

Insulation

All cables in general wiring are required to be insulated, there are many types of insulating materials. The most commonly used insulating material is PVC (polyvinyl chloride), some other types include fiberglass, mineral insulation, paper & synthetic rubber. The maximum temperature & voltage ratings are derived from the insulating material used on a particular cable.

Sheathing

The primary layer of insulation is known as the functional insulation, some types of cable (such as TPS) have a second layer of insulation known as the sheathing. The sheathing provides additional mechanical strength & double insulation.

Shielding

Cables which are required to be protected against electronic noise or interference have a layer of braid, usually tinned copper between the cables sheath & functional insulation, this is known as shielding.

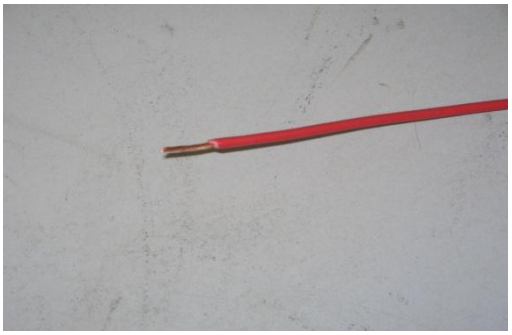
Armouring

Some installations & cables require additional mechanical protection, (usually industrial applications such as mining) without the use of metallic conduit. Armouring is similar to shielding, however a much larger, heavier gauge wrap is used. This also is placed between the sheath & functional insulation, there is also a "serving" (a layer of insulation) around the armouring to hold it in place.

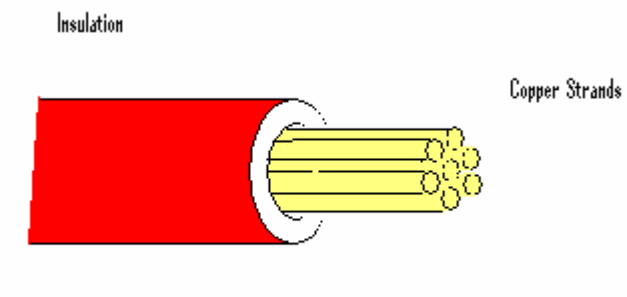
Cable Types

Thermoplastic Insulated (TPI)

TPI cable has a single, coloured layer of insulation over the current carrying conductors the insulation is of PVC type. TPI cable is often referred to as “building wire” & is only single insulated due to having only one functional layer of insulation. This means TPI cable must be installed in a suitable enclosure (conduit, switchboard).



Building wire (TPI) is available in a range of sizes varying from 1 sq mm to over 25 sq mm. Commonly TPI cable is stranded, containing 7 stands per core.

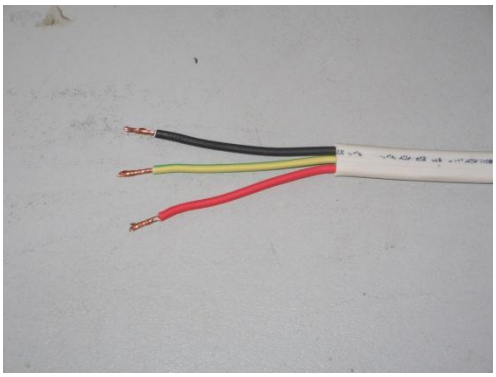


Applications of TPI Cable

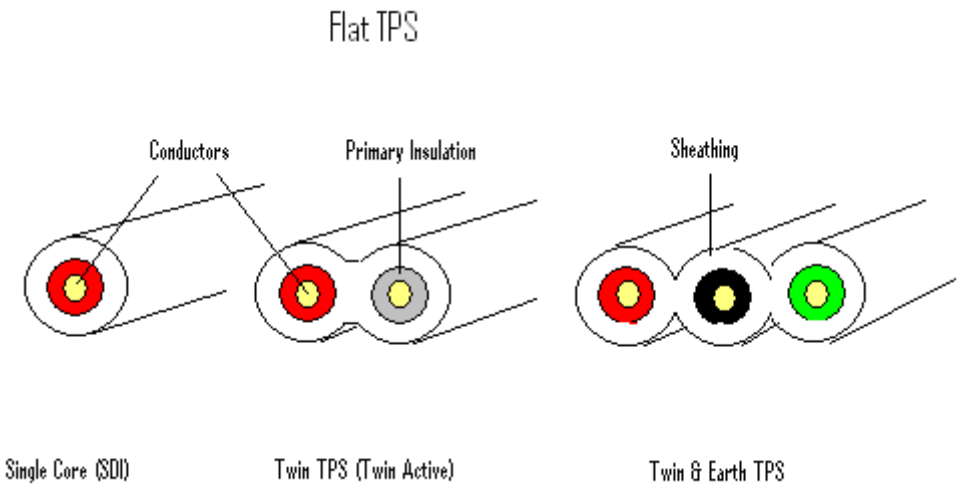
Thermoplastic Insulated (TPI) cables are used for wiring in domestic & non domestic installations, where the cables are contained in a suitable enclosure. A suitable enclosure may constitute PVC conduit, metallic conduit or a switch board. TPI cables are not permitted to be embedded in cement render or plaster with no additional protection.

Thermoplastic Sheathed (TPS)

Virtually identical to the TPI cable, except it has an added layer of insulation wrapped around the individually insulated cores (sheathed). The cores can be removed from a multi-core TPS cable & be used as TPI.



TPS cable can be flat or round, some examples are shown below.



Applications of TPS Cable

Thermoplastic Sheathed (TPS) cables are also used in domestic & non domestic wiring, however by using a TPS cable additional enclosures are not required. An example of this would be, if you were to use a TPI cable in the roof space of a house, you would be required to install that cable in conduit, where as TPS cable used in the same scenario would only require adequate retention (clipping, securing) of the cable. (Clause 3.9.3 AS/NZS 3000:2000).

Colour Coding of Cable (fixed wiring)

TPI & Flat TPS cables generally follow the Australian Standard Colour Coding which is:

Neutral Black

Earth Green/Yellow

Active Any colour other than black, green, yellow or green/yellow combination.

Suggested Current Ratings of Typical TPS/TPI Cable

Cable Size	Number of Strands	Current Rating
1.0mm2	1/1.13	10.0 A
1.5 mm2	7/0.50	15.0 A
2.5 mm2	7/0.67	20.0A
4.0 mm2	7/0.85	32.0 A

Flexible Cords (TPS Circular)

A flexible cord is defined as a “flexible cable”, they do not exceed 4 mm2 in cross sectional area & have no more than 5 conductors. The most common types of flexible cord used in electrical work are listed below:

2 Core - parallel unsheathed (Figure 8 or speaker wire)

- light duty sheathed

Multi-Core -light duty sheathed

- ordinary sheathed

- heavy duty sheathed

Most flexible cords consist of several cables or cores which are thermo-plastic insulated (TPI) enclosed in an outer sheath of PVC, the cord itself, due to the sheath is also known as “Circular TPS” or Thermo-Plastic Sheathed.

Flexible cords are usually used to connect or extend the leads of portable electrical appliances to a supply.

*Limitations to the current carrying capacity of “flexible cords” can be found in **Table 16 of AS/NZS 3008***

Colour Coding of Flexible Cords

The colour coding of flexible cords is set to “international standards”:

Brown	Active
Blue	Neutral
Green/Yellow	Earth

Applications of Flexible Cord

Light Duty Sheathed

Is required to be not smaller than 0.75mm2, it can be used for appliances or luminaries where the cord will not be subjected to “rough usage”.

This cord is not allowable for use in damp situations.

Ordinary Duty Sheathed

Is required to be not smaller than 0.75mm2 for any appliance or unsupported pendant provided that the cord is not subjected to excess temperature

Or

Required to be not smaller than 1.0mm2, for any appliance, unsupported pendant or extension cord set.

Suggested Current Ratings of Typical Cords

Cable Size	Number of Strands	Current Rating
0.75 mm2	24/0.2	7.5 A
1.0 mm2	32/0.2	10.0 A
1.5 mm2	30/0.25	15.0A
2.5 mm2	50/0.25	20.0 A

AS/NZS - 3199:2007

Colour of Outer Sheath (Flexible Cords)

All extension leads are constructed using circular TPS cable with appropriate plug tops, they come in many sizes, lengths & colours. The colour of a lead usually represents the purpose of the lead, for example:

Orange Leads = Heavy Duty Applications

Grey Leads = Ordinary Duty Applications

Cable Terminations

Technical Standards

The electricity supplied to domestic & industrial installations is potentially hazardous, it may cause injury or death. In order to minimize the risk associated with electricity, various types of legislation have been developed in the form of “technical standards”.

Technical standards are documents which specify the “minimum requirement” to safety & correct operation of equipment, they are supported by legislation which give these standards the force of law.

Contravening the standards may result in:

- Warnings
- Fines
- Loss of License (Electrical)
- Possibly Criminal Charges

The main publications in regards to “electrical standards” are:

- Electricity (Licensing) Regulations 1991

- The Wiring Rules (AS/NZS 3000:2007)

- W.A. Electrical Requirements

- Other AS/NZS Standards (3008, 3017 & 3018)

These standards must be referred to & adhered at all times while conducting electrical work. If you are unsure on the “minimum requirements” for any task, consult the standards, mainly “Wiring Rules, AS/NZS 3000:2007”

Terminating Cable

When preparing cable for termination (connection) several factors need to be considered.

- Material of the conductor & it's insulation
- Number & shape of wires forming the conductor
- Cross sectional area of the conductor
- Number of conductors to be connected
- Environment in which the connection will be in

Material of conductor & it's insulation

Is the conductor soft (aluminum)?

Are there special requirements for the conductors material or insulation?

Does the insulation need to be replaced?

Number & shape of wires

Is the conductor stranded or solid?

How many strands are there?

Do the strands require retaining?

Cross sectional area

Will the conductor fit?

Does it need to be doubled over?

Is there special requirements in relation to the conductor size?

Number of conductors to be connected

Do the conductors require retaining together?

Do the conductors fit the termination point?

Environment of the connection

Is there ambient moisture or heat present?

These are a suggestion of factors to be considered, depending on the circumstances other factors will need to be addressed. If you are in doubt on the correct "termination method" for a particular scenario, consult the **Wiring Rules AS/NZS 3000:2007.**

Preparing Cable for Termination

In general to terminate cables to a satisfactory standard, regardless of the type of terminating device, firstly, these steps must be followed.

1. **Remove insulation without:**

    - Damaging the inner insulation (for sheathed cable)

    - Damaging conductors (all cables)

    Damage may mean nicks, scratches any marks what so ever.

2. **Retain the stands of the exposed conductors, as to avoid spreading**

    Twist the stranded conductors together, tightly

3. **If the conductor is considerably smaller than the termination point, the exposed conductive strands must be folded to ensure a "good connection".**

    The exposed section of cable will need to be longer

    Note: If two conductors are terminating at the same point, they must be twisted together, usually they will not require folding.

Once the conductor has been prepared (as above) the type of termination needs to be considered.

Types of Terminations

***Pressure Termination**:* From the previous steps the cable should be ready to terminate, the exposed conductive material should be placed all the way into the terminal point, however there should be no insulation in this point. The insulation should begin immediately after the terminal point.

Screw Termination: From the previous steps the cable should be ready to terminate, the exposed conductive material should be placed all the way into the terminal point, however there should be no insulation in this point. The insulation should begin immediately after the terminal point.

Crimp Termination: From the previous steps the cable should be ready to terminate, the exposed conductive material should be placed all the way into the crimp fitting, however there should be no insulation in this point. The insulation should begin immediately after the crimp fitting.

Solder Termination: If the connection is to be soldered, further preparation may be needed, depending on what the connection is (2 cables together, soldered to a terminal etc.)

Soldering Outline:

Note: Use appropriate PPE while working with soldering irons & solder.

1. Heat soldering iron, clean the tip, place a small amount of solder on the tip.
2. Tin (pre-solder) the cable that is being terminated
3. Tin (pre-solder) the termination point
4. Place cable at point where it needs to be connected, use the soldering iron to re-heat both pre-soldered points, they should fuse together.

Important Notes

One of the most important factors is, there should be no insulation in the termination, this will cause a “high resistance join”. It may cause excessive heat & current which could compromise the connection.

However there must not be excessive copper showing outside the termination point, this may cause a safety issue with indirect contact of a “live” conductor to other parts of the installation or yourself/someone else.

If soldering you connection, it must not be moved or vibrated until the solder has set/hardened. If the solder is moved when not “finished” it can create a “cold join” which also may cause excessive current & heat which may compromise the connection.

Extension Leads

Selection of Cords & Plug Tops:

As discussed there are many different cables/cords, there are also many plug/socket types, each with differing characteristics. Particular environments or purposes may require particular cables/cords & plugs/sockets to be used.

It is important to be able to identify, select & terminate a wide range of these components/accessories. Many types of plug tops can be found in manufacturer catalogues, the appropriate information regarding cord/cable to be used can be found also in these catalogues.

The two most common types of “cords” a electrician will encounter include:

- Extension Leads (250 V)
- Appliance Leads (250 V)
- Appliance Leads (415 V)

Flexible Cords

It is important to note that any flexible cord must be attached to the appliance, appliance connector, plug or socket in a manner that no un-due mechanical stress can be placed on the connection point. This is usually achieved by a “torturous path”, tying a knot in the cord itself is not an example of a torturous path.

Extension Lead Construction:

All extension leads are constructed using circular TPS cable with appropriate plug tops, they come in many sizes, lengths & colours.

The colour of a lead usually represents the purpose of the lead, for example:

Orange Leads = Heavy Duty Applications

Grey Leads = Ordinary Duty Applications

It is a requirement that in any industrial situation or construction site, “Heavy Duty” extension leads must be used, which are not of the re-wirable type or have a clear plug & socket. Extension cords must also be inspected by a licensed electrical worker regularly.

The purpose of a extension lead is to **“temporarily”** extend the length of the cord supplied with a portable appliance. Extension leads must have cords used which have 3 cores, each core conductor size must not be less than 1 mm2. The maximum permissible length of an extension lead is governed by the conductorvsize of the cord.

Rating of Extension Lead	Conductor Size	Maximum Length
10 Amps	1.0 mm2	25 m
	1.5 mm2	32 m
15 Amps	1.5 mm2	25 m
	2.5 mm2	40 m
20 Amps	2.5 mm2	32 m
	4.0 mm2	40 m

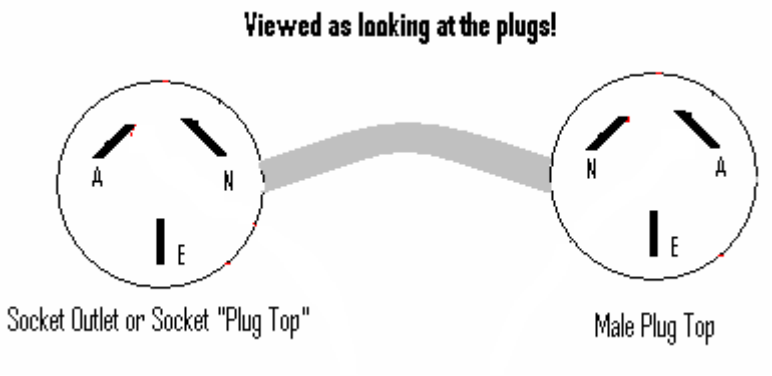
Polarisation

The extension leads cord & socket must be polarised (conductor arrangement) to suit that of a single phase 3 pin socket outlet. When viewed from the front of the **socket outlet** the order of connection starting at the earth pin (bottom straight pin) must be:

Earth (Green/Yellow) » Active (Red or Brown) » Neutral (Black or Blue)

In a clockwise motion

Polarisation of an Extension Lead



Notice that the Active & Neutral are opposite on the “Male Plug Top” compared to the “Female Socket” or “Socket Outlet”.

De-rating

If a cord or extension lead is stored on a drum or reel, it should be unwound completely before use. If it is not unwound the cables “current carrying capacity” will significantly be reduced which may cause damage to the cable from over heating.

Please refer to the following table

Number of Layers	1	2	3	4
De-rating Factor	X 0.76	X 0.58	X 0.47	X 0.4

For each layer or coil of the cable that is not unwound, you multiply the “normal current carrying capacity” of the cable by the “de-rating factor” listed.

For example, if you were using a “10 A extension lead” that was left wound on a drum with four layers. The extension lead would now be rated to ***4 A.***

10 A x 0.4 = 4 A

This is a significant drop in current carrying capacity, possibly the lead may become too hot compromising the insulation which may cause contact of live components or fire.

Joins in Extension Leads

It is not permissible to join an extension cord by any method other than the use of an appropriate plug & socket connection device. Soldering the cables & then taping them up, for example, **is not permissible.**

Constructing an Extension Lead

When you are fitting a plug top or socket you must take care to observe the following points:

- Remove the sheathing (outer insulation) of the cord without damaging the functional (inner) insulation.
- Do not remove any more sheathing than is absolutely necessary
- Twist the strands of the cable conductors together & double over (if necessary) before placing them in the termination point
- Do not allow any insulation to be clamped in the termination point
- Ensure that the plug & socket is polarised correctly
- Ensure that the functional insulation of the cable cores is as close as possible to the termination point
- Observe the required colour coding for the cable insulation
- Ensure the cord, plug & socket have the correct voltage, current & temperature rating for the application of the extension cord
- Ensure that the cord passes through the torturous path in the accessory or plug tops.

Torturous Path

Is a route the cables must run or some type of clamping device, the torturous path ensures no excessive force is placed on the electrical connections when the lead is being handled. The conductors should not be able to fall out of the termination

Inspection & Testing Extension Leads

A finished extension lead must be inspected & tested for the following aspects before it can be regarded as “safe to use”.

- Correct Polarity
- Correct Colour Coding
- Correct Terminations
- Continuity of all Conductors, continuity of the Active & Neutral conductors can be checked with a multi-meter, but continuity of the Earth conductor should be checked with a high current tester such as a “Safe-T Checker” if available.
- Insulation Resistance, between all cores. The Insulation Resistance should be “Infinity (œ) when checked at 500 V Dc for a 240 V cord.
- No unnecessary removal of insulation
- No cores extending outside of the plug or socket
- No nicks in the insulation, what so ever
- No insulation in the termination point
- No mechanical damage to any part of the cord
- The correct cable, plug & socket have been used

Visual Inspection

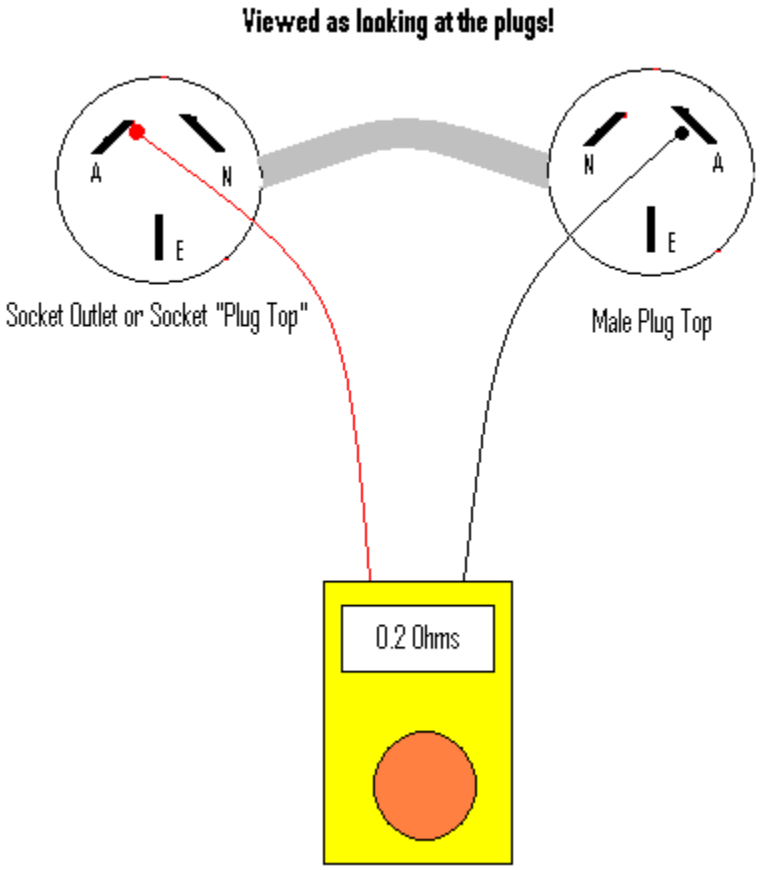
Visually inspect the lead, checking for:

- Insulation damage to the lead, nicks, cuts, dents or marks to the “outer sheath of the lead.
- Plug tops, male & female ends. Ensure there is no mechanical damage, nicks, cuts, or bent pins. Ensure the torturous path is functional, if the plug top is transparent, visually check the termination points, ensure there are no damaged conductors, loose or broken connections & excess copper in the termination.

Polarity

If plug tops are transparent, ensure the correct colour coding of cables have been connected to the appropriate terminals. Using a **multi-meter** measure the resistance from the “plug end Active terminal” to the socket end “Active terminal”, a reading of 0.0 Ω to 0.2 Ω is preferable. Repeat this step for all terminals, Active – Active, Neutral – Neutral & Earth – Earth.

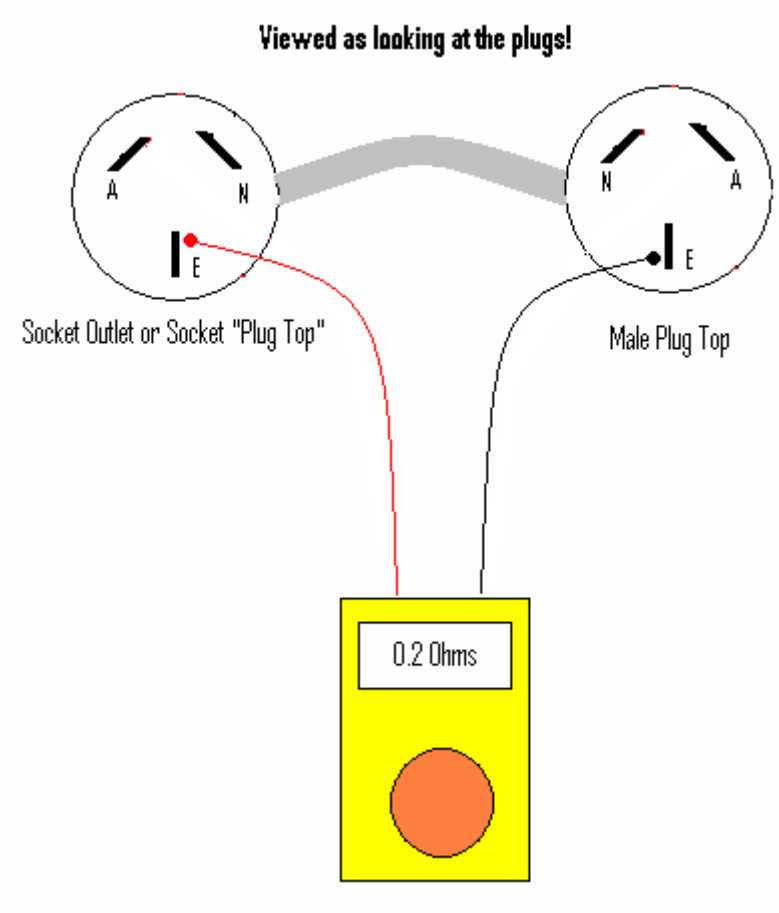
If the plug top is clear, ensure you are testing at the correct terminals, rather than looking at which conductor is connected to that terminal.



This test will verify that the conductors are terminated to the appropriate terminals.

Earth Continuity

Using a **multi-meter**, measure the resistance of the “Earth Conductor”, (earth terminal of the plug end – earth terminal of the socket end). Ensure the resistance measurement is not greater than 1 Ω.



This test will verify that the earth conductor has a low enough resistance for any fault current to pass through & trip the protective device.

To achieve the necessary results for the "polarity & earth continuity tests", you can simply measure the resistance of each conductor, ***terminal to terminal*** *(Active – Active, Neutral – Neutral & Earth – Earth). Record the results for each measurement & then assess whether the results are acceptable. For example:*

Example of a satisfactory lead

Resistance Measurements (from terminal – terminal):

Active – Active = 0.1 Ω

Neutral – Neutral = 0.1 Ω

Earth – Earth = 0.1 Ω

Result Assessment:

Earth continuity is satisfactory, measuring less than 1.0 Ω between earth terminals.

Polarity is correct, verifying continuity between the:

Active – Active terminals

Neutral – Neutral terminals

Earth – Earth terminals

Example of an unsatisfactory lead

Resistance Measurements (from terminal – terminal):

Active – Active	=	0.L	***open circuit, should be continuous***
Neutral – Neutral	=	0.L Ω	***open circuit, should be continuous***
Earth – Earth	=	1.8 Ω	***resistance is too high***

Result Assessment:

Earth continuity is not satisfactory, measuring more than 1.0 Ω between earth terminals.

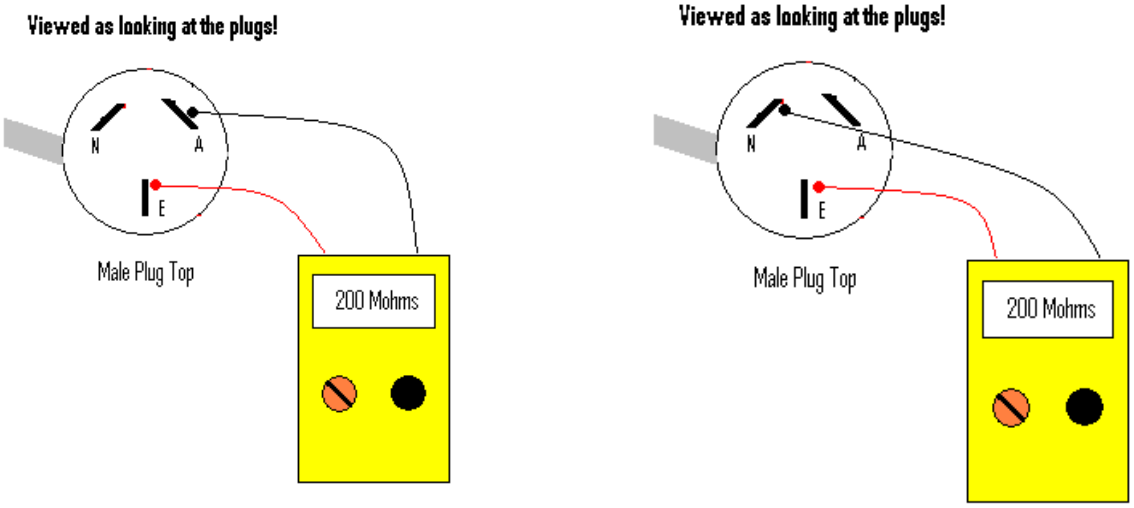
Polarity is incorrect, verifying there is no continuity between the:

Active – Active terminals

By taking & recording the measurement it is easily identified if the lead is functional or not.

Insulation Resistance Test

Using an **insulation tester (megger)**, set to 500 V (double the rated voltage of the appliance), measure the insulation resistance between current carrying conductors & earth, active – earth & neutral – earth of the plug top or the socket. Ensure the insulation resistance measurement is not less than 1 MΩ.



This test stresses the insulation with an applied voltage, it is used to verify whether there are any short circuits between the current carrying conductors & earth.

Example of a satisfactory lead

Insulation Resistance Measurements (@ 500 V):

Active – Earth = ∞

Neutral – Earth = ∞

Active – Neutral = ∞

Result Assessment:

The insulation resistance between all conductors is greater than 1 MΩ, verifying a satisfactory reading.

Example of an unsatisfactory lead

Insulation Resistance Measurements (@ 500 V):

Active – Earth	=	0.0 MΩ	**Dead Short**
Neutral – Earth	=	∞	
Active – Neutral	=	∞	

Result Assessment:

The insulation resistance between the active & earth conductor is less than 1 MΩ, verifying a faulty lead (short circuit).

Commissioning of Lead

Once these four tests have been verified as correct & safe, you are required to attach a tag which includes information like:

- What appliance was tested
- The date the appliance was tested
- Who tested the appliance
- When the next test is due

All portable appliances & extension leads are required to undergo regular testing to ensure they are in good, safe, working order.

Electrical Components (Accessories)

Electrical Component Terminology:

There are many components involved in the electrical industry, as a electrician you will be required to have a good basic understanding of each & also know where to locate further, detailed information.

Throughout a electrical installation, or equipment, several differing components will be used. These components can be catagorised as:

- Accessories
- Appliances
- Cable
- Fixings

Accessories:

An accessory is any device which is associated with electrical circuits that are not intended to consume power, their role is to control or protect the circuit in some form. Examples of accessories include;

- Functional switches
- Circuit breakers
- Plugs
- Sockets
- Socket outlets
- Light fittings (excluding the globe)

Appliances:

An appliance is the component that “does the work”, it consumes power. An appliance will use or consume the provided electricity, & turn that form of energy into another form of energy, such as a globe will produce light, a power tool will create moving parts. The following are some examples of common appliances:

- Globe
- T.V.
- Power Tools
- Kitchen Appliances
- Motor
- Transformer

Cables:

Cables could also be described as a electrical accessories. Obviously the electricity needs to be transported “through” the accessories, & “to” the appliance, electrical cables offer a safe route to provide for the transmission of electricity. As with all other electrical components, cables also come in many shapes & forms, each with differing characteristics. Cables will be discussed in further detail in a later workbook.

Fixings:

A fixing is any device that is used to mount or secure any electrical component, including;

- Accessories
- Appliances
- Cable

Fixings come in many shapes & forms, each with differing characteristics to serve different purposes. Fixings will be discussed in greater detail later in this book.

Selection of Electrical Components:

Selecting the correct electrical components for an appropriate application is essential, whether they be accessories, appliances, cables or fixings. You will need a good understanding of these components as to advise clients on the characteristics of each when necessary.

The main source of information on electrical components can be found in the respective manufacturer catalogues, such as the “Clipsal Catalogue”. These catalogues will provide information on the electrical component including types, part numbers & pricing.

It is not sufficient to specify “lamp holder” when selecting or ordering one, there are many types, each with differing characteristics. Most catalogues will provide a picture of the component with other descriptive information, as to make selecting the correct component as easy as possible.

Recognising Electrical Components:

Within the electro-technology industry there are many components, each represented by differing symbols. It is equally important that you can recognise various components physically a swell as their pictorial symbols.

Components usually fall into three main groups, knowing these groups may help you recognise the components symbol or the component itself.

The three groups are:

- Supply or Source (Where the voltage originates)
- Control (accessories such as functional switches, protective devices)
- Load (appliances/current consuming devices, resistors, inductors, power tool & lights)

Supply Components

A component that is considered as a supply can be many things, from a alternator, transformer or a socket outlet. Any thing that we can use to “supply” electricity is considered as the source or supply. Many common “supplies” will fall into both the “accessory” & “appliance” category.

All circuits should begin & end at the supply.

Examples include:

- GPO or Socket Outlets
- Alternator/Generator
- Battery
- Transmission Lines
- Transformers

Control Components

As the name suggests these are the components that “control” the circuit, either switching it on/off via a manually or automatically operated switch or protection devices such as fuses, circuit breakers, RCD’s, light switches & contacts. All control components will be from the “accessory” category.

All circuits will have some form of control & protection

Examples include:

- Circuit Breakers, circuit protection replaced fuses
- Isolating Switches, main isolation point
- Cable, transmission of electricity
- Functional Switches, operate the circuit they include:
- Contactor Contacts
- Light Switches
- Push Button Switches
- Timers

Load Components

These are the components that use or consume the electricity. Lights (actual globe), appliances, resistors are all examples of loads. If a component has “resistance” it generally is a load or current consuming device. Typically unless otherwise stated/shown, a resistor symbol is usually used to represent a load.

A circuit requires all of these components to operate safely & sufficiently.

Examples include:

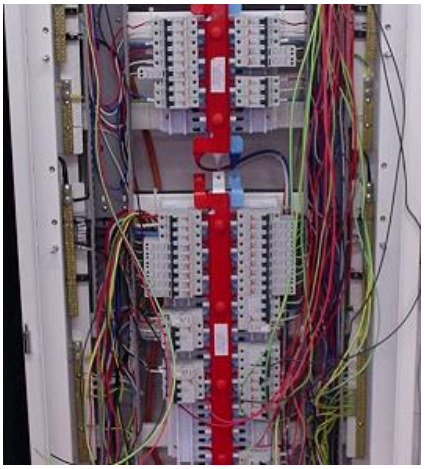
- Resistors
- Lights
- Motors
- Appliances, they may include:
- Toasters
- Kettles
- Power Tools

AS/NZS3000:2007 Wiring Rules

Section 3
Selection and Installation of Wiring Systems

3.1.2 Selection and installation

Wiring systems shall be selected and installed to perform the following functions associated with the safe design and construction and proper operation of the electrical installation:



(a) Protect against physical contact with live parts by durable insulation materials or by placing live parts out of reach.

(b) Satisfy current-carrying capacity, voltage drop and other minimum size requirements for conductors.

(c) Provide reliability and electrical continuity of connections, joints and terminations.

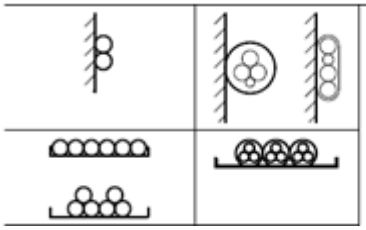
(d) Provide adequate strength of supports, suspensions and fixings.

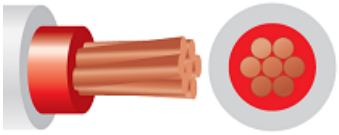
(e) Suit intended use, including applications requiring a particular type of wiring system, e.g. fire-resistance, explosion protection, safety services.

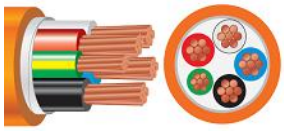
(f) Protect against mechanical damage, environmental and other external influences by enclosure or other means.

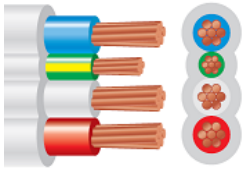
TABLE 3.1

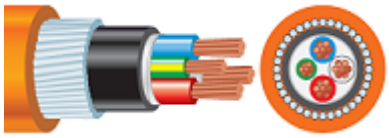
Cable Types and their Application in Wiring Systems

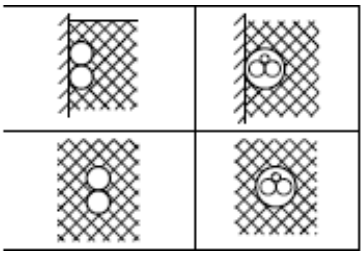
Installation method	Description		Typical cable types
	Unenclosed	On a surface (including cable tray or ladder)	Insulated and sheathed Screened or armoured Mineral insulated, metal sheathed (MIMS) Earthing conductors

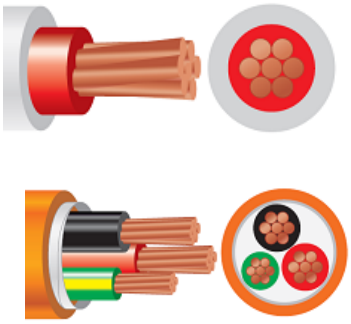


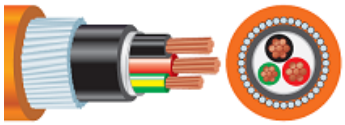




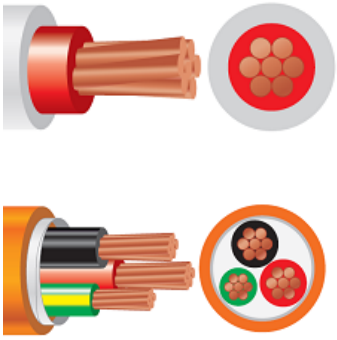


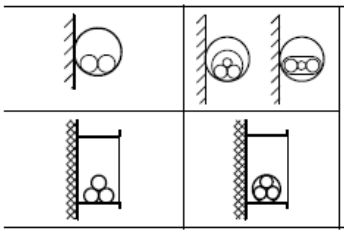
Installation method	Description	Typical cable types
	Unenclosed: On a surface partly surrounded by thermal insulation	Insulated and sheathed Screened or armoured Mineral insulated, metal sheathed (MIMS) Earthing conductors
	Unenclosed: Fully surrounded by thermal insulation	

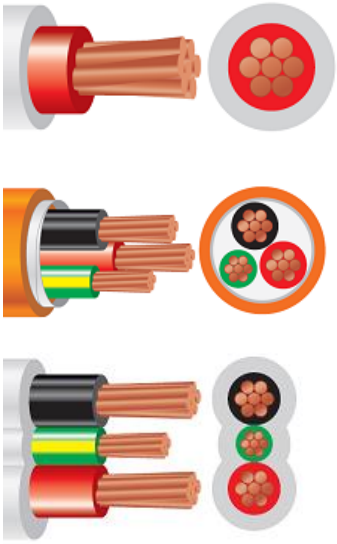


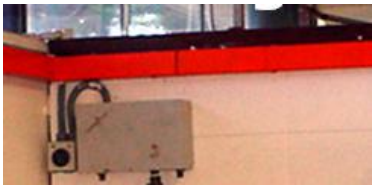


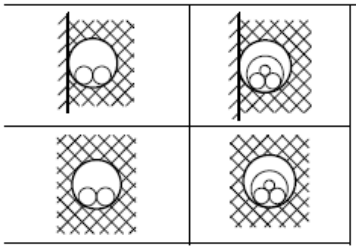
Installation method	Description	Typical cable types
	Unenclosed: Buried direct in the ground, subject to the requirements of Clause 3.11	Insulated and sheathed, screened or armoured, earthing conductors

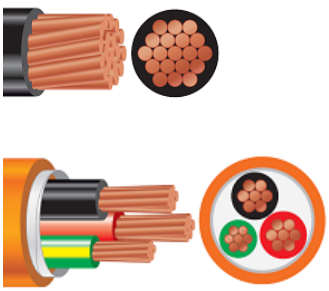


Installation method	Description	Typical cable types
	In an enclosure	On a surface (including cable trunking)	Insulated, unsheathed Insulated and sheathed Screened or armoured MIMS Earthing conductors

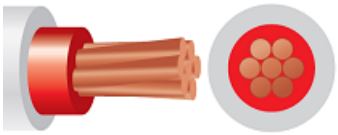


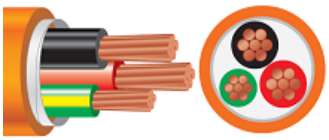


Installation method	Description	Typical cable types
	Enclosed	On a surface and partly surrounded by thermal insulation	Insulated, unsheathed Insulated and sheathed Screened or armoured MIMS Earthing conductors
		Fully surrounded by thermal insulation	

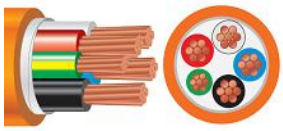


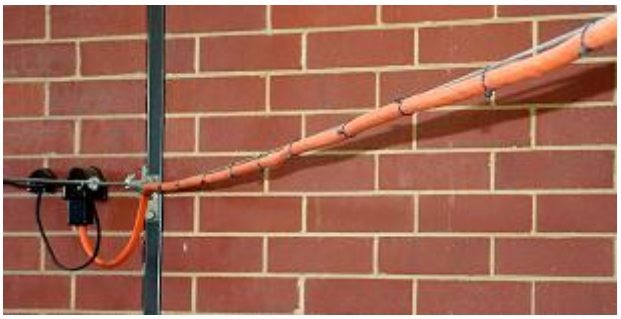
Installation method	Description	Typical cable types
 	In an Enclosure	Underground, subject to the requirements of Clause 3.11	Insulated, unsheathed Insulated and sheathed Screened or armoured Earthing conductors





Installation method	Description	Typical cable types
	Supported on a catenary system	Insulated and sheathed Screened or armoured Earthing conductors





Installation method	Description	Typical cable types
	Supported on insulators	Aerial conductors Earthing conductors

3.3 EXTERNAL INFLUENCES

3.3.1 General

Wiring systems shall be able to operate safely and shall function properly in the conditions to which they are likely to be exposed at the point of installation.

Characteristics of wiring systems may comprise—

(a) suitable design and construction of the wiring system; or

(b) additional means, provided as part of the electrical installation, that do not adversely affect their operation; to effectively protect against the presence and extent of relevant
environmental and other influences.

NOTE: AS 60529 provides an IP Classification and marking system for electrical equipment and enclosures that provide different degrees of protection against the entry of water and solid objects (see Appendix G for illustrations).

Protection against contact of external solids

	TEST	PROTECTION
X	No test applied	No specific protection.
0	No test applied	Inherent degree of protection.
1		Protected against solid objects larger than 50mm (eg. accidental contact with hand).
2		Protected against solid objects larger than 12mm (eg. contact with finger).
3		Protected against solid objects larger than 2.5mm (eg. tools and wires).
4		Protected against solid objects larger than 1mm (eg. fine tools and wires).
5		Protected against dust. Prevent entry in sufficient quantity to interfere with satisfactory operation.
6		Completely protected against dust.

Protection against the penetration of liquids

	TEST	PROTECTION
X	No test applied	No specific protection.
0	No test applied	Inherent degree of protection.
1		Protected against drops of water falling vertically.
2		Protected against drops of water falling at up to 15° from the vertical.
3		Protected against spraying water at up to 60° from the vertical.
4		Protected against splashing water from all directions.
5		Protected against jets of water from all directions.
6		Protected against jets of water of similar force to heavy seas.
7		Protected against the effects of immersion.
8		Protected against the effects of submersion.

Mechanical protection against impact

	TEST	PROTECTION
X	No test applied	No specific protection.
1		Resistant to impacts of weight up to 150g falling from 15cm.
3		Resistant to impacts of weight up to 250g falling from 20cm.
5		Resistant to impacts of weight up to 500g falling from 40cm.
7		Resistant to impacts of weight up to 1.5kg falling from 40cm.
9		Resistant to impacts of weight up to 5kg falling from 40cm.

Wiring systems shall be selected and installed so as to be suitable for the highest and lowest local ambient temperatures.

What are the ambient temperatures stipulated for Australia for:

Cables in air _____

Cable installed underground _____

What is the AS/NZS3000:2007 Clause number relating to this question?
_____

Wiring systems shall be protected against the effects of heat from external sources, including solar gain.

What is one of the methods for this protection?

_____

_____

What is the AS/NZS3000:2007 Clause number relating to this question?
_____

Wiring systems shall be selected and installed so that high humidity or the entry of water does not cause damage.

Please fill in the missing word:

Where water may collect or _____ may form in a wiring system, to the extent that it creates a hazard, provision shall be made for its harmless escape through suitably located drainage points.

What is the AS/NZS3000:2007 Clause number relating to this question?
_____

Wiring systems shall be selected and installed so as to minimize the entry of solid foreign bodies during installation, use and maintenance.

Please fill in the missing word:

In a location where _____ or any other substance, in significant quantity, may be present, additional precautions shall be taken to prevent its accumulation in quantities that could adversely affect the heat dissipation from the wiring system.

What is the AS/NZS3000:2007 Clause number relating to this question?

_____

Where the presence of corrosive or polluting substances is likely to give rise to corrosion or deterioration, parts of the wiring system likely to be affected shall be suitably protected or manufactured from materials resistant to such substances.

Dissimilar metals liable to initiate galvanic action shall not be placed in contact with each other.

What are two common metals that are used for the connection of electrical equipment that could cause galvanic action if incorrectly joined? (Not directly referred to in the wiring rules)

_____

_____

What is the AS/NZS3000:2007 Clause number relating to this question?

_____

Wiring systems shall be selected and installed so as to minimize the risk of mechanical damage.

What is one of the methods for this protection?

_____

_____

What is the AS/NZS3000:2007 Clause number relating to this question?

_____

Please fill in the missing word:

Wiring systems subject to vibration that is likely to cause _____ to the wiring system, including all cables, fixings and connections, shall be suitable for the conditions.

What is the AS/NZS3000:2007 Clause number relating to this question?

_____

Wiring systems shall be selected and installed so as to minimize damage to the cable insulation, sheathing and connections during installation, operation and maintenance.

What is one of the Measures undertaken to minimize damage?

_____

_____

What is the AS/NZS3000:2007 Clause number relating to this question?

_____

Please fill in the missing word for the following statements:

Where the presence of flora is expected to constitute a _____, either the wiring system shall be selected accordingly, or special protective measures shall be adopted.

What is the AS/NZS3000:2007 Clause number relating to this question?

_____

Where the presence of fauna is _____ to constitute a hazard, either the wiring system shall be selected accordingly, or special protective measures shall be adopted.

What is the AS/NZS3000:2007 Clause number relating to this question?

_____

Where a wiring system is, or may be, exposed to _____ sunlight, either a wiring system suitable for the conditions shall be selected and installed, or adequate shielding shall be provided, in accordance with Clause 3.3.2.2.

What is the AS/NZS3000:2007 Clause number relating to this question?

_____

Wiring systems installed in areas subject to explosive gas and _____ atmospheres shall be selected and installed in accordance with Clause 7.7 and AS/NZS 2381.1 and AS/NZS 61241.14.

What is the AS/NZS3000:2007 Clause number relating to this question?

_____

3.7 ELECTRICAL CONNECTIONS

3.7.1 General

Connections between conductors and between conductors and other electrical equipment shall provide electrical continuity, an appropriate level of insulation and adequate mechanical strength.

The method of joining or connecting cables shall be suitable for the application and ensure that the conductivity of the joint or connection is not less than that of the conductor.

There shall be no undue pressure on conductors or on the connection after the connection has been made.

Please fill in the missing word for the following statements:

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

For connections between insulated conductors, the connection shall be _____ to provide a degree of insulation not inferior to that of the conductors. Any damaged insulation shall be reinstated.

What is the AS/NZS3000:2007 Clause number relating to this question?
_____

Conductors joined or terminated by means of a crimp (compression) connection shall be securely retained within a suitable crimping device.

The connection shall be made using a tool _____for the purpose and techniques specified by the manufacturer.

What is the AS/NZS3000:2007 Clause number relating to this question?
_____

Please fill in the missing word for the following:

Mechanical connection devices that meet the following criteria may be used for the connection of conductors.

Such devices shall—

(a)

(b)

(c)

(d)

(e)

(f)

(g)

Please fill in the missing word for the following:

The ends of stranded conductors shall be secured by suitable means, so as to _____ the spreading or escape of individual strands.

What is the AS/NZS3000:2007 Clause number relating to this question?

_____

Is a conductor that is going to be clamped under a screw or between two metal surfaces allowed to be soft soldered?

What is the AS/NZS3000:2007 Clause number relating to this question?

_____

Joints shall not be made in flexible cords.

What is the exception to this clause when relating to flexible cords not used for fixed wiring?

What is the AS/NZS3000:2007 Clause number relating to this question?

_____

What are the conductor colours for installation wiring for the following applications?

Protective earth

Neutral

Active

What is the AS/NZS3000:2007 Clause number relating to this question?

_____

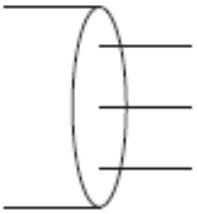
Is it permissible to use coloured sleeving to identify a green / yellow conductor and an active conductor?

What is the AS/NZS3000:2007 Clause number relating to this question?

_____

Indicate the appropriate colours for identifying cores of flexible cables:

SUPERSEDED AS/NZS FLEXIBLE CORDS

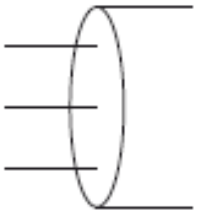


..... Active .....

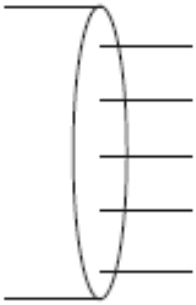
..... Neutral .....

..... Earth.....

EUROPEAN CABLES AND CURRENT AS/NZS FLEXIBLE CORDS, FLEXIBLE CABLES AND EQUIPMENT WIRING



CURRENT AS/NZS CABLES AND FLEXIBLE CORDS



..... Phase 1.....

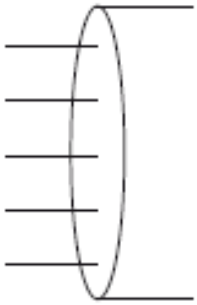
..... Phase 2 .....

..... Phase 3.....

..... Neutral .....

..... Earth .....

EUROPEAN FLEXIBLE CORDS, FLEXIBLE CABLES AND EQUIPMENT WIRING



COMPRESSION TERMINATION THEORY

(From the Utilux web site http://www.utilux.com.au/)

Utilux crimp lugs, links and stalk lugs are designed to be compatible with Utilux indent tools and hydraulic tools with hexagonal or indent dies.

Through this exact matching the resultant terminations achieve a consistently precise compression – neither over stressed nor understressed – to produce the correct indent or hexagonal force.

The crimp is designed to bring all conductors and the connector itself into intimate contact.

At the same time, the crimp is designed to avoid any reduction in the cross sectional area of the conductor, with an increased contact area.

BASIC COMPRESSION TERMINATION PRACTICES

1. Strip the cable insulation to the recommended length. Recommended stripping lengths of conductors should correspond to the barrel lengths shown in this catalogue.

2. With non plated copper conductors, scratch brushing may be carried out on the bare copper conductor.
On aluminium conductors however, scratch brushing must be carried out. Terminating should be completed as soon as possible after stripping of the insulation.

Long barrel or palm for easy heat shinking

3. To ensure a reliable termination, the correct connector for a given cable size must be selected.
Moreover, the recommended indent tool or hexagon tool and die must also be used.

4. Fit the connector over the stripped conductor and place the connector into the hand or hydraulic tool.
Apply the recommended pressure. With hand tools, the crimp is not complete until the jaws
meet or the ratchet releases. With hex dies in hydraulic tools, the faces of the die must meet.

5. The number of crimps per connector can vary. Some lugs have markings for crimps, if you require more information please contact Utilux.

TERMINATION RECOMMENDATIONS

The palm contact areas of Utilux lugs are designed to give more than that the surface of lugs are used upon has corresponding contact area.
Excessive drilling out of palm holes must be avoided, to ensure that adequate palm contact, heavy gauge washers are recommended.

FLEXIBLE CABLE CRIMPING

The crimping of connectors onto flexible conductors is problematic due to the large amount of air gaps between conductor strands. This results in a large physical size for a relatively small conductor cross section.

Thus the standard size lug for a given area of flexible conductor is usually too small. If a larger size lug is used instead, the standard die for that size lug will not achieve the desired compression.

Flared lugs for flexible cables

Indent crimping is not recommended, as the indent may damage the very fine strands of a flexible conductor which may in turn cause connector failure.

Adopting the Utilux "Half Hex" crimping method solves the problem.

This method employs a crimping shape in the form of one half of the standard hexagon shape. The dies used comprise a normal hexagon crimp die, along with a special flat die to give the half hexagon shape.
The hexagon die is sufficiently large to close around the lug completely, giving adequate compression.

Normally the conductor's area will be known or can be located on the chart below. However if not known, it has to be established. To do this we require the amount of strands and individual strand diameter.
Counting the amount of strands is not as daunting a task as it appears. The lay of the conductor will generally be a series of bundled strands, with each bundle having the same lay as a regular laid conductor, eg 7, 19, 37 strands etc.
Having established the amount of strands to a bundle, count the amount of bundles and multiply.
For example for a 95mm2 the conductor may be 259/0.7 with a nominal diameter of 13.8mm, from this the true area is 99.7mm2. The diameter is too large for a 95mm2 barrel but will fit a 120mm2 barrel. It can then be crimped using the half hex method.
Rule of thumb for matching conductor to lug, providing conductor diameter allows, is whatever the area of the conductor, choose the next size larger lug.