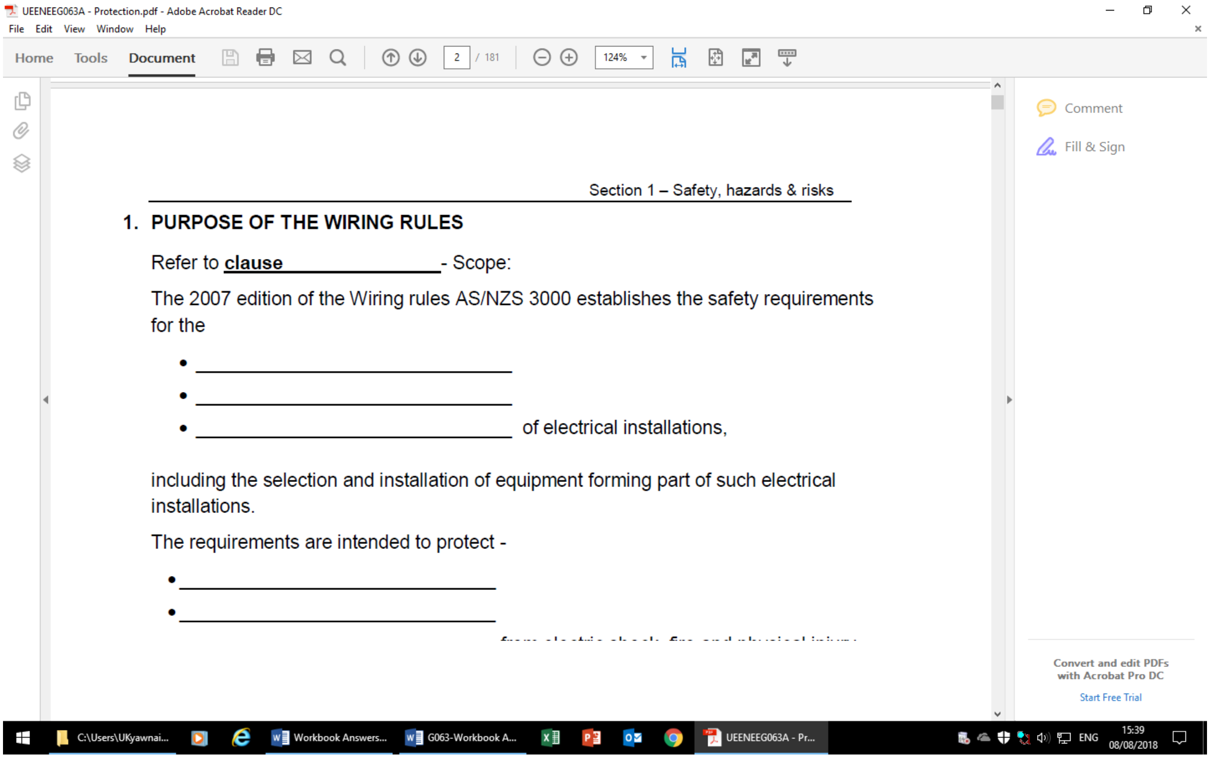
Page 2



Section 1 – Safety, hazards & risks

1. **PURPOSE OF THE WIRING RULES**

Refer to **clause** ________________- Scope:

The 2007 edition of the Wiring rules AS/NZS 3000 establishes the safety requirements for the

- ______________________________
- ______________________________
- ______________________________ of electrical installations,

including the selection and installation of equipment forming part of such electrical installations.

The requirements are intended to protect -

- ______________________________
- ______________________________

1.1 SCOPE

This Standard sets out requirements for the design, construction and verification of electrical installations, including the selection and installation of electrical equipment forming part of such electrical installations.

These requirements are intended to protect persons, livestock, and property from electric shock, fire and physical injury hazards that may arise from an electrical installation that is used with reasonable care and with due regard to the intended purpose of the electrical installation.

2.APPLICATION OF THE RULES

Refer to **clause** - Application:

The principal application of the Wiring Rules relates to electrical installations in -

____

____

____

____

Electrical work is to comply with sections 2-8 of the AS/NZS3000 standard, and any other relevant standard or code of practice that may pertain to any particular installation.

The principal application of this Standard is to electrical installations in all
types of premises and land used by electricity consumers.

(1.2 APPLICATION)

However, the
Standard may also be referenced or applied through legislative or other requirements relating to the effect of electrical installations in matters such
as the following:

Refer to **clause** – Definitions (1.4 DEFINITIONS)

4.FUNDAMENTAL PRICIPLES

AS/NZS 3000 establishes a set of fundamental principles in order to provide protectionfor safety.

Refer to **clause** - Protection against dangers and damage

1.4.97 Protection, basic

Protection against dangers that may arise from direct contact with live parts of the installation (see Figure 1.2 and Clause 1.4.38 Contact, direct

In electrical installations the three major types of risk are -

______________________________ - arising from contact with parts which are live in normal service (direct contact) or parts which become live under fault conditions (indirect contact).

______________________________ - likely to cause burns, fires and other injurious effects.

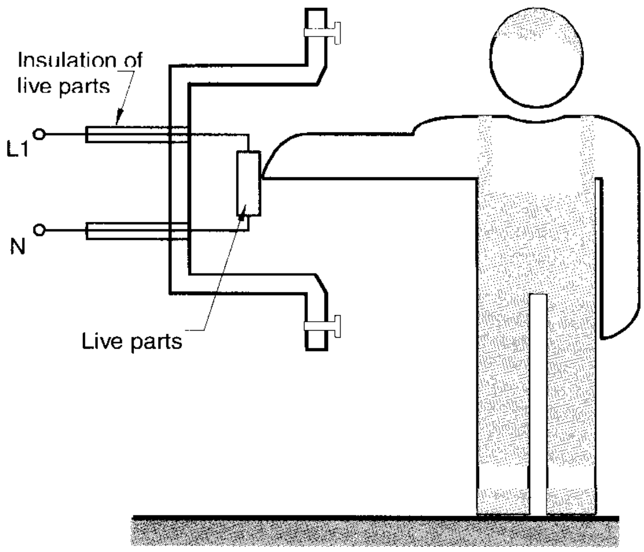
______________________________- equipment installed in areas where explosive gases or dusts may be present

Electrocution/ Electric Arc/ Explosion

5.BASIC PROTECTION - (PROTECTION AGAINST DIRECT CONTACT)

Refer to **clause 1.4.34** – Contact, direct:

Direct contact occurs when a person contacts a conductor or conductive part that is –



1.4.38 Contact, direct
Contact with a conductor or conductive part that is live in normal service (see Figure 1.2 and Clause 1.4.97 Protection, basic).

Refer to **clause 1.5.4.2** – Methods of Protection:
Protection against direct contact with live parts shall be provided by one or any combination of the following methods –
1.5.4.2 Methods of protection
Basic protection shall be provided by one or any combination of the following methods:
(a) Insulation, in accordance with Clause 1.5.4.3.
(b) Barriers or enclosures, in accordance with Clause 1.5.4.4.
(c) Obstacles, in accordance with Clause 1.5.4.5.
(d) Placing out of reach, in accordance with Clause 1.5.4.6.
RCDs are not recognized as a sole means of basic protection against contact with live parts but may be used to augment one of the above methods.

Refer to **clause 1.5.4.4** - Protection by barriers or enclosures:
Where barriers or enclosures protect live parts, the degree of protection afforded shall be at least -
□____

□____
(a) Degree of protection Live parts shall be inside enclosures or behind barriers that provide a degree of protection of at least—
(i) IPXXB or IP2X; and
(ii) IP4X for horizontal top surfaces that are readily accessible.
* The IP rating shall suit the environmental conditions and the relevant mounting position as specified by the manufacturer.
NOTE: This applies in particular to parts of enclosures that might serve as—
(a) a floor; or

(b) a surface where objects on surrounding surfaces may be displaced into openings.
Larger openings are allowable in electrical equipment where they may be necessary for the proper operation and functioning of electrical equipment, or where they are required for the replacement of parts, such as lamps or fuses. In such cases—
(A) suitable precautions shall be taken to prevent unintentional contact with live parts; and
(B) as far as practicable, persons shall be advised that live parts can be touched through the opening and are not to be touched intentionally.

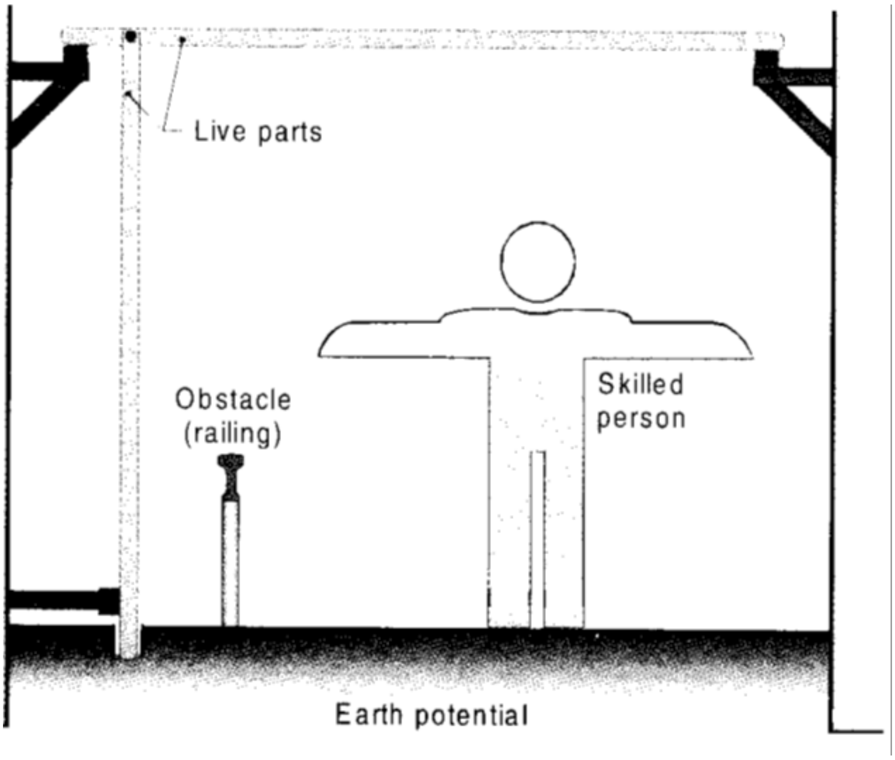
The removal of doors, lids and covers from an enclosure shall not be possible unless -

- ____
- ____
- ____

The removal of barriers, opening of enclosures, or withdrawal of parts of enclosures (doors, casings, lids, covers and the like) shall not be possible.
Exception: The removal of barriers is permitted where one of the following conditions apply:
1 The use of a key or tool is required.
NOTE: Electrical equipment complying with an appropriate Standard that allows the removal of barriers or enclosures by an alternative method is not prohibited.
2 An interlocking device is fitted that requires—
— switching off, or automatic disconnection, of the supply to all live parts protected by the barrier or enclosure that might be touched accidentally during or after the removal, opening or withdrawal process; and
— the barrier or enclosure to be replaced or closed before the supply can normally be switched on.
NOTE: Account should be taken of danger that may exist from the stored energy of power capacitors in electrical equipment or the capacitive effect of electrical equipment, such as busways, that have been isolated from the supply.
3 An intermediate barrier is provided that—
— prevents contact with all live parts when the barrier or enclosure is removed;
— is permanently in position, or arranged so that it is automatically put in position when the barrier or enclosure is removed; and
— requires the use of a key or tool to remove.

Refer to **clause 1.5.4.5** - Protection by obstacles:

Obstacles are intended to prevent ________________________ contact with live parts but not ______________________ contact by deliberate circumvention of the obstacle

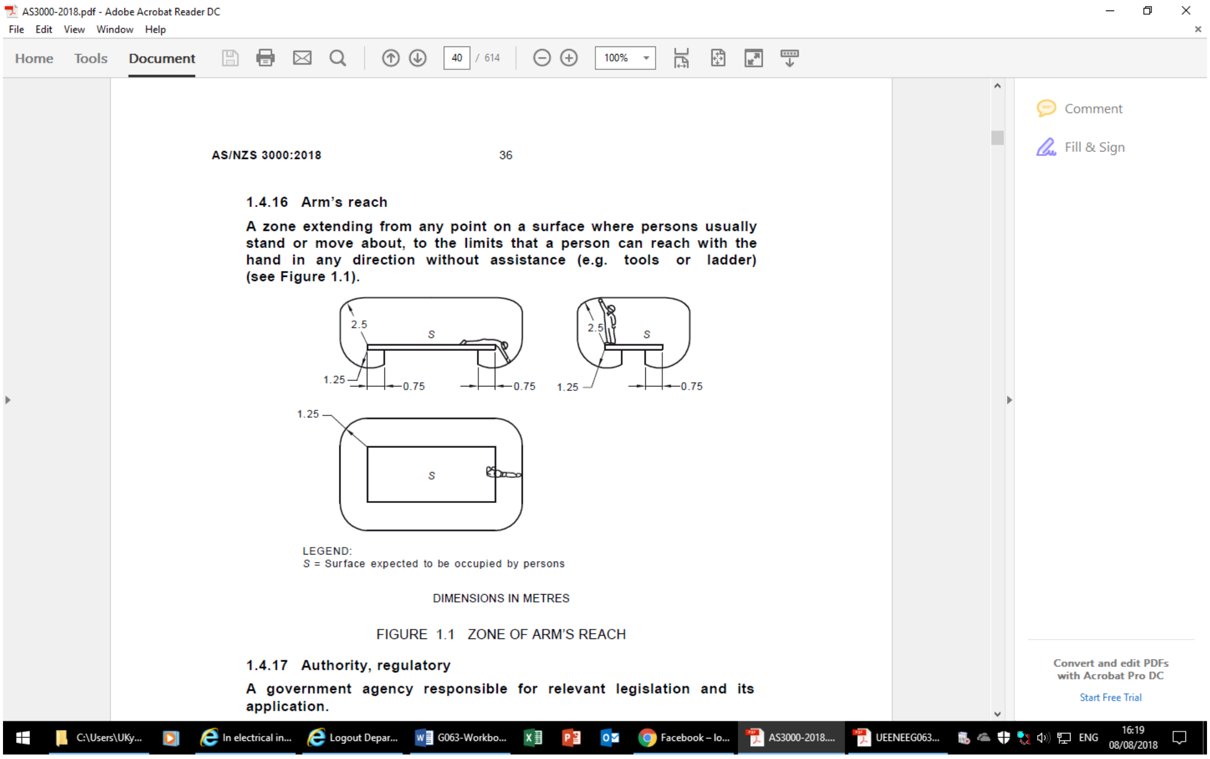


Obstacles are intended to prevent unintentional contact with live parts but not intentional contact by deliberate circumvention of the obstacle

Refer to **clause 1.5.4.6** - Protection by placing out of reach:
Simultaneously accessible parts at different voltages shall not be within arm's reach.
If two parts are said to be simultaneously accessible, they are not more than _________ metres apart.

1 Two parts are deemed to be simultaneously accessible if they are not more than 2.5 m apart.

Refer to **clause 1.4.12** - Arm's reach:
Arms reach is defined as:
The limit a person can _________________ without assistance, from any point on a surface where persons usually _________________ or _______________________.



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1.4.16 Arm's reach

A zone extending from any point on a surface where persons usually stand or move about, to the limits that a person can reach with the hand in any direction without assistance (e.g. tools or ladder) (see Figure 1.1).

LEGEND:
S = Surface expected to be occupied by persons

DIMENSIONS IN METRES

FIGURE 1.1 ZONE OF ARM'S REACH

1.4.17 Authority, regulatory

A government agency responsible for relevant legislation and its application.

the limits that a person can reach with the
hand in any direction without assistance (e.g. tools or ladder)

The limit of arms reach -
☐above a surface is

_____________ metres 2.5m

☐adjacent to a surface is

_____________ metres 1.25m

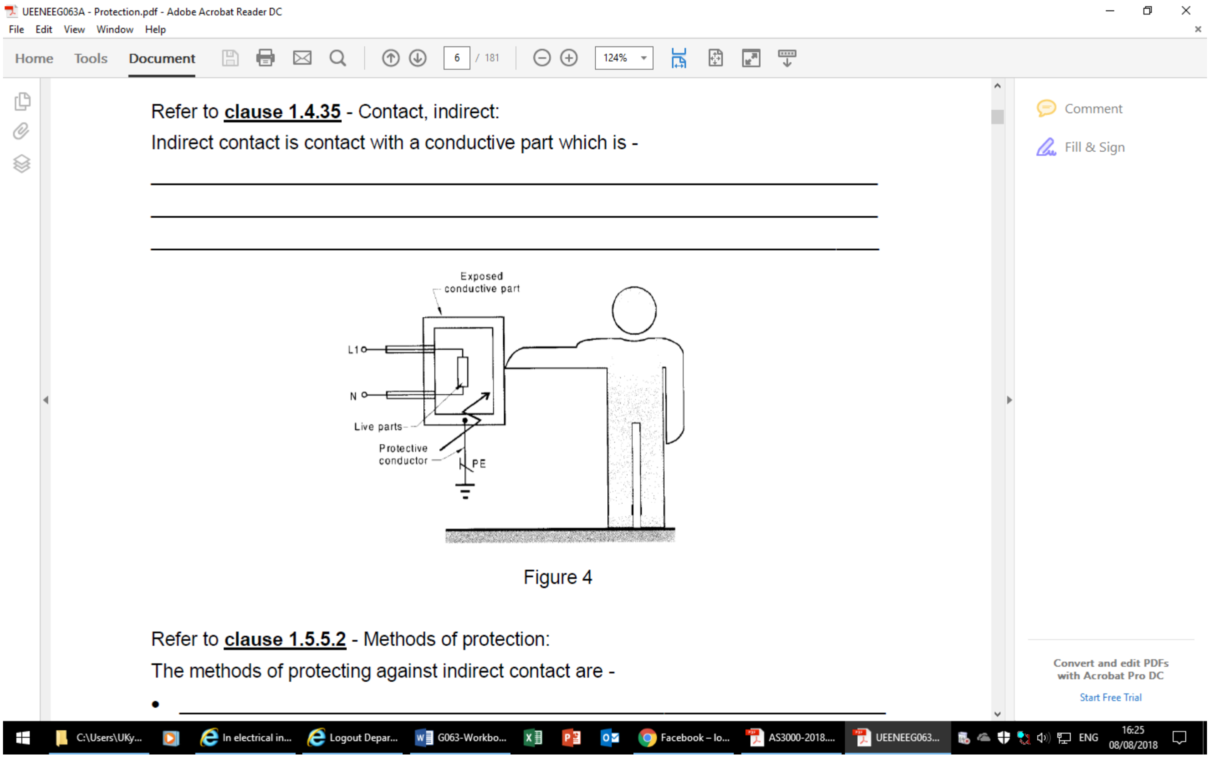
☐below a surface is

_____________ metres. 0.75m

FAULT PROTECTION - (PROTECTION AGAINST INDIRECT CONTACT)
Refer to **clause 1.5.5.1** - Protection against indirect contact:
The Rules require that protection shall be provided against ____________________ that may arise from contact with exposed conductive parts which may become live – ____ (indirect contact).

Protection shall be provided against dangers that may arise from contact with exposed conductive parts that may become live under fault conditions.

Refer to **clause 1.4.35** - Contact, indirect:
Indirect contact is contact with a conductive part which is - ___________________________


Refer to **clause 1.4.35** - Contact, indirect:

Indirect contact is contact with a conductive part which is -

____

____

____

Figure 4

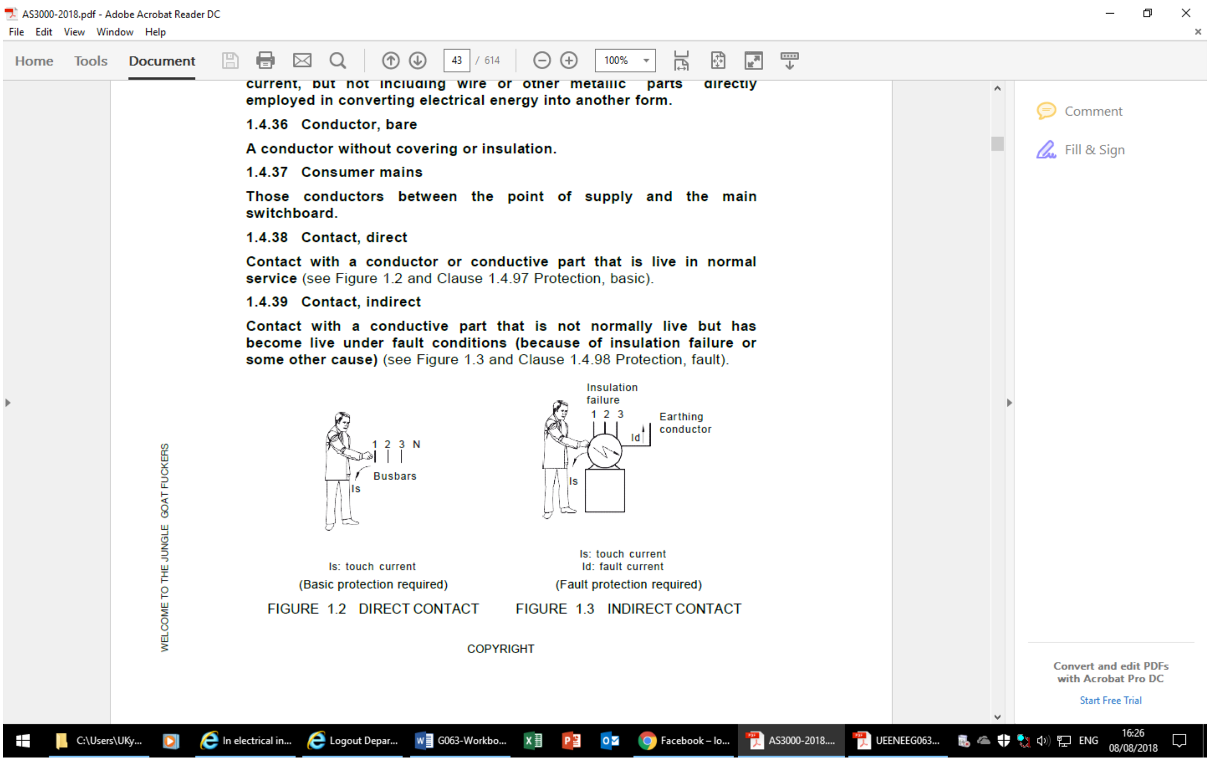
Refer to **clause 1.5.5.2** - Methods of protection:

The methods of protecting against indirect contact are -

- ____

1.4.39 Contact, indirect

Contact with a conductive part that is not normally live but has become live under fault conditions (because of insulation failure or some other cause) (see Figure 1.3 and Clause 1.4.98 Protection, fault).


current, but not including wire or other metallic parts directly employed in converting electrical energy into another form.

1.4.36 Conductor, bare

A conductor without covering or insulation.

1.4.37 Consumer mains

Those conductors between the point of supply and the main switchboard.

1.4.38 Contact, direct

Contact with a conductor or conductive part that is live in normal service (see Figure 1.2 and Clause 1.4.97 Protection, basic).

1.4.39 Contact, indirect

Contact with a conductive part that is not normally live but has become live under fault conditions (because of insulation failure or some other cause) (see Figure 1.3 and Clause 1.4.98 Protection, fault).

FIGURE 1.2 DIRECT CONTACT FIGURE 1.3 INDIRECT CONTACT

WELCOME TO THE JUNGLE GOAT FUCKERS

Refer to **clause 1.5.5.2** - Methods of protection:

The methods of protecting against indirect contact are -

☐ ____

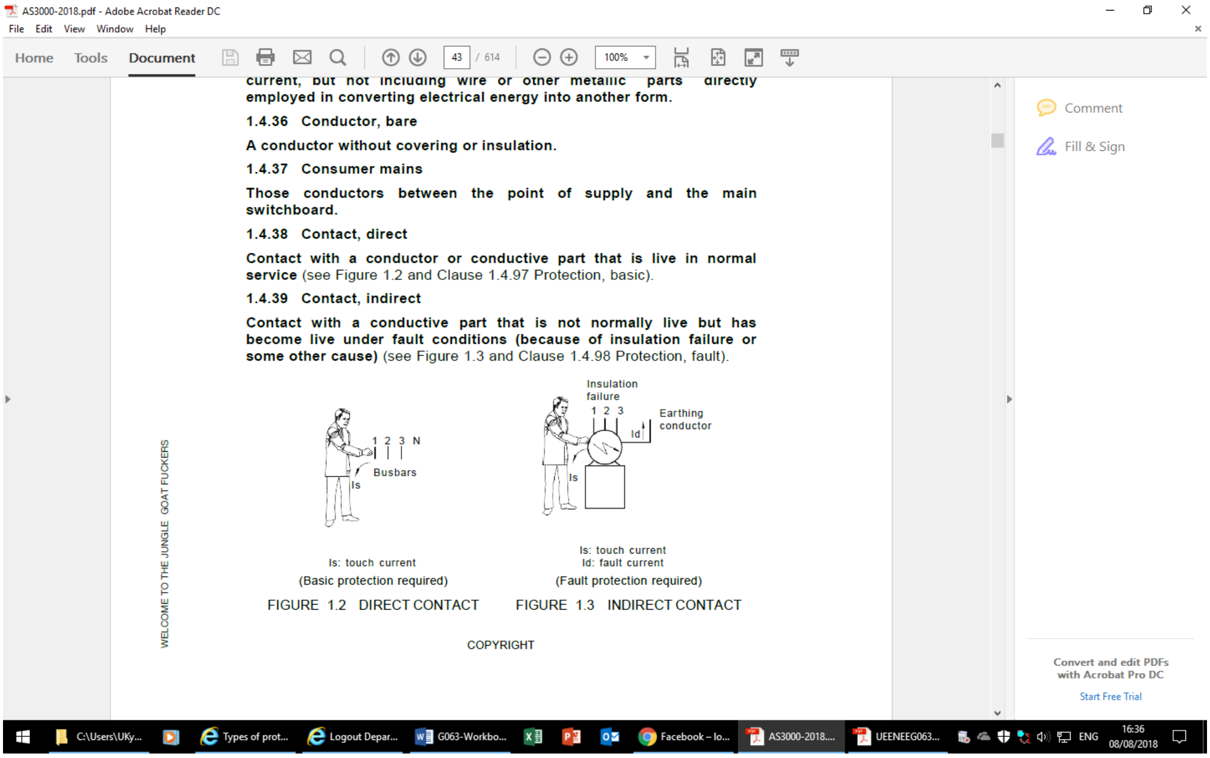
☐ ____

☐ ____

☐ ____

1.4.98 Protection, fault

Protection against dangers that may arise from indirect contact with live parts of the installation (contact with an exposed conductive part that is not normally live but has become live under fault conditions) (see Figure 1.3 and Clause 1.4.39 Contact, indirect).



current, but not including wire or other metallic parts directly employed in converting electrical energy into another form.

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Contact with a conductor or conductive part that is live in normal service (see Figure 1.2 and Clause 1.4.97 Protection, basic).

1.4.39 Contact, indirect

Contact with a conductive part that is not normally live but has become live under fault conditions (because of insulation failure or some other cause) (see Figure 1.3 and Clause 1.4.98 Protection, fault).

(Basic protection required) FIGURE 1.2 DIRECT CONTACT

(Fault protection required) FIGURE 1.3 INDIRECT CONTACT

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1.5.5.2 Methods of protection

Fault protection shall be provided by one or any combination of the following methods:

(a) Automatically disconnect the supply on the occurrence of a fault likely to cause a current flow through a body in contact with exposed conductive parts, where the value of that current is equal to or greater than the shock current, in accordance with Clause 1.5.5.3.

(b) Prevent a fault current from passing through a body by the use of Class II equipment or equivalent insulation, in accordance with Clause 1.5.5.4.

(c) Prevent a fault current from passing through a body by electrical separation of the system, in accordance with Clause 1.5.5.5.

NOTE: Clause 7.4 provides further guidance on electrical separation.

(d) Limit the fault current that can pass through a body to a value lower than the shock current.

The most commonly used method to protect against indirect contact is:

______________________________.

Earth fault protection

The severity of electric shock depends on the –

The severity of electrical shock or electrocution injuries usually **depends** on three things: (1) the path the current travels in and through the body, (2) the amount of voltage (high-voltage versus low-voltage), and (3) the type of current (alternating current or AC versus direct current or DC).

Refer to **clause 1.4.95** - Touch voltage:
A touch voltage is a voltage –

1.4.125 Touch voltage
Voltage appearing between simultaneously accessible parts.
NOTES:
1 This term is used only in connection with fault protection.
2 In certain cases the value of the touch voltage may be appreciably influenced by the impedance of the person or livestock in contact with these parts.

Refer to **clause 1.4.94** - Touch current:
A touch current is a current –

1.4.124 Touch current
Electric current that passes through a human body, or an animal body, when that body touches one or more accessible parts of electrical equipment or an electrical installation, under normal conditions or fault conditions.

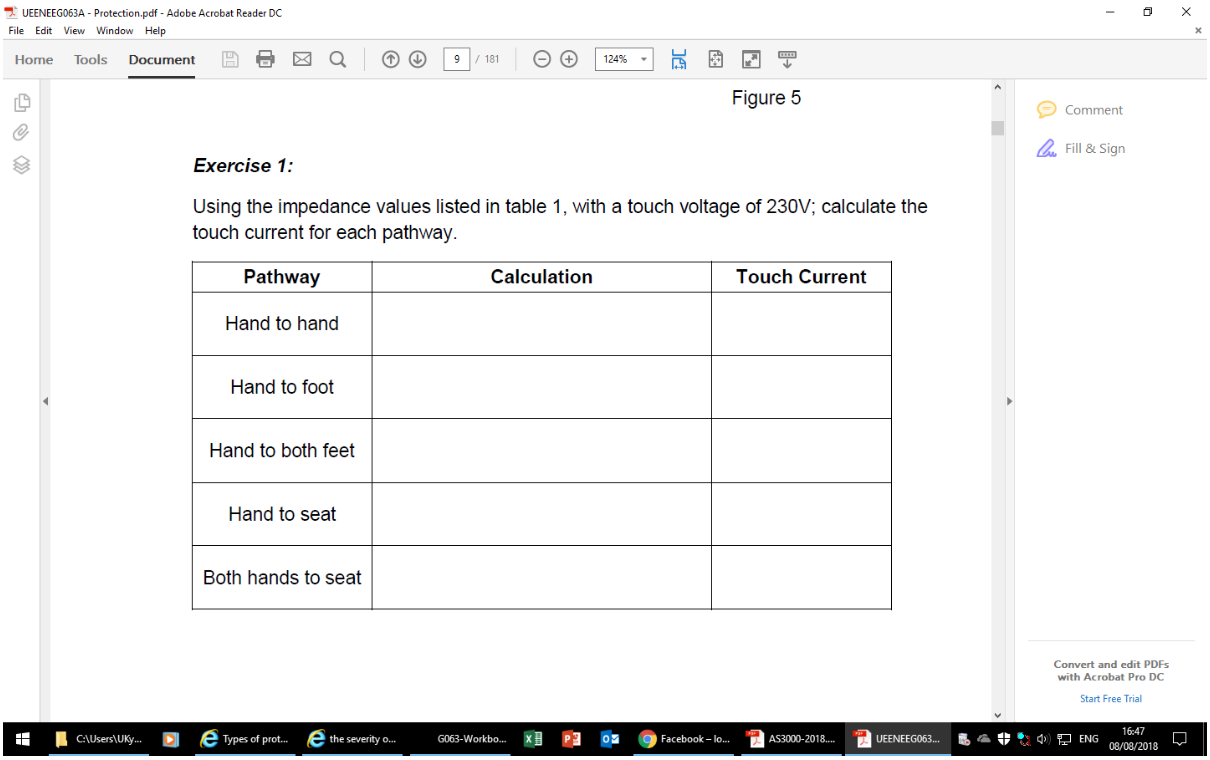


Figure 5

Exercise 1:

Using the impedance values listed in table 1, with a touch voltage of 230V; calculate the touch current for each pathway.

Pathway	Calculation	Touch Current
Hand to hand		
Hand to foot		
Hand to both feet		
Hand to seat		
Both hands to seat		

Figure 5 and table 1 show approximate impedance values for various current paths through the human body.

Table 1

Current Path	Impedance ohms
Hand to hand	1000Ω
Hand to foot	1000Ω
Hand to both feet	750Ω
Hand to seat	500Ω
Both hands to seat	250Ω

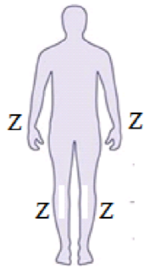


Figure 5

Exercise 1:

Using the impedance values listed in table 1, with a touch voltage of 230V; calculate the touch current for each pathway.

Hand to hand = 230V/1000 ohm = 0.23A

Hand to foot= 230V/1000 ohm = 0.23A

Hand to both feet = 230V/750 ohm=

Hand to seat =230V/500 ohm= 0.46A

Both hands to seat = 230V/ 250 ohm =

The time-current effects on the human body are shown in figure 6 and have been accepted as the international standard for the development of techniques of protection against electric shock.

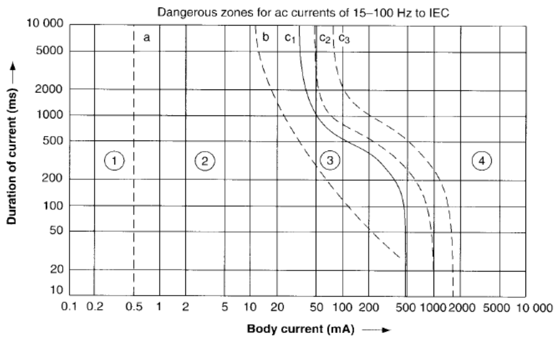
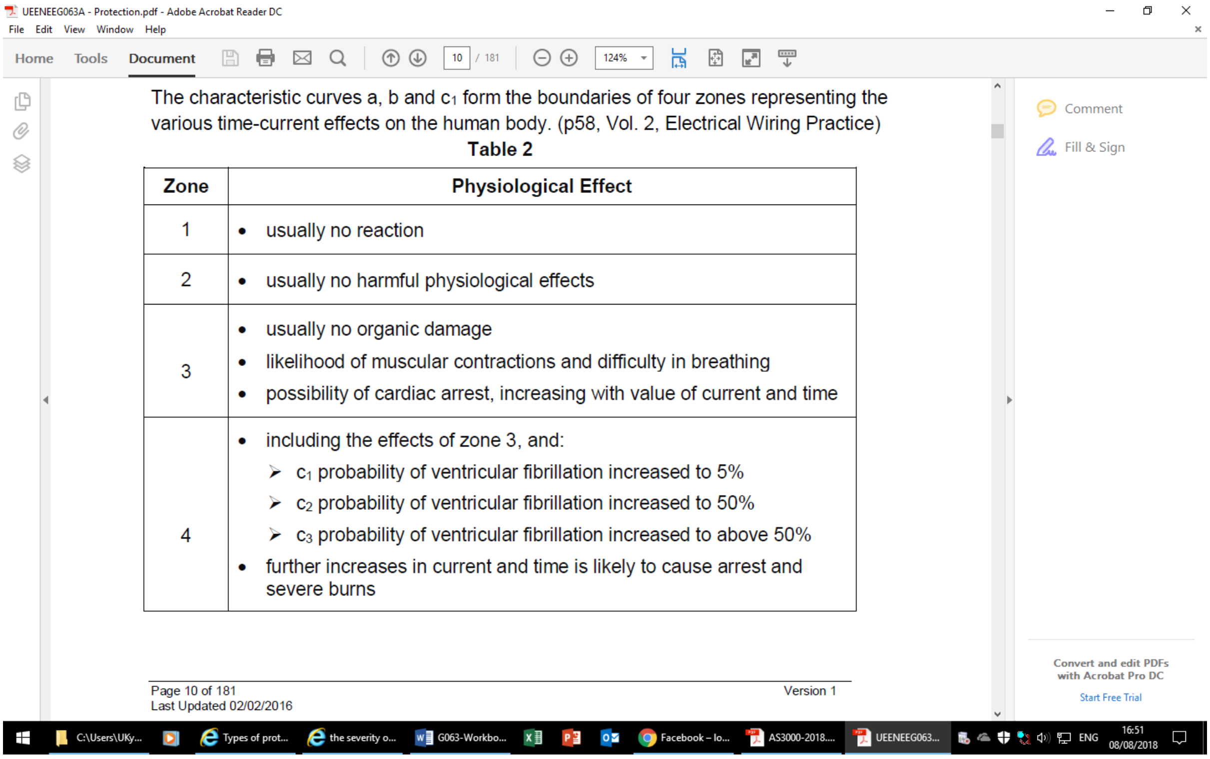


Figure 6

The characteristic curves a, b and c_1 form the boundaries of four zones representing the various time-current effects on the human body. (p58, Vol. 2, Electrical Wiring Practice)

Table 2

Zone	Physiological Effect



The characteristic curves a, b and c_1 form the boundaries of four zones representing the various time-current effects on the human body. (p58, Vol. 2, Electrical Wiring Practice)

Table 2

Zone	Physiological Effect
1	• usually no reaction
2	• usually no harmful physiological effects
3	• usually no organic damage • likelihood of muscular contractions and difficulty in breathing • possibility of cardiac arrest, increasing with value of current and time
4	• including the effects of zone 3, and: ➢ c_1 probability of ventricular fibrillation increased to 5% ➢ c_2 probability of ventricular fibrillation increased to 50% ➢ c_3 probability of ventricular fibrillation increased to above 50% • further increases in current and time is likely to cause arrest and severe burns

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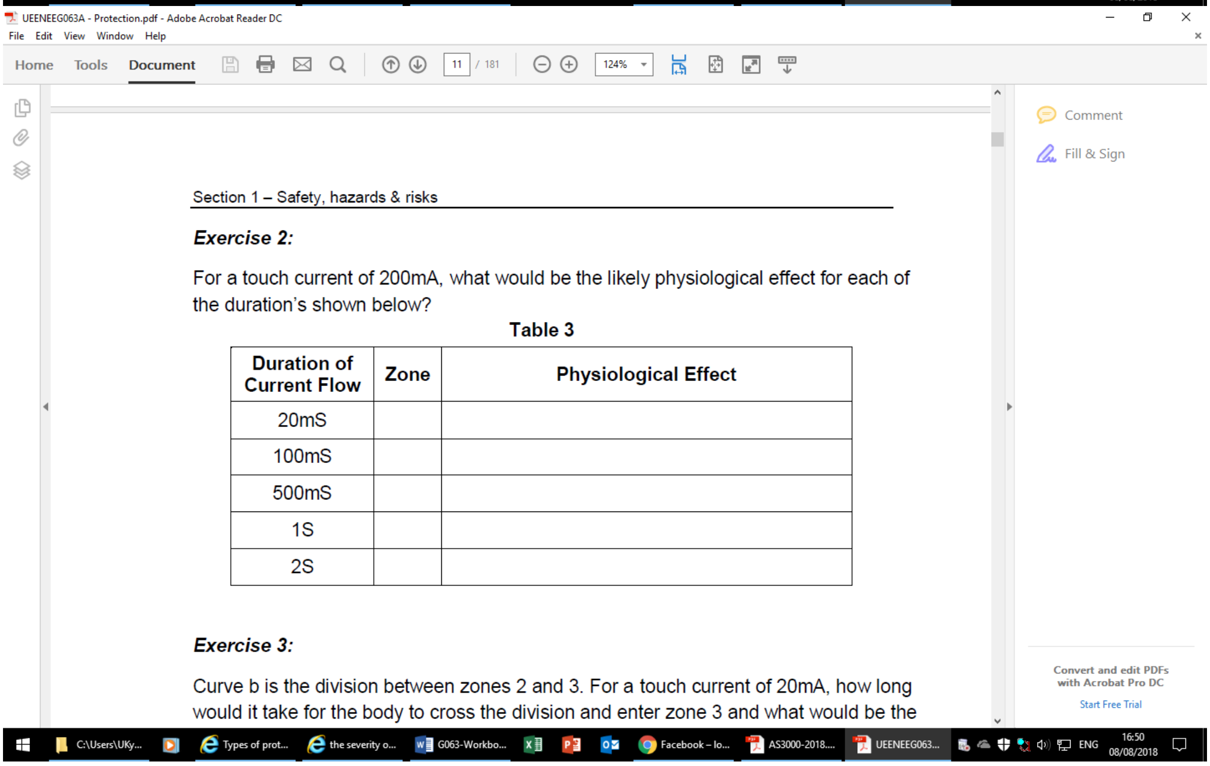


Section 1 – Safety, hazards & risks

Exercise 2:

For a touch current of 200mA, what would be the likely physiological effect for each of the duration's shown below?

Table 3

Duration of Current Flow	Zone	Physiological Effect
20mS		
100mS		
500mS		
1S		
2S		

Exercise 3:

Curve b is the division between zones 2 and 3. For a touch current of 20mA, how long would it take for the body to cross the division and enter zone 3 and what would be the

200mA, 20ms= Zone 2=
usually no harmful physiological effects

200mA, 100ms—Zone 3 -
•usually no organic damage
□likelihood of muscular contractions and difficulty in breathing
□possibility of cardiac arrest, increasing with value of current and time

200mA, 500ms- Zone 3 C1-
usually no organic damage
- likelihood of muscular contractions and difficulty in breathing
- possibility of cardiac arrest, increasing with value of current and time

c_1 probability of ventricular fibrillation increased to 5%

200mA, 1S- Zone 3-C2
usually no organic damage
- likelihood of muscular contractions and difficulty in breathing
- possibility of cardiac arrest, increasing with value of current and time

c_2 probability of ventricular fibrillation increased to 50%

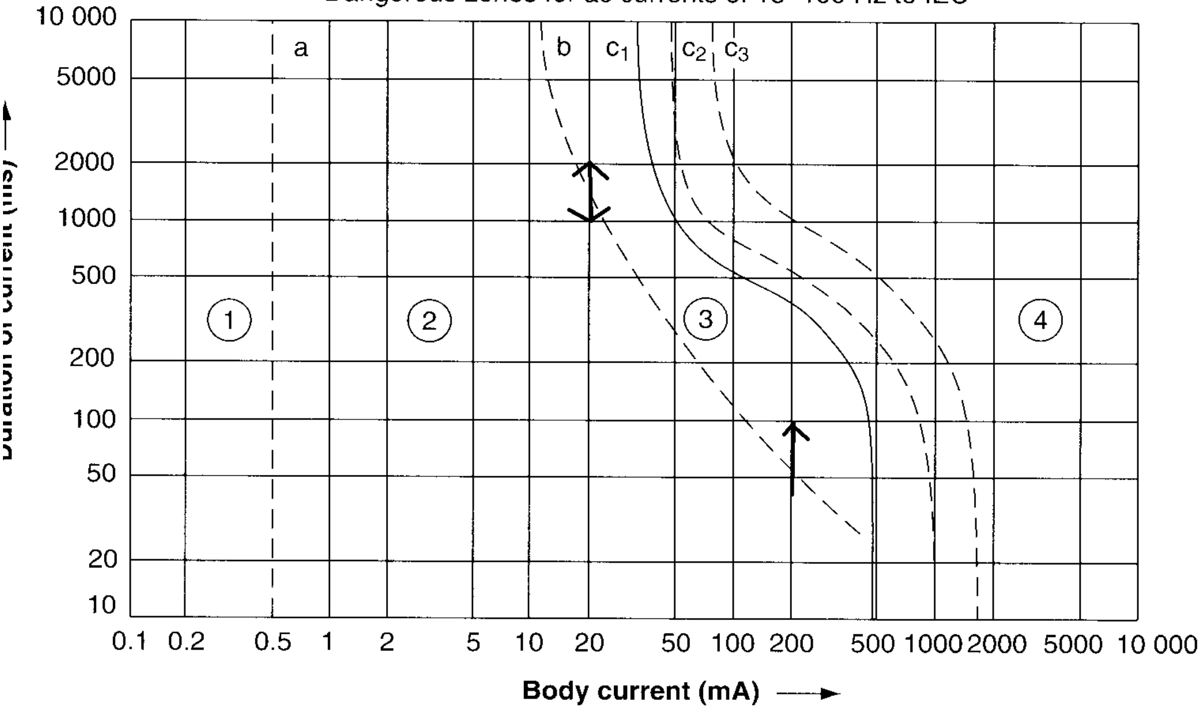
200mA, 2S Zone 3 C3
usually no organic damage
- likelihood of muscular contractions and difficulty in breathing
- possibility of cardiac arrest, increasing with value of current and time

c_3 probability of ventricular fibrillation increased to above 50%

Exercise 3:

Curve b is the division between zones 2 and 3. For a touch current of 20mA, how long would it take for the body to cross the division and enter zone 3 and what would be the impedance of the body when the touch voltage is 230V?

Dangerous zones for ac currents of 15–100 Hz to IEC



2 sec – 1 sec = 1 sec

Z = 230V/ 20ma = 11.5 x 1000 = 11500 ohm

What is the effect on the heat produced, if the current in a conductor is doubled?
4 times higher

Refer to **clause 1.5.8** - Protection against thermal effects in normal service:
Electrical installations shall be arranged so that there is no risk of ignition of flammable materials because of -

- _______________________________ or
- _______________________________ in normal service.

1.5.8 Protection against thermal effects in normal service
Electrical installations shall be arranged so that there is no risk of ignition of flammable materials because of high temperature or electric arc in normal service. During normal operation of the electrical equipment there shall be no risk of persons or livestock suffering burns.

During normal operation of the electrical equipment there shall be no risk of ________ or livestock suffering _________.

During normal operation of the electrical equipment there shall be no risk of persons or livestock suffering burns.

Where a wiring system passes through a wall, floor or ceiling, what should be maintained?
____

1.5.12 Protection against the spread of fire
Protection shall be provided against fire initiated or propagated by components of the electrical installation.
Electrical equipment shall be selected, installed and protected such that the equipment will not—
(a) obstruct escape routes, either directly or by the products of combustion;
(b) contribute to or propagate a fire;

Refer to **clause 3.7.2.3** - Loosening of connections:
Connections shall be made so that ______________________________ is likely due to vibration, alteration of materials or temperature variations to which the connections are likely to be subjected in normal service. Loosening of connections may lead to arcing, fire and explosion.

3.7.2.3 Loosening of connections
3.7.2.3.1 General
Connections shall be made so that no loosening is likely because of vibration, alteration of materials or temperature variations to which the

connections are likely to be subjected in normal service.

Refer to **clause 4.2.2.3** – Protection from high temperatures:
Provision shall be made against the effects of:
□________________________________ (as a result of direct contact), and;

□________________________________ (air temperature rise)

4.2.2.3 Protection from high temperatures
(a) High surface temperature Where fixed electrical equipment could attain surface temperatures that would cause a fire hazard to adjacent materials, the electrical equipment shall be—
(i) mounted on or within materials that will withstand such temperatures and are of low thermal conductance;
(ii) screened from combustible building elements by materials that will withstand such temperatures and are of low thermal conductance; or
(iii) mounted at a sufficient distance from any material on which such temperatures could have deleterious thermal effects, any means of support being of low thermal conductance so as to allow safe dissipation of heat.

230

TABLE 4.2

MINIMUM DISTANCE BETWEEN LAMP AND ILLUMINATED FLAMMABLE MATERIALS

Rating W	Minimum distance m
≤100	0.6
>100 ≤300	1.0
>300	1.8

What is the minimum default distance a 500 W directional shop-lighter fitting should be from the front edge of a book rack in a department store? _________
1.8 m

11. PROTECTION AGAINST OVERCURRENT
Refer to **clause 1.5.9** - Protection against overcurrent:
Protection against overcurrent may be provided by -
□____
____

□____
____

1.5.9 Protection against overcurrent
Protection shall be provided against injury or property damage because of excessive temperatures or electromechanical stresses caused by any overcurrents likely to arise in live conductors.
Protection may be provided by one of the following methods:
(a) Automatic disconnection on the occurrence of an overcurrent, before this overcurrent attains a dangerous value, taking into account its duration.
(b) Limiting the maximum overcurrent to a safe value and duration.

An overcurrent is a current that exceeds a particular rated value. An Overcurrent may occur in a circuit as a result of:
□_________________________________

□_________________________________

1.4.90 Overcurrent
A current exceeding the rated value of electrical equipment.

Overload or Under voltage

Refer to **clause 1.4.37** - Current, fault:
A fault current is defined as a current resulting from an _____________________________ or from the bridging of ______________________________.

1.4.41 Current, fault
A current resulting from an insulation failure or from the bridging of insulation.

Refer to **clause 1.4.38** - Current, overload:
An overload current is defined as an ____ ____.

1.4.42 Current, overload
An overcurrent occurring in a circuit that is electrically sound.

Refer to **clause 1.4.39** - Current, short-circuit:
A short-circuit is defined a fault current arising from ________________________________ ____.

1.4.43 Current, short-circuit
A fault current resulting from a fault of negligible impedance between live conductors having a difference in potential under normal operating conditions. The fault path may include the path from active via earth to the neutral.
Refer to **clause 1.5.10** - Protection against earth fault currents:

Protective earthing conductors and any other parts intended to carry an earth fault current shall be capable of carrying that current without attaining -

1.5.10 Protection against earth fault currents
Protective earthing conductors and any other parts intended to carry an earth fault current shall be capable of carrying that current without attaining excessive temperature.

12. PROTECTION AGAINST OVERVOLTAGE
Refer to **clause 2.7.1 -** Protection against overvoltage - general:
Overvoltage may occur in an installation as a result of:

- ☐____
- ☐__________________________________
- ☐__________________________________
- ☐__________________________________

2.7.1 General
Where an electrical installation is protected against overvoltages that may cause danger to persons or property, the requirements of Clauses 2.7.2 and 2.7.3 shall apply.
NOTES:
1 The causes of overvoltage in an electrical installation include the following:
(a) An insulation fault between the electrical installation and a circuit of higher voltage.
(b) Switching operations.
(c) Lightning.
(d) Resonant phenomena.
2 Protection against overvoltages should be provided in areas where lightning is prevalent.

Protection against overvoltage may be achieved by:

- ☐__________________________________
- ☐__________________________________

2.7.2 Protection by insulation or separation
2.7.3 Protection by protective devices

A common method to protect circuits and equipment from the undesirable effects of overvoltage is to install __________________________________ (S.P.D's)
Fuse/ Overload Protection Circuit breaker

PROTECTION AGAINST MECHANICAL HAZARDS
Refer to **clause 1.5.13** - Protection against injury from mechanical movement:
Protection shall be provided against injury from mechanical movement of electricallyactuated equipment, where -

- ☐____

□____

1.5.13 Protection against injury from mechanical movement
Protection shall be provided against injury from mechanical movement of electrically actuated equipment, where—

(a) mechanical maintenance may involve risk of physical injury; or
(b) emergency stopping may be necessary to remove any unexpected danger.

Protection may be provided by the provision of devices to disconnect or isolate electrical equipment, as may be necessary to prevent or remove danger

Electric motors shall be provided with suitable devices for –

Overload protection'
'

Name a possible cause of automatic motor restarting and reversal that must be protected against

Phase **reversal protection**

Refer to Section 1, Clause 1.6 of AS/NZS3000 and complete the following:
An electrical installation shall be designed to:
a)protect ___________, ___________ and ___________from harmful effects;

b)function _____________ as intended;

c)connect, __________ _________ and be _____________ with the electricitydistribution system, or other source of supply, to which the electricalinstallation is to be connected;

d)minimize ________________ in the event of a fault; and

e)facilitate __________ operation, inspection, testing and _________________.

1.6 DESIGN OF AN ELECTRICAL INSTALLATION
1.6.1 General
An electrical installation shall be designed to—
(a) protect persons, livestock and property from harmful effects;
(b) function correctly as intended;
(c) connect, operate safely and be compatible with the electricity distribution system, or other source of supply, to which the electrical installation is to be connected;
(d) facilitate safe operation, inspection, testing and maintenance; and
* (e) reduce inconvenience in the event of a fault.

The nominal voltage for supply in Australia is ______/ ______V, generated at _____
230V 50HZ

Generally the supply in Australia is A.C or D.C? ______________________
(b) The number of supply phases connected / permitted will depend on the maximum demand and load types. Phases permitted will generally be:
- Installations with a maximum demand less than 100A _________________
- Installations exceeding 100A or with 3 phase equipment _______________
(Note: 3 phase supply is not always available. The NSW Service and Installation Rules gives guidance on the number of phases permitted to be connected)

AC

Table 1.1: Allowable Number of Phases

Not exceeding 100 A	One phase and neutral
Exceeding 100A	Two or three phases and neutral
A motor exceeding 2.0 kW	Three phases and neutra

NSW Electrical Service Rules

One phase and neutral
Two or three phases and neutral

The nominal supply voltage in Australia is _______ / _______ volts
Not 240/415 Volts.

230V/50Hz

Voltage should not rise above: ______% (_______ / _______ V)
- Voltage should not fall below: ______% (_______ / _______ V)

(a) for Australia, 230/400 V + 10% to ·6% (in accordance with AS 60038); and
(b) for New Zealand, 230/400 V + 6% to ·6% (in accordance with IEC 60038).

The standard generated frequency in Australia is _________ Hz.

50HZ

The ________ earthing system is used for protection in Australia.
Neutral

Harmonic current or other limitations. Modern electronic equipment such as P.C's, inverters, electronic ballasts and variable speed drives cause harmonics. Harmonics can cause transformers and neutral conductors to ______________.

These **harmonic** loads have a significant **impact** on distribution **transformers**. The primary **effect** of **harmonic currents** are the additional power losses in **transformer** components, which result in increase in generated heat, as well as reduction of **transformer's** life-expectancy.

The 4 methods permitted to be used in the determination of maximum demand:

- ☐ ______________________________
- ☐ ______________________________
- ☐ ______________________________
- ☐ ______________________________

2.2.2 Maximum demand

The maximum demand in consumer mains, submains and final subcircuits, taking account of the physical distribution and intended usage of electrical equipment in the electrical installation and the manner in which the present requirements might vary, shall be determined using one of the methods set out in Items (a) to (d).

If the actual measured maximum demand is found to exceed that obtained by calculation or assessment, the measured value shall be deemed to be the maximum demand.

(a) Calculation The maximum demand may be calculated in accordance with the guidance given in this Standard for the appropriate type of electrical installation and electrical equipment supplied.

NOTE: Guidance on the determination of maximum demand is provided for basic electrical installations in Appendix C.

It is recognized that there may be considerable differences in loading from one electrical installation to another. Alternative methods of calculating the maximum demand may be used taking account of all the relevant information available for any particular electrical installation.

(b) Assessment The maximum demand may be assessed where—

(i) the electrical equipment operates under conditions of fluctuating or intermittent loading, or a definite duty cycle;

(ii) the electrical installation is large and complex; or

(iii) special types of occupancy exist.

(c) Measurement The maximum demand may be determined by the highest rate of consumption of electricity recorded or sustained over a period of 30 minutes when demand is at its highest by a maximum demand indicator or recorder.

(d) Limitation The maximum demand may be determined by the current rating of a fixed setting circuit-breaker, or by the load setting of an adjustable circuit-breaker.

The maximum demand of consumer mains and submains may be determined by the sum of the current settings of the circuit-breakers protecting the associated final subcircuit/s and any further submain/s.

If the actual measured maximum demand is found to exceed that obtained by calculation or assessment, which value should be used?
□___________________________
Measured value

17. VOLTAGE DROP CONSIDERATIONS
As discussed earlier in this section, the nominal supply voltage for Australian installations is ________ / ________ V with a tolerance of +10% and – 6%.
Therefore the voltage at the terminals of energy consuming equipment (load) should not fall below _________ V for single phase, or _________V for 3 phase.
Installations need to be designed so as the collective or total voltage drop across all parts of a circuit (mains, sub-mains and final sub-circuits) is not to high so as to limit the remaining voltage at the equipment terminals.
This percentage of voltage drop is spread across the whole installation, from the point of supply to the load. It is not applied separately to consumer's main, sub-main and final sub-circuit. See figure 15.

230V/50HZ

230-23= 217V or 400-40= 360V

In A.C. circuits, opposition to current flow occurs because of cable resistance and circuit reactance. This "total" opposition is known as _________________.
Impedance

Voltage drop in an AC circuit can be determined by $V_d = IZ$.
□ It can be seen by the equation that if I is increased, voltage drop will ____________.

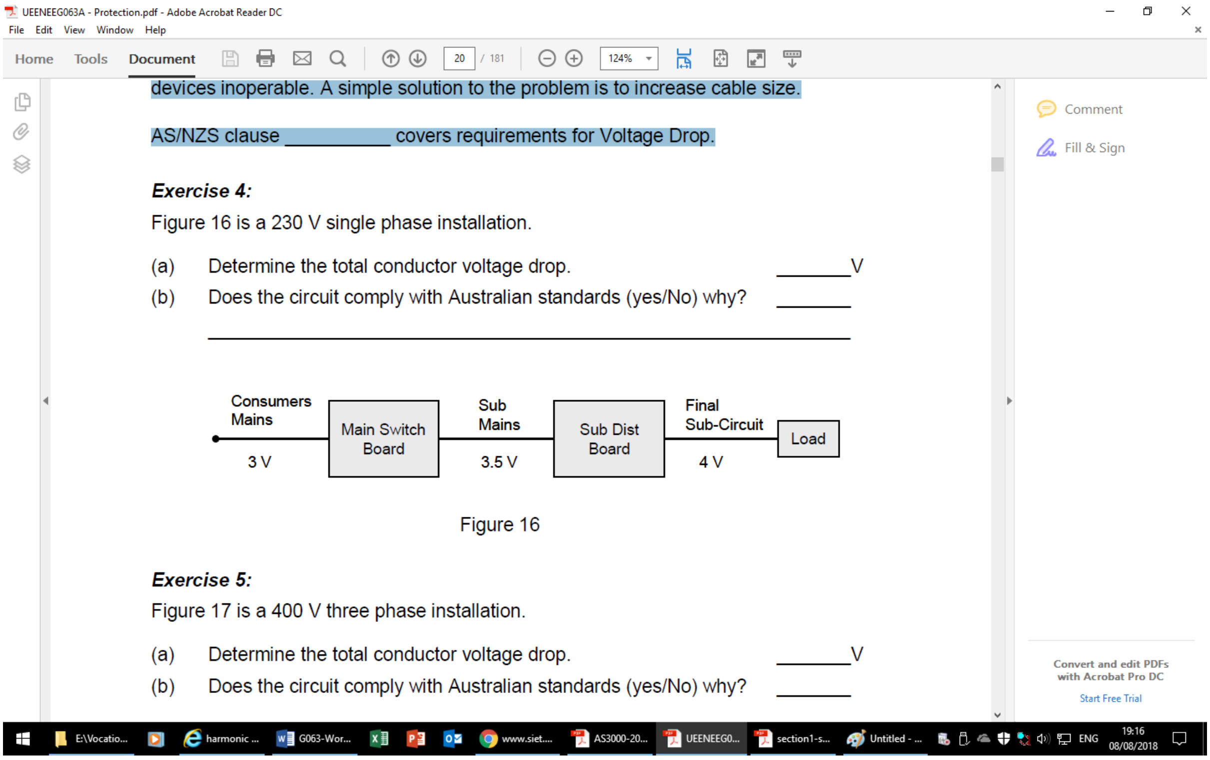
□ It can also be determined that if Z is increased, voltage drop will _____________.

As current is generally fixed by the impedance of the connected load, the resistance of the cable is all that can be altered. Long runs of cable anywhere in the installation will cause the voltage drop to increase toward the permissible amount.
Under-voltage can cause electric motors to overheat and fail and render some electronic devices inoperable. A simple solution to the problem is to increase cable size.
AS/NZS clause __________ covers requirements for Voltage Drop.

Increase/ increase

3.6.1 General
Under normal service conditions, the voltage at the terminals of any powerconsuming
electrical equipment shall be not less than the lower limit
specified in the relevant electrical equipment Standard.
Where the electrical equipment concerned is not covered by a Standard,
the voltage at the terminals shall be such as not to impair the safe
functioning of the electrical equipment.
3.6.2 Value
The cross-sectional area of every current-carrying conductor shall be

such that the voltage drop between the point of supply for the low voltage electrical installation and any point in that electrical installation does not exceed 5% of the nominal voltage at the point of supply.



devices inoperable. A simple solution to the problem is to increase cable size.

AS/NZS clause ___________ covers requirements for Voltage Drop.

Exercise 4:

Figure 16 is a 230 V single phase installation.

(a) Determine the total conductor voltage drop. _______V

(b) Does the circuit comply with Australian standards (yes/No) why? _______

Figure 16

Exercise 5:

Figure 17 is a 400 V three phase installation.

(a) Determine the total conductor voltage drop. _______V

(b) Does the circuit comply with Australian standards (yes/No) why? _______

Vt= 3+3.5+4 = 10.5V

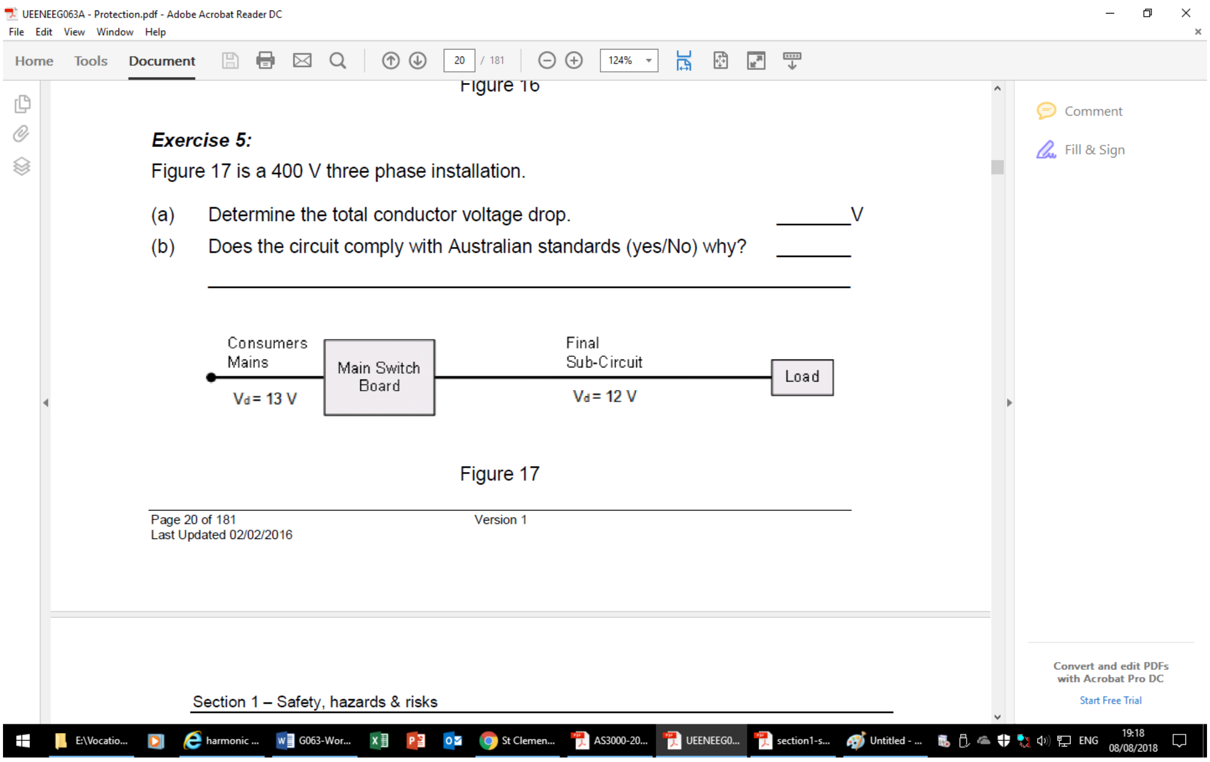


Figure 16

Exercise 5:

Figure 17 is a 400 V three phase installation.

(a) Determine the total conductor voltage drop. _______V

(b) Does the circuit comply with Australian standards (yes/No) why? _______

Figure 17

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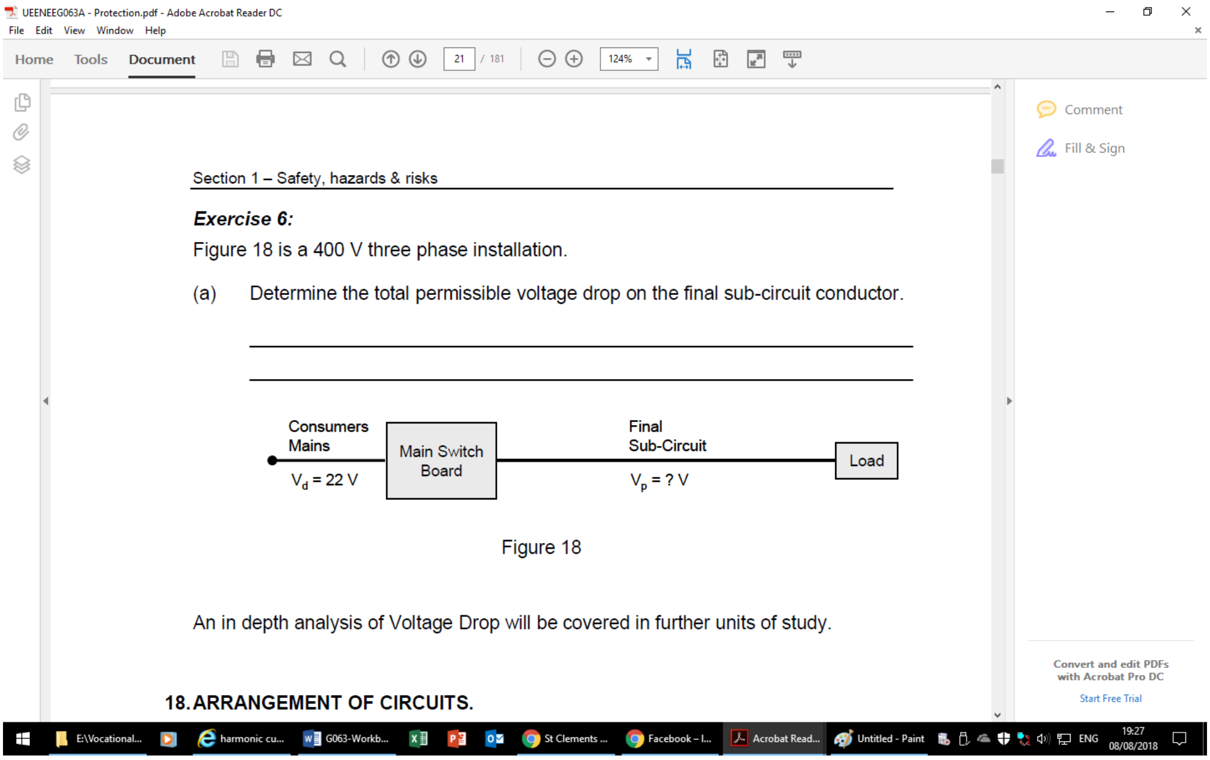
Section 1 – Safety, hazards & risks

Vt = 25 V

400v   5% = 20v   It is more than 5%

Not compliance



Section 1 – Safety, hazards & risks

Exercise 6:

Figure 18 is a 400 V three phase installation.

(a) Determine the total permissible voltage drop on the final sub-circuit conductor.

____

____

Figure 18

An in depth analysis of Voltage Drop will be covered in further units of study.

18. ARRANGEMENT OF CIRCUITS.

ARRANGEMENT OF CIRCUITS.

To satisfy the design requirements AS/NZS3000, it is necessary to split the installation into a number of circuits. It was noted earlier that reducing the current drawn by a circuit, we can also reduce the voltage drop across the circuit conductor(s). (V=IZ).

Refer to **clause 1.6.5** – Electrical Installation Circuit Arrangement

Arranging installations into circuits:

- ☐ provides minimised ___________________ in the event of a fault,

and facilitates;

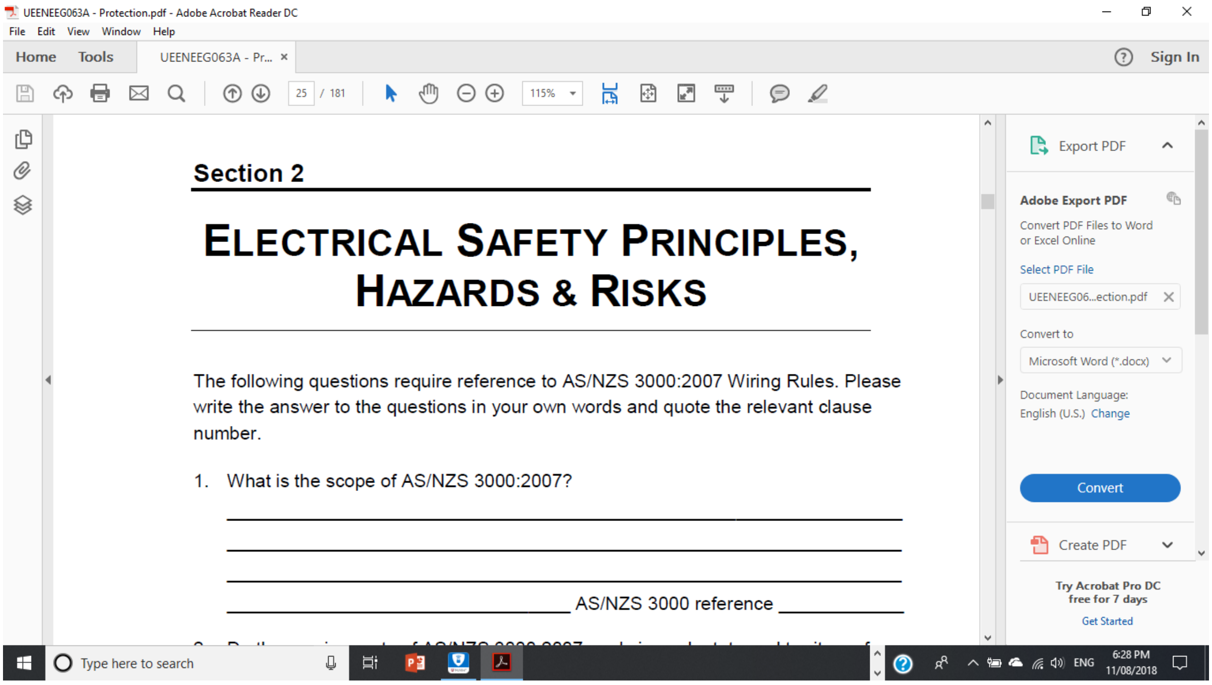
- ☐ ______________________________
- ☐ ______________________________
- ☐ ______________________________
- ☐ ______________________________

1.6.5 Electrical installation circuit arrangement

Every electrical installation shall be divided into circuits as necessary to—

(a) avoid danger and minimize inconvenience in the event of a fault; and

(b) facilitate safe operation, inspection, testing and maintenance.



Section 2

ELECTRICAL SAFETY PRINCIPLES, HAZARDS & RISKS

The following questions require reference to AS/NZS 3000:2007 Wiring Rules. Please write the answer to the questions in your own words and quote the relevant clause number.

1. What is the scope of AS/NZS 3000:2007?

____

____

____

______________ AS/NZS 3000 reference ______

1.What is the scope of AS/NZS 3000:2007?

1.1 SCOPE

This Standard sets out requirements for the design, construction and verification of electrical installations, including the selection and installation of electrical equipment forming part of such electrical installations.

These requirements are intended to protect persons, livestock, and property from electric shock, fire and physical injury hazards that may arise from an electrical installation that is used with reasonable care and with due regard to the intended purpose of the electrical installation.

2.Do the requirements of AS/NZS 3000:2007 apply in each state and territory of Australia?

1.2 APPLICATION

This Standard may be applied through legislative requirements, made in each state and territory of Australia and in New Zealand, concerned with the safety of electrical installations. The Standard may also be applied in conjunction with any additional requirements, exemptions or restrictions in such legislation.

The principal application of this Standard is to electrical installations in all

types of premises and land used by electricity consumers. However, the Standard may also be referenced or applied through legislative or other

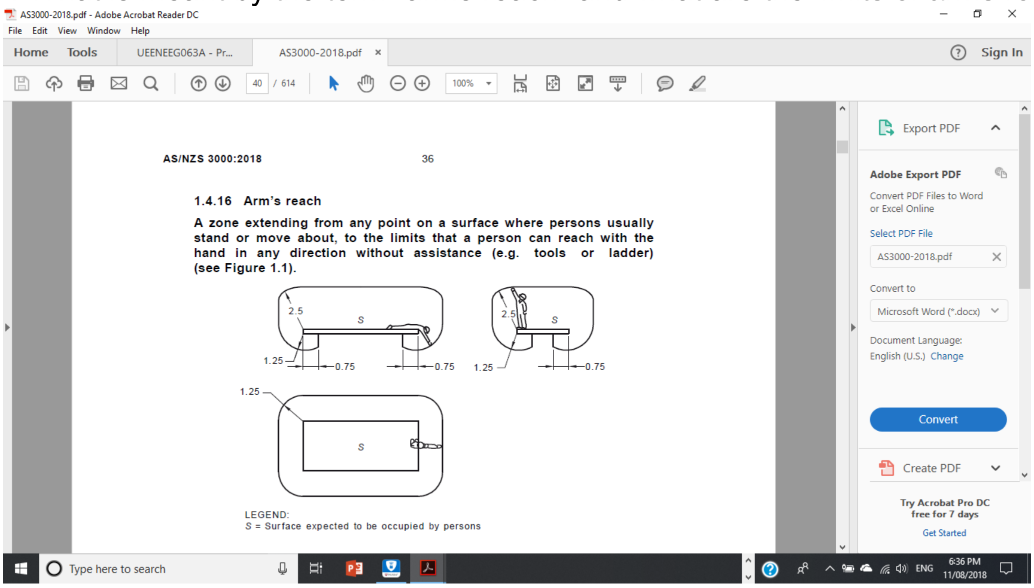
requirements relating to the effect of electrical installations in matters such
as the following:
(a) Safety of workplaces.
NOTE: For example, any relevant work health and safety legislation and associated codes.
(b) Safe design and construction of buildings.
NOTE: For example, national building codes [such as the National Construction Code (NCC), New Zealand Building Code (NZBC)] and the associated referenced Standards. See Appendix E for information on NCC and NZBC.
(c) Electricity generation, transmission and distribution systems.
(d) Safe connection to electricity distribution systems.
NOTE: For example, service rules and conditions provided by local electricity distributors.
(e) Qualifications of electricity workers.

3.What is meant by the term “readily accessible”?

1.4.3 Accessible, readily

* Capable of being reached quickly and without climbing over or removing obstructions, or using a movable ladder, and in any case not more than 2.0 m above the ground, floor or platform.

4.What is meant by the term “arms reach” and what are the limits of arms reach?



5.What level of insulation applies to Class I equipment?

1.4.31 Class I equipment

Equipment in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in that accessible conductive parts are connected to the protective earthing conductor in the electrical installation in such a way that accessible parts cannot become live in the event of a failure of the basic insulation.

NOTES:

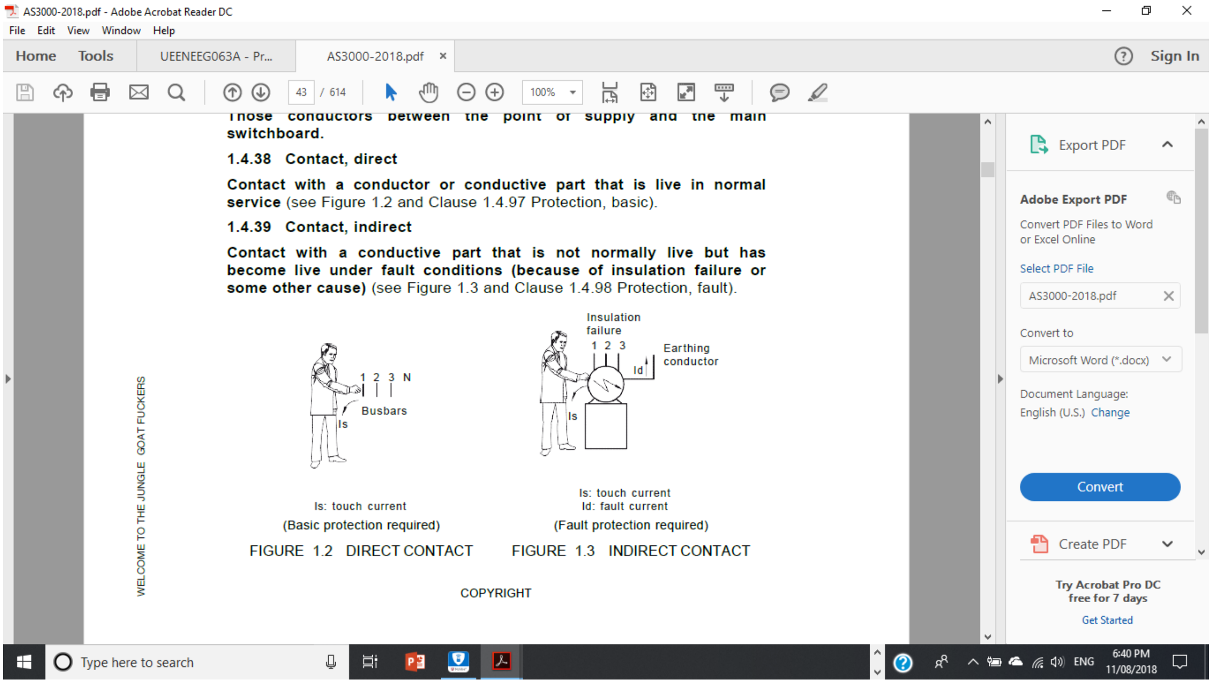
1 Class I equipment may have parts with double insulation or parts operating at SELV.

2 For equipment intended for use with a flexible cord or cable, this provision includes a protective earthing conductor as part of the flexible cord or cable

6.What is direct contact?

1.4.38 Contact, direct

Contact with a conductor or conductive part that is live in normal service (see Figure 1.2 and Clause 1.4.97 Protection, basic).


Those conductors between the point of supply and the main switchboard.

1.4.38 Contact, direct

Contact with a conductor or conductive part that is live in normal service (see Figure 1.2 and Clause 1.4.97 Protection, basic).

1.4.39 Contact, indirect

Contact with a conductive part that is not normally live but has become live under fault conditions (because of insulation failure or some other cause) (see Figure 1.3 and Clause 1.4.98 Protection, fault).

FIGURE 1.2 DIRECT CONTACT

FIGURE 1.3 INDIRECT CONTACT

7.A person receives an electric shock from the metal frame of an electric motor.According to AS/NZS 3000:2007, what is the name given to this type of contact?

1.4.39 Contact, indirect

Contact with a conductive part that is not normally live but has become live under fault conditions (because of insulation failure or some other cause)

8.A circuit does not have an electrical fault, but draws excessive current. What is thename given to this current?

1.4.42 Current, overload

An overcurrent occurring in a circuit that is electrically sound.

9.What is the definition of an obstacle?
1.4.87 Obstacle
A part preventing unintentional direct contact, but not preventing direct contact by deliberate action.

10.Describe the meaning of the term “touch voltage”.
1.4.125 Touch voltage
Voltage appearing between simultaneously accessible parts.
NOTES:
1 This term is used only in connection with fault protection.
2 In certain cases the value of the touch voltage may be appreciably influenced by the impedance of the person or livestock in contact with these parts.

11.What is meant by the term “touch current”?
1.4.124 Touch current
Electric current that passes through a human body, or an animal body, when that body touches one or more accessible parts of electrical equipment or an electrical installation, under normal conditions or fault conditions.

12.List the three major types of risk in an electrical installation as identified byAS/NZS 3000:2007.
1.5 FUNDAMENTAL PRINCIPLES
1.5.1 Protection against dangers and damage
The requirements of this Standard are intended to ensure the safety of persons, livestock, and property against dangers and damage that may arise in the reasonable use of electrical installations.
In electrical installations, the three major types of risk are listed below, along with applicable requirements:
(a) Shock current Shock current arising from contact with parts that are live in normal service (direct contact) and contact with parts that become live under fault conditions (indirect contact).
NOTES:
1 A ‘shock current’ is an electric current of sufficient magnitude and duration to cause an electric shock. AS/NZS 60479 provides further information on the effects of shock current through the human body.
2 Protection under normal conditions, designated as ‘basic protection’ (direct contact) is defined in Clause 1.4.97.
3 Protection under fault conditions, designated as ‘fault protection’ (indirect contact) is defined in Clause 1.4.98.
(b) Excessive temperatures Excessive temperatures likely to cause burns, fires and other damaging effects.
Persons, fixed equipment, and fixed materials adjacent to electrical

equipment shall be protected against harmful effects of heat developed by electrical equipment, or thermal radiation, particularly the following effects:
(i) Combustion or degradation of materials.
(ii) Risk of burns.
(iii) Impairment of the safe function of installed equipment.
(c) Explosive atmospheres Equipment installed in areas where explosive gases or dusts may be present shall provide protection against the ignition of such gases or dusts.

13.If a “touch voltage” exceeds certain values a protective device must disconnectthe supply. What are the limits of “touch voltage”?

1.5.5.3 Protection by automatic disconnection of supply
The following applies:
(a) Automatic disconnection of supply is intended to limit the prospective touch voltage arising between simultaneously accessible conductive parts in the event of a fault between a live part and exposed conductive parts or a protective earthing conductor.
This method of protection shall be achieved by—
(i) provision of a system of equipotential bonding in which exposed conductive parts are connected to a protective earthing conductor; and
(ii) disconnection of the fault by a protective device.
NOTES:
1 Automatic disconnection of supply may also be required for protection against overcurrents, in accordance with Clause 1.5.9 and Clause 2.5.
2 Clause 5.6 contains requirements for equipotential bonding.
3 Section 2 contains requirements for the disconnection of a fault by a protective device.
(b) Touch-voltage limits In the event of a fault between a live part and an exposed conductive part that could give rise to a prospective touch voltage exceeding 50 V a.c. or 120 V ripple-free d.c., a protective device shall automatically disconnect the supply to the circuit or electrical equipment concerned.
NOTE: Lower touch-voltage limits are required for special electrical installations or locations by the relevant clauses of Sections 6 and 7.

14.When protection against indirect contact is provided by automatic disconnection of the supply, what is the maximum disconnection time for –

a)a power circuit with a rating of less than 63A

b)equipment that has only single insulation

c)an electric range

d)a submain

1.5.5.3 Protection by automatic disconnection of supply
(d) Disconnection times The maximum disconnection time for 230/400 V supply voltage shall not exceed the following:
(i) 0.4 s for final subcircuits that supply—
(A) socket-outlets having rated currents not exceeding 63 A;
WELCOME
(B) hand-held Class I equipment; or
(C) portable equipment intended for manual movement during use.
(ii) 5 s for other circuits including submains and final subcircuits supplying fixed or stationary equipment.
NOTE: Maximum disconnection times will vary for other voltages and installation conditions. Appendix B provides further guidance regarding disconnection times.

15.Using the time-current curves of figure 1, for a duration of 500mS, what zoneswould result for a body current of –

a)20mA-----------------2

b)200mA------------------3 c2

(a)____

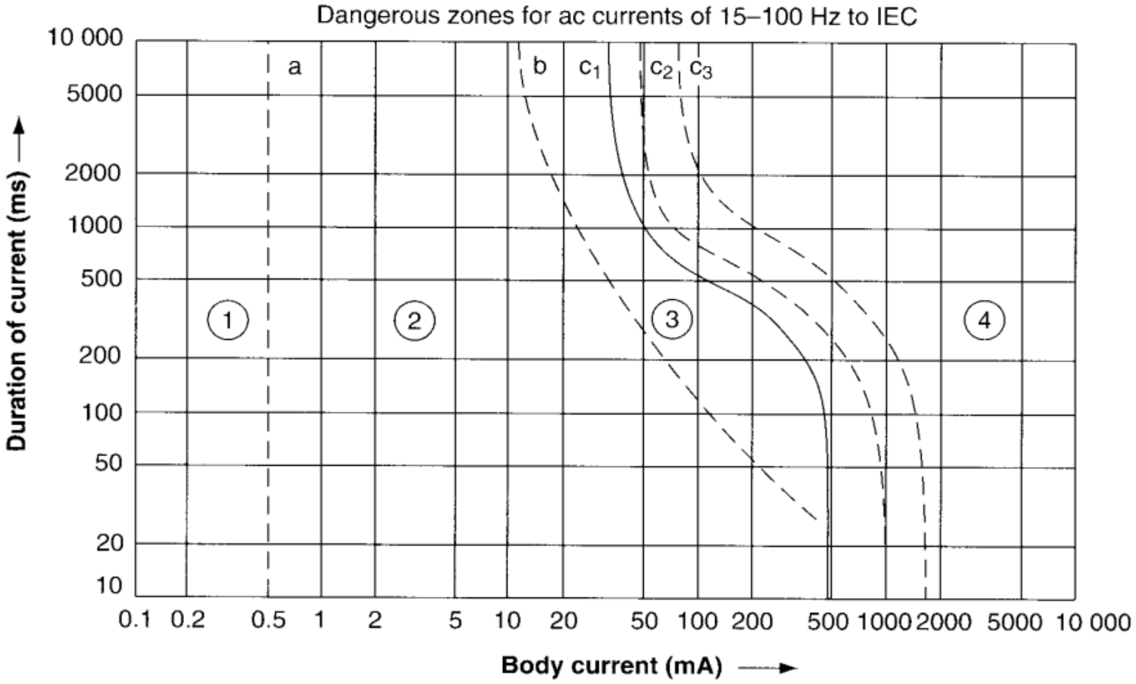
(b)____

16.Using the time-current curves of figure 1, for a body current of 20mA, identify thezone and the physiological effect that would result for the following time periods –

a)20mS---------2

b)200mS------2

c)2,000mS----3b



To satisfy the design requirements and Clause 1.6 of AS/NZS3000, it is necessary to split the installation into a number of circuits.
Circuits can be classified into 3 broad groups:

□_____________________________ - used to connect the entire installation to the street supply at only one point for ease of isolation.

□_____________________________ - used to connect between switchboards;no load is connected directly to this cable.

□_____________________________ - used to connect the load to the main switch board or distribution / sub-board.

Consumer main/ Submain / Final sub circuit

Refer to Section 1, Clause 1.6.5 of AS/NZS3000 and complete the following:
Every electrical installation shall be divided into circuits as necessary to avoid ____________ and minimize ________________ in the event of a fault.
Furthermore, installations are divided into circuits to:

□ facilitate ___safe operation_____

□ allow full and thorough _______inspection_____ and ____testing________

□ allow for ongoing repair and _______maintenance.__________.

1.6.5 Electrical installation circuit arrangement
Every electrical installation shall be divided into circuits as necessary to—
(a) avoid danger and minimize inconvenience in the event of a fault; and
(b) facilitate safe operation, inspection, testing and maintenance.

Exercise 1:
Read Clause 2.2.1.1 and discuss the above list as a class group. Can you determine 2 more examples of what else may need to be considered when designing an installation and separating circuits.

2.2.1.1 General
The electrical installation shall be arranged into an appropriate number of separate circuits taking the following into account:
(a) The relationship of the equipment, including any requirement for operation as a group and any special need identified by the user.
(b) The load and operating characteristics of the equipment in relation to the rating of the circuit components.
(c) The limitation of consequences of circuit failure including loss of supply to critical equipment, overload and the ability to locate a fault.
(d) The facility for maintenance work, and capacity for alterations and additions, to be performed without interrupting supply to other parts of the installation.

* NOTE: Specific design and equipment may need to be considered to ensure the

continuity of supply. For further guidance, refer to Appendix M.
Circuits for safety services shall be separate from those used to supply the remainder of the electrical installation, as required by Clause 7.2.2.

NOTES:

1 The most common distribution arrangement for a low voltage electrical installation is radial branched distribution, an example of which is shown in Figure B1 (Appendix B).

2 Division of circuits falls logically into several categories, each an individual circuit or group of circuits. Typically, the circuit groups selected are as follows:

(a) Lighting.
(b) Socket-outlets.
(c) Heating and/or airconditioning appliances.
(d) Motor-driven plant.
(e) Auxiliary services, such as indication and control.
(f) Safety services.

3 Appendix C provides guidance on circuit arrangements for basic applications.

Exercise 2:

List 6 Load groups that are typically divided into separate final sub-circuits:

□______________________________

□______________________________

□______________________________

□______________________________

□______________________________

□______________________________

(a) Lighting.
(b) Socket-outlets.
(c) Heating and/or airconditioning appliances.
(d) Motor-driven plant.
(e) Auxiliary services, such as indication and control.
(f) Safety services.

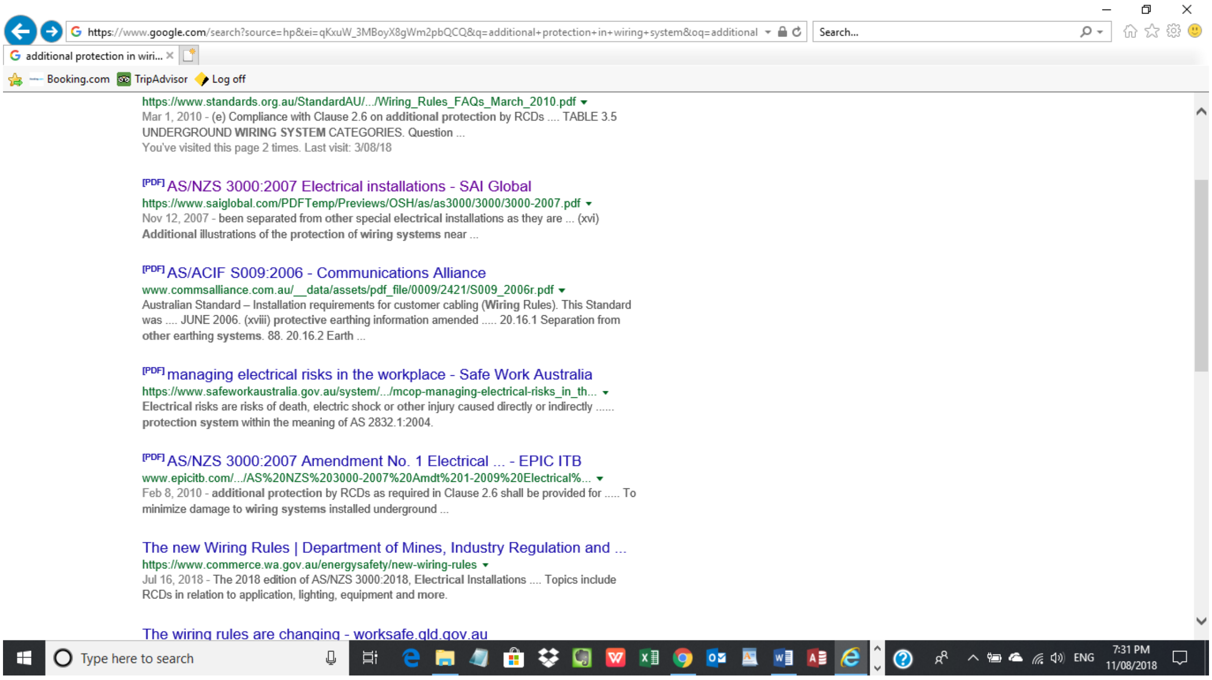
Exercise 3:

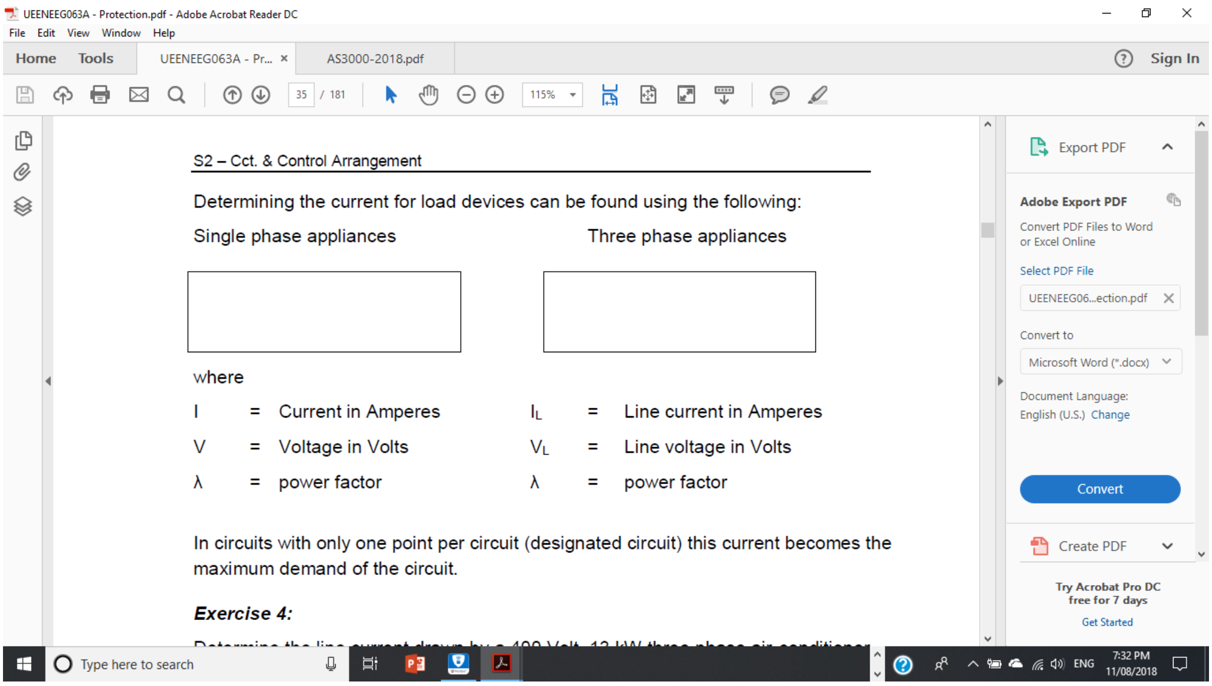
Which Appendix in AS/NZS3000 can be referred to seek recommended circuit arrangements for basic installations?

□Appendix ______. Table 1 in this appendix indicates different load groups

Appendix C

Once the load is appropriately separated into circuits a suitable circuit protection device and cable can be selected for each circuit. The protection device which is typically a circuit breaker or HRC fuse is selected to allow supply the load and to protect the circuit conductors. For some circuits, the 'additional' protection of a ___________ ____________ ____________ will also be required. RCD





$P = VI\ Cos\lambda$ $P = \sqrt{3}\ VI\ Cos\lambda$

Exercise 4:

Determine the line current drawn by a 400 Volt, 13 kW three phase air-conditioner operating at a rated power factor of 0.95.

V = ……………… ____

P = ……………… ____

λ = ……………… ____

I = ? ____

____

13000 = 400 I x 0.95

$$I = \frac{13000}{400 \times 0.95} = \quad A$$

Exercise 5:

Determine the current drawn by a 230 Volt, 6 kW electric cooktop (resistive load)

V = ……..……… ____

P = ……………… ____

λ = ..……………. ____

I = ? ____

____

$$I = \frac{6000}{230 \times 1} = \quad A$$

Exercise 6:

Refer to Appendix C – Circuit Arrangements

Read the following and complete the exercise below.

- Clause 5.1
- Clause 5.2
- Table C8
- footnotes to Table C8

C5 NUMBER OF POINTS CONNECTED TO CIRCUITS

C5.1 Number of circuits

Each item of equipment that has a current rating in excess of 20 A per phase should be connected to a separate and distinct circuit.

Where more than one item of equipment is to be connected to a circuit, consideration needs to be given to—

(a) the number, distribution and type of equipment (lighting, socket-outlets or appliances, etc.), i.e. points, that are to be supplied in combination;

(b) the operating characteristics of the different items of equipment, including seasonal or daily variations;

(c) the circuit current under expected operating conditions and the coordination with cable and protective device ratings to minimize the risk of an overload fault; and

(d) the effects of an overload fault on the circuit, including loss of supply to equipment that performs a special function, e.g. security, emergency, medical or critical information and telecommunications purposes.

Paragraph C5.2, together with Table C9, provides a method that has been used over several editions of this Standard and, provided that care is taken to assess the presence of unusual equipment loads, is considered appropriate for many typical applications.

C5.2 Final subcircuits

Guidance on the determination of the number of socket-outlets, lighting and appliances, i.e. points that may be connected to a final subcircuit, is given in Table C9.

TABLE C9

GUIDANCE ON THE LOADING OF POINTS PER FINAL SUBCIRCUIT

Cable cross-sectional area[1]	Rating of circuit-breaker[1]	Contribution of each point (A) (sum not to exceed rating of circuit-breaker)						Maximum connected load for a range[4, 5]
		Lighting points[6]	10 A single-phase or multiphase socket-outlets[3, 7, 8, 9]		15 A single-phase or multi-phase socket-outlets[8, 9]	20 A single-phase or multi-phase socket-outlets[8, 9]	Permanently connected fixed or stationary appliances[6, 10] or water heaters	
			Non-domestic installations without permanent airconditioning	All domestic installations and non-domestic installations with permanent airconditioning				
mm²	A							W
1	6	0.5	NP	NP	NP	NP	Connected load	NP
1	8	0.5	NP	NP	NP	NP		NP
1	10	0.5	NP	NP	NP	NP		NP
1	13	0.5	NP	NP	NP	NP		NP
1	16	0.5	NP	NP	NP	NP		NP
1.5	8	0.5	NP	NP	NP	NP		NP
1.5	10	0.5	NP	NP	NP	NP		NP
1.5	13	0.5	NP	NP	NP	NP		NP
1.5	16	0.5	NP	NP	NP	NP		5000
1.5	20	0.5	NP	NP	NP	NP		5000
2.5	10	0.5	NP	NP	NP	NP		NP
2.5	13	0.5	2	1	NP	NP		NP
2.5	16	0.5	2	1	15	NP		5000
2.5	20	0.5	2	1	12	20		8000
2.5	25	0.5	2	1	10	18		8000

(continued)

A **Domestic Home** is wired using T.P.S. cable and has the following load items installed:

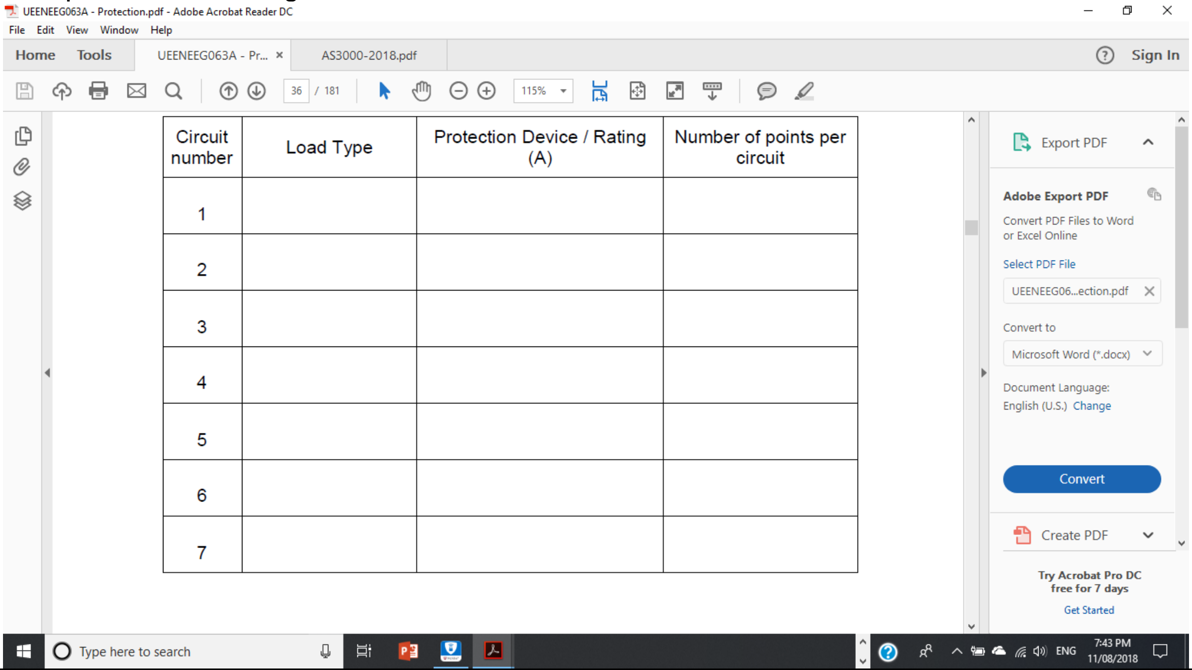
□36 lights (10A C.B.)

□24 Double 10A Socket Outlets (20A C.B.)

□1 25A Single Phase Air-conditioner (25A C.B.)

□1 3.6 kW Hot Water System (16A C.B.)

Complete the following table:



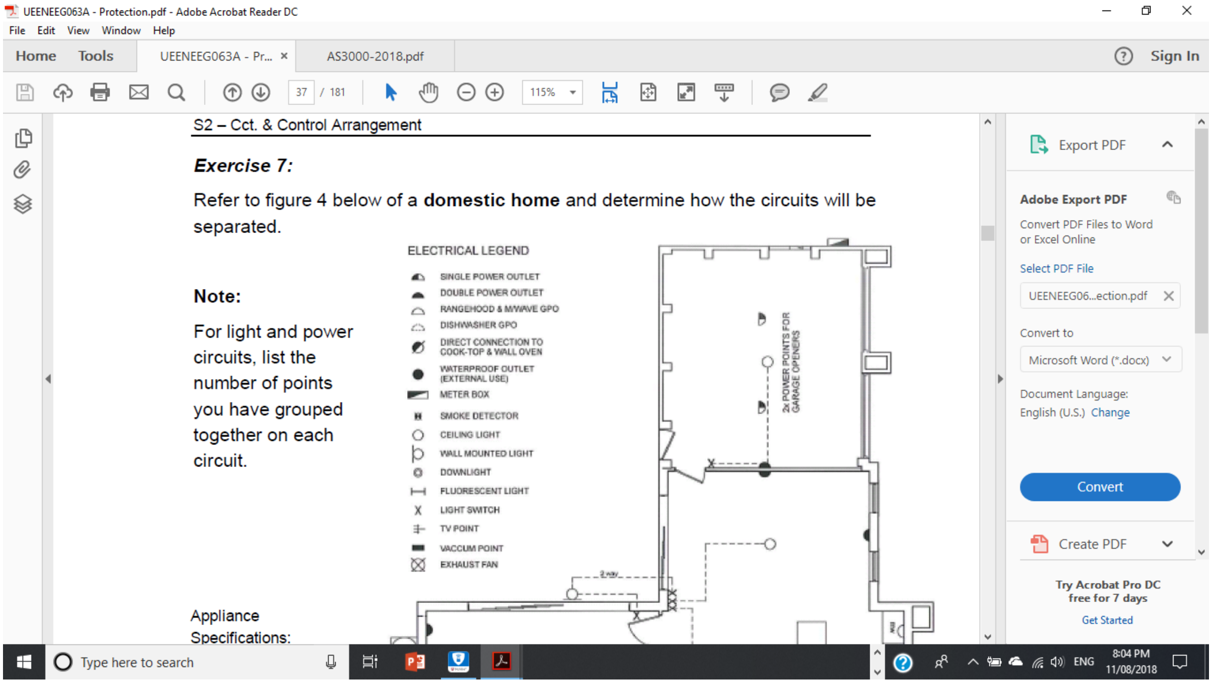
Circuit number	Load Type	Protection Device / Rating (A)	Number of points per circuit
1			
2			
3			
4			
5			
6			
7			

Circuit Number	Load Type	Protective device rating (A)	Number of points per circuit
	36 lights (10A C.B.)= 36 x 0.5A/Pt= 18A Divide 2 Circuit each 18 pt and current 9A		
1 A	18 lights	10A	18
1B	18 lights	10A	18
	24 Double 10A Socket Outlets (20A C.B.)		
	24x2=48 Pt 2A per point Total z x 48 = 96 A 5 Double 10A socket/ circuit		
2	5 Double 10A socket/ circuit	20A	5
3	5 Double 10A socket/ circuit	20A	5
4	5 Double 10A socket/ circuit	20A	5
5	5 Double 10A socket/ circuit	20A	5
6	4 Double 10A socket/ circuit	20A	4
7	1 x25A Single Phase Air-conditioner (25A C.B.)	25A	1
8	1 x3.6 kW Hot Water System (16A C.B.)	16A	1

Lighting points A luminaire is deemed to comprise one or more lighting points, according to the number of points at which it is connected by flexible cords to the installation wiring, or according to the number of sections in which it is switched or controlled. Connections of festoon lighting and decorative lighting are not regarded as lighting points. See Table C1 for track systems and ELV lighting.

A socket-outlet installed more than 2.3 m above a floor for the connection of a luminaire may be included as a lighting point.

An appliance rated at not more than 150 W, which is permanently connected, or connected by means of a socket-outlet installed more than 2.3 m above a floor, may be included as a lighting point.



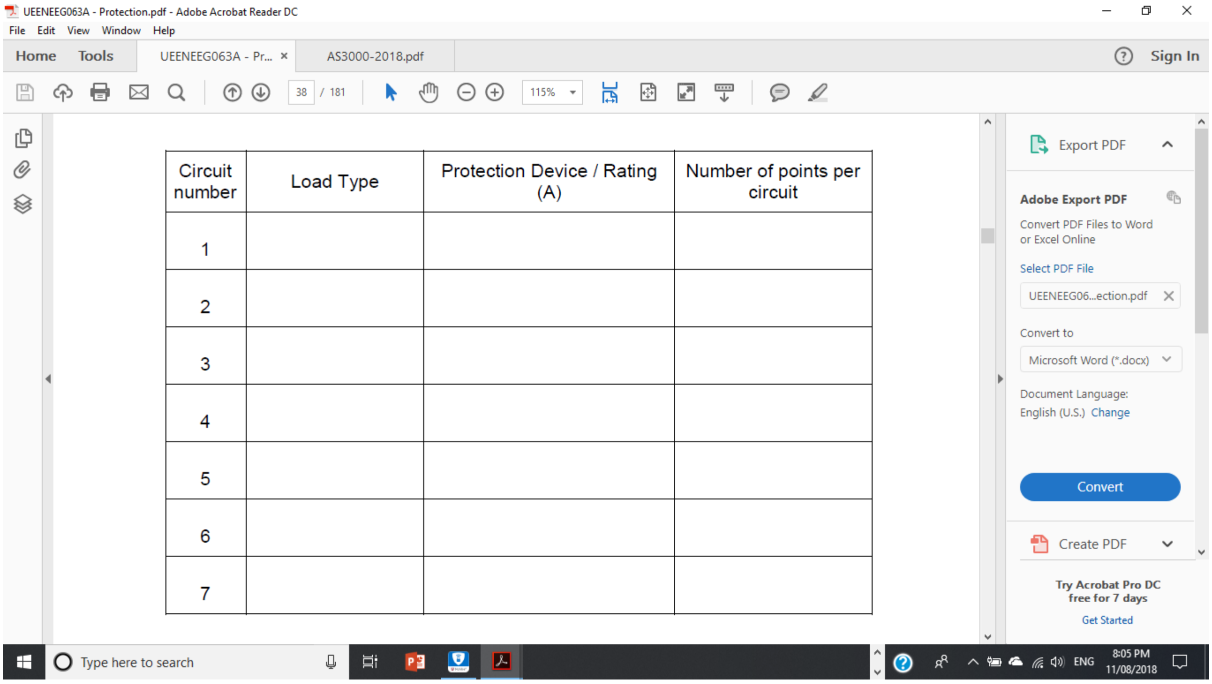
Project Assignment

Exercise 8:

A **Commercial Office** is wired using T.P.S. cable and has the following load items installed:

- 43 lights (20A C.B.)
- 23 10A Socket Outlets (20A C.B.)

Complete the following table



Circuit number	Load Type	Protection Device / Rating (A)	Number of points per circuit
1			
2			
3			
4			
5			
6			
7			

Do it yourself

CIRCUIT SCHEDULES

Circuit schedules are used to detail which protection device controls which circuit. Domestic homes usually do not require schedules due to the small number of circuits installed and simply label the switchboard or distribution directly.

In industrial or commercial installations, the number of circuits is increased and schedules are required.

An example is shown in figure 5.

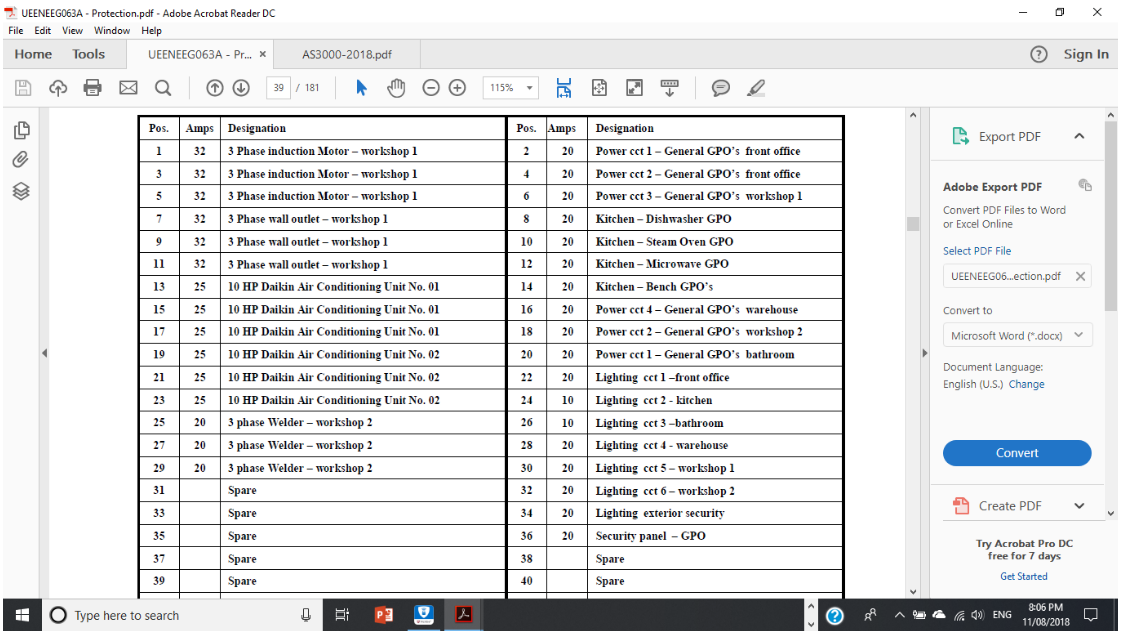
Installation By: Sparky

Phone: 0414 123 456

Sub Board No.: DB1-G1

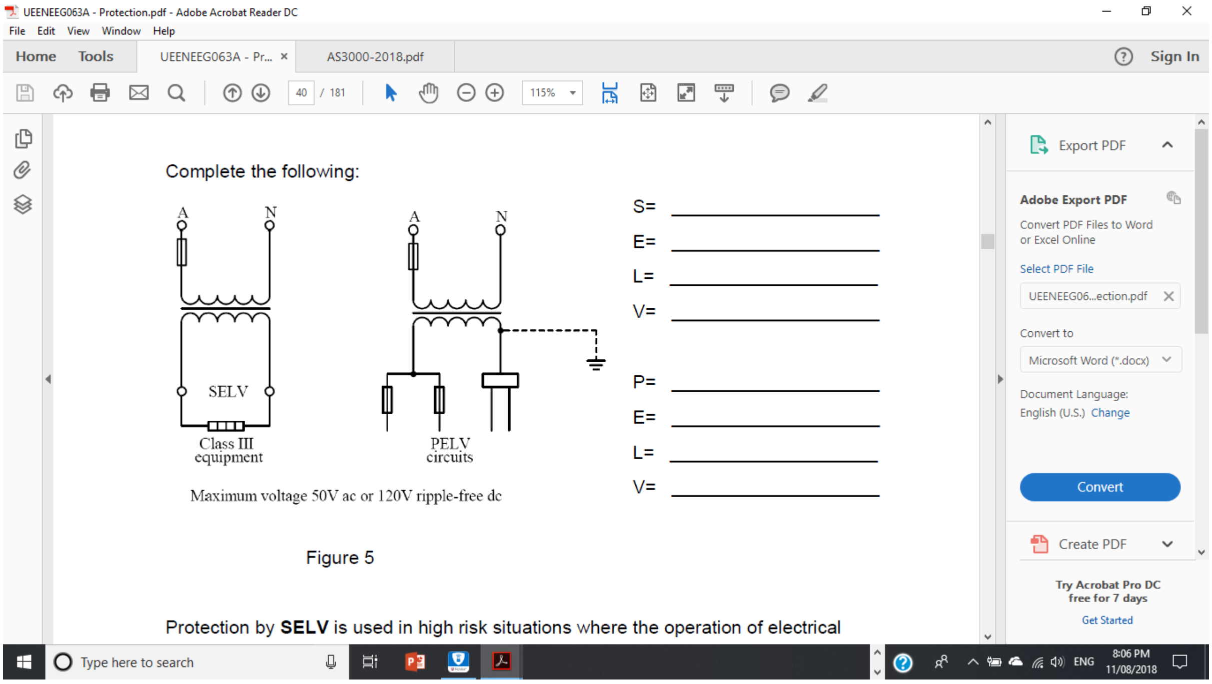
Fed From: Main Switchboard C.B.10

Cable Size: 25mm 4core XLPE + E



Pos.	Amps	Designation	Pos.	Amps	Designation
1	32	3 Phase induction Motor – workshop 1	2	20	Power cct 1 – General GPO's front office
3	32	3 Phase induction Motor – workshop 1	4	20	Power cct 2 – General GPO's front office
5	32	3 Phase induction Motor – workshop 1	6	20	Power cct 3 – General GPO's workshop 1
7	32	3 Phase wall outlet – workshop 1	8	20	Kitchen – Dishwasher GPO
9	32	3 Phase wall outlet – workshop 1	10	20	Kitchen – Steam Oven GPO
11	32	3 Phase wall outlet – workshop 1	12	20	Kitchen – Microwave GPO
13	25	10 HP Daikin Air Conditioning Unit No. 01	14	20	Kitchen – Bench GPO's
15	25	10 HP Daikin Air Conditioning Unit No. 01	16	20	Power cct 4 – General GPO's warehouse
17	25	10 HP Daikin Air Conditioning Unit No. 01	18	20	Power cct 2 – General GPO's workshop 2
19	25	10 HP Daikin Air Conditioning Unit No. 02	20	20	Power cct 1 – General GPO's bathroom
21	25	10 HP Daikin Air Conditioning Unit No. 02	22	20	Lighting cct 1 –front office
23	25	10 HP Daikin Air Conditioning Unit No. 02	24	10	Lighting cct 2 - kitchen
25	20	3 phase Welder – workshop 2	26	10	Lighting cct 3 –bathroom
27	20	3 phase Welder – workshop 2	28	20	Lighting cct 4 - warehouse
29	20	3 phase Welder – workshop 2	30	20	Lighting cct 5 – workshop 1
31		Spare	32	20	Lighting cct 6 – workshop 2
33		Spare	34	20	Lighting exterior security
35		Spare	36	20	Security panel – GPO
37		Spare	38		Spare
39		Spare	40		Spare

Study



1.5.7 Basic and fault protection by use of extra-low voltage

Separated extra-low voltage (SELV) or protected extra-low voltage (PELV)

Refer to Clause 1.5.7

Separated extra-low voltage (SELV) or protected extra-low voltage (PELV) systems may be used to provide both basic and fault protection subject to the following:

a)The nominal voltage shall not be capable of exceeding the limits for ________________ ___________ (50 V a.c. or 120 V ripple-free d.c.) and the source of supplyis arranged so that it cannot exceed these values.

b)Circuits shall be electrically ___________ from each other and from circuits at___________ voltages.

c)Live parts of SELV circuits shall not be connected to __________ or to protectiveearthing conductors that are part of other circuits or to other live parts.

d)Live parts of PELV circuits shall be protected from direct contact by ___________or ______________ unless the voltage does not exceed 25 V a.c. or 60 V ripple-free d.c. in dry areas where a large contact area with the human body is notexpected or 6 V a.c. or 15 V ripple-free d.c. in all other areas.

1.5.7 Basic and fault protection by use of extra-low voltage

Separated extra-low voltage (SELV) or protected extra-low voltage (PELV) systems may be used to provide both basic and fault protection subject to the following conditions:

(a) The nominal voltage shall not be capable of exceeding the limits for extra-low voltage (50 V a.c. or 120 V ripple-free d.c.) and the source of supply is arranged so that it cannot exceed these values.

(b) Circuits shall be electrically segregated from each other and from circuits at higher voltages.

(c) Live parts of SELV circuits shall not be connected to earth or to protective earthing conductors that are part of other circuits or to other live parts.

(d) Live parts of PELV circuits shall be protected from direct contact by barriers or insulation unless the voltage does not exceed 25 V a.c. or 60 V ripple-free d.c. in dry areas where a large contact area with the human body is not expected or 6 V a.c. or 15 V ripple-free d.c. in all other areas.

Refer to Section 7: clause ___________ Sources of supply by SELV and PELV
The source supplying an SELV or a PELV system shall be one of the following:
(a) A __________________________________ complying with AS/NZS 61558.
(b) A source of current independent of a higher voltage supply, such as an engine-driven __________, or an electrochemical source, such as a ________.
(c) A source of current separated from higher voltage electrical installations, such as a motor-generator set, with electrically separate windings having a degree of electrical separation equivalent to that required by Item (a).
(d) Certain electronic devices complying with appropriate Standards.

7.5.3 Sources of supply to SELV and PELV systems
The source supplying a SELV or PELV system shall be one of the following:
(a) A safety isolating transformer complying with AS/NZS 61558.
(b) A source of current independent of a higher voltage supply, such as an engine-driven generator, or an electrochemical source, such as a battery.
(c) A source of current separated from higher voltage electrical installations, such as a motor-generator set, with electrically separate windings having a degree of electrical separation equivalent to that specified by Item (a).
(d) Certain electronic devices complying with appropriate Standards, where, in the case of an internal fault, the voltage at the output terminals cannot exceed extra-low voltage. Higher voltages at the output terminals may be used, provided that the voltage at the output terminals is immediately reduced to extra-low voltage if contact is made with live parts under normal or fault conditions.
NOTE: Such devices include insulation testing equipment.

Refer to Section 7: clause ____________ Arrangement of **SELV** circuits
Live parts of SELV circuits shall not be connected to earth or protective earthing conductors that are part of other circuits or to other live parts.
Class III equipment (clause 1.4.29) may only be connected to and supplied by a SELV system that will not supply circuit equipment any higher than ELV (max. 50V ac or 120V ripple free dc)
SELV circuits shall not be connected to—

- _________________________
- _________________________
- ____
- ____

7.5.5 Arrangement of SELV circuits
Live parts of SELV circuits shall not be connected to earth or protective earthing conductors that are part of other circuits or to other live parts.

SELV circuits shall not be connected to—
(a) other circuits;
(b) earth;
(c) earthing conductors or exposed conductive parts of another system; or
(d) extraneous conductive parts.
Exception: Connection to extraneous conductive parts may be made where electrical equipment is inherently required to be so connected and it is ensured that the extraneous conductive parts cannot attain a voltage exceeding that of the SELV circuit.

Refer to Section 7: **clause** ____________ Arrangement of **PELV** circuits
The following applies for PELV circuits, where one conductor of the output circuit is earthed.
Basic protection shall be provided by—
(a) __________ or _____________ affording the degree of protection at least IPXXB or IP2X
(b) insulation capable of withstanding a test voltage of 500 V a.c. for 1min.
Note: There are exceptions to this clause.

7.5.6 Arrangement of PELV circuits
The following applies for PELV circuits, where one conductor of the output circuit is earthed.
Basic protection shall be provided by—
(a) barriers or enclosures affording a degree of protection of at least IPXXB or IP2X; or
(b) insulation capable of withstanding a test voltage of 500 V a.c. for 1 min.
Exception: Basic protection shall be deemed unnecessary if electrical equipment is within the zone of influence of equipotential bonding and the nominal voltage does not exceed—
1 25 V a.c. or 60 V ripple-free d.c., when electrical equipment is normally used in a dry location only and large-area contact with the human body is not to be expected; or
2 6 V a.c. or 15 V ripple-free d.c., in all other cases.

Refer to the following clauses and complete exercise 9:
- Clause 7.5.7 to 7.5.11

Exercise 9

- Voltage drop at any point in an extra-low voltage electrical installation shall not exceed ________% of the nominal value at I_{FL} unless the equipment is designed for such operation.

- The supply to an extra-low voltage electrical installation shall be controlled by a ________ ___________ or switches operating in all unearthed conductors, unless it is fed from a LV supply where a main switch will disconnect supply.

- Every extra-low voltage circuit shall be individually protected at its origin against overload and short-circuit currents by a protective device that complies with clauses _______ and _______ .

□List the 3 requirements that plug and socket-outlet devices, including installation couplers, need to comply to when used for SELV and PELV circuits:

a)____

b)____

c)____

□Conductors and insulation of cables used for extra-low voltage electrical installations shall be _____________ for the intended purpose.

7.5.7 Voltage drop in conductors

The drop in voltage at any point in an extra-low voltage electrical installation shall not exceed 10% of the nominal value when all live conductors are carrying the circuit-operating current.

7.5.8 Control of an electrical installation

7.5.8.1 Main switches

The supply to an extra-low voltage electrical installation shall be controlled by a main switch or switches operating in all unearthed conductors.

7.5.9 Overcurrent protection

7.5.9.1 General

Every extra-low voltage circuit shall be individually protected at its origin against overload and short-circuit currents by a protective device that—

(a) shall comply with the applicable requirements of Clauses 2.2 and 2.5; and

(b) may be provided in one conductor less than the number of conductors

7.5.10 Connecting devices

Plug and socket-outlet devices, including installation couplers, for SELV and PELV shall comply with the following:

(a) Plugs shall not be able to enter sockets of other voltage systems.

(b) Sockets shall not accept plugs of other voltage systems.

(c) Sockets shall not have a contact for a protective earthing conductor in the circuit.

Protection by electrical separation shall be compliant with Clauses 7.4.2 to 7.4.4, and with—

(a) Clause 7.4.5 for a supply to _____________________________; or

(b) Clause 7.4.6 for a supply to ________________ item of equipment

7.4.5 Supply to single item of electrical equipment

7.4.6 Supply to multiple items of electrical equipment

Refer to Clause 7.4.3 – Arrangement of circuits

Separated circuits shall comply with the following requirements:

(a) Circuit voltage shall not exceed _______ V.

(b) All live parts of a separated circuit shall be reliably and effectively electrically ____________ from all other circuits, including other separated circuits and earth.

(c) Exposed conductive parts of electrical equipment supplied by a separated circuit shall not be connected to the protective earthing conductor, or the exposed

conductive parts, of the source of supply.
(d) Cables and supply flexible cords to electrical equipment shall be protected against mechanical damage or otherwise arranged to ensure that any damage that might occur is readily visible.

7.4.3 Arrangement of circuits
Separated circuits shall comply with the following requirements:
(a) Circuit voltage shall not exceed 500 V.
(b) All live parts of a separated circuit shall be reliably and effectively electrically separated from all other circuits, including other separated
circuits and earth.

Refer to Clause 7.4.5 - Single item of electrical equipment
Where a separated circuit supplies a single item of electrical equipment, any exposed conductive parts of the electrical equipment shall ________________________ to the ______________________ parts of any other circuit, including other separated circuits or earth.

7.4.5 Supply to single item of electrical equipment
Where a separated circuit supplies a single item of electrical equipment, any exposed conductive parts of the electrical equipment shall not be connected to the exposed conductive parts of any other circuit, including other separated circuits or earth

Refer to Clause 7.4.6 - Multiple items of electrical equipment
Where a separated circuit supplies more than one item of electrical equipment, the following shall apply:
(a) Any exposed conductive parts of the separated circuit shall be connected together by an insulated equipotential bonding conductor that is not connected to:
□ ______________; or

□ a _______________________ conductor or exposed conductive parts of

another circuit, including another separated circuit; or
□ any ______________________________________.

7.4.6 Supply to multiple items of electrical equipment
Where a separated circuit supplies more than one item of electrical equipment, the following requirements apply:
(a) Any exposed conductive parts of the separated circuit shall be connected together by an insulated equipotential bonding conductor that is not connected to—
(i) earth;
(ii) a protective earthing conductor or exposed conductive parts of another circuit, including another separated circuit; or
(iii) any extraneous conductive parts.

The designated earthing contact of any socket-outlet installed on the separated circuit shall be connected to the ______________________ conductor.

The designated earthing contact of any socket-outlet installed on the separated circuit shall be connected to the equipotential bonding conductor.

Exposed conductive parts of the ____________________ that are earthed, shall not be simultaneously accessible with any _________________________ of the separated circuit.
Exposed conductive parts of the source of supply that are earthed, shall not be simultaneously accessible with any exposed conductive part of the separated circuit.

A protective device shall operate to disconnect the separated circuit ___________ in the event of two faults resulting in exposed conductive parts being connected to live parts of different polarity..

A protective device shall operate to disconnect the separated circuit automatically in the event of two faults resulting in exposed conductive parts being connected to live parts of different polarity. If the protective device is a circuit-breaker, the protective.

CONTROL OF ELECTRICAL INSTALLATIONS AND CIRCUITS
The term 'control' as applied to electrical installations can be defined in a number of ways. There are control requirements for:

- ______________________________________
- ______________________________________
- ______________________________________

2.3.1 General
Electrical installations shall be provided with devices to prevent or remove hazards associated with the electrical installation and for maintenance of electrically activated equipment.
NOTE: The measures specified in this Clause (Clause 2.3) are in addition to, and not alternatives to, the protective measures specified in Clause 2.4.
Electrical installations shall include all switching devices or other means of disconnection necessary to enable operations, repairs and maintenance work to be carried out safely.

The supply to an extra-low voltage electrical installation shall be controlled by a main switch or switches operating in all unearthed conductors.
Control of an entire installation or part thereof, may be required for a number of reasons. These include:

- ____Isolation of the installation_____
- ____emergency reasons__(fire, machine safety,etc)__
- ____maintenence__________
- ___functional control___(machines, appliances)___

2.3 CONTROL OF ELECTRICAL INSTALLATION

2.3.1 General

Electrical installations shall be provided with devices to prevent or remove hazards associated with the electrical installation and for maintenance of electrically activated equipment.

NOTE: The measures specified in this Clause (Clause 2.3) are in addition to, and not alternatives to, the protective measures specified in Clause 2.4.

Electrical installations shall include all switching devices or other means of disconnection necessary to enable operations, repairs and maintenance work to be carried out safely.

Any device provided shall comply with the relevant requirements of this Clause (Clause 2.3), in accordance with the intended function or functions.

Such devices are classified according to one of the following functions:

(a) Isolation, in accordance with Clause 2.3.2.2.
(b) Emergency, in accordance with Clause 2.3.5.2.
(c) Mechanical maintenance, in accordance with Clause 2.3.6.2.
(d) Functional (control), in accordance with Clause 2.3.7.2.

Control and isolation of installations and circuits is commonly provided by the installation of the following devices:

□ ____________________________

□ ____________________________

□ ____________________________

Main Switch Circuit Breaker Fuse

Which section of AS/NZS3000 sets out the requirements for general arrangement, control and protection of electrical installations?

□ ______________________________

2.1 GENERAL

2.1.1 Application

This Section specifies the minimum requirements for the selection and installation of switchgear and control gear that shall be achieved to satisfy Part 1 of this Standard.

2.1.2 Selection and installation

When selected devices for control of installations and circuits, consideration needs to be given to suitability of the device, including:

□ ______(2.1.2)______________________

□ ____________________________

□ ____________________________

□ ____________________________

□ _________ip rating___________________

2.1.2 Selection and installation

Switchgear and control gear shall be selected and installed to perform

the following functions or have the following features:
(a) Provide control or isolation of the electric al installation, circuits or individual items of apparatus as required for maintenance, testing, fault detection or repair.
(b) Enable automatic disconnection of supply in the event of an overload, short-circuit or excess earth leakage current in the protected part of the electrical installation.
(c) Provide protection of the electrical installation against failure from overvoltage or undervoltage conditions.
(d) Provide for switchgear and control gear to be grouped and interconnected on switchboards, enclosed against external influences, and located in accessible positions.
(e) Separately control and protect the circuit arrangements without affecting the reliability of supply to, or failure of, other parts of the installation.
* (f) Installed in accordance with the requirements of this Section, and the additional requirements as specified in the manufacturer’ s instructions.

Refer to definitions: **Clause 1.4.62** – Isolation (isolating function)
Isolation is a function intended to cut off the supply from:
□______________________________ or,

□______________________________ ,

by separating it from every source of electrical energy for reasons of safety

1.4.75 Isolation (Isolating function)
Function intended to cut off the supply from the whole installation, or a discrete section of it, by separating it from every source of electrical energy
for reasons of safety.

Refer to definitions: **Clause 1.5.2** – Control and Isolation
Electrical installations shall be provided with control and isolation devices to prevent or remove:
□____ and to allow

□____.
1.5.2 Control and isolation
Electrical installations shall be provided with control and isolation devices to prevent or remove hazards associated with the electrical installation and to allow maintenance of electrical equipment.

The control of **safety services** shall be arranged so that the control devices are:
□____ and are not

□____
The control of safety services shall be arranged so that the control devices

are separate from the control of other equipment and are not unintentionally interrupted by the operation of other equipment.

An isolation device shall interrupt all:
☐______________________
An isolation device shall interrupt all active conductors and may be required to operate in a neutral conductor.
NOTE: Clause 2.3.2.1.1 contains requirements for the operation of isolation devices in neutral conductors.

An isolation device or switch **shall not** interrupt:
☐___________________________ or

☐____.
An isolation device or switch shall not interrupt an earthing conductor or a combined protective earthing and neutral (PEN) conductor

Refer to Clause 2.1.2 – Selection and Installation
Switchgear and control gear shall be selected and installed to perform the following functions:
(a) Provide ____________or ______________ of the electrical installation, circuits or individual items of apparatus as required for maintenance, testing, fault detection or repair.
(b) Enable ______________ disconnection of supply in the event of an overload, short-circuit or excess earth leakage current in the _______________ part of the electrical installation.
(c) Provide _____________ of the electrical installation against failure from _____________ or _____________ conditions.
(d) Provide for switchgear and control gear to be ____________ and interconnected on___________________, enclosed against external influences, and located in accessible positions.
(e) _____________ control and protect the circuit arrangements without affecting the reliability of supply to, or failure of, other parts of the installation.
2.1.2 Selection and installation
Switchgear and controlgear shall be selected and installed to perform the following functions or have the following features:
(a) Provide control or isolation of the electric al installation, circuits or individual items of apparatus as required for maintenance, testing, fault detection or repair.
(b) Enable automatic disconnection of supply in the event of an overload, short-circuit or excess earth leakage current in the protected part of the electrical installation.
(c) Provide protection of the electrical installation against failure from overvoltage or undervoltage conditions.
(d) Provide for switchgear and controlgear to be grouped and interconnected on switchboards, enclosed against external influences, and located in accessible positions.
(e) Separately control and protect the circuit arrangements without affecting the reliability of supply to, or failure of, other parts of

the installation.
* (f) Installed in accordance with the requirements of this Section, and the additional requirements as specified in the manufacturer's instructions.

Refer to Clause 2.3 – Control of Electrical Installation – General
Electrical installations shall be provided with devices to prevent or remove hazards associated with the electrical installation and for maintenance of electrically activated equipment.
Any device provided shall comply with the relevant requirements of Clause 2.3, and for specific purposes, shall comply with the following clauses:
(a) Isolation: Clause ______________
(b) Emergency: Clause ______________
(c) Maintenance: Clause ______________.
(d) Functional Control: Clause ______________

(a) Isolation, in accordance with Clause 2.3.2.2.
(b) Emergency, in accordance with Clause 2.3.5.2.
(c) Mechanical maintenance, in accordance with Clause 2.3.6.2.
(d) Functional (control), in accordance with Clause 2.3.7.2.

Refer to Clause 2.3.2 – Common Requirements
□Every circuit shall be capable of being isolated from each of the supply conductors,in accordance with Clause ___________ or ____________.

□Provided that the service conditions allow and the appropriate safety measures are maintained, a ___________________ may be isolated by a ____________ switch.

□Provision shall be made to enable isolation of electrical equipment and to prevent electrical equipment from being _________________energized.

2.3.2 Common control requirements
2.3.2.1 General
* 2.3.2.1.1 All systems
Every circuit shall be capable of being isolated from each of the supply conductors, in accordance with Clause 2.3.2.1.2 or 2.3.2.1.3, as appropriate.
Provided that the service conditions allow it, and the appropriate safety measures are maintained, a group of circuits may be isolated by a common switch.
Provision shall be made to enable isolation of electrical equipment and to prevent electrical equipment from being inadvertently energized. The means of isolation shall be such that a deliberate action in addition to the normal method of operation is required to energize the circuit.
Exercise 10:
List 3 precautions which may be used to prevent electrical equipment from being inadvertently (accidently) energized.
(a) ____
(b) ____

(c) ____

2.3.2.1.1 All systems
(a) Provision for the fitting of a padlock.
(b) Warning tags or notices.
(c) Location within a lockable space or enclosure.
(d) Short-circuiting and earthing may be used as a supplementary measure only.

Refer to Clause 2.3.2.1.1 – Alternating Current Systems:
Read t the requirements of this clause and answer the following:
In a 3 phase circuit how many active conductors are required to be switched by the isolation device?

3
2.3.2.1.2 Alternating current systems
Provisions for isolation of conductors in a.c. systems are as follows:
(a) Active conductors All active conductors of an a.c. circuit shall be capable of being isolated by a device for isolation.

May an isolation device be placed in the neutral of a consumer's main or a P.E.N. conductor?

____

No
2.3.2.1.2 Alternating current systems
Provisions for isolation of conductors in a.c. systems are as follows:
(a) Active conductors All active conductors of an a.c. circuit shall be capable of being isolated by a device for isolation.
(b) Neutral conductor:
(i) No switch or circuit-breaker shall be inserted in the neutral conductor—
(A) of consumer mains; or
(B) where the neutral conductor is used as a combined protective earthing and neutral (PEN) conductor for protective earthing of any portion of an electrical installation.

Are there any exceptions that would allow the neutral of a consumer's main neutral or a P.E.N. conductor to be switched or isolated?
(ii) A switch or circuit-breaker may operate in the neutral conductor of circuits other than those in Item (i) where—
(A) the neutral pole of a multi-pole switch or circuit-breaker, having an appropriate short-circuit breaking and making capacity, is linked and arranged to switch substantially together with all active poles; or
(B) the switch or circuit-breaker is linked with corresponding switches so that the neutral contact cannot remain open

when the active contacts are closed.
A switched neutral pole shall not open before and shall not close after the active pole(s).

May an isolation device be placed in a circuit other than in a consumer's mainneutral or a P.E.N. conductor?
Yes
2.3.2.1.2 Alternating current systems
Provisions for isolation of conductors in a.c. systems are as follows:
(a) Active conductors All active conductors of an a.c. circuit shall be capable of being isolated by a device for isolation.

As discussed earlier, is permitted to switch an earthing conductor or PEN?
No

Refer to Clause 2.3.2.1.2 – Direct Current Systems:
Common DC systems include the output of Photo-Voltaic (PV) systems, Extra Low Voltage systems, battery backup systems, some machine control circuits and the like.
Read the requirements of this clause and answer the following:
In a d.c. circuit how many conductors are required to be switched by the isolation device?
____
how many conductors are required to be switched by the isolation device if it is installed in an Extra Low Voltage (ELV) or a circuit where one pole is connected to earth?

2.3.2.1.3 Direct current systems
* All conductors of a d.c. circuit shall be capable of being isolated by a device
for isolation.
2

Refer to Clause 2.3.2.2.1 – Devices for Isolation
Devices for isolation shall effectively isolate all active supply conductors from the circuit.
A semiconductor (solid-state) device shall **not** be used for isolation purposes.
A solid-state device is ____

Read the Requirements of this clause and answer the following:
What do the symbols "O" and "I" indicate?
2.3.2.2.1 General
The symbols 'O' (OFF) and 'I' (ON)

Should an isolation device be readily available / accessible
Yes
(f) shall be readily available.

(c) shall clearly and reliably indicate the isolating position of the device

What current should the isolation device be able to safely interrupt?
2.3.4.1 Electrical installation in an outbuilding
An electrical installation in an outbuilding shall comply with the following:
(a) General An electrical installation in an outbuilding shall be treated as a separate electrical installation if it—
(i) has a maximum demand of 100 A or more per phase; and
(ii) is provided with a switchboard.

2.3.4.2 Submains and final subcircuits greater than 100 A
Every submain and final subcircuit having a rating exceeding 100 A per phase shall be controlled by a separate isolating switch on the switchboard at which the circuit originates.

Refer to Clause 2.3.3.1 – General (Main Switches)
The supply to every electrical installation shall be controlled on the main switchboard by a main switch or switches that control the whole of the electrical installation.
Where multiple supplies are provided, each supply shall be controlled by a main switch or switches on the main switchboard for each supply.
How should Main switches be identified?
Main switches shall be located, arranged and legibly and permanently identified, in accordance with Clauses 2.3.3.3 to 2.3.3.5, to allow for their effective operation in an emergency.
2.3.3.5 Identification
Main switches shall be identified as follows:
(a) Each main switch shall be marked 'MAIN SWITCH' and shall be readily distinguishable from other switchgear by means of grouping, contrasting colouring or other suitable means to provide for prompt operation in an emergency.
(b) Where there is more than one main switch, each main switch shall be marked to indicate the electrical installation or portion of the electrical installation it controls.
(c) Where the opening of a main switch brings into operation or isolates an alternative supply, a notice shall be provided to indicate the position of the main switch controlling the alternative supply.
Where supply is provided at more than one point in any building, a prominent notice shall be provided at each main switchboard, indicating the presence of other supplies and the location of other main switchboards.
* (e) Main switches for supplementary or alternative supplies shall be labelled to indicate the energy source.

What are the requirements for Main switches supplying safety services?
Each part of an electrical installation supplying a safety service in accordance with Clause 7.2 shall be controlled by a main switch or switches, separate from those used to control the remainder of the

electrical installation, as required by Clause 7.2.3.

7.2.3 Main switchboard and switchgear
7.2.3.1 General
A safety service shall be controlled by a main switch that is separate from main switches used to control—
(a) any part of the general electrical installation; and
(b) other types of safety services

Refer to Clause 2.3.3.2 – Number of Main Switches
What is the maximum number of main switches permitted in a domestic installation?

2.3.3.3 Number of main switches
The number of main switches shall be kept to the minimum practicable to provide for effective operation in an emergency.
Domestic electrical installations, including each separate domestic electrical installation forming part of a multiple electrical installation, shall
be provided with not more than one main switch for—
(a) each separately metered supply; or
(b) where there is more than one separately controlled supply from a meter, a main switch for each of the separately controlled supplies.

How many main switches would be required if a domestic installation had off-peak?
One
A block of 3 units has 3 meters, 1 per unit, and a 4th meter for common lighting. How many main switches will be on the Main Switchboard

4
(b) where there is more than one separately controlled supply from a meter, a main switch for each of the separately controlled supplies.

Refer to Clause 2.3.3.3 – Location
In general, main switches shall be:
☐______________________________ , and located;
☐____.

In multiple installations such as living units, flats etc, each occupier shall have:

(b) Main switches:
(i) General A main or isolating switch or switches shall be installed on the switchboard in the outbuilding to control the electrical installation in the outbuilding.

Main switch

Refer to Clause 2.3.3.4 – Identification

Main switches shall be:
□Identified as____

□Be readily____

□Marked to indicate____

□If the operation of a main switch brings in to function an alternate supply,the alternate supply main switch location shall be ________________________

2.3.3.5 Identification
Main switches shall be identified as follows:
(a) Each main switch shall be marked 'MAIN SWITCH' and shall be readily distinguishable from other switchgear by means of grouping, contrasting colouring or other suitable means to provide for prompt operation in an emergency.
(b) Where there is more than one main switch, each main switch shall be marked to indicate the electrical installation or portion of the electrical installation it controls.
(c) Where the opening of a main switch brings into operation or isolates an alternative supply, a notice shall be provided to indicate the position of the main switch controlling the alternative supply.

Refer to Clause 7.2 – Safety Services
The requirements of clause *7.2.1.1 – General*, are to ensure that:
□____ from electrical equipment that is required to operate;

□____ for which there is no alternate supply.
These requirements are intended to ensure that electricity supply is not inadvertently disconnected from electrical equipment that is required to operate during emergency conditions

7.2.1.1 Scope
The particular requirements of this Clause (Clause 7.2) apply to the electrical installation of building services that are essential for the safe operation of safety services consisting of fire detection, warning and extinguishing systems, smoke control systems, evacuation systems and the safety of persons using lifts.

7.2.2.3 Alternative supply systems
7.2.2.3.1 Continued occupation
Where an alternative supply is provided for continued safe occupation of the building, the following requirements apply:
(a) Safety services The alternative supply system shall have sufficient capacity to operate all safety services.
(b) Continued occupation of any portion of the building (during loss of normal supply) The alternative supply system shall have sufficient

capacity to supply electrical equipment associated with the continued occupation of the building.

Exercise 11:
Read clauses 7.2.1.2 and 7.2.1.3 and list 6 types of safety service that would be separate from one and other and controlled by their own main switch:

- ☐ ________________________________
- ☐ ________________________________
- ☐ ________________________________
- ☐ ________________________________
- ☐ ________________________________
- ☐ ________________________________

Escalators or moving walkways (travelators).
2 A lift in a single private residence that is installed in accordance with AS/NZS 1735.18 need not comply with the requirements of this Clause (Clause 7.2).
3 Lifts that are not defined as emergency lifts in the National Construction Code (NCC) or New Zealand Building Code (NZBC).
4 Pumps for 'jacking' or water pressure maintenance, the failure of which does not deprive the fire hydrant or sprinkler pump of adequate water supply.
5 Fire detection, alarm and intercom systems with battery backup complying with AS 1670 or NZS 4512.
6 Smoke alarms installed in single private residences (see Clause 4.6 for information relating to smoke alarms).

Exercise 12:
Read clause 2.3.6.1 and answer the following:
List 2 types of injury that may occur if equipment is not shut down and isolated:

- ☐ ________________________________
- ☐ ________________________________

Means of disconnecting electricity supply (shutting down) shall be provided where mechanical maintenance of electrically powered equipment might involve a risk of physical injury.
NOTES:
1 Such injuries include burns and those caused by radiated heat and unexpected mechanical movements.
2 Electrically powered mechanical equipment may include rotating machines, heating elements and electromagnetic equipment.
3 Examples of electrical installations where means of shutting down for mechanical maintenance are used include cranes, lifts, escalators, conveyors, machine tools and pumps.
4 Systems powered by other means, e.g. pneumatic, hydraulic or steam, are not within the scope of this Clause. In such cases, shutting down any associated supply of electricity may not be sufficient to ensure safety.

List 6 Examples of electrical installations where means of shutting down for mechanical maintenance are used:

- ☐ ________________________________
- ☐ ________________________________
- ☐ ________________________________
- ☐ ________________________________
- ☐ ________________________________
- ☐ ________________________________

a) Machinery.
(b) Conveyors.
(c) Groups of machines.
(d) Pumping facilities for flammable liquids.
(e) Ventilation systems.
(f) Certain large buildings, e.g. department stores.
(g) Electrical testing and research facilities.
(h) Boiler rooms.
(i) Large kitchens.

Refer to Clause 2.3.6.2 – Devices for Shutting Down
Devices for shutting down for mechanical maintenance shall:
(a) require _____________ operation; and
(b) clearly and reliably indicate the '______' position; and
(c) be ___________ or ___________ so as to prevent _______________________.

2.3.6.2 Devices for shutting down
Devices for shutting down for mechanical maintenance shall—
(a) require manual operation; and
(b) clearly and reliably indicate the 'OFF' position; and
(c) be designed or installed so as to prevent unintentional closure.

Refer to Clause 2.3.6.3 - Installation
Devices for shutting down for mechanical maintenance shall be inserted in the main circuit.
Where switches are provided for this purpose they shall be capable of interrupting the ___________________ of the relevant part of the electrical installation.

2.3.6.3 Installation
Devices for shutting down for mechanical maintenance shall be inserted in the main circuit
Where switches are provided for this purpose, they shall be capable of interrupting the full-load current of the relevant part of the electrical installation. They need not interrupt all live conductors

Refer to Clause 2.3.6.4 - Identification
Devices for shutting down for mechanical maintenance shall be placed and marked so as to be _____________________ and ______________ for their intended use.

2.3.6.4 Identification
Devices for shutting down for mechanical maintenance shall be placed and marked so as to be readily identifiable and convenient for their intended use.

Refer to Clause 4.13.1.1 – Switching Devices (for motors)
Isolation switches in motor circuits are installed to provide protection against injury from mechanical movement.
Every motor shall be provided with a switching device capable of:
(a) starting and stopping the motor; and
(b) emergency stopping, in accordance with Clause 2.3.5; and
(c) ____
An isolating switch is only required for motors rated above ______________.

4.13.1.1 Switching devices
Every motor shall be provided with a switching device capable of performing all of the following functions:
(a) Starting and stopping the motor.
(b) Emergency stopping, in accordance with Clause 2.3.5.
(c) Isolating the motor for mechanical maintenance, in accordance with Clause 2.3.6.

Refer to Clause 4.13.1.2 – Rating of Switches (for motors)
Isolating switches for motors shall have a rating of not less than:
(a) the _________________ of the motor when installed directly in the motor supply circuit; or
(c) the ____________________________ when installed in the motor-starter circuit.

The isolating switch shall have a rating of not less than—
(d) the full-load current of the motor when installed directly in the motor supply
circuit; or
(b) the control-circuit current when installed in the motor-starter circuit.

AS/NZS 3000 default values used to determine locked rotor current are:
- ________________ the full load current for A.C. motors
- ________________ the full load current for D.C. motors

(i) eight times the full-load current for a.c. motors; or
(ii) four times the full-load current for d.c. motors

FUNCTIONAL CONTROL SWITCHES
Functional switching is required for _________________ only and not for safety reasons. Functional switches do not necessarily provide isolation of electrical equipment, but merely a way to control or operate it.
Functional switching devices may be:

Switches

Semiconductor devices

Contactors
2.3.7 Functional (control) switching
2.3.7.1 General
Functional switching may be used where switching of electrical equipment, or part of an electrical installation, is required for operational control only
and not for safety reasons.

Refer to Clause 4.7.1 –Switching device (Cooking Appliances)
A circuit for a fixed or stationary cooking appliance having an open cooking surface incorporating electric heating elements, such as

- Cooktops
- deep fat fryer
- barbecue griddle etc;

shall be provided with a switch, operating in _______ active conductors, mounted near the appliance in a visible and _______________________ position.

A circuit for a fixed or stationary cooking appliance having an open cooking surface incorporating electric heating, e.g. a cooktop, deep fat fryer, barbecue griddle or similar, shall be provided with a switch, operating in all active conductors, mounted near the appliance in a visible and readily accessible position.

A functional switch for a cooktop should be mounted within _____ metres of the appliance.
The switch shall not be mounted on the cooking appliance.
NOTE: The switch should be mounted within 2 m of the cooking appliance

Does a built in wall oven require a functional switch? ___________________.
This requirement need not apply to built-in hobs and ovens.
No

Does an upright stove require a functional switch? _____________________.
What recommendation is given for functional switches installed to control domestic appliances? ____.

4.7.1 Switching device
A circuit for a fixed or stationary cooking appliance having an open cooking surface incorporating electric heating, e.g. a cooktop, deep fat fryer, barbecue griddle or similar, shall be provided with a switch, operating in all active conductors, mounted near the appliance in a visible and readily accessible position.

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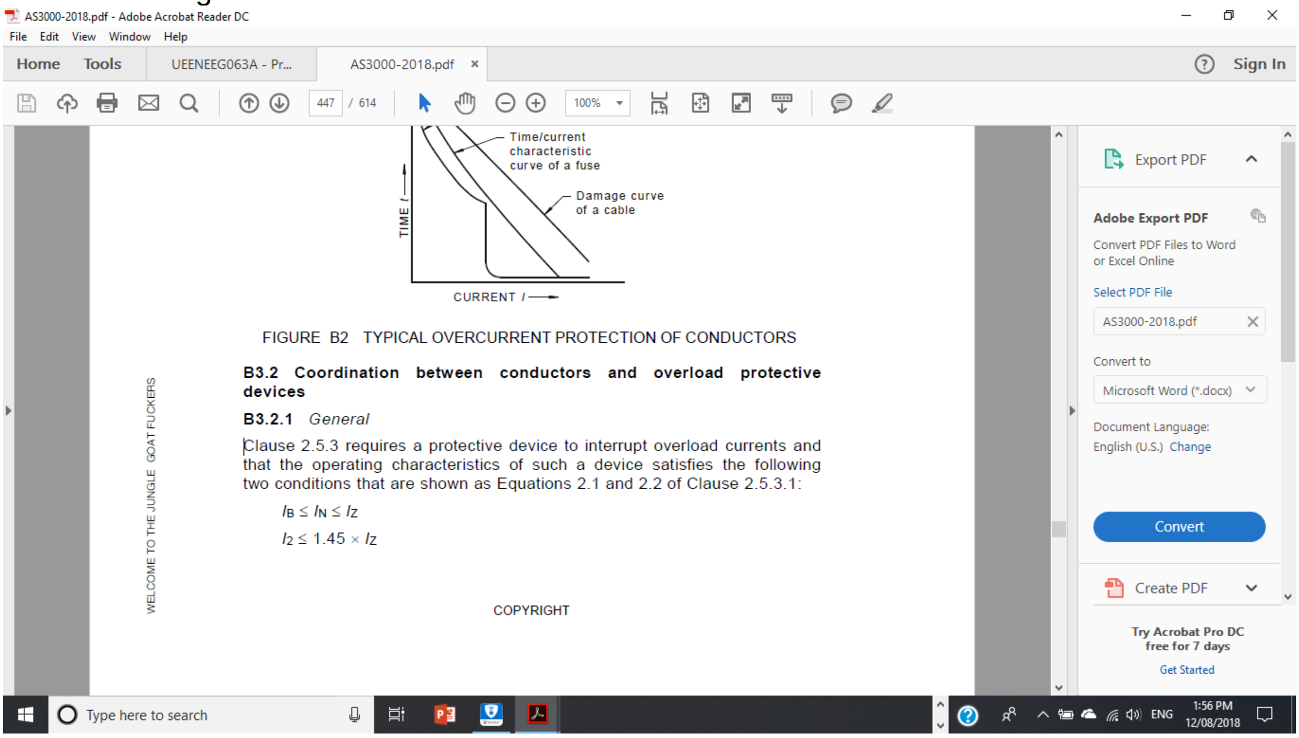
When selecting a circuit breaker for a water heater final sub-circuit, its current rating should be:

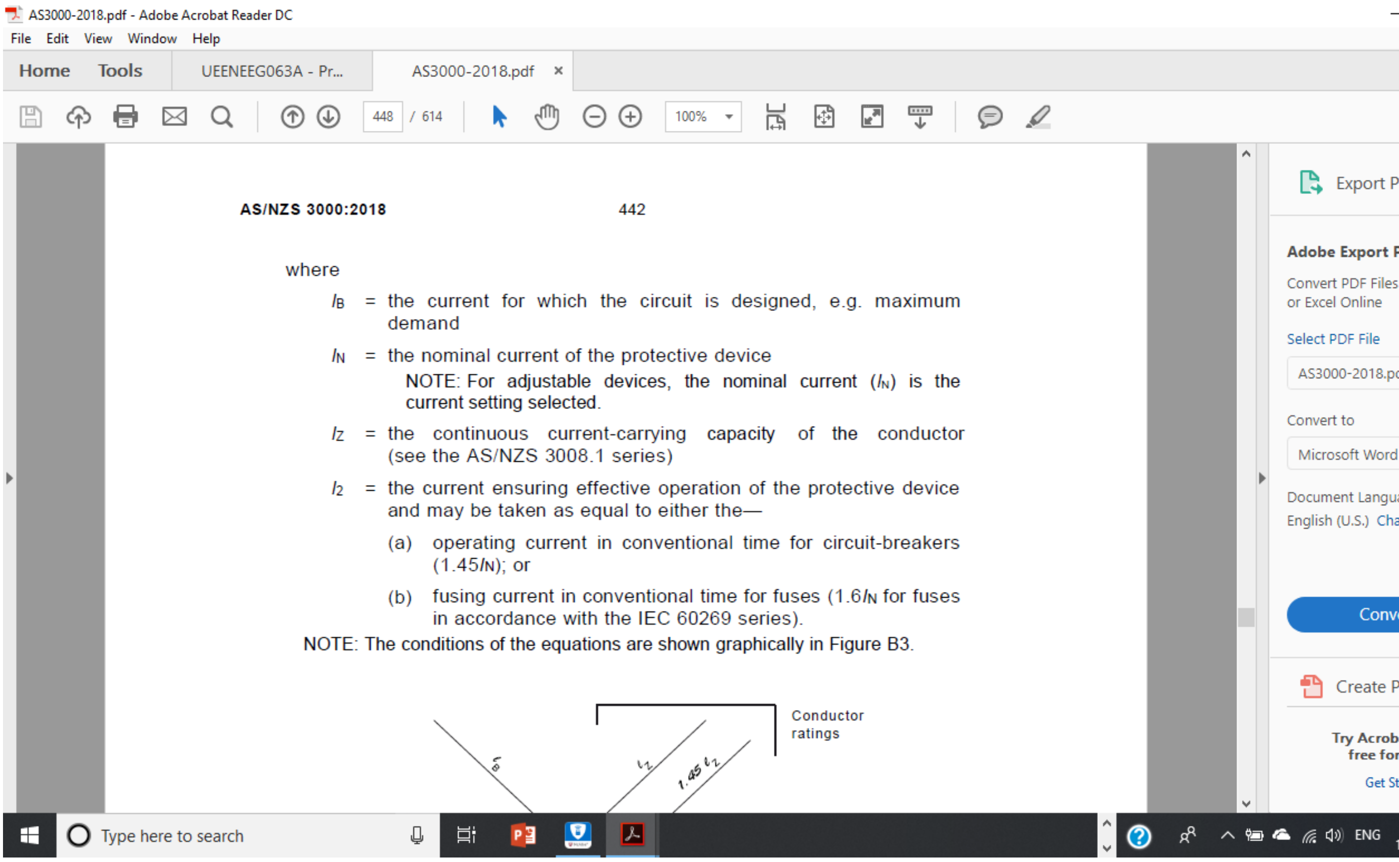
equal to or less than the demand of the final sub-circuit and equal to or less than the cable rating

equal to or greater than the demand of the final sub-circuit and equal to or less than the cable rating

equal to or less than the demand of the final sub-circuit and equal to or greater than the cable rating

equal to or greater than the demand of the final sub-circuit and equal to or greater than the cable rating.





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where

I_B = the current for which the circuit is designed, e.g. maximum demand

I_N = the nominal current of the protective device

NOTE: For adjustable devices, the nominal current (I_N) is the current setting selected.

I_Z = the continuous current-carrying capacity of the conductor (see the AS/NZS 3008.1 series)

I_2 = the current ensuring effective operation of the protective device and may be taken as equal to either the—

(a) operating current in conventional time for circuit-breakers ($1.45 I_N$); or

(b) fusing current in conventional time for fuses ($1.6 I_N$ for fuses in accordance with the IEC 60269 series).

NOTE: The conditions of the equations are shown graphically in Figure B3.

A separate final sub-circuit is recommended for any single point of load exceeding;
16A.
20A.
25A.
32A.

C5 NUMBER OF POINTS CONNECTED TO CIRCUITS
C5.1 Number of circuits
Each item of equipment that has a current rating in excess of 20 A per phase should be connected to a separate and distinct circuit.

The recommended number of lighting points that can be connected to a circuit wired in 1.0 mm^2 TPS cable and protected by a 6A type C circuit breaker in a domestic installation is:
10
12
20
Unlimited

6A / 0.5 = 12 pt

The recommended number of double 10A socket outlets that can be connected to a circuit wired in 2.5 mm^2 TPS cable and protected by a 20A type C circuit breaker in a factory without air conditioning is:
5

10
20
Unlimited

Double 10A = 20A   No 20

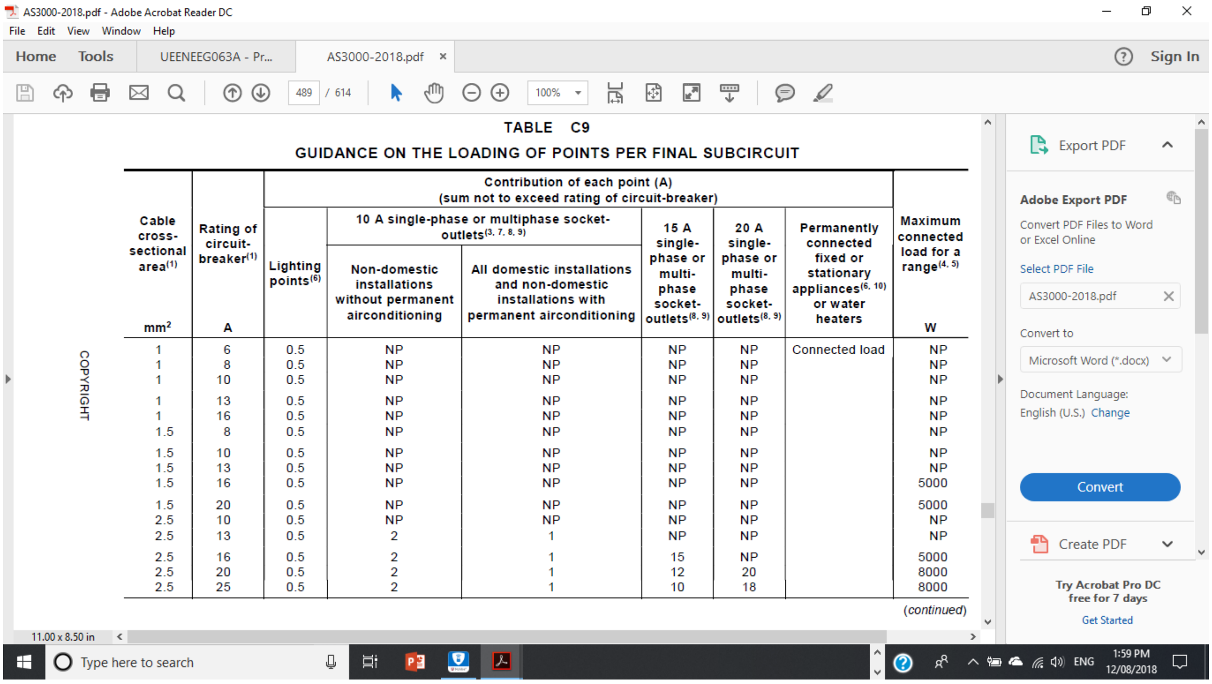


TABLE C9

GUIDANCE ON THE LOADING OF POINTS PER FINAL SUBCIRCUIT

Cable cross-sectional area[(1)] mm²	Rating of circuit-breaker[(1)] A	Contribution of each point (A) (sum not to exceed rating of circuit-breaker) Lighting points[(6)]	10 A single-phase or multiphase socket-outlets[(3, 7, 8, 9)] Non-domestic installations without permanent airconditioning	10 A single-phase or multiphase socket-outlets[(3, 7, 8, 9)] All domestic installations and non-domestic installations with permanent airconditioning	15 A single-phase or multi-phase socket-outlets[(8, 9)]	20 A single-phase or multi-phase socket-outlets[(8, 9)]	Permanently connected fixed or stationary appliances[(6, 10)] or water heaters	Maximum connected load for a range[(4, 5)] W
1	6	0.5	NP	NP	NP	NP	Connected load	NP
1	8	0.5	NP	NP	NP	NP		NP
1	10	0.5	NP	NP	NP	NP		NP
1	13	0.5	NP	NP	NP	NP		NP
1	16	0.5	NP	NP	NP	NP		NP
1.5	8	0.5	NP	NP	NP	NP		NP
1.5	10	0.5	NP	NP	NP	NP		NP
1.5	13	0.5	NP	NP	NP	NP		NP
1.5	16	0.5	NP	NP	NP	NP		5000
1.5	20	0.5	NP	NP	NP	NP		5000
2.5	10	0.5	NP	NP	NP	NP		NP
2.5	13	0.5	2	1	NP	NP		NP
2.5	16	0.5	2	1	15	NP		5000
2.5	20	0.5	2	1	12	20		8000
2.5	25	0.5	2	1	10	18		8000

(continued)

The switch used to isolate a 12.5 kW range (cook top and oven) that is connected to two phases and neutral, would have as a minimum:
one pole.
two poles.
three poles.
four poles

For a single domestic installation, with a maximum demand of less than 100 A, the maximum number of main switches per tariff is
1
6
10
no limit.

2.3.4 Additional isolating switches
2.3.4.1 Electrical installation in an outbuilding
An electrical installation in an outbuilding shall comply with the following:
(a) General An electrical installation in an outbuilding shall be treated as a separate electrical installation if it—
(i) has a maximum demand of 100 A or more per phase; and
(ii) is provided with a switchboard.

A main switch should be located;
as close as possible to the load it isolates.
at the main switch board.

at the distribution board.
point of supply.

2.3.3.2 General
The supply to every electrical installation shall be controlled on the main switchboard by a main switch or switches that control the whole of the electrical installation.
Where multiple supplies are provided, each supply shall be controlled by a main switch or switches on the main switchboard for each supply.

The maximum permissible height for a main switch for a main switch above the ground, a floor or platform is;
0.6m
1.2m
2.0m
2.5m

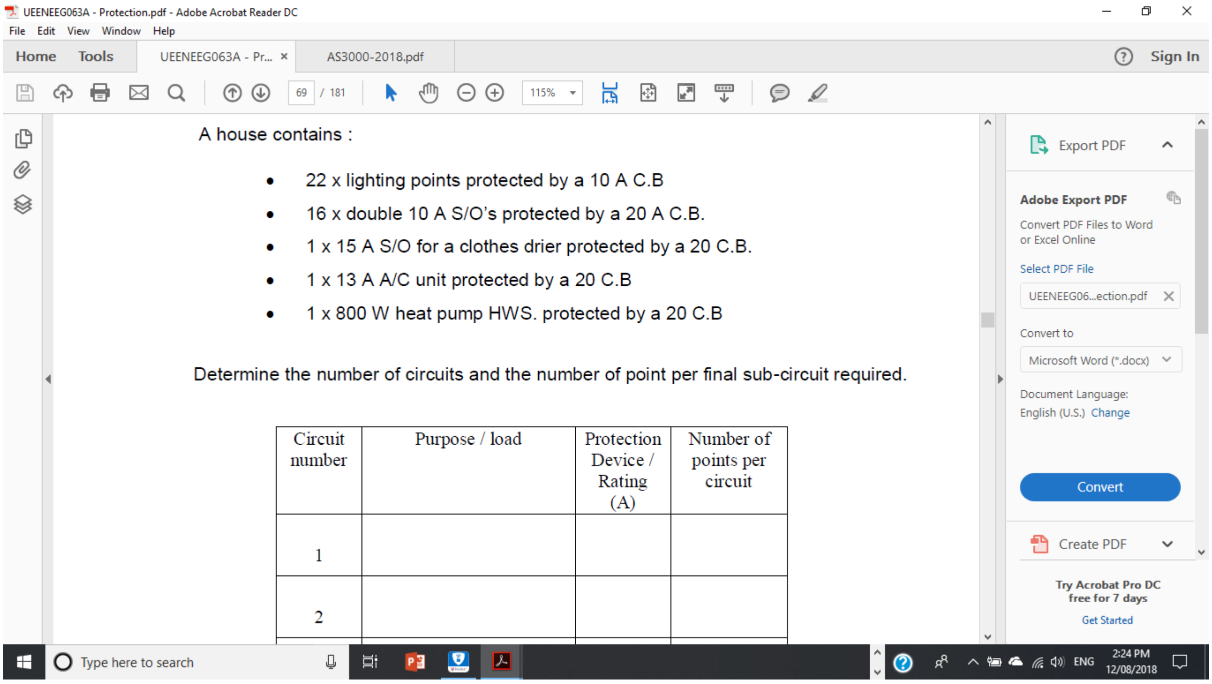
2.3.3.4 Location and operation
Main switches shall be accessible as follows:
(a) General Main switches shall be readily accessible and the means of operating such switches shall be not more than two metres above the ground, floor or a suitable platform.

It is not permitted to install an isolation switch in;
Active conductors
Neutral conductors
Protective Earthing conductors
Switch wires

2.3.2.1.2 Alternating current systems
Provisions for isolation of conductors in a.c. systems are as follows:
(a) Active conductors All active conductors of an a.c. circuit shall be capable of being isolated by a device for isolation.
(b) Neutral conductor:
(i) No switch or circuit-breaker shall be inserted in the neutral conductor—

Switching of earthing conductor prohibited An earthing conductor shall not be isolated or switched.

2.3.2.1.2 Alternating current systems
(b) A conductor used as a combined protective earthing and neutral (PEN) conductor shall not be isolated or switched



A house contains :

- 22 x lighting points protected by a 10 A C.B
- 16 x double 10 A S/O's protected by a 20 A C.B.
- 1 x 15 A S/O for a clothes drier protected by a 20 C.B.
- 1 x 13 A A/C unit protected by a 20 C.B
- 1 x 800 W heat pump HWS. protected by a 20 C.B

Determine the number of circuits and the number of point per final sub-circuit required.

Circuit number	Purpose / load	Protection Device / Rating (A)	Number of points per circuit
1			
2			

Circuit Number	Purpose/Load	Protection Device Rating A	Number of points per circuit
	22 lighting points 10A CB 10/0.5 = 20 pt Divide two circuit with each 11 Pt	10A	
1	Lighting 1	10A	11 lighting points
2	Lighting 2	10A	11 lighting points
	16 x double 10A SO 20A CB 2A per socket For 20A--- 10 Pt 32/10 = 3.2 4 Circuits, each 8 pt		
3	10A SO	8	20A
4	10A SO	8	20A
5	10A SO	8	20A
6	10A SO	8	20A
7	1x15A So 20A CB	1	20A
8	1x13A Aircon 20A CB	1	20A
9	1x800W HW 20ACB	1	20A

AS/NZS 3000 defines a SELV wiring system as:

AS/NZS 3000 reference

1.4.105 Separated extra-low voltage (SELV)
An extra-low voltage system that is electrically separated from earth and from other systems in such a way that a single fault cannot give rise to the risk of electric shock
AS/NZS 3000 defines a PELV wiring system as:

AS/NZS 3000 reference

1.4.96 Protected extra-low voltage (PELV)
An extra-low voltage system that is not electrically separated from earth, but that otherwise satisfies all the requirements for SELV.
The nominal voltage of a SELV or PELV wiring system shall not be capable of exceeding:

AS/NZS 3000 reference

1.4.128 Voltage
Differences of potential normally existing between conductors or between conductors and earth as follows:
(a) Extra-low voltage Not exceeding 50 V a.c. or 120 V ripple-free d.c.
(b) Low voltage Exceeding extra-low voltage, but not exceeding 1000 V a.c. or 1500 V d.c.
(c) High voltage Exceeding low voltage.

Can an Extra Low Voltage cable be run in a common conduit with a cable supplied at Low Voltage?

AS/NZS 3000 reference

Yes
3.9.8.2.2 Segregation
* Where conductors for different electrical installations, or for individual occupancies forming part of single or multiple electrical installations are installed in a common enclosure, they shall be effectively segregated from each other within that enclosure.
3.9.8.3 Segregation of different voltage levels
Cables of high voltage circuits and cables of low or extra-low voltage circuits shall not be enclosed in the same wiring system.
Cables of low voltage circuits and cables of extra-low voltage circuits shall only be enclosed in the same wiring system where one of the following arrangements is employed:
(a) The low voltage cables are of a type providing the equivalent of double insulation.

(b) All cables or each conductor of a multi-core cable are insulated for the highest voltage present.
(c) The low voltage cables are installed in a separate compartment of a common cable trunking system having fixed and continuous barriers between compartment

7.5.5 Arrangement of SELV circuits

Live parts of SELV circuits shall not be connected to earth or protective earthing conductors that are part of other circuits or to other live parts. SELV circuits shall not be connected to—

(a) other circuits;
(b) earth;
(c) earthing conductors or exposed conductive parts of another system; or
(d) extraneous conductive parts.

Exception: Connection to extraneous conductive parts may be made where electrical equipment is inherently required to be so connected and it is ensured that the extraneous conductive parts cannot attain a voltage exceeding that of the SELV circuit.

NOTE: If SELV circuits are liable to come into contact, either fortuitously or intentionally, with the exposed conductive parts of other circuits, protection against electric shock no longer depends solely on protection by SELV but on the protective measure to which the latter exposed conductive parts are subject.

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Can an AUTO-TRANSFORMER be used to step down the voltage to supply a SELV or PELV wiring system? Explain your answer.

____
____
___________________________________ AS/NZS 3000 reference ____________

4.14.4 Autotransformers

An autotransformer shall not be used to supply electrical equipment, including circuit wiring, having a voltage rating of less than the highest input or output voltage of the autotransformer.

Unless acceptable by connected ELV equipment, the maximum permissible volt-drop permitted in a ELV wiring system is:

___________________________________ AS/NZS 3000 reference ____________

7.5.7 Voltage drop in conductors

The drop in voltage at any point in an extra-low voltage electrical installation shall not exceed 10% of the nominal value when all live conductors are carrying the circuit-operating current.

List 4 items that SELV circuits shall NOT be connected to:

____
____
____
___________________________________ AS/NZS 3000 reference ____________

7.5.5 Arrangement of SELV circuits
Live parts of SELV circuits shall not be connected to earth or protective earthing conductors that are part of other circuits or to other live parts.
SELV circuits shall not be connected to—
(a) other circuits;
(b) earth;
(c) earthing conductors or exposed conductive parts of another system; or
(d) extraneous conductive parts.

Explain why it is not permitted to connect a protective earthing conductor from a SELV or PELV circuit to the primary of a supply system or any other circuit:

____
____
____
____
____

7.5.4 Separation requirements for SELV and PELV circuits
Live parts of SELV and PELV circuits shall be electrically separated from each other and from other higher voltage circuits.
Arrangements shall ensure a level of electrical separation equivalent to that between the input and output of a safety isolating transformer complying with AS/NZS 61558.
SELV and PELV circuit conductors shall be segregated from those of other circuit conductors.
Exception: SELV and PELV circuit conductors installed in accordance with Clause 3.9.8.3 may be contained within the same wiring system as low voltage circuits.
Live parts shall be arranged so that short-circuit or arcing, either between live parts or between live parts and other conductive material, will not take place under the conditions that may reasonably be expected in service.
7.5.5 Arrangement of SELV circuits
Live parts of SELV circuits shall not be connected to earth or protective earthing conductors that are part of other circuits or to other live parts.
SELV circuits shall not be connected to—
(a) other circuits;
(b) earth;
(c) earthing conductors or exposed conductive parts of another system; or
(d) extraneous conductive parts.
NOTE: If SELV circuits are liable to come into contact, either fortuitously or intentionally, with the exposed conductive parts of other circuits, protection against electric shock no longer depends solely on protection by SELV but on the protective measure to which the latter exposed conductive parts are subject.

A circuit connected to an ISOLATED supply shall not exceed how many volts?
___________________________________ AS/NZS 3000 reference ____________
7.4.3 Arrangement of circuits

Separated circuits shall comply with the following requirements:
(a) Circuit voltage shall not exceed 500 V.
(b) All live parts of a separated circuit shall be reliably and effectively electrically separated from all other circuits, including other separated circuits and earth.
This requirement shall also apply to live parts of relays, contactors and similar electrical equipment installed in the separated circuit.
NOTES:
1 This requirement can be satisfied by insulation of the live parts to Class II (double or reinforced insulation) or measures that are equivalent to the input and output transformer winding isolation provisions of AS/NZS 61558.
2 Each separated circuit should comprise a separate cable or wiring system. However, multi-core cables or a common non-conductive wiring enclosure may be used where the segregation requirements of Clause 3.9.8 are satisfied.
(c) Exposed conductive parts of electrical equipment supplied by a separated circuit shall not be connected to the protective earthing conductor, or the exposed conductive parts, of the source of supply.
(d) Cables and supply flexible cords to electrical equipment shall be protected against mechanical damage or otherwise arranged to ensure that any damage that might occur is readily visible.

Can the equipotential bonding conductors connected between socket outlets of an ISOLATED circuit be connected to the equipotential bond of the MEN system? ________________________________ AS/NZS 3000 reference ____________

No

7.4.6 Supply to multiple items of electrical equipment
Where a separated circuit supplies more than one item of electrical equipment, the following requirements apply:
(a) Any exposed conductive parts of the separated circuit shall be connected together by an insulated equipotential bonding conductor that is not connected to—
   (i) earth;
(b) The designated earthing contact of any socket-outlet installed on the separated circuit shall be connected to the equipotential bonding conductor.
(c) The designated protective earthing conductor in any supply cable or flexible cord to electrical equipment [other than Class II (double or reinforced insulation) equipment] connected to the separated circuit shall be connected to the equipotential bonding conductor.
(d) Exposed conductive parts of the source of supply that are earthed, shall not be simultaneously accessible with any exposed conductive part of the separated circuit.
(e) A protective device shall operate to disconnect the separated circuit automatically in the event of two faults resulting in exposed conductive parts being connected to live parts of different polarity. If the protective

device is a circuit-breaker, the protective device shall open in all
(i) unearthed conductors substantially together.

List the minimum values of Insulation Resistance that should be expected during the following tests on a circuit connected to an ISOLATED supply:

□Between transformer primary and secondarywindings:______________

□Between Isolated circuit active conductors andearth:________________

□Between Isolated circuit equipotential boning conductors andtransformer primary earth conductors:_____________________________________

AS/NZS 3000 reference _____________

7.4.8.1 General

In addition to the testing requirements of Section 8, the separation of each separated circuit (transformer secondary winding or isolated winding generator output) and the wiring to the socket-outlet shall be individually confirmed.

Separation shall be verified by a measurement of the insulation resistance between the separated circuit and—

(a) if a transformer is the source of the separated supply, the transformer primary winding;

(b) any other wiring;

(c) any other separated circuit; and

(d) earth.

Insulation resistance values obtained shall be not less than 1 MOhm, when tested at a voltage of 500 V d.c

NOTE: Where final subcircuits are not of significant length, the insulation resistance of the separated circuit should be significantly greater than 1 MOhm, e.g. with short lengths (say 50 m) of polymeric cable, a value in excess of 50 MOhm would be expected.

List the resistance you would expect to measure between the equipotentially bonded earth pins of multiple socket outlets connected as an ISOLATED circuit:

____

AS/NZS 3000 reference _____________

7.4.8.4 Bonding conductor continuity

The resistance of an equipotential bonding conductor for the earth contacts of socket-outlets, or exposed conductive parts connected to the same separated circuit, shall not exceed 0.5 ohm.

An electrical installation has an electric cook top. What are the requirements for the functional switch and in what position must the switch be located?

____

AS/NZS 3000 reference _____________

4.7 COOKING APPLIANCES

4.7.1 Switching device

A circuit for a fixed or stationary cooking appliance having an open cooking surface incorporating electric heating, e.g. a cooktop, deep fat fryer, barbecue griddle or similar, shall be provided with a switch, operating in all active conductors, mounted near the appliance in a visible and readily accessible position.

NOTE: This requirement need not apply to enclosed cooking appliances, such as built-in ovens and microwave ovens.

In Australia only, where the appliance has an open cooking surface incorporating both gas and electric cooking, the switching device shall operate in all live (active and neutral) conductors.

In New Zealand only, where the appliance has an open cooking surface incorporating both gas and electric cooking, the switching device shall operate in all active conductors.

A single switch is permissible for the control of associated cooking appliances that are in the same room.

The switch shall not be mounted on the cooking appliance.

NOTE: The switch should be mounted within 2 m of the cooking appliance.

The switch shall not be mounted in such a position that the user must reach across the open cooking surface to operate it.

Switches for cooking appliances, including the combined gas/electric cooking appliances specified in Clause 4.18.1, shall not be installed in the prohibited location specified in Clause 4.7.3 and Figure 4.17.

Switches shall be marked to identify the appliance controlled.

Exception: Where an electric cooking surface is installed in a public park or other open area, to prevent damage by vandalism, the switch may be installed under a lockable cover that is located so that it is able to be operated as required for servicing and maintenance purposes of the cooking surface.

4.7.2 Connection—New Zealand only

In New Zealand only, a freestanding cooking appliance shall be connected to the electrical installation wiring by a socket-outlet or an installation coupler.

NOTE: This requirement need not apply to built-in hobs and ovens.

* 4.7.3 Clearance from open cooking surfaces

Socket-outlets and switches shall not be installed in the prohibited location shown in Figure 4.17, on any wall, cupboard or other surface within 150 mm of the edge of an open gas or electric cooking surface, in the area extending from the top of the cooking surface to a range hood, cupboard or ceiling located directly above the cooking surface, or 2.5 m above the floor that is directly below the cooking surface, whichever is the lower.

Can the main switch for a pump that operates the fire sprinkler system in a building, be installed downstream of the general services main switch?

____

AS/NZS 3000 reference ______________

No

7.2.5.3 Switchgear for fire pumps and fire pump control equipment

Where emergency equipment is required by national building codes, all switchboards that sustain supply to such equipment shall be constructed so that the emergency equipment switchgear is separated from other switchgear by metal partitions designed to minimize the spread of a fault from the other switchgear to the emergency switchgear.

7.2.5.4 Interposing switches for fire pumps and fire pump control equipment

No switch shall be interposed between a main switch and downstream switchboards supplying fire pumps and fire pumps control equipment.

FAULT PROTECTION (AGAINST INDIRECT CONTACT)

Refer to **clause 1.4.35** - Contact, indirect:

Indirect contact is contact with a conductive part which is -

---

1.4.38 Contact, direct

Contact with a conductor or conductive part that is live in normal service (see Figure 1.2 and Clause 1.4.97 Protection, basic).

Exercise 1:

List 2 fault conditions that may cause conductive parts of electrical equipment to become 'live' as a result of the fault.

8.____

9.____

Insulation failure

Contact to live part

List 4 electrical items that may cause electric shock as a result of indirect contact.

10.______________________________________

__

11.____

12.____

13.____

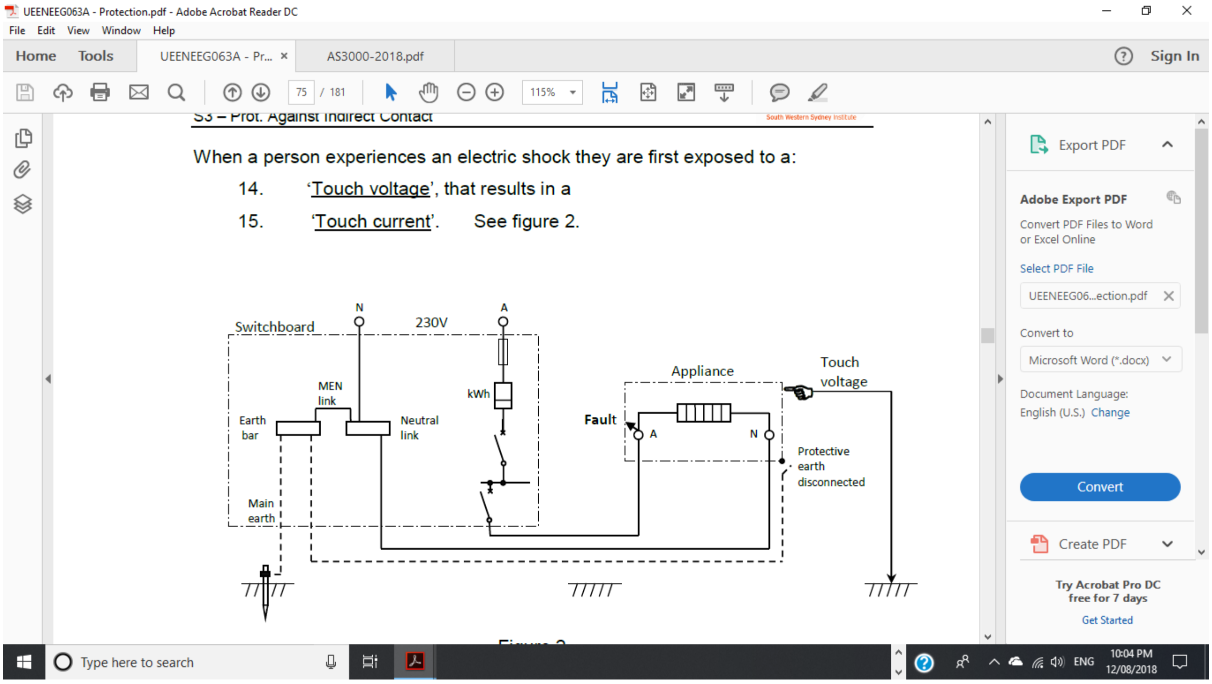
Electric Iron
Range
Electric Motor
Transformer

Refer to **clause 1.4.78** – Protection, fault:

'Fault Protection' must be provided to protect against –

1.4.98 Protection, fault

Protection against dangers that may arise from indirect contact with live parts of the installation (contact with an exposed conductive part that is not normally live but has become live under fault conditions) (see Figure 1.3 and Clause 1.4.39 Contact, indirect).



Refer to **clause 1.4.2** - Accessible, readily:
The term accessible means –

1.4.2 Accessible
* Capable of being reached for inspection, maintenance or repairs but does not include the destructive dismantling of structural components.
1.4.3 Accessible, readily
* Capable of being reached quickly and without climbing over or removing obstructions, or using a movable ladder, and in any case not more than 2.0 m above the ground, floor or platform

Refer to **clause 1.4.95** - Touch voltage:
A touch voltage is a voltage –

1.4.125 Touch voltage
Voltage appearing between simultaneously accessible parts.
NOTES:
1 This term is used only in connection with fault protection.
2 In certain cases the value of the touch voltage may be appreciably influenced by the impedance of the person or livestock in contact with these parts.

Refer to **clause 1.4.94** - Touch current:
A touch current is a current –

1.4.124 Touch current
Electric current that passes through a human body, or an animal body,

when that body touches one or more accessible parts of electrical equipment or an electrical installation, under normal conditions or fault conditions.

Clause 1.5.5 of the wiring rules sets out the requirements for fault protection.
Refer to **clause 1.5.5.2** – Methods of protection
Protection against indirect contact may be provided by one or any combination of the following methods –

16.____

17.____

18.____

19.____

1.5.5.2 Methods of protection
Fault protection shall be provided by one or any combination of the following methods:
(a) Automatically disconnect the supply on the occurrence of a fault likely to cause a current flow through a body in contact with exposed conductive parts, where the value of that current is equal to or greater than the shock current, in accordance with Clause 1.5.5.3.
(b) Prevent a fault current from passing through a body by the use of Class II equipment or equivalent insulation, in accordance with Clause 1.5.5.4.
(c) Prevent a fault current from passing through a body by electrical separation of the system, in accordance with Clause 1.5.5.5.
NOTE: Clause 7.4 provides further guidance on electrical separation.
(d) Limit the fault current that can pass through a body to a value lower than the shock current.

clause 1.5.5.3 (a) – Protection by automatic disconnection of supply
1.5.5.3 Protection by automatic disconnection of supply
The following applies:
(a) Automatic disconnection of supply is intended to limit the prospective touch voltage arising between simultaneously accessible conductive parts in the event of a fault between a live part and exposed conductive parts or a protective earthing conductor.
This method of protection shall be achieved by–
(i) provision of a system of equipotential bonding in which exposed conductive parts are connected to a protective earthing conductor; and
(ii) disconnection of the fault by a protective device.

Refer to **clause 1.5.5.3 (b)** – Touch voltage limits
In the event of a fault between a live part and an exposed conductive part that could give rise to a prospective touch voltage exceeding –
28.____

or

29.____,

(b) Touch-voltage limits In the event of a fault between a live part and an exposed conductive part that could give rise to a prospective touch voltage exceeding 50 V a.c. or 120 V ripple-free d.c., a protective device shall automatically disconnect the supply to the circuit or electrical equipment concerned.

Refer to **clause 1.5.5.3 (d)** – Disconnection times
The maximum disconnection time for 230/400V supply voltage shall not exceed the following –
30. ________ seconds for final sub-circuits that supply –

a)socket outlets having rated currents not exceeding 63A

b)hand held class I equipment

c)Portable equipment intended for manual movement during use

31.________ seconds for other circuits including sub-mains and final sub-circuitssupplying fixed or stationary equipment.

(d) Disconnection times The maximum disconnection time for 230/400 V supply voltage shall not exceed the following:
(i) 0.4 s for final subcircuits that supply–
(A) socket-outlets having rated currents not exceeding 63 A;
(B) hand-held Class I equipment; or
(C) portable equipment intended for manual movement during use.

Automatic disconnection of the supply relies on a combination of two conditions -
32.the provision of a conducting path, known as the "______________________",to provide for circulation of the fault current; and

33. the interruption of the fault current within the maximum time by an appropriateprotection device.

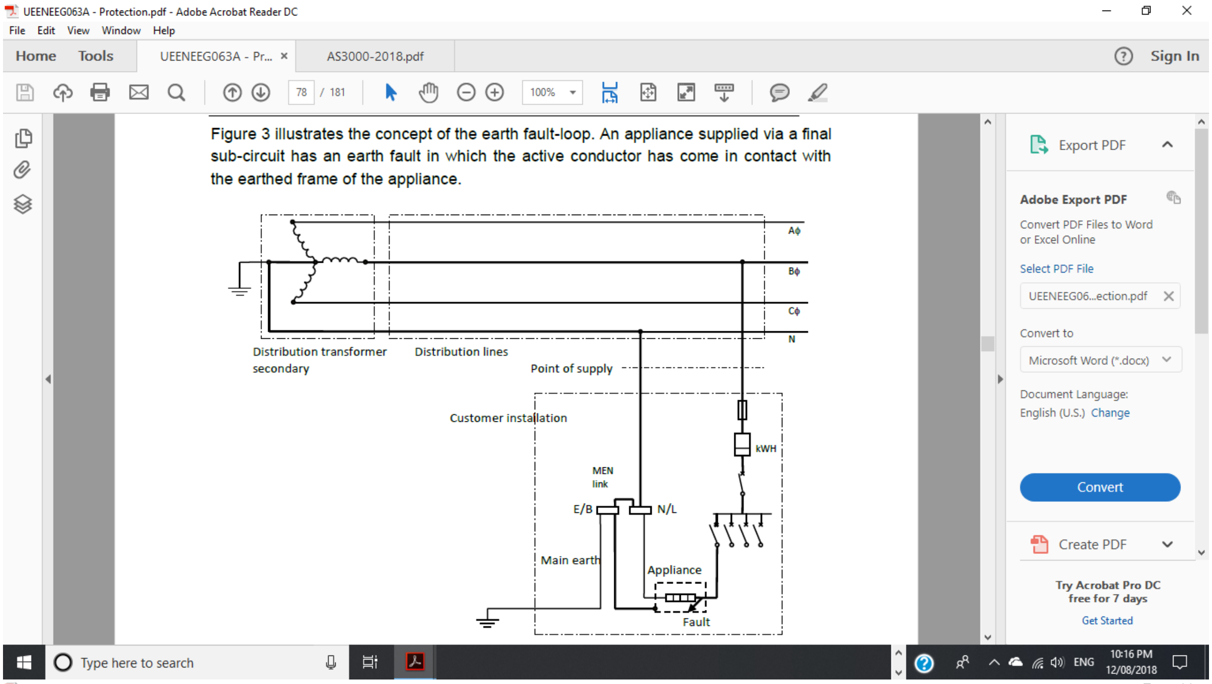
(ii) 5 s for other circuits including submains and final subcircuits supplying fixed or stationary equipment.

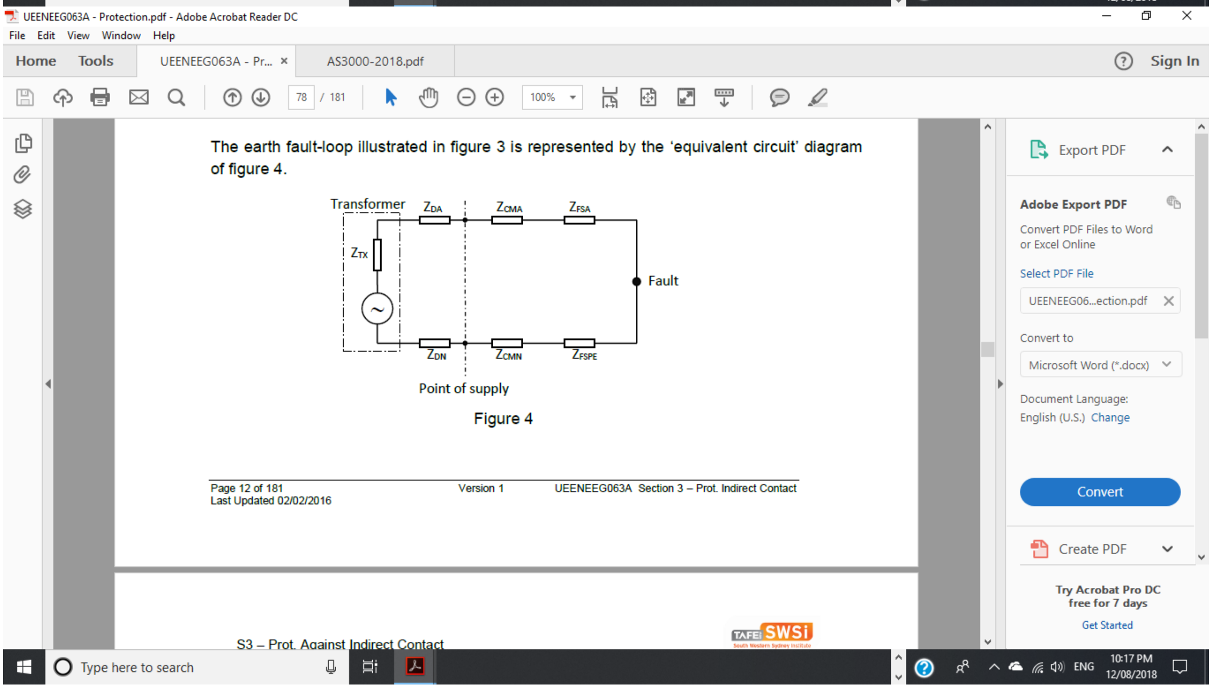
Automatic disconnection of the supply relies on a combination of two conditions -
32.the provision of a conducting path, known as the "____earth fault loop __________________",to provide for circulation of the fault current; and

33. the interruption of the fault current within the maximum time by an appropriateprotection device.

Supplementary equipotential bonding Bonding of extraneous conductive parts and their connection to the earthing system may be used to reduce the earth fault-loop impedance, in order to ensure that the disconnection time of the protective device is sufficient to satisfy the requirements of Items (b) to (d) above.

NOTE: This provision does not preclude other measures, such as selection of an alternative protective device that has a lower automatic operating current (I_a) within the required disconnection time, e.g. an RCD.





In the example shown in figures 3 and 4 –

34. if the touch voltage on the appliance frame rises to a value above ______V a.c.the circuit breaker protecting the circuit must operate within the prescribed timeto isolate the faulty circuit. 240V

35. Under fault conditions, the level of current that flows is only limited by the___________________Earth fault loop resistance_.

36. To ensure very fast operation of the circuit breaker the current that flows in theearth fault-loop must be __________high _______.

37. Therefore the earth fault-loop impedance must be __________low_____________to ensure operation of the protective device.

15.PROTECTION BY ELECTRICAL SEPARATION

The general requirements for protection by separation (isolated supply) have beencovered in section 2 of this workbook. Below is a review only of the requirementscovered in section 2 for electrical separation.

Electrical separation can provide protection from the potential hazard that may arise from the rest of the installation. Electrically separating a portion of a system means to electrically isolate it from the main supply grid and MEN system.

This method of protection typically uses a supply from:

38.______________________________________

39.______________________________________

40.______________________________________

2.5.1.2 Consumer mains

* Overcurrent protection of consumer mains shall be arranged in accordance with one of the following:

(a) Short-circuit protection and overload protection shall be provided at the origin of the consumer mains (the point of supply) (see Notes 1 and 2).

(b) Short-circuit protection shall be provided at the origin of the consumer mains and overload protection shall be provided at the main switchboard (see Notes 1, 3, and 4.)

(c) Short-circuit protection need not be provided where overload protection is provided at the main switchboard and the consumer mains are constructed and installed

1.5.5.5 Protection by electrical separation

Separation is intended, in an individual circuit, to prevent shock current through contact with exposed conductive parts that might be energized by a fault in the basic insulation of that circuit.

Live parts of a separated circuit shall not be connected at any point to earth or to another circuit.

Any protective bonding conductor associated with a separated circuit shall not be connected at any point to earth.

NOTE: Clause 7.4 contains requirements for protection by electrical separation

7.4.1 General

The particular requirements of this Clause (Clause 7.4) provide methods of protection against electric shock arising from indirect contact that are deemed to comply with Clause 1.5.5.5. These methods include that of protection by electrical separation of the supply.

Protection by electrical separation is an alternative to other recognized methods and is intended, in an individual circuit, to prevent shock current through contact with exposed conductive parts that might be energized by a

fault in the basic insulation of that circuit.
Protection by electrical separation shall be afforded by compliance with Clauses 7.4.2 to 7.4.4, and with—
(a) Clause 7.4.5 for a supply to one item of equipment; or
(b) Clause 7.4.6 for a supply to more than one item of equipment.

7.4.5 Supply to single item of electrical equipment
Where a separated circuit supplies a single item of electrical equipment, any exposed conductive parts of the electrical equipment shall not be connected to the exposed conductive parts of any other circuit, including other separated circuits or earth.
7.4.6 Supply to multiple items of electrical equipment
Where a separated circuit supplies more than one item of electrical equipment, the following requirements apply:
(a) Any exposed conductive parts of the separated circuit shall be connected together by an insulated equipotential bonding conductor that is not connected to—
(i) earth;
(ii) a protective earthing conductor or exposed conductive parts of another circuit, including another separated circuit; or
(iii) any extraneous conductive parts.
(b) The designated earthing contact of any socket-outlet installed on the separated circuit shall be connected to the equipotential bonding conductor.
(c) The designated protective earthing conductor in any supply cable or flexible cord to electrical equipment [other than Class II (double or reinforced insulation) equipment] connected to the separated circuit shall be connected to the equipotential bonding conductor.
(d) Exposed conductive parts of the source of supply that are earthed, shall not be simultaneously accessible with any exposed conductive part of the separated circuit.
(e) A protective device shall operate to disconnect the separated circuit automatically in the event of two faults resulting in exposed conductive parts being connected to live parts of different polarity. If the protective device is a circuit-breaker, the protective device shall open in all
(i) unearthed conductors substantially together.

Refer to **clause 1.5.5.5** – Protection by electrical separation
Protection by electrical separation is intended, in an individual circuit, to prevent shock current through contact with exposed conductive parts that might be energized by a fault in the basic insulation of that circuit.
Live parts of a separated circuit shall:
41.____

Any protective bonding conductor associated with a separated circuit shall:
42.____

NOTE: Clause 7.4 contains requirements for protection by electrical separation.

1.5.5.5 Protection by electrical separation
Separation is intended, in an individual circuit, to prevent shock current through contact with exposed conductive parts that might be energized by a fault in the basic insulation of that circuit.
Live parts of a separated circuit shall not be connected at any point to earth or to another circuit.
Any protective bonding conductor associated with a separated circuit shall not be connected at any point to earth.
NOTE: Clause 7.4 contains requirements for protection by electrical separation

Refer to **Clause 1.4.98** –Voltage
Extra Low Voltage is defined as voltage:
43.____

Protection can be provided by the use of:
44.________________________ or,

45.________________________

1.4.128 Voltage
Differences of potential normally existing between conductors or between conductors and earth as follows:
(a) Extra-low voltage Not exceeding 50 V a.c. or 120 V ripple-free d.c.
(b) Low voltage Exceeding extra-low voltage, but not exceeding 1000 V a.c. or 1500 V d.c.
(c) High voltage Exceeding low voltage.
7.5.9 Overcurrent protection
7.5.9.1 General
Every extra-low voltage circuit shall be individually protected at its origin against overload and short-circuit currents by a protective device that—
(a) shall comply with the applicable requirements of Clauses 2.2 and 2.5; and
(b) may be provided in one conductor less than the number of conductors in the circuit.
Where the extra-low voltage supply is earthed at the point of supply, the protective devices shall be installed in all the unearthed conductors.
2.5.2 Devices for protection against both overload and short-circuit currents
Protective devices providing protection against both overload and shortcircuit current shall be capable of breaking any overcurrent up to and including the prospective short-circuit current at the point where the device is installed.
The device shall comply with the requirements of Clauses 2.5.3 and 2.5.4.
Exception: A protective device having a breaking capacity below the value of the prospective short-circuit current may be used in conjunction with another device in accordance with Clause 2.5.7.2.

Protective devices may be one of the following:

(a) Circuit-breakers incorporating short-circuit and overload releases

(b) Fuse-combination units (CFS units).

(c) Fuses having enclosed fuse-links (HRC fuses).

(a) (d) Circuit-breakers in conjunction with fuses

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The use of fixed setting RCDs with a rated operating residual current not exceeding ______ mA, is recognized as providing additional protection in areas where excessive earth leakage current could present a significant risk of electric shock.

2.6.3.2.3.3 Requirements for additional protection

Additional protection by RCDs with a maximum rated residual current of 30 mA shall be provided for final subcircuits with a rating not exceeding 32 A supplying—

(a) socket-outlets;

(b) lighting;

RCD's provide protection against indirect contact by automatically disconnecting the supply from the affected circuit or circuits. As the current required to trip a RCD is very ________, it is not dependent on a very low 'fault loop impedance' value which is necessary to operate protective devices such as circuit breakers and fuses.

Low

1.4.102 Residual current device (RCD)

A device intended to isolate supply to protected circuits, socketoutlets or electrical equipment in the event of a current flow to earth that exceeds a predetermined value.

Refer to **clause 1.5.6** – Additional protection by the use of RCDs

Read clauses 1.5.6.1 to 1.5.6.3 and answer the following:

50. RCDs are ________________ as a sole means of basic protection

1.5.6.1 Basic protection

RCDs are not recognized as a sole means of basic protection (in normal service) but may be used to augment one of the means set out in Clause 1.5.4.2.

51. RCDs are recognized as a means of providing ______________________ of supply (fault protection)

1.5.6.2 Fault protection

RCDs are recognized as a means of providing automatic disconnection of supply in accordance with Clause 1.5.5.3

52.RCDs shall be installed for additional protection of the following:

(a)____________________________________

____
____
______________________________________ as specified in Clause 2.6

2.6.3.2.3.3 Requirements for additional protection
Additional protection by RCDs with a maximum rated residual current of 30 mA shall be provided for final subcircuits with a rating not exceeding 32 A supplying—
(a) socket-outlets;
(b) lighting;
(c) direct connected hand-held electrical equipment, e.g. directly connected tools; and
(d) direct connected electrical equipment that represents an increased risk of electric shock.
Factors that may represent an increased risk of electric shock include but are not limited to—
(i) external influences (refer Clause 1.5.14); and
(ii) type of electrical installation and processes being conducted (e.g. workshops and particular industrial activities).

(b) Wiring systems as specified in Clause _______________

2.6.3.2.1 General
RCD installation requirements, for Australia only, shall comply with Clauses 2.6.3.2.2 to 2.6.3.2.6.
Exceptions: These requirements need not apply to the following:
1 Final subcircuits supplied at ELV in accordance with Clause 7.5.
2 Final subcircuits supplied from a separated supply in accordance with Clause 7.4.

(c) Electric heating cables as specified in Clause 4.10.5.
(d) Electrical equipment, including socket-outlets, installed in ________
________________as specified in Section 6.

2.6.3.1 General
The requirements of this Clause for the installation of RCDs are in addition to the RCD requirements for electrical installations as specified in—
(a) other Australian and New Zealand Standards, e.g. AS/NZS 3001, AS/NZS 3002, AS/NZS 3003, AS/NZS 3004 series and AS/NZS 3012;
(b) other Sections of this Standard, e.g.—
(i) Section 3 for protection against mechanical damage;
(ii) Section 6 for baths, showers and other water containers; and
(iii) Section 7 for special electrical installations; and
(c) the requirements and regulations of legislation, such as work health and safety legislation.
(e) Specific electrical installations as specified in AS/NZS 3001, AS/NZS 3002, AS/NZS 3003, AS/NZS 3004, AS/NZS 3012 and AS/NZS 4249.

Refer to **clause 1.4.40** – Damp Situation
A damp situation is defined as a situation in which:

Refer to **Section 6 – Damp Situations** and **clause 6.1.2** – Selection and Installation
In addition to the requirements of AS3000 sections 1 - 5, electrical equipment used in damp situations shall be selected and installed to perform the following functions associated with the proper design, correct construction and safe operation of the electrical installation:
(a) Provide ___________ ___________ against **electric shock** in locations where the presence of _________ or high ____________ present an increased risk.

(b) Provide ___________ protection against **damage** that might reasonably be expected from the presence of water or high humidity.

6.1.2 Selection and installation
In addition to the requirements of Sections 2 to 5 of this Standard, electrical equipment used in damp situations shall be selected and installed to perform the following functions:
(a) Provide enhanced protection against electric shock in locations where the presence of water or high humidity present an increased risk.
NOTE: This increased risk of electric shock is generated by a reduction in body resistance and the likelihood of contact of the body with earth potential.
(b) Provide adequate protection against damage that might reasonably be expected from the presence of water or high humidity.
NOTE: Appendix G describes the IP system of classification of degrees of
(c) protection for electrical equipment.

AS3000 defines specific additional requirements for equipment installed in the following damp situations:

- ☐ __________________________
- ☐ __________________________
- ☐ __________________________
- ☐ __________________________

This Section applies to the following damp situations:
(i) Baths, showers and other fixed water containers.
(ii) Swimming pools, paddling pools and spa pools or tubs.
(iii) Fountains and water features.
(iv) Saunas.
(v) Refrigeration rooms.
(vi) Sanitization and general hosing-down operations.
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17.INTERNATIONAL PROTECTION RATINGS

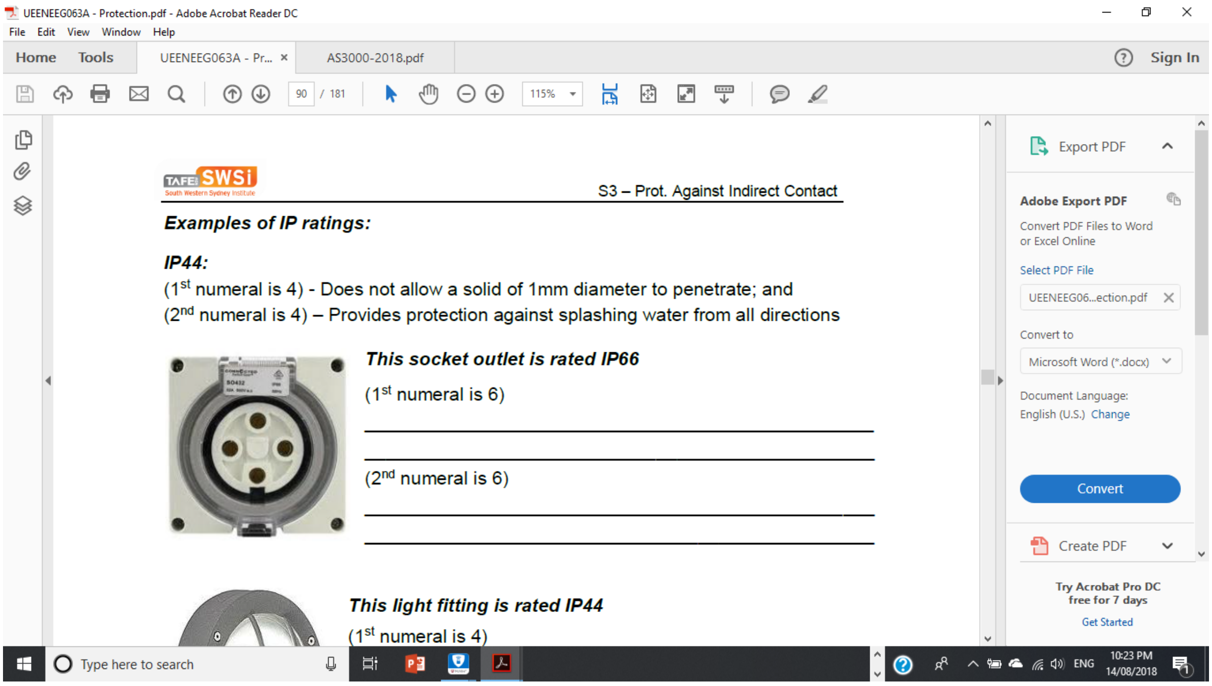
Refer to AS/NZS 3000 **Appendix G** – G1 Introduction.
The 'IP' rating is usually written as 'IP' followed by two numbers and, sometimes, anadditional letter.

□The first number, from1 to 6 designates a degree of protection against_____________________________

□The second number, from 1 to 8, designates a degree of protection against_____________________________

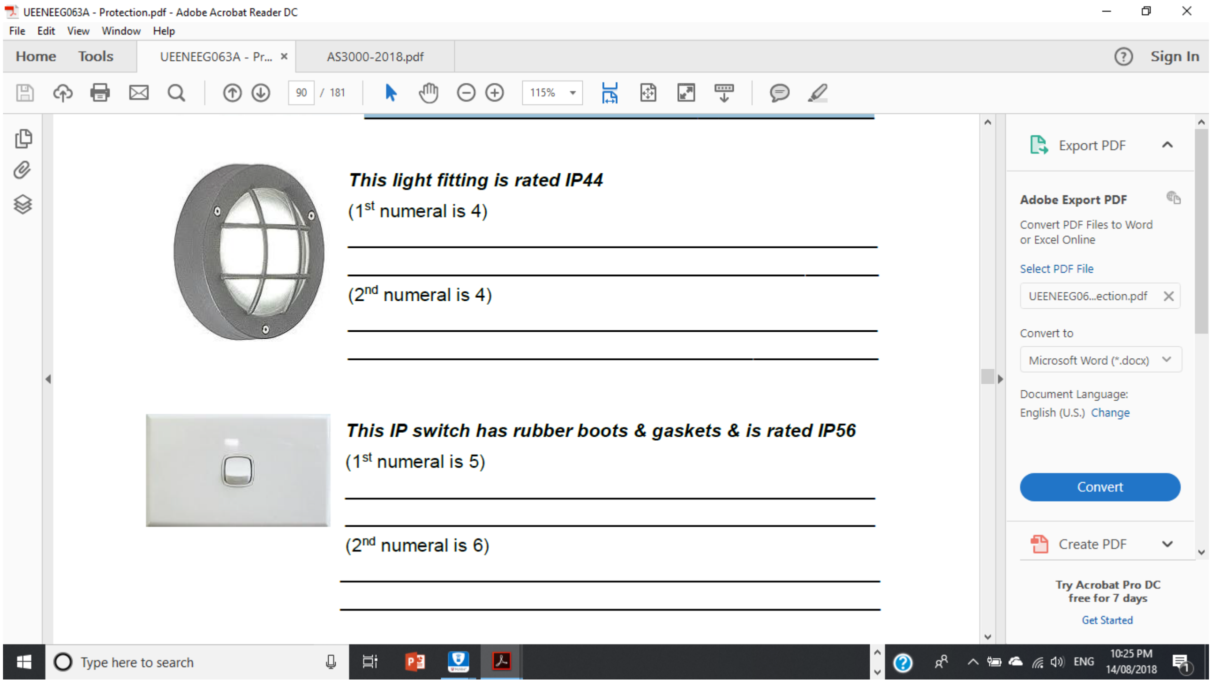
If a specific degree of protection is not designated, an 'X' is used instead of either one or both numbers. See AS/NZS 3000 figures G1a to G1d below.

The first number, from 1 to 6, designates a degree of 'protection against solid objects', and 'protection of persons against access to hazardous parts'.
The second number, from 1 to 8, designates a degree of 'protection against entry of water with harmful effects'.
If a specific degree of protection is not designated, an 'X' is used instead of either one or both numbers.

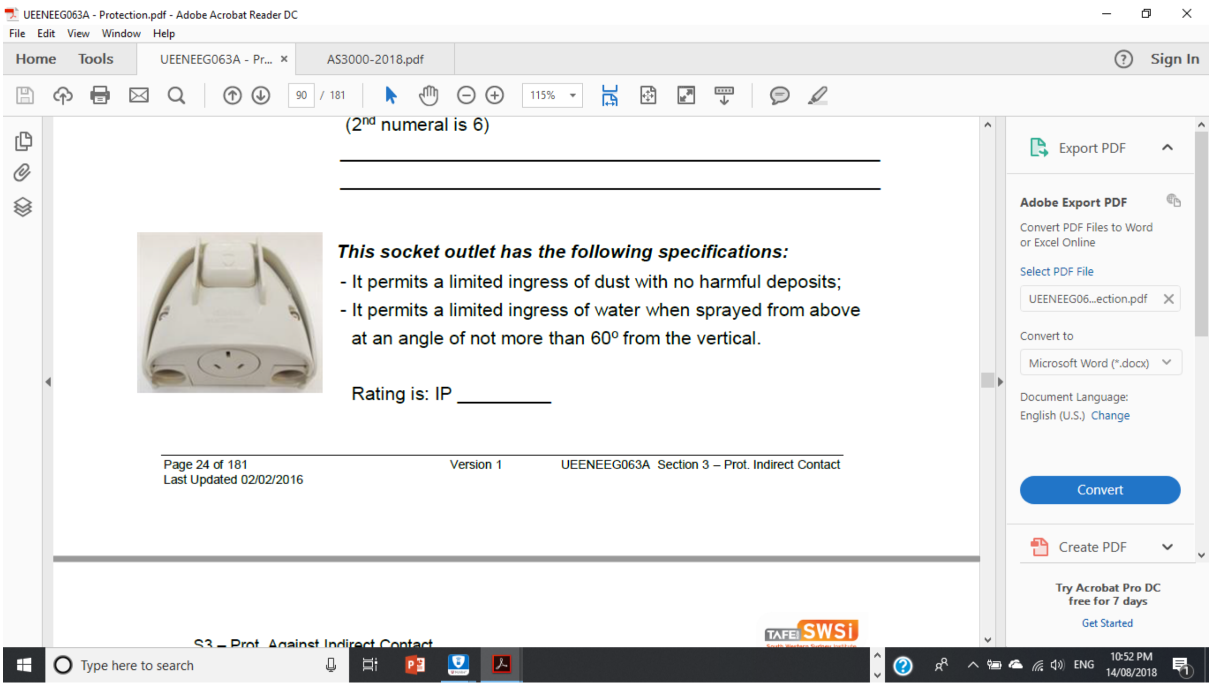


This socket outlet is rated IP66
(1st numeral is 6)
Totally protected against ingress of dust_____________________________

(2nd numeral is 6)
Protected against strong jets of water. Limited ingress permitted_____________________________



(1st numeral is 4)
The access probe of 1.0 mm
diameter is not to penetrate
Protected against water
Second number is 4
splashed from all directions.
Limited ingress permitted



Limited ingress of dust
permitted (no harmful deposit)--- First Number 5
Protected against sprays to 60°
from the vertical. Limited
ingress permitted—Second number 3 IP 53

Baths, showers & other fixed water containers

a)	What is the minimum horizontal distance (↔) that a non I.P. rated socket outlet may be installed next to a bath?	
b)	What is the minimum horizontal distance (↔) that a non I.P. rated light switch may be installed next to a bath?	
c)	To what horizontal distances (↔) does zone 2 of a bath without a fixed barrier extend?	
d)	What is the minimum horizontal distance (↔) that a non I.P. rated socket outlet may be installed next to a shower screen?	
e)	To what vertical distances (↕) does zone 2 of a shower base without a fixed barrier extend?	
f)	What is the minimum horizontal distance (↔) that a non I.P. rated socket outlet may be installed next to a hand basin <45L?	
g)	What is the minimum vertical distance (↕) than a non I.P. rated socket outlet may be installed above a bathroom floor?	
h)	What is the minimum horizontal distance (↔) that a non I.P. rated socket outlet may be installed next to a kitchen sink <45L?	
i)	What is the minimum horizontal distance (↔) that a non I.P. rated socket outlet may be installed next to a laundry tub >45L?	

a)

* Electricity generation systems, including engine-driven generator sets, stand-alone power systems, grid-connected inverter systems and battery systems shall not be installed within any classified zone.

TABLE 6.1

SELECTION AND INSTALLATION OF ELECTRICAL EQUIPMENT FOR BATHS, SHOWERS AND OTHER FIXED WATER CONTAINERS

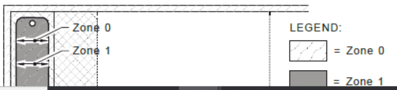
Equipment	Zone 0	Zone 1	Zone 2	Zone 3
Clause 6.2.4.2— Socket-outlets	Not permitted	Not permitted	(a) A shaver outlet; or (b) RCD-protected and in a cupboard (no specific IP rating).	(a) <0.3 m not permitted (b) ≥0.3 m no IP rating† but shall have— (i) RCD protection; (ii) separated supply; or (iii) SELV or PELV supply.
Clause 6.2.4.3— Switches/ accessories	Not permitted	Same as Zone 2	<0.3 m not permitted ≥0.3 m IPX4†	<0.3 m not permitted ≥0.3 m—No IP rating†

(continued)

TABLE 6.1 *(continued)*

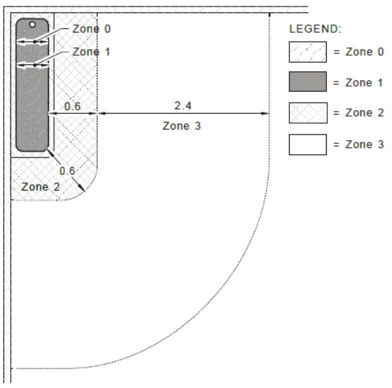
Equipment	Zone 0	Zone 1	Zone 2	Zone 3
Clause 6.2.4.4—Luminaires	IPX7 and specifically for use and SELV or PELV supply	IPX4†	IPX4†; or Class II construction (double or reinforced insulation); or SELV or PELV; or recessed into ceiling	No IP rating†
Clause 6.2.4.5—Other electrical equipment	IPX7 and specifically for use and SELV or PELV supply	IPX4†	IPX4†; or recessed into ceiling	No IP rating†
Clause 6.2.4.6—Switchboards	Not permitted	Not permitted	Not permitted	Not permitted
* Clause 6.2.4.7—Electricity generation systems	Not permitted	Not permitted	Not permitted	Not permitted

† Degree of protection IPX5 required in communal baths/showers.



systems

† Degree of protection IPX5 required in communal baths/showers.



DIMENSIONS IN METRES

FIGURE 6.1 ZONE DIMENSIONS (PLAN)—
BATH WITHOUT SHOWER OR FIXED BARRIER

Refer to AS/NZS3000 **Table 6.2** and **figures 6.12 to 6.16** and answer the following:

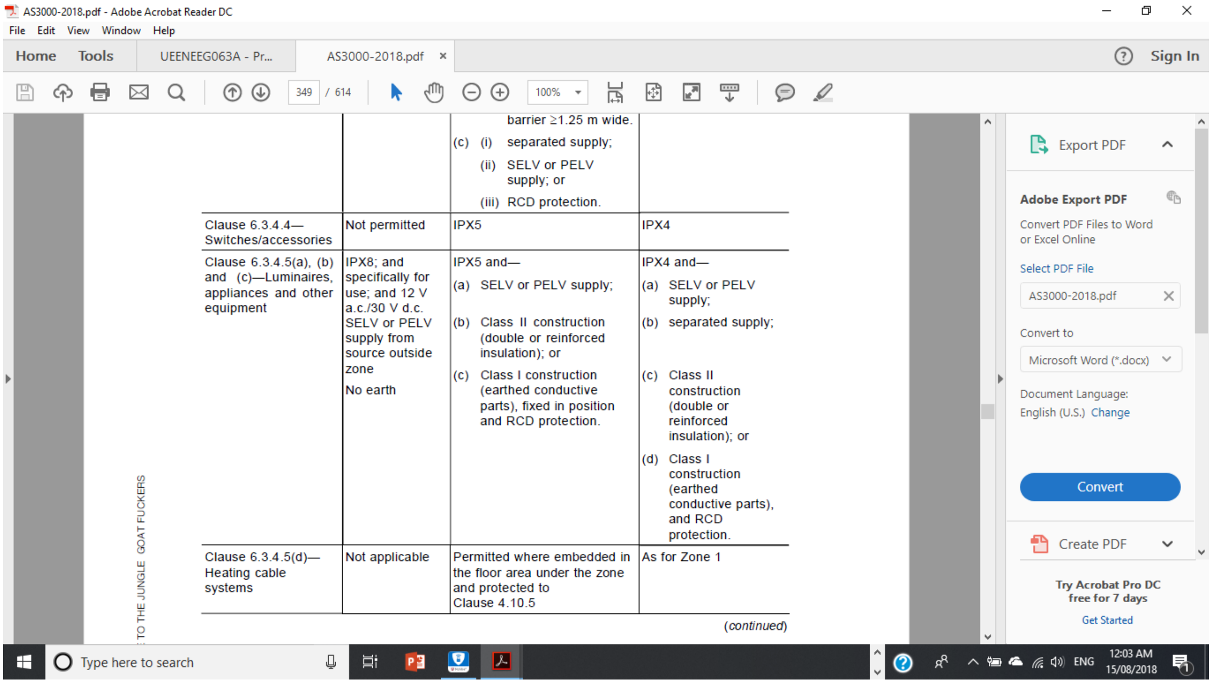
Pools, paddling pools & spa pools or tubs

a)	What area is described as zone 0 of an in-ground swimming pool?	
b)	To what horizontal distances (↔) does zone 1 of an in-ground swimming pool extend from the water's edge?	
c)	Is it permissible to install an I.P. 53 rated 10A socket outlet at a horizontal distance (↔) of 1.5m from the internal rim of the pool to supply the pool pump? (without further enclosure)	
d)	Is it permissible to install a 230V light fitting at a horizontal distance (↔) of 2.1m from the internal rim of the pool?	
e)	Is a water container with a capacity of 4000L classed as a pool or a spa?	
f)	What are the requirements for pool lights installed in zone 0 of a pool or spa zone?	

TABLE 6.2

SELECTION AND INSTALLATION OF ELECTRICAL EQUIPMENT FOR SWIMMING POOLS, PADDLING POOLS AND SPA POOLS OR TUBS

Equipment	Zone 0	Zone 1	Zone 2
Clause 6.3.4.3—Socket-outlets	Not permitted	Not permitted for general use For pool equipment only: (a) IPX5. (b) (i) ≥0.45 m high; and ≥1.25 m from internal rim; or (ii) under and ≥0.5 m from edge of fixed continuous horizontal barrier ≥1.25 m wide. (c) (i) separated supply; (ii) SELV or PELV supply; or (iii) RCD protection.	IPX4 and— (a) separated supply; (b) SELV or PELV supply; or (c) RCD protection.
Clause 6.3.4.4—Switches/accessories	Not permitted	IPX5	IPX4
Clause 6.3.4.5(a), (b) and (c)—Luminaires, appliances and other equipment	IPX8; and specifically for use; and 12 V a.c./30 V d.c. SELV or PELV	IPX5 and— (a) SELV or PELV supply; (b) Class II construction	IPX4 and— (a) SELV or PELV supply; (b) separated supply;



		barrier ≥1.25 m wide. (c) (i) separated supply; (ii) SELV or PELV supply; or (iii) RCD protection.	
Clause 6.3.4.4—Switches/accessories	Not permitted	IPX5	IPX4
Clause 6.3.4.5(a), (b) and (c)—Luminaires, appliances and other equipment	IPX8; and specifically for use; and 12 V a.c./30 V d.c. SELV or PELV supply from source outside zone No earth	IPX5 and— (a) SELV or PELV supply; (b) Class II construction (double or reinforced insulation); or (c) Class I construction (earthed conductive parts), fixed in position and RCD protection.	IPX4 and— (a) SELV or PELV supply; (b) separated supply; (c) Class II construction (double or reinforced insulation); or (d) Class I construction (earthed conductive parts), and RCD protection.
Clause 6.3.4.5(d)—Heating cable systems	Not applicable	Permitted where embedded in the floor area under the zone and protected to Clause 4.10.5	As for Zone 1

(continued)

*19.*EQUIPOTENTIAL BONDING IN DAMP SITUATIONS

Refer to **clause 5.6.2.5** – Showers and bathrooms
Any conductive reinforcing within a concrete floor or wall of a room containing a shower or bath shall be bonded to the earthing system of the electrical installation.
An equipotential bonding conductor, in accordance with Clause 5.6.3, shall be connected between the reinforcing material and any part of the earthing system.
The minimum CSA of the equipotential bonding conductor shall be _______mm^2

5.6.3.2 Size
The size of equipotential bonding conductors shall be determined from the requirements of this Clause 5.6.3, as appropriate to the particular bonding conductor application.
The size of equipotential bonding conductors shall be in accordance with the following:
(a) Conductive piping, cable sheaths and wiring enclosures The equipotential bonding conductor required in accordance with Clauses 5.6.2.2 to 5.6.2.4 shall have a cross-sectional area not less than 4 mm^2.
(b) Showers, bathrooms, swimming and spa pools The equipotential bonding conductors required to connect conductive parts of a shower, bathroom, swimming or spa pool in accordance with Clauses 5.6.2.5 and 5.6.2.6 shall have a cross-sectional area not less than 4 mm^2.
Exception: The cross-sectional area of the equipotential bonding conductor for a swimming or spa pool may be determined as for an earthing conductor, in accordance with Clause 5.3.3.4(c), where the equipotential bonding conductor is incorporated in a multi-core flexible cord supplying electrical equipment that is required to be removed for maintenance.
(c) Telephone and telecommunication earthing systems The

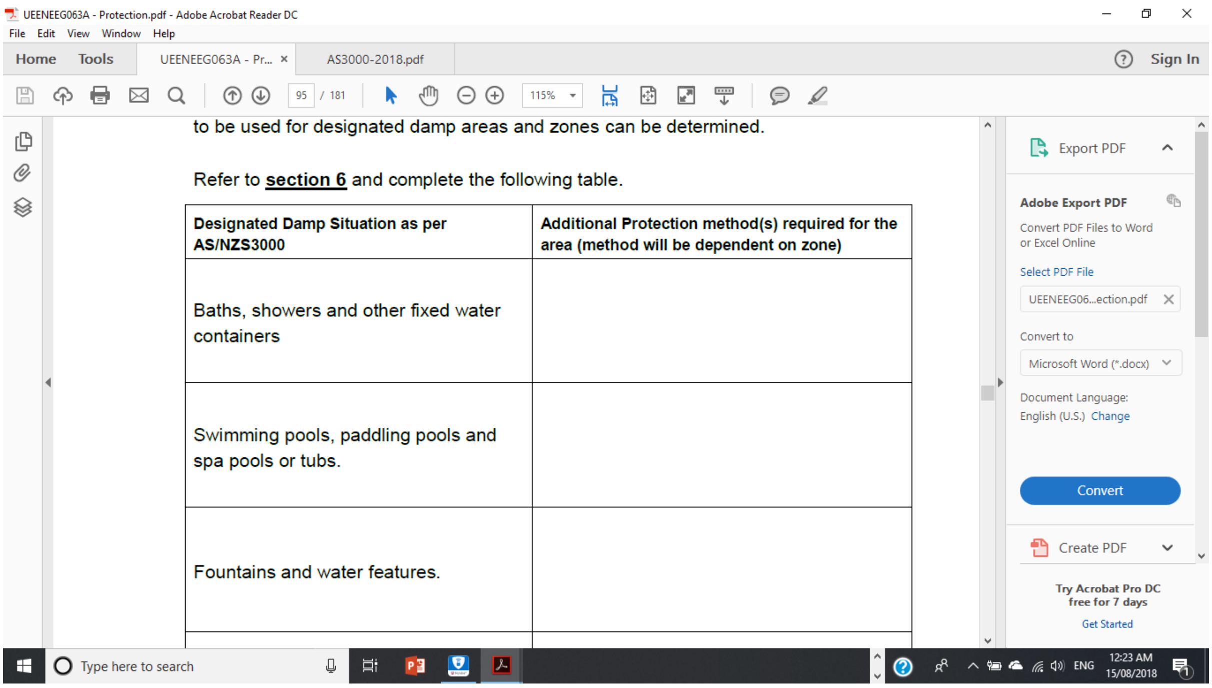
equipotential bonding conductors required to connect a telephone and telecommunication earthing system in accordance with Clause 5.6.2.7 shall have a cross-sectional area not less than 6 mm^2.

NOTE: Refer to the AS/NZS 60079 series for minimum sizes of equipotential bonding conductors in explosive atmospheres.

Refer to **clause 5.6.2.6** – Swimming and spa pools
The following items shall be equipotentially bonded:
(a) The exposed conductive part of any electrical equipment in the classified pool zones.
(b) Any ________________________________ of electrical equipment that are not separated from live parts by double insulation and that are in contact with the pool water, including water in the circulation or filtering system.
5.6.2.6.4 Electrical equipment
The following items associated with electrical equipment shall be equipotentially bonded:
(a) The exposed conductive parts of any electrical equipment in the classified pool zones.
(b) Any exposed conductive parts of electrical equipment in contact with the pool water, including water in the circulation or filtration system, e.g. filtration pumps and heating systems

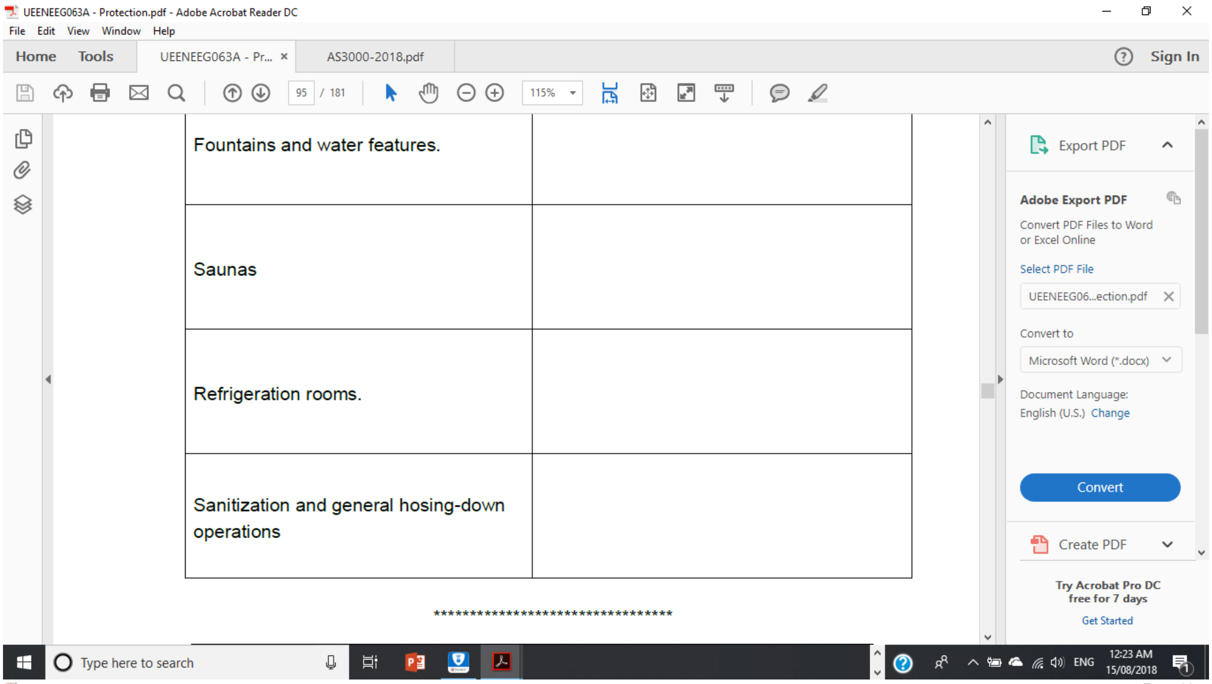
Where any of the items described in Item (a) or Item (b) exist, the bonding shall be extended to the following additional items:
(i) Any fixed ________________ conductive parts of the pool structure, including the ____________________ of the pool shell and deck.
(ii) Any conductive fittings within or attached to the pool structure, such as pool ladders and diving boards.
(iii) Any fixed conductive material within arm's reach of the pool edge, such as conductive fences, lamp standards and pipe work.
An equipotential bonding conductor, in accordance with Clause 5.6.3, shall be connected between the bonded parts and the earthing conductor associated with each circuit supplying the pool or spa, or the earthing bar at the switchboard at which the circuit originates.
The minimum CSA of the equipotential bonding conductor shall be _______mm^2
5Where any items specified in Clauses 5.6.2.6.2 or 5.6.2.6.4 are required to be equipotentially bonded, the bonding shall be extended to any fixed conductive material (such as pool ladders, diving boards, conductive fences, pipework and reinforcing metal in a concrete slab) that is installed within arm's reach of the pool edge, and that is in contact with the general mass of earth either directly or indirectly.
The size of equipotential bonding conductors shall be in accordance with the following:
5.6.3 Bonding conductors
(a) Conductive piping, cable sheaths and wiring enclosures The equipotential bonding conductor required in accordance with Clauses 5.6.2.2 to 5.6.2.4 shall have a cross-sectional area not less than 4 mm^2.
(b) Showers, bathrooms, swimming and spa pools The equipotential bonding conductors required to connect conductive parts of a shower,

bathroom, swimming or spa pool in accordance with Clauses 5.6.2.5 and 5.6.2.6 shall have a cross-sectional area not less than 4 mm^2.
Exception: The cross-sectional area of the equipotential bonding conductor for a swimming or spa pool may be determined as for an earthing conductor, in accordance with Clause 5.3.3.4(c), where the equipotential bonding conductor is incorporated in a multi-core flexible cord supplying electrical equipment that is required to be removed for maintenance.
(c) Telephone and telecommunication earthing systems The equipotential bonding conductors required to connect a telephone and telecommunication earthing system in accordance with Clause 5.6.2.7 shall have a cross-sectional area not less than 6 mm^2.


to be used for designated damp areas and zones can be determined.

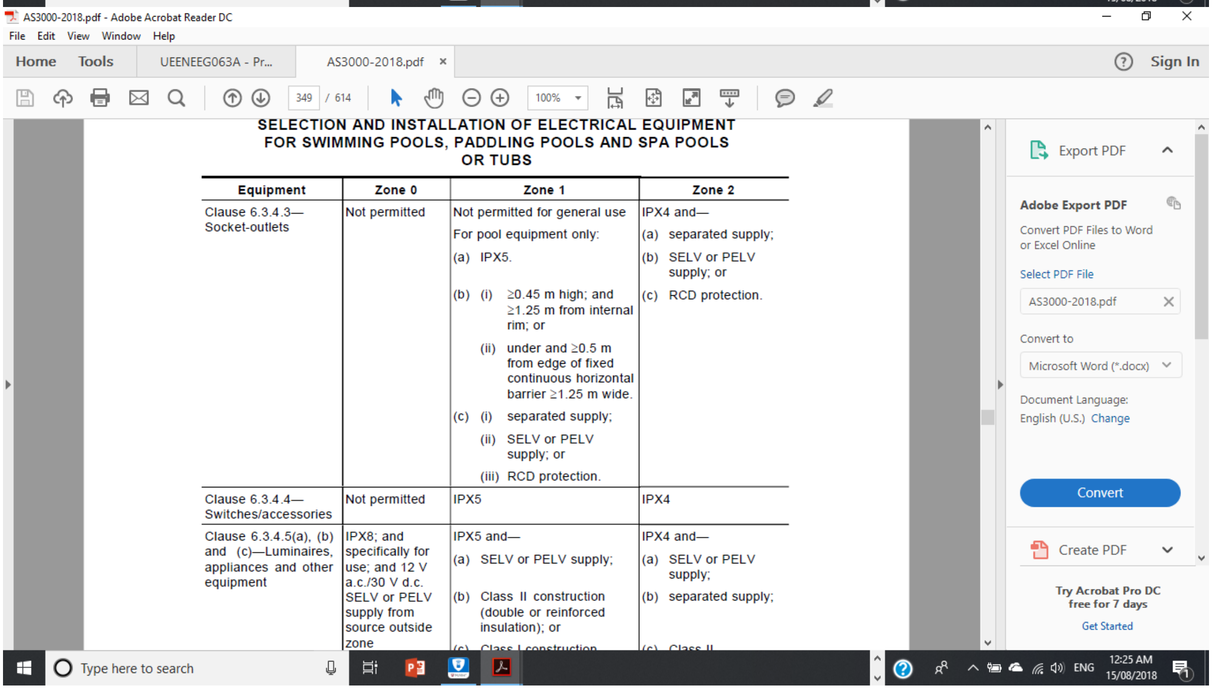
Refer to **section 6** and complete the following table.

Designated Damp Situation as per AS/NZS3000	**Additional Protection method(s) required for the area (method will be dependent on zone)**
Baths, showers and other fixed water containers	
Swimming pools, paddling pools and spa pools or tubs.	
Fountains and water features.	



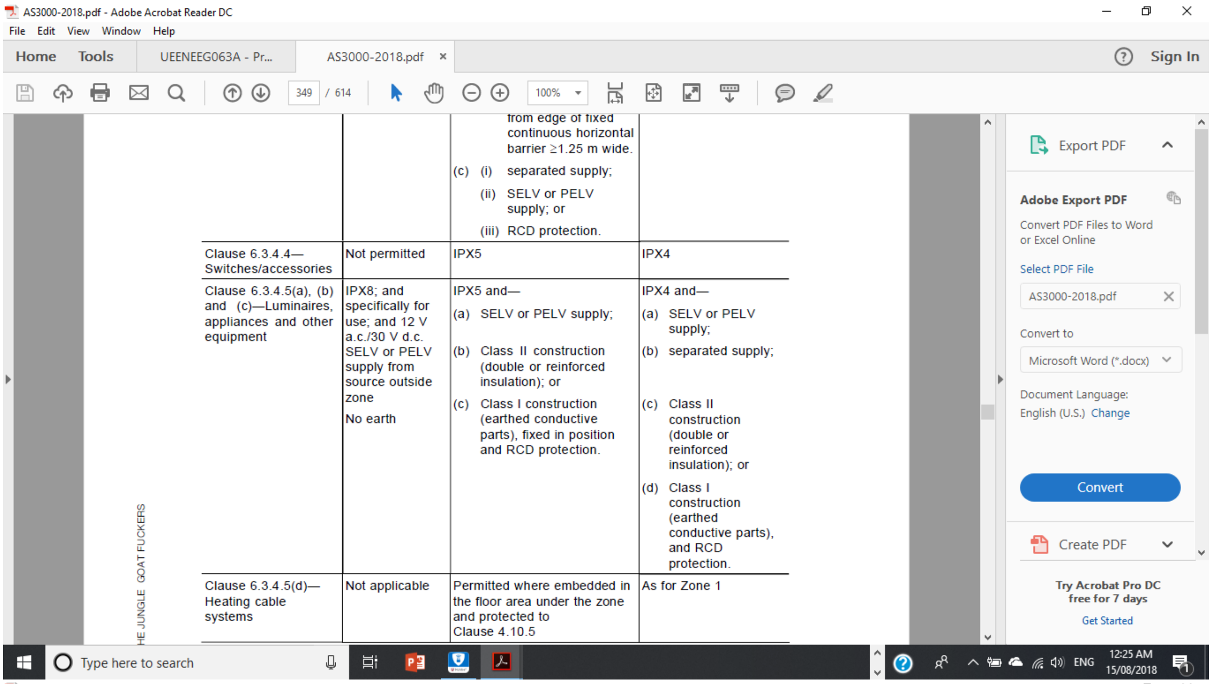
Fountains and water features.	
Saunas	
Refrigeration rooms.	
Sanitization and general hosing-down operations	

****

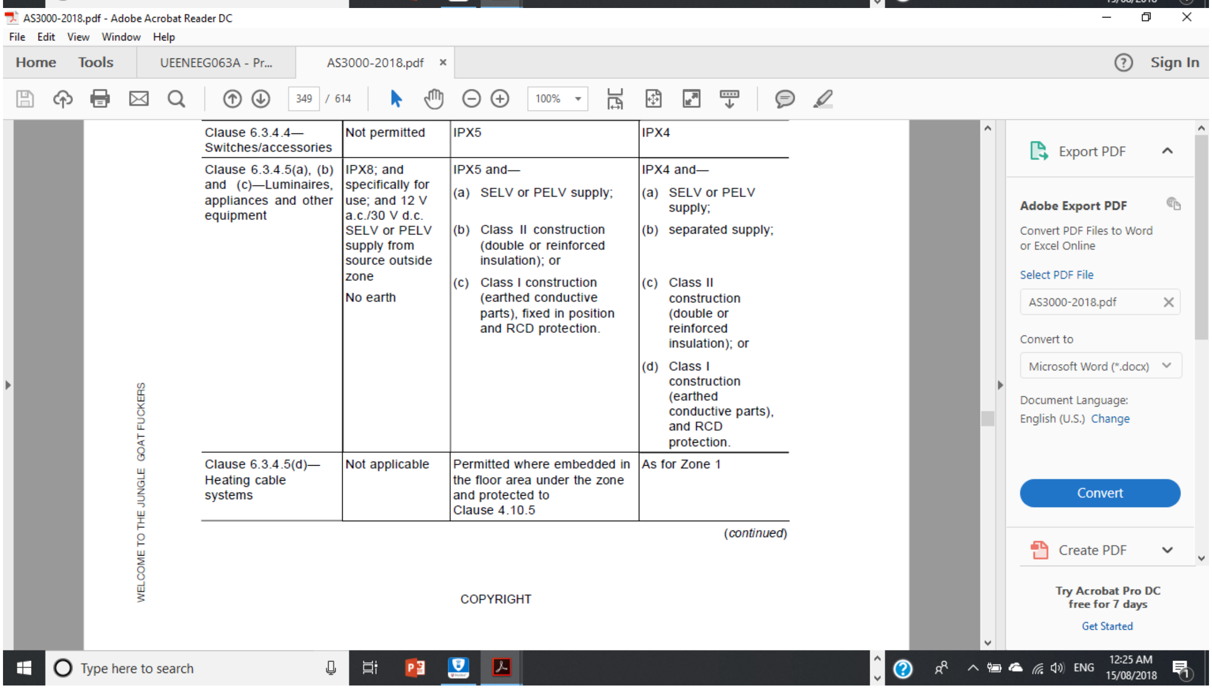


SELECTION AND INSTALLATION OF ELECTRICAL EQUIPMENT FOR SWIMMING POOLS, PADDLING POOLS AND SPA POOLS OR TUBS

Equipment	Zone 0	Zone 1	Zone 2
Clause 6.3.4.3—Socket-outlets	Not permitted	Not permitted for general use For pool equipment only: (a) IPX5. (b) (i) ≥0.45 m high; and ≥1.25 m from internal rim; or (ii) under and ≥0.5 m from edge of fixed continuous horizontal barrier ≥1.25 m wide. (c) (i) separated supply; (ii) SELV or PELV supply; or (iii) RCD protection.	IPX4 and— (a) separated supply; (b) SELV or PELV supply; or (c) RCD protection.
Clause 6.3.4.4—Switches/accessories	Not permitted	IPX5	IPX4
Clause 6.3.4.5(a), (b) and (c)—Luminaires, appliances and other equipment	IPX8; and specifically for use; and 12 V a.c./30 V d.c. SELV or PELV supply from source outside zone	IPX5 and— (a) SELV or PELV supply; (b) Class II construction (double or reinforced insulation); or (c) Class I construction	IPX4 and— (a) SELV or PELV supply; (b) separated supply; (c) Class II



		from edge of fixed continuous horizontal barrier ≥1.25 m wide. (c) (i) separated supply; (ii) SELV or PELV supply; or (iii) RCD protection.	
Clause 6.3.4.4—Switches/accessories	Not permitted	IPX5	IPX4
Clause 6.3.4.5(a), (b) and (c)—Luminaires, appliances and other equipment	IPX8; and specifically for use; and 12 V a.c./30 V d.c. SELV or PELV supply from source outside zone No earth	IPX5 and— (a) SELV or PELV supply; (b) Class II construction (double or reinforced insulation); or (c) Class I construction (earthed conductive parts), fixed in position and RCD protection.	IPX4 and— (a) SELV or PELV supply; (b) separated supply; (c) Class II construction (double or reinforced insulation); or (d) Class I construction (earthed conductive parts), and RCD protection.
Clause 6.3.4.5(d)—Heating cable systems	Not applicable	Permitted where embedded in the floor area under the zone and protected to Clause 4.10.5	As for Zone 1



Clause 6.3.4.4—Switches/accessories	Not permitted	IPX5	IPX4
Clause 6.3.4.5(a), (b) and (c)—Luminaires, appliances and other equipment	IPX8; and specifically for use; and 12 V a.c./30 V d.c. SELV or PELV supply from source outside zone No earth	IPX5 and— (a) SELV or PELV supply; (b) Class II construction (double or reinforced insulation); or (c) Class I construction (earthed conductive parts), fixed in position and RCD protection.	IPX4 and— (a) SELV or PELV supply; (b) separated supply; (c) Class II construction (double or reinforced insulation); or (d) Class I construction (earthed conductive parts), and RCD protection.
Clause 6.3.4.5(d)—Heating cable systems	Not applicable	Permitted where embedded in the floor area under the zone and protected to Clause 4.10.5	As for Zone 1

(continued)

When protection against indirect contact is provided by automatic disconnection of the supply, what is the maximum disconnection time for –

e)a power circuit with a rating of less than 63A

f)equipment that has only single insulation

g)an electric range

h)a submain.
(a)____________________(b)____________________(c)____________________
(d)____________________________ AS/NZS 3000 reference ___________
1.5.5.3 Protection by automatic disconnection of supply

(d) Disconnection times The maximum disconnection time for 230/400 V supply voltage shall not exceed the following:
(i) 0.4 s for final subcircuits that supply—
(A) socket-outlets having rated currents not exceeding 63 A;
(B) hand-held Class I equipment; or
(C) portable equipment intended for manual movement during use.
(ii) 5 s for other circuits including submains and final subcircuits supplying fixed or stationary equipment.

If a "touch voltage" exceeds certain values a protective device must disconnect thesupply. What are the limits of "touch voltage"?

____ AS/NZS 3000 reference ____________

1.5.5.3 Protection by automatic disconnection of supply
(b) Touch-voltage limits In the event of a fault between a live part and an exposed conductive part that could give rise to a prospective touch voltage exceeding 50 V a.c. or 120 V ripple-free d.c., a protective device shall automatically disconnect the supply to the circuit or electrical equipment concerned.
NOTE: Lower touch-voltage limits are required for special electrical installations or locations by the relevant clauses of Sections 6 and 7.

What are the four acceptable methods for protection against indirect contact specified in AS/NZS 3000:2007?

____

____ AS/NZS 3000 reference

1.5.5.2 Methods of protection
Fault protection shall be provided by one or any combination of the following methods:
(a) Automatically disconnect the supply on the occurrence of a fault likely to cause a current flow through a body in contact with exposed conductive parts, where the value of that current is equal to or greater than the shock current, in accordance with Clause 1.5.5.3.
(b) Prevent a fault current from passing through a body by the use of Class II equipment or equivalent insulation, in accordance with Clause 1.5.5.4.
(c) Prevent a fault current from passing through a body by electrical separation of the system, in accordance with Clause 1.5.5.5.
NOTE: Clause 7.4 provides further guidance on electrical separation.
(d) Limit the fault current that can pass through a body to a value lower than the shock current.

7.Protection against indirect contact by automatic disconnection of the supply is achieved by two factors. What are the two factors?

____
_____________________________________ AS/NZS 3000 reference____________

1.5.5.3 Protection by automatic disconnection of supply
The following applies:
(a) Automatic disconnection of supply is intended to limit the prospective touch voltage arising between simultaneously accessible conductive parts in the event of a fault between a live part and exposed conductive parts or a protective earthing conductor.
This method of protection shall be achieved by—
(i) provision of a system of equipotential bonding in which exposed conductive parts are connected to a protective earthing conductor; and
(ii) disconnection of the fault by a protective device.

8.Where may socket outlets be installed in a pool zone for the connection of pool equipment?

____
_____________________________________ AS/NZS 3000 reference ____________

6.2.4.2 Socket-outlets
Socket-outlets shall not be installed within 0.3 m of the floor of a bathroom, laundry or other similar location where the floor is likely to become wet.
Regardless of the degree of protection provided by the equipment, the following requirements apply to the installation of socket-outlets in classified zones:
(a) Zone 0 and Zone 1 Socket-outlets shall not be installed in Zone 0 or 1.
(b) Zone 2 Socket-outlets installed in Zone 2 shall be—
(i) of the automatic switching type incorporated in a shaver supply unit complying with AS/NZS 3194; or
(ii) protected by an RCD with a fixed rated residual current not exceeding 30 mA and enclosed in a cupboard that maintains the enclosure of the socket-outlet during normal operation of the connected equipment.
(c) Zone 3 Socket-outlets installed in Zone 3 shall be—
(i) protected by an RCD with a fixed rated residual current not exceeding 30 mA;
(ii) supplied individually as a separated circuit, in accordance with Clause 7.4; or
(iii) supplied as an SELV or a PELV system, in accordance with Clause 7.5.

Describe one method of supply for luminaires immersed in pool water.

____
____

AS/NZS 3000 reference

6.2.4.4 Luminaires

The following requirements apply to the installation of luminaires in classified zones:

(a) Zone 0 Luminaires installed in Zone 0 shall be—

(i) provided with the required degree of protection;

(ii) designed and constructed specifically for use in a bath, shower or water container;

(iii) supplied at a nominal voltage not exceeding 12 V a.c. or 30 V ripple-free d.c.; and

(iv) supplied from a source located outside Zone 0 as an SELV or a PELV system, in accordance with Clause 7.5.

(b) Zones 1, 2 and 3 Luminaires installed in Zones 1, 2 and 3 shall be provided with at least the required degree of protection.

Exceptions: Regardless of the degree of protection provided by the equipment, the following luminaires may be installed in Zone 2:

1 Luminaires of Class II construction (double or reinforced insulation) that require the removal of a cover to access lamps.

NOTE: A batten holder is not a Class II luminaire.

2 Luminaires supplied from a source located outside Zone 2 as an SELV or a PELV system, in accordance with Clause 7.5.

State two alternative supply requirements for a circuit that supplies a pool filter pump.

AS/NZS 3000 reference

6.4.4.2 Wiring systems

Wiring systems for a fountain or water feature shall be—

(a) elastomer or thermoplastic insulated and sheathed copper cables or flexible cords suitable for immersion in the type of water being used;

(b) where subject to mechanical damage, installed in a wiring enclosure; and

(c) installed so as to prevent—

(i) entry of moisture to any connection; and

(ii) water siphoning through any wiring enclosure or cable.

6.3.4.5 Luminaires, appliances and other electrical equipment

* The following requirements apply to the installation of luminaires, appliances and other items of electrical equipment, excluding those specified in Clauses 6.3.4.3 (Socket-outlets) and 6.3.4.4 (Switches and other accessories), in classified zones:

(a) Zone 0 Luminaires, appliances and other electrical equipment installed in Zone 0 shall be—

(i) designed and constructed specifically for use in a swimming or spa pool; and

(ii) provided with the required degree of protection.
Each luminaire, appliance or other item of electrical equipment shall be supplied—

(A) from an individual source installed outside Zone 0

NOTE: An individual source may be an individual isolation transformer or an individual winding on an isolation transformer having a number of secondary windings, provided that the output complies with Clause 7.5.3.

(B) at a nominal voltage not exceeding 12 V a.c. or 30 V ripple-free d.c.; and

(A) (C) as an SELV or a PELV system, in accordance with Clause 7.5.

Is it permissible to install unenclosed socket outlets within zones 1 or 2 of a bathroom?
_________________________________ AS/NZS 3000 reference ___________
No

6.2.4.2 Socket-outlets

Socket-outlets shall not be installed within 0.3 m of the floor of a bathroom, laundry or other similar location where the floor is likely to become wet.
Regardless of the degree of protection provided by the equipment, the following requirements apply to the installation of socket-outlets in classified zones:

(a) Zone 0 and Zone 1 Socket-outlets shall not be installed in Zone 0 or 1.

(b) Zone 2 Socket-outlets installed in Zone 2 shall be—

(i) of the automatic switching type incorporated in a shaver supply unit complying with AS/NZS 3194; or

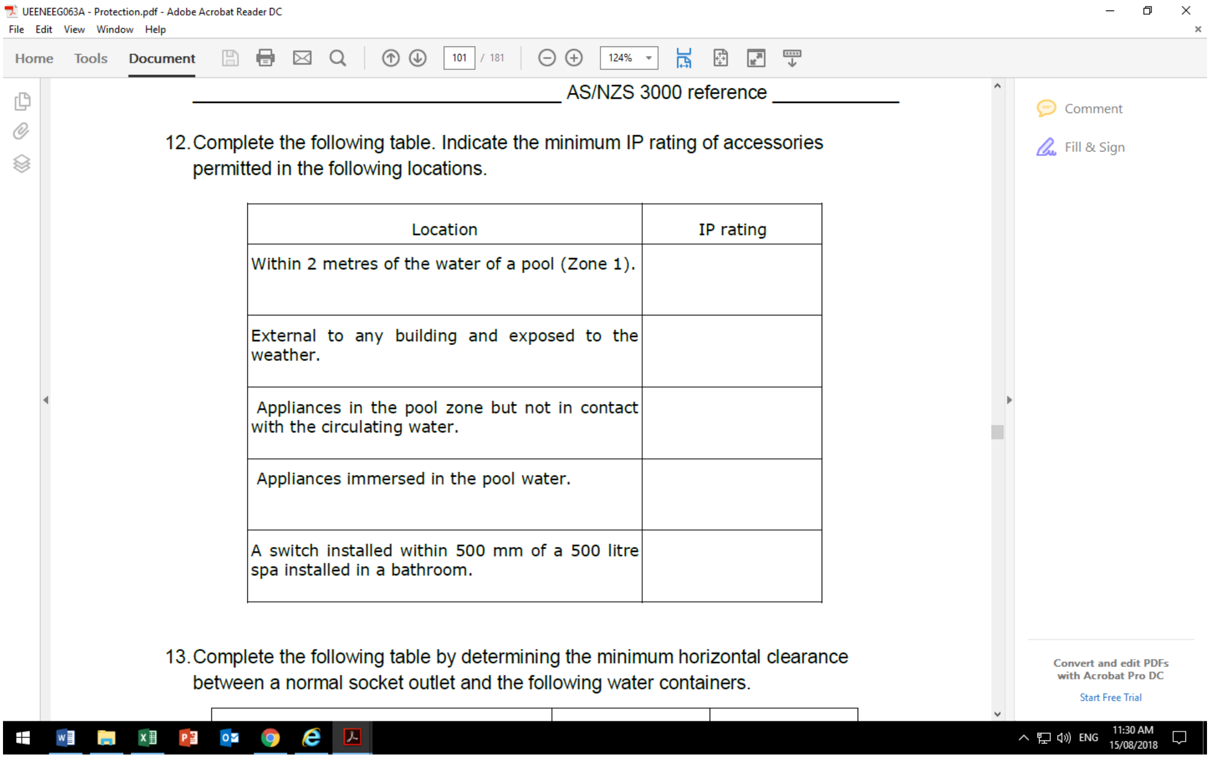
(ii) protected by an RCD with a fixed rated residual current not exceeding 30 mA and enclosed in a cupboard that maintains the enclosure of the socket-outlet during normal operation of the connected equipment.

(c) Zone 3 Socket-outlets installed in Zone 3 shall be—

(i) protected by an RCD with a fixed rated residual current not exceeding 30 mA;

(ii) supplied individually as a separated circuit, in accordance with Clause 7.4; or

(iii) supplied as an SELV or a PELV system, in accordance with Clause 7.5.



AS/NZS 3000 reference

12. Complete the following table. Indicate the minimum IP rating of accessories permitted in the following locations.

Location	IP rating
Within 2 metres of the water of a pool (Zone 1).	
External to any building and exposed to the weather.	
Appliances in the pool zone but not in contact with the circulating water.	
Appliances immersed in the pool water.	
A switch installed within 500 mm of a 500 litre spa installed in a bathroom.	

13. Complete the following table by determining the minimum horizontal clearance between a normal socket outlet and the following water containers.

6.3.4 Selection and installation of electrical equipment

6.3.4.1 Degree of protection required

Electrical equipment permitted to be installed in a classified zone shall have at least the following degree of protection:

(a) In Zone 0–IPX8.

(b) In Zone 1–IPX5.

(c) In Zone 2–IPX4.

The requirements for selection and installation of electrical equipment are provided in Table 6.2.

TABLE 6.2

SELECTION AND INSTALLATION OF ELECTRICAL EQUIPMENT FOR SWIMMING POOLS, PADDLING POOLS AND SPA POOLS OR TUBS

Equipment	Zone 0	Zone 1	Zone 2
Clause 6.3.4.3—Socket-outlets	Not permitted	Not permitted for general use For pool equipment only: (a) IPX5. (b) (i) ≥0.45 m high; and ≥1.25 m from internal rim; or (ii) under and ≥0.5 m from edge of fixed continuous horizontal barrier ≥1.25 m wide. (c) (i) separated supply; (ii) SELV or PELV supply; or (iii) RCD protection.	IPX4 and— (a) separated supply; (b) SELV or PELV supply; or (c) RCD protection.
Clause 6.3.4.4—Switches/accessories	Not permitted	IPX5	IPX4
Clause 6.3.4.5(a), (b) and (c)—Luminaires, appliances and other equipment	IPX8; and specifically for use; and 12 V a.c./30 V d.c. SELV or PELV supply from source outside zone No earth	IPX5 and— (a) SELV or PELV supply; (b) Class II construction (double or reinforced insulation); or (c) Class I construction (earthed conductive parts), fixed in position and RCD protection.	IPX4 and— (a) SELV or PELV supply; (b) separated supply; (c) Class II construction (double or reinforced insulation); or (d) Class I construction (earthed conductive parts), and RCD protection.
Clause 6.3.4.5(d)—Heating cable systems	Not applicable	Permitted where embedded in the floor area under the zone and protected to Clause 4.10.5	As for Zone 1

(continued)

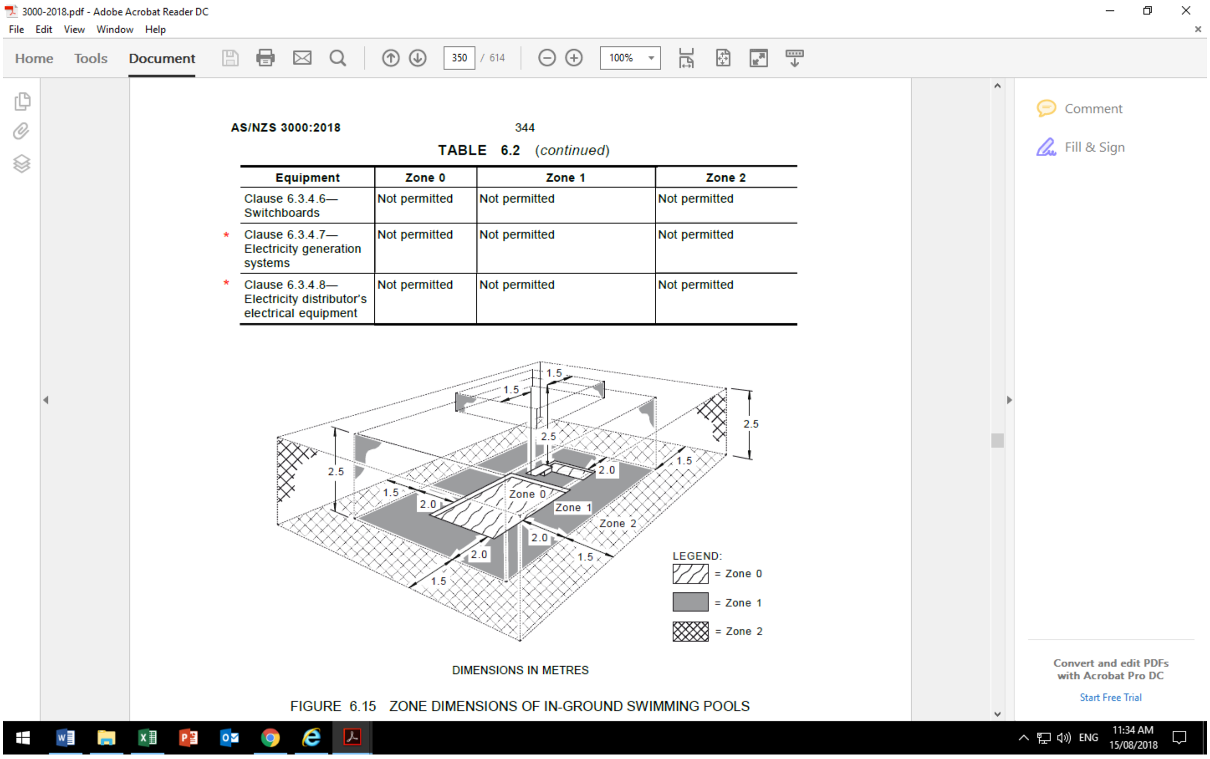


TABLE 6.2 (*continued*)

Equipment	Zone 0	Zone 1	Zone 2
Clause 6.3.4.6—Switchboards	Not permitted	Not permitted	Not permitted
* Clause 6.3.4.7—Electricity generation systems	Not permitted	Not permitted	Not permitted
* Clause 6.3.4.8—Electricity distributor's electrical equipment	Not permitted	Not permitted	Not permitted

FIGURE 6.15 ZONE DIMENSIONS OF IN-GROUND SWIMMING POOLS

6.4.4 Selection and installation of electrical equipment

6.4.4.1 Degree of protection required

Electrical equipment permitted to be installed in the classified zone shall have at least the following degree of protection:

(a) In Zone 0—IPX8.

(b) In Zone 1—IPX5.

The requirements for selection and installation of electrical equipment are provided in Table 6.3.

spa installed in a bathroom.		

13. Complete the following table by determining the minimum horizontal clearance between a normal socket outlet and the following water containers.

Water Container	Distance	Reference
Bath.		
Washtubs less than 45 litres.		
Washtubs over 45 litres.		
Spa of 6500 litre capacity.		
Spa of 620 litre capacity.		

6.2.4.2 Socket-outlets

Socket-outlets shall not be installed within 0.3 m of the floor of a bathroom, laundry or other similar location where the floor is likely to become wet.

Regardless of the degree of protection provided by the equipment, the following requirements apply to the installation of socket-outlets in classified zones:

6.2.4.6 *Switchboards*

A switchboard shall not be located within any classified zone.

6.2.4.7 *Electricity generation systems*

* Electricity generation systems, including engine-driven generator sets, stand-alone power systems, grid-connected inverter systems and battery systems shall not be installed within any classified zone.

TABLE 6.1

SELECTION AND INSTALLATION OF ELECTRICAL EQUIPMENT FOR BATHS, SHOWERS AND OTHER FIXED WATER CONTAINERS

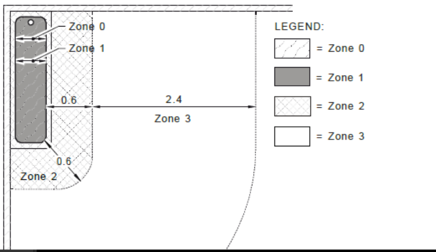
Equipment	Zone 0	Zone 1	Zone 2	Zone 3
Clause 6.2.4.2— Socket-outlets	Not permitted	Not permitted	(a) A shaver outlet; or (b) RCD-protected and in a cupboard (no specific IP rating).	(a) <0.3 m not permitted (b) ≥0.3 m no IP rating† but shall have— (i) RCD protection; (ii) separated supply; or (iii) SELV or PELV supply.
Clause 6.2.4.3— Switches/ accessories	Not permitted	Same as Zone 2	<0.3 m not permitted ≥0.3 m IPX4†	<0.3 m not permitted ≥0.3 m—No IP rating†

(continued)

TABLE 6.1 *(continued)*

Equipment	Zone 0	Zone 1	Zone 2	Zone 3
Clause 6.2.4.4— Luminaires	IPX7 and specifically for use and SELV or PELV supply	IPX4†	IPX4†; or Class II construction (double or reinforced insulation); or SELV or PELV; or recessed into ceiling	No IP rating†
Clause 6.2.4.5— Other electrical equipment	IPX7 and specifically for use and SELV or PELV supply	IPX4†	IPX4†; or recessed into ceiling	No IP rating†
Clause 6.2.4.6— Switchboards	Not permitted	Not permitted	Not permitted	Not permitted
* Clause 6.2.4.7— Electricity generation systems	Not permitted	Not permitted	Not permitted	Not permitted

† Degree of protection IPX5 required in communal baths/showers.



6.2.2.2 Other fixed water containers

Two zones (Zones 0 and 2) are classified for fixed water containers other than baths and showers:

(a) Zone 0 shall be the area of the interior of the water container.

* (b) Zone 2 for an individual water container with a capacity not exceeding 40 L, and having fixed water outlets, shall be the area limited by—

(i) the vertical plane 0.15 m from the internal rim of the water container; and

(ii) the floor and the horizontal plane 0.4 m above the water container.

NOTE: Figure 6.12 shows a typical double bowl sink where the capacity of each container does not exceed 40 L.

* (c) Zone 2 for water containers having either a capacity exceeding 40 L, or a water outlet through a flexible hose, shall be the area limited by—

(i) the vertical plane 0.5 m from the internal rim of the water container; and

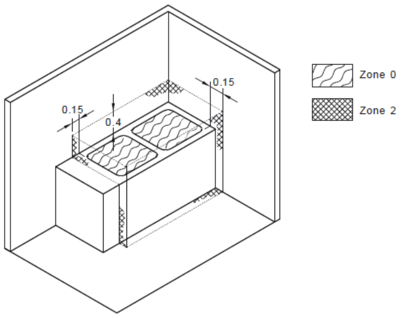
(ii) the floor and the horizontal plane 1.0 m above the water container.

Examples of these zones are shown in Figures 6.13 and 6.14.

NOTES:

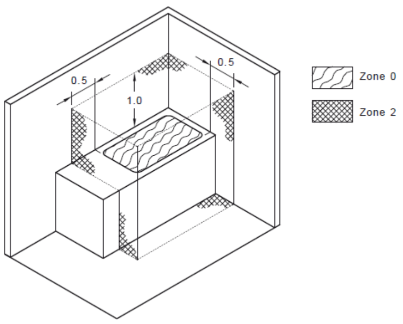
1 There is no Zone 1 or 3 for these water containers.

2 An example of a water outlet through a flexible hose is a vegetable sprayer.



DIMENSIONS IN METRES

* FIGURE 6.13 ZONE DIMENSIONS FOR OTHER FIXED WATER CONTAINERS WITH FIXED WATER OUTLETS WHERE NO CONTAINER HAS A CAPACITY EXCEEDING 40 L



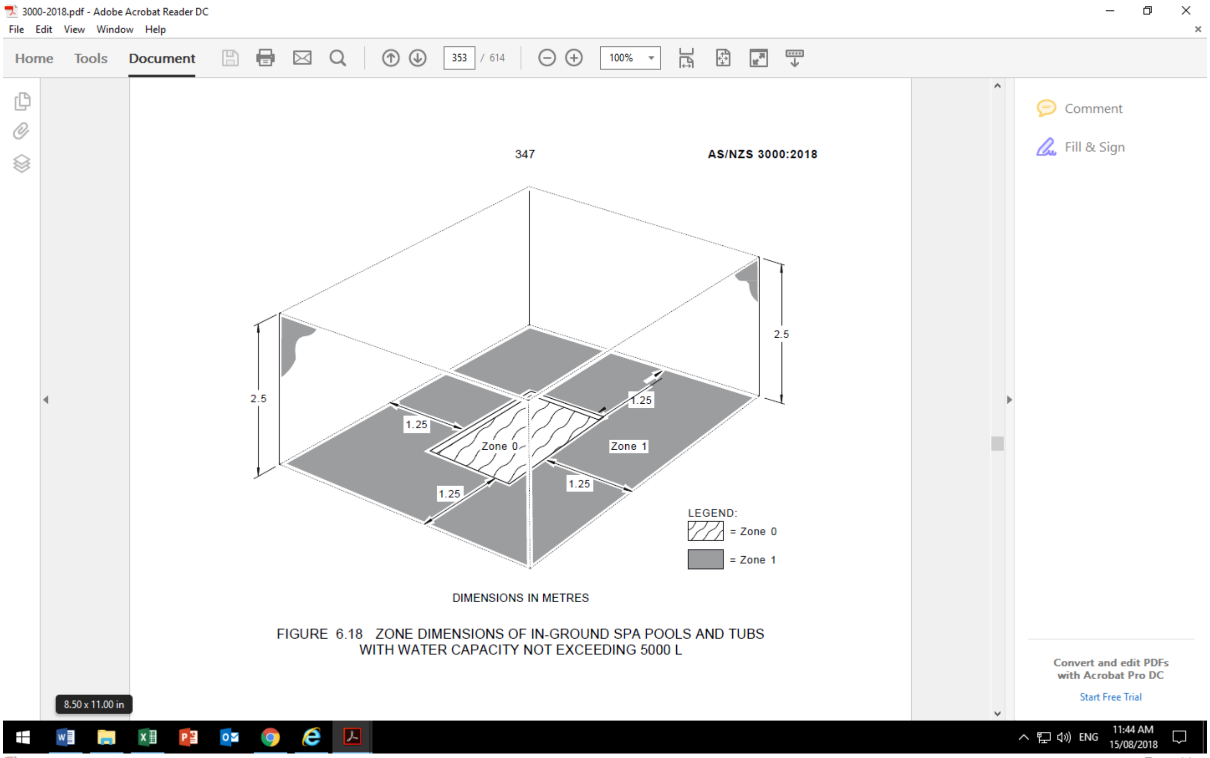
DIMENSIONS IN METRES

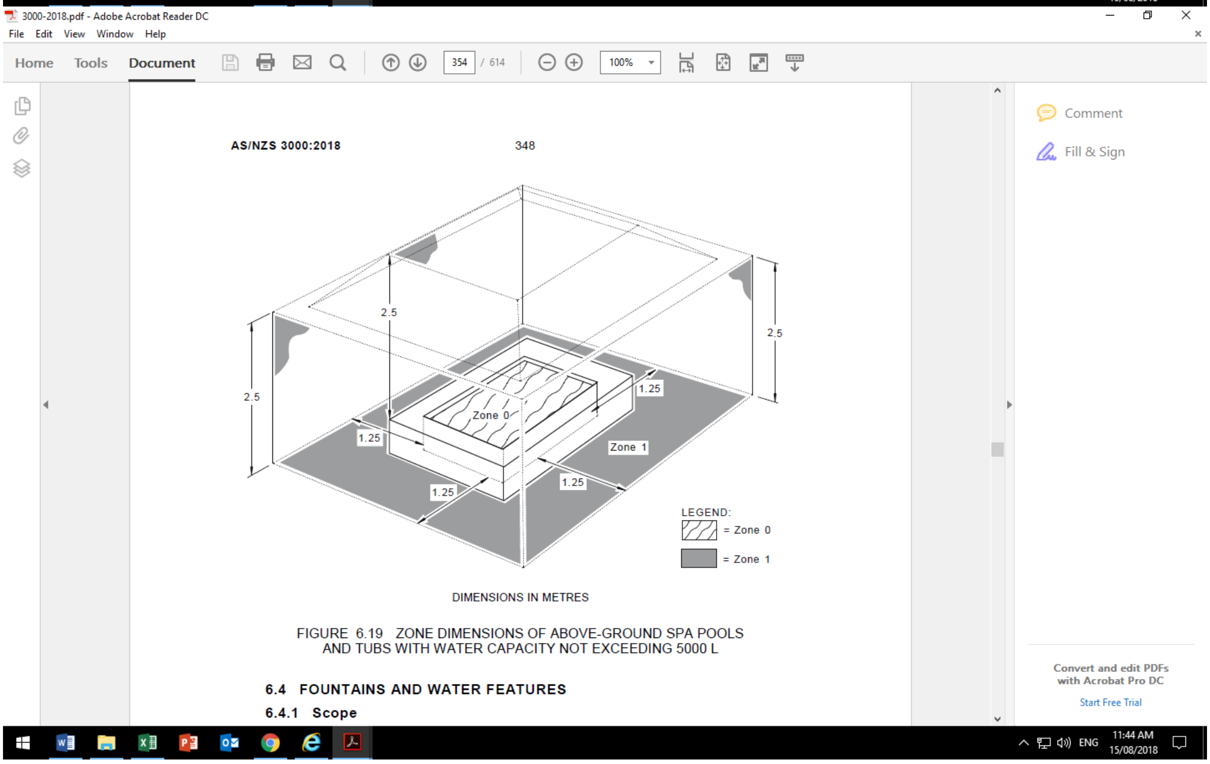
* FIGURE 6.14 ZONE DIMENSIONS FOR OTHER FIXED WATER CONTAINERS WITH A FLEXIBLE WATER OUTLET OR WITH A CAPACITY EXCEEDING 40 L

6.3 SWIMMING POOLS, PADDLING POOLS AND SPA POOLS OR TUBS

6.3.1 Scope

The particular requirements of this Clause (Clause 6.3) apply to electrical installations in locations containing swimming pools,





6.3.2.2 Spa pools or tubs

6.3.2.2.1 General

* Spa pools or tubs with a water capacity not exceeding 680 L shall comply with the requirements of Clause 6.2.

A spa pool that is attached to a swimming or paddling pool shall be considered to be an extension to the swimming or paddling pool.

NOTE: Electrical equipment installed behind a fixed panel that provides a degree of protection not less than IPX4, and to which access may only be gained by the use of a tool, would not be considered to be in a classified zone.

6.3.2.2.2 Water capacity exceeding 5000 L
Three zones (Zones 0, 1 and 2) are classified for spa pools or tubs with a capacity exceeding 5000 L, as set out in Clause 6.3.2.1.
6.3.2.2.3 Water capacity not exceeding 5000 L
Two zones (Zones 0 and 1) are classified for spa pools and tubs with a capacity exceeding 680 L and up to and including 5000 L, as set out below:
(a) Zone 0 shall be the area of the interior of the water container.
(b) Zone 1 shall be the area limited by—
(i) the vertical plane 1.25 m from the internal rim of the water container; and
(ii) the floor, or the surface expected to be occupied by persons, and the horizontal plane 2.50 m above the floor or surface.
Examples of these zones are given in Figures 6.17 to 6.19.

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INTRODUCTION
Although the earthing system does not affect the actual operation of appliances or equipment, it is the most important part of the installation in its protective role against the risk of –
____ and
____
Leakage current and Electrocution

Refer to AS/NZS 3000 Section 1, clause 1.4 - Definitions.
clause Exposed conductive part:
An exposed conductive part is a part of electrical equipment which –
____
____
1.4.62 Exposed conductive part
A conductive part of electrical equipment that—
(a) can be touched with the standard test finger as specified in AS/NZS 3100; and
(b) is not a live part but can become live if basic insulation fails.

clause - Extraneous conductive part:
An extraneous conductive part is a conductive part that -
□ ____
1.4.63 Extraneous conductive part
A conductive part that does not form part of an electrical installation but that may be at the electrical potential of a local earth.

2 examples of extraneous conductive parts are:
□ ____

□ _____________________________________
1.4.63 Extraneous conductive part
A conductive part that does not form part of an electrical installation

but that may be at the electrical potential of a local earth.
NOTE: Examples of extraneous conductive parts include the following:
(a) Metal waste, water or gas pipe from outside.
(b) Cooling or heating system parts.
(c) Metal or reinforced concrete building components.
(d) Steel-framed structure.
(e) Floors and walls of reinforced concrete without further surface treatment.
(f) Tiled surfaces, conductive wall coverings.
(g) Conductive fittings in washrooms, bathrooms, lavatories, toilets, etc.
(h) Metallized papers

REASONS FOR EARTHING

A fundamental safety principle of electrical installations is the protection of - ___________________________ and __________________________ against the danger that may arise from contact with exposed conductive parts which may become live under fault conditions - known as _______________________ contact.
Earthing also provides ______________________________ and in doing so ensures the supply actives and neutral are maintained at a fixed potential with respect to earth

Persons / Equipment /Indirect/Leakage current flowing path to earth

EARTHING TERMS

Refer to definitions: **clause** - Accessible, readily:
1.4.3 Accessible, readily
* Capable of being reached quickly and without climbing over or removing obstructions, or using a movable ladder, and in any case not more than 2.0 m above the ground, floor or platform.

An object is deemed to be readily accessible if it is capable of being reached quickly and easily and is less than _____________ metres above the ground, floor or platform.
2.0 m

Refer to definitions: **clause** - Earthed:
1.4.47 Earthed
Connected to the general mass of earth, and where relevant, the supply neutral in accordance with the appropriate requirements of this Standard.

Refer to definitions: **clause** - Earthed situation:
An earthed situation is anywhere a person may be able to touch exposed conductive parts and, at the same time, come into contact with earth or any other material that may provide a path to earth.

1.4.48 Earthed situation
A situation wherein there is a reasonable chance of a person touching exposed conductive parts and, at the same time, coming into contact with earth or with any conducting medium that may be in electrical

contact with the earth or through which a circuit may be completed to earth. The following situations are deemed to be earthed situations:

Examples of earthed situations include -
□all parts of - ____________________,____________________,

____________________, ____________________.
□any outdoor equipment mounted within _________________ metres of the ground

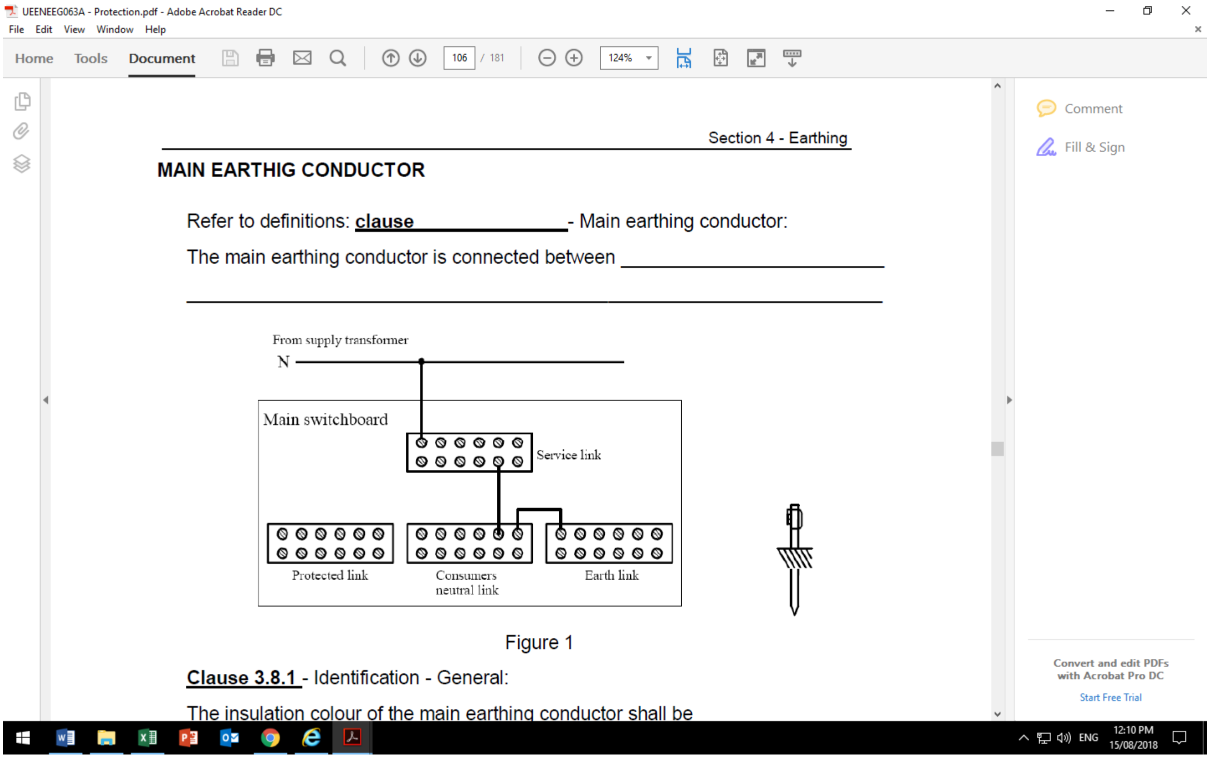
□within ____________ metres of the ground, floor or platform in rooms containing socket outlets, where a person may be able to make simultaneous contact with exposed conductive parts of equipment and exposed conductive parts of appliances plugged into socket outlets

□within ___________ metres in any direction from a conductive floor, permanently damp surface, metallic conduit or building materials on which a person may stand.

1.4.48 Earthed situation
A situation wherein there is a reasonable chance of a person touching exposed conductive parts and, at the same time, coming into contact with earth or with any conducting medium that may be in electrical contact with the earth or through which a circuit may be completed to earth. The following situations are deemed to be earthed situations:
(a) Within 2.5 m in any direction from a conductive floor (such as earthen, concrete, tile or brickwork flooring), permanently damp surface, metallic conduit or pipe, metallic cable sheath or armour, or any other conductive material on which a person may stand.
(b) External to a building.
Exception: An isolated piece of equipment, such as a luminaire that is mounted more than 2.5 m from the ground and from any exposed conductive part or other conductive material that is in contact with earth, is not deemed to be in an earthed situation.
(c) Within 2.5 m of the ground, floor or platform in rooms containing socket-outlets, the earthing terminals of which are earthed, and where there is a reasonable chance of a person making simultaneous contact with any exposed conductive part of electrical equipment and any exposed conductive part of an appliance connected to any of the socket-outlets.
(d) All parts of a bathroom, laundry, lavatory, toilet or kitchen.

List three examples of a conductive floor - ____________________________
____
____

Within 2.5 m in any direction from a conductive floor (such as earthen, concrete, tile or brickwork flooring), permanently damp surface, metallic conduit or pipe, metallic cable sheath or armour, or any other conductive material on which a person may stand.



Section 4 - Earthing

MAIN EARTHIG CONDUCTOR

Refer to definitions: **clause** ________________ - Main earthing conductor:

The main earthing conductor is connected between ______________________

____

Figure 1

Clause 3.8.1 - Identification - General:

The insulation colour of the main earthing conductor shall be

1.4.81 Main earthing conductor

A conductor connecting the main earthing terminal/connection or bar to the earth electrode or to the earthing system of the source of supply.

Clause 3.8.1 - Identification - General:

The insulation colour of the main earthing conductor shall be ____________________

3.8.1 General

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

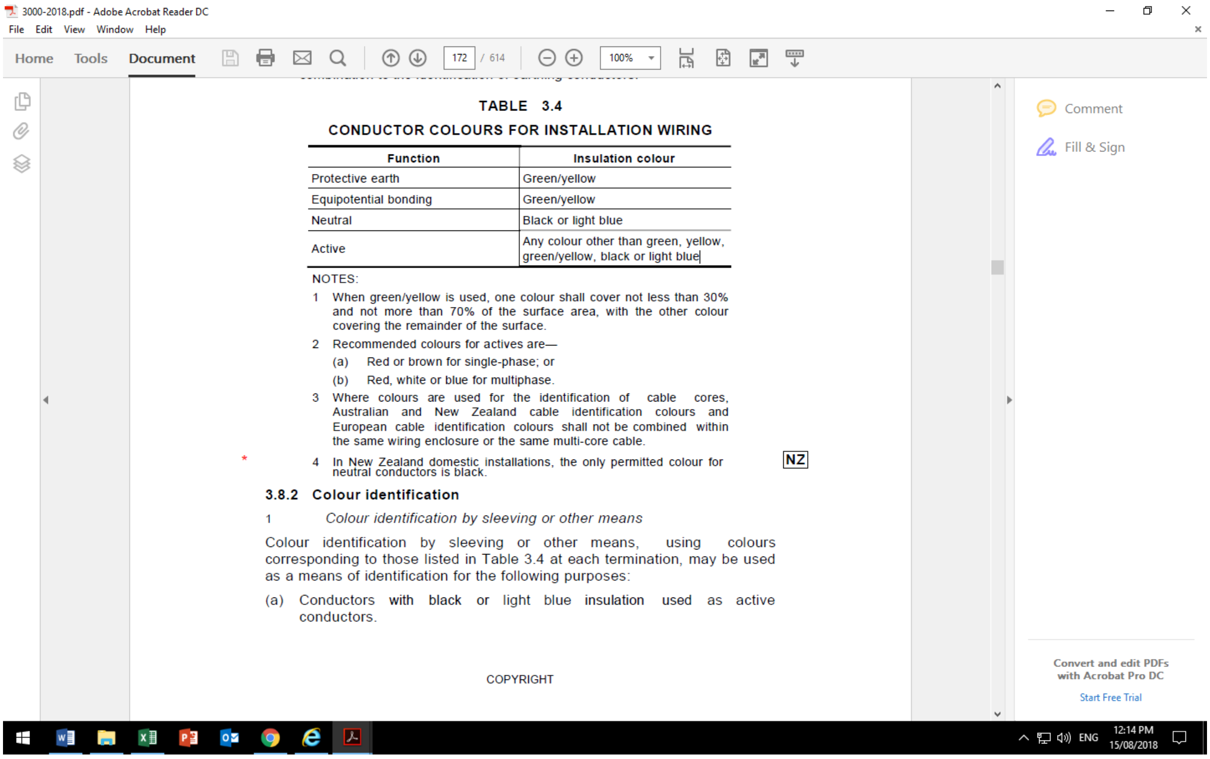


TABLE 3.4

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 as a means of identification for the following purposes:

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

Refer to Section 5: **clause** - Minimum size: (of the main earthing conductor)

The minimum allowable size for a copper main earthing conductor is _____________

5.3.3.2 Main earthing conductor

Where the main earthing conductor connects the main earth terminal to an electrode (arrangement depicted in Figure 5.1), the conductor shall be determined from Table 5.1 in relation to the cross-sectional area of the largest active conductor of the consumer mains.

The cross-sectional area of such a copper main earthing conductor shall be not less than 4 mm2 and need not be greater than 120 mm2.

5.3.3 Earthing conductor size (cross-sectional area)

5.3.3.1 Protective earthing conductors

5.3.3.1.1 General

The cross-sectional area of a protective earthing conductor shall ensure—

(a) adequate current-carrying capacity for prospective fault currents for a time at least equal to the operating time of the associated overcurrent protective device;

(b) appropriate earth fault-loop impedance (see Clause 5.7);

(c) adequate mechanical strength and resistance to external influences; and

(d) for parts of the protective earthing conductor that do not consist of cables, or parts of cables, that there is an allowance for the subsequent deterioration in conductivity that may reasonably be expected.

AS/NZS 3008.1 series.

If application of the equation produces non-standard sizes, conductors of the nearest higher standard cross-sectional area shall be used.

NOTE: Maximum permissible temperatures for joints should be considered (see the AS/NZS 3008.1 series).

TABLE 5.1

MINIMUM COPPER EARTHING CONDUCTOR SIZE

Nominal size of active conductor mm^2	Nominal size of copper earthing conductor, mm^2	
	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.

Where the active conductor comprises a number of conductors, connected in parallel, the earthing conductor shall be determined in relation to the summation of the cross-sectional areas of the individual conductors forming the largest active conductor to be protected.

Where the summation of cross-sectional areas does not correspond exactly with the nominal size of the active conductor given in Table 5.1, the conductor shall be determined in relation to the nearest larger size of active conductor.

The minimum cross-sectional area of any conductive wiring enclosure, cable component, framework or catenary wire used as an earthing medium in accordance with Clause 5.3.2.2, shall be such that the impedance of the medium is not greater than that determined for a copper earthing conductor in accordance with this Clause (Clause 5.3.3.1.2).

5.3.3.1.3 *Calculation*

The minimum cross-sectional area determined by calculation shall be not less than the value determined by the following equation (applicable only for disconnection times not less than 0.1 s but not exceeding 5 s):

$$S = \sqrt{(I^2 t / K^2)} \qquad \ldots 5.1$$

where

S = cross-sectional area of protective earthing conductor, in mm^2

I = the value of the fault current in amperes (for a.c. r.m.s. value) that would flow through the overcurrent protective device of the circuit concerned in the event of a short-circuit of negligible impedance

t = the disconnecting time of the overcurrent protective device in seconds, corresponding to the value of fault current I

Refer to Section 5: **clause** - Resistance of main earthing conductor:

5.5.1.4 Resistance

The resistance of the main earthing conductor, measured between the main earthing terminal/connection or bar and the earth electrode, including the connection to the earth electrode, shall be not more than 0.5 Ohm

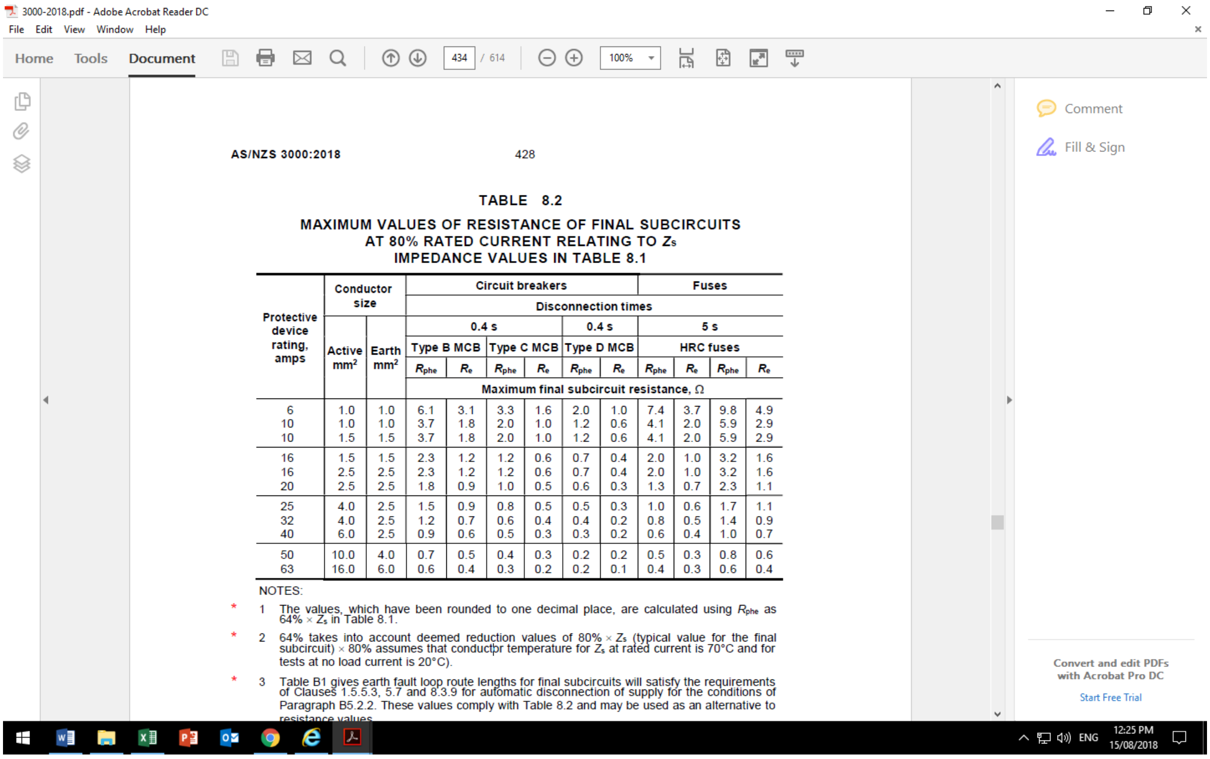


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TABLE 8.2

MAXIMUM VALUES OF RESISTANCE OF FINAL SUBCIRCUITS AT 80% RATED CURRENT RELATING TO Z_s IMPEDANCE VALUES IN TABLE 8.1

Protective device rating, amps	Conductor size		Circuit breakers						Fuses			
			Disconnection times									
			0.4 s				0.4 s		5 s			
	Active mm²	Earth mm²	Type B MCB		Type C MCB		Type D MCB		HRC fuses			
			R_{phe}	R_e	R_{phe}	R_e	R_{phe}	R_e	R_{phe}	R_e	R_{phe}	R_e
			Maximum final subcircuit resistance, Ω									
6	1.0	1.0	6.1	3.1	3.3	1.6	2.0	1.0	7.4	3.7	9.8	4.9
10	1.0	1.0	3.7	1.8	2.0	1.0	1.2	0.6	4.1	2.0	5.9	2.9
10	1.5	1.5	3.7	1.8	2.0	1.0	1.2	0.6	4.1	2.0	5.9	2.9
16	1.5	1.5	2.3	1.2	1.2	0.6	0.7	0.4	2.0	1.0	3.2	1.6
16	2.5	2.5	2.3	1.2	1.2	0.6	0.7	0.4	2.0	1.0	3.2	1.6
20	2.5	2.5	1.8	0.9	1.0	0.5	0.6	0.3	1.3	0.7	2.3	1.1
25	4.0	2.5	1.5	0.9	0.8	0.5	0.5	0.3	1.0	0.6	1.7	1.1
32	4.0	2.5	1.2	0.7	0.6	0.4	0.4	0.2	0.8	0.5	1.4	0.9
40	6.0	2.5	0.9	0.6	0.5	0.3	0.3	0.2	0.6	0.4	1.0	0.7
50	10.0	4.0	0.7	0.5	0.4	0.3	0.2	0.2	0.5	0.3	0.8	0.6
63	16.0	6.0	0.6	0.4	0.3	0.2	0.2	0.1	0.4	0.3	0.6	0.4

NOTES:

* 1 The values, which have been rounded to one decimal place, are calculated using R_{phe} as 64% × Z_s in Table 8.1.

* 2 64% takes into account deemed reduction values of 80% × Z_s (typical value for the final subcircuit) × 80% assumes that conductor temperature for Z_s at rated current is 70°C and for tests at no load current is 20°C).

* 3 Table B1 gives earth fault loop route lengths for final subcircuits will satisfy the requirements of Clauses 1.5.5.3, 5.7 and 8.3.9 for automatic disconnection of supply for the conditions of Paragraph B5.2.2. These values comply with Table 8.2 and may be used as an alternative to resistance values.

Refer to Section 5: **clause** - Connection to earth electrode:

When a main earthing conductor is connected to an earth electrode, four requirements must be satisfied, these are -

☐ ____

☐ ____

____

☐ ____

☐ ____

5.5.1.2 Connection to earth electrode

The connection of the main earthing conductor to the earth electrode shall—

(a) be accessible for visual inspection and for the purposes of testing;

NOTES:

1 Where necessary, access by means of an underground pit with its cover accessible above ground is considered acceptable, provided adequate space is available for the connection of test leads and the pit is suitably identified as to its purpose.

2 Where the reinforcing steel is used as the earth electrode, this testing condition is deemed to be satisfied by the provision of a test point on the main earthing electrode.

(b) be made by means of a suitable device, in accordance with the manufacturer's specification, that provides adequate electrical conductivity;

(c) provide protection against mechanical damage likely to occur to the main earthing conductor or the connection to the electrode at the

location, in accordance with Clause 5.5.5.2; and
(d) be suitably protected against corrosion in accordance with Clause 5.5.5.3.

Refer to Section 5: **clause** - General:

The connection of the electrical installation earthing system to the general mass of earth shall be achieved by means of an ________________________________. Earth electrode

5.3.6.1 General

The connection of the electrical installation earthing system to the general mass of earth shall be achieved by means of an earth electrode.

Refer to Section 5: **clause** - Types:

The following types of earth electrode may be used -

☐ ____

☐ ____

☐ ____

Figures 2 and 3 show the requirements in relation to rod and strip earth electrodes.

5.3.6.2 Types

Materials and dimensions of earth electrodes shall be selected to withstand corrosion and to have adequate mechanical strength

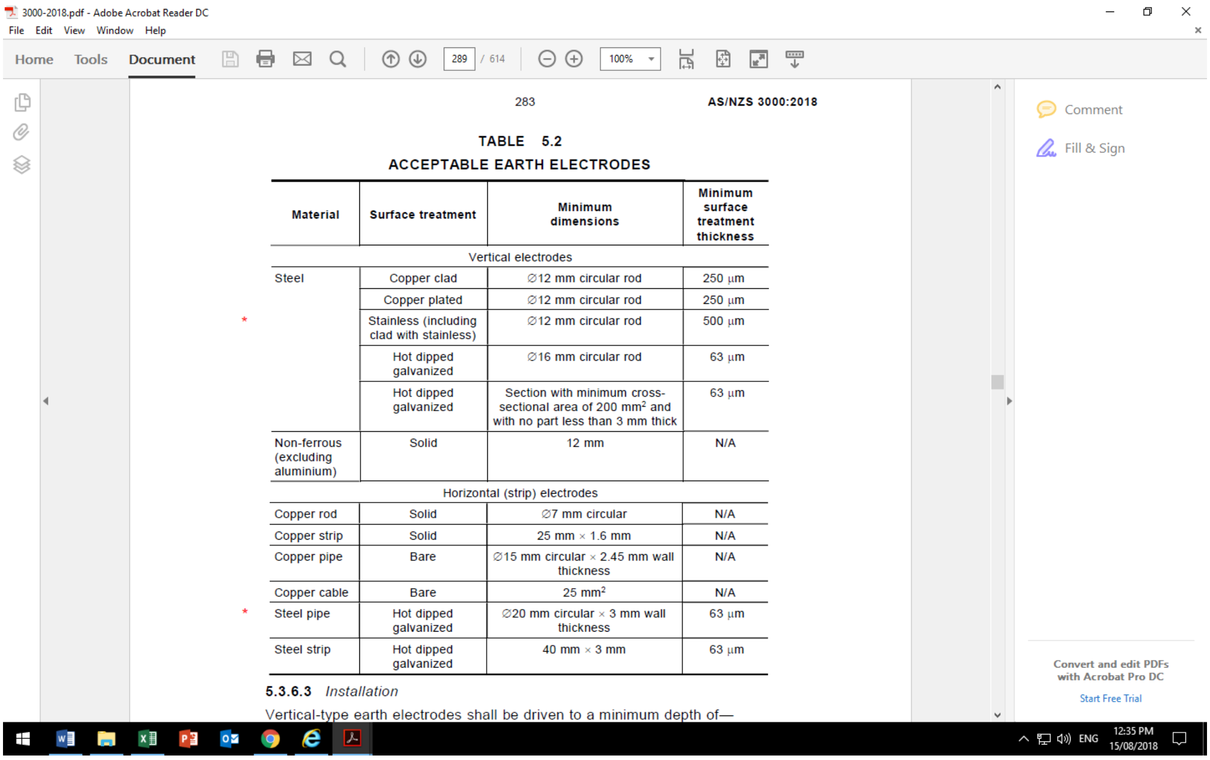

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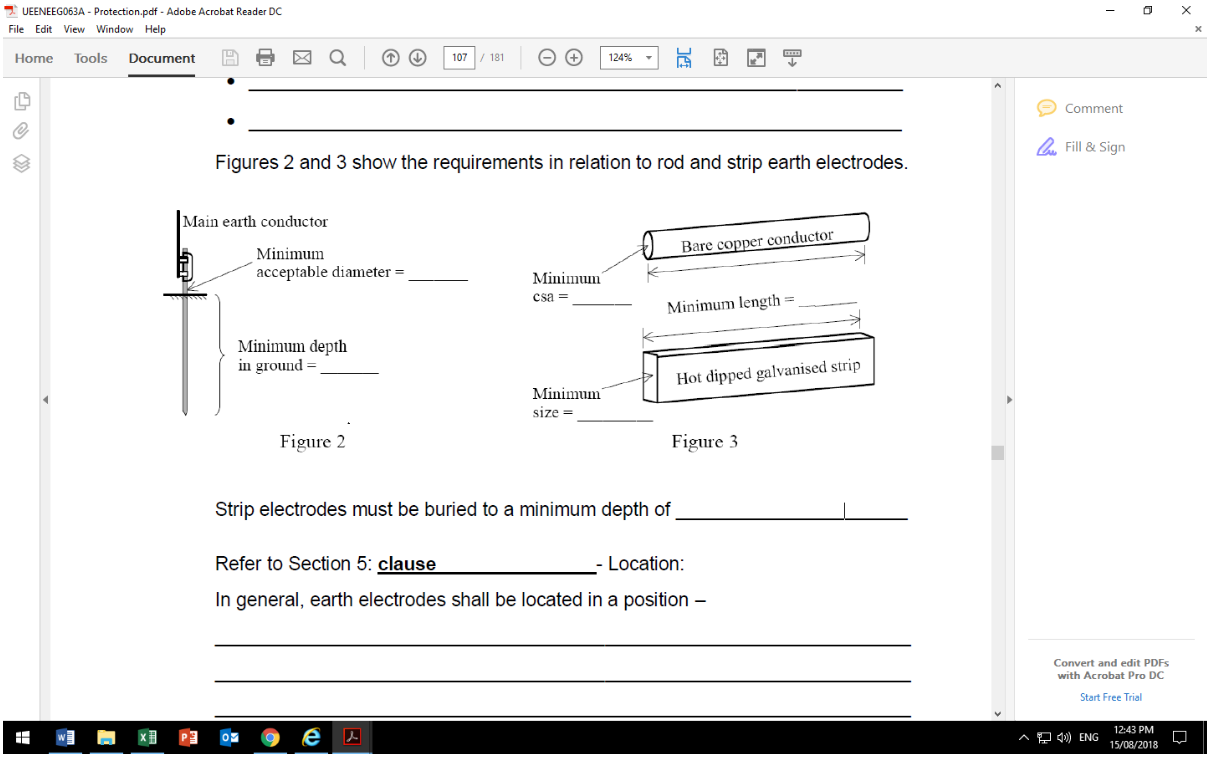
TABLE 5.2

ACCEPTABLE EARTH ELECTRODES

Material	Surface treatment	Minimum dimensions	Minimum surface treatment thickness
Vertical electrodes			
Steel	Copper clad	∅12 mm circular rod	250 μm
	Copper plated	∅12 mm circular rod	250 μm
	Stainless (including clad with stainless)	∅12 mm circular rod	500 μm
	Hot dipped galvanized	∅16 mm circular rod	63 μm
	Hot dipped galvanized	Section with minimum cross-sectional area of 200 mm² and with no part less than 3 mm thick	63 μm
Non-ferrous (excluding aluminium)	Solid	12 mm	N/A
Horizontal (strip) electrodes			
Copper rod	Solid	∅7 mm circular	N/A
Copper strip	Solid	25 mm × 1.6 mm	N/A
Copper pipe	Bare	∅15 mm circular × 2.45 mm wall thickness	N/A
Copper cable	Bare	25 mm²	N/A
Steel pipe	Hot dipped galvanized	∅20 mm circular × 3 mm wall thickness	63 μm
Steel strip	Hot dipped galvanized	40 mm × 3 mm	63 μm

5.3.6.3 *Installation*

Vertical-type earth electrodes shall be driven to a minimum depth of—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Comment

Fill & Sign

- ______________________________
- ______________________________

Figures 2 and 3 show the requirements in relation to rod and strip earth electrodes.

Main earth conductor

Minimum acceptable diameter = ______

Minimum depth in ground = ______

Figure 2

Bare copper conductor

Minimum csa = ______

Minimum length = ______

Hot dipped galvanised strip

Minimum size = ______

Figure 3

Strip electrodes must be buried to a minimum depth of ______________

Refer to Section 5: **clause** ______________ - Location:

In general, earth electrodes shall be located in a position –

____

____

____

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5.3.6.3 Installation

Vertical-type earth electrodes shall be driven to a minimum depth of—

(a) in Australia, 1.2 m; and

(b) in New Zealand, 1.8 m.

Strip-type earth electrodes buried in a horizontal trench shall be laid at a depth having not less than 0.5 m cover and with a minimum horizontal length of—

(i) in Australia, 3 m; and A

(ii) in New Zealand, 7.5 m

Refer to Section 5: **clause** - Location:

In general, earth electrodes shall be located in a position –

____

____

____

5.3.6.4 Location

Earth electrodes shall be installed in a location that satisfies the following conditions:

(a) The electrode maintains effective contact with moist soil that is not subject to excessive drying out.

NOTE: This condition is deemed to be satisfied by locating the electrode—

(a) external to the building in ground that is exposed to the weather; or

(b) in other locations where the ground remains moist because of soil conditions or covers that reduce loss of moisture.

(b) The electrode is separated from conductive enclosures of other buried services, such as water, gas, telecommunications and flammable liquid, in order to reduce possible electrolytic action affecting the electrode or the other service.

NOTE: Separation distances are specified in Table 3.7.

(c) The main earthing conductor connection to an electrode is accessible, in accordance with Clause 5.5.1.2.

The location of the earth electrode shall be identified at the main switchboard.

What is the recommended separation between an earth electrode and other services such as water, gas, flammable liquid and telecommunications?

Why is this separation recommended? ___________________________________

____

b) The electrode is separated from conductive enclosures of other buried services, such as water, gas, telecommunications and flammable liquid, in order to reduce possible electrolytic action affecting the electrode or the other service

The abbreviation MEN stands for ____________________________________

1.4.83 Multiple earthed neutral (MEN) system

* A system of earthing in which the parts of an installation, required under this Standard to be earthed, are connected to the general mass of earth and, in addition, are connected within the installation to the neutral conductor of the supply system or the PEN conductor

Refer to definitions: **clause** - Multiple earthed neutral system

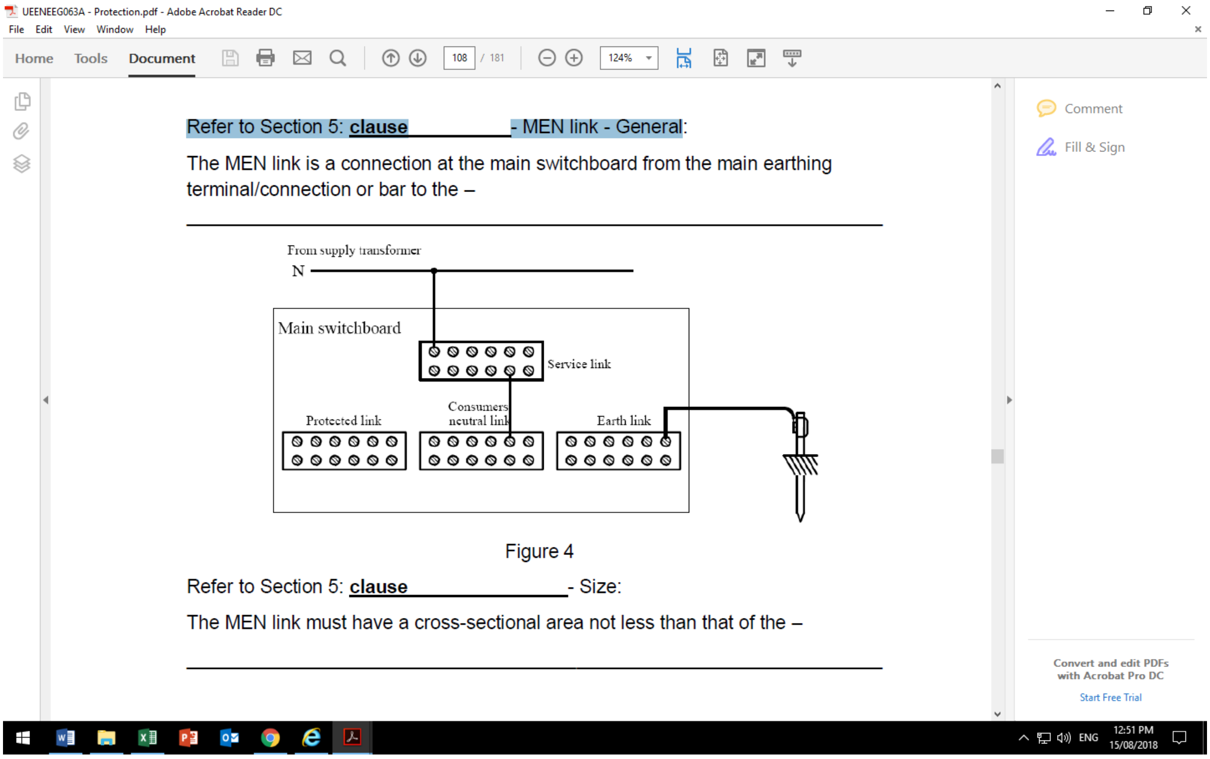
1.4.83 Multiple earthed neutral (MEN) system

Refer to Section 5: **clause** - MEN link – General

5.3.5 MEN connection

5.3.5.1 General

In every electrical installation there shall be an MEN connection (also known as the MEN link) at the main switchboard.



Refer to Section 5: **clause ______________** - MEN link - General:

The MEN link is a connection at the main switchboard from the main earthing terminal/connection or bar to the –

____

Figure 4

Refer to Section 5: **clause ________________** - Size:

The MEN link must have a cross-sectional area not less than that of the –

____

Earth

Refer to Section 5: **clause** - Size:
The MEN link must have a cross-sectional area not less than that of the –

____

5.3.5.2 Size
The MEN connection shall be a conductor complying with Clause 5.3.2 and have a cross-sectional area capable of carrying the maximum current that it may be required to carry under short-circuit conditions.
The minimum size shall be—
(a) not less than the current-carrying capacity of the main neutral conductor; or
(b) for switchboards described in Clause 2.5.5 as rated at 800 A or more per phase, as determined for a protective earthing conductor from Table 5.1 or by calculation.

Where consumers' mains are not protected on the supply side by short circuit protective devices the MEN link shall have a cross-sectional area not less than that of the

____

Exceptions: The minimum size of the MEN connection need not exceed that of the main earthing conductor in the following circumstances:
1 Where short-circuit protection is provided on the supply side of the consumer mains.
2 Where the earthing of an enclosure containing consumer mains not provided with short-circuit protection on the supply side is made by connection directly to the neutral bar in accordance with Clause 5.5.3.5.
3 Where double insulation of the consumer mains conductors is

maintained up to the supply terminal/s of the service protective device/s, and short-circuit protection is provided by such device/s.
NOTE: An electricity distributor' s upstream service protective device may provide short-circuit protection of consumer mains.

Refer to Section 5: **clause** - Identification:
5.3.5.3 Identification
Where the MEN connection is insulated, the insulation shall be coloured green or in a combination of green and yellow, in accordance with Clause 3.8

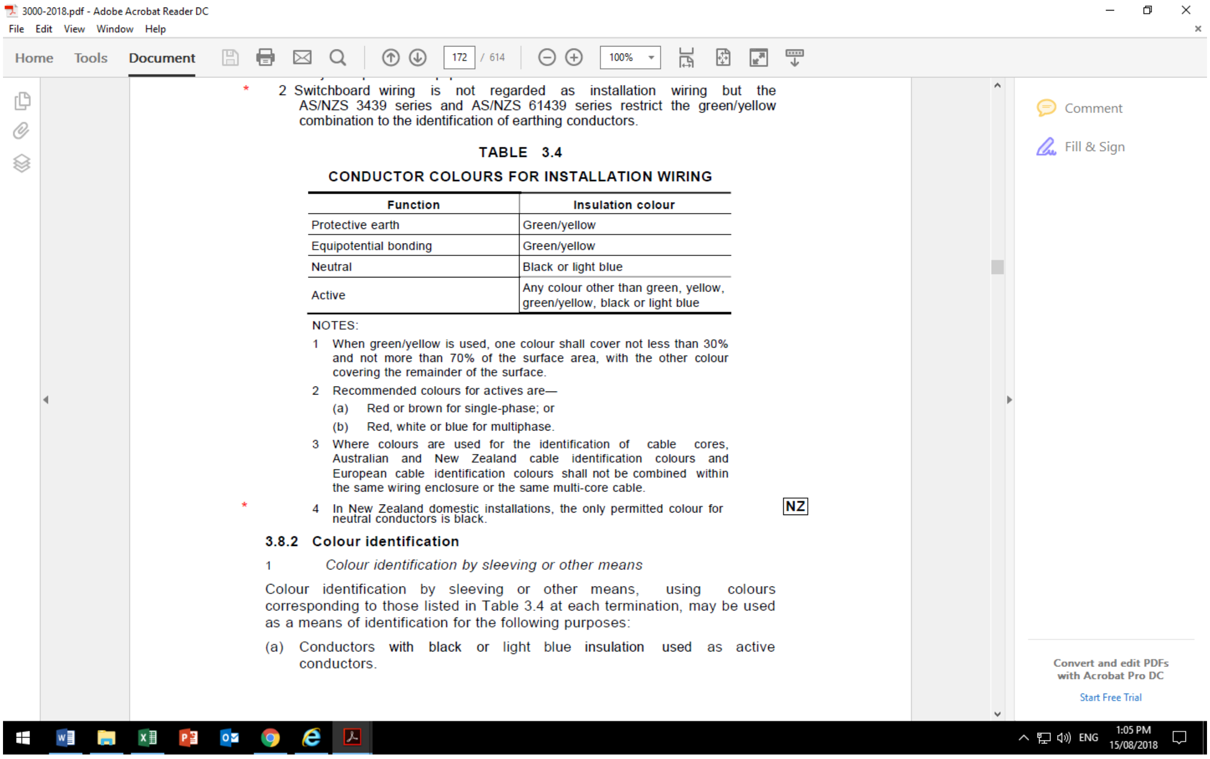

2 Switchboard wiring is not regarded as installation wiring but the AS/NZS 3439 series and AS/NZS 61439 series restrict the green/yellow combination to the identification of earthing conductors.

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*
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.

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.

Sleeving of existing live conductors

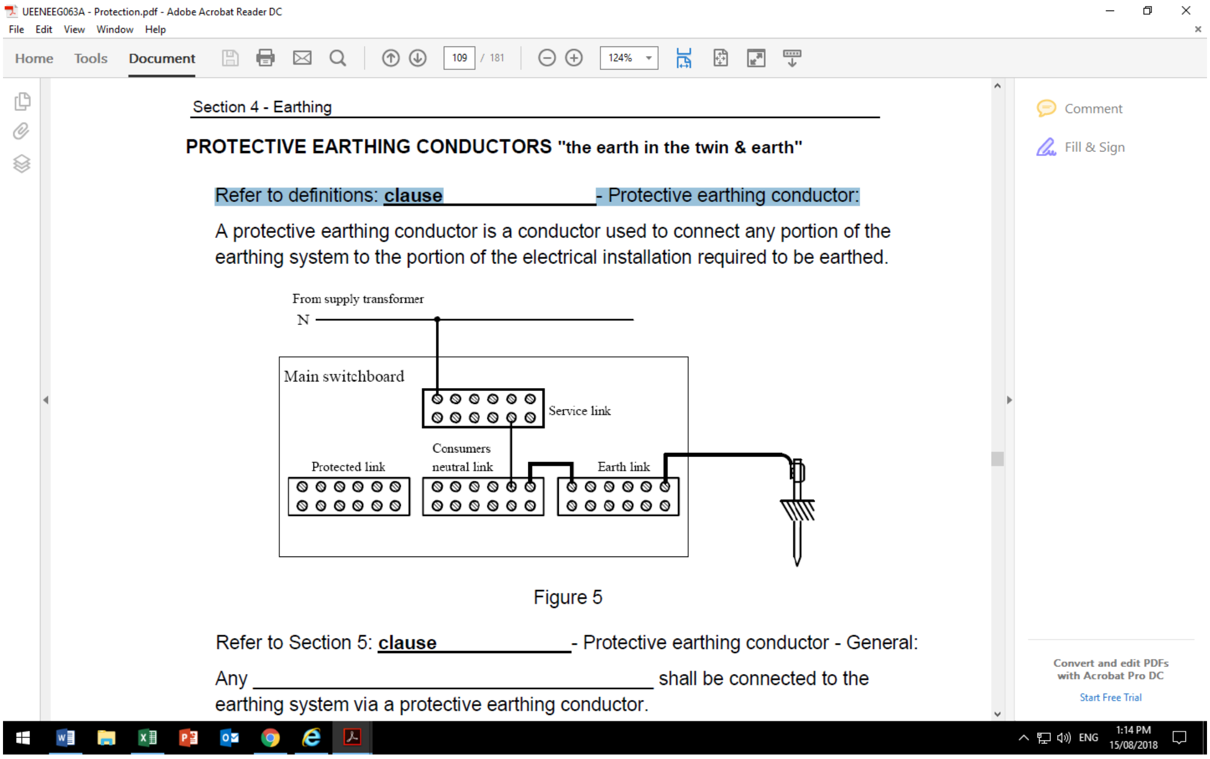
* In electrical installations where conductors with yellow insulation have been
previously installed as live conductors, complying with previous editions of this Standard, such conductors with yellow insulation may remain.
* When alterations or repairs are carried out that result in new terminations 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.

If the MEN link is insulated, the insulation shall be coloured ____________________
Green/yellow

Refer to definitions: **clause** - Protective earthing conductor:

1.4.100 Protective earthing conductor

An earthing conductor, other than a main earthing conductor, intended to carry earth fault currents and connecting any portion of the earthing system to the portion of the electrical installation or electrical equipment required to be earthed, or to any other portion of the earthing system.



Section 4 - Earthing

PROTECTIVE EARTHING CONDUCTORS "the earth in the twin & earth"

Refer to definitions: **clause** ______________ - Protective earthing conductor:

A protective earthing conductor is a conductor used to connect any portion of the earthing system to the portion of the electrical installation required to be earthed.

Figure 5

Refer to Section 5: **clause** ______________ - Protective earthing conductor - General:

Any ________________________________ shall be connected to the earthing system via a protective earthing conductor.

Refer to Section 5: **clause** - Protective earthing conductor - General:

Any ____ shall be connected to the earthing system via a protective earthing conductor

5.3 EARTHING SYSTEM PARTS

5.3.1 General

The protective earthing arrangement for an electrical installation providing protection by means of automatic disconnection of supply and connected to the MEN system of distribution shall include the following parts:

(a) Protective earthing conductors connecting exposed conductive parts as required.

(b) Main earthing conductor.

(c) Main earthing terminal, connection or bar.

(d) MEN connection between the main earthing terminal, connection or bar and the supply neutral bar.

(e) Earth electrode.

(f) Equipotential bonding of extraneous conductive and other parts as required.

Protective earthing conductors shall be connected to -

☐an earthing terminal/connection or bar at the ____________________________________

Main switchboard

☐any point on the ____

☐an earth terminal or bar at a ____

☐any point on a ____________________________________ earthing conductor

5.5.2 Protective earthing conductors

5.5.2.1 Arrangement
All protective earthing conductors shall be directly connected to the main earthing conductor or to another point on an earthing system that is connected to the main earthing conductor. Protective earthing conductors shall not normally carry load current.
The connection shall be made at one or a combination of the following points:
(a) An earthing terminal/connection or bar at the main switchboard provided specifically for the connection of earthing conductors and that is directly connected to the main earthing conductor.
(b) Any point on the main earthing conductor.
(c) An earthing terminal/connection or bar at a distribution board provided specifically for the connection of protective earthing conductors and arranged to comply with Clause 5.5.2.2.
(d) Any point on a protective earthing conductor providing facilities for earthing at a distribution board and arranged to comply with
Clause 5.5.2.2.

5.4.3 Lighting points
5.4.4 Luminaires
5.4.2 Socket-outlets
5.4.5 Conductive supports for aerial conductors
5.4.6 Structural metalwork including conductive building materials
5.4.7 Submersible pumps
5.4.8 Variable frequency devices
5.5.1 Main earthing conductor
5.5.1.1 Arrangement
An earthing conductor, deemed to be the main earthing conductor, shall be taken from the main earthing terminal/connection or bar at the main switchboard to an earth electrode complying with Clause 5.3.6.
The main earthing conductor shall be run in as direct a manner as possible and shall not be directly connected to the terminal of any accessory, luminaire or appliance

Refer to AS/NZS 3000 Figure 5.3 for examples of earthing connections.
Refer to Section 5: **clause** - Conductor material and type - General:
When copper earthing conductors are used they shall be of high conductivity copper and can be in the form of -
□__________________________ conductors; or
□__________________________ conductors; or
□__________________________ conductors having a CSA of not less than 10mm$_2$ and a thickness of not less than 1.5mm$_2$

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.

Exceptions:

1 A smaller solid conductor may be used where permitted by a particular cable Standard.

2 This Clause need not apply where copper cable components, such as sheaths or screens, are deemed to be an earthing conductor in accordance with Clause 5.3.2.2.

5.3.2.1.2 Aluminium conductors

Aluminium conductors may be used as earthing conductors, provided that they comply with the following conditions:

(a) Conductors of 10 mm^2 or less shall be solid conductors.

(b) Minimum 16 mm^2 conductors shall be used for main earthing conductors.

(c) Connection methods shall comply with Section 3 of this Standard.

(d) Installation methods shall prevent corrosion of the conductor and connections.

(e) Conductors shall not be installed underground or in damp situations.

Exception: Aluminium earthing conductors may be installed underground or in damp situations where designed and suitable for such use.

Refer to Section 5: **clause** - Size - General:

The cross-sectional area of a protective earthing conductor shall ensure -

 adequate ________________________________ for prospective fault currents for a time at least equal to the operating time of the associated protective device

NOTE: *Prospective fault current means the highest possible fault current that could flow at the point of a fault or the maximum fault current that would flow in the worse possible instance. ie: when the impedance at the fault is at its lowest possible value.*

 appropriate ____

 adequate ___________________ strength and resistance to external influences

 allowance for deterioration in ________________ that may be reasonably be expected.

5.3.3 Earthing conductor size (cross-sectional area)

5.3.3.1 Protective earthing conductors

5.3.3.1.1 General

The cross-sectional area of a protective earthing conductor shall ensure—

(a) adequate current-carrying capacity for prospective fault currents for a time at least equal to the operating time of the associated

overcurrent protective device;
(b) appropriate earth fault-loop impedance (see Clause 5.7);
(c) adequate mechanical strength and resistance to external influences; and
(d) for parts of the protective earthing conductor that do not consist of cables, or parts of cables, that there is an allowance for the subsequent deterioration in conductivity that may reasonably be expected.

Refer to Section 5: **clause** - Selection of CSA of protective earthing conductor:
The CSA of protective earthing conductors shall be determined -
 by calculation using clause ___________________

and
 shall be not less than the appropriate value shown in table _________.
5.3.3.1.2 Selection
The cross-sectional area of any copper protective earthing conductor required for the protection of any portion of an electrical installation shall be
determined either-
(a) from Table 5.1 in relation to the cross-sectional area of the largest active conductor supplying the portion of the electrical installation to be protected; or
b) by calculation, in accordance with Clause 5.3.3.1.3.
Exceptions:
1 The minimum size of a conductor required for the earthing of exposed conductive parts associated with unprotected consumer mains shall be in accordance with Clauses 5.3.3.2 and 5.5.3.5.
2 Aerial earthing conductors shall comply with Clause 5.3.3.3.
3 Earthing conductors in cables, flexible cables or flexible cords shall comply with Clause 5.3.3.4.
NOTES:
1 The installation should be so prepared that electrical equipment terminals are capable of accepting the protective earthing conductors.
2 Calculation may be necessary if the choice of cross-sectional area of phase conductors has been determined by consideration of short-circuit current.
Where the active conductor comprises a number of conductors, connected in parallel, the earthing conductor shall be determined in relation to the summation of the cross-sectional areas of the individual conductors forming the largest active conductor to be protected.
Where the summation of cross-sectional areas does not correspond exactly with the nominal size of the active conductor given in Table 5.1, the conductor shall be determined in relation to the nearest larger size of active conductor.
The minimum cross-sectional area of any conductive wiring enclosure, cable component, framework or catenary wire used as an earthing medium in accordance with Clause 5.3.2.2, shall be such that the impedance of the

medium is not greater than that determined for a copper earthing conductor in accordance with this Clause (Clause 5.3.3.1.2).

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- by calling using clause ____________________ and
- shall be not less than the appropriate value shown in table __________.

Example: 1

Select the minimum size protective earthing conductors for the conditions shown below.

Table 1

Active Conductor Size	Active Conductor Material	Copper Earthing Conductor Minimum Size
1.5mm²	Copper	
2.5mm²	Copper	
16mm²	Copper	
50mm²	Aluminium	
120mm²	Copper	
240mm²	Aluminium	
500mm²	Copper	

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the nearest higher standard cross-sectional area shall be used.

NOTE: Maximum permissible temperatures for joints should be considered (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	Nominal size of copper earthing conductor, mm² — 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.

.

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.

Refer to Section 5: **clause** - Types - General:
List 5 types of protective earthing conductor that may be used to earth exposed conductive parts –

- earthing conductors that are ______________________________________

- earthing conductors in a ____

- earthing conductors in ____

- __________________

- ____and similar wiring enclosures.

5.3.2.2 Conductor type
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.
Sprinkler pipes or pipes conveying gas, water, flammable liquid or other conductive non-electrical service enclosures shall not be used as an earthing medium

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

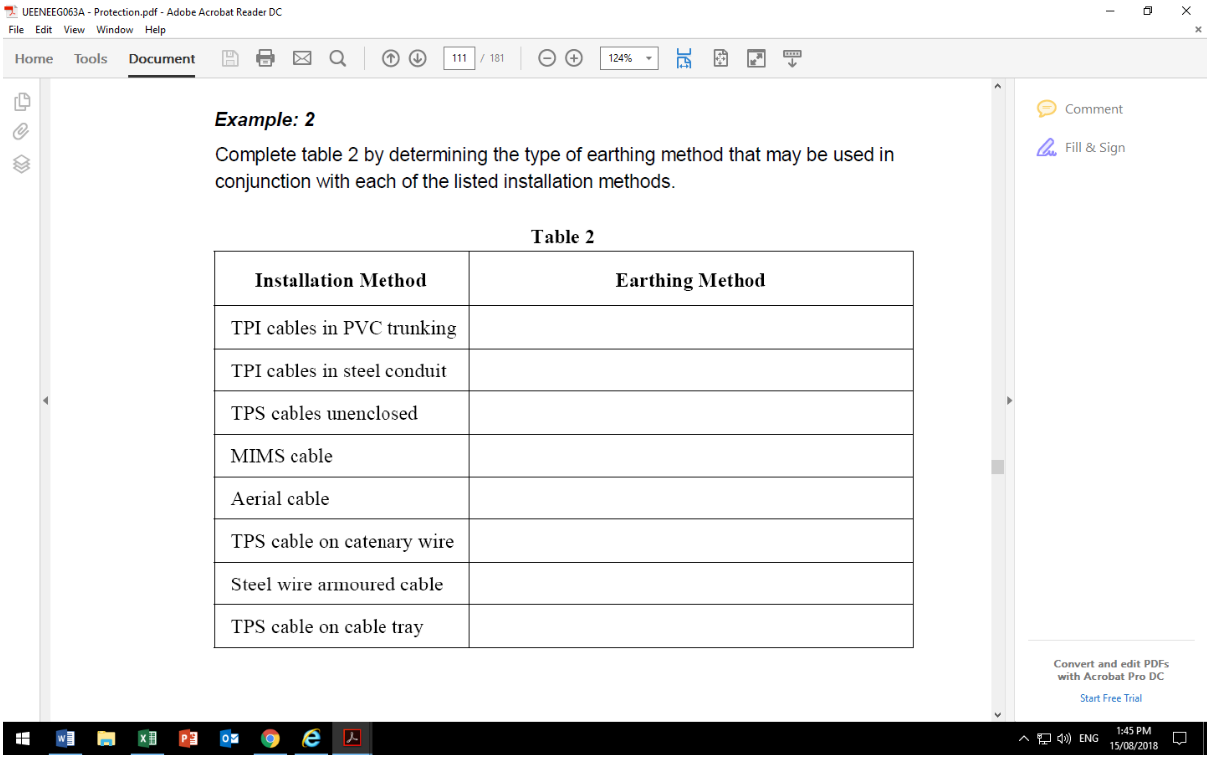
electrical equipment to be earthed.
(b) Conductive sheaths, armours and screens of cables May be regarded as a protective earthing conductor, provided that the electrical equipment to be earthed is supplied only by live conductors incorporated in the cable.

Can sprinkler pipes, gas pipes, water pipes or other metallic non-electrical service enclosures be used as earthing conductors?

No

5.3.2.2 Conductor type

Sprinkler pipes or pipes conveying gas, water, flammable liquid or other conductive non-electrical service enclosures shall not be used as an earthing medium



Example: 2

Complete table 2 by determining the type of earthing method that may be used in conjunction with each of the listed installation methods.

Table 2

Installation Method	Earthing Method
TPI cables in PVC trunking	
TPI cables in steel conduit	
TPS cables unenclosed	
MIMS cable	
Aerial cable	
TPS cable on catenary wire	
Steel wire armoured cable	
TPS cable on cable tray	

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.
(b) Conductive sheaths, armours and screens of cables May be regarded as a protective earthing conductor, provided that the

electrical equipment to be earthed is supplied only by live conductors incorporated in the cable.
Exception: This condition does not preclude the use of a MIMS cable sheath as a main earthing conductor, provided that any circuit protective earthing conductors connected to the sheath are associated only with the circuits supplied through the MIMS cable.

(c) Conductive framework:
(i) General Conductive framework may be regarded as a protective earthing conductor, provided that-
(A) the exposed conductive parts of electrical equipment are mounted on, and in effective electrical contact with, the framework; and
(B) the conductive framework is earthed by the connection of a protective earthing conductor directly to the framework.
(ii) Contact with hinged components Hinged components of conductive framework, such as cubicle doors, may be regarded as a protective earthing conductor, provided that-
(A) the fixed component of the framework is connected to a protective earthing conductor; and
(B) the fixed and hinged components of the framework are connected by means of a flexible protective earthing conductor.
(iii) Contact with moving components The interface between moving components may be regarded as a protective earthing conductor, provided that-
(A) the fixed component of the equipment is directly connected to a protective earthing conductor; and
(B) the fixed and movable components of the equipment are in effective contact by means of metal-to-metal bearing surfaces, such as the contact between a rail and wheel or between an axle and bearing.
Additional means of electrical continuity, such as sliding shoes or spring-loaded brushes, may be required where an accumulation of rust or non-conductive dust is likely to occur.
(d) Catenary wires A catenary wire may be regarded as a protective earthing conductor, provided that it-
(i) has not less than seven strands;
(ii) is supported by means of suitable anchorages;
(iii) has a nominal cross-sectional area of not less than 8.5 mm^2 if constructed of hard-drawn copper or galvanized low carbon (mild) steel;
(iv) has a resistance in accordance with the requirements of Clause 5.3.3; and
(v) is identified as an earthing conductor, in accordance with Clause 3.8.3.4, and for aerial earthing conductors, at each

anchorage point or catenary support.

5.4 EARTHING OF EQUIPMENT

5.4.1 General

5.4.1.1 Exposed conductive parts

The exposed conductive parts of electrical equipment shall be earthed where the electrical equipment is—

(a) installed or could operate in an earthed situation; or

(b) not installed in an earthed situation but any exposed conductive part of the electrical equipment is electrically continuous with an extraneous conductive part that is located in an earthed situation.

Exposed conductive parts of electrical equipment protected by electrical separation in accordance with Clause 7.4.3(c) shall not be earthed.

Exposed conductive parts need not be earthed if supplied by a SELV or PELV system in accordance with Clause 7.5.

Exception: Electrical equipment need not be earthed where the wiring of the electrical equipment conforms to protection by the use of double insulation, where the following conditions apply:

(a) Electrical equipment complying with AS/NZS 3100 for double

(b)

insulation need not be earthed.

Installation wiring entering equipment

Where cables connecting electrical equipment having double insulation enter the electrical equipment in such a manner that they may come into contact with accessible external conductive parts of the electrical equipment, the cables shall be of a type affording double insulation.

NOTE: Where double insulation is afforded by means of insulated and sheathed cables alone, care should be taken that screws or nails forming part of the structure or equipment are not liable to penetrate the cable, particularly where the cable is subject to movement during maintenance or

(a) other operations. See also Clauses 3.9.3 and 3.9.4.

Internal electrical equipment wiring

Conductors within electrical equipment having double insulation shall be protected, secured or insulated so that, if any one conductor becomes detached from its termination, neither the conductor nor its functional insulation can come into contact with accessible conductive parts.

The attachment of one conductor to another by tying, lacing, clipping or the like, in such a manner as to prevent either conductor coming into contact with accessible conductive parts if it becomes detached from its termination, shall be deemed to comply with this requirement.

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

(a) 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.
Equipotential bonding shall be arranged in accordance with Clause 5.6.

5.4.2 Socket-outlets

The earthing contact of every socket-outlet shall be earthed.
Exceptions:
1 An earthing contact of a socket-outlet supplied as a separated circuit shall be bonded to the protective bonding system, in accordance with Clause 7.4.
2 In accordance with Clause 7.5.10, a socket-outlet supplied as an extra-low voltage circuit shall not be provided with an earthing contact.

5.4.3 Lighting points

A protective earthing conductor, connected to a terminal or suitably insulated and enclosed, shall be provided at every lighting point, including
(a) transformers supplying ELV lighting systems.

5.4.4 Luminaires

(a) The exposed conductive parts of luminaires shall be earthed

5.4.5 Conductive supports for aerial conductors

Conductive poles, posts, struts, brackets, stay wires and other conductive supports for low voltage aerial conductors shall be earthed.
Exceptions:
1 Conductive supports effectively and permanently separated from all conductors by double insulation need not be earthed. An acceptable method would include use of XLPE type X-90UV cable to AS/NZS 3560 with insulated strain clamps and double insulated connectors to AS/NZS 4396.
2 Conductive supports effectively and permanently separated from aerial conductors by insulators mounted on timber, or other insulating supports, need not be earthed where the space between the conductors and the conductive supports is not less than—
· for single-core conductors, half the space between the conductors as specified in Clause 3.12.5.4; or
· for multi-core conductors, 100 mm.
3 Conductive supports beyond arm’s reach and effectively and permanently separated from any conductive guttering, roof or structural metalwork by a clearance or creepage distance of at least 25 mm need not be earthed.
4 Any stay wire that is attached to a conductive support fitted with a robust strain insulator so that any portion of the stay wire that is within arm’s reach and that is readily accessible is isolated from the
(a) remainder of the stay wire, need not be earthed.

5.4.6 Structural metalwork including conductive building materials

5.4.6.1 General

* Structural metalwork forming the frame of a structure containing an electrical installation or part thereof, including sheds or similar structures that are permanently connected to the electrical installation wiring, shall be earthed. The size of the earthing conductor used for earthing the frames shall be determined from Clause 5.3.3 in relation to the cross-sectional area of the largest active conductor that is contained within the framework of that electrical installation.

* For combined outbuildings, each outbuilding shall contain its own individual (a) bonding connection to the conductive frames within that outbuilding

All other conductive building materials shall be earthed where–

(a) the risk of contact with live parts of electrical equipment or insulated, unsheathed cables exists; or

(b) double insulation of cables in contact with conductive building materials is not permanently and effectively maintained.

The breaking of a conductor at a termination shall not result in contact between unearthed conductive building material and–

(i) live parts; or

(ii) parts separated from live parts by single insulation.

This requirement may be satisfied by–

(A) restraining the conductor by tying, lacing or clipping; or

(B) containing the termination within a non-conductive shroud or enclosure.

5.4.6.2 Connection to protective earthing conductors

Earthing of parts of structural metalwork, including conductive building materials, may be effected by the connection of a protective earthing conductor of appropriate size at one point of the metalwork, provided that the resistance between the earth bar and any part required to be earthed does not exceed 0.5 ·.

5.4.7 Submersible pumps

The exposed conductive parts of a submersible pump shall be earthed by means of a protective earthing conductor that is terminated at the pump (a) motor.

Refer to Section 5: **clause** - Special conditions:

List two requirements that apply when metallic conduit or trunking is used as a protective earthing conductor.

□ ____

____

□ ____

____

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:

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.

Fixed and hinged components of metallic framework such as cubicle doors are deemed to be earthed provided that –

- ____
____

and

- ____
____

5.3.2.3 Special conditions
(ii) Contact with hinged components Hinged components of conductive framework, such as cubicle doors, may be regarded as a protective earthing conductor, provided that—
(A) the fixed component of the framework is connected to a protective earthing conductor; and
(B) the fixed and hinged components of the framework are connected by means of a flexible protective earthing conductor.

Refer to Section 5: **clause** - Continuity - General:
Protective earthing conductors shall be suitably protected against –
____
____

5.5.4 Continuity
5.5.4.1 General
Earthing conductors shall be suitably protected against mechanical and chemical deterioration and electrodynamic forces. Star or cutting washers or similar devices that effectively cut through paint or similar coatings are considered to be an acceptable method of ensuring earth continuity across bolted or clamped joints between metal equipment panels or framework that have painted or coated surfaces.

Metallic wiring enclosures, metallic sheaths, armours and screens of cables that are required to be earthed or used as an earthing medium must be -
_________________________ and _________________________ continuous

5.5.4.3 Conductive sheaths, armours and screens of cables
Conductive sheaths, armours and screens of cables and associated fittings that are required to be earthed, including those used as an earthing medium, shall be mechanically and electrically continuous. The impedance of such cable components and associated fittings providing earth continuity shall be in accordance with that required for a copper earthing conductor determined in accordance with Clause 5.3.3.

Refer to Section 8: **clause** - Continuity of earthing system:
The resistance of protective earthing conductors shall be low enough to permit the passage of current necessary to operate the circuit ________________________.
breaker

5.4.6.2 Connection to protective earthing conductors
Earthing of parts of structural metalwork, including conductive building materials, may be effected by the connection of a protective earthing conductor of appropriate size at one point of the metalwork, provided that the resistance between the earth bar and any part required to be earthed does not exceed 0.5 ·.

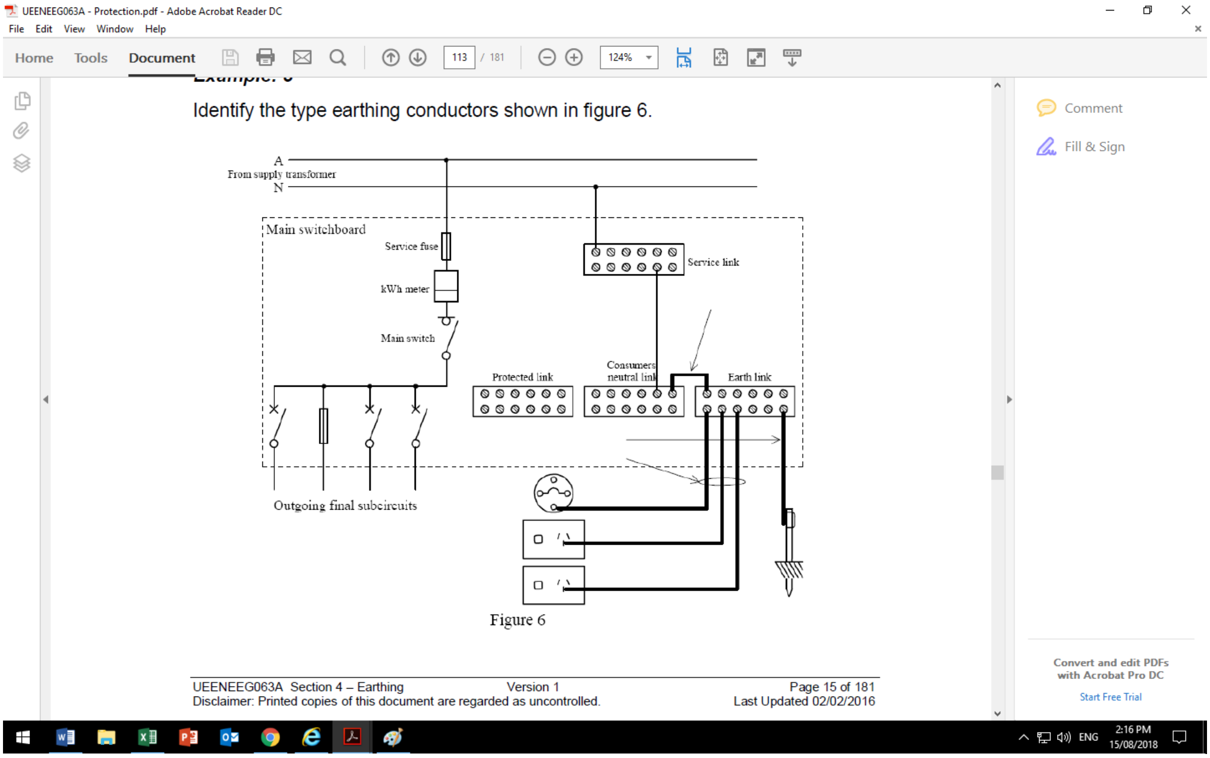
The maximum resistance of the protective earthing conductor associated with any particular circuit depends on -
- ____ of the protective device

and the
- ____________________________ of the live conductors that comprise the circuit.

Resistance/Resistance
FUNCTIONAL EARTH CONDUCTOR
Refer to definitions: **clause** - Functional earthing:
Functional earth conductors are used to ensure the correct operation of electrical equipment. Functional earth conductors are commonly found in -
- ____ equipment;
- ____ equipment;
- ____.

5.2.2 Functional earthing (FE)
Equipment may be required to be connected to the earthing system for purposes of correct operation rather than the safety conditions associated with protective earthing. In such cases, functional earthing conductors are not required to be selected and installed to withstand fault currents or to be identified in the same manner as a protective earthing conductor.
Examples:
1 Functional earth (FE) connections fitted to certain types of RCDs to provide an earth for an alternative supply connection for the internal electronic circuit operation in the event of the incoming neutral connection becoming disconnected.
2 Conductors connecting cathodic protection systems or radio

interference suppression devices to a separate earthing arrangement.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Identify the type earthing conductors shown in figure 6.

Figure 6

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Identify the type earthing conductors shown in figure 6.

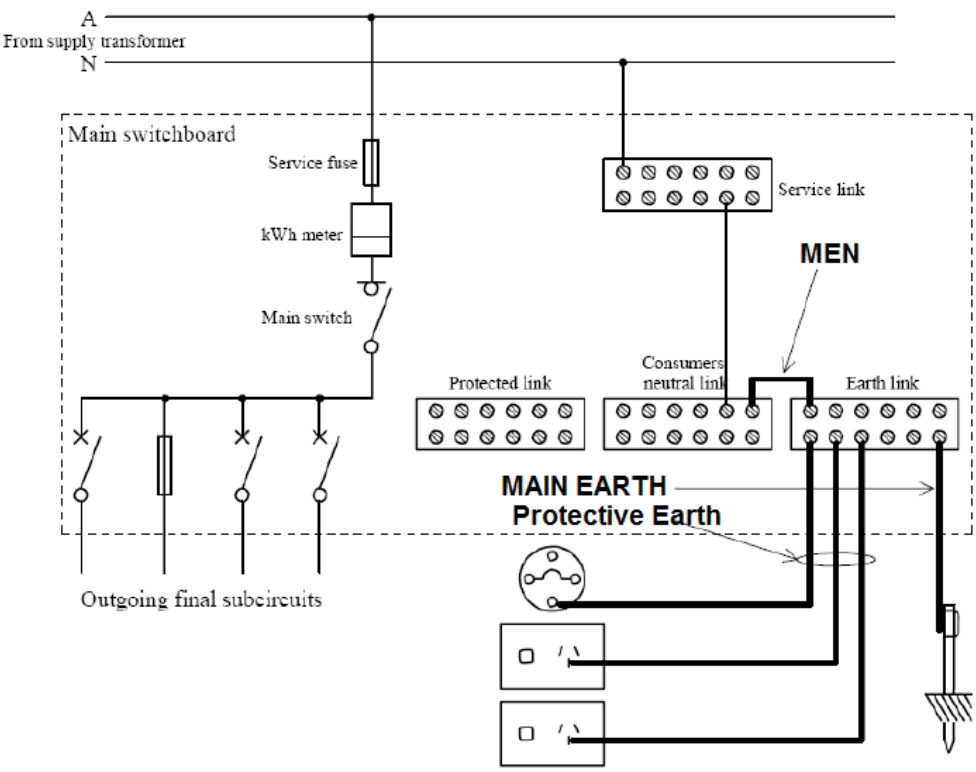


Figure 6

EARTHING OF ELECTRICAL EQUIPMENT – PROTECTIVE EARTHING

Refer to Section 5: **clause** - Earthing of equipment - General:
Refer to Section 5: **clause** - Exposed conductive parts
Except where exempted, exposed conductive parts of electrical equipment shall be earthed where the electrical equipment is -
a)____
b)____
____
____

5.1.2 Selection and installation

Earthing arrangements shall be selected and installed to perform the following functions, or have the following features:
(a) Enable automatic disconnection of supply in the event of a short circuit to earth fault or excessive earth leakage current in the protected part of the installation through protective earthing arrangements.
(b) Enable equipment requiring an earth reference to function correctly through functional earth (FE) arrangements.
(c) Mitigate voltage differences appearing between exposed conductive parts of equipment and extraneous conductive parts through equipotential bonding arrangements.
(d) Provide an effective and reliable low impedance fault path capable of carrying earth fault and earth leakage currents without danger or failure from thermal, electromechanical, mechanical, environmental and other external influences.
(e) Provide measures for the connection of exposed conductive parts and extraneous conductive parts.

5.2.1 Protective earthing

When a fault occurs between a live part and an exposed conductive part or parts of the protective earthing system, a prospective touch voltage may arise between simultaneously accessible conductive parts. Fault protection by means of automatic disconnection of supply is intended to limit this voltage.
Automatic disconnection is achieved by—
(a) the provision of a protective earthing system in which exposed conductive parts are connected via conductors or similar medium to the earthed neutral of the distribution system; and
(b) in the event of a fault current or excessive earth leakage current flowing in the protective earthing system, overcurrent or earth leakage current protective devices operate to disconnect the affected part of the installation within the specified maximum duration of the prospective touch voltage.

Refer to Section 5: **clause** - Exposed conductive parts
Except where exempted, exposed conductive parts of electrical equipment shall be earthed where the electrical equipment is -
a)____
b)____

5.4 EARTHING OF EQUIPMENT

5.4.1 General

5.4.1.1 Exposed conductive parts

The exposed conductive parts of electrical equipment shall be earthed where the electrical equipment is–

(a) installed or could operate in an earthed situation; or

(b) not installed in an earthed situation but any exposed conductive part of the electrical equipment is electrically continuous with an extraneous conductive part that is located in an earthed situation.

Exposed conductive parts of electrical equipment protected by electrical (a) separation in accordance with Clause 7.4.3(c) shall not be earthed.

7.4.3 Arrangement of circuits

Separated circuits shall comply with the following requirements:

(a) Circuit voltage shall not exceed 500 V.

(b) All live parts of a separated circuit shall be reliably and effectively electrically separated from all other circuits, including other separated circuits and earth.

This requirement shall also apply to live parts of relays, contactors and similar electrical equipment installed in the separated circuit.

NOTES:

1 This requirement can be satisfied by insulation of the live parts to Class II (double or reinforced insulation) or measures that are equivalent to the input and output transformer winding isolation provisions of AS/NZS 61558.

2 Each separated circuit should comprise a separate cable or wiring system. However, multi-core cables or a common non-conductive wiring enclosure may be used where the segregation requirements of Clause 3.9.8 are satisfied.

(c) Exposed conductive parts of electrical equipment supplied by a separated circuit shall not be connected to the protective earthing conductor, or the exposed conductive parts, of the source of supply.

Exceptions:

Electrical equipment need not be earthed where it complies with any of the following provisions:

□ ______________________________

□ ______________________________

□ ______________________________

5.4.1 General

5.4.1.1 Exposed conductive parts

Exception: Electrical equipment need not be earthed where the wiring of the electrical equipment conforms to protection by the use of double insulation, where the following conditions apply:

(a) Electrical equipment complying with AS/NZS 3100 for double
(b)
insulation need not be earthed.
Installation wiring entering equipment
Where cables connecting electrical equipment having double insulation enter the electrical equipment in such a manner that they may come into contact with accessible external conductive parts of the electrical equipment, the cables shall be of a type affording double insulation.
NOTE: Where double insulation is afforded by means of insulated and sheathed cables alone, care should be taken that screws or nails forming part of the structure or equipment are not liable to penetrate the cable, particularly where the cable is subject to movement during maintenance or other operations. See also Clauses 3.9.3 and 3.9.4.
Internal electrical equipment wiring
Conductors within electrical equipment having double insulation shall be protected, secured or insulated so that, if any one conductor becomes detached from its termination, neither the conductor nor its functional insulation can come into contact with accessible conductive parts.
The attachment of one conductor to another by tying, lacing, clipping or the like, in such a manner as to prevent either conductor coming into contact with accessible conductive parts if it becomes detached from its termination, shall be deemed to comply with this requirement

Refer to Section 5: **clause** - Particular electrical equipment - Wiring systems:
The exposed conductive parts of wiring enclosures or conductive sheaths, armours or screens required to be earthed, shall be earthed at the -
☐____

5.3.2.3 Special conditions
c) Conductive framework:
(i) General Conductive framework may be regarded as a protective earthing conductor, provided that—
(A) the exposed conductive parts of electrical equipment are mounted on, and in effective electrical contact with, the framework; and
(B) the conductive framework is earthed by the connection of a

protective earthing conductor directly to the framework

A metallic screen or braid incorporated in a cable need not be earthed where -
☐____

☐____

☐____

____

5.3.2.3 Special conditions

Additionally, metallic cable sheathing, armouring, screening or braiding need not be earthed if the requirements of **clause** _______________ are met

5.3.2.3 Special conditions
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.

(b) Conductive sheaths, armours and screens of cables May be regarded as a protective earthing conductor, provided that the electrical equipment to be earthed is supplied only by live conductors incorporated in the cable.

Refer to Section 5: **clause** - Earthing of equipment supplied by flexible cord or cable:
The exposed conductive parts of electrical equipment supplied by flexible cords or cables shall be earthed by connection to a protective earthing conductor:

5.5.3.3 Electrical equipment supplied by flexible cord or flexible cable
The exposed conductive parts of electrical equipment supplied by flexible cord or flexible cable shall be earthed by connection to a protective earthing conductor incorporated with the associated live conductors in the sheath, braid or enclosure of the supply cord or cable.

Refer to Section 5: **clause** - Socket-outlets:
The earthing contact of every socket-outlet shall be earthed except:

☐ ____

____

☐ ____

____

5.4.2 Socket-outlets
The earthing contact of every socket-outlet shall be earthed.
Exceptions:
1 An earthing contact of a socket-outlet supplied as a separated circuit shall be bonded to the protective bonding system, in accordance with Clause 7.4.
2 In accordance with Clause 7.5.10, a socket-outlet supplied as an extra-low voltage circuit shall not be provided with an earthing contact.

Refer to Section 5: **clause** - Lighting points:
A protective earthing conductor, connected to a terminal or suitably insulated and enclosed, shall be provided -

____
____

5.4.3 Lighting points
A protective earthing conductor, connected to a terminal or suitably insulated and enclosed, shall be provided at every lighting point, including transformers supplying ELV lighting systems.

Protective earthing conductor shall not be provided for -

____
____

5.4.3 Lighting points
A protective earthing conductor, connected to a terminal or suitably insulated and enclosed, shall be provided at every lighting point, including transformers supplying ELV lighting systems.
Exceptions:
1 A protective earthing conductor shall not be provided for luminaires located in Zone 0 of swimming and spa pools installed in accordance with Clause 6.3.4.5 and Zone 0 of fountains and water features installed in accordance with Clause 6.4.4.5

List four types of lighting points that need not be earthed:
- ☐ ____
- ☐ ____

____
- ☐ ____

____
- ☐ ____

5.4.3 Lighting points

A protective earthing conductor need not be provided for the following lighting points:
- · Festoon-type lampholders of the all-insulated type.
- · Lighting points where the luminaire is earthed by attachment to screwed conductive conduit or pipe in accordance with Clause 5.3.2.3.
- · Lighting points consisting of a luminaire installed outdoors on a non-conductive pole where the luminaire is not in an earthed situation.
- · ELV lighting points.

Refer to Section 5: **clause** - Unprotected consumers mains:

NOTE: The definition of unprotected consumers' mains may vary between electricity distributors. Local service rules should be checked with the relevant distributor.

Any metallic equipment associated with unprotected consumers mains shall be earthed by connection to the:

- ☐ ____________________

or

- ☐ ____________________

Provide four examples of metallic equipment that may required to be earthed when associated with unprotected consumer's mains.

- ☐ ____________________
- ☐ ____________________
- ☐ ____________________
- ☐ ____________________

5.5.3.5 Unprotected consumer mains

Exposed conductive parts associated with consumer mains not provided with short-circuit protection on the supply side shall be earthed by a conductor or by direct connection to an earth bar such that either has a current-carrying capacity not less than that of the main neutral conductor. Unprotected consumer mains are those that are not protected by a service protective device (SPD) as shown in Figure 2.1.

NOTE: Short-circuit of an unprotected active conductor to a switchboard surround, riser bracket, etc. will cause the earthing conductor to continuously carry the maximum fault current available through those consumer mains. Reduced sizes for protective earthing conductors in other situations are permitted because the fault current is of limited duration.

This conductor shall be connected to—

(a) the main neutral conductor or bar [see Figure 5.6(A)]; or

(b) the main earthing terminal/connection or bar, in which case, in accordance with Clause 5.3.5.2, the cross-sectional area of the MEN connection shall be not less than that of the main neutral conductor

Where double insulation of the consumer mains conductors is maintained up to the supply terminal/s of the service protective device/s, and shortcircuit
protection is provided by that device, this requirement need not apply [see Figure 5.6(C)].

NOTES:

1 A system that is deemed to provide double insulation for aerial conductors would include use of XLPE type X-90UV cable to AS/NZS 3560 with insulated strain clamps and double insulated connectors to AS/NZS 4396.

2 Exposed conductive parts associated with consumer mains include—

(a) switchboard cases, surrounds and enclosures;

(b) wiring enclosures;
(c) boxes and accessories; and
(d) supports for aerial conductors.

3 A distributor's upstream service protective device may provide short-circuit protection of consumer mains.

Refer to Section 5: **clause** - Conductive supports for aerial conductors:
Supports for low voltage aerial conductors such as metallic poles, posts, struts, brackets and stay wires shall be earthed when within ___________________________

5.4.5 Conductive supports for aerial conductors

Conductive poles, posts, struts, brackets, stay wires and other conductive supports for low voltage aerial conductors shall be earthed.

Exceptions:

1 Conductive supports effectively and permanently separated from all conductors by double insulation need not be earthed. An acceptable method would include use of XLPE type X-90UV cable to AS/NZS 3560 with insulated strain clamps and double insulated connectors to AS/NZS 4396.

2 Conductive supports effectively and permanently separated from aerial conductors by insulators mounted on timber, or other insulating supports, need not be earthed where the space between the conductors and the conductive supports is not less than—

· for single-core conductors, half the space between the conductors as specified in Clause 3.12.5.4; or

· for multi-core conductors, 100 mm.

3 Conductive supports beyond arm's reach and effectively and permanently separated from any conductive guttering, roof or structural metalwork by a clearance or creepage distance of at least 25 mm need not be earthed.

4 Any stay wire that is attached to a conductive support fitted with a robust strain insulator so that any portion of the stay wire that is within arm's reach and that is readily accessible is isolated from the remainder of the stay wire, need not be earthed.

Refer to Section 5: **clause** - Structural metalwork including conductive building materials:
Parts of structural metalwork, including conductive building materials, shall be earthed where -

□ ____

____

□ ____

____

5.4.6 Structural metalwork including conductive building materials

5.4.6.1 General

* Structural metalwork forming the frame of a structure containing an

electrical installation or part thereof, including sheds or similar structures that are permanently connected to the electrical installation wiring, shall be earthed. The size of the earthing conductor used for earthing the frames shall be determined from Clause 5.3.3 in relation to the cross-sectional area of the largest active conductor that is contained within the framework of that electrical installation.

* For combined outbuildings, each outbuilding shall contain its own individual bonding connection to the conductive frames within that outbuilding.

All other conductive building materials shall be earthed where—

(a) the risk of contact with live parts of electrical equipment or insulated, unsheathed cables exists; or

(b) double insulation of cables in contact with conductive building materials is not permanently and effectively maintained.

The breaking of a conductor at a termination shall not result in contact between unearthed conductive building material and—

(i) live parts; or

(ii) parts separated from live parts by single insulation.

This requirement may be satisfied by—

(A) restraining the conductor by tying, lacing or clipping; or

(B) containing the termination within a non-conductive shroud or enclosure.

5.4.6.2 Connection to protective earthing conductors

Earthing of parts of structural metalwork, including conductive building materials, may be effected by the connection of a protective earthing conductor of appropriate size at one point of the metalwork, provided that the resistance between the earth bar and any part required to be earthed does not exceed 0.5 ·.

The breaking of a conductor at a termination shall not result in contact between unearthed conductive building material and -

□ ____

□ ____

(i) live parts; or

(ii) parts separated from live parts by single insulation

Refer to Section 5: **clause** –Domestic electrical installations

□ ____

1.4.53 Electrical installation, domestic

An electrical installation in a private dwelling or that portion of an electrical installation associated solely with a flat or living unit.

Clause 5.4.6.3 - *Connection to protective earthing conductors,* further states that the earthing of structural metalwork and building materials may be affected by the connection of a protective earthing conductor (of appropriate size) at one point of the metalwork provided that the:

____

____

5.4.6.2 Connection to protective earthing conductors

Earthing of parts of structural metalwork, including conductive building materials, may be effected by the connection of a protective earthing conductor of appropriate size at one point of the metalwork, provided that the resistance between the earth bar and any part required to be earthed does not exceed 0.5 ohm

BONDING

Refer to definitions: **clause** -Equipotential bonding:
Equipotential bonding conductors are used to minimise the risk of potential differences occurring between exposed conductive parts and extraneous conductive parts of an installation. Equipotential bonding conductors are not intended to carry current in ___________________________________.

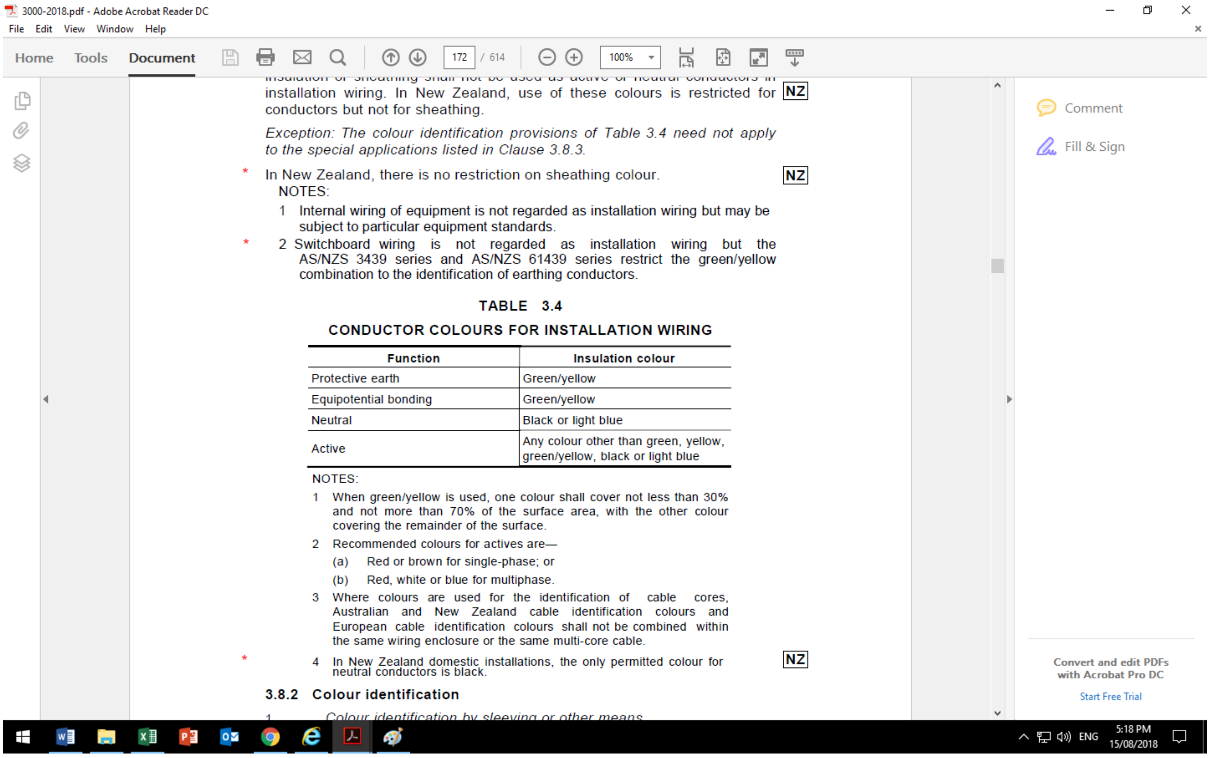
5.6.1 General
Equipotential bonding is intended to minimize the risks associated with the occurrence of voltage differences between exposed conductive parts of electrical equipment and extraneous conductive parts.

Refer to Section 5: **clause** - Arrangement:
Bonding shall be arranged by the connection of the extraneous conductive parts to the earthing system of the installation by equipotential bonding conductors in accordance with clauses ___________________________________.

5.6.2 Arrangement
5.6.2.1 General
Equipotential bonding arrangements shall be provided in accordance with Clauses 5.6.2.2 to 5.6.2.6 to avoid any potential differences that may occur between electrical equipment connected to the electrical installation earthing system and any conductive piping (including taps etc.) that may independently be in contact with the mass of earth (see Figures 5.7 and 5.8 for arrangement details).
Additional equipotential bonding requirements apply for:
(a) Patient areas of hospitals, medical and dental practices and dialyzing locations, in accordance with AS/NZS 3003.
(b) Explosive atmospheres, in accordance with Clause 7.7.
(c) Telecommunications installations, in accordance with AS/NZS 3015.
(d) Film, video and television sites, in accordance with AS/NZS 4249.
(e) Photovoltaic arrays, in accordance with AS/NZS 5033.
* (f) Grid connected inverters, in accordance with AS/NZS 4777.1.
(g) Generating systems, in accordance with Clause 7.3.
(h) Separated circuits, in accordance with Clause 7.4.

Refer to Section 5: **clause** - Insulation and identification:

Equipotential bonding conductors shall be coloured ______________________________.



installation wiring. In New Zealand, use of these colours is restricted for conductors but not for sheathing. NZ

Exception: The colour identification provisions of Table 3.4 need not apply to the special applications listed in Clause 3.8.3.

* In New Zealand, there is no restriction on sheathing colour. NZ

NOTES:

1 Internal wiring of equipment is not regarded as installation wiring but may be subject to particular equipment standards.

* 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

Refer to Section 5: **clause** - Conductive water piping:

Under what two conditions shall metallic water piping be equipotentially bonded?

5.6.2.2 Conductive water piping

Conductive water piping that is both—

(a) installed and accessible within the building containing the electrical installation; and

(b) continuously conductive from inside the building to a point of contact with the ground,

shall be bonded to the earthing system of the electrical installation.

Any equipotential bonding of conductive water piping shall be effected by means of an equipotential bonding conductor connected to the main earthing conductor or earth terminal or bar.

The connection of the bonding conductor to the conductive water piping shall be as close as practicable to the entry of the conductive water piping to the building.

When conductive water piping is bonded -

□To which conductor must the equipotential bond connect? ____________________

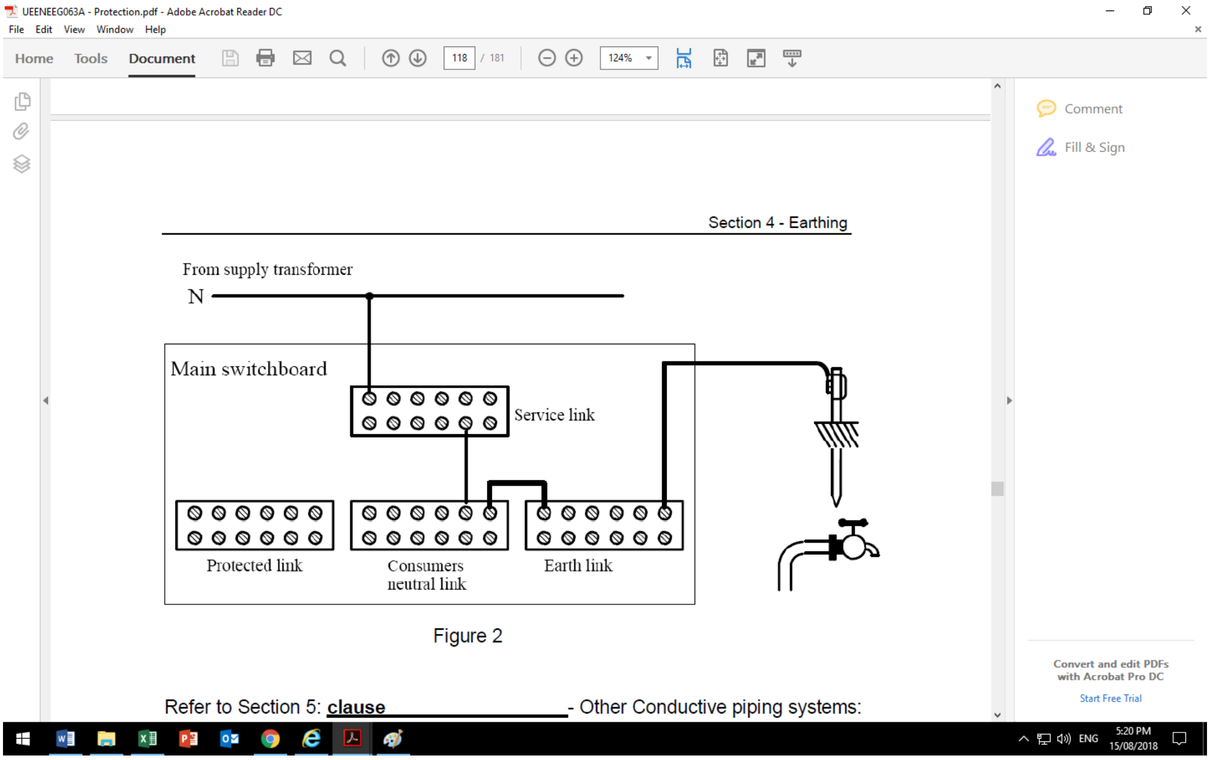
□Where is the connection of the bond to be made? __________________________

5.6.2.2 Conductive water piping

shall be bonded to the earthing system of the electrical installation.

Any equipotential bonding of conductive water piping shall be effected by means of an equipotential bonding conductor connected to the main earthing conductor or earth terminal or bar.

The connection of the bonding conductor to the conductive water piping shall be as close as practicable to the entry of the conductive water piping to the building.



Refer to Section 5: **clause** - Other Conductive piping systems:
Provide four examples of metallic piping that must be bonded if in contact with the exposed metallic parts of wiring enclosures or electrical equipment.

- ☐ ____________________
- ☐ ____________________

5.6.2.3 Other conductive piping systems
Conductive piping systems associated with fire sprinklers, gas, water or flammable liquid that are unavoidably in contact with the exposed conductive parts of wiring enclosures, cable components or other electrical equipment shall be connected to such equipment by means of an equipotential bonding conductor.
Exception: Bonding need not be provided where the piping system is effectively earthed by connection to an associated item of electrical equipment, e.g. pipes connected to electric hot water systems.
5.6.2.4 Conductive cable sheaths and conductive wiring enclosures
The conductive sheath, armour or conductive wiring enclosure of conductors operating at above extra-low voltage shall comply with one of the following:
(a) The conductive sheath, armour or conductive wiring enclosure of conductors shall be bonded to any conductive pipes containing flammable agents, such as gas or oil, with which they are in contact. The bonding shall be arranged to prevent appreciable voltage differences at points of contact.

Refer to Section 5: **clause** - Conductive cable sheaths and conductive wiring enclosures:

Where metal sheaths, armours or wiring enclosures are in contact with pipes containing ____they shall be bonded to prevent voltage differences at points of contact.

5.6.2.4 Conductive cable sheaths and conductive wiring enclosures

The conductive sheath, armour or conductive wiring enclosure of conductors operating at above extra-low voltage shall comply with one of the following:

(a) The conductive sheath, armour or conductive wiring enclosure of conductors shall be bonded to any conductive pipes containing flammable agents, such as gas or oil, with which they are in contact. The bonding shall be arranged to prevent appreciable voltage differences at points of contact.

Refer to Section 5: **clause** - Showers and Bathrooms:

Any _________________________________ within a concrete floor or wall forming part of a shower or bathroom shall be bonded to the earthing system of the electrical installation.

5.6.2.5 Showers and bathrooms

Any conductive reinforcing within a concrete floor or wall of a room containing a shower or bath shall be bonded to the earthing system of the electrical installation.

An equipotential bonding conductor, in accordance with Clause 5.6.3, shall be connected between the reinforcing material and any part of the earthing system.

* For a combined outbuilding, each structure within that outbuilding that contains a shower or bathroom shall contain its own individual bonding connection to the conductive reinforcing within that structure.

Refer to Section 5: **clause** - Swimming and spa pools:

List the items to be equipotentially bonded around swimming and spa pools.

☐ ____

____

☐ ____

5.6.2.6 Swimming and spa pools

* 5.6.2.6.1 Bonding arrangement

An equipotential bonding conductor, in accordance with Clause 5.6.3, shall be connected between—

(a) the conductive pool structure and the pool equipotential bonding conductor connection point specified in Clauses 5.6.2.6.2 and 5.6.2.6.3;

(b) the items of electrical equipment specified in Clause 5.6.2.6.4;

(c) the conductive fixtures and fittings specified in Clause 5.6.2.6.5; and

(d) the earthing conductors associated with each circuit supplying the pool or spa, or the earthing bar at the switchboard at which the circuits

originate.
The resistance of an equipotential bonding conductor connected between the items listed (a) to (d) shall not exceed 0.5 ohm

5.6.2.6.4 Electrical equipment

5.6.2.6.5 Conductive fixtures and fittings

Refer to Section 5: **clause** - Telephone and telecommunications earthing systems:

5.6.2.7 Telephone and telecommunication earthing systems

Telecommunications earthing systems may be connected in common with the electrical installation earthing system in order to:

____

____

The telephone and telecommunication earthing system may be connected in common with the electrical installation earthing system in order to minimize the risk associated with different voltages appearing on the two systems.

If the telecommunications earthing system is bonded to the installation earthing system it shall be connected:

□____

____

If the telephone and telecommunication earthing system is directly connected to the electrical installation earthing system, it shall be connected either—

(a) to the electrical installation earthing system at an enclosed terminal provided for the purpose; or

(b) directly to the earth electrode by an independent connecting device, and shall be clearly identified

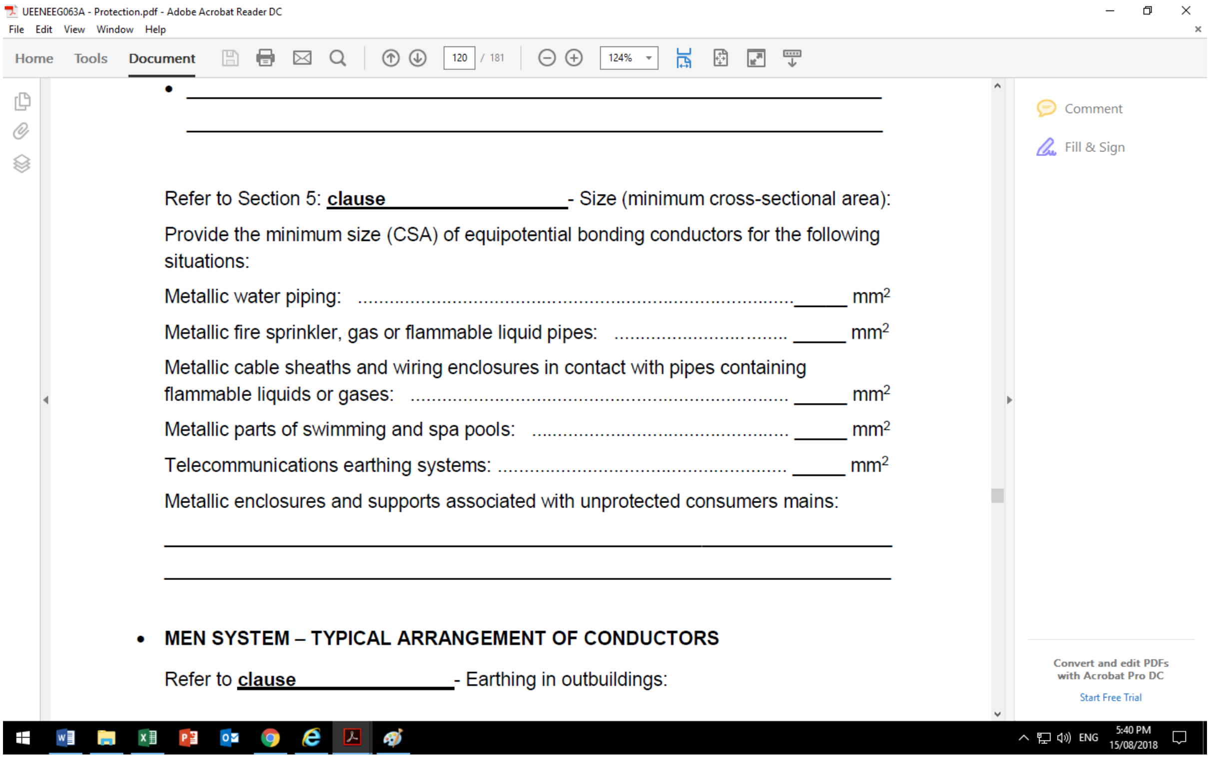
If an enclosed terminal is used the following conditions shall apply:

(i) The terminal shall be connected by means of a protective earthing conductor to the main earthing conductor of the electrical installation earthing system in accordance with the connection methods specified in Clause 5.5.2.

(ii) The terminal shall not be installed within a switchboard.

(iii) The terminal shall be installed in a convenient and readily accessible position.

(iv) The minimum cross-sectional area of the protective earthing conductor used for the connection shall be 6 mm^2.



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Refer to Section 5: **clause** ________________ - Size (minimum cross-sectional area):

Provide the minimum size (CSA) of equipotential bonding conductors for the following situations:

Metallic water piping: .... _____ mm^2

Metallic fire sprinkler, gas or flammable liquid pipes: .... _____ mm^2

Metallic cable sheaths and wiring enclosures in contact with pipes containing flammable liquids or gases: .... _____ mm^2

Metallic parts of swimming and spa pools: .... _____ mm^2

Telecommunications earthing systems: .... _____ mm^2

Metallic enclosures and supports associated with unprotected consumers mains:

____

____

- **MEN SYSTEM – TYPICAL ARRANGEMENT OF CONDUCTORS**

Refer to **clause** ________________ - Earthing in outbuildings:

The equipotential bonding conductor need not be larger than the sizes specified below, provided the installation conditions are such that mechanical damage is unlikely to occur, and, in accordance with Clause 5.7.5, a larger size is not required to reduce the earth fault-loop impedance.

The size of equipotential bonding conductors shall be in accordance with the following:

(a) Conductive piping, cable sheaths and wiring enclosures The equipotential bonding conductor required in accordance with Clauses 5.6.2.2 to 5.6.2.4 shall have a cross-sectional area not less than 4 mm2.

(b) Showers, bathrooms, swimming and spa pools The equipotential bonding conductors required to connect conductive parts of a shower, bathroom, swimming or spa pool in accordance with Clauses 5.6.2.5 and 5.6.2.6 shall have a cross-sectional area not less than 4 mm2.

Exception: The cross-sectional area of the equipotential bonding conductor for a swimming or spa pool may be determined as for an earthing conductor, in accordance with Clause 5.3.3.4(c), where the equipotential bonding conductor is incorporated in a multi-core flexible cord supplying electrical equipment that is required to be removed for maintenance.

(c) Telephone and telecommunication earthing systems The equipotential bonding conductors required to connect a telephone and telecommunication earthing system in accordance with Clause 5.6.2.7 shall have a cross-sectional area not less than 6 mm2.

NOTE: Refer to the AS/NZS 60079 series for minimum sizes of equipotential bonding conductors in explosive atmospheres.

MEN SYSTEM – TYPICAL ARRANGEMENT OF CONDUCTORS

Refer to **clause** - Earthing in outbuildings:

5.5.3 Particular methods of earthing

5.5.3.1 Outbuildings

All parts of an electrical installation in or on an outbuilding that are required
to be earthed in accordance with Clause 5.4 shall be earthed by one of the following methods:

* (a) Individual outbuildings The earthing system in an individual outbuilding shall be either—

(i) connected to a protective earthing conductor connected in accordance with Clause 5.5.2.1; or

(ii) connected as a separate MEN installation in accordance with Clauses 5.5.3.1(c) and 5.5.3.2.

* (b) Combined outbuildings The earthing system in a combined outbuilding shall be connected to a protective earthing conductor, connected in accordance with Clause 5.5.2.1, and shall not be connected as a separate MEN installation.

(c) Separate MEN installation The earthing system in a separate MEN installation shall be connected to the submain neutral conductor supplying the outbuilding. In this case, the submain neutral conductor supplying the outbuilding is a combined protective earthing and neutral (PEN) conductor.

The electrical installation in the outbuilding shall be regarded as a separate electrical installation, and shall be earthed in accordance with other relevant Clauses of this Standard. The following requirements and recommendations also apply:

(i) There shall be not more than one MEN connection in any one individual outbuilding.

(ii) The distribution board in the outbuilding shall be regarded as a main switchboard for the purpose of effecting the MEN connection.

(iii) The earthing conductor between the distribution board in the outbuilding and the earth electrode shall be regarded as a main earthing conductor for the purposes of earthing of the electrical installation in the outbuilding.

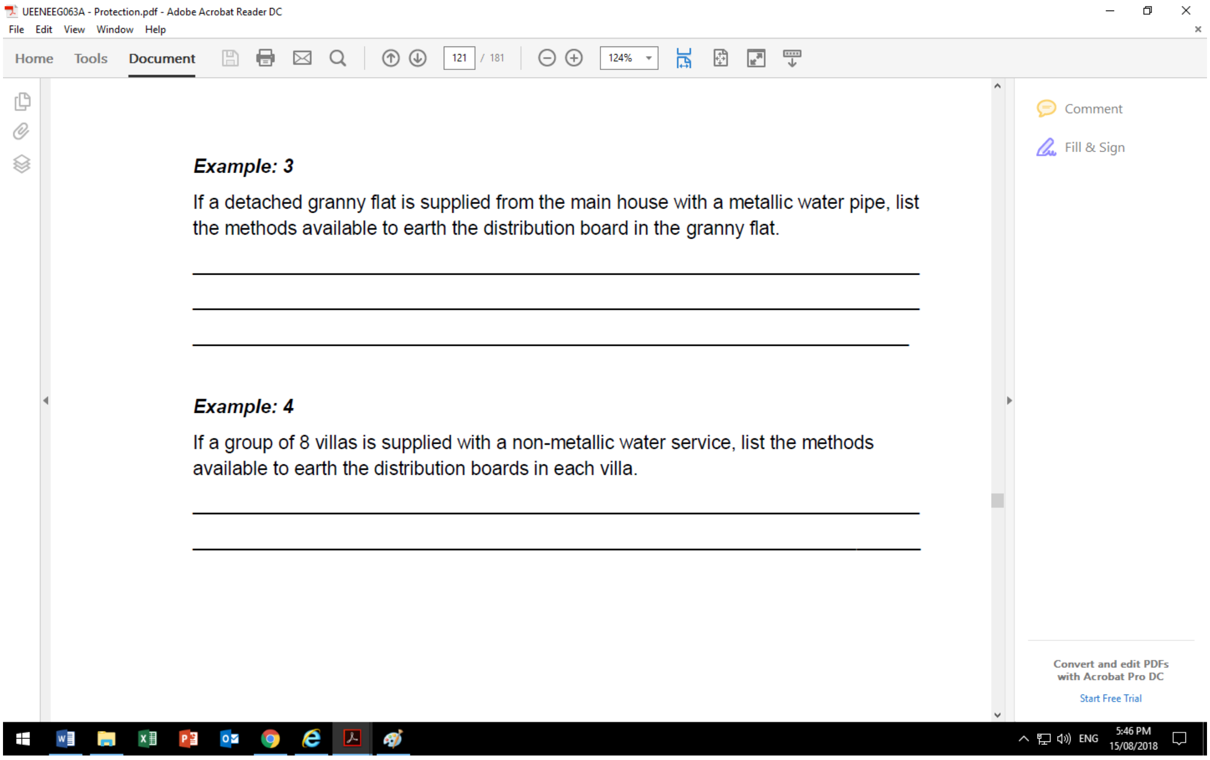
(iv) The submain supplying the outbuilding shall be run either—

(A) directly from the main switchboard; or

(B) from the main switchboard via distribution boards in one or more other outbuildings, to one distribution board only in the outbuilding.

(v) Where the combined protective earthing and neutral (PEN) conductor supplying the distribution board in the outbuilding runs from the main switchboard via distribution boards in one or more other outbuildings, the terminals on such distribution boards shall not be depended on for continuity of the combined protective earthing and neutral (PEN) conductor.

(vi) The combined protective earthing and neutral (PEN) conductor supplying the distribution board in the outbuilding should not be connected in parallel, by means of earthing or equipotential bonding conductors, with conductive pipes or structural metal within the electrical installation.



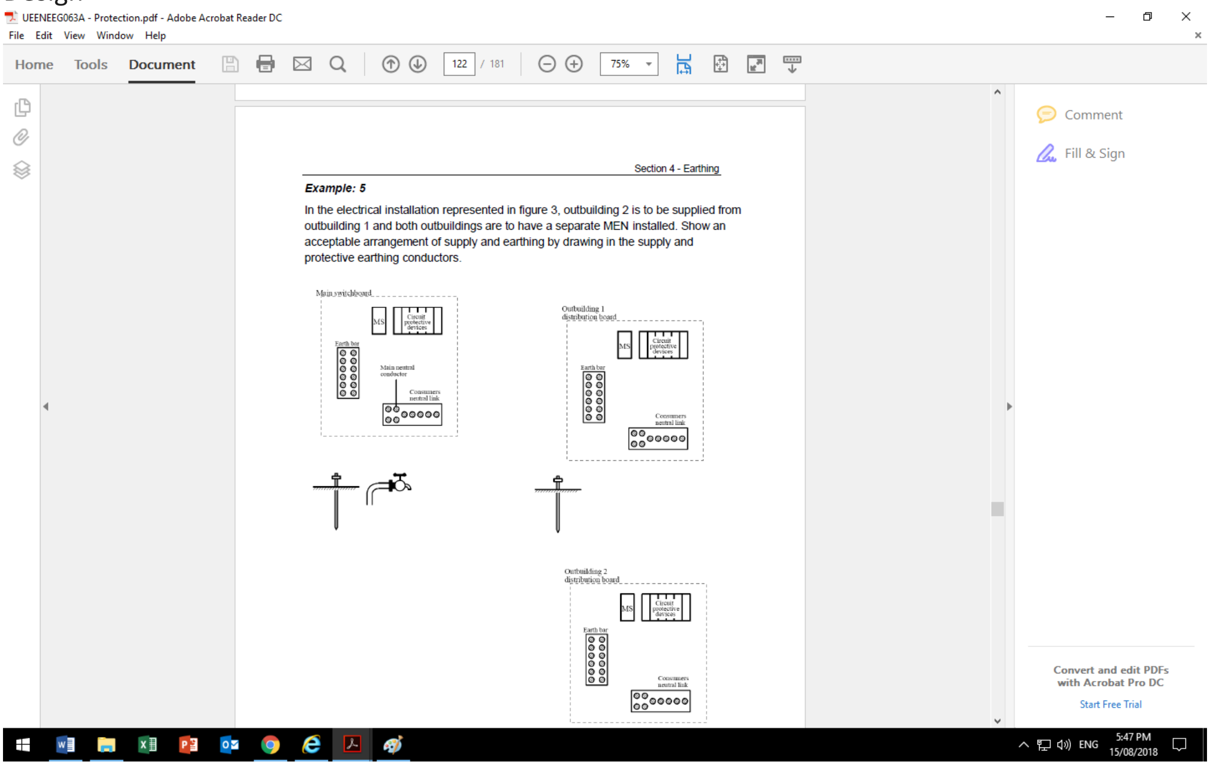
Example: 3

If a detached granny flat is supplied from the main house with a metallic water pipe, list the methods available to earth the distribution board in the granny flat.

Example: 4

If a group of 8 villas is supplied with a non-metallic water service, list the methods available to earth the distribution boards in each villa.

Design



Section 4 - Earthing

Example: 5

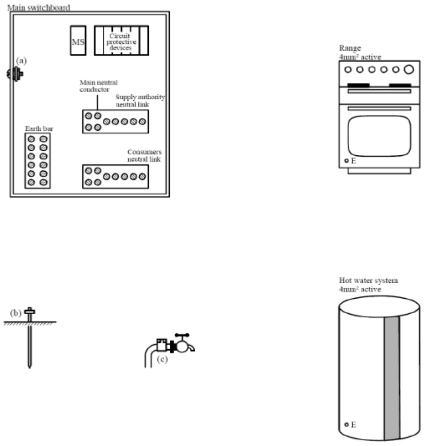
In the electrical installation represented in figure 3, outbuilding 2 is to be supplied from outbuilding 1 and both outbuildings are to have a separate MEN installed. Show an acceptable arrangement of supply and earthing by drawing in the supply and protective earthing conductors.

Example: 6

On the arrangement shown in figure 4, draw a wiring diagram for a MEN earthing system. On the diagram -

(a) identify the items labelled (a), (b) and (c)

(b) identify the type and size of each conductor given the consumers mains are $16mm^2$ and deemed as unprotected.



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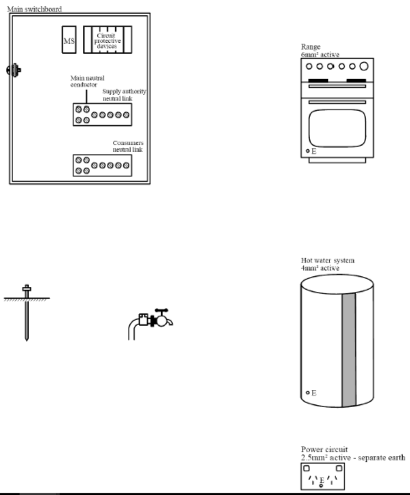
Section 4 - Earthing

Example: 7

Using the arrangement shown in figure 5, draw a wiring diagram for a MEN earthing system.

On the diagram identify the size of each conductor given the consumers mains are $35mm^2$ and deemed as unprotected.



Example: 8

On the figure 6 below:

a) Identify each of the 13 parts indicated using the correct terminology
b) With the assistance of your teacher, draw the fault current path (earth fault loop) using a highlighter or coloured pen assuming an active to earth fault on the single power point.

Note: Earth fault loop and fault current values will be discussed in further sections.

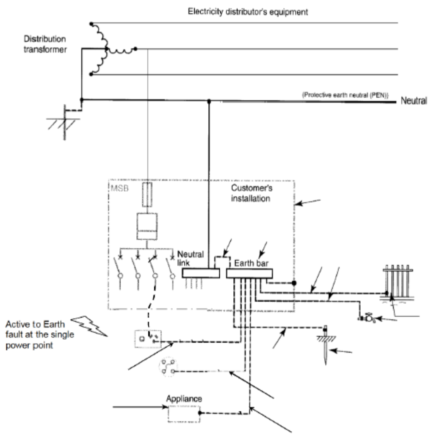
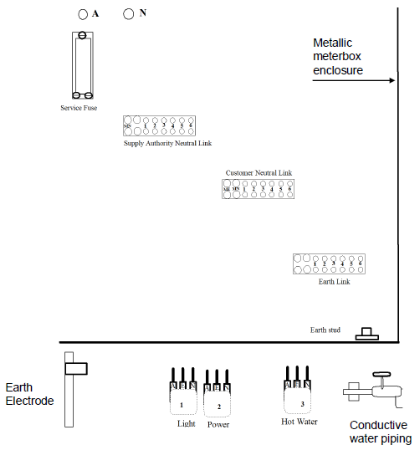


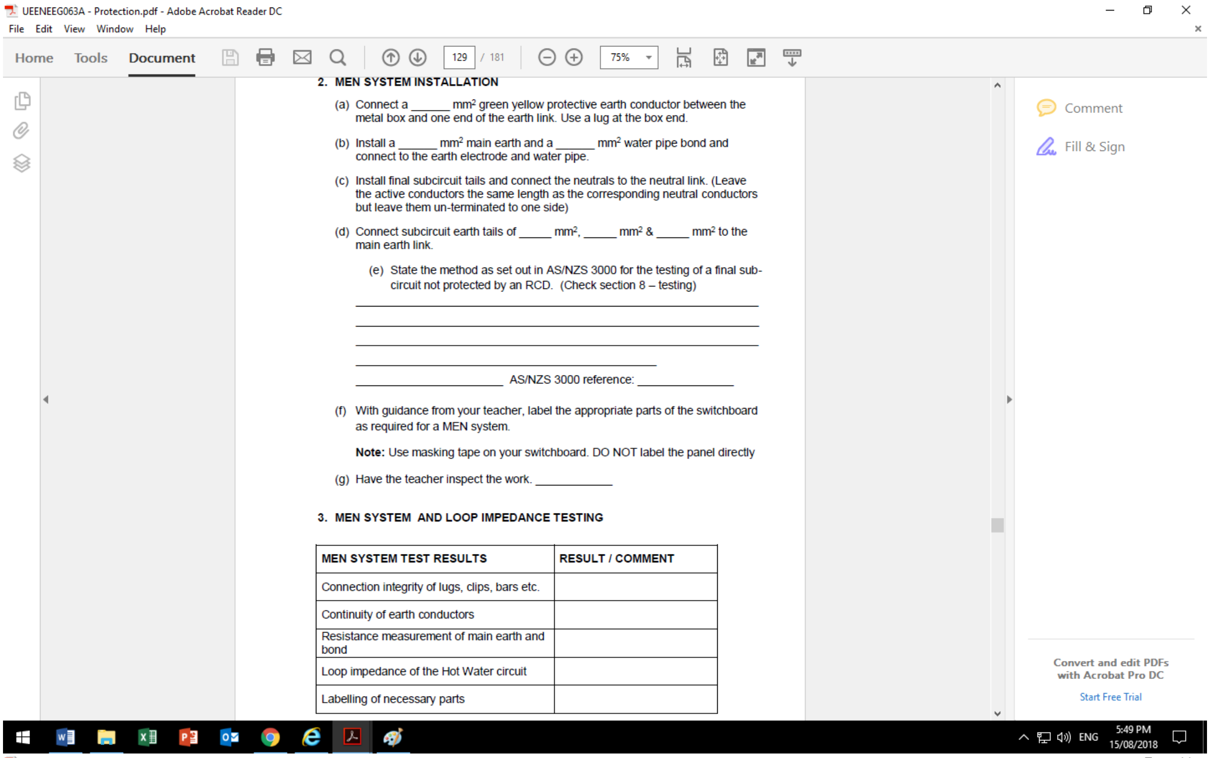
Figure 6

1. CABLE SIZE and WIRING DIAGRAM

On the diagram below, draw the connections for a MEN system using a main earth terminal/bar connection. Label the size AND type of earthing conductor for the following:

(a) The consumer mains active and neutral conductors **(16mm² SDI - unprotected)**
(b) The Main Neutral for the Customer Neutral link
(c) The MEN link
(d) The Main earth conductor
(e) The water pipe equipotential bond
(f) Sub-circuit earth conductors
(g) Sub-circuit neutral conductors (assume circuits are protected by RCD combo's, therefore terminate neutrals in the customer neutral link)





2. MEN SYSTEM INSTALLATION

(a) Connect a ______ mm^2 green yellow protective earth conductor between the metal box and one end of the earth link. Use a lug at the box end.

(b) Install a ______ mm^2 main earth and a ______ mm^2 water pipe bond and connect to the earth electrode and water pipe.

(c) Install final subcircuit tails and connect the neutrals to the neutral link. (Leave the active conductors the same length as the corresponding neutral conductors but leave them un-terminated to one side)

(d) Connect subcircuit earth tails of _____ mm^2, _____ mm^2 & _____ mm^2 to the main earth link.

(e) State the method as set out in AS/NZS 3000 for the testing of a final sub-circuit not protected by an RCD. (Check section 8 – testing)

____

____

____

____

____________________ AS/NZS 3000 reference: ______________

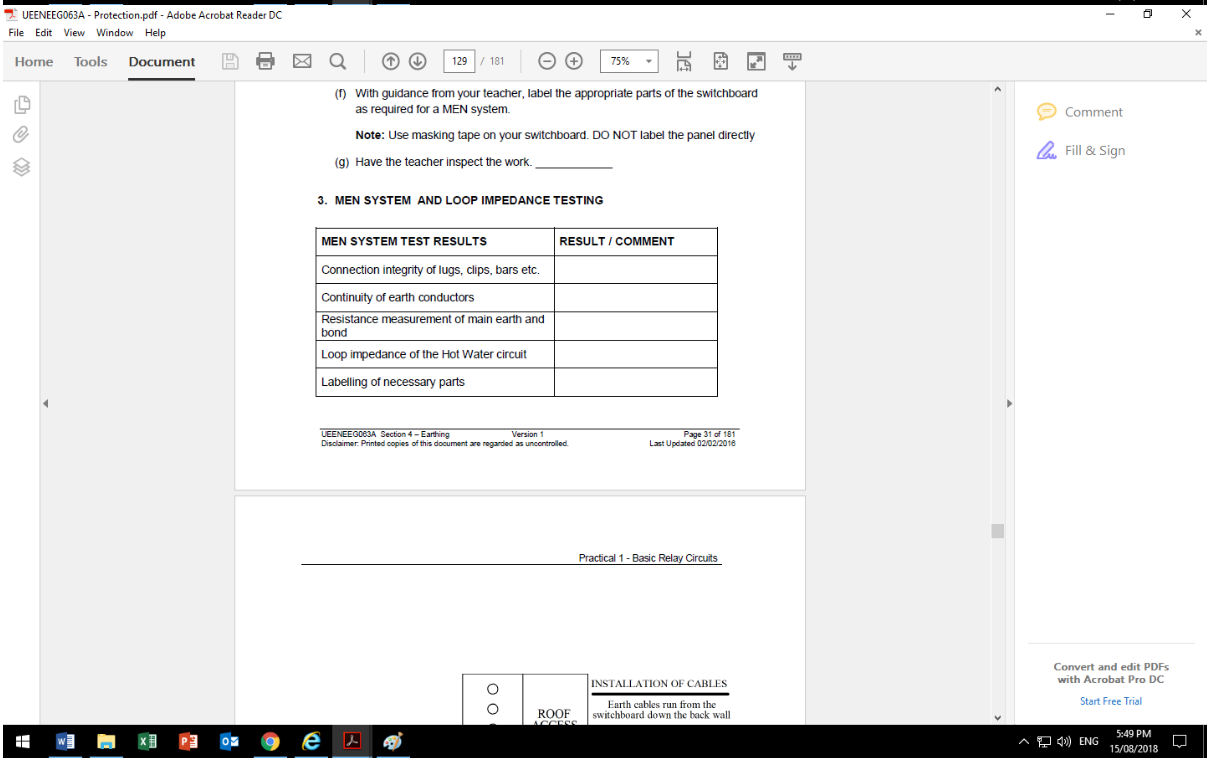
(f) With guidance from your teacher, label the appropriate parts of the switchboard as required for a MEN system.

Note: Use masking tape on your switchboard. DO NOT label the panel directly

(g) Have the teacher inspect the work. ___________

3. MEN SYSTEM AND LOOP IMPEDANCE TESTING

MEN SYSTEM TEST RESULTS	RESULT / COMMENT
Connection integrity of lugs, clips, bars etc.	
Continuity of earth conductors	
Resistance measurement of main earth and bond	
Loop impedance of the Hot Water circuit	
Labelling of necessary parts	



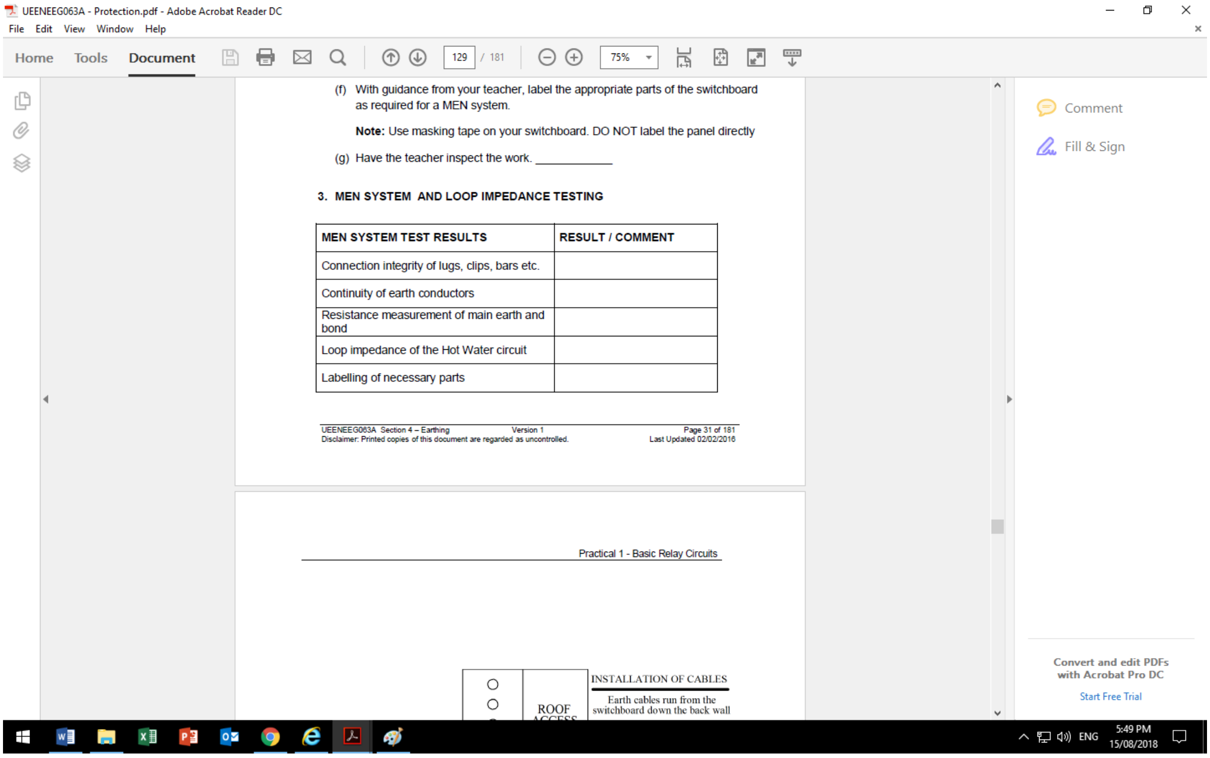
(f) With guidance from your teacher, label the appropriate parts of the switchboard as required for a MEN system.

Note: Use masking tape on your switchboard. DO NOT label the panel directly

(g) Have the teacher inspect the work. ___________

3. MEN SYSTEM AND LOOP IMPEDANCE TESTING

MEN SYSTEM TEST RESULTS	RESULT / COMMENT
Connection integrity of lugs, clips, bars etc.	
Continuity of earth conductors	
Resistance measurement of main earth and bond	
Loop impedance of the Hot Water circuit	
Labelling of necessary parts	


(f) With guidance from your teacher, label the appropriate parts of the switchboard as required for a MEN system.

Note: Use masking tape on your switchboard. DO NOT label the panel directly

(g) Have the teacher inspect the work. __________

3. MEN SYSTEM AND LOOP IMPEDANCE TESTING

MEN SYSTEM TEST RESULTS	RESULT / COMMENT
Connection integrity of lugs, clips, bars etc.	
Continuity of earth conductors	
Resistance measurement of main earth and bond	
Loop impedance of the Hot Water circuit	
Labelling of necessary parts	

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Practical 1 - Basic Relay Circuits

ROOF ACCESS

INSTALLATION OF CABLES

Earth cables run from the switchboard down the back wall

Page 133

A situation where there is a chance of a person touching an exposed conductive part and at the same time coming in contact with earth is referred to as an ____________ situation.

AS/NZS Clause no. _________________

1.4.48 Earthed situation

A situation wherein there is a reasonable chance of a person touching exposed conductive parts and, at the same time, coming into contact with earth or with any conducting medium that may be in electrical contact with the earth or through which a circuit may be completed to earth. The following situations are deemed to be earthed situations:

Copper earthing conductors of 1mm^2 and 1.5mm^2 shall only be used in what form?____

AS/NZS Clause no. _________________

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.

Exceptions:

1 A smaller solid conductor may be used where permitted by a particular

cable Standard.
2 This Clause need not apply where copper cable components, such as sheaths or screens, are deemed to be an earthing conductor in accordance with Clause 5.3.2.2.

Why is it necessary to maintain a separation of at least 0.5 metres between an earth electrode and buried metallic services? ________________________________

AS/NZS Clause no. ________________

5.3.6.4 Location

Earth electrodes shall be installed in a location that satisfies the following conditions:

(a) The electrode maintains effective contact with moist soil that is not subject to excessive drying out.

NOTE: This condition is deemed to be satisfied by locating the electrode—

(a) external to the building in ground that is exposed to the weather; or

(b) in other locations where the ground remains moist because of soil conditions or covers that reduce loss of moisture.

(b) The electrode is separated from conductive enclosures of other buried services, such as water, gas, telecommunications and flammable liquid, in order to reduce possible electrolytic action affecting the electrode or the other service.

Where consumers mains are not protected on the supply side by short circuit protective devices, the MEN link shall have a CSA of ______________________

____

AS/NZS Clause no. ________________

5.5.3.5 Unprotected consumer mains

Exposed conductive parts associated with consumer mains not provided with short-circuit protection on the supply side shall be earthed by a conductor or by direct connection to an earth bar such that either has a current-carrying capacity not less than that of the main neutral conductor This conductor shall be connected to—

(a) the main neutral conductor or bar [see Figure 5.6(A)]; or

(b) the main earthing terminal/connection or bar, in which case, in accordance with Clause 5.3.5.2, the cross-sectional area of the MEN connection shall be not less than that of the main neutral conductor [see Figure 5.6(B)].

The resistance of the main earthing conductor shall not exceed? ______________

AS/NZS Clause no. ________________

5.5.1.4 Resistance

The resistance of the main earthing conductor, measured between the main earthing terminal/connection or bar and the earth electrode, including the connection to the earth electrode, shall be not more than 0.5 Ohm

At what point should steel conduit be earthed when enclosing a single insulated circuit?

____

AS/NZS Clause no. ___________________

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.

A metal control panel (electrical equipment) is located outside an earthed situation but is supplied with a metallic conduit which passes through an earthed situation. Is it necessary to earth the control box? ____

AS/NZS Clause no. ___________________

Yes

5.3.2.3 Special conditions
(c) Conductive framework:
(i) General Conductive framework may be regarded as a protective earthing conductor, provided that—
(A) the exposed conductive parts of electrical equipment are mounted on, and in effective electrical contact with, the framework; and
(B) the conductive framework is earthed by the connection of a protective earthing conductor directly to the framework.

Which of the following metallic parts *shall not* be used as a protective earthing conductor?

a)Metallic sheaths, armours and screening

b)Metallic conduits, tubes or trunking

c)Sprinkler pipes or pipes conveying gas or water

d)Metallic framework for mounting electrical equipment

AS/NZS Clause no. ___________________

5.3.2.2 Conductor type
Sprinkler pipes or pipes conveying gas, water, flammable liquid or other conductive non-electrical service enclosures shall not be used as an earthing medium.

Is it necessary to mark the terminals for the connection of the MEN connection and the main neutral conductor on the main neutral link? __________________________

AS/NZS Clause no. ___________________

Yes

5.3.5.3 Identification
Where the MEN connection is insulated, the insulation shall be coloured green or in a combination of green and yellow, in accordance with Clause 3.8.

What identification is required at the connection between the main earth and the earth stake? ____

AS/NZS Clause no. __________________

5.5.1.2 Connection to earth electrode
The connection of the main earthing conductor to the earth electrode shall—
(a) be accessible for visual inspection and for the purposes of testing;
NOTES:
1 Where necessary, access by means of an underground pit with its cover accessible above ground is considered acceptable, provided adequate space is available for the connection of test leads and the pit is suitably identified as to its purpose.
2 Where the reinforcing steel is used as the earth electrode, this testing condition is deemed to be satisfied by the provision of a test point on the main earthing electrode.
(b) be made by means of a suitable device, in accordance with the manufacturer's specification, that provides adequate electrical conductivity;
(c) provide protection against mechanical damage likely to occur to the main earthing conductor or the connection to the electrode at the location, in accordance with Clause 5.5.5.2; and
(d) be suitably protected against corrosion in accordance with Clause 5.5.5.3.
5.5.1.3 Labelling
The main earthing conductor shall have a permanent label attached at the connection to the earth electrode with a legible warning against disconnection in the following form:
WARNING: MAIN ELECTRICAL EARTHING CONDUCTOR—DO NOT DISCONNECT.

What is the minimum CSA of any equipotential bonding conductor that may be required in an installation? __________________________
AS/NZS Clause no. __________________
5.6.3.2 Size
The size of equipotential bonding conductors shall be determined from the requirements of this Clause 5.6.3, as appropriate to the particular bonding conductor application.
The size of equipotential bonding conductors shall be in accordance with the following:
(a) Conductive piping, cable sheaths and wiring enclosures The equipotential bonding conductor required in accordance with Clauses 5.6.2.2 to 5.6.2.4 shall have a cross-sectional area not less

than 4 mm^2.
(b) Showers, bathrooms, swimming and spa pools The equipotential bonding conductors required to connect conductive parts of a shower, bathroom, swimming or spa pool in accordance with Clauses 5.6.2.5 and 5.6.2.6 shall have a cross-sectional area not less than 4 mm^2.
Exception: The cross-sectional area of the equipotential bonding conductor for a swimming or spa pool may be determined as for an earthing conductor, in accordance with Clause 5.3.3.4(c), where the equipotential bonding conductor is incorporated in a multi-core flexible cord supplying electrical equipment that is required to be removed for maintenance.
(c) Telephone and telecommunication earthing systems The equipotential bonding conductors required to connect a telephone and telecommunication earthing system in accordance with Clause 5.6.2.7 shall have a cross-sectional area not less than 6 mm^2.
NOTE: Refer to the AS/NZS 60079 series for minimum sizes of equipotential bonding conductors in explosive atmospheres.

In general, is a protective earth cable required to be installed at a batten holder or light point if the light point is non conductive? ______________________________

AS/NZS Clause no. __________________

No

5.4.3 Lighting points

A protective earthing conductor, connected to a terminal or suitably insulated and enclosed, shall be provided at every lighting point, including transformers supplying ELV lighting systems.

Exceptions:

1 A protective earthing conductor shall not be provided for luminaires located in Zone 0 of swimming and spa pools installed in accordance with Clause 6.3.4.5 and Zone 0 of fountains and water features installed in accordance with Clause 6.4.4.5.

2 A protective earthing conductor need not be provided for the following lighting points:

- Festoon-type lampholders of the all-insulated type.
- Lighting points where the luminaire is earthed by attachment to screwed conductive conduit or pipe in accordance with Clause 5.3.2.3.
- Lighting points consisting of a luminaire installed outdoors on a non-conductive pole where the luminaire is not in an earthed situation.
- ELV lighting points.

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All conductors and items of electrical equipment have certain limiting factors, one of these factors is the maximum safe working current or as it is commonly called the –

Operation current

the specified current limits are exceeded and there is no protection, or if the protection is either inadequate or ineffective, the resulting abnormal conditions could produce -
k)______________________________ of conductors; and

l)subsequent insulation _____________________________.

Heating/ break down

To ensure that wiring operates within its current-carrying capacity, devices are employed for the protection of a circuit against current overcurrent. The most commonly used overcurrent protective devices are the -
m)______________________________; and

n)______________________________.

Fuse/ Circuit breaker

If the overload is large, as would occur with a short circuit, the protection must be capable of interrupting the fault current before it can rise to a dangerous value. The protection must also be able to disconnect the supply to the fault without damage to itself. To achieve this, the protection must have adequate ______________________ capacity. Known as -
o)____________________ capacity for circuit breakers

and
p)____________________ capacity for fuses.

This value is in kA. The making **capacity** is expressed as a peak value as the dc offset during fault conditions is taken into account. **Breaking capacity** of the **circuit breaker** refers to the maximum current in rms value the **circuit breaker** can break

Breaking **capacity** or interrupting rating is the current that a **fuse**, circuit breaker, or other electrical apparatus is able to interrupt without being destroyed or causing an electric arc with unacceptable duration.

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Refer to **clause 1.4.70** - Overcurrent:
The Wiring Rules defines an overcurrent as a current _________________________.
1.4.90 Overcurrent
A current exceeding the rated value of electrical equipment.

Refer to **clause 1.5.9** - Protection against overcurrent:
Protection against overcurrent may be provided by either of two methods -
w) ____

x)____
1.5.9 Protection against overcurrent
Protection shall be provided against injury or property damage

because of excessive temperatures or electromechanical stresses caused by any overcurrents likely to arise in live conductors.
Protection may be provided by one of the following methods:
(a) Automatic disconnection on the occurrence of an overcurrent, before this overcurrent attains a dangerous value, taking into account its duration.
(b) Limiting the maximum overcurrent to a safe value and duration.

Refer to **Clause 2.5.1** - General:

_________________ conductors shall be protected by one or more devices that automatically disconnect the supply in the event of overcurrent, before the overcurrent attains a magnitude or duration that could cause –

____ or

____ or

2.5 PROTECTION AGAINST OVERCURRENT

2.5.1 General

* 2.5.1.1 General requirements

Active conductors shall be protected by one or more devices that automatically disconnect the supply in the event of overcurrent, before such overcurrent attains a magnitude or duration that could cause injury to persons or livestock or damage because of excessive temperatures or electromechanical stresses in the electrical installation.

Protection against overcurrent shall consist of protection against -

bb) ____________________________ and

cc) ____________________________.

Protection against overcurrent shall consist of protection against-
(a) overload current, in accordance with Clauses 2.5.2 and 2.5.3; and
(b) short-circuit current, in accordance with Clauses 2.5.2 and 2.5.4.

Refer to **Clause 2.5.1.2** – Submains and final subcircuits

An overcurrent protective device or devices ensuring protection against overload current and short circuit current shall be placed at the

dd) ___________________ of every circuit and at each point where a

ee) ________________________ occurs in the current carrying capacity of conductors.

2.5.1.2 Consumer mains

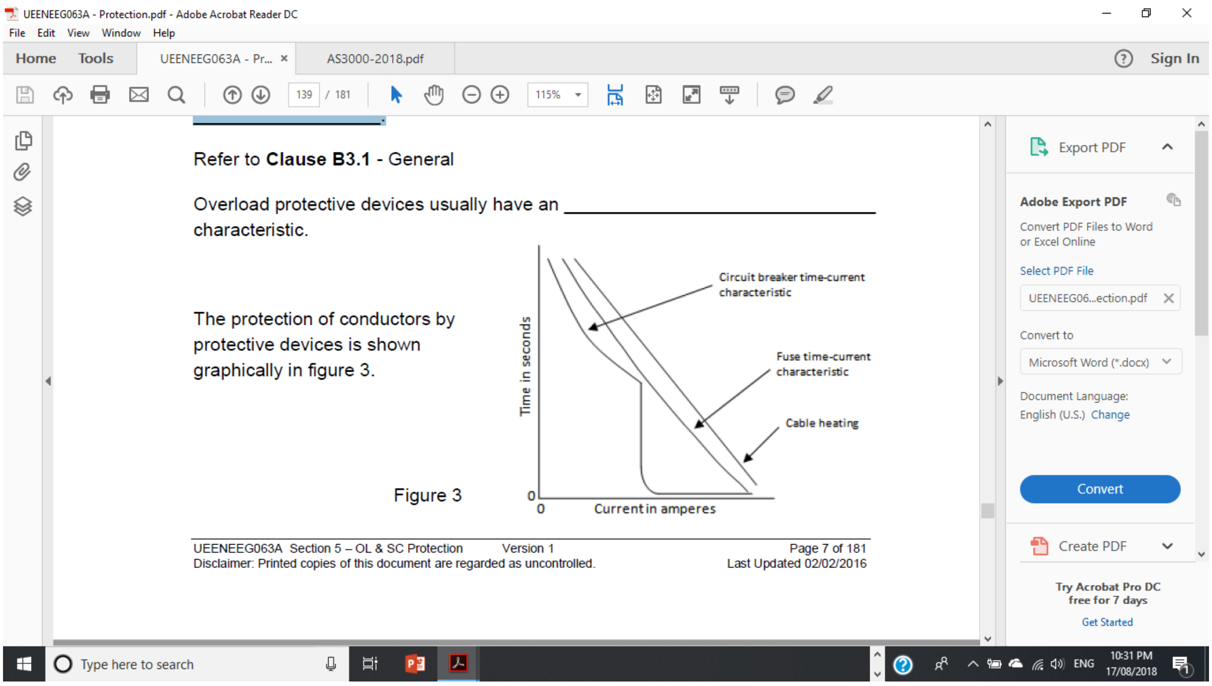
* Overcurrent protection of consumer mains shall be arranged in accordance with one of the following:
(a) Short-circuit protection and overload protection shall be provided at the origin of the consumer mains (the point of supply) (see Notes 1 and 2).
(b) Short-circuit protection shall be provided at the origin of the consumer mains and overload protection shall be provided at the main switchboard (see Notes 1, 3, and 4.)

(c) Short-circuit protection need not be provided where overload protection is provided at the main switchboard and the consumer mains are constructed and installed in accordance with Clause 3.9.7.1.2 (see Notes 1 and 5).
This arrangement is regarded as unprotected consumer mains.
* Unprotected consumer mains are those that are not protected by a service protective device (SPD) as shown in Figure 2.1. Refer to Figures 5.6(A), 5.6(B) and 5.6(C) for the earthing requirements for enclosures containing service protection devices.

Refer to **Clause 2.5.2** – Devices for protection against both overload and short circuit currents.
Protective devices providing protection against both overload and short circuit current shall be capable of breaking any overcurrent up to and including the ______________
______________________________________ at the point where the device is installed.

2.5.2 Devices for protection against both overload and short-circuit currents
Protective devices providing protection against both overload and shortcircuit current shall be capable of breaking any overcurrent up to and including the prospective short-circuit current at the point where the device is installed.
The device shall comply with the requirements of Clauses 2.5.3 and 2.5.4.

Refer to **Clause 1.4.38** – Current, overload
An overload current is an overcurrent occurring in a circuit that is ________________
____________________.
1.4.42 Current, overload
An overcurrent occurring in a circuit that is electrically sound.


Refer to **Clause B3.1** - General

Overload protective devices usually have an ____________________ characteristic.

The protection of conductors by protective devices is shown graphically in figure 3.

Figure 3

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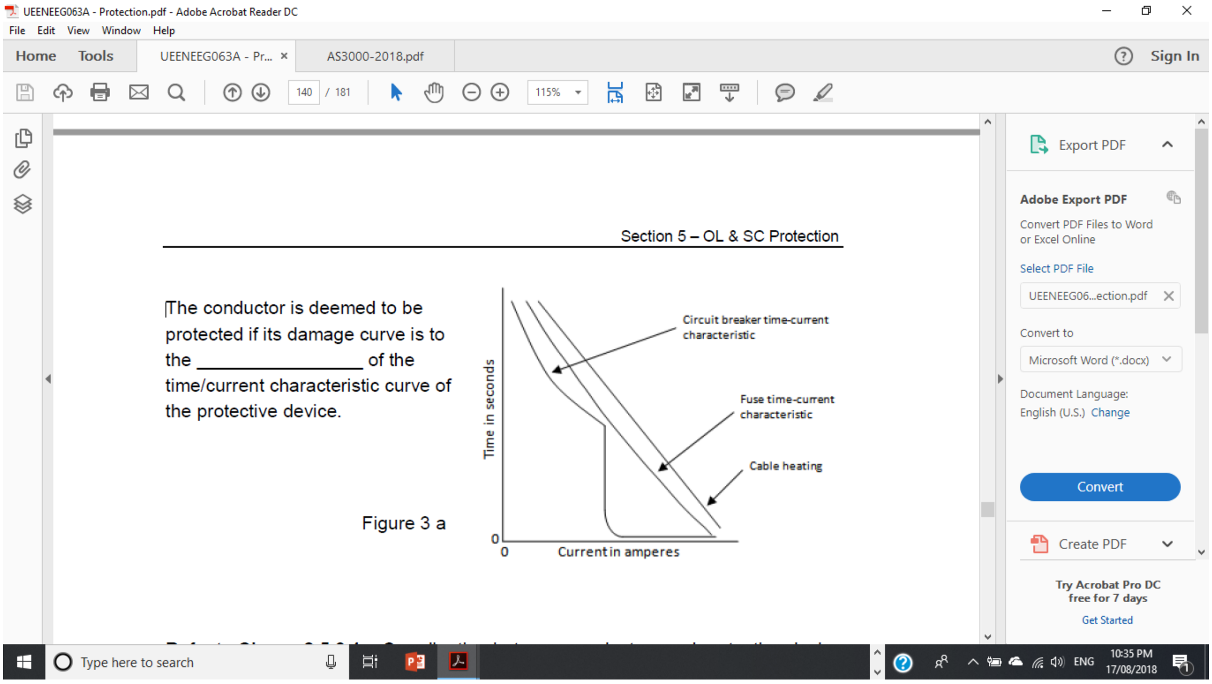
Inverse time characteristics

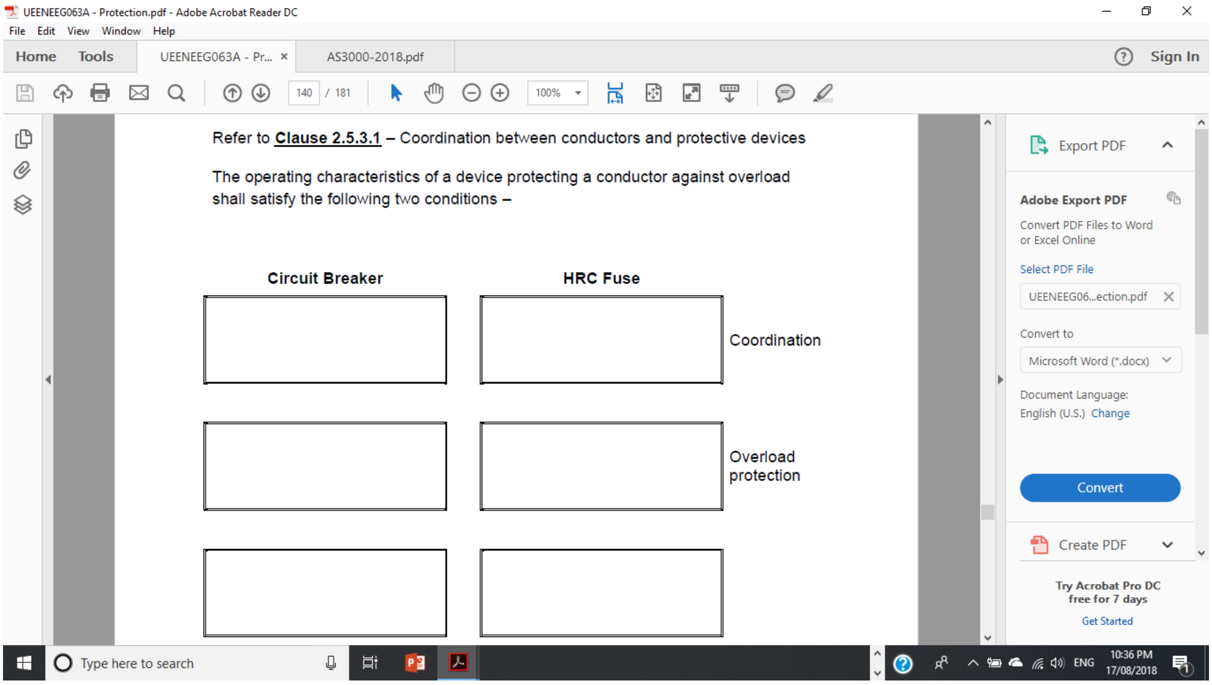


Section 5 – OL & SC Protection

The conductor is deemed to be protected if its damage curve is to the ________________ of the time/current characteristic curve of the protective device.

Figure 3 a

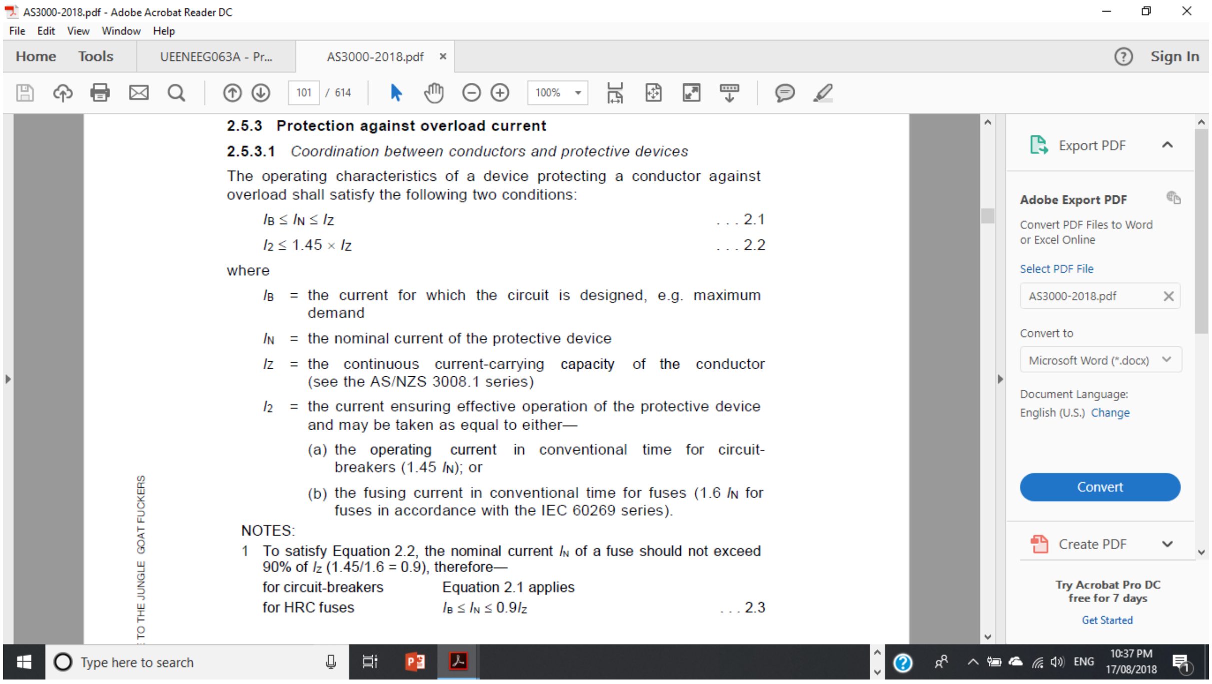
Above



Refer to **Clause 2.5.3.1** – Coordination between conductors and protective devices

The operating characteristics of a device protecting a conductor against overload shall satisfy the following two conditions –

Circuit Breaker	HRC Fuse	
		Coordination
		Overload protection



2.5.3 Protection against overload current

2.5.3.1 *Coordination between conductors and protective devices*

The operating characteristics of a device protecting a conductor against overload shall satisfy the following two conditions:

$I_B \leq I_N \leq I_Z$ . . . 2.1

$I_2 \leq 1.45 \times I_Z$ . . . 2.2

where

I_B = the current for which the circuit is designed, e.g. maximum demand

I_N = the nominal current of the protective device

I_Z = the continuous current-carrying capacity of the conductor (see the AS/NZS 3008.1 series)

I_2 = the current ensuring effective operation of the protective device and may be taken as equal to either—

(a) the operating current in conventional time for circuit-breakers (1.45 I_N); or

(b) the fusing current in conventional time for fuses (1.6 I_N for fuses in accordance with the IEC 60269 series).

NOTES:

1 To satisfy Equation 2.2, the nominal current I_N of a fuse should not exceed 90% of I_Z (1.45/1.6 = 0.9), therefore—

for circuit-breakers Equation 2.1 applies

for HRC fuses $I_B \leq I_N \leq 0.9 I_Z$ . . . 2.3

Example 1:

A circuit with a maximum demand of 15A is to be protected by a miniature circuit breaker. Determine each of the following values -

a)maximum demand of the circuit,I_B = ___________

b)minimum acceptable current rating for the circuit breaker,I_N = ___________

c)minimum acceptable current carrying capacity for the circuit cable, I_Z = ___________

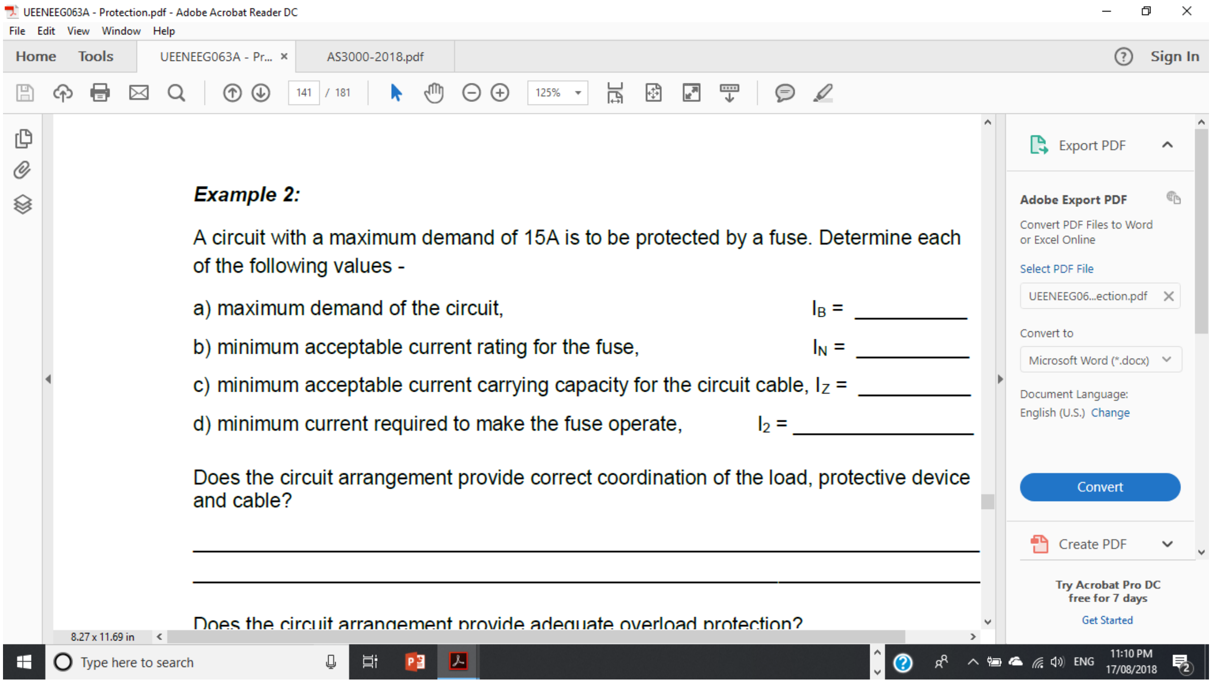
d)minimum current required to make circuit breaker trip,I_2 = _________________

Ib = 15A

IN > = IB 15A

Iz>= IB 15A

I2 = 1,45 IN or 1,45 x 15A



Example 2:

A circuit with a maximum demand of 15A is to be protected by a fuse. Determine each of the following values -

a) maximum demand of the circuit, I_B = __________

b) minimum acceptable current rating for the fuse, I_N = __________

c) minimum acceptable current carrying capacity for the circuit cable, I_Z = __________

d) minimum current required to make the fuse operate, I_2 = __________

Does the circuit arrangement provide correct coordination of the load, protective device and cable?

____

____

Does the circuit arrangement provide adequate overload protection?

Do it yourself

Example 3:

A 2.5mm2, copper, 2-core and earth, insulated and sheathed flat cable supplies a 4.8kW, 240V hot water system. The circuit is protected by a circuit breaker.The cable is installed in non-metallic conduit in air and has a current carrying capacity of 22A.

Note: The current carrying capacity is determined using AS/NZS 3008.

Determine the following -

(a) Maximum demand current (I_B) ______________________________________

(b) Nominal current of circuit protective device (I_N) ____________________________

(c) Current carrying capacity of cable (I_Z) _____________________________________

(d) Current ensuring operation of protective device (I_2) _________________________

Does the circuit arrangement provide correct coordination of the load, protective device and cable?

____

Does the circuit arrangement provide adequate overload protection? ______________

IN= C1 Hotwater

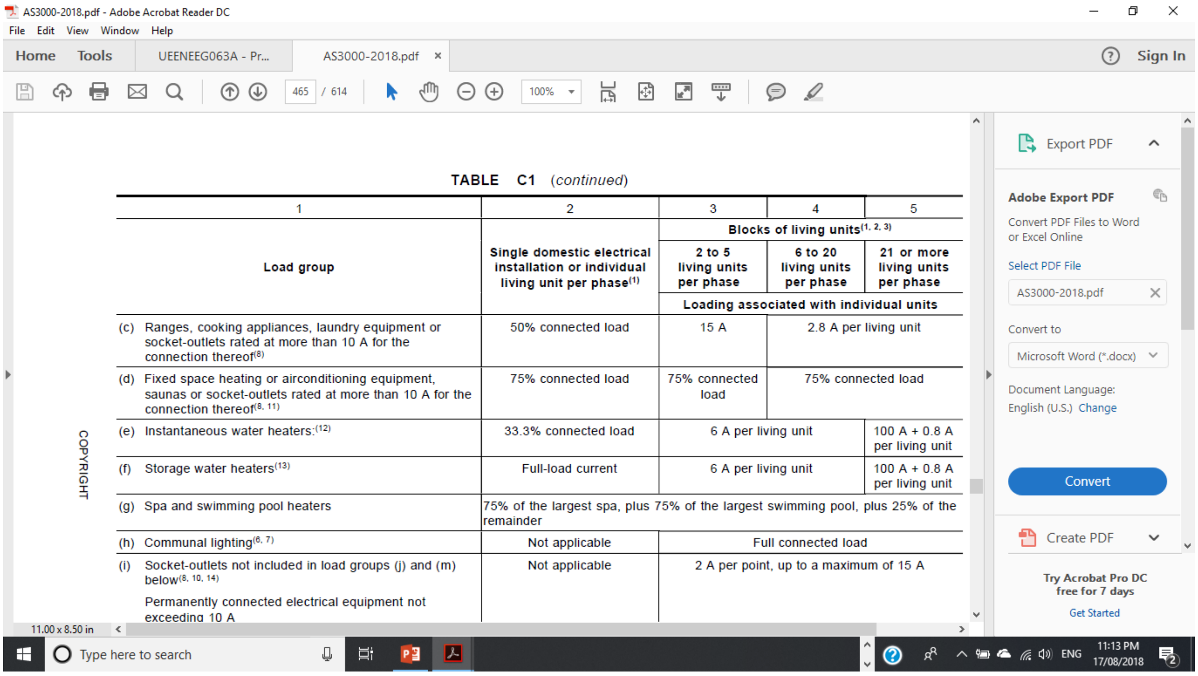


TABLE C1 (continued)

1	2	3	4	5
		Blocks of living units[1, 2, 3]		
Load group	Single domestic electrical installation or individual living unit per phase[1]	2 to 5 living units per phase	6 to 20 living units per phase	21 or more living units per phase
		Loading associated with individual units		
(c) Ranges, cooking appliances, laundry equipment or socket-outlets rated at more than 10 A for the connection thereof[8]	50% connected load	15 A	2.8 A per living unit	
(d) Fixed space heating or airconditioning equipment, saunas or socket-outlets rated at more than 10 A for the connection thereof[8, 11]	75% connected load	75% connected load	75% connected load	
(e) Instantaneous water heaters[12]	33.3% connected load	6 A per living unit		100 A + 0.8 A per living unit
(f) Storage water heaters[13]	Full-load current	6 A per living unit		100 A + 0.8 A per living unit
(g) Spa and swimming pool heaters	75% of the largest spa, plus 75% of the largest swimming pool, plus 25% of the remainder			
(h) Communal lighting[6, 7]	Not applicable	Full connected load		
(i) Socket-outlets not included in load groups (j) and (m) below[8, 10, 14] Permanently connected electrical equipment not exceeding 10 A	Not applicable	2 A per point, up to a maximum of 15 A		

Load group F Column 2

Full load = 4800/240 = 20A Thus IN= 20A

IB=22A

IZ AS3008

A 2.5mm2, copper, 2-core and earth, Assume V75

Assume Enclosed in air

Table 3.2

2 cores--- Item 7 Table 10+11 Col 11 to 13 Table 12 Col 9 and 11

V75 Table 10--- Col 11 Solid strand Iz = 23A

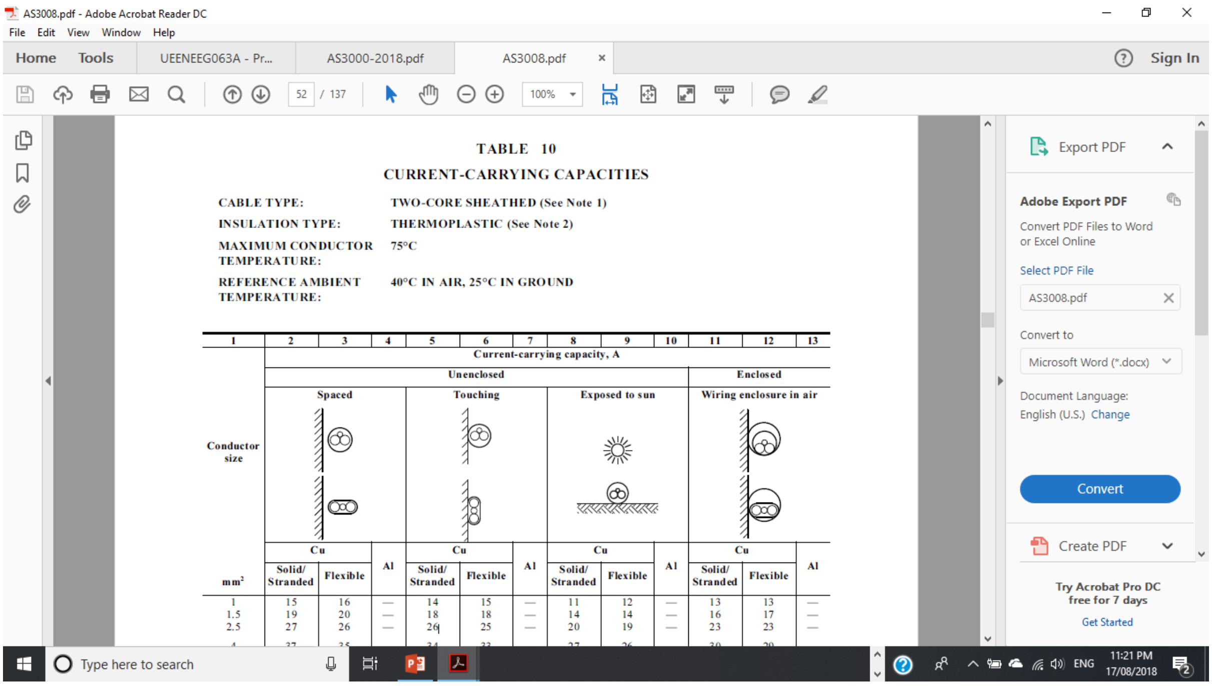


TABLE 10

CURRENT-CARRYING CAPACITIES

CABLE TYPE: TWO-CORE SHEATHED (See Note 1)

INSULATION TYPE: THERMOPLASTIC (See Note 2)

MAXIMUM CONDUCTOR TEMPERATURE: 75°C

REFERENCE AMBIENT TEMPERATURE: 40°C IN AIR, 25°C IN GROUND

1	2	3	4	5	6	7	8	9	10	11	12	13
	Current-carrying capacity, A											
	Unenclosed									Enclosed		
Conductor size	Spaced			Touching			Exposed to sun			Wiring enclosure in air		
	Cu		Al	Cu		Al	Cu		Al	Cu		Al
mm²	Solid/ Stranded	Flexible		Solid/ Stranded	Flexible		Solid/ Stranded	Flexible		Solid/ Stranded	Flexible	
1	15	16	—	14	15	—	11	12	—	13	13	—
1.5	19	20	—	18	18	—	14	14	—	16	17	—
2.5	27	26	—	26	25	—	20	19	—	23	23	—

IN=20A<IB=22A<Iz=23A

Refer to **Clause 1.4.39** - Current, short-circuit
A fault resulting from a fault of ________________ impedance between ____________ conductors having a difference in potential under normal operating conditions. The fault path may include the path from active via earth to neutral.
This current is also referred to as ____.
Short circuits may occur between –
hh) ____

ii)____

jj) ____
1.4.43 Current, short-circuit
A fault current resulting from a fault of negligible impedance between live conductors having a difference in potential under normal operating conditions. The fault path may include the path from active via earth to the neutral.
NOTE: This current is also referred to as 'prospective short-circuit current' or a 'bolted fault'. It is the maximum value, at the relevant points for the existing installation. Unless otherwise stated, it is the three-phase r.m.s. value

Short circuits may occur between –
hh) ____

ii)____

jj) ____
Line to line/ Line to neutral
3 lines

Refer to **Clause 2.5.4.1** – Determination of prospective fault current
The prospective short-circuit current at every relevant point of the electrical installation shall be determined either by _____________________ or measurement.
Devices used for protection against short circuit currents may be –
____; or
____

2.5.4.1 Determination of prospective short-circuit current
The prospective short-circuit current at every relevant point of the electrical
installation shall be determined either by calculation or by measurement
Circuit breaker/ Fuse

Refer to **Clause 2.5.4.5** – Characteristics of short-circuit protective devices
The breaking capacity shall be not less than the ______________________________ at the point where the devices are installed.
Maximum demand
However, a lower capacity protective device is permitted provided another protective device (having the required breaking capacity) is installed on the _________________ ________________________. same circuit
These devices are known as ____.

2.5.2 Devices for protection against both overload and short-circuit

currents
Protective devices providing protection against both overload and shortcircuit current shall be capable of breaking any overcurrent up to and including the prospective short-circuit current at the point where the device is installed.

The device shall comply with the requirements of Clauses 2.5.3 and 2.5.4.

Exception: A protective device having a breaking capacity below the value of the prospective short-circuit current may be used in conjunction with another device in accordance with Clause 2.5.7.2.

2.5.7.2 Coordination of protective devices

＊ 2.5.7.2.1 General

Coordination of protective devices requires consideration of both discrimination (selectivity) and backup (cascading) protection.

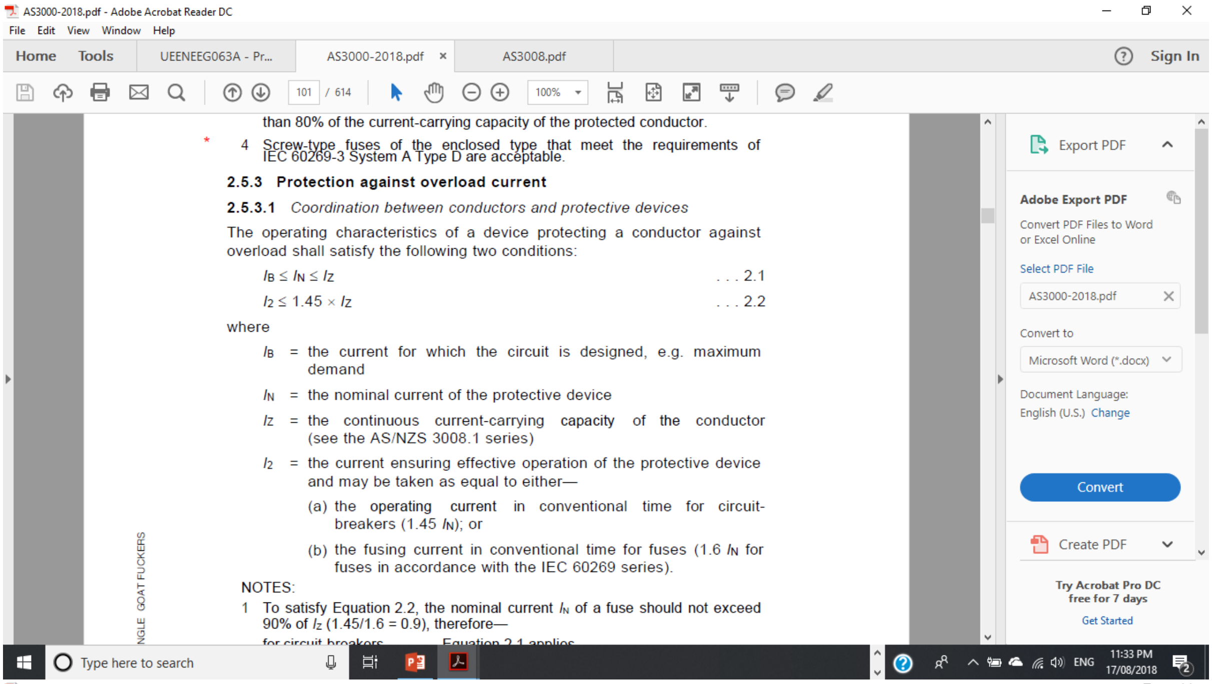
Discrimination (selectivity) between protective devices depends on the operating characteristics of two or more protective devices such that the protective device for the downstream circuit shall operate for a given fault current while the protective device(s) for the upstream circuit shall not operate.

Backup (cascading) depends on the characteristics of each of the two devices as well as the behaviour of the two devices when operating in series. This includes the energy let through when sharing the fault as well as the peak current withstand of the downstream device

2.5.2 Devices for protection against both overload and short-circuit currents

Protective devices providing protection against both overload and shortcircuit current shall be capable of breaking any overcurrent up to and including the prospective short-circuit current at the point where the device is installed.

The device shall comply with the requirements of Clauses 2.5.3 and 2.5.4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than 80% of the current-carrying capacity of the protected conductor.

* 4 Screw-type fuses of the enclosed type that meet the requirements of IEC 60269-3 System A Type D are acceptable.

2.5.3 Protection against overload current

2.5.3.1 *Coordination between conductors and protective devices*

The operating characteristics of a device protecting a conductor against overload shall satisfy the following two conditions:

$$I_B \leq I_N \leq I_Z \qquad \ldots 2.1$$

$$I_2 \leq 1.45 \times I_Z \qquad \ldots 2.2$$

where

I_B = the current for which the circuit is designed, e.g. maximum demand

I_N = the nominal current of the protective device

I_Z = the continuous current-carrying capacity of the conductor (see the AS/NZS 3008.1 series)

I_2 = the current ensuring effective operation of the protective device and may be taken as equal to either—

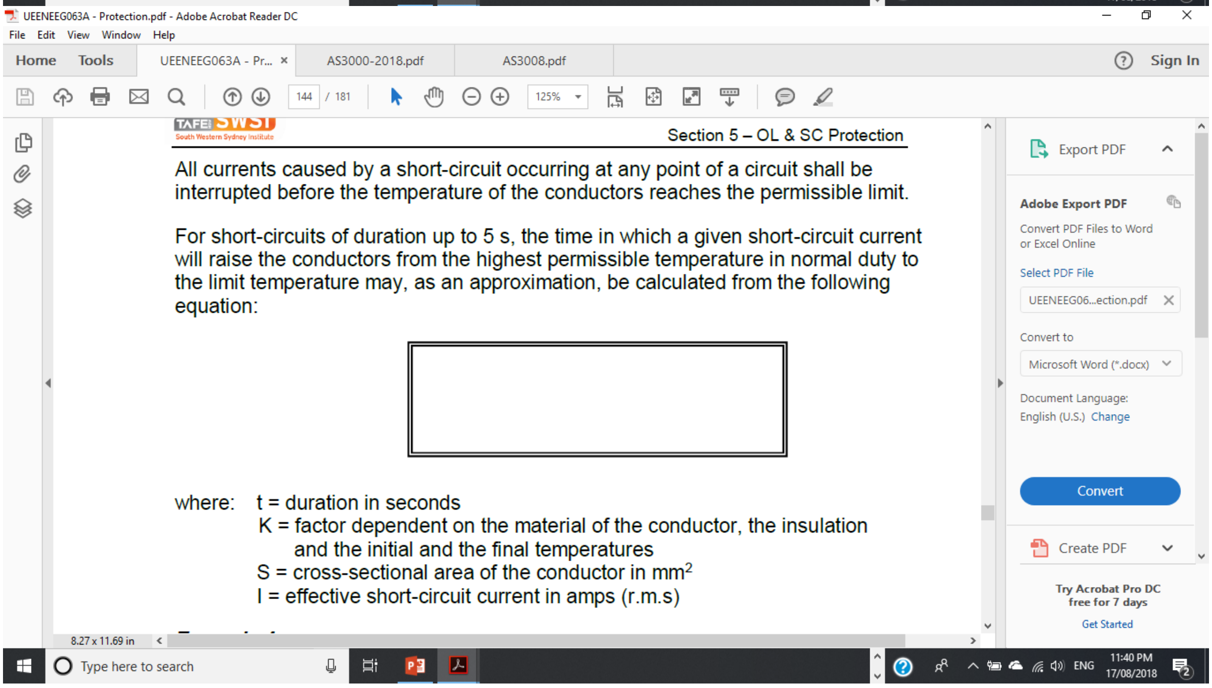
(a) the operating current in conventional time for circuit-breakers (1.45 I_N); or

(b) the fusing current in conventional time for fuses (1.6 I_N for fuses in accordance with the IEC 60269 series).

NOTES:

1 To satisfy Equation 2.2, the nominal current I_N of a fuse should not exceed 90% of I_Z (1.45/1.6 = 0.9), therefore—

for circuit breakers .... Equation 2.1 applies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All currents caused by a short-circuit occurring at any point of a circuit shall be interrupted before the temperature of the conductors reaches the permissible limit.

For short-circuits of duration up to 5 s, the time in which a given short-circuit current will raise the conductors from the highest permissible temperature in normal duty to the limit temperature may, as an approximation, be calculated from the following equation:

where: t = duration in seconds

K = factor dependent on the material of the conductor, the insulation and the initial and the final temperatures

S = cross-sectional area of the conductor in mm^2

I = effective short-circuit current in amps (r.m.s)

2.5.5.3 *Limitation of the harmful effects of a switchboard internal arcing fault*

Protective devices shall be provided to limit, as far as practicable, the harmful effects of a switchboard internal arcing fault by automatic disconnection.

The arcing fault current between phases, or between phase and earth, is deemed to be in the range of 30% to 60% of the prospective short-circuit current.

Protection shall be initiated, i.e. pick up at a current less than 30% of the three-phase prospective fault level.

To minimize damage to the switchboard, the interrupting time shall not exceed the value obtained from the following equation.

The general damage limit is given by the following:

$$\text{Clearing time } t = \frac{k_e \times I_r}{I_f^{1.5}} \qquad \ldots 2.5$$

where

t = clearing time, in seconds

I_f = 30% of the prospective fault current

I_r = current rating of the switchboard

k_e = 250 constant, based on acceptable volume damage

Example:

The maximum arcing fault clearing time at a customer's 800 A-rated main switchboard with a prospective fault current at the switchboard of 16.67 kA.

Therefore—

Ir = 30% of 16.67 kA = 5 kA

$$t = \frac{250 \times 800}{5000^{1.5}} = 0.57 \text{ s}$$

i.e. the protective device settings are set to clear an arcing fault of 5 kA in less than 0.57 s.

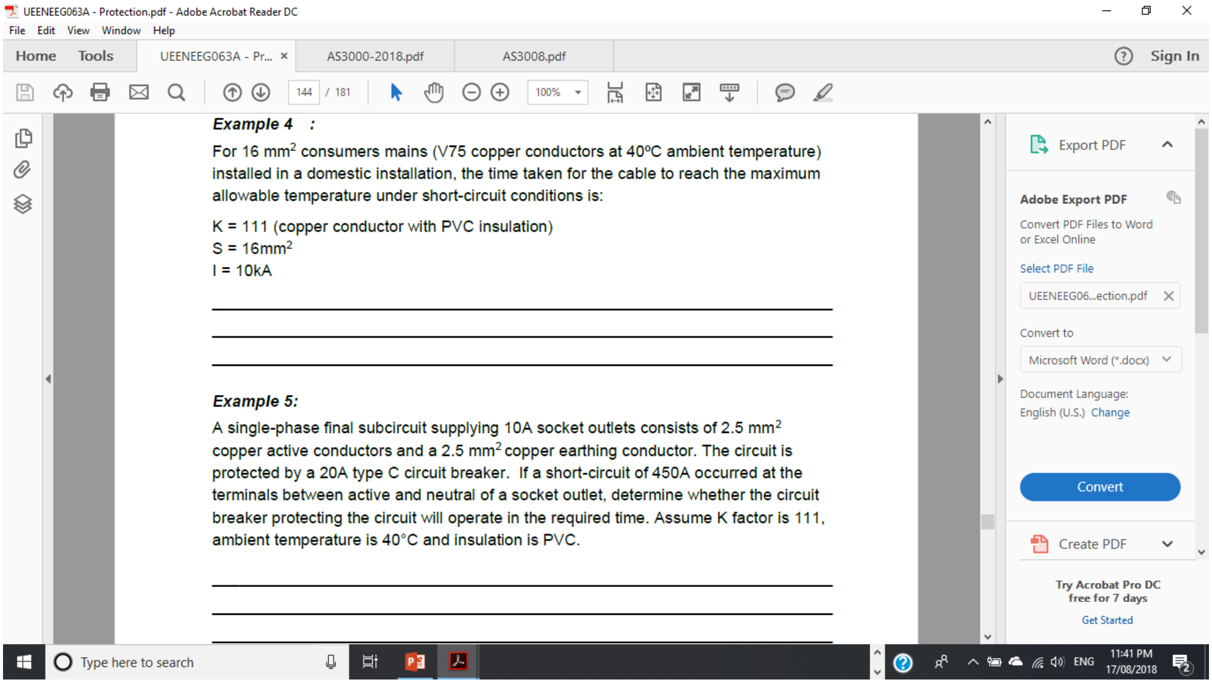
NOTE: Overcurrent protective devices should be set to as low an initiation current as possible while still maintaining the correct function of the installation, e.g. set higher than motor-starting currents.

Earth fault protective devices shall have a maximum setting of 1200 A.

The settings of protective devices shall be verified by inspection [see Clause 8.2.2(c)(ii)].

NOTE: The electricity distributor should be consulted for discrimination requirements between installation protective devices and the electricity distributor's service protective devices. The curves and settings of service protective devices will be required.

Where arc detectors are used, immunity to extraneous light sources that may cause operation of the protection is necessary. Arc detectors do not obviate requirements for discrimination.



Example 4 **:**

For 16 mm^2 consumers mains (V75 copper conductors at 40ºC ambient temperature) installed in a domestic installation, the time taken for the cable to reach the maximum allowable temperature under short-circuit conditions is:

K = 111 (copper conductor with PVC insulation)
S = 16mm^2
I = 10kA

Example 5:

A single-phase final subcircuit supplying 10A socket outlets consists of 2.5 mm^2 copper active conductors and a 2.5 mm^2 copper earthing conductor. The circuit is protected by a 20A type C circuit breaker. If a short-circuit of 450A occurred at the terminals between active and neutral of a socket outlet, determine whether the circuit breaker protecting the circuit will operate in the required time. Assume K factor is 111, ambient temperature is 40°C and insulation is PVC.

Do it yourself

EARTH FAULT LOOP

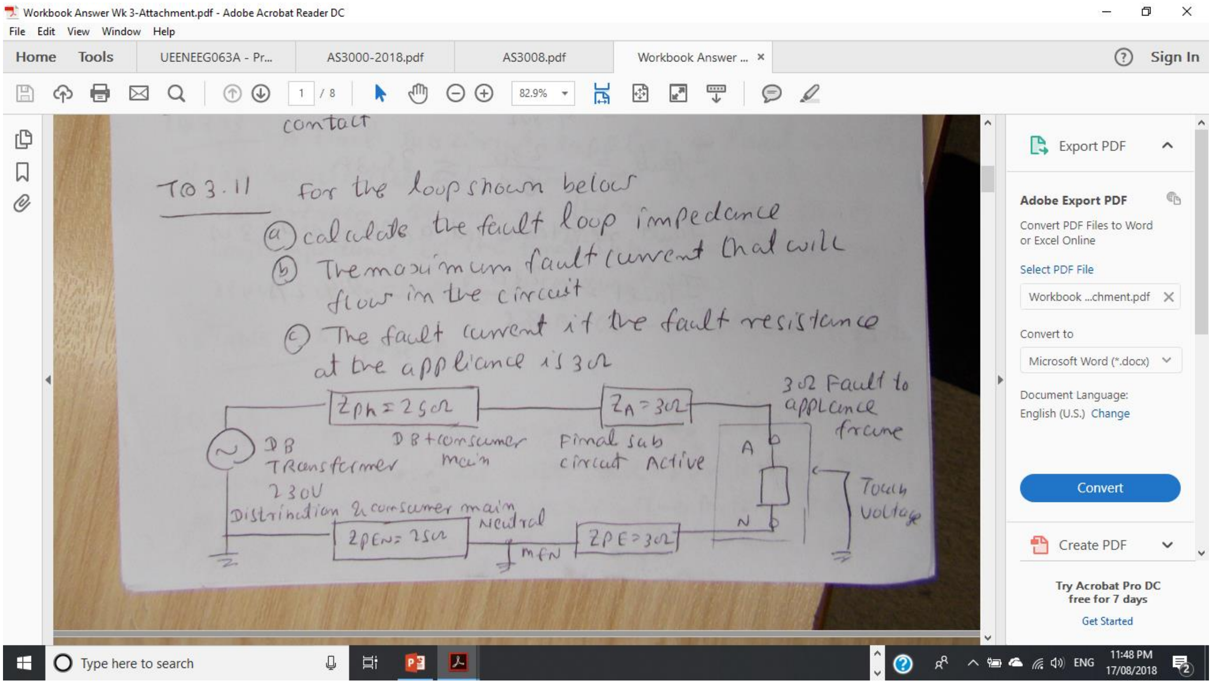
Refer to AS/NZS 3000 Section 1 definitions for 'Earth Fault Loop Impedance'.

Earth fault loop impedance is the impedance of the ______________________________

____

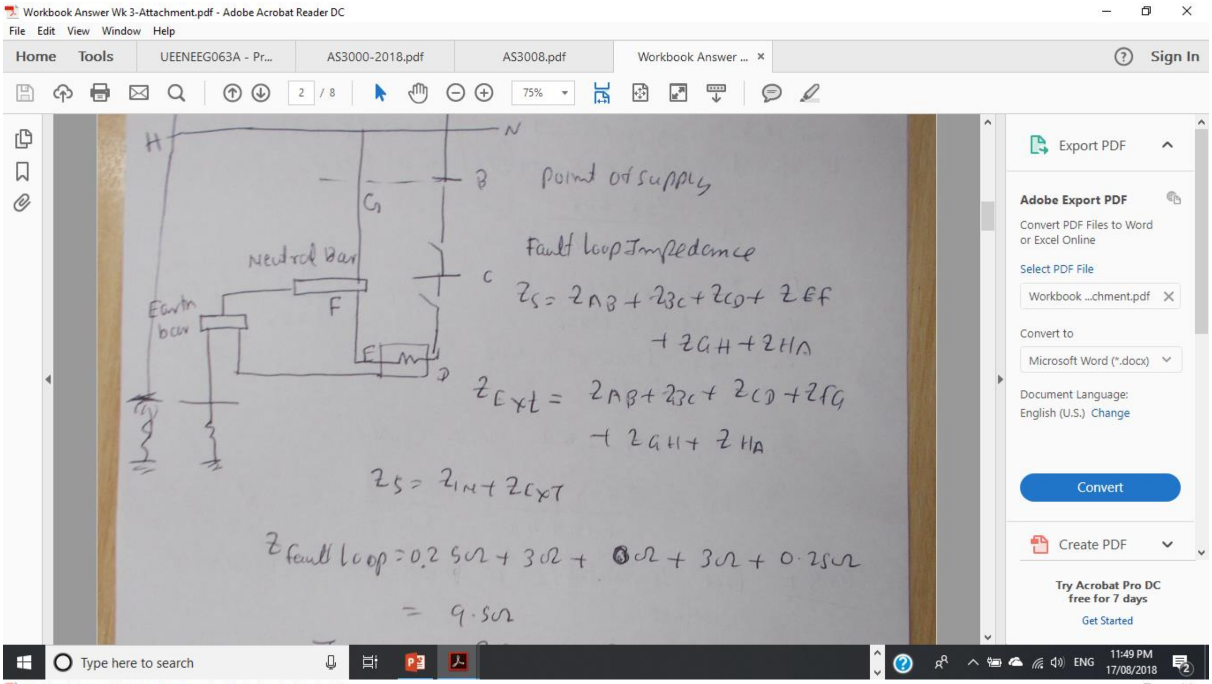
1.4.49 Earth fault-loop impedance

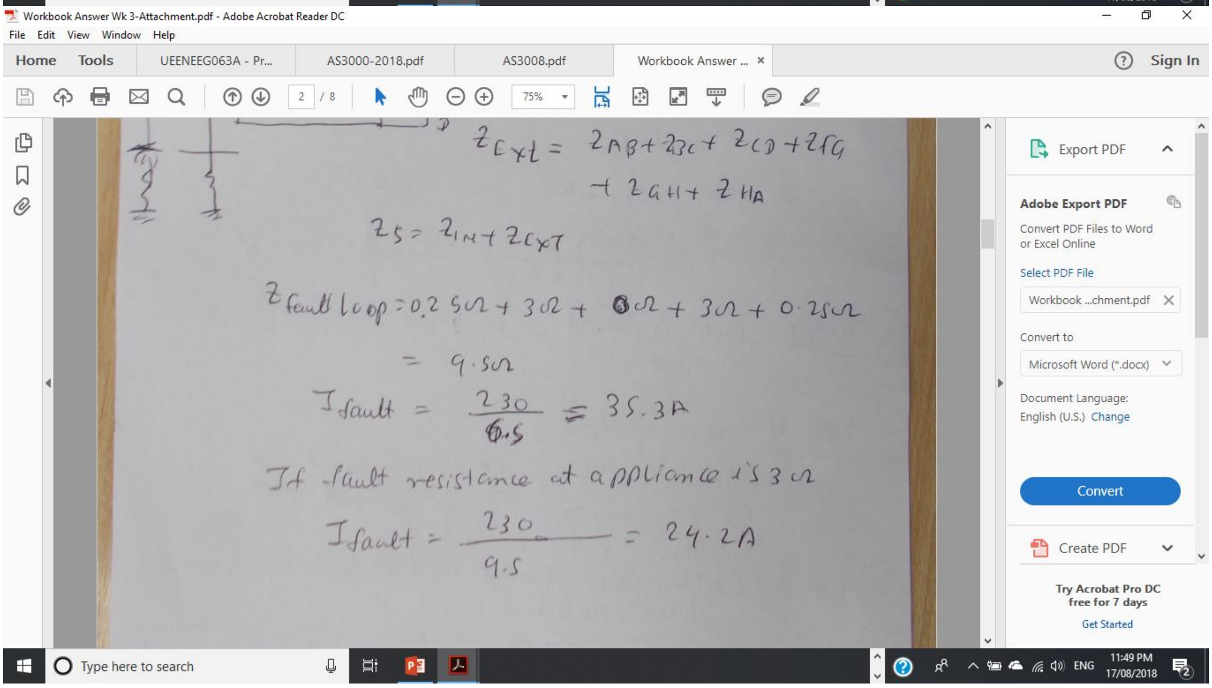
The impedance of the earth fault-current loop (active-to-earth loop) starting and ending at the point-of-earth fault



contact

TQ 3.11 For the loop shown below
(a) calculate the fault loop impedance
(b) The maximum fault current that will flow in the circuit
(c) The fault current if the fault resistance at the appliance is 3Ω


Workbook Answer Wk 3-Attachment.pdf - Adobe Acrobat Reader DC
H
N
B
G
C
Neutral Bar
F
Earth bar
E
M
D
Point of supply
Fault loop Impedance
$Z_S = Z_{AB} + Z_{BC} + Z_{CD} + Z_{EF} + Z_{GH} + Z_{HA}$
$Z_{Ext} = Z_{AB} + Z_{BC} + Z_{CD} + Z_{FG} + Z_{GH} + Z_{HA}$
$Z_S = Z_{INT} + Z_{EXT}$
$Z_{fault\ loop} = 0.25\Omega + 3\Omega + 3\Omega + 3\Omega + 0.25\Omega$
$= 9.5\Omega$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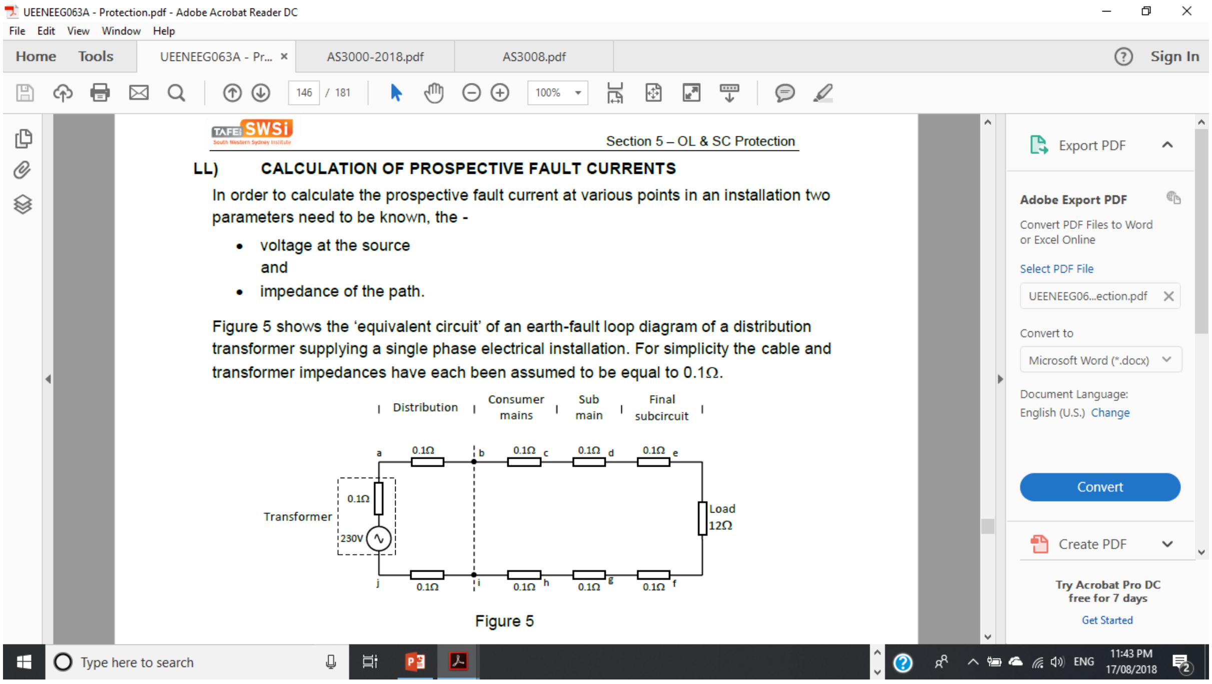
$Z_{Ext} = Z_{AB} + Z_{BC} + Z_{CD} + Z_{FG} + Z_{GH} + Z_{HA}$
$Z_S = Z_{INT} + Z_{EXT}$
$Z_{fault\ loop} = 0.25\Omega + 3\Omega + 3\Omega + 3\Omega + 0.25\Omega$
$= 9.5\Omega$
$I_{fault} = \frac{230}{6.5} = 35.3A$
If fault resistance at appliance is 3 Ω
$I_{fault} = \frac{230}{9.5} = 24.2A$



LL) CALCULATION OF PROSPECTIVE FAULT CURRENTS

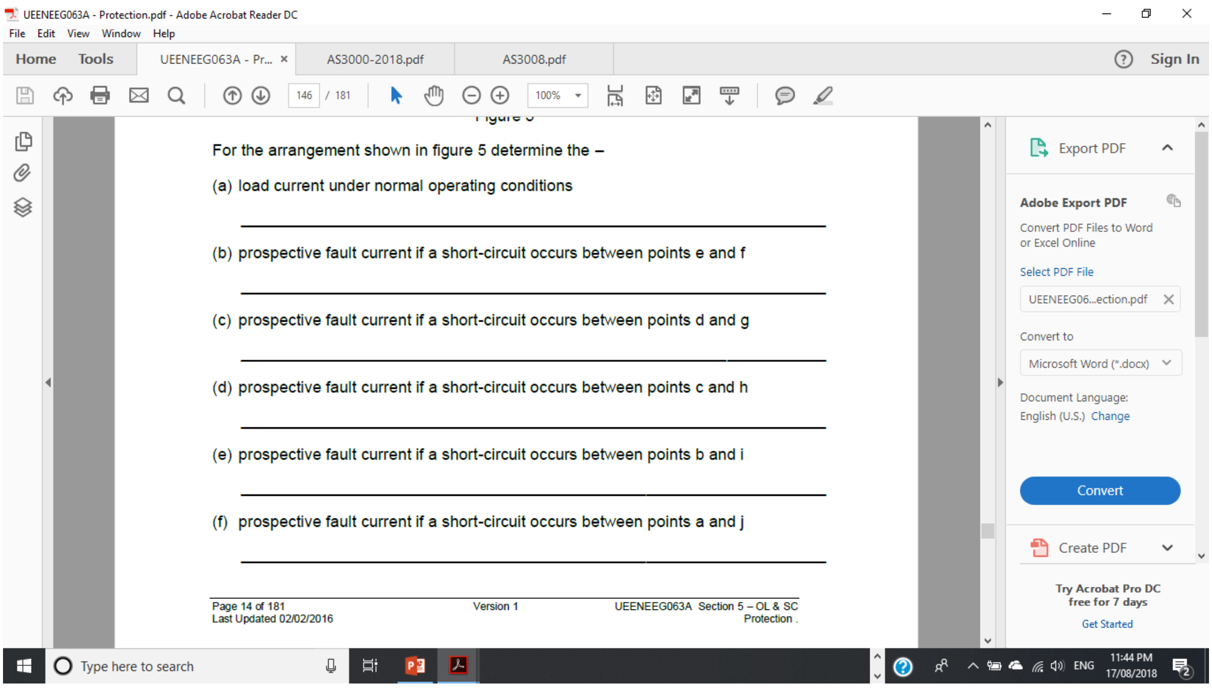
In order to calculate the prospective fault current at various points in an installation two parameters need to be known, the -

- voltage at the source
  and
- impedance of the path.

Figure 5 shows the 'equivalent circuit' of an earth-fault loop diagram of a distribution transformer supplying a single phase electrical installation. For simplicity the cable and transformer impedances have each been assumed to be equal to 0.1Ω.

Figure 5

Exam



For the arrangement shown in figure 5 determine the –

(a) load current under normal operating conditions

(b) prospective fault current if a short-circuit occurs between points e and f

(c) prospective fault current if a short-circuit occurs between points d and g

(d) prospective fault current if a short-circuit occurs between points c and h

(e) prospective fault current if a short-circuit occurs between points b and i

(f) prospective fault current if a short-circuit occurs between points a and j

Do it yourself

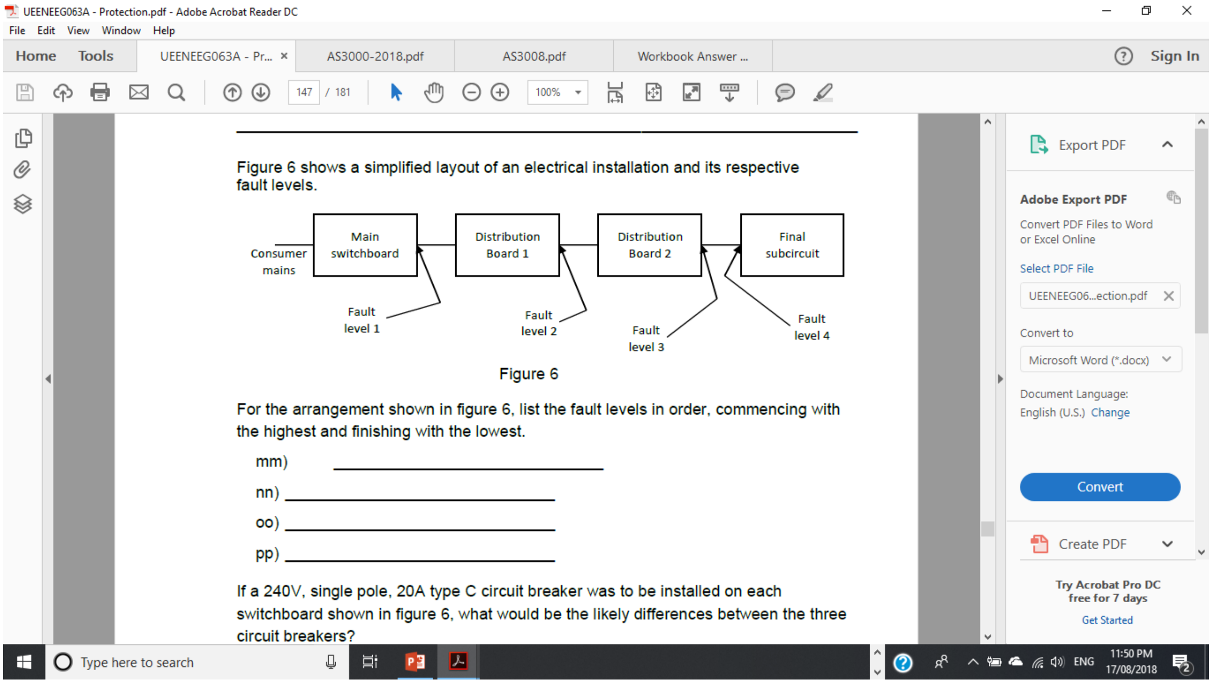


Figure 6 shows a simplified layout of an electrical installation and its respective fault levels.

Figure 6

For the arrangement shown in figure 6, list the fault levels in order, commencing with the highest and finishing with the lowest.

mm) ______________________

nn) ______________________

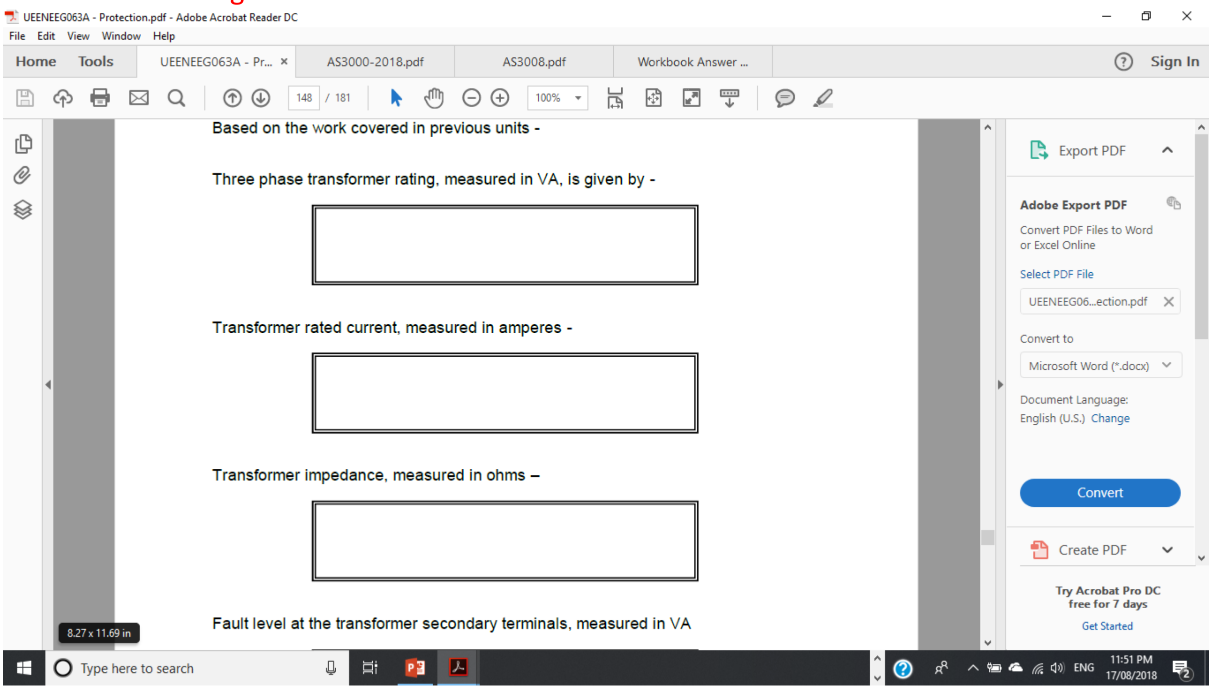
oo) ______________________

pp) ______________________

If a 240V, single pole, 20A type C circuit breaker was to be installed on each switchboard shown in figure 6, what would be the likely differences between the three circuit breakers?

Level 1 / Level 4

Transformer Rating



Based on the work covered in previous units -

Three phase transformer rating, measured in VA, is given by -

Transformer rated current, measured in amperes -

Transformer impedance, measured in ohms –

Fault level at the transformer secondary terminals, measured in VA

(6)

TQ 3.29 Given a 11kV/400V (Delta/star) 600 kVA transformer has an impedance of 4%, determine the (a) rated current (b) fault current at the transformer secondary terminals (c) fault level at transformer secondary terminals (d) transformer impedance in ohms

Rated current $= \frac{kVA}{\sqrt{3} \times E} = \frac{600 \times 10^3}{1.7321 \times 11 \times 10^3} = 31.49A$

Secondary current $= \frac{kVA}{\sqrt{3} \times E} = \frac{600 \times 10^3}{1.7321 \times 400} = 866A$

Fault current $- I_{sn} = \frac{I_{fL}}{\% Z} \times 100 = \frac{866}{4} \times 100 = 21650$ A

Fault level $= MVA_{sn} = \frac{MVA_{fL}}{\% Z} \times 100$

ohms

Rated current $= \frac{kVA}{\sqrt{3} \times E} = \frac{600 \times 10^3}{1.7321 \times 11 \times 10^3} = 31.49A$

Secondary current $= \frac{kVA}{\sqrt{3} \times E} = \frac{600 \times 10^3}{1.7321 \times 400} = 866A$

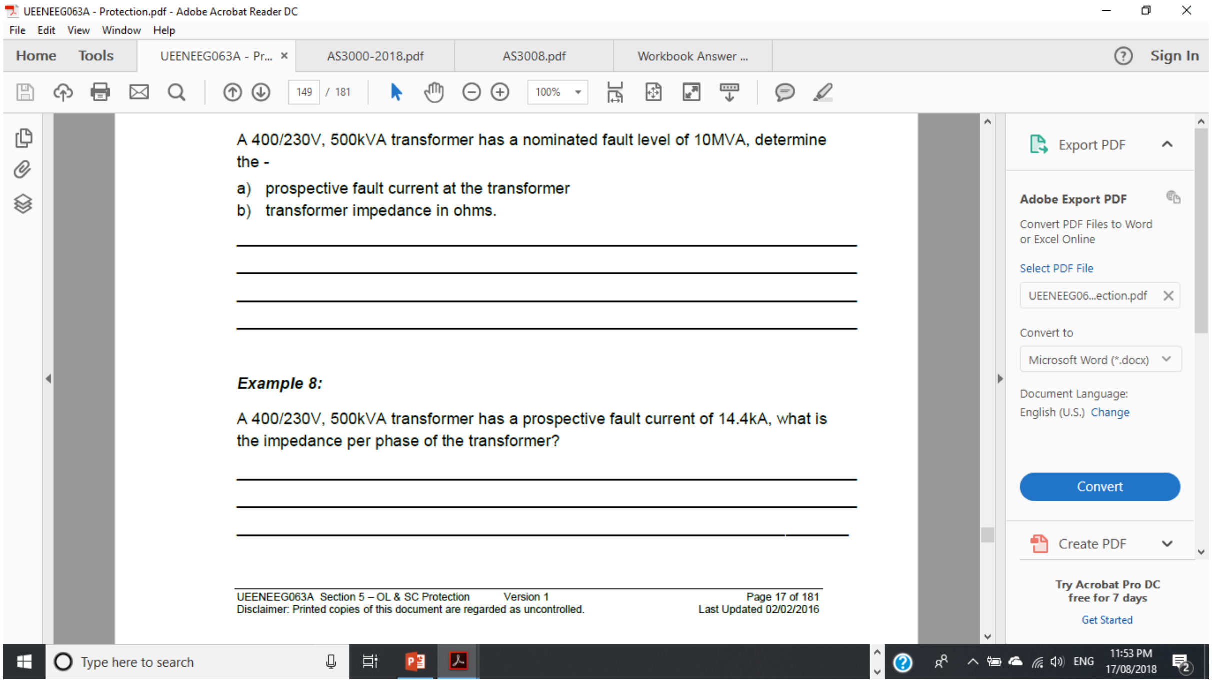
Fault current $- I_{sn} = \frac{I_{fL}}{\% Z} \times 100 = \frac{866}{4} \times 100 = 21650$ A

Fault level $= MVA_{sn} = \frac{MVA_{fL}}{\% Z} \times 100$

$= \frac{600}{4} \times 100 = 15$ MVA

$\% Z = \frac{I_{fL} \times Z_{ph}}{E_{ph}} \times 100$ $\quad \Delta = 11kV = E_{ph}$

$4 = \frac{31.49 \times Z_{ph}}{11 \times 10^3} \times 100 \Rightarrow Z_{ph} = \frac{4 \times 11000}{31.44 \times 100} = 13.99\ \Omega$



A 400/230V, 500kVA transformer has a nominated fault level of 10MVA, determine the -

a) prospective fault current at the transformer
b) transformer impedance in ohms.

Example 8:

A 400/230V, 500kVA transformer has a prospective fault current of 14.4kA, what is the impedance per phase of the transformer?

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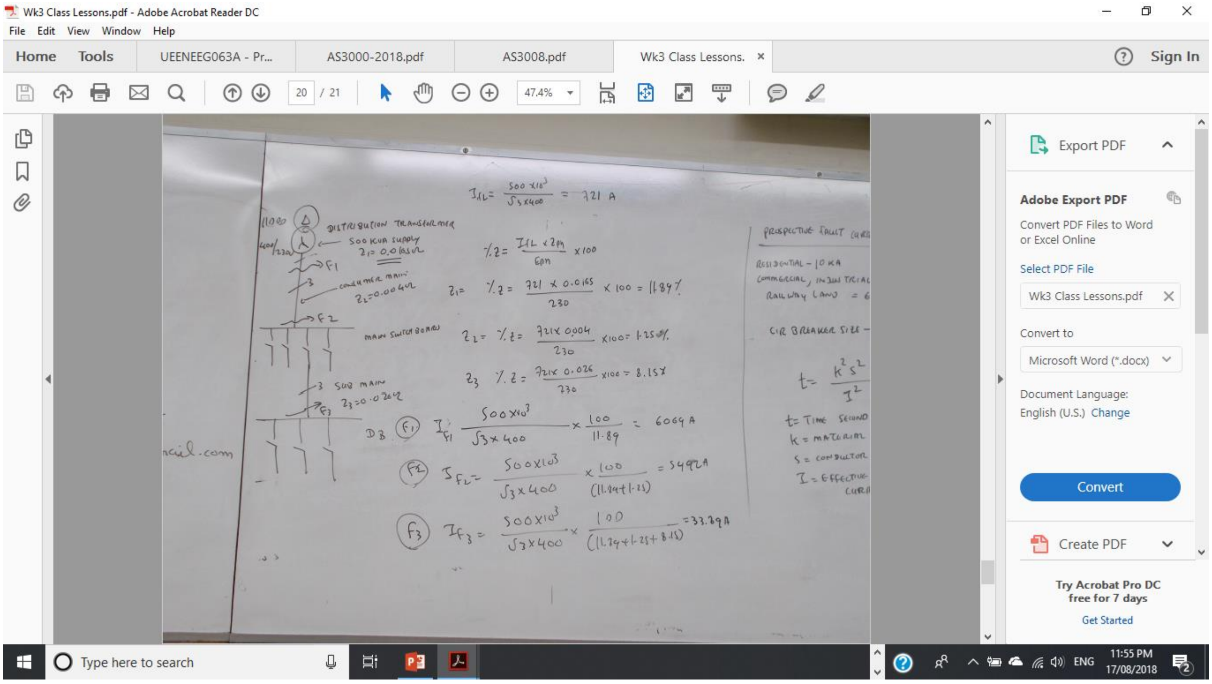
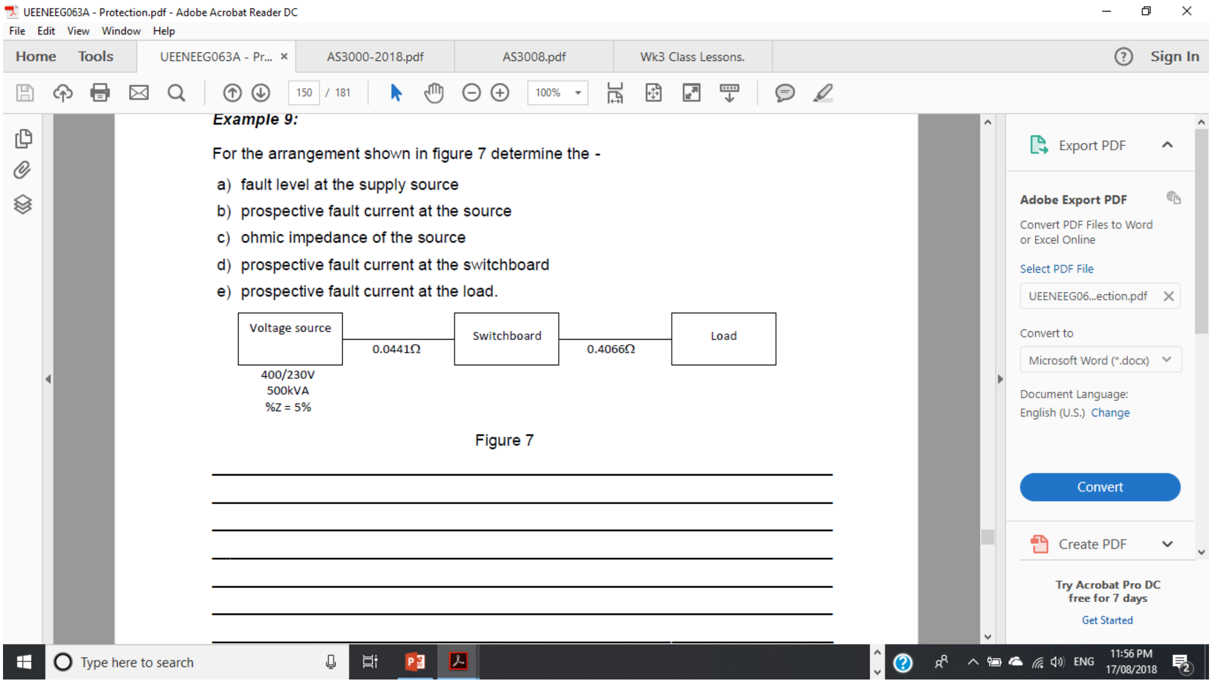




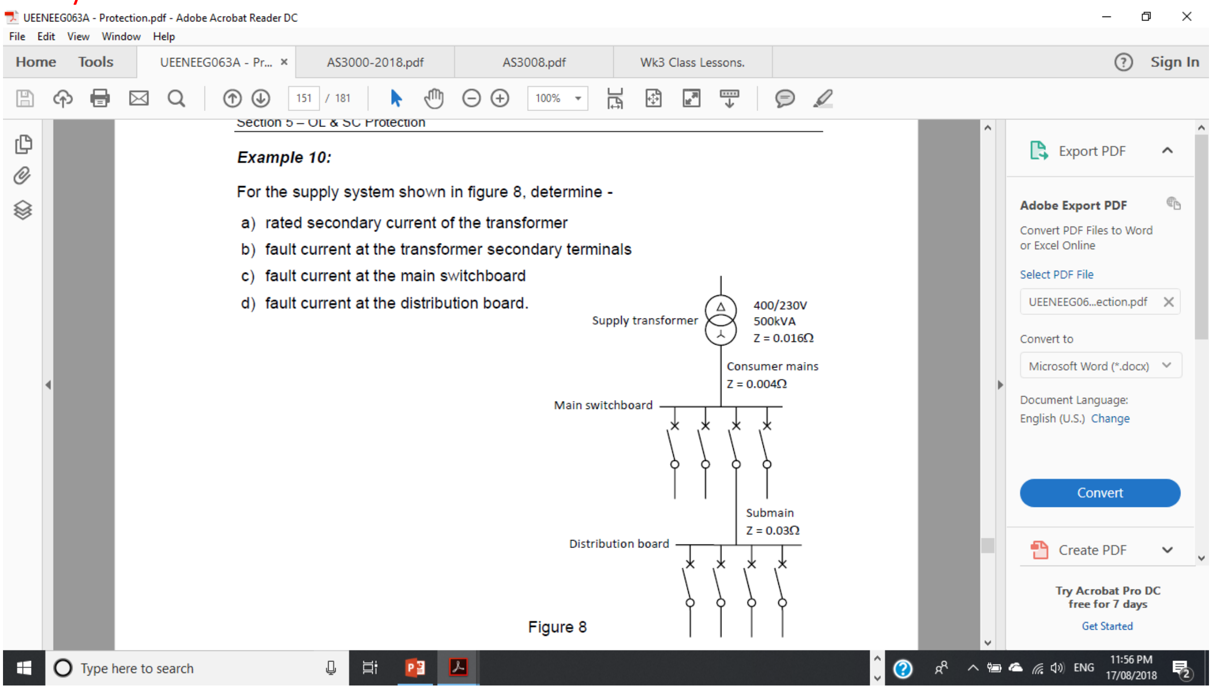
Example 9:

For the arrangement shown in figure 7 determine the -

a) fault level at the supply source
b) prospective fault current at the source
c) ohmic impedance of the source
d) prospective fault current at the switchboard
e) prospective fault current at the load.

Figure 7

Do it yourself



Section 5 – OL & SC Protection

Example 10:

For the supply system shown in figure 8, determine -

a) rated secondary current of the transformer
b) fault current at the transformer secondary terminals
c) fault current at the main switchboard
d) fault current at the distribution board.

Figure 8

Do it yourself

Page 157

The term 'over-current' is defined as____

____

AS/NZS Clause no. ____________________

1.4.90 Overcurrent

A current exceeding the rated value of electrical equipment

What is the meaning of 'overload current?__________________________________

____

AS/NZS Clause no. ____________________

1.4.42 Current, overload

An overcurrent occurring in a circuit that is electrically sound.

What is a short circuit current?____

____

____

AS/NZS Clause no. ____________________

1.4.43 Current, short-circuit

A fault current resulting from a fault of negligible impedance between live conductors having a difference in potential under normal operating conditions. The fault path may include the path from active via earth to the neutral.

NOTE: This current is also referred to as 'prospective short-circuit current' or a 'bolted fault'. It is the maximum value, at the relevant points for the existing installation. Unless otherwise stated, it is the three-phase r.m.s. value.

All currents caused by a short circuit shall, shall be interrupted before the temperature of the conductors reach what limit? _____________________________

AS/NZS Clause no. ____________________

3.4.2 Operating temperature limits

The operating temperatures of conductors shall not exceed the limits given in Table 3.2

1.5.9 Protection against overcurrent

Protection shall be provided against injury or property damage because of excessive temperatures or electromechanical stresses caused by any overcurrents likely to arise in live conductors.

Protection may be provided by one of the following methods:

(a) Automatic disconnection on the occurrence of an overcurrent, before this overcurrent attains a dangerous value, taking into account its duration.

(c) Limiting the maximum overcurrent to a safe value and duration.

What are the four ways of providing protection against both overload currents and short circuit current?

____

____

____

____

AS/NZS Clause no. ____________________

2.3 CONTROL OF ELECTRICAL INSTALLATION

2.3.1 General

Electrical installations shall be provided with devices to prevent or remove hazards associated with the electrical installation and for maintenance of electrically activated equipment.

NOTE: The measures specified in this Clause (Clause 2.3) are in addition to, and not alternatives to, the protective measures specified in Clause 2.4.

Electrical installations shall include all switching devices or other means of disconnection necessary to enable operations, repairs and maintenance work to be carried out safely.

Any device provided shall comply with the relevant requirements of this Clause (Clause 2.3), in accordance with the intended function or functions.

Such devices are classified according to one of the following functions:

(a) Isolation, in accordance with Clause 2.3.2.2.

(b) Emergency, in accordance with Clause 2.3.5.2.

(c) Mechanical maintenance, in accordance with Clause 2.3.6.2.

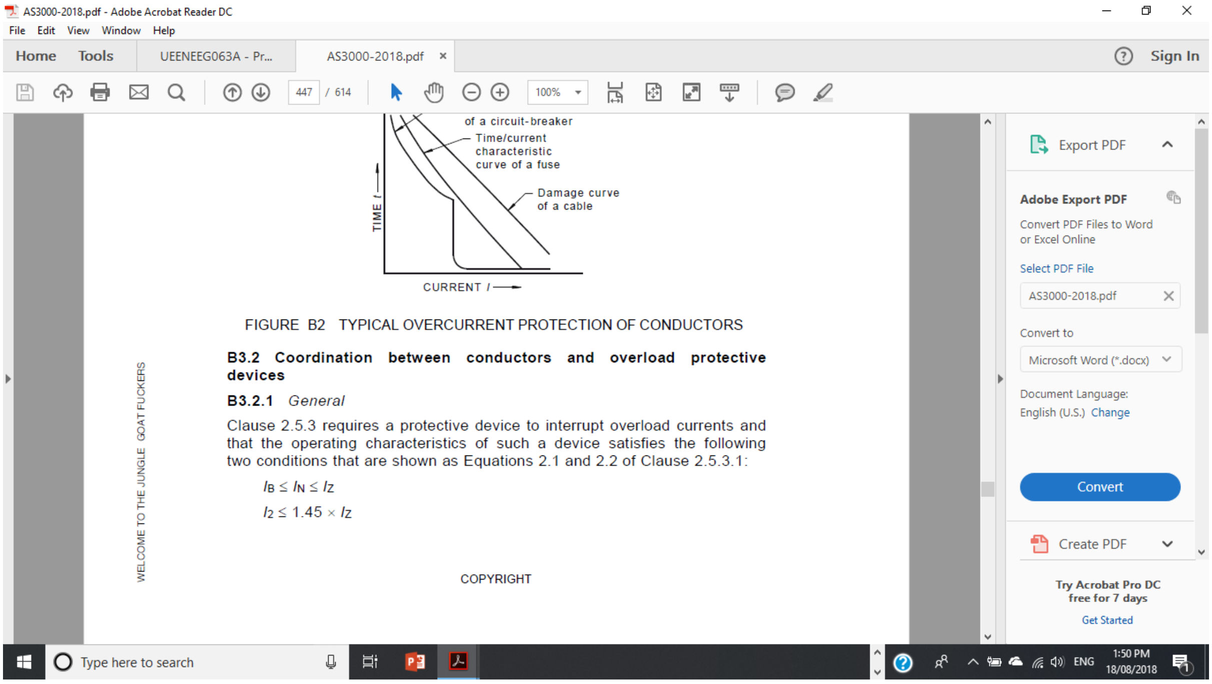
(d) Functional (control), in accordance with Clause 2.3.7.2.

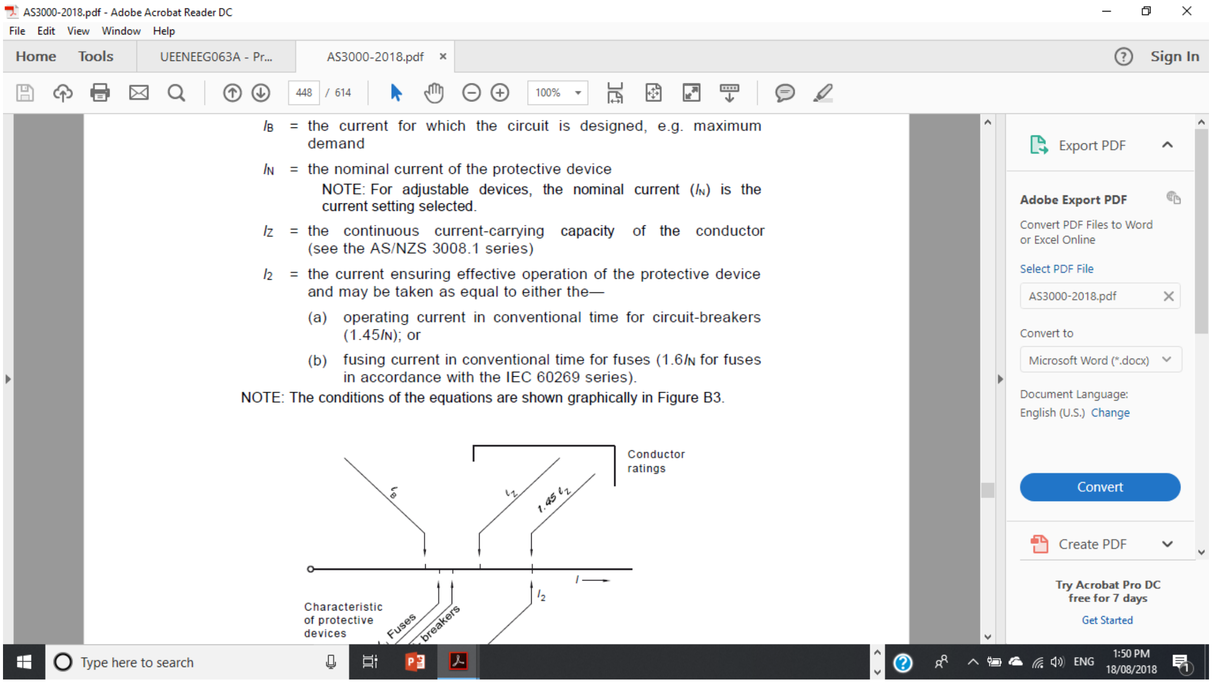
To adequately protect a cable from the heating effects of an electric current, a fuse must operate within conventional time with a prescribed value of current. What is the value of current that ensures effective operation of a 20 Amp fuse?

____

AS/NZS Clause no. ____________________

I max demand <= 20A (Fuse rating)





Electrical equipment which is double insulated is defined as being class ____________?

AS/NZS Clause no. ______________________

1.4.32 Class II equipment

Equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation, are provided, there being no provision for protective earthing or reliance upon installation conditions. Such equipment may be one of the following types:

(a) Equipment having durable and substantially continuous enclosures of insulating material that envelope all metal parts, with the exception of small parts, such as nameplates, screws and rivets, that are isolated from live parts by insulation at least equivalent to reinforced insulation. Such equipment is called insulation-encased Class II equipment.

(b) Equipment having a substantially continuous metal enclosure, in which double insulation is used throughout, except for those parts where reinforced insulation is used because the application of double insulation is manifestly impracticable. Such equipment is called metal-encased Class II equipment.

(c) Equipment that is a combination of the types described in Items (a) and (b).

If a cable rated at 20A is overloaded to 40A, the extra value of the heating effect is ______________ times greater than the original value.

AS/NZS Clause no. ______________________

1.5.8 Protection against thermal effects in normal service

Electrical installations shall be arranged so that there is no risk of ignition of flammable materials because of high temperature or electric arc in normal service. During normal operation of the electrical equipment there shall be no risk of persons or livestock

suffering burns.
The selection and installation of electrical equipment shall be such that the temperature characteristics of the electrical equipment, properly installed and operated, do not adversely affect the electrical equipment, the electrical installation itself or any other installation, whether electrical or
otherwise.

Four

Refer to figure 9 below and determine the following:
(a) load current under normal operating conditions ______________________________

____

(b) prospective fault current if a short-circuit occurs across the load.

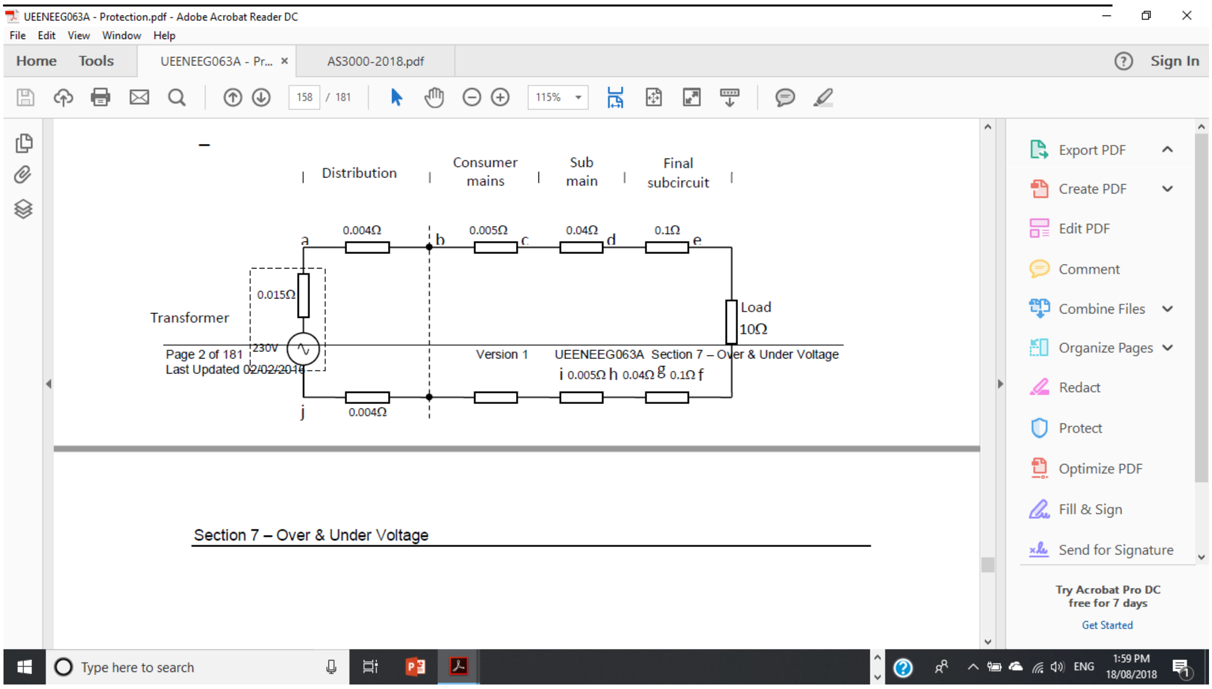
____

(c) prospective fault current if a short-circuit occurs between points b and i

____

(d) An appropriately rated circuit breaker (minimum current AND kA rating). Explain.

____



TO 3.29 Given a 11kV/400V (Delta/star) 600 kVA transformer has an impedance of 4%, determine the (a) rated current (b) fault current at the transformer secondary terminals (c) fault level at transformer secondary terminals (d) transformer impedance in ohms

$$\text{Rated current} = \frac{kVA}{\sqrt{3} \times E} = \frac{600 \times 10^3}{1.7321 \times 11 \times 10^3} = 31.49A$$

$$\text{Secondary current} = \frac{kVA}{\sqrt{3} \times E} = \frac{600 \times 10^3}{1.7321 \times 400} = 866A$$

$$\text{Fault current} - I_{sh} = \frac{I_{fl}}{\% Z} \times 100 = \frac{866}{4} \times 100 = 21650 \text{ A}$$

$$\text{Fault level} = MVA_{sh} = \frac{MVA_{fl}}{\% Z} \times 100$$

ohms

$$\text{Rated current} = \frac{kVA}{\sqrt{3} \times E} = \frac{600 \times 10^3}{1.7321 \times 11 \times 10^3} = 31.49A$$

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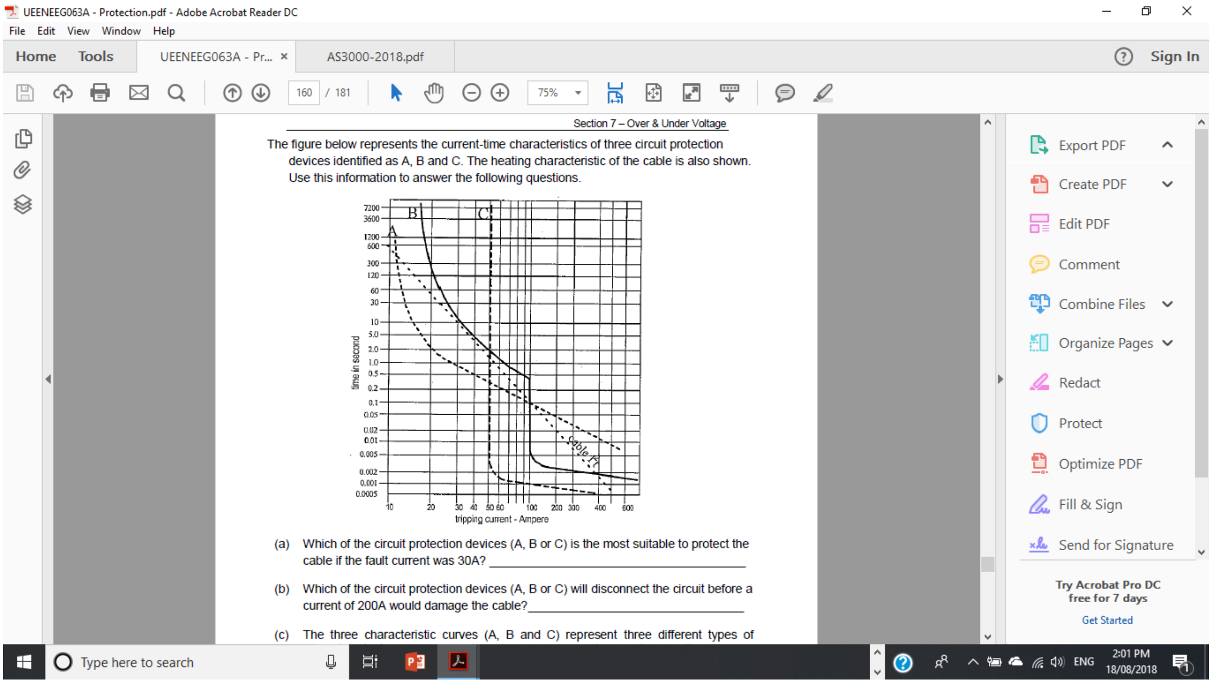
$$\text{Fault current} - I_{sh} = \frac{I_{fl}}{\% Z} \times 100 = \frac{866}{4} \times 100 = 21650 \text{ A}$$

$$\text{Fault level} = MVA_{sh} = \frac{MVA_{fl}}{\% Z} \times 100$$

$$= \frac{600}{4} \times 100 = 15 \text{ MVA}$$

$$\% Z = \frac{I_{fl} \times Z_{ph}}{E_{ph}} \times 100 \qquad \Delta = 11kV = E_{ph}$$

$$4 = \frac{31.49 \times Z_{ph}}{11 \times 10^3} \times 100 \Rightarrow Z_{ph} = \frac{4 \times 11000}{31.44 \times 100} = 13.99 \ \Omega$$



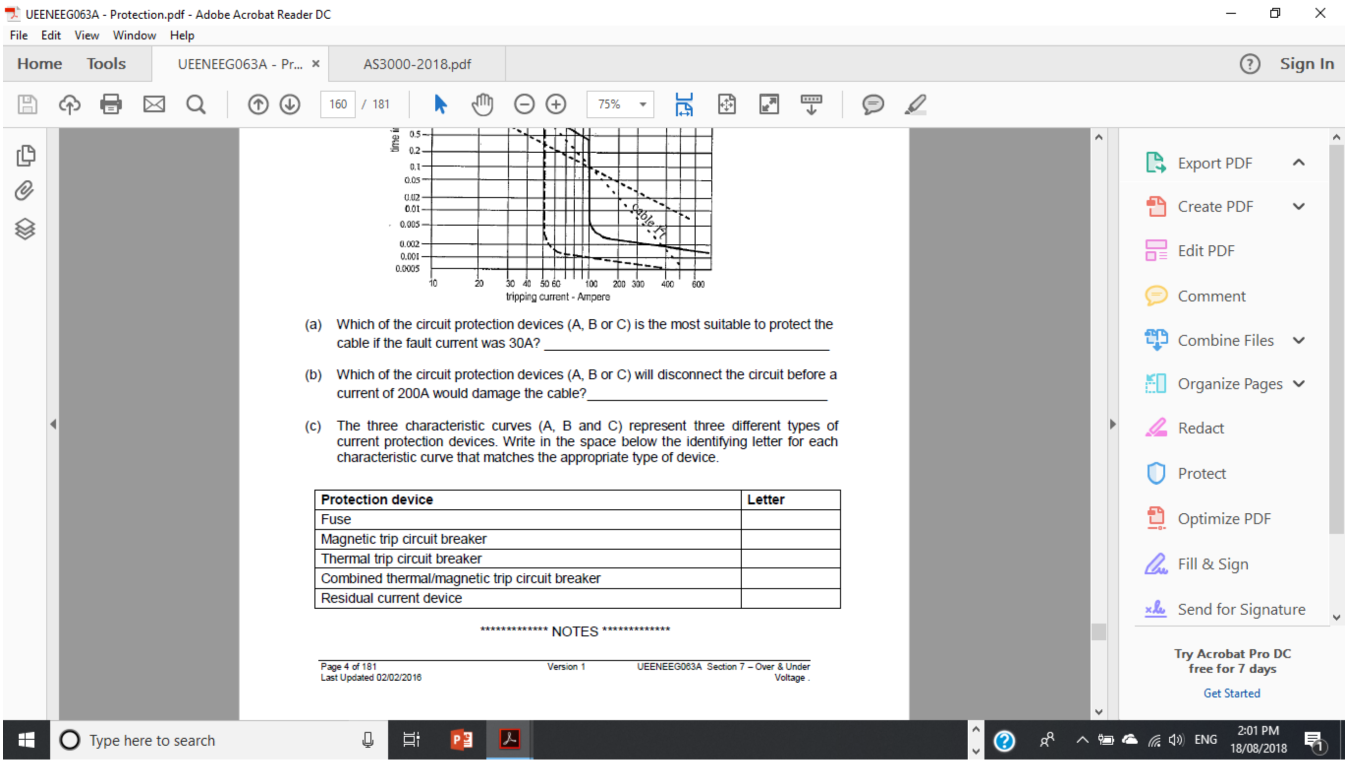
Section 7 – Over & Under Voltage

The figure below represents the current-time characteristics of three circuit protection devices identified as A, B and C. The heating characteristic of the cable is also shown. Use this information to answer the following questions.

(a) Which of the circuit protection devices (A, B or C) is the most suitable to protect the cable if the fault current was 30A? ______________________

(b) Which of the circuit protection devices (A, B or C) will disconnect the circuit before a current of 200A would damage the cable? ______________________

(c) The three characteristic curves (A, B and C) represent three different types of



(a) Which of the circuit protection devices (A, B or C) is the most suitable to protect the cable if the fault current was 30A? ______________________

(b) Which of the circuit protection devices (A, B or C) will disconnect the circuit before a current of 200A would damage the cable? ______________________

(c) The three characteristic curves (A, B and C) represent three different types of current protection devices. Write in the space below the identifying letter for each characteristic curve that matches the appropriate type of device.

Protection device	Letter
Fuse	
Magnetic trip circuit breaker	
Thermal trip circuit breaker	
Combined thermal/magnetic trip circuit breaker	
Residual current device	

************* NOTES *************

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Classification of Circuit Breakers

Circuit breakers are classified by:

- number of poles (ranging from single pole to four pole with the two and four pole types available with one unprotected pole)
- protection against external influences (enclosed or unenclosed)
- rated voltage, frequency and current (230/400V; 50Hz with current ratings such as 6A, 8A, 10A, 13A, 16A, 20A, 25A, 32A, 40A, 50A, 63A, 80A, 100A, and 125A)

- range of instantaneous tripping current

- Type B having a tripping range of 3 to 5 times rated current (mean trip 4 times)
- Type C having a tripping range of 5 to 10 times rated current (mean trip 7.5 times)
- Type D having a tripping range of 10 to 50 times rated current
  See the time current curves in **Fig. F-3-5-5**.

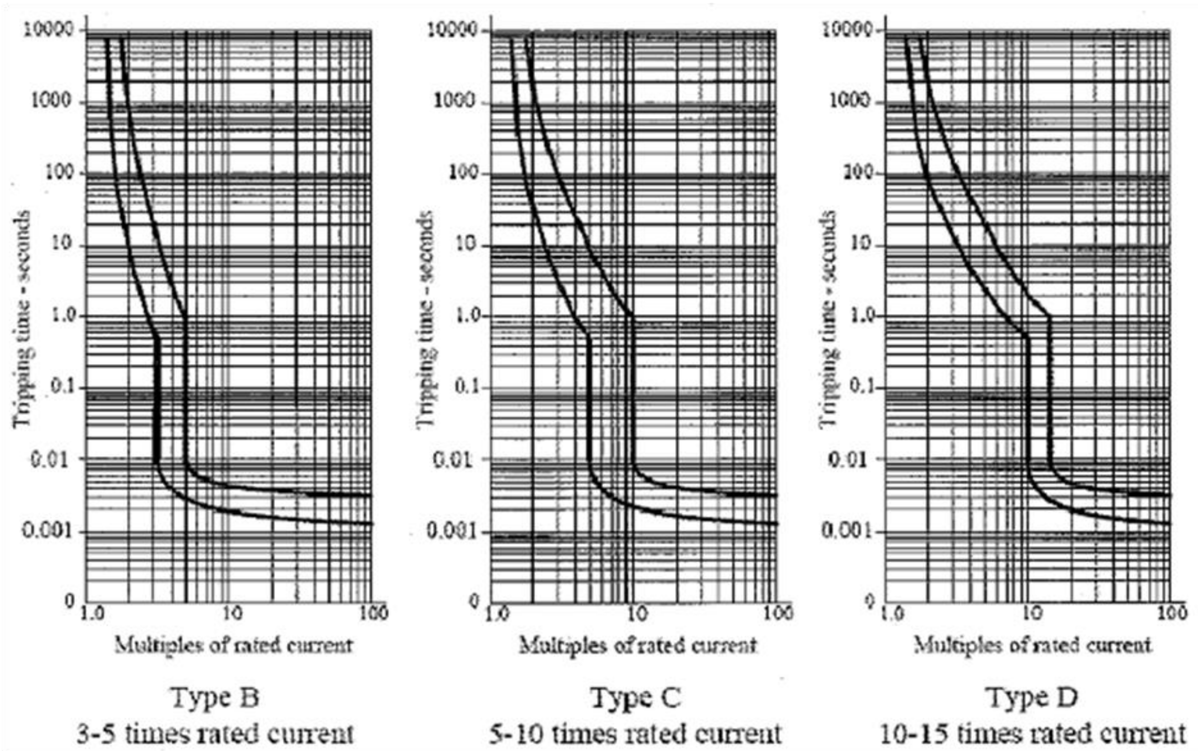

Fig. F-3-5-5 Time-Current Tripping Curves for type B, C, and D Circuit Breaker

(1) A
(2) C
(3) C- Magnatic CB, A= Thermal CB   B – Fuse

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VOLTAGE LEVELS
Refer to **clause 1.4.98** - Voltage:
Differences of potential normally exist between conductors and between conductorsand earth as follows -

- **extra low voltage** - not exceeding ____________ or ____________ ripple free dc
- **low voltage** - exceeding extra low voltage, but not exceeding ________ or ________
- **high voltage** - exceeding low voltage.

1.4.128 Voltage
Differences of potential normally existing between conductors or between conductors and earth as follows:
(a) Extra-low voltage Not exceeding 50 V a.c. or 120 V ripple-free d.c.
(b) Low voltage Exceeding extra-low voltage, but not exceeding 1000 V a.c. or 1500 V d.c.
(c) High voltage Exceeding low voltage.

SUPPLY CHARACTERISTICS
Refer to **clause 1.6.2** - Supply characteristics:
The nominal voltage and tolerances for low voltage supply systems and electricalinstallations in Australia are -
____ (in accordance with AS 60038)..

1.6.2 Supply characteristics
The following characteristics of the electricity supply shall be determined:
(a) Nature of current, a.c. or d.c.
(b) Nature and number of conductors, as follows:
(i) Active (phase), neutral and protective earthing conductors for a.c.
(ii) Equivalent conductors for d.c.
(c) Voltage and voltage tolerances.
NOTE: The nominal voltage and tolerances for low voltage supply systems and electrical installations are–
(a) for Australia, 230/400 V + 10% to · 6% (in accordance with AS 60038); and
(b) for New Zealand, 230/400 V + 6% to · 6% (in accordance with IEC 60038).
(d) Frequency and frequency tolerances.
(e) Maximum current that can be supplied.
(f) Prospective short-circuit current.
NOTE: Information regarding prospective short-circuit and fault currents at the point of supply may be obtained from the local electricity distributor.

(g) Protective measures inherent in the supply, e.g. MEN earthing system.
(h) Limits on the use of equipment.
(i) Harmonic current or other limitations.

Example 1:
Calculate the range of voltages available at the point of supply for a single phase installation given the above voltages and tolerances.

____

____

Within a distribution system –
installations closer to the distribution transformer will have __________________ voltages at the point of supply
installations further from the distribution transformer will have _______________ voltages at the point of supply

higher/ lower

Example: 2
Using the NSW Service and Installation Rules, provide two examples of equipment that would cause fluctuations in the voltage and distortion of the supply wave shape:
Voltage Fluctuation:

- ____
- ____

Wave Shape Distortion:

- ____
- ____

Bad Wiring

Bad wiring can also lead to voltage fluctuations. This happens when the wiring has been designed to handle less electricity than what the entire unit might need. Or, there could be ungrounded outlets that leak electricity.

Other possible wiring-related causes are damage caused by insects and pests or a disconnection.

To detect if the voltage fluctuation is caused by wiring, an electrician or electrical systems expert will use specific equipment. He/she will also fix the problem using special equipment that will prevent the need to access the wiring directly.

Interference

Interference occurs when a number of sensitive and wrong combinations of electrical devices or machinery are operated on the same circuit. It is common for a lot of electrical devices to cause surges. This can be confirmed by observing the lights when any of the suspected devices or machinery are being used. If the lights (in the same circuit) flicker when said devices or machinery are on, it means you have interference-related voltage fluctuations

As power utilities continue to be pushed to the limits of supply capability, rising energy costs and decreasing power quality will continue to be an issue for consumers. Users continually search for ways to not only reduce energy costs, but also ensure their processes will continue to operate, no matter the quality of the incoming power. To accomplish this, more and more variable frequency drives, UPS systems, and other non-linear loads are being installed. The usual waveform of an alternating current (AC) is generally that of a sine wave or a sinusoidal waveform. This is considered the fundamental waveform. Linear loads draw current in proportion to the sinusoidal voltage. Non-linear loads, such as drives, change their impedance by conducting current only near the peak of the wave. Switching loads on and off during the waveform results in non-sinusoidal current pulses. These pulses introduce reflective currents (harmonics) back into the power distribution system. The non-sinusoidal waveforms have the fundamental wave plus integral multiples of that fundamental wave

Refer to **clause 2.1.2** – Selection and installation
Switchgear and control gear shall be selected and installed to perform the following functions or have the following features associated with the proper design, correct construction and safe operation of the electrical installation:

Provide protection of the electrical installation against failure from ________________________ or ______________________ conditions.

2.1.2 Selection and installation
Switchgear and controlgear shall be selected and installed to perform the following functions or have the following features:

(a) Provide control or isolation of the electric al installation, circuits or individual items of apparatus as required for maintenance, testing, fault detection or repair.

(b) Enable automatic disconnection of supply in the event of an overload, short-circuit or excess earth leakage current in the protected part of the electrical installation.

(c) Provide protection of the electrical installation against failure from overvoltage or undervoltage conditions.

(d) Provide for switchgear and control gear to be grouped and interconnected on switchboards, enclosed against external influences, and located in accessible positions.

(e) Separately control and protect the circuit arrangements without affecting the reliability of supply to, or failure of, other parts of the installation.

* (f) Installed in accordance with the requirements of this Section, and the additional requirements as specified in the manufacturer's instructions.

Refer to **clause 2.8** – Protection against under voltage.

Suitable protective measures shall be taken where the ___________ and subsequent _____________________ of voltage; or a _____________ in voltage; could cause ______________ to persons or property

2.8 PROTECTION AGAINST UNDERVOLTAGE

2.8.1 General

Suitable protective measures shall be taken where—

(a) the loss and subsequent restoration of voltage; or

(b) a drop in voltage,

could cause danger to persons or property

Example 3:

Provide an example of where restoration of voltage after a loss of supply could cause danger.

For best safety practices, machines must be prevented from automatically or unintentionally restarting when a power interruption occurs. To determine if your machine has drop-out (anti-restart) protection, perform the following steps:

1. With the motor running, turn off the power to the machine at the motor starter disconnect, or unplug it from the outlet. Do not do this as a normal means of motor stopping unless the electrical system is designed for it.
2. Let the motor ramp down to a complete stop.
3. Turn the power back on.
4. If the machine starts, you do not have drop-out protection.

When a machine is running and then unexpectedly loses power, the main motor stops after a certain rundown time. The safety concern is what happens when the power returns. Perhaps the greatest hazard is that an unexpected motor startup directly initiates hazardous motion. Several methods can be used to prevent unintended machine motor startup, whether for initial start or restart. One commonsense requirement found in machine safety regulations is to protect the main motor start button from accidental operation, such as accidentally bumping the start button. This can be accomplished by using:

- A ring guard around the start button
- A start button that is recessed or flush to the surface
- A fabricated shield over the start button

Safety regulations that reference preventing accidental operation can be found in OSHA 1910.217 (b)(8)(ii) and ANSI B11.1-2009 (6)(2)(3). OSHA 1910 Subpart O specifies two categories of machines that require a motor starter with an anti-restart feature, also known as drop-out protection. These machines are mechanical power presses (OSHA 1910.217) and woodworking machines (OSHA 1910.213).

In their respective mechanical power press requirements, OSHA 1910.217 (b)(8)(iii) and ANSI B11.1-2009 (6)(2)(4) both state, "All power press controls shall incorporate a type of drive motor starter that will disconnect the drive motor from the power source in the event of control-voltage or power source failure. Operation of the motor-start button shall be required to restart the motor when voltage conditions are restored to normal."

OSHA 1910.213 (b)(3) for woodworking machines states, "On applications where injury to the operator might result if motors were to restart after power failures, provision shall be made to prevent machines from automatically restarting upon restoration of power."

The most common method to prevent unexpected machine restart after a power failure, then power restoration, is a magnetic-type motor starter. Electrical contacts within the starter are magnetically separated upon loss of power. When power is restored, the main motor start button must be pushed to reconnect the electrical contacts and restart the machine.

Another more compact device designed for smaller machines is a drop-out device that is hard-wired to the machine. This Sensing Saf-Start device features a reset button that must be pushed to restart the machine once power has been lost and then restored.

NFPA 79-2007 "Electrical Standard for Industrial Machinery" covers all industrial machines and states in 7.5.3, "Upon restoration of the voltage or upon switching on the incoming supply, automatic or unintentional restarting of the machine shall be prevented when such a restart causes a hazardous condition."

The implication here is for an anti-restart feature – also known as drop-out protection.

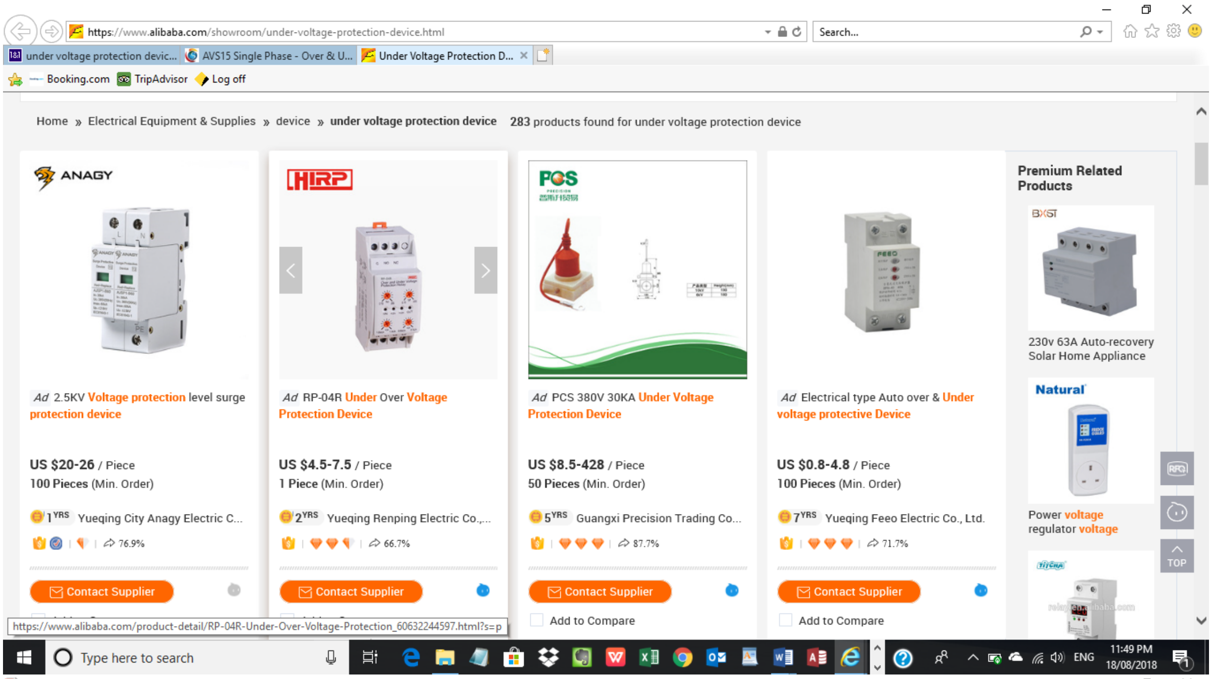
For best safety practice, determine if your machine has drop-out/anti-restart protection. Refer to OSHA, ANSI and NFPA 79 for all electrical requirements. It is a safety responsibility to protect against supply interruption or voltage reduction and subsequent restoration

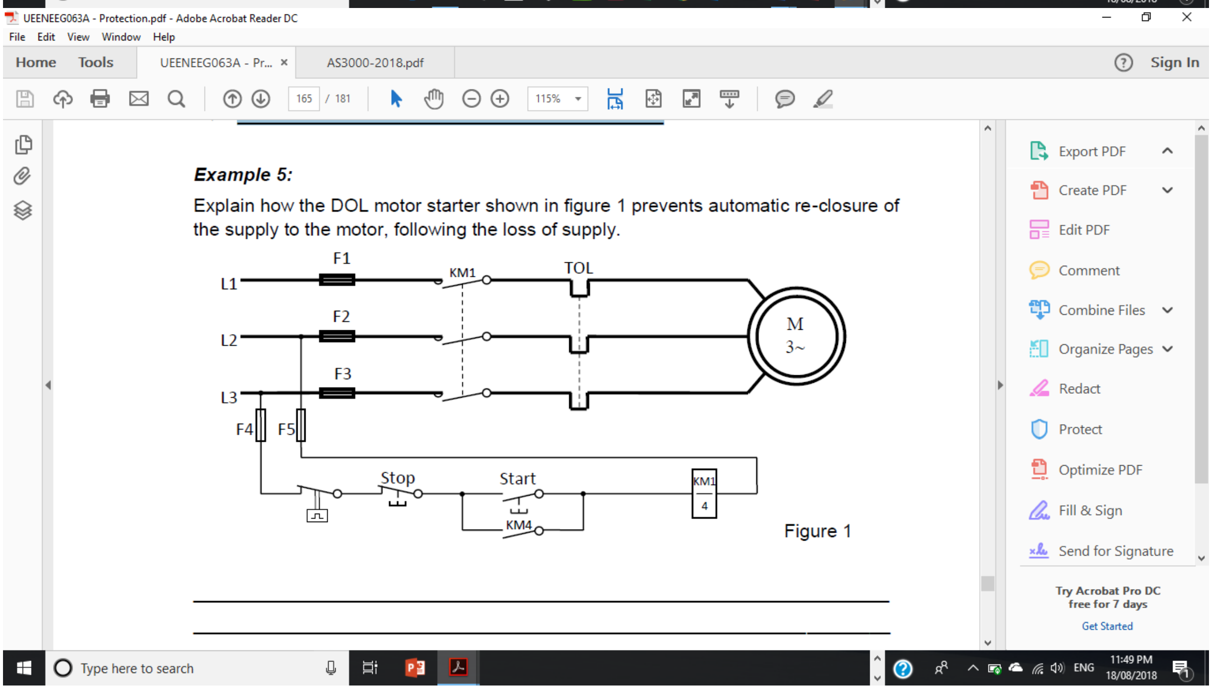
Refer to **clause 2.8.2** – Selection of protective device
Where the re-closure of a protective device is likely to create a dangerous situation, the re-closure shall not be ________________________________.

2.8.2 Selection of protective device
The characteristics of the undervoltage protective device shall be compatible with the requirements of the appropriate Standards for starting and the use of electrical equipment.
Where the re-closure of a protective device is likely to create a dangerous situation, the re-closure shall not be automatic.
Instantaneous disconnection by the undervoltage device shall not be impaired by contacts that have intentional delays in their operation.
Exception: The operation of undervoltage protective devices may be delayed if the operation of the protected electrical equipment allows a brief interruption or loss of voltage without danger

Example 4:
Provide two examples of under voltage protection devices:

- ➢ ____
- ➢ ____



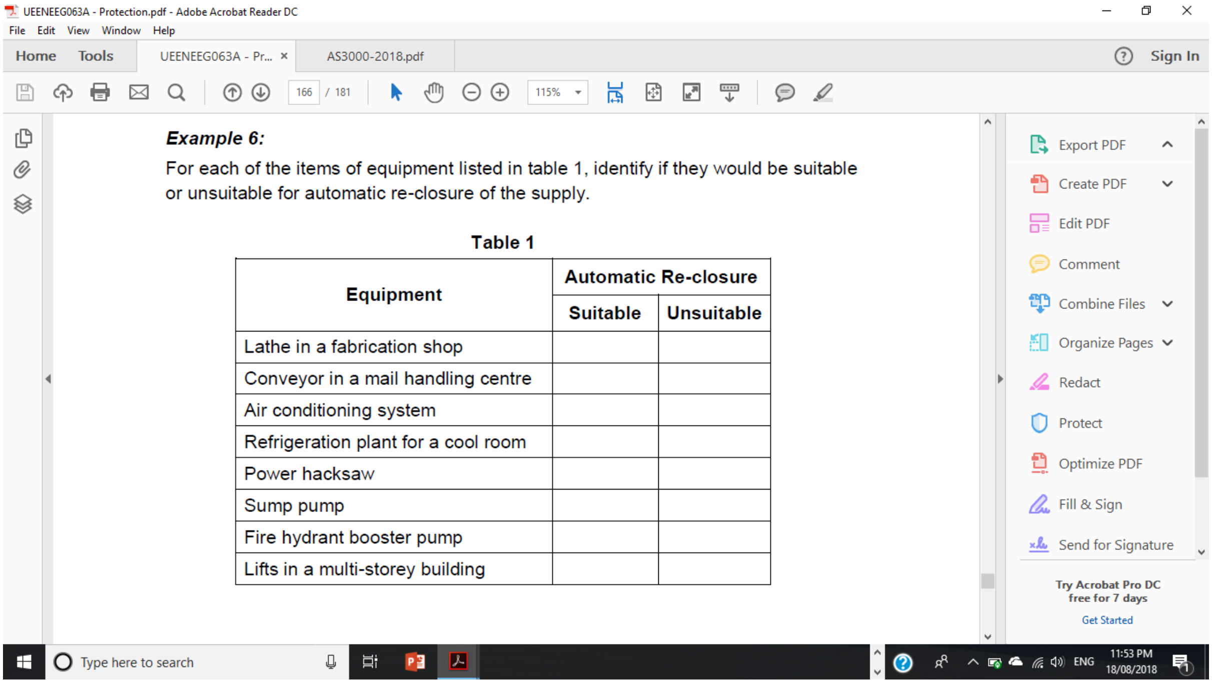


Example 5:

Explain how the DOL motor starter shown in figure 1 prevents automatic re-closure of the supply to the motor, following the loss of supply.

Figure 1

Loss of supply cause KM4 Auxiliary contact will open and without pressing the start button motor will not be energnized



Example 6:

For each of the items of equipment listed in table 1, identify if they would be suitable or unsuitable for automatic re-closure of the supply.

Table 1

Equipment	Automatic Re-closure	
	Suitable	Unsuitable
Lathe in a fabrication shop		
Conveyor in a mail handling centre		
Air conditioning system		
Refrigeration plant for a cool room		
Power hacksaw		
Sump pump		
Fire hydrant booster pump		
Lifts in a multi-storey building		

Lathe in a fabrication shop ---------Not suitable

Conveyor in a mail handling centre --Suitable

Air conditioning system---- Not suitable

Refrigeration plant for a cool room --Suitable

Power hacksaw ----Not suitable

Sump pump ---- Suitable

Fire hydrant booster pump ---- Suitable
Lifts in a multi-storey building --- Suitable

OVERVOLTAGE
Refer to **clause 2.7** – Protection against overvoltage
Where an electrical installation is protected against over voltages which may causedanger to persons or property the requirements of clauses 2.7.2 and 2.7.3 shallapply.
The causes of overvoltage in an electrical installation include -

➢ ____
____
____

Top 5 Probable Causes of Over Voltage

- Power system surges. Due to poor regulation of the power source or power utility company, voltage fluctuations either over or under may occur. ...
- Insulation Failure. The most common form of insulation failure is when there is

grounding of the conductor. ...
- Arcing Ground. ...
- Resonance. ...
- External causes.

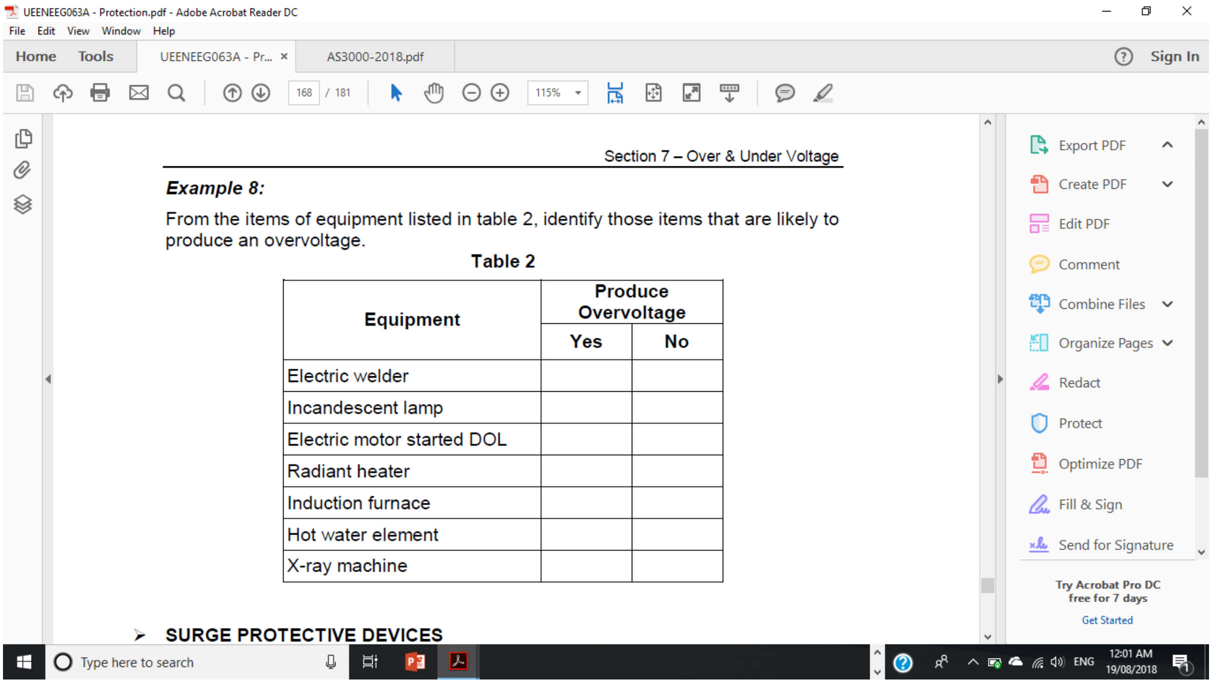
2.7.2 Protection by insulation or separation
Measures to prevent danger because of faults between live parts of the electrical installation and circuits supplied at higher voltages shall consist of the following:
(a) For conductors, the provision of adequate insulation screening or segregation of circuits in accordance with Clause 3.9.8.3.
(b) For transformers, the provision of adequate insulation, screening or separation of windings.
Transformer windings that operate at different voltages shall be insulated from one another by insulation with a specified test voltage or alternatively separated from one another by means of a conductive screen connected to the protective earthing conductor so as to ensure automatic disconnection of the supply in the event of a fault.
2.7.3 Protection by protective devices
Protective devices may be used to protect against the effects of overvoltage arising from such causes as lightning and switching operations.
Where installed, such devices shall—
(a) limit the (transient) voltage to a value below the insulation level of the electrical installation or the part thereof that the device protects;
(b) operate at voltages not less than or equal to the highest voltage likely to occur in normal operation; and
(c) cause no hazard to persons or livestock during operation.

Example 7:
Is it mandatory to provide electrical installations with:
➢overvoltage protection?

➢surge protection devices (SPDs)?

____

Yes/No



Section 7 – Over & Under Voltage

Example 8:

From the items of equipment listed in table 2, identify those items that are likely to produce an overvoltage.

Table 2

Equipment	Produce Overvoltage	
	Yes	No
Electric welder		
Incandescent lamp		
Electric motor started DOL		
Radiant heater		
Induction furnace		
Hot water element		
X-ray machine		

➢ **SURGE PROTECTIVE DEVICES**

Electric welder -------------Yes
Incandescent lamp ------------------No
Electric motor started DOL -----No
Radiant heater ------------------------No
Induction furnace --------------------------Yes
Hot water element --------------------No
X-ray machine --------------------------Yes

INSTALLATION OF SURGE PROTECTIVE DEVICES

Refer to **clause F1.2** – Selection and installation of SPDs

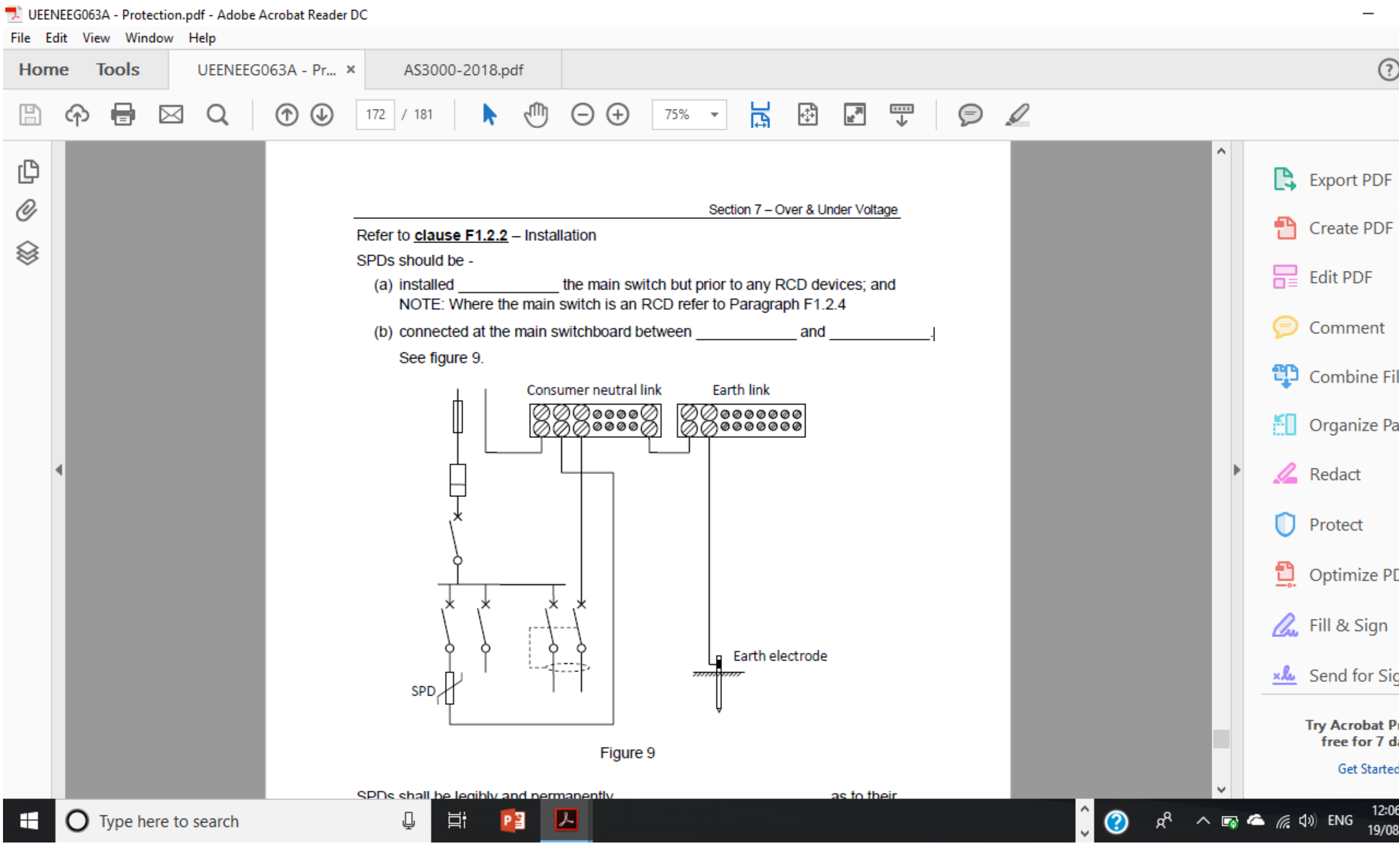
Primary SPDs should be installed near the ______________ of the electrical installation or in the

____.

F1.2 Selection and installation of SPDs

F1.2.1 Location

Primary SPDs are installed near the origin of the electrical installation or at
the main switchboard.



Section 7 – Over & Under Voltage

Refer to clause F1.2.2 – Installation

SPDs should be -

(a) installed ___________ the main switch but prior to any RCD devices; and
NOTE: Where the main switch is an RCD refer to Paragraph F1.2.4

(b) connected at the main switchboard between ___________ and ___________

See figure 9.

Figure 9

SPDs shall be legibly and permanently ... as to their

F1.2.2 Installation

SPDs should be–

(a) installed after the main switch but prior to any RCD devices. Where the main switch is an RCD, refer to Paragraph F2.4;

(b) protected by an appropriate fuse or circuit-breaker separate from the SPD;

(c) connected at the main switchboard between phase and neutral;

NOTE: Figure F1 shows a typical connection of a primary SPD for a single-phase installation.

(d) connected at switchboards remote from the main switchboard and without MEN connection, from each phase to neutral and from neutral to earth;

NOTE: Figure F2 shows a typical installation of a secondary SPD for a single-phase installation.

(e) be legibly and permanently labelled as to their function, in accordance with Clause 2.10.5.1; and

(e) where alarmed to provide status indication, fail safe in operation.

SPDs shall be legibly and permanently ____________________________ as to their function, in accordance with Clause 2.9.5.1.

F1.2.2 Installation

SPDs should be–

(a) installed after the main switch but prior to any RCD devices. Where the main switch is an RCD, refer to Paragraph F2.4;

(b) protected by an appropriate fuse or circuit-breaker separate from the SPD;
(c) connected at the main switchboard between phase and neutral;
NOTE: Figure F1 shows a typical connection of a primary SPD for a single-phase installation.
(d) connected at switchboards remote from the main switchboard and without MEN connection, from each phase to neutral and from neutral to earth;
NOTE: Figure F2 shows a typical installation of a secondary SPD for a single-phase installation.
(e) be legibly and permanently labelled as to their function, in accordance with Clause 2.10.5.1; and
(f) where alarmed to provide status indication, fail safe in operation.

Refer to **clause F1.2.3** – Selection of SPDs
For most domestic single-phase supplies in urban environments, a surge rating of -
➢ I_{max} = __________ kA per phase for an __________ µs impulse and aminimum working voltage of __________ V a.c. is suitable.

In the case of installations in exposed locations, e.g. high lightning areas, long overhead service lines, industrial and commercial premises, it may be prudent to install SPDs with a higher surge rating, typically –
➢ __________ kA per phase for an __________ µs impulse.

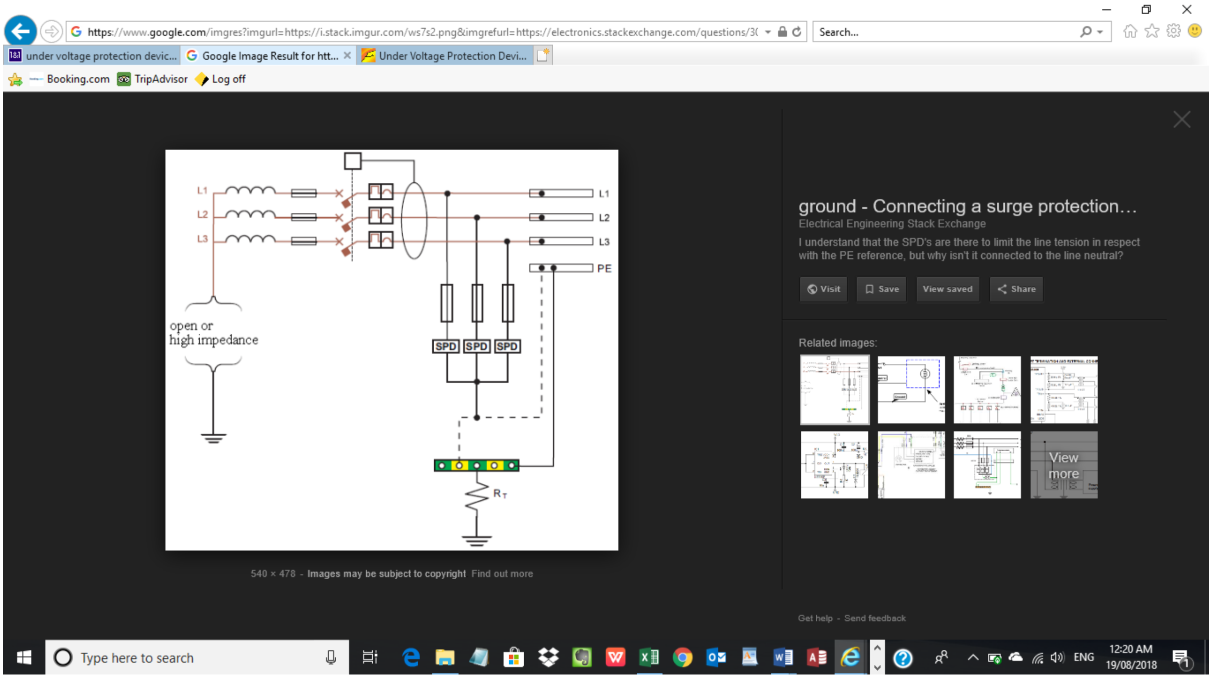
F1.2.3 Selection of surge protection devices (SPDs)
For most domestic supplies in urban environments, a surge rating of I_{max} = 40 kA per phase for an 8/20 ·s impulse and a maximum working voltage of 275 V a.c. to 320 V a.c. is suitable.
In the case of installations in exposed locations in high lightning areas, with
long overhead service lines, or industrial and commercial premises, it may be prudent to install SPDs with a higher surge rating (typically 100 kA per phase for an 8/20 micro s impulse).

Refer to **clause F1.2.4** – Overcurrent protective devices
The short-circuit withstand of the SPD, together with the overcurrent protective device, shall be not less than the ____ at the point of installation.
A 40 kA SPD may be protected by a _____________ HRC fuse or circuit-breaker having a breaking capacity not less than the prospective short-circuit current at the point of installation or by other means recommended by the manufacturer.
If an SPD is installed on the load side of an RCD, the RCD shall have a breaking capacity of not less than _____________.

F1.2.4 Overcurrent protective devices
SPDs should be protected against short-circuit by suitable overcurrent protective devices. In accordance with Clause 2.5.2, the short-circuit withstand of the SPD, together with the overcurrent protective device,

should be not less than the prospective short-circuit current at the point of installation.
The current rating of the SPD overcurrent protective device should be—
(a) as recommended by the SPD manufacturer but not greater than the manufacturer's declared maximum backup fuse rating; and
(b) less than the rating of the immediate upstream protective device.
NOTE: Notwithstanding the above, the following current ratings of HRC fuses or circuit-breakers are suitable for typical domestic applications, such as households:
(a) 32 A for a 40 kA SPD.
or
(b) 63 A for a 100 kA SPD.
If an SPD is installed on the load side of an RCD, the RCD should have a breaking capacity of not less than 3 kA. S-type RCDs, in accordance with AS/NZS 61008.1 and AS/NZS 61009.1 are deemed to satisfy this recommendation.

Refer to **clause F1.2.5** – Connecting conductors
Conductors used to connect an SPD to both the line via the overcurrent protective device, and to the main earthing or neutral conductor, should be not less than____________ and as "short and direct" as possible, with "no loops".
The total conductor length between the two points of connection, including both active and earth/neutral, must be less than one metre, ideally ___________ to ____________, overall.
A connection to the neutral link should be as close as practicable to the MEN connection
F1.2.5 Connecting conductors
Conductors used to connect an SPD to both the line, via the overcurrent protective device, and to the main earthing or neutral conductor should be consistent with the current rating of the backup fuse or circuit-breaker but should be not less than 6 mm^2, be as short and direct as possible and with no loops.
The total conductor length between the two points of connection including both active and earth/neutral should be less than 1 m (ideally 300 mm-600 mm) overall.
A connection to the neutral conductor should be as close as practicable to the MEN link.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I understand that the SPD's are there to limit the line tension in respect with the PE reference, but why isn't it connected to the line neutral?
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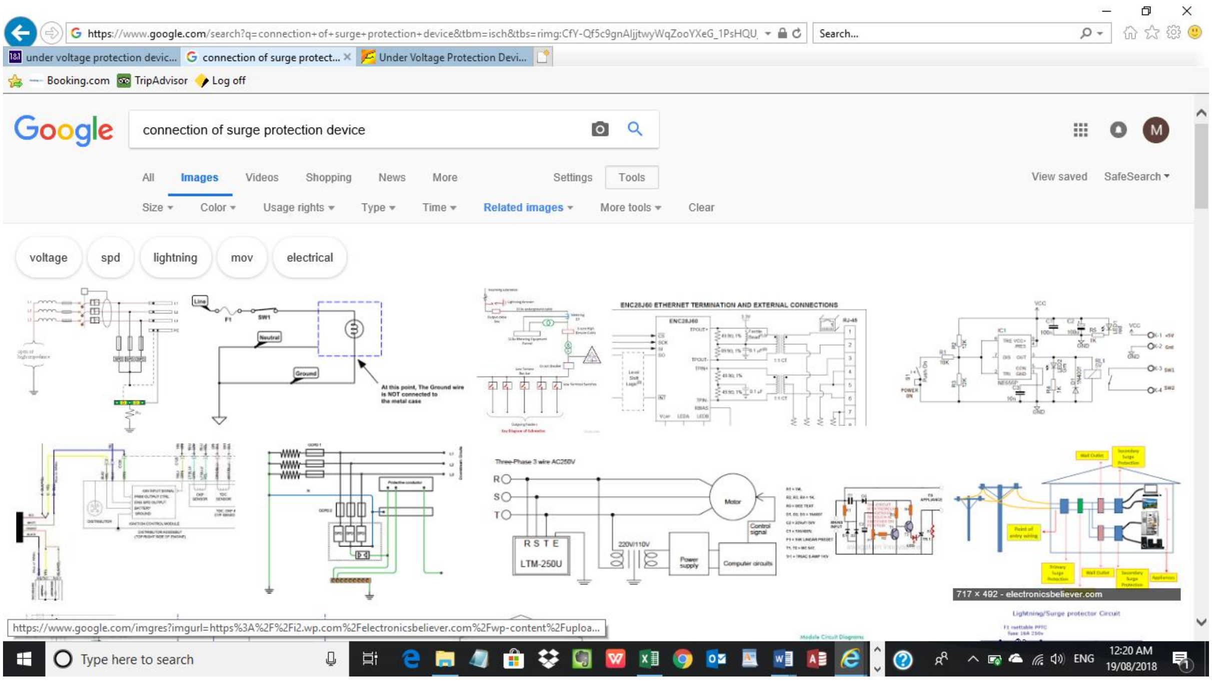
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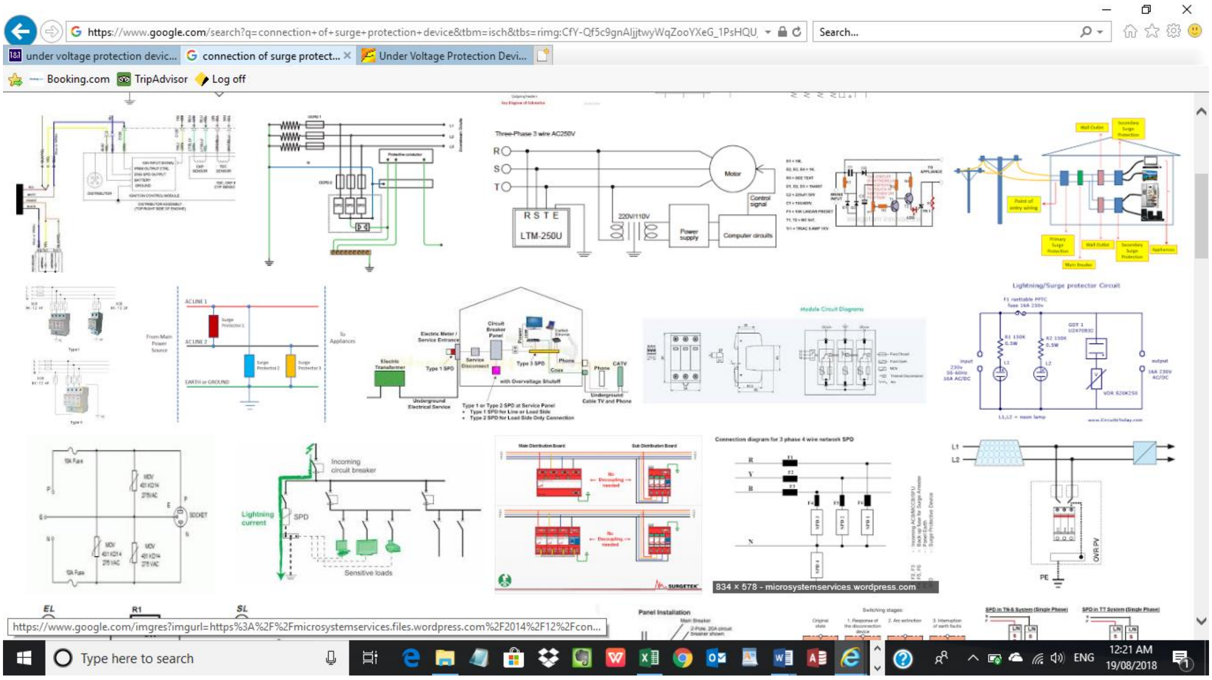
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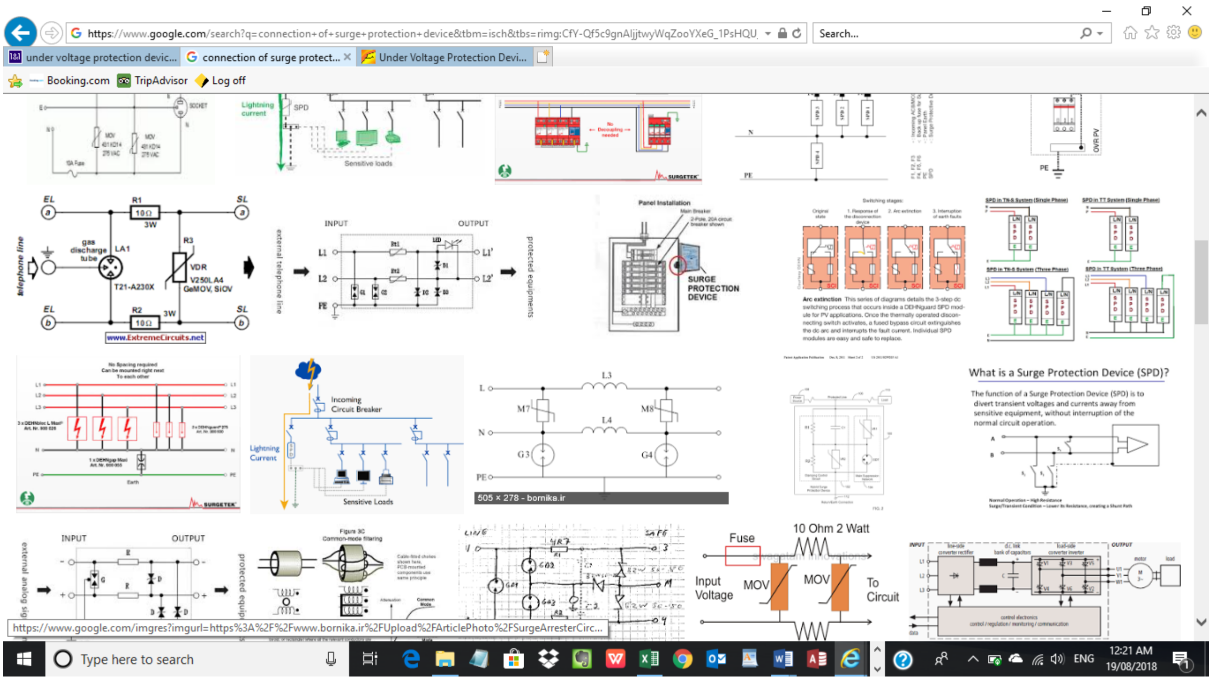
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Sensitive Loads
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What is a Surge Protection Device (SPD)?
The function of a Surge Protection Device (SPD) is to divert transient voltages and currents away from sensitive equipment, without interruption of the normal circuit operation.
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10 Ohm 2 Watt
Input Voltage
MOV
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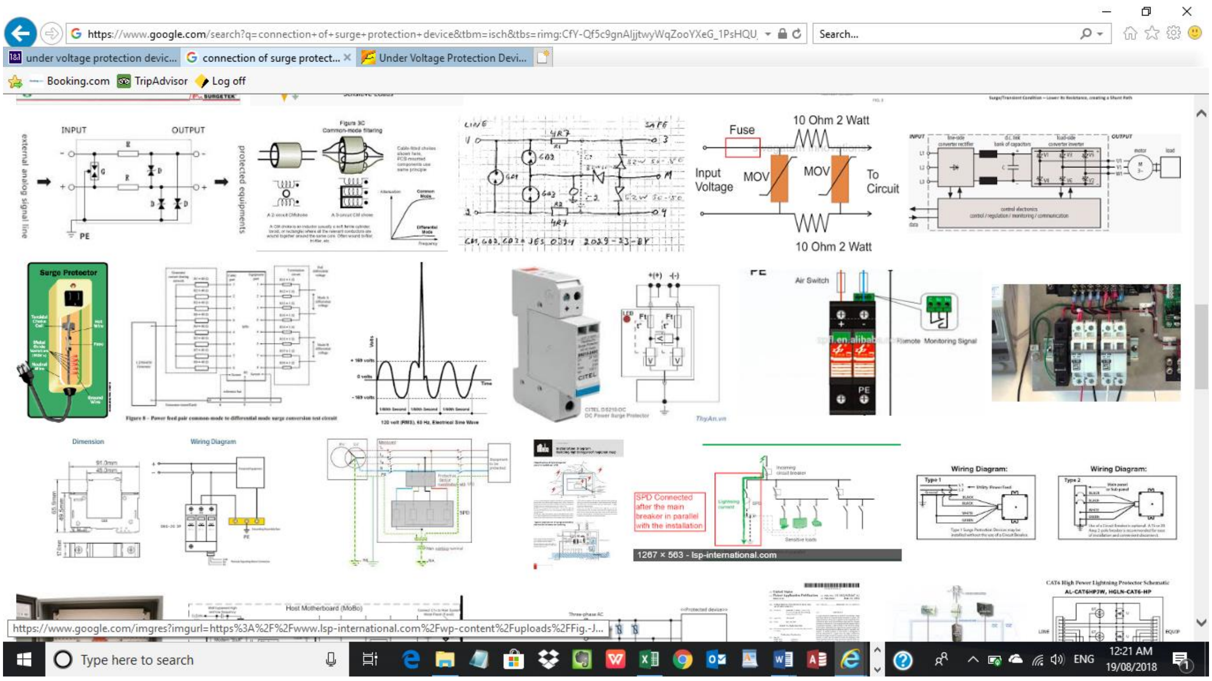
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Remote Monitoring Signal
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Wiring Diagram
SPD Connected after the main breaker in parallel with the installation
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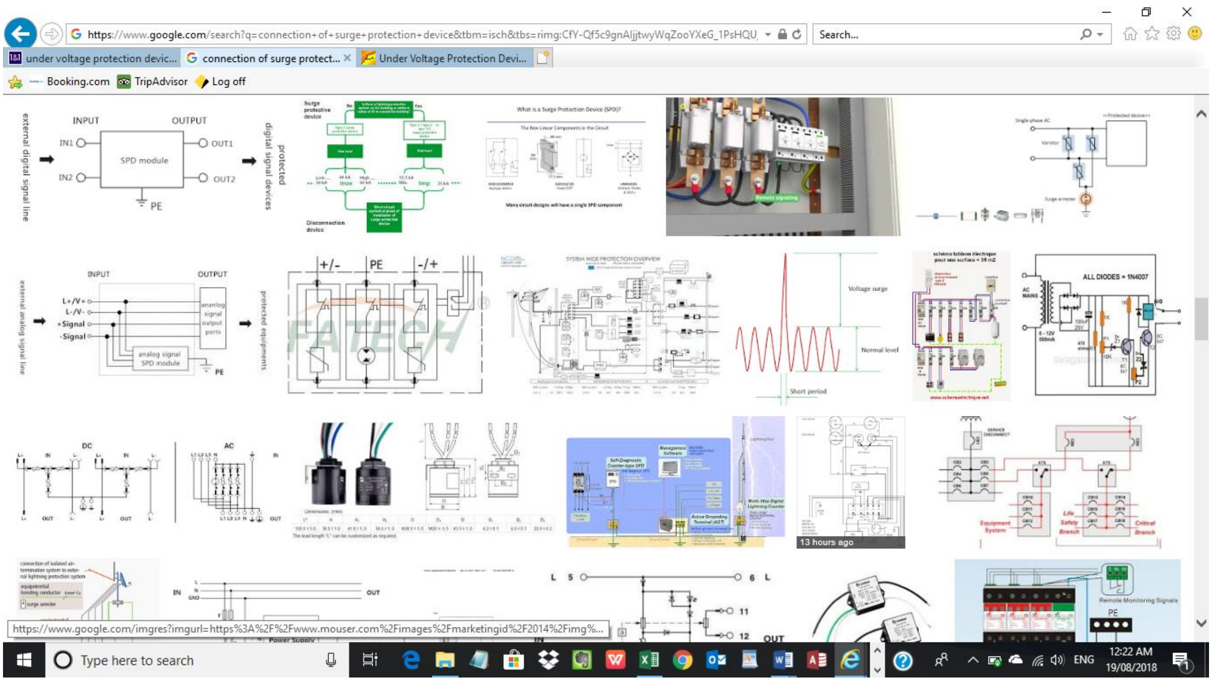
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SYSTEM WIDE PROTECTION OVERVIEW
Voltage surge
Normal level
Short period
ALL DIODES = 1N4007
DC
AC
OUT
13 hours ago
IN
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Remote Monitoring Signals
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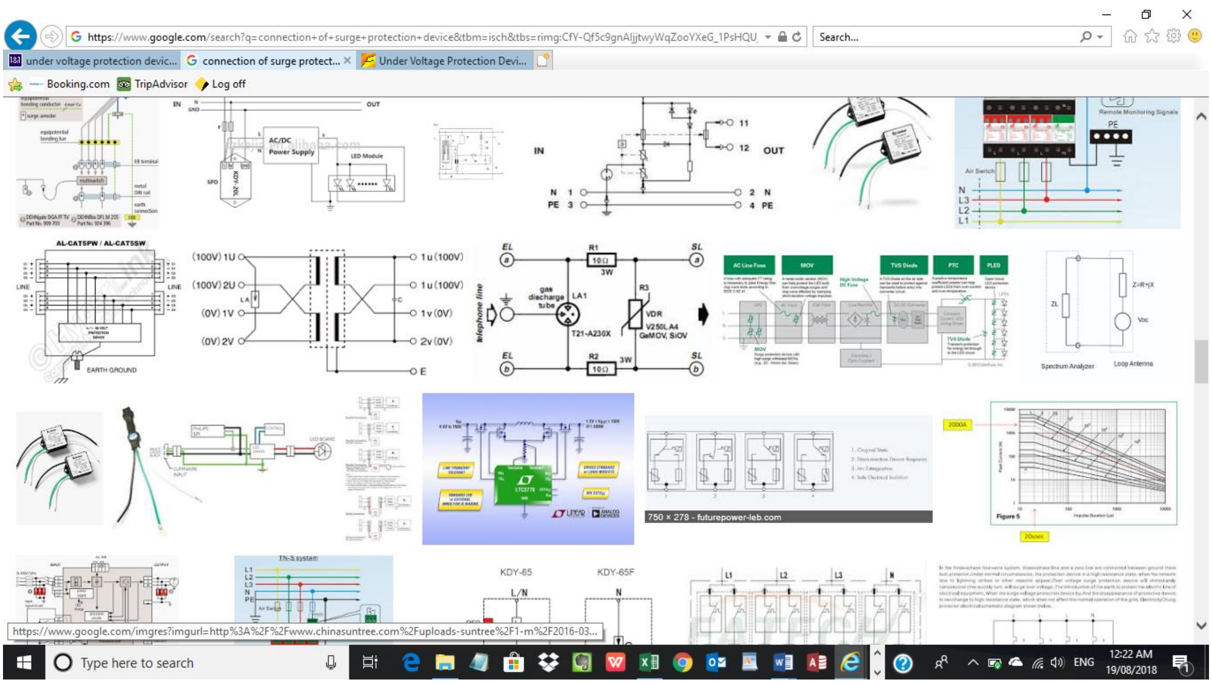
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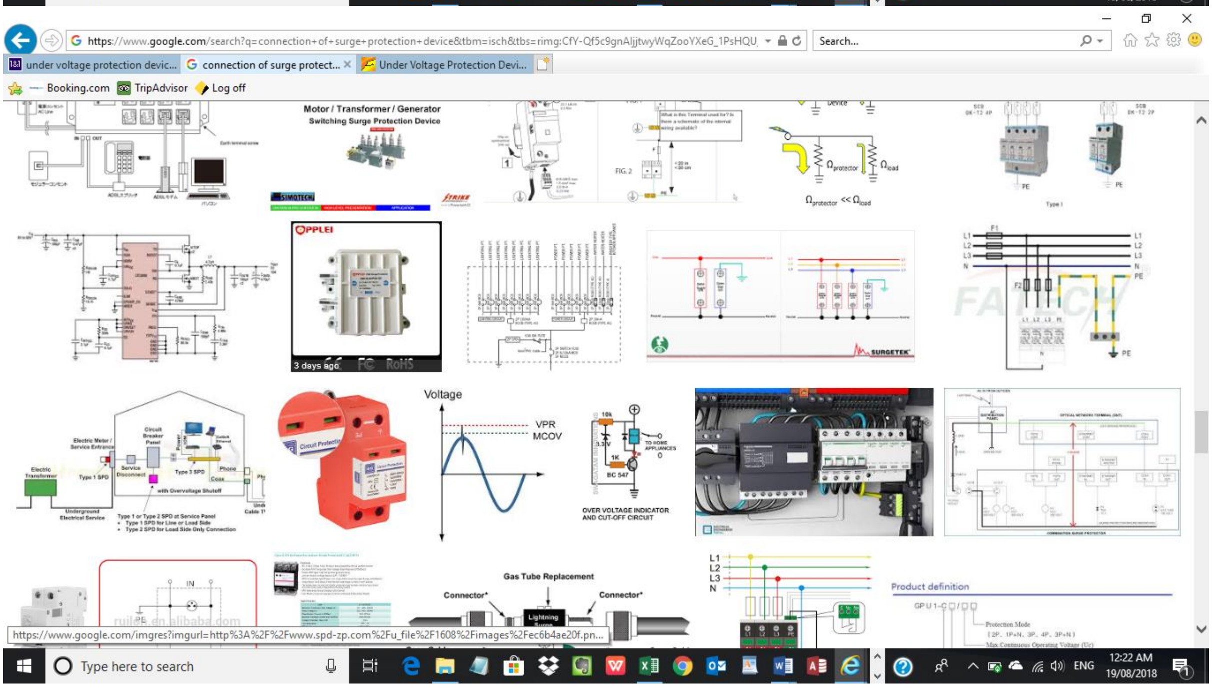
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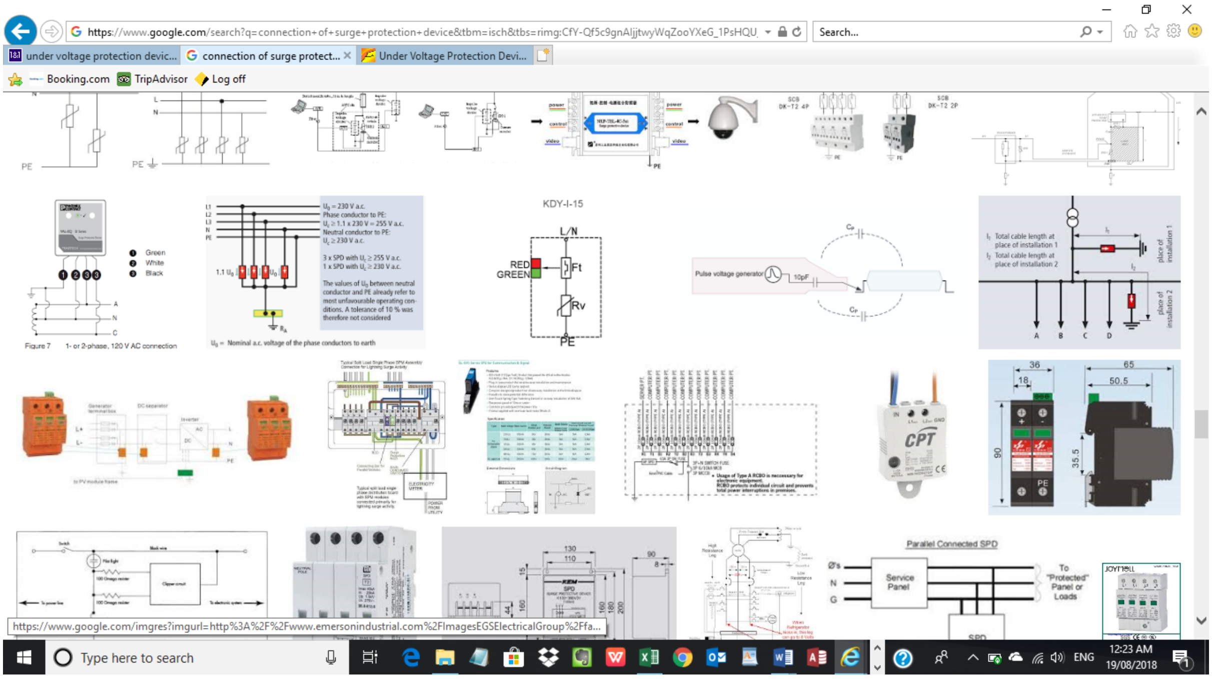

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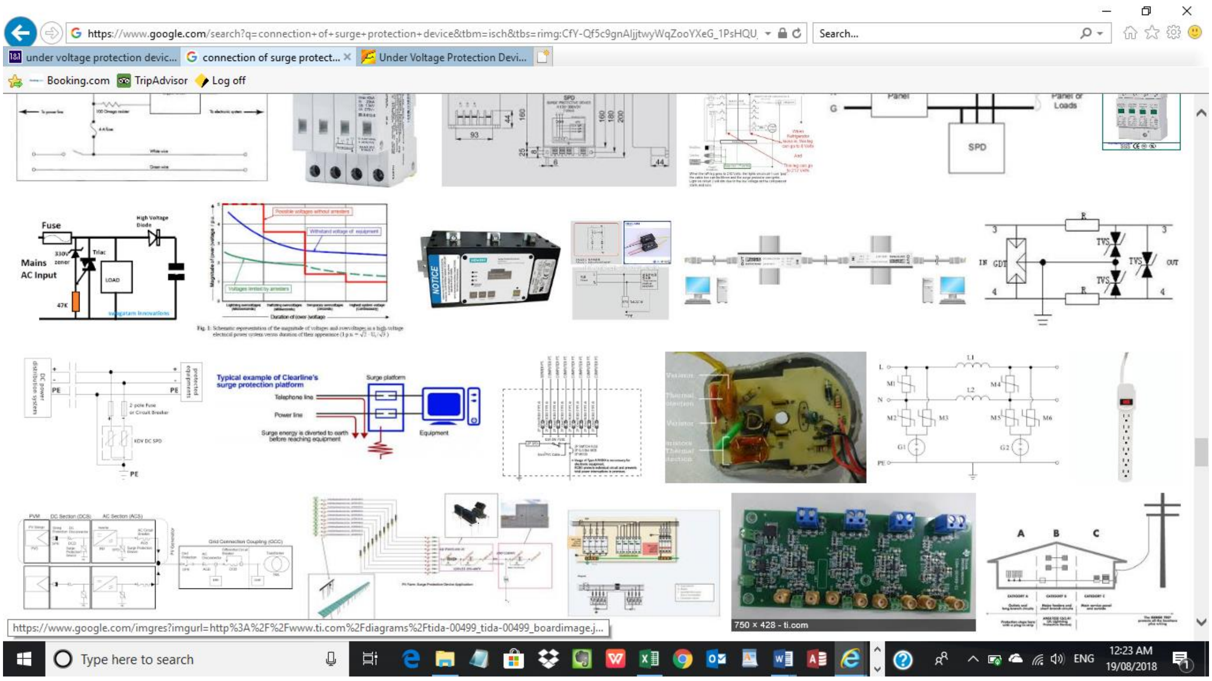

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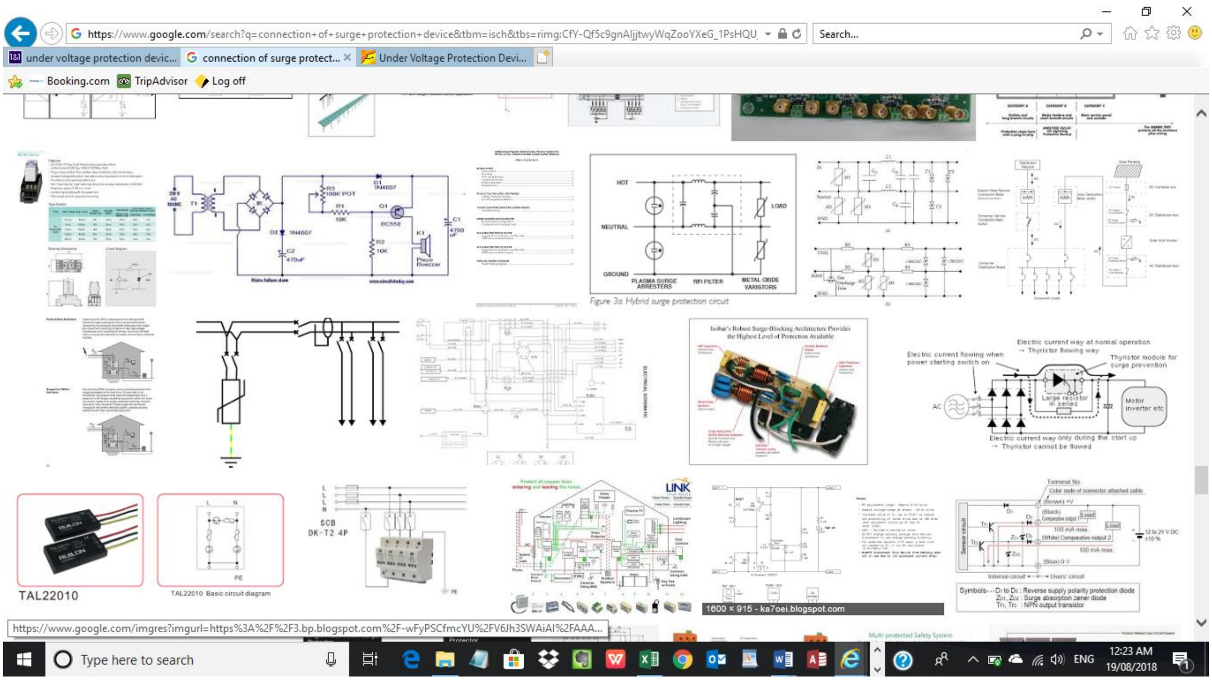
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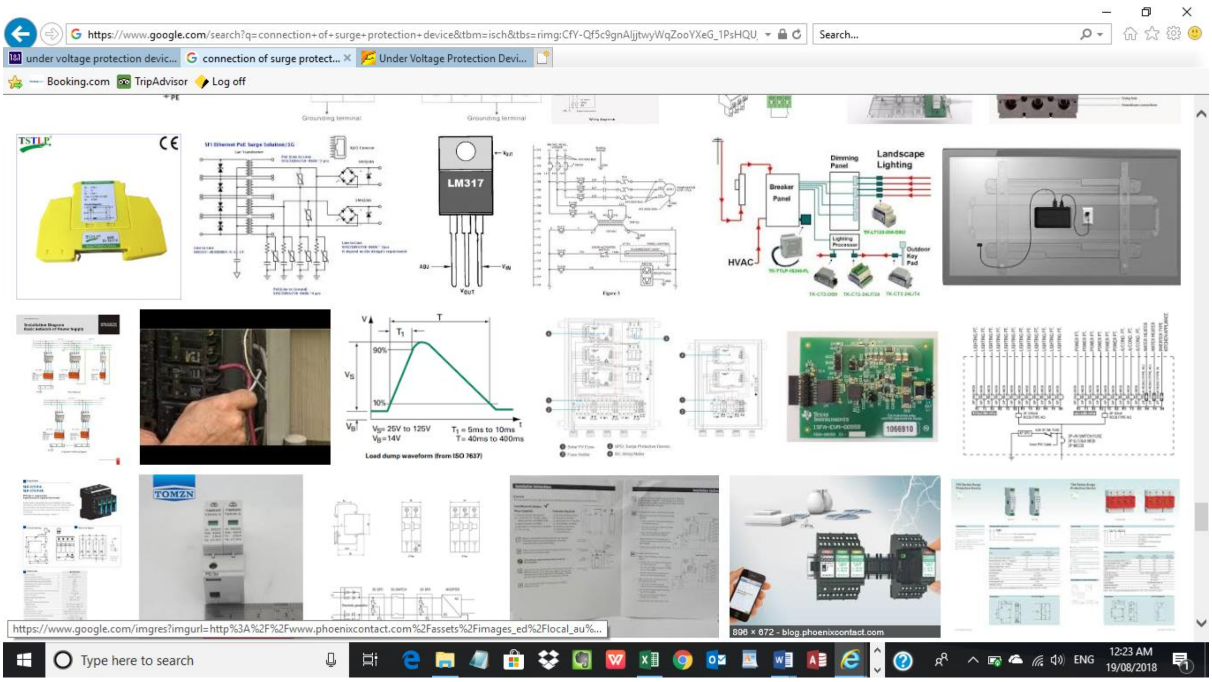
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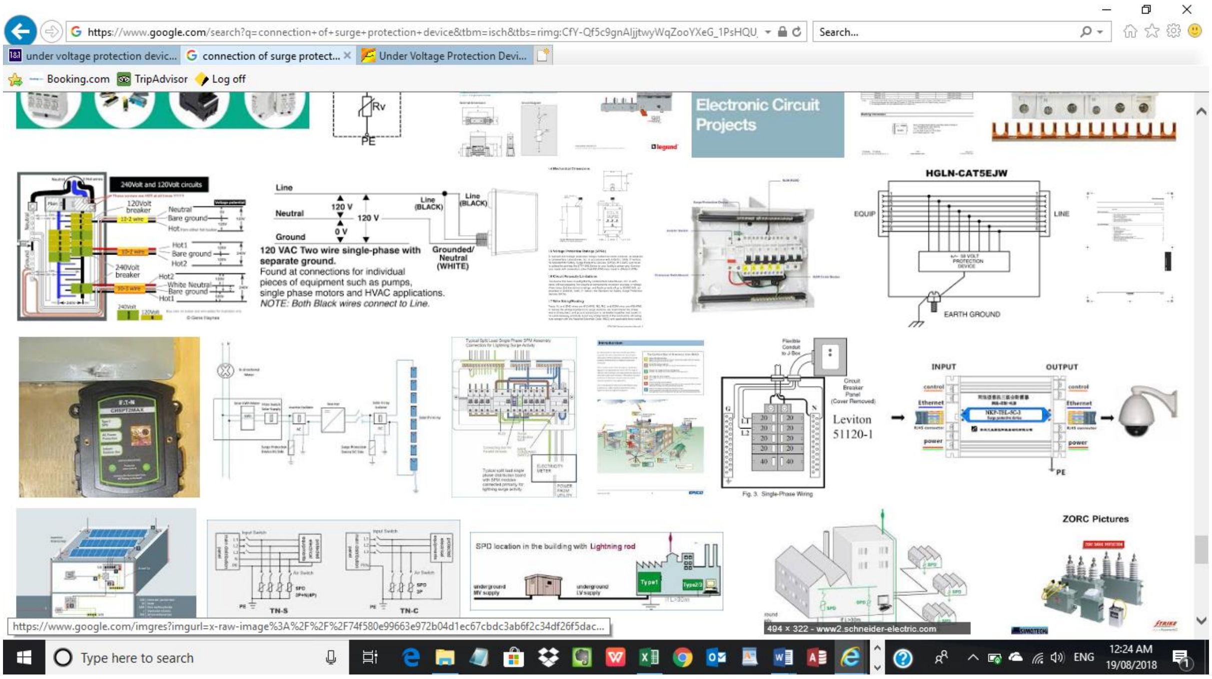
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Electronic Circuit Projects
240Volt and 120Volt circuits
120 VAC Two wire single-phase with separate ground.
Found at connections for individual pieces of equipment such as pumps, single phase motors and HVAC applications.
NOTE: Both Black wires connect to Line.
HGLN-CAT5EJW
EARTH GROUND
INPUT
OUTPUT
Leviton 51120-1
SPD location in the building with Lightning rod
ZORC Pictures
494 × 322 - www2.schneider-electric.com
https://www.google.com/imgres?imgurl=x-raw-image%3A%2F%2F%2F74f580e99663e972b04d1ec67cbdc3ab6f2c34df26f5dac...
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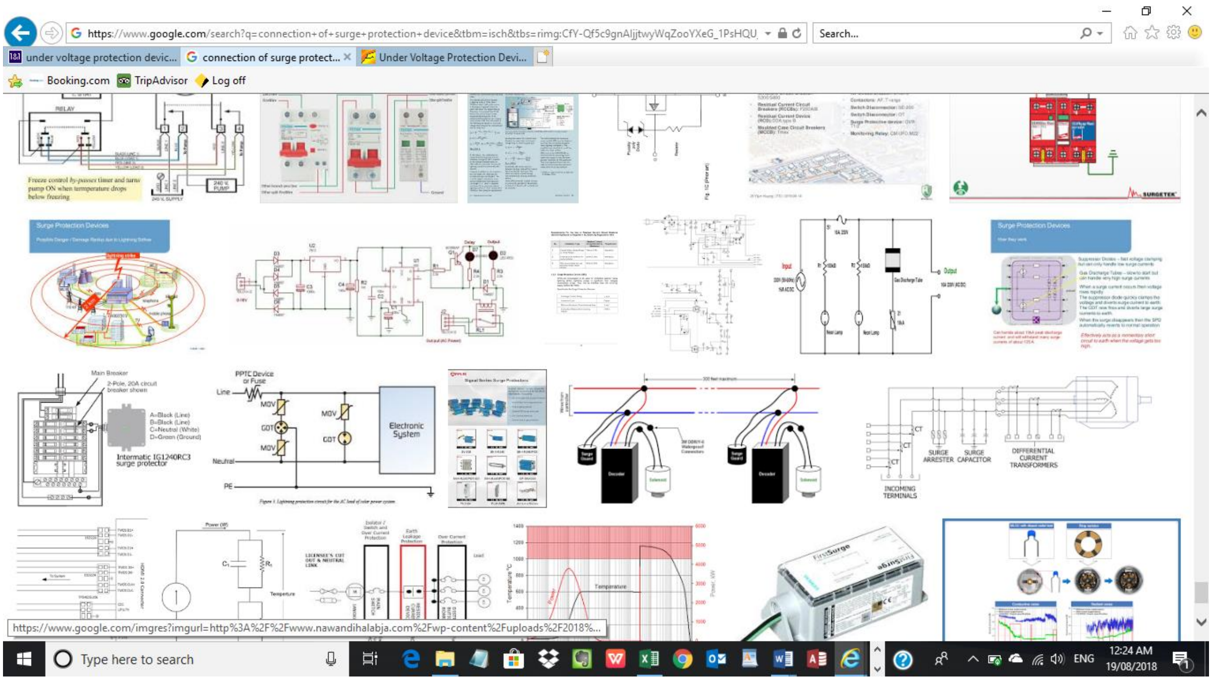
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Intermatic IG1240RC3 surge protector
Electronic System
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SURGE CAPACITOR
DIFFERENTIAL CURRENT TRANSFORMERS
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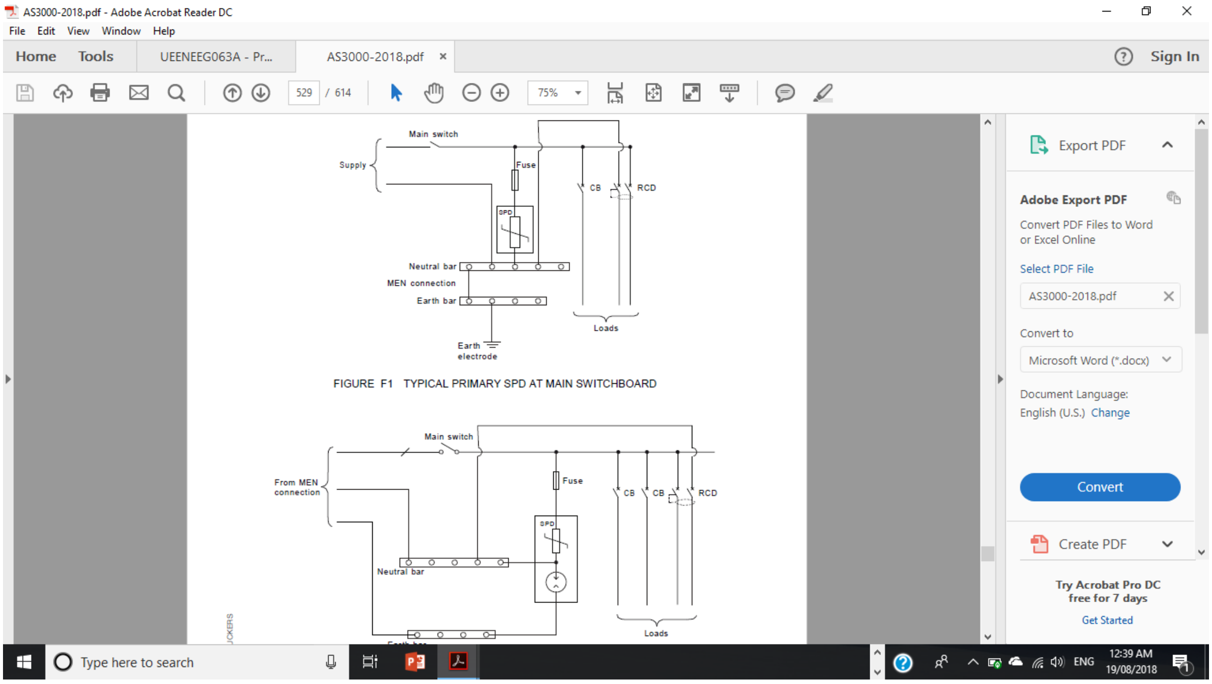
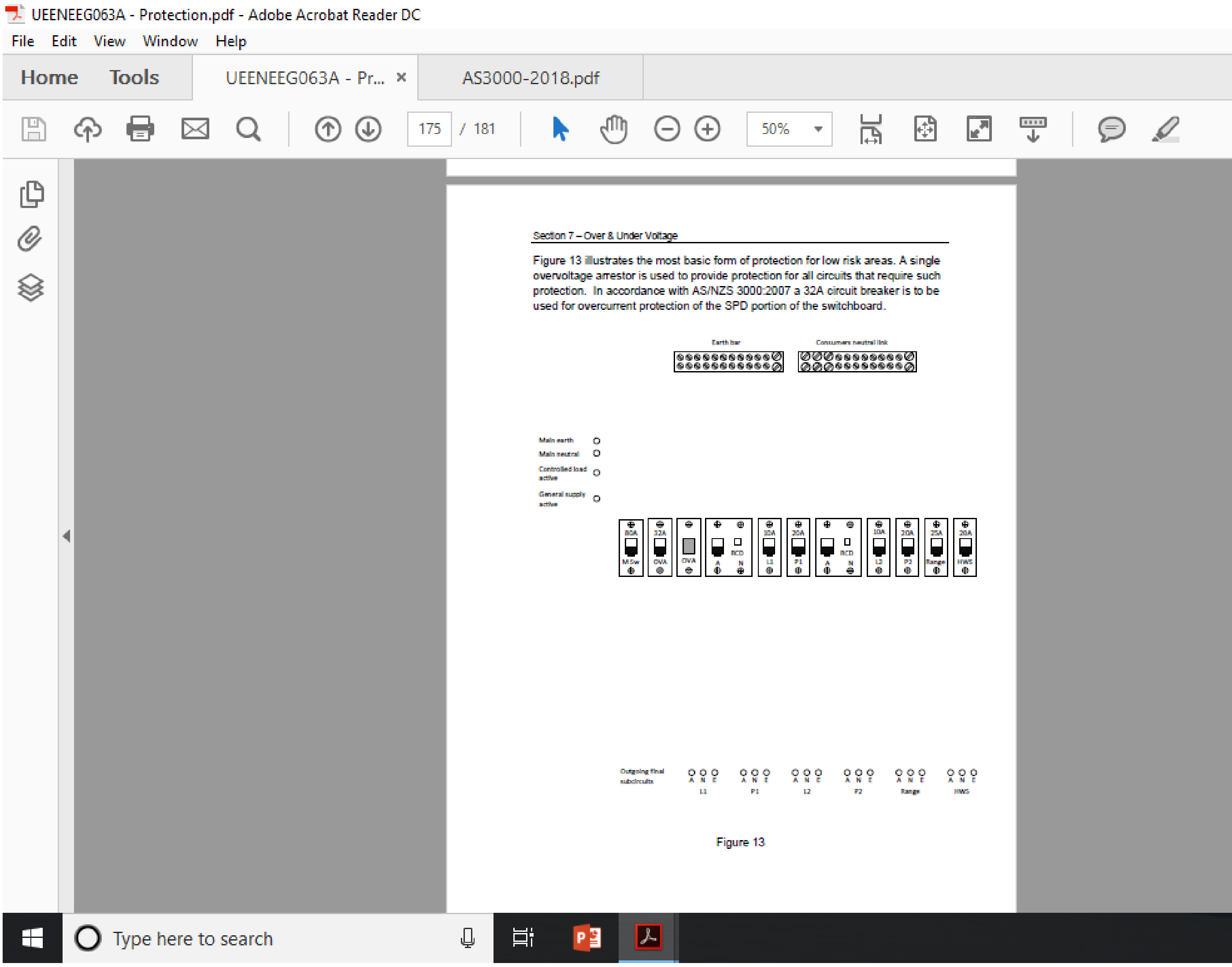
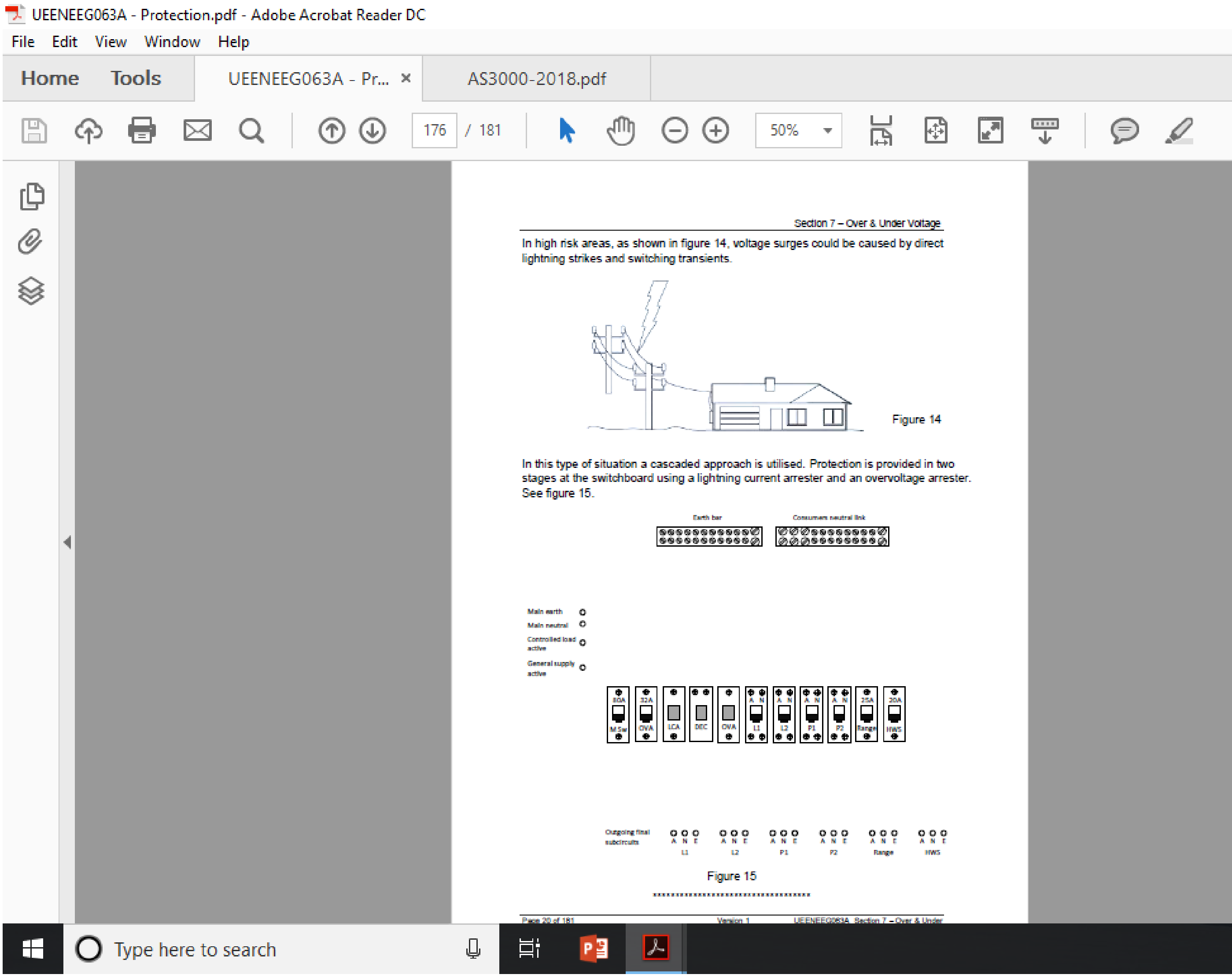

AS3000-2018.pdf - Adobe Acrobat Reader DC
Main switch
Supply
Fuse
SPD
CB
RCD
Neutral bar
MEN connection
Earth bar
Loads
Earth electrode
FIGURE F1 TYPICAL PRIMARY SPD AT MAIN SWITCHBOARD
Main switch
From MEN connection
Fuse
SPD
CB
CB
RCD
Neutral bar
Loads
Export PDF
Adobe Export PDF
Convert PDF Files to Word or Excel Online
Convert

Do yourself


UEENEEG063A - Protection.pdf - Adobe Acrobat Reader DC
Section 7 – Over & Under Voltage
Figure 13 illustrates the most basic form of protection for low risk areas. A single overvoltage arrestor is used to provide protection for all circuits that require such protection. In accordance with AS/NZS 3000:2007 a 32A circuit breaker is to be used for overcurrent protection of the SPD portion of the switchboard.
Earth bar
Consumers neutral link
Main earth
Main neutral
Controlled load active
General supply active
Outgoing final subcircuits
L1
P1
L2
P2
Range
HWS
Figure 13



Section 7 – Over & Under Voltage

In high risk areas, as shown in figure 14, voltage surges could be caused by direct lightning strikes and switching transients.

Figure 14

In this type of situation a cascaded approach is utilised. Protection is provided in two stages at the switchboard using a lightning current arrester and an overvoltage arrester. See figure 15.

Figure 15

1.In past versions of Standards, and in trade practice devices for protection against overvoltage have been called 'surge diverters'. What is the internationally recognise d term, and the name given to these devices in AS/NZS 3000:2007?

____ AS/NZS 3000 reference _____________

1.5.11.3 Voltage disturbances and electromagnetic influences

Protection against damage as a consequence of overvoltage, such as that originating from lightning or from switching operations, is not a requirement of this Standard.

NOTE: Clause 2.7 and Appendix F provide guidance on overvoltage (surge) protection.

2.For the purposes of primary protection (formerly called 'coarse or basic protection'), at which point should a SPD be fitted in an installation?

____ AS/NZS 3000 reference _____________

F1.1 General

This Appendix provides details on the installation of surge protection devices (SPDs) to provide limitation of transient overvoltages caused by powerline disturbances and by natural events, such as lightning strikes, to or near to exposed conductors, as discussed in Clause 2.7.3.

3.Is it necessary to protect a SPD against the effects of overcurrent, where the device is fitted at a main switchboard?
___________________________________ AS/NZS 3000 reference ____________

Yes
F1.2.4 Overcurrent protective devices
SPDs should be protected against short-circuit by suitable overcurrent protective devices. In accordance with Clause 2.5.2, the short-circuit withstand of the SPD, together with the overcurrent protective device, should be not less than the prospective short-circuit current at the point of installation.

4.In addition to AS/NZS 3000.2007, which AS/NZS Standard provides guidance on the installation of SPDs in MEN systems?
___________________________________ AS/NZS 3000 reference ____________

F1.2.2 Installation
SPDs should be—
(a) installed after the main switch but prior to any RCD devices. Where the main switch is an RCD, refer to Paragraph F2.4;
(b) protected by an appropriate fuse or circuit-breaker separate from the SPD;
(c) connected at the main switchboard between phase and neutral;
NOTE: Figure F1 shows a typical connection of a primary SPD for a single-phase installation.
(d) connected at switchboards remote from the main switchboard and without MEN connection, from each phase to neutral and from neutral to earth;

NOTE: Figure F2 shows a typical installation of a secondary SPD for a single-phase installation.
(e) be legibly and permanently labelled as to their function, in accordance with Clause 2.10.5.1; and
(f) where alarmed to provide status indication, fail safe in operation.
AS/NZS 1768 provides further details on the selection of primary and secondary SPDs.

5.Where SPDs are fitted to a switchboard, is labelling required? If so what would be asuitable

label?____
____

____________________________________ AS/NZS 3000 reference ____________

F1.2.2 Installation

SPDs should be—

(a) installed after the main switch but prior to any RCD devices. Where the main switch is an RCD, refer to Paragraph F2.4;

(b) protected by an appropriate fuse or circuit-breaker separate from the SPD;

(c) connected at the main switchboard between phase and neutral;

NOTE: Figure F1 shows a typical connection of a primary SPD for a single-phase installation.

(d) connected at switchboards remote from the main switchboard and without MEN connection, from each phase to neutral and from neutral to earth;

NOTE: Figure F2 shows a typical installation of a secondary SPD for a single-phase installation.

(e) be legibly and permanently labelled as to their function, in accordance with Clause 2.10.5.1; and

(f) where alarmed to provide status indication, fail safe in operation.

AS/NZS 1768 provides further details on the selection of primary and secondary SPDs.

6.Where a fuse is used to provide overcurrent protection for a 40kA SPD, what type of fuse is required, and what current rating is recommended?

____________________________________ AS/NZS 3000 reference ____________

F1.2.5 Connecting conductors

Conductors used to connect an SPD to both the line, via the overcurrent protective device, and to the main earthing or neutral conductor should be consistent with the current rating of the backup fuse or circuit-breaker but should be not less than 6 mm^2, be as short and direct as possible and with no loops.

The total conductor length between the two points of connection including both active and earth/neutral should be less than 1 m (ideally 300 mm-600 mm) overall.

A connection to the neutral conductor should be as close as practicable to the MEN link.

7.Where a residual current device is used as a main switch, and a SPD is fitted, what is therecommended minimum fault current interrupting capacity of the RCD?

____________________________________ AS/NZS 3000 reference ____________

F1.2.4 Overcurrent protective devices

SPDs should be protected against short-circuit by suitable overcurrent protective devices. In accordance with Clause 2.5.2, the short-circuit withstand of the SPD, together with the overcurrent protective device, should be not less than the prospective short-circuit current at the point of

installation.
The current rating of the SPD overcurrent protective device should be—
(a) as recommended by the SPD manufacturer but not greater than the manufacturer's declared maximum backup fuse rating; and
(b) less than the rating of the immediate upstream protective device.
NOTE: Notwithstanding the above, the following current ratings of HRC fuses or circuit-breakers are suitable for typical domestic applications, such as households:
(a) 32 A for a 40 kA SPD.
or
(b) 63 A for a 100 kA SPD.
If an SPD is installed on the load side of an RCD, the RCD should have a breaking capacity of not less than 3 kA. S-type RCDs, in accordance with AS/NZS 61008.1 and AS/NZS 61009.1 are deemed to satisfy this recommendation.

8.What is the minimum recommended size for cabling used to connect a SPD in a switchboard?
_________________________________ AS/NZS 3000 reference ___________
F1.2.5 Connecting conductors
Conductors used to connect an SPD to both the line, via the overcurrent protective device, and to the main earthing or neutral conductor should be consistent with the current rating of the backup fuse or circuit-breaker but should be not less than 6 mm^2, be as short and direct as possible and with no loops.
The total conductor length between the two points of connection including both active and earth/neutral should be less than 1 m (ideally 300 mm-600 mm) overall.

9.Where a circuit breaker is used to provide overcurrent protection for a SPD, what rating is required for a 40kA SPD?
_________________________________ AS/NZS 3000 reference ___________

F1.2.4 Overcurrent protective devices
(b) less than the rating of the immediate upstream protective device.
NOTE: Notwithstanding the above, the following current ratings of HRC fuses or circuit-breakers are suitable for typical domestic applications, such as households:
(a) 32 A for a 40 kA SPD.
or
(b) 63 A for a 100 kA SPD.

10. What minimum working voltage is recommended for SPDs fitted to a domestic switchboard?
_________________________________ AS/NZS 3000 reference ___________

F1.2.3 Selection of surge protection devices (SPDs)
For most domestic supplies in urban environments, a surge rating of I_{max} = 40 kA per phase for an 8/20 ·s impulse and a maximum working voltage of 275 V a.c. to 320 V a.c. is suitable.

11. What is the maximum recommended length for cabling used to connect a SPD in a switchboard?
____ AS/NZS 3000 reference ____________

F1.2.5 Connecting conductors
Conductors used to connect an SPD to both the line, via the overcurrent protective device, and to the main earthing or neutral conductor should be consistent with the current rating of the backup fuse or circuit-breaker but should be not less than 6 mm^2, be as short and direct as possible and with no loops.
The total conductor length between the two points of connection including both active and earth/neutral should be less than 1 m (ideally 300 mm-600 mm) overall.
A connection to the neutral conductor should be as close as practicable to the MEN link.

12. In which part of Section 8 of AS/NZS 3000:2007 does it recommend the disconnection of SPD units when insulation resistance testing?
____ AS/NZS 3000 reference ____________

8.3.10 Operation of RCDs
* To verify that RCDs have been correctly installed, tests shall be performed on all RCDs.
* The function of the RCD shall be verified either by the operation of the integral test device, or by the use of special test equipment.
* In all cases, isolation of all switched poles shall be verified after the RCD
has operated to disconnect the designated circuit.
* Isolation of all poles shall be verified by voltage tests or, after removing supply, by continuity checks through each pole.

13. Where it is impractical to disconnect a SPD during insulation testing, what is the minimum permitted test voltage and insulation resistance?
____ AS/NZS 3000 reference ____________

8.3.3 Mandatory tests
8.3.3.1 Low voltage
* Testing shall be carried out on parts of electrical installations designed to operate at low voltage as follows:

(a) Continuity of the earthing system (earth resistance of the main earthing conductor, protective earthing conductors, PEN conductors and bonding conductors), in accordance with Clause 8.3.5.
(b) Insulation resistance, in accordance with Clause 8.3.6.
(c) Polarity, in accordance with Clause 8.3.7.
(d) Correct circuit connections, in accordance with Clause 8.3.8.
(e) Verification of impedance required for automatic disconnection of supply (earth fault-loop impedance), in accordance with Clause 8.3.9.
(f) Operation of RCDs, in accordance with Clause 8.3.10.

8.3.3.2 Extra-low voltage
Testing shall be carried out on parts of electrical installations designed to operate at extra-low voltage as follows:
(a) Continuity of the earthing system for PELV circuits in accordance with Clause 8.3.5.
(b) Insulation resistance in accordance with Clause 7.5.12.
(c) Polarity for PELV circuits in accordance with Clause 8.3.7.
(d) Correct circuit connections in accordance with Clause 8.3.8.

8.3.6 Insulation resistance
8.3.6.1 General
Insulation resistance testing shall be carried out to ensure that the insulation resistance between all live conductors and earth or, as the case may be, all live parts and earth, is adequate to ensure the integrity of the insulation. This testing is to prevent—
(a) electric shock hazards from inadvertent contact;
(b) fire hazards from short-circuits; and
(c) equipment damage.
In addition, an insulation resistance test between conductors is necessary for consumer mains and submains to minimize risk of injury or property damage because of insulation breakdown.
8.3.6.2 Method
The integrity of the insulation is stressed by applying a direct current at 500 V for low voltage circuits.

14. Under which conditions is it mandatory to provide under voltage protection?

AS/NZS 3000 reference

2.8.1 General
The requirements of Clause 2.8.2 shall apply where an electrical installation is protected against undervoltage that may cause danger to persons or property.
NOTE: The causes of undervoltage in an electrical installation may include the following:

(a) Overload, or conductors of inadequate cross-section, producing excessive voltage drop.
(b) A fault in the high voltage supply system.
(c) Failure of, or high impedance in, a supply conductor

2.8 PROTECTION AGAINST UNDERVOLTAGE
2.8.1 General
Suitable protective measures shall be taken where—
(a) the loss and subsequent restoration of voltage; or
(b) a drop in voltage,
could cause danger to persons or property.
NOTE: The causes of undervoltage in an electrical installation may include the following:
(a) Overload, or conductors of inadequate cross-section, producing excessive voltage drop.
(b) A fault in the high voltage supply system.
(c) Failure of, or high impedance in, a supply conductor.

15. Is under voltage protection required for machines such as guillotines, lathes, gates etc,where an unexpected reconnection of supply would cause danger to persons or property?
____________________________________ AS/NZS 3000 reference ____________

No
2.8.1 General

Exception: Where potential damage to electrical equipment is considered an acceptable risk, undervoltage protection may be omitted.
NOTES:
1 Examples where the loss and subsequent restoration of voltage might cause danger include unexpected restarting of equipment, such as a guillotine, press or electrically operated gates. See also Clause 4.13 regarding protection of motors.
2 Failure to provide sufficient voltage will significantly reduce motor torque and will result either in an excessively long starting time or, for extreme cases, in failure to start.

16. Name two devices that are identified in AS/NZS 3000:2007 as being considered suitable for protection against under voltage.

____
____________________________________ AS/NZS 3000 reference ____________

2.8.2 Selection of protective device
The characteristics of the undervoltage protective device shall be compatible with the requirements of the appropriate Standards for starting and the use of electrical equipment.

Where the re-closure of a protective device is likely to create a dangerous situation, the re-closure shall not be automatic.

Instantaneous disconnection by the undervoltage device shall not be impaired by contacts that have intentional delays in their operation.

Exception: The operation of undervoltage protective devices may be delayed if the operation of the protected electrical equipment allows a brief interruption or loss of voltage without danger.

NOTES:

1 Protective devices having time-delay facilities should permit the starting of motors where the supply voltage exceeds 85% of rated voltage and continued operation where the voltage is within 10% of the rated voltage.

2 Examples of protective devices for undervoltage are—

(a) undervoltage relays or releases operating a switch or a circuit-breaker; and

(b) non-latched contactors.

17.Would it be acceptable to have automatic restarting of a refrigerator motor, when supply returned to normal after an under voltage problem had caused stopping of the motor?

____ ***reference not required***

Yes

18.Would it be acceptable to have automatic restarting of a large fan motor, wholly enclosed within a ventilation duct that is large enough to allow person access, when supply returned to normal after an under voltage problem had caused stopping of the motor?

____ ***reference not required***

No