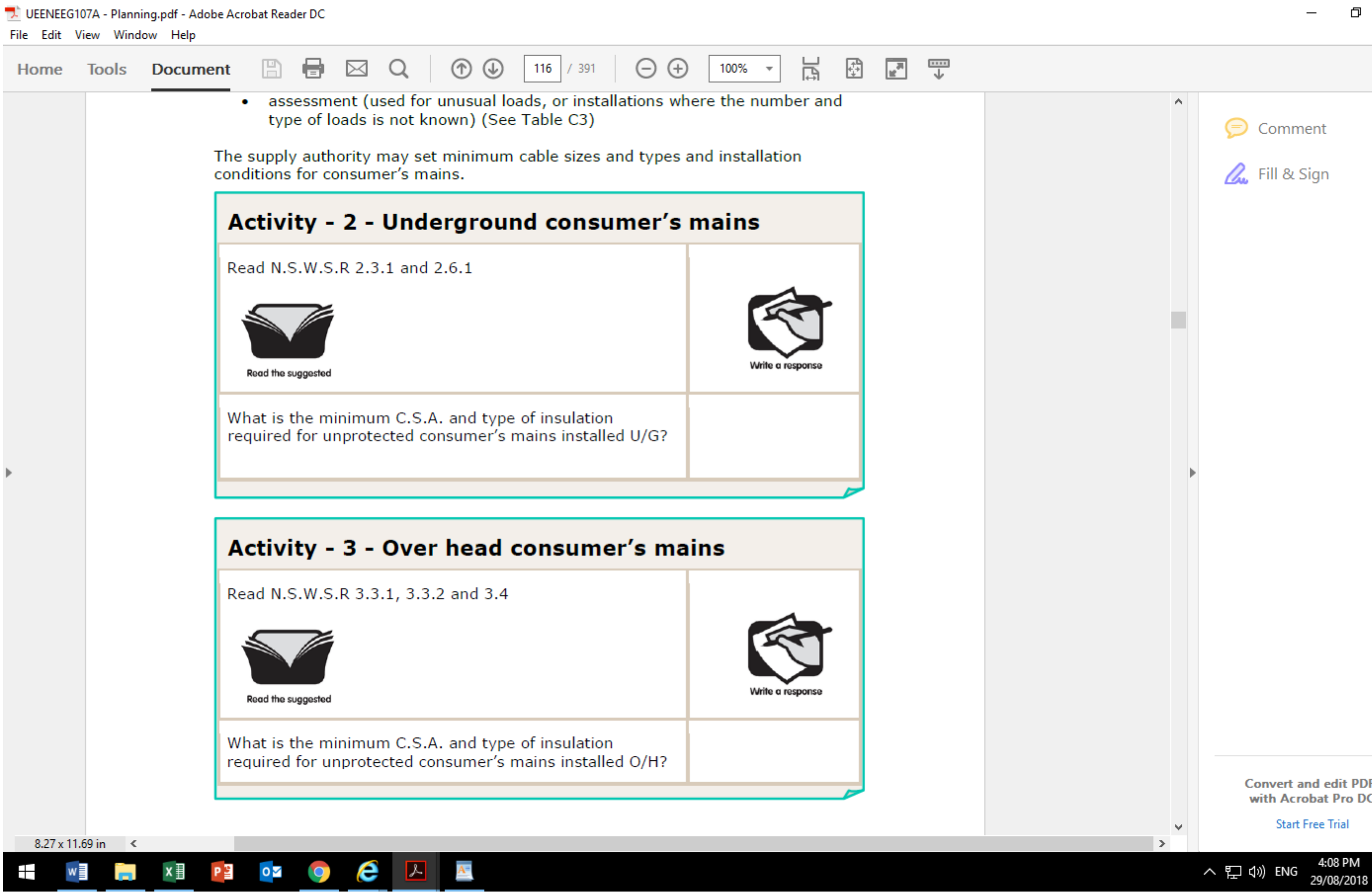

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- assessment (used for unusual loads, or installations where the number and type of loads is not known) (See Table C3)

The supply authority may set minimum cable sizes and types and installation conditions for consumer's mains.

Activity - 2 - Underground consumer's mains

Read N.S.W.S.R 2.3.1 and 2.6.1 Read the suggested	Write a response
What is the minimum C.S.A. and type of insulation required for unprotected consumer's mains installed U/G?	

Activity - 3 - Over head consumer's mains

Read N.S.W.S.R 3.3.1, 3.3.2 and 3.4 Read the suggested	Write a response
What is the minimum C.S.A. and type of insulation required for unprotected consumer's mains installed O/H?	

2.3 CONSUMERS MAINS

2.3.1 Electrically Un-Protected Underground Consumers Mains

To provide similar performance characteristics to the underground service cable, electrically unprotected underground consumers mains must be installed using the same cable type and minimum size as specified for the underground service cable. Refer to clause 2.6.1.

2.6 CABLE REQUIREMENTS

2.6.1 Cable Specifications

The following information provides the minimum specifications for single and multiphase underground service cables:

All underground services must be four-wire three phase, except for single domestic premises, duplexes and builder's services. In these cases a two-wire single-phase service is permissible provided the service cable does not require a direct buried joint.

The cable size and service ratings are set out in Table 2.1.

Service cables must be XLPE insulated PVC sheathed, comply with Table 2.1 and be comprised of either:

(a) Single core cables; or

(b) One 4-core circular cable; and

(c) Must comply with AS/NZS 4026:2001.

Service cables with a CSA of 240mm^2 must be of four-core aluminium, XLPE insulated, PVC- sheathed construction. Single core cables shall only be connected at pillars or to service tails. Check what method of connection is required prior to purchasing cable.

Table 2.1: Service cable size and ratings **Cable CSA**	**Conductor Material** Cu	**Cable Rating Amps** 100	**No. of Cable Cores** 1 or 4

(mm2) 16			
25	Cu	100	1 or 4
50	Cu	200	1 or 4
70	Cu	200	1 or 4
240	Al	400	4

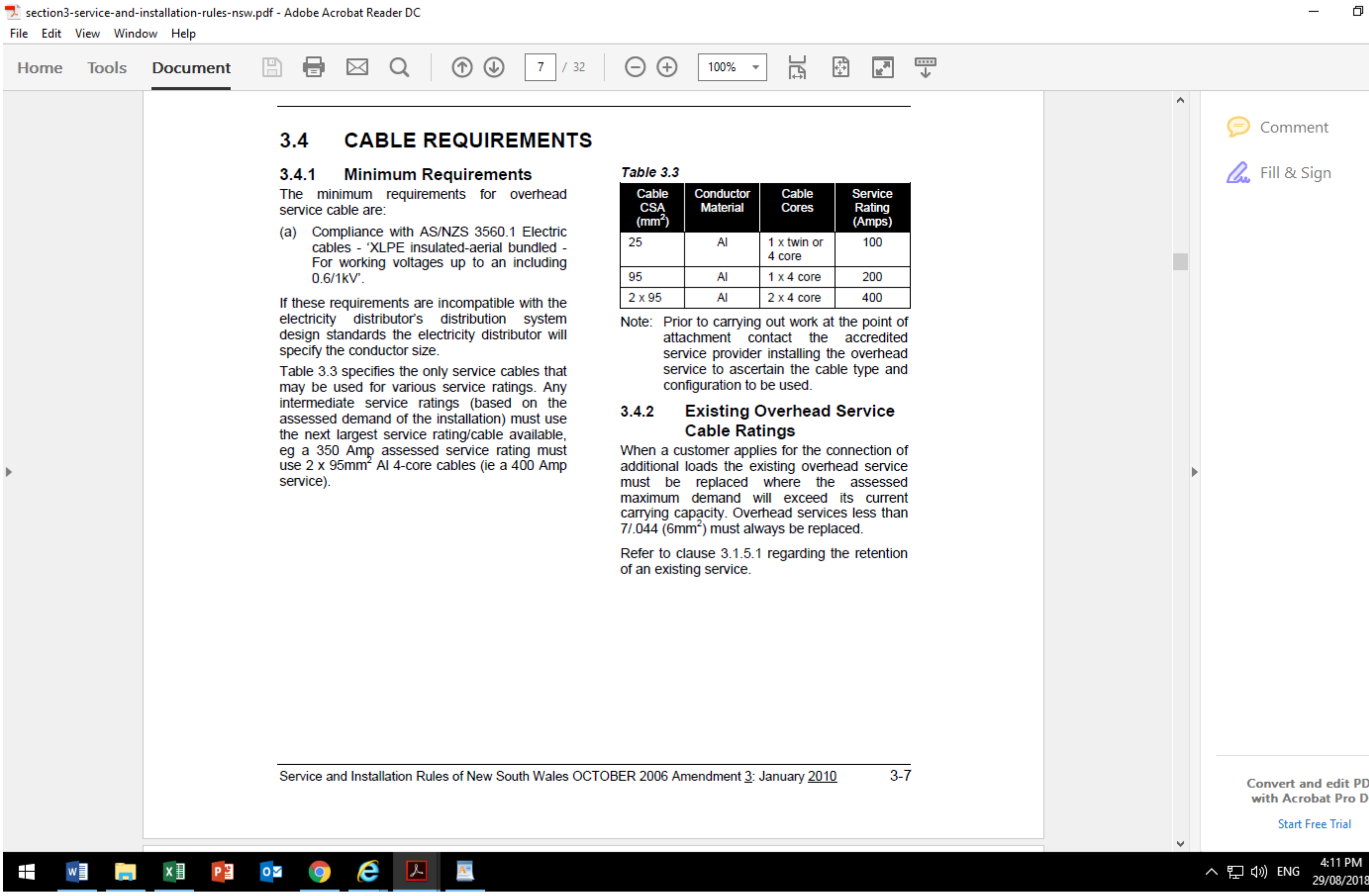
16 sqmm

3.3.1 Electrically Un-Protected Aerial Consumer Mains

Electrically Unprotected aerial consumers mains must comply with the same requirements as the overhead service with regard to cable size and compliance with the Australian Standards referred to in clause 3.4.

3.3.2 Other than Aerial

Electrically Unprotected consumers mains must have a minimum cross sectional area of 16mm² copper or 25mm² Aluminium, XLPE insulated.



3.4 CABLE REQUIREMENTS

3.4.1 Minimum Requirements

The minimum requirements for overhead service cable are:

(a) Compliance with AS/NZS 3560.1 Electric cables - 'XLPE insulated-aerial bundled - For working voltages up to an including 0.6/1kV'.

If these requirements are incompatible with the electricity distributor's distribution system design standards the electricity distributor will specify the conductor size.

Table 3.3 specifies the only service cables that may be used for various service ratings. Any intermediate service ratings (based on the assessed demand of the installation) must use the next largest service rating/cable available, eg a 350 Amp assessed service rating must use 2 x 95mm² Al 4-core cables (ie a 400 Amp service).

Table 3.3

Cable CSA (mm²)	Conductor Material	Cable Cores	Service Rating (Amps)
25	Al	1 x twin or 4 core	100
95	Al	1 x 4 core	200
2 x 95	Al	2 x 4 core	400

Note: Prior to carrying out work at the point of attachment contact the accredited service provider installing the overhead service to ascertain the cable type and configuration to be used.

3.4.2 Existing Overhead Service Cable Ratings

When a customer applies for the connection of additional loads the existing overhead service must be replaced where the assessed maximum demand will exceed its current carrying capacity. Overhead services less than 7/.044 (6mm²) must always be replaced.

Refer to clause 3.1.5.1 regarding the retention of an existing service.

Service and Installation Rules of New South Wales OCTOBER 2006 Amendment 3: January 2010 3-7

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- This information is obtained from job specification and or job plans.

- What equipment is in each load group?
  - Equipment in each load group is specified in column 1 of Tables C1 & C2.
  - Footnotes to the tables give additional information on the equipment in the various load groups
- Is the installation to be supplied with single, two or three phase?
  - Local supply authorities stipulate the maximum total load for single and two phase supplies. For example, single phase for total loads up to 100A, two phase for total load greater than 100A and up to 200A (maximum 100A per phase) and three phase for total load over 200 A (split over three phases). An installation is supplied with three phase where individual three phase loads are installed such as a three phase motors (multi phase supply may not be available in some rural areas).

Activity - 4 - Number of phases

Read N.S.W.S.R 1.5.3.3 	
What is the minimum kilowatt rating of a motor to require three phase supply?	

- Is the load to be arranged on more than one phase?
  - Distribute the loads evenly across all phases.
  - This is a preliminary arrangement and may need adjusting after calculating the maximum demand in each phase

8.27 x 11.69 in

1.5.3.3 Number of Phases

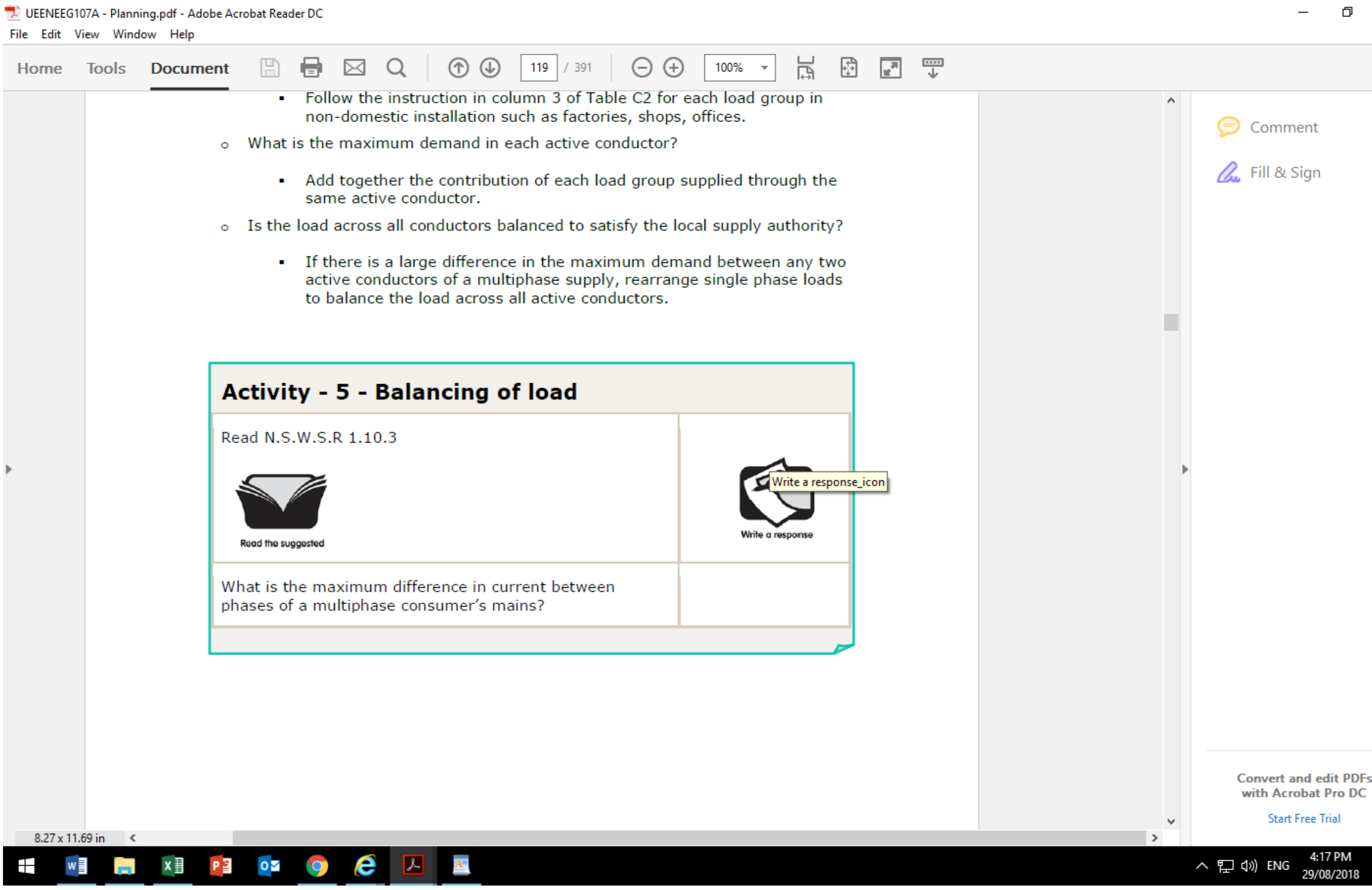
The number of phases required to supply an installation must be determined by:

(a) The maximum load permitted by the electricity distributor in accordance with Table 1.1; and

(b) The load characteristics of customer's equipment, eg three phase motors, instantaneous water heaters, 400V welders, large heat/air conditioning loads.

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 neutral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- Follow the instruction in column 3 of Table C2 for each load group in non-domestic installation such as factories, shops, offices.
- What is the maximum demand in each active conductor?
  - Add together the contribution of each load group supplied through the same active conductor.
- Is the load across all conductors balanced to satisfy the local supply authority?
  - If there is a large difference in the maximum demand between any two active conductors of a multiphase supply, rearrange single phase loads to balance the load across all active conductors.

Activity - 5 - Balancing of load

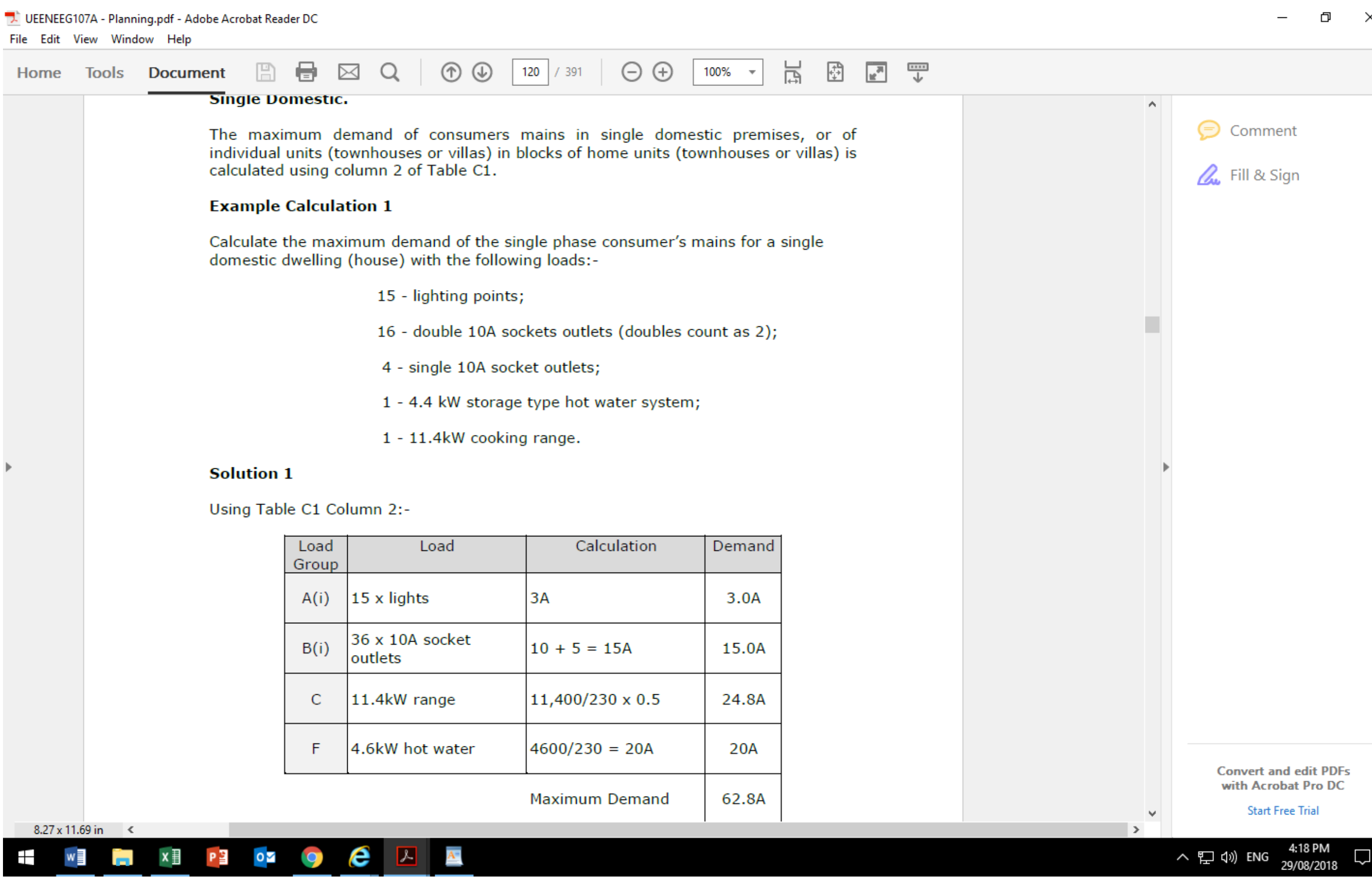
Read N.S.W.S.R 1.10.3 Read the suggested	Write a response
What is the maximum difference in current between phases of a multiphase consumer's mains?	

1.10.3 Balancing of Load

The loading of an installation, or a separately metered part of an installation, which is supplied by more than one phase, must be arranged so that the maximum demand in an active service conductor is not more than 25A above the current in any other active service conductor.

The total current in the service neutral conductor of a three phase supply must not exceed the highest simultaneous current in any active conductor, including the effects of harmonic currents.

The electricity distributor may agree to other limits.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Single Domestic.

The maximum demand of consumers mains in single domestic premises, or of individual units (townhouses or villas) in blocks of home units (townhouses or villas) is calculated using column 2 of Table C1.

Example Calculation 1

Calculate the maximum demand of the single phase consumer's mains for a single domestic dwelling (house) with the following loads:-

15 - lighting points;

16 - double 10A sockets outlets (doubles count as 2);

4 - single 10A socket outlets;

1 - 4.4 kW storage type hot water system;

1 - 11.4kW cooking range.

Solution 1

Using Table C1 Column 2:-

Load Group	Load	Calculation	Demand
A(i)	15 x lights	3A	3.0A
B(i)	36 x 10A socket outlets	10 + 5 = 15A	15.0A
C	11.4kW range	11,400/230 x 0.5	24.8A
F	4.6kW hot water	4600/230 = 20A	20A
		Maximum Demand	62.8A

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Activity - 6 - Calculation of consumer's mains maximum demand

Calculate the maximum demand for the single domestic installation from section 2

- Complete the table below

Write a response

22 - Light points
24 - Double 10A Socket Outlets
1 - 15A socket outlet
1 - 6.0 kW cook top
1 - 3.9 kW wall oven
1 - 4.4 kW storage H.W.S.

Load Group	Load	Calculation	Demand

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Activity - 7 - Calculation of consumer's mains maximum demand

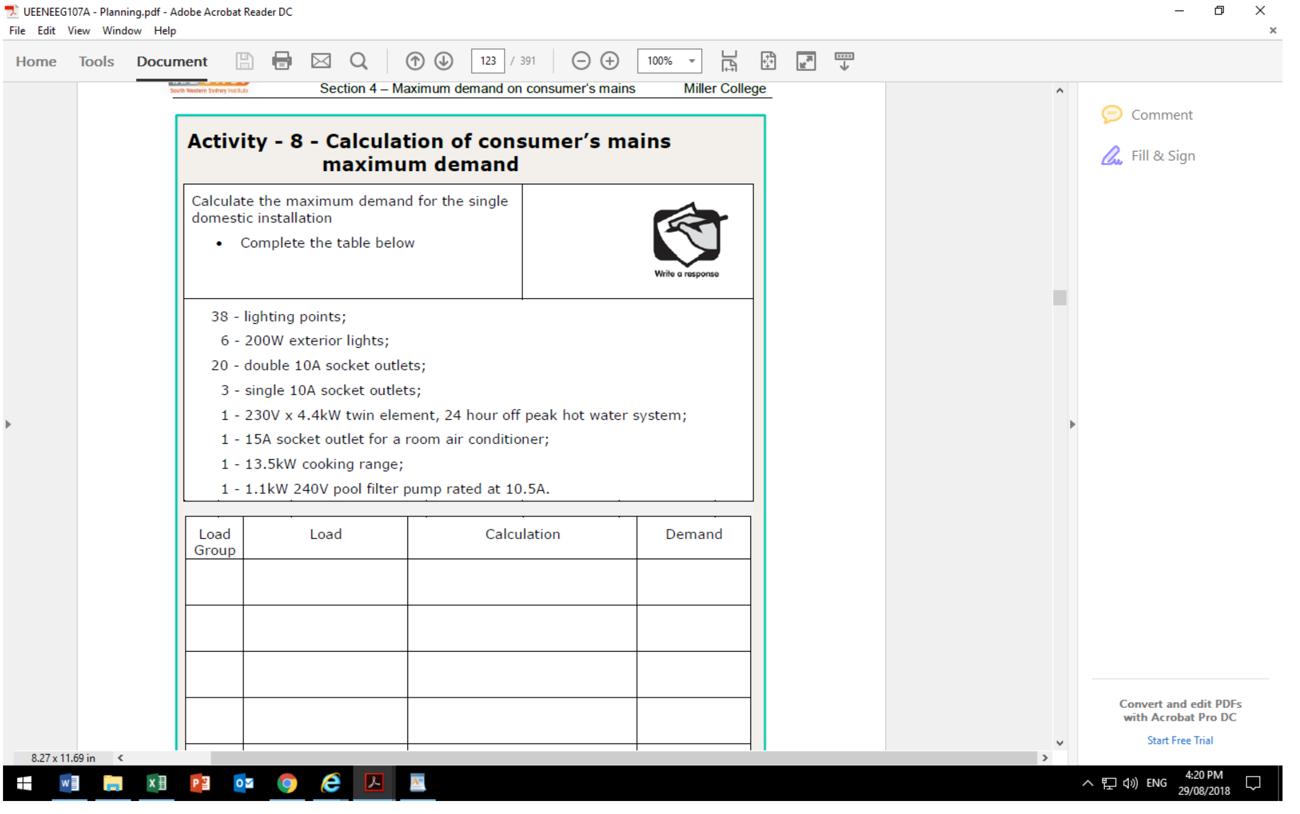
Calculate the maximum demand for the single domestic installation

- Complete the table below

Write a response

16 - lighting points;
15 - double 10A socket outlets;
2 - single 10A socket outlets;
1 - 4.4 kW controlled load water heater;
1 - 6.0kW oven.

Load Group	Load	Calculation	Demand



Section 4 – Maximum demand on consumer's mains Miller College

Activity - 8 - Calculation of consumer's mains maximum demand

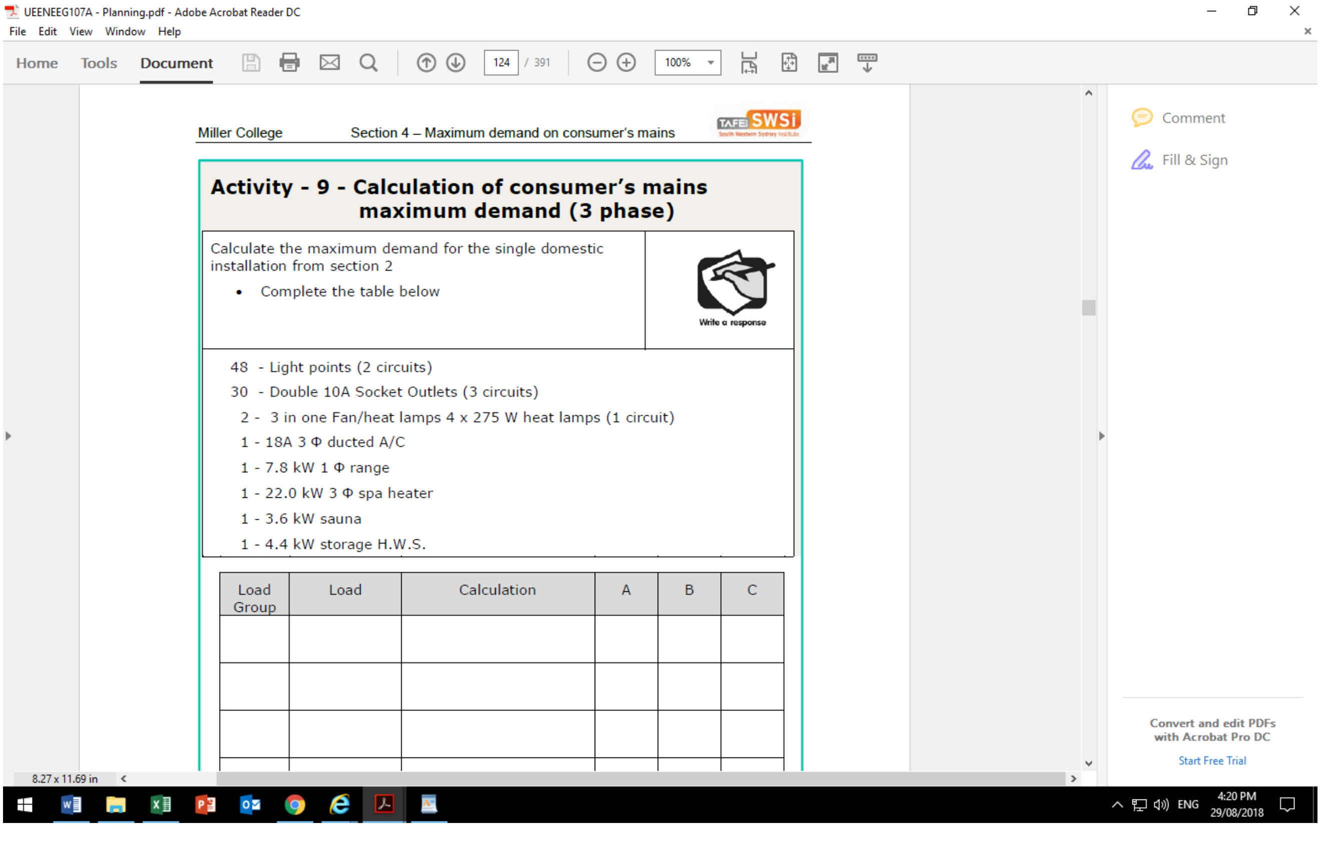
Calculate the maximum demand for the single domestic installation

- Complete the table below

Write a response

38 - lighting points;
6 - 200W exterior lights;
20 - double 10A socket outlets;
3 - single 10A socket outlets;
1 - 230V x 4.4kW twin element, 24 hour off peak hot water system;
1 - 15A socket outlet for a room air conditioner;
1 - 13.5kW cooking range;
1 - 1.1kW 240V pool filter pump rated at 10.5A.

Load Group	Load	Calculation	Demand



Miller College Section 4 – Maximum demand on consumer's mains

Activity - 9 - Calculation of consumer's mains maximum demand (3 phase)

Calculate the maximum demand for the single domestic installation from section 2

- Complete the table below

Write a response

48 - Light points (2 circuits)
30 - Double 10A Socket Outlets (3 circuits)
2 - 3 in one Fan/heat lamps 4 x 275 W heat lamps (1 circuit)
1 - 18A 3 Φ ducted A/C
1 - 7.8 kW 1 Φ range
1 - 22.0 kW 3 Φ spa heater
1 - 3.6 kW sauna
1 - 4.4 kW storage H.W.S.

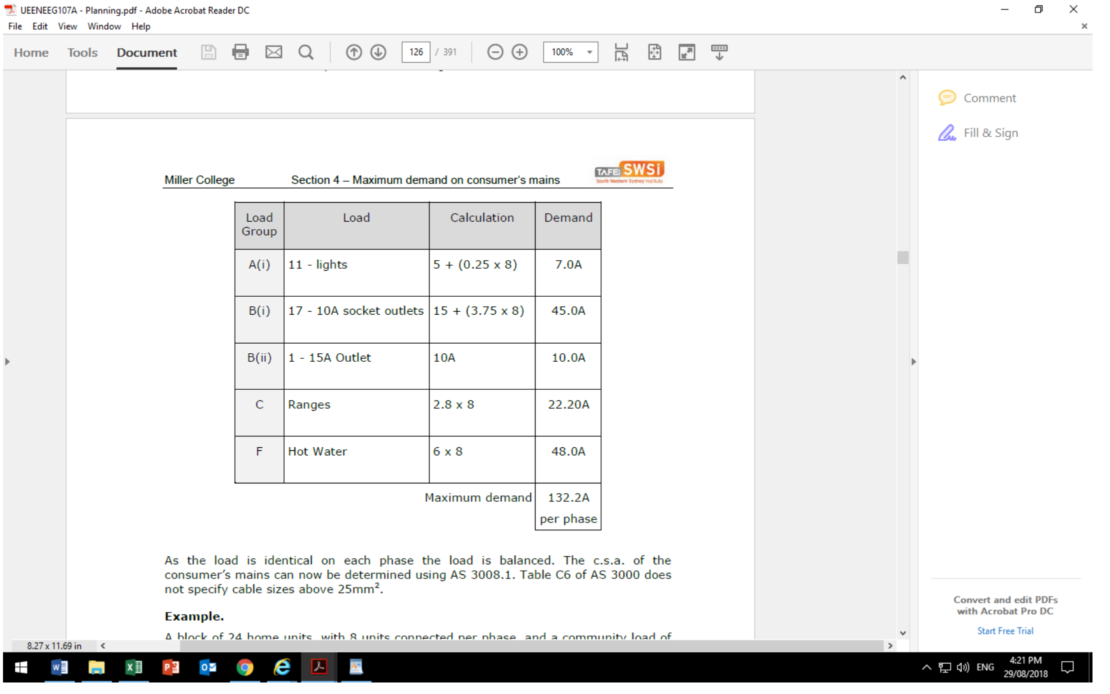
Load Group	Load	Calculation	A	B	C

Example Calculation 2

A block of 24 home units is connected across three phases but each unit is supplied with single phase only. Each unit has the following loads:-

11 - lighting points;
7 - double socket outlets;
3 - single socket outlets;
1 - 15A socket outlet;
1 - 9.2kW range;
1 - 4.4 kW storage water heater.

There is no communal load Using Table C1 Column 4 (24/3 = 8 units per phase):-


Miller College Section 4 – Maximum demand on consumer's mains

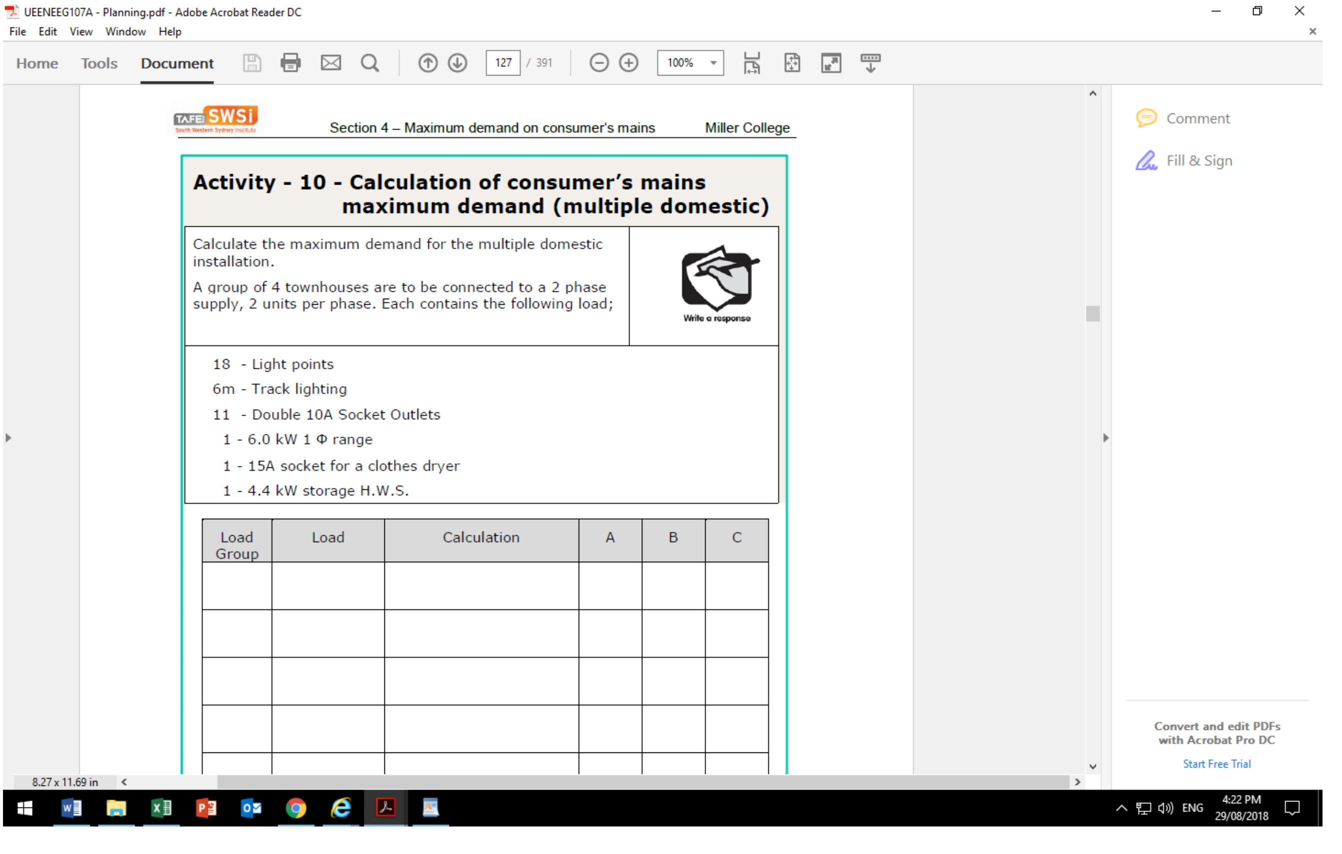
Load Group	Load	Calculation	Demand
A(i)	11 - lights	5 + (0.25 x 8)	7.0A
B(i)	17 - 10A socket outlets	15 + (3.75 x 8)	45.0A
B(ii)	1 - 15A Outlet	10A	10.0A
C	Ranges	2.8 x 8	22.20A
F	Hot Water	6 x 8	48.0A
		Maximum demand	132.2A per phase

As the load is identical on each phase the load is balanced. The c.s.a. of the consumer's mains can now be determined using AS 3008.1. Table C6 of AS 3000 does not specify cable sizes above 25mm².

Example.

Example.
A block of 24 home units, with 8 units connected per phase, and a community load of 35 amperes would have an out of balance in the maximum demands per phase of 35 amperes, outside the maximum of 25A. If the number of units per phase were reassigned as 9 units per phase on A and B phases, then 6 units plus community loads on C phase the balance would be closer.

Do yourself


Section 4 – Maximum demand on consumer's mains Miller College

Activity - 10 - Calculation of consumer's mains maximum demand (multiple domestic)

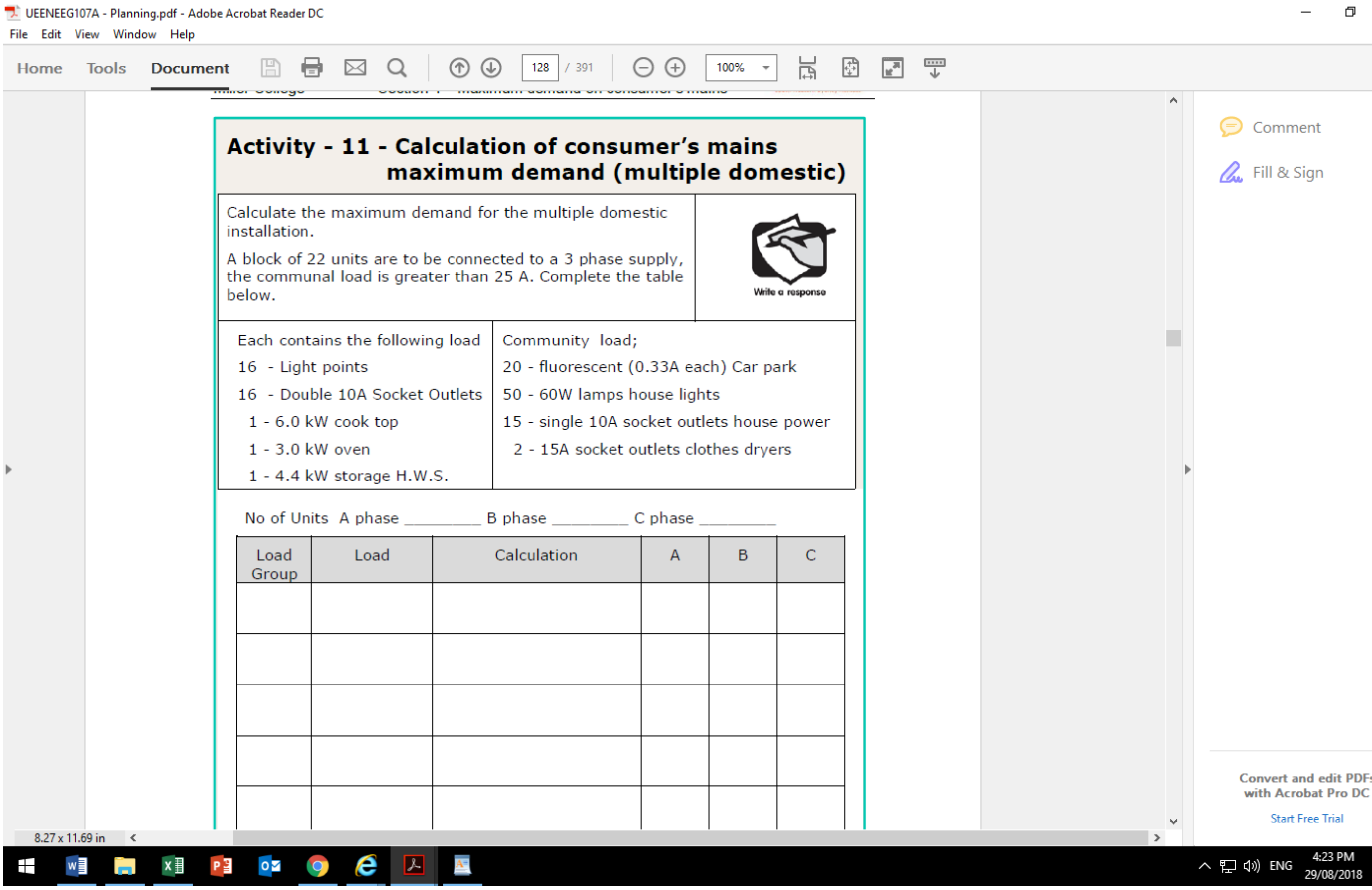
Calculate the maximum demand for the multiple domestic installation.

A group of 4 townhouses are to be connected to a 2 phase supply, 2 units per phase. Each contains the following load;

Write a response

18 - Light points
6m - Track lighting
11 - Double 10A Socket Outlets
1 - 6.0 kW 1 Φ range
1 - 15A socket for a clothes dryer
1 - 4.4 kW storage H.W.S.

Load Group	Load	Calculation	A	B	C



Activity - 11 - Calculation of consumer's mains maximum demand (multiple domestic)

Calculate the maximum demand for the multiple domestic installation.

A block of 22 units are to be connected to a 3 phase supply, the communal load is greater than 25 A. Complete the table below.

Each contains the following load	Community load;
16 - Light points	20 - fluorescent (0.33A each) Car park
16 - Double 10A Socket Outlets	50 - 60W lamps house lights
1 - 6.0 kW cook top	15 - single 10A socket outlets house power
1 - 3.0 kW oven	2 - 15A socket outlets clothes dryers
1 - 4.4 kW storage H.W.S.	

No of Units A phase ________ B phase ________ C phase ________

Load Group	Load	Calculation	A	B	C

Page 135

Example Calculation 1.

Determine the maximum demand of an industrial installation comprising:-
6 - twin x 36W fluorescent lights rated at 0.46A each;
12 - mercury vapour high bay lights rated at 1.8A each;
21 - single phase double 10A socket outlets;
2 - three phase 10A socket outlets;
2 - 15A single phase socket outlets;
2 - three phase 20A socket outlets;
1 - single phase 2.2kW instantaneous water heater;
1 - single phase 3.6kW storage water heater;
1 - three phase 5 kW, 9A compressor;
1 - three phase 4.1 kW, 8A milling machine;
1 - three phase 2.2 kW, 5A lathe;
1 - three phase 370W, 1A pedestal drill;
1 - three phase 560W, 3A grinder;
1 - single phase, 400V electric arc welder rated at 14A.

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Solution.

Using Table C2 Column 3 and balancing loads over all phases as much as possible:-

Load Group	Load	Calculation	A Phase	B Phase	C Phase
A	6 x 0.46A Fl Lts (C Φ)	6 x 0.46 = 2.76A (2.8A)			2.8A
A	12 x MV Lts (A & C Φ)	6 x 1.8 = 10.8A	10.8A		10.8A
B(i)	21 x 2 x 1Φ 10A S/Os (14/Φ) + 2 x 3Φ 10A S/Os 16 points per phase	1000 + (750 x 15) / 230	53.3A	53.3A	53.3A
B(i)	2 x 3Φ 10A S/Os	add extra 2 points above			
B(iii)	2 x 3Φ 20A S/Os	20 + (0.75 x 20) = 35A	35.0A	35.0A	35.0A
B(iii)	2 x 1Φ 15A S/Os (A & BΦ)	(0.75 x 15) = 11.25A (11.3A)	11.3A	11.3A	
C	1 x 1Φ 2.2kW Inst HW(BΦ)	2,200/230 =		9.6	
D	1 x 9A motor	9 + (0.75 x 8) + 0.5(5 + 3 + 1) = 19.5A	19.5A	19.5A	19.5A
D	1 x 8A motor				
D	1 x 5A motor				
D	1 x 3A motor				
D	1 x 1A motor				
G	1 x 1Φ 3.6kW storage HW	3600/230 = 15.7A			15.7
H	1 x 400V 14A welder		14.0A	14.0A	
		Demand	137.3A	142.7A	137.1A

Do yourself

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Activity - 1 - Calculation of consumer's mains maximum demand (non domestic)

Use AS3000 to calculate the maximum demand in the consumer's mains for a factory with the following load;

Write a response

36 - high bay MV luminaries rated at 2.6A each (12/phase)

21 - 10A double single phase socket outlets (7/phase)

4 - 20A three phase socket outlets

2 - lathes with three phase induction motors rated at 28A

3 - 400V single phase spot welders with a rated primary current of 40A and a duty cycle of 40%.

Load Group	Load	Calculation	A	B	C

Comment

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Activity - 2 - Calculation of consumer's mains maximum demand (non domestic)

Use AS3000 to calculate the maximum demand in the consumer's mains for a factory with the following load;

Write a response

30 - twin 36W fluorescent lights rated at 0.5 amperes each;
12 - single 36W fluorescent lights rated at 0.25 amperes each;
3 - 500W floodlights;
6 - 100W incandescent lamps;
9 - 10 ampere single phase socket outlets
12 - three phase 15 ampere socket outlets;
1 - 2.3kW 230V quick recovery water heater;
1 - 1.102kW 230V food warmer;
2 - three phase motors rated at 42 amperes each;
3 - three phase motors rated at 16.8 amperes each;
4 - three phase motors rated at 2.8 amperes each.

Load Group	Load	Calculation	A	B	C

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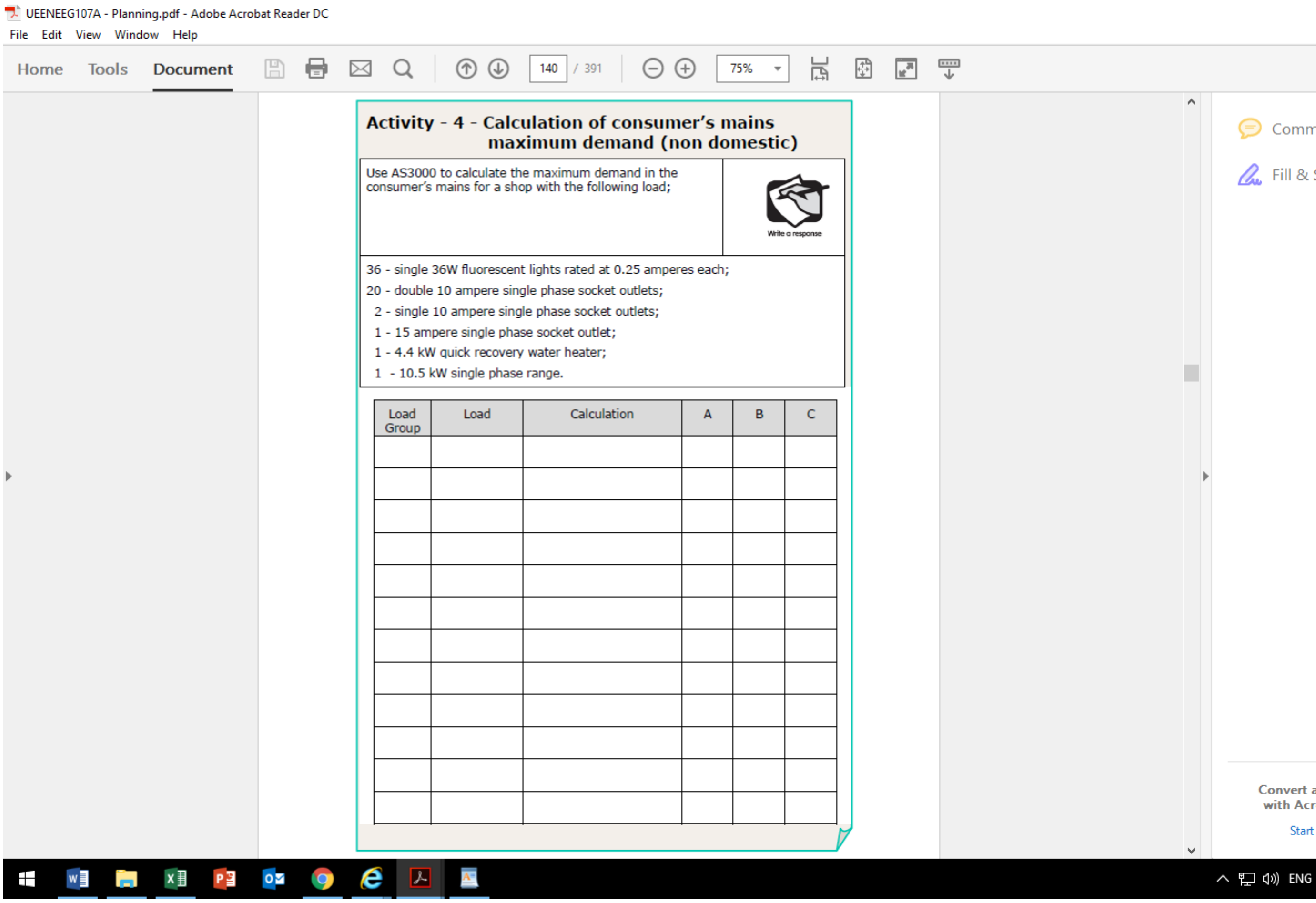
Activity - 3 - Calculation of consumer's mains maximum demand (non domestic)

Use AS3000 to calculate the maximum demand in the consumer's mains for a factory with the following load;

Write a response

28 - single 36W fluorescent lights rated at 0.25 amperes each (2 circuits);
1 - three phase rectifier rated primary current 72 amperes per phase;
20 - double 10 ampere single phase socket outlets;
7 - three phase 20 ampere socket outlets;
2 - three phase exhaust fan motors rated at 5.2 amperes each;
3 - three phase exhaust fan motors rated at 6.3 amperes each.

Load Group	Load	Calculation	A	B	C



Activity - 4 - Calculation of consumer's mains maximum demand (non domestic)

Use AS3000 to calculate the maximum demand in the consumer's mains for a shop with the following load;

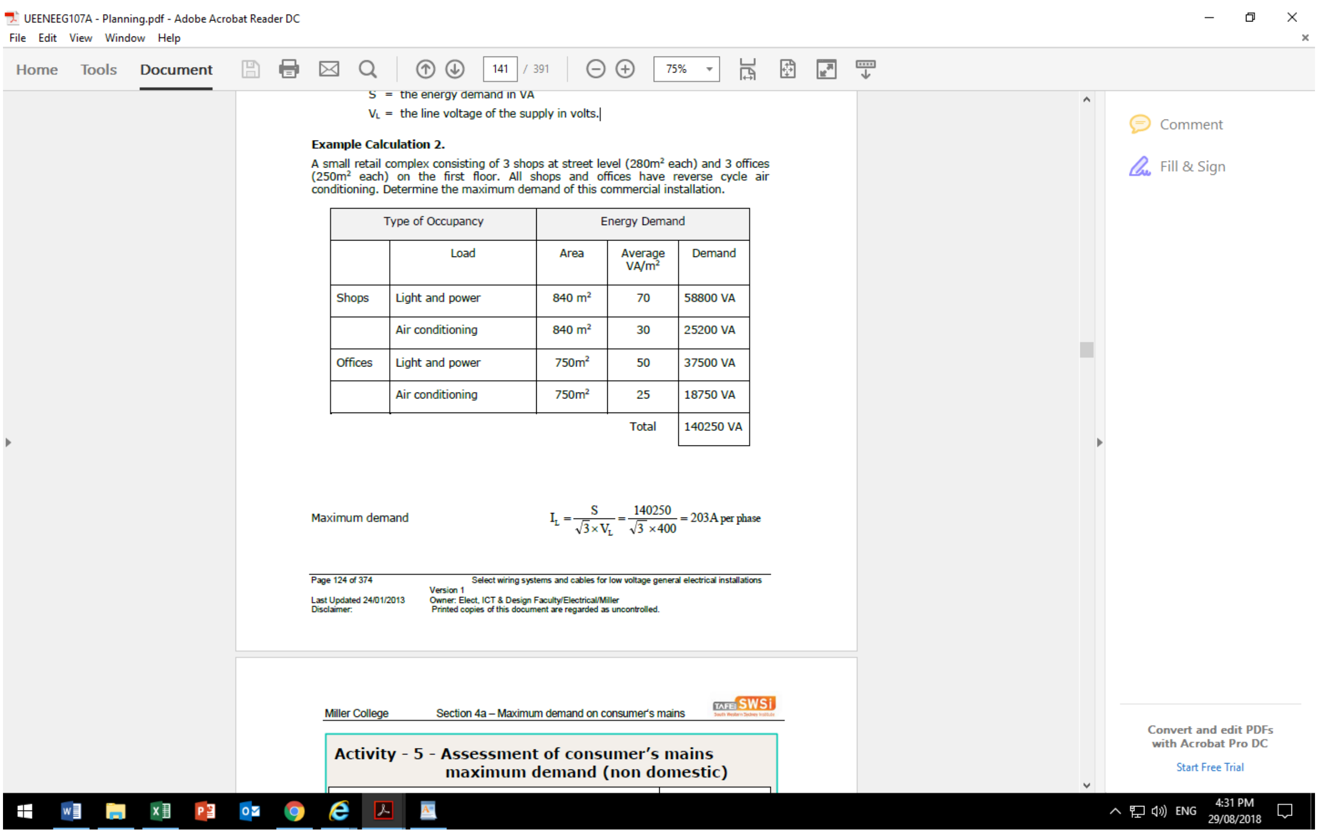
36 - single 36W fluorescent lights rated at 0.25 amperes each;
20 - double 10 ampere single phase socket outlets;
2 - single 10 ampere single phase socket outlets;
1 - 15 ampere single phase socket outlet;
1 - 4.4 kW quick recovery water heater;
1 - 10.5 kW single phase range.

Load Group	Load	Calculation	A	B	C

Page 141

S= √ 3VI Il

I_L = the line current /maximum demand current in Amperes
S = the energy demand in VA
V_L = the line voltage of the supply in volts.



S = the energy demand in VA
V_L = the line voltage of the supply in volts.

Example Calculation 2.

A small retail complex consisting of 3 shops at street level (280m² each) and 3 offices (250m² each) on the first floor. All shops and offices have reverse cycle air conditioning. Determine the maximum demand of this commercial installation.

Type of Occupancy		Energy Demand		
	Load	Area	Average VA/m²	Demand
Shops	Light and power	840 m²	70	58800 VA
	Air conditioning	840 m²	30	25200 VA
Offices	Light and power	750m²	50	37500 VA
	Air conditioning	750m²	25	18750 VA
			Total	140250 VA

Maximum demand $I_L = \frac{S}{\sqrt{3}\times V_L} = \frac{140250}{\sqrt{3}\times 400} = 203A$ per phase

Page 124 of 374 Select wiring systems and cables for low voltage general electrical installations
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Miller College Section 4a – Maximum demand on consumer's mains

Activity - 5 - Assessment of consumer's mains maximum demand (non domestic)

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Activity - 5 - Assessment of consumer's mains maximum demand (non domestic)

Use AS3000 table C3 to determine the maximum demand in the consumer's mains for a shop with the following load;

Write a response

A retail complex consisting of 5 shops at street level (330m² each) and 3 offices (300m² each) on the first floor. All shops and offices have reverse cycle air conditioning. Determine the maximum demand of this commercial installation.

Type of Occupancy		Energy Demand		
	Load	Area	Average VA/m²	Demand
			Total	

Maximum demand =

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TABLE C3

MAXIMUM DEMAND—ENERGY DEMAND METHOD FOR NON-DOMESTIC INSTALLATIONS

Type of occupancy		Energy demand Range, VA/m²	Energy demand Average, VA/m²
Offices	Light and power	40–60	50
	Airconditioning:		
	— Cooling	30–40	35
	— Reverse cycle	20–30	25
	— Zonal reheat	40–60	50
	— Variable volume	20	20
* Carparks	Open air EV charging Basement EV charging	0–10 5–15 10–20 10–30	5 10 15 20
Retail shops	Light and power Airconditioning	40–100 20–40	70 30
Warehouses	Light and power Ventilation Special equipment	5–15 5 (use load details)	10 5
Light industrial	Light and power Ventilation Airconditioning Special equipment	10–20 10–20 30–50 (use load details)	15 15 40
Taverns, licensed clubs	Total	60–100	80
Theatres	Total	80–120	100

NOTE: EV charging relates to charging equipment associated with electric vehicles and should be considered in addition to all other energy demands.

* **C2.4.4** *Alternative method using switchboard diversity*

For switchboards conforming with the AS/NZS 3439 series or the

Do yourself

Activity - 6 - Assessment of consumer's mains maximum demand (non domestic)

Use AS3000 table C3 to determine the maximum demand in the consumer's mains for a complex with the following load;

Write a response

A complex consisting of

- 2200m² of ventilated warehouse,
- 250 m² of reverse cycle air conditioning offices
- 500 m² of open air car park.

Type of Occupancy		Energy Demand		
	Load	Area	Average VA/m²	Demand
			Total	

Maximum demand =

Activity - 7 - Assessment of consumer's mains maximum demand (non domestic)

Use AS3000 table C3 to determine the maximum demand in the consumer's mains for a factory unit complex with the following load;

Write a response

A complex consisting of

- 1200m² of ventilated light industrial units,
- 850 m² of reverse cycle air conditioning offices
- 500 m² of open air car park.

Type of Occupancy		Energy Demand		
	Load	Area	Average VA/m²	Demand
			Total	

Maximum demand =

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Topic 2 - *Calculation the maximum demand of sub mains*

The methods used to calculate the maximum demand of sub are exactly the same as consumer's main as stated in AS 3000 clause 2.2.2;

- Calculation
- Assessment
- Measurement
- Limitation

The only variation is that only the load connected to the sub-main is included in the calculation of the sub-main.

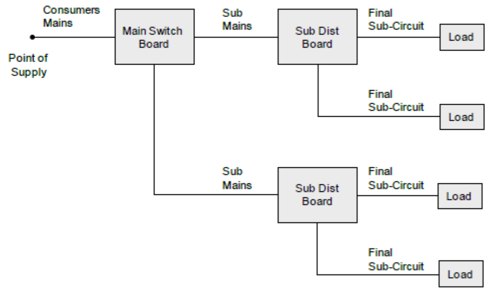

figure 1.

Sub-mains in Single domestic installations

In modern domestic installations the space available on the customer's main switchboards has decreased, supply authorities are requiring larger "foot prints" for metering equipment. There has also been an increase in the number of final sub-circuits and protection devices such as 2 pole combination R.C.D / M.C.B and voltage surge diverters fitted in main switch boards. It now common practice in larger installations, to run a sub-main to a location such as the garage or kitchen. A distribution board placed in the kitchen shortens the runs of a majority of the final sub-circuits, reducing cost and provides the convenience to customer of not having to go outside to reset a tripped circuit breaker. Sub-mains are also used to supply out buildings such as granny flats or garages.

Unlike consumer's mains, sub-mains are **electrically protected** at their origin. The

Do it yourself

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Activity - 8 - Calculation of sub-main maximum demand

Calculate the maximum demand for a granny flat in a single domestic installation

- Complete the table below

8 - lighting points;
5 - double 10A socket outlets;
1 - single 10A socket outlets;
1 - 3.3 kW heat pump storage H.W.S;
1 - 4.4 kW Range.
1 - 15A socket outlet for a split system air conditioner

Load Group	Load	Calculation	Demand
		Maximum Demand	

Activity - 9 - Calculation of sub-main maximum demand

Calculate the maximum demand for the garage of a single domestic installation

- Complete the table below

Write a response

12 - lighting points;
1 - 1100W flood light
6 - double 10A socket outlets;
1 - single 10A socket outlet;

Load Group	Load	Calculation	Demand
		Maximum Demand	

In cases such as the one in activity 8 where the demand is low, it is not cost effective to run sub-mains and distribution board. A simpler alternative is to wire the garage as a mixed circuit supplied from a C.B. at the house main switch board.

used. Below is the example of 4 town houses from the previous section. In this case the load within the unit not the number of units per phase will set the maximum demand of the sub-main.

Activity - 10 - Calculation of sub-main maximum demand (multiple domestic)

Calculate the maximum demand for the sub-main of a single unit in a multiple domestic installation.

A group of 4 townhouses are to be connected to a 2 phase supply, 2 units per phase. Each contains the following load;

Write a response

18 - Light points
6m - Track lighting
11 - Double 10A Socket Outlets
1 - 6.0 kW 1 Φ range
1 - 15A socket for a clothes dryer
1 - 4.4 kW storage H.W.S.

Load Group	Load	Calculation	Demand

Activity - 11 - Calculation of sub-main maximum demand (multiple domestic)

Calculate the maximum demand for the sub-main of a single unit in a multiple domestic installation.

A block of 22 units are to be connected to a 3 phase supply, the communal load is greater than 25 A. Complete the table below.

Write a response

Each contains the following load	Community load;
16 - Light points	20 - fluorescent (0.33A each) Car park
16 - Double 10A Socket Outlets	50 - 60W lamps house lights
1 - 6.0 kW cook top	15 - single 10A socket outlets house power
1 - 3.0 kW oven	2 - 15A socket outlets clothes dryers
1 - 4.4 kW storage H.W.S.	

Load Group	Load	Calculation	Demand

Sub-mains in non domestic installations

Once again the procedure to determine the maximum demand of sub-mains in a non domestic installation is the same as consumer's mains, but only the load in that section of the building is included.

Activity - 12 - Calculation of sub-mains maximum demand (non domestic)

Use AS3000 to calculate the maximum demand in the sub mains for a factory unit with the following load;

Write a response

- 6 - high bay MV luminaries rated at 2.6A each (1 circuit)
- 30 - twin 36W fluorescent lights 0.333A each (1 circuit)
- 20 - 10A double single phase socket outlets (5 circuits 4 points per)
- 4 - 20A three phase socket outlets
- 4 - three phase induction motors rated at 32A
- 1 - 400V single phase arc welding machines with a rated primary current of 40A
- 1 - 4.4 kW 230V HWS

Load Group	Load	Calculation	A	B	C

Non Domestic Energy Demand Method

Example Calculation.

From the previous section, recall the small retail complex consisting of 3 shops at street level (280m² each) and 3 offices (250m² each) on the first floor. All shops and offices have reverse cycle air conditioning. In the previous section the maximum demand of the entire complex was calculated at 203A per phase. Determine the maximum demand of the sub-main supplying the individual shops and offices.

Type of Occupancy		Energy Demand		
	Load	Area	Average VA/m²	Demand
Shops	Light and power	280 m²	70	19600 VA
	Air conditioning	280 m²	30	8400 VA
			Total	28000 VA
Offices	Light and power	250m²	50	12500 VA
	Air conditioning	250m²	25	6250 VA
			Total	18750 VA

Shop Maximum demand

$$I_L = \frac{S}{\sqrt{3} \times V_L} = \frac{28000}{\sqrt{3} \times 400} = 41\text{A per phase}$$

- A 50A H.R.C. fuse or circuit breaker would be selected as the protection device.
- A cable size is then selected to that it has a current carrying capacity higher than or equal to 50A after any applicable de-ratings have been applied.

Office Maximum demand

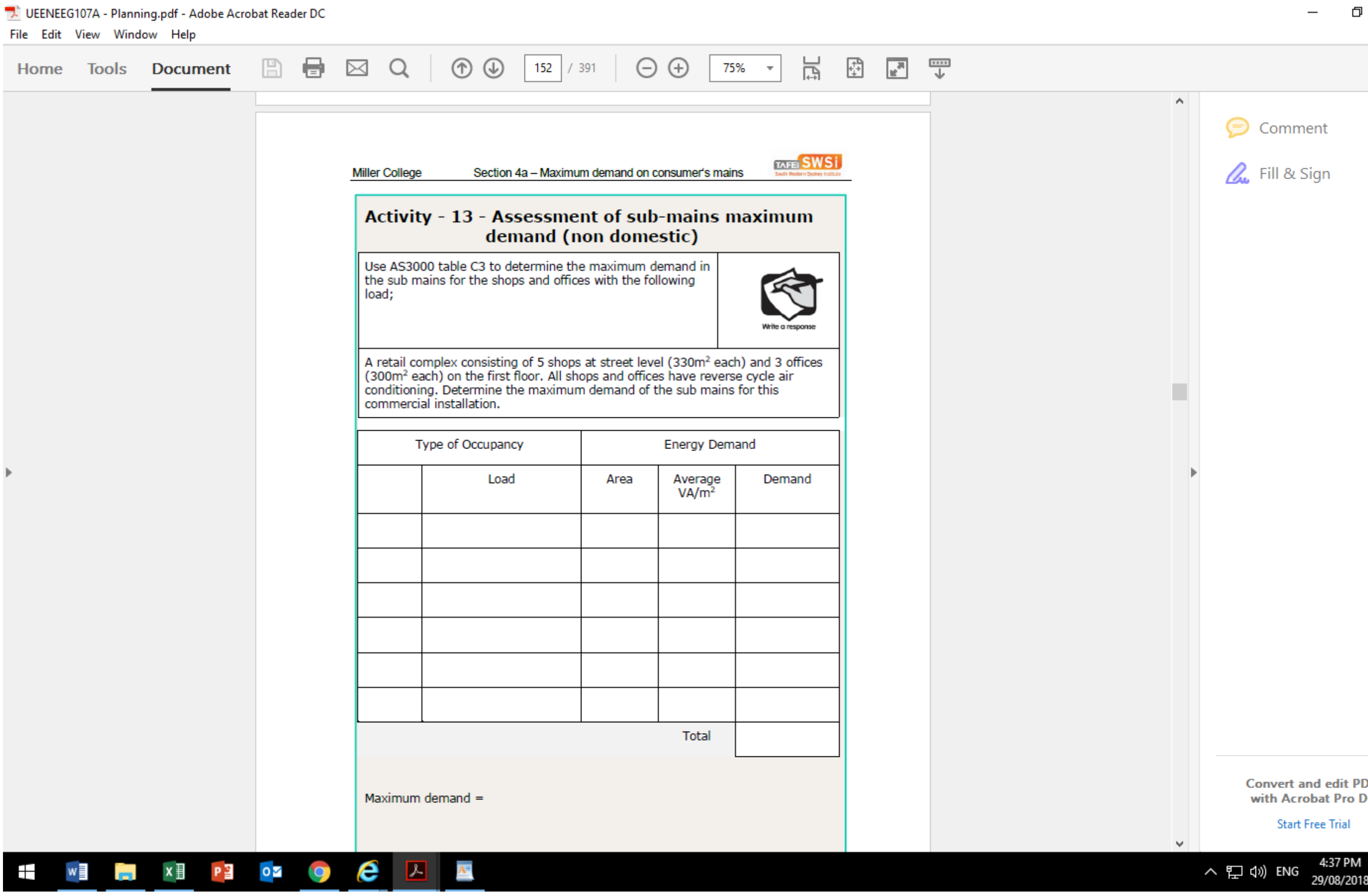
$$I_L = \frac{S}{\sqrt{3} \times V_L} = \frac{18750}{\sqrt{3} \times 400} = 28\text{A per phase}$$

- A 32A H.R.C. fuse or circuit breaker would be selected as the protection device.

A 32A H.R.C. fuse or circuit breaker would be selected as the protection device.

• A cable size is then selected to that it has a current carrying capacity higher than or equal to 32A after any applicable de-ratings have been applied.

Do it yourself



Miller College Section 4a – Maximum demand on consumer's mains

Activity - 13 - Assessment of sub-mains maximum demand (non domestic)

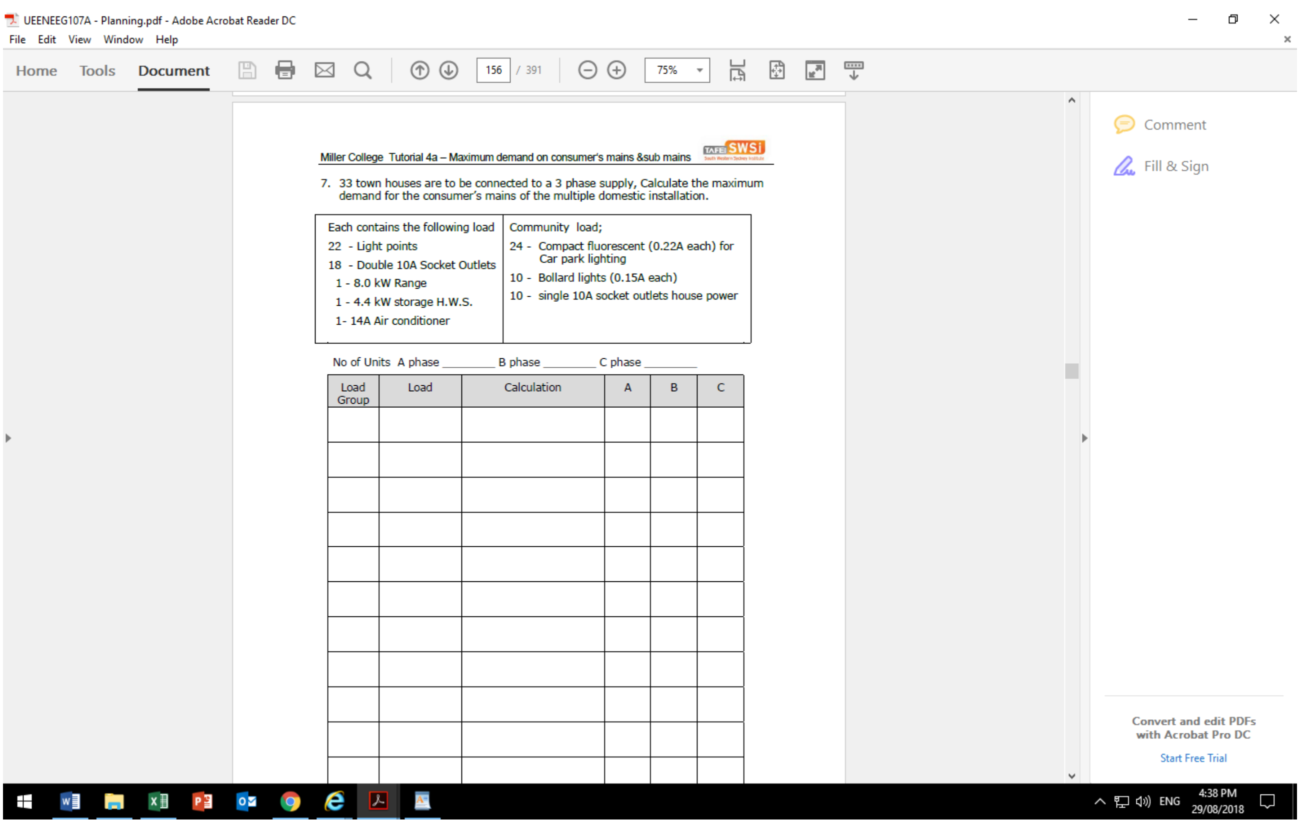
Use AS3000 table C3 to determine the maximum demand in the sub mains for the shops and offices with the following load;

A retail complex consisting of 5 shops at street level (330m² each) and 3 offices (300m² each) on the first floor. All shops and offices have reverse cycle air conditioning. Determine the maximum demand of the sub mains for this commercial installation.

Type of Occupancy		Energy Demand		
	Load	Area	Average VA/m²	Demand
			Total	

Maximum demand =

Do yourself



Miller College Tutorial 4a – Maximum demand on consumer's mains &sub mains

7. 33 town houses are to be connected to a 3 phase supply, Calculate the maximum demand for the consumer's mains of the multiple domestic installation.

Each contains the following load	Community load;
22 - Light points	24 - Compact fluorescent (0.22A each) for Car park lighting
18 - Double 10A Socket Outlets	10 - Bollard lights (0.15A each)
1 - 8.0 kW Range	10 - single 10A socket outlets house power
1 - 4.4 kW storage H.W.S.	
1- 14A Air conditioner	

No of Units A phase ________ B phase ________ C phase ________

Load Group	Load	Calculation	A	B	C

Table 3 of AS3008.1.1 (2009) gives guidance to installation methods

- Table 3(1) ________________________________

- Table 3(2) ________________________________

• Table 3(3) ________________________________

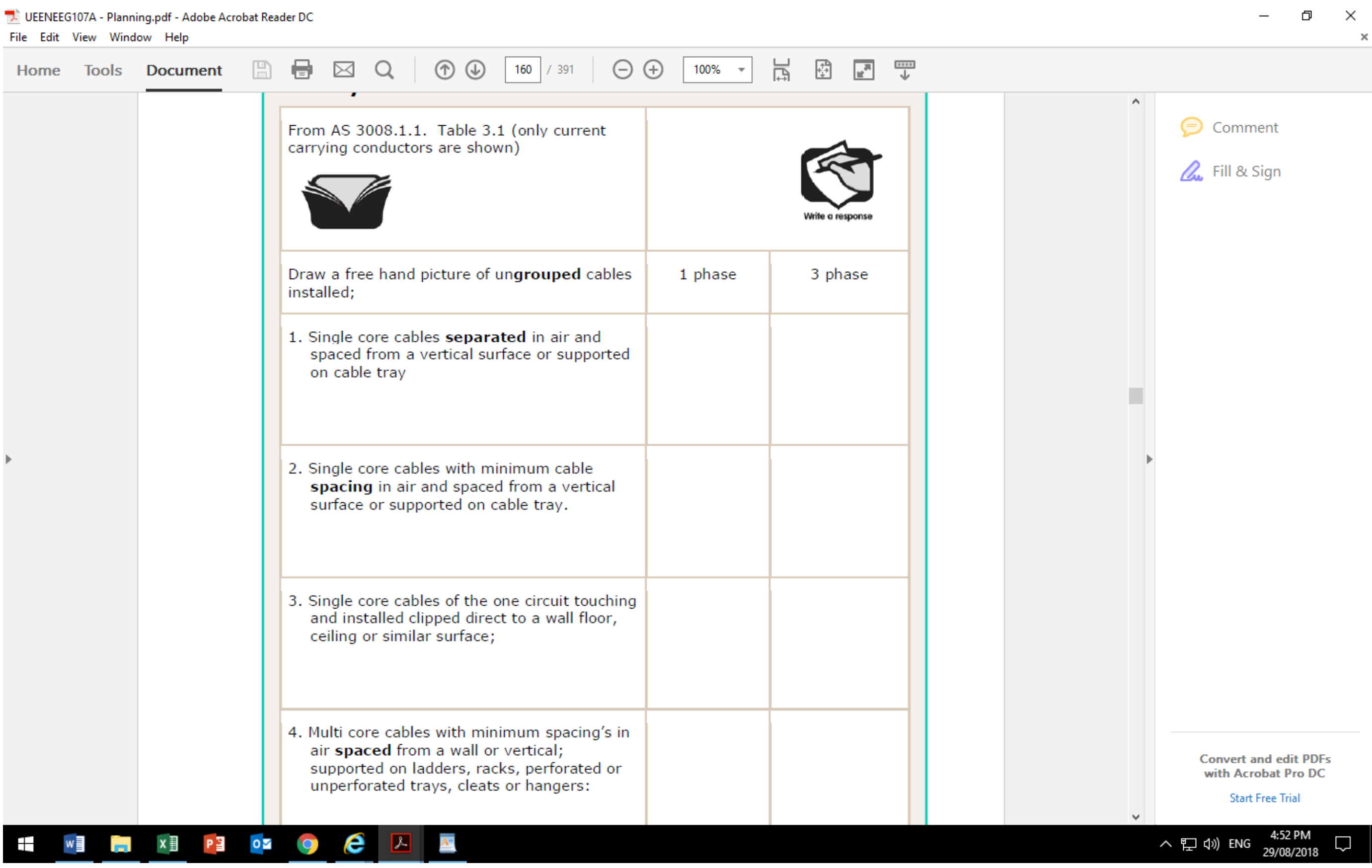
• Table 3(4) ________________________________

TABLE 3(1)
SCHEDULE OF INSTALLATION METHODS FOR CABLES DEEMED TO HAVE THE SAME CURRENT-CARRYING CAPACITY AND CROSS-REFERENCES TO APPLICABLE DERATING TABLES—UNENCLOSED IN AIR

TABLE 3(2)
SCHEDULE OF INSTALLATION METHODS FOR CABLES DEEMED TO HAVE THE SAME CURRENT-CARRYING CAPACITY AND CROSS-REFERENCES TO APPLICABLE DERATING TABLES—ENCLOSED

TABLE 3(3)
SCHEDULE OF INSTALLATION METHODS FOR CABLES DEEMED TO HAVE THE SAME CURRENT-CARRYING CAPACITY AND CROSS-REFERENCES TO APPLICABLE DERATING TABLES—BURIED DIRECT IN THE GROUND

TABLE 3(4)
SCHEDULE OF INSTALLATION METHODS FOR CABLES DEEMED TO HAVE THE SAME CURRENT-CARRYING CAPACITY AND CROSS-REFERENCES TO APPLICABLE DERATING TABLES—UNDERGROUND WIRING ENCLOSURES



From AS 3008.1.1. Table 3.1 (only current carrying conductors are shown)		
Draw a free hand picture of un**grouped** cables installed;	1 phase	3 phase
1. Single core cables **separated** in air and spaced from a vertical surface or supported on cable tray		
2. Single core cables with minimum cable **spacing** in air and spaced from a vertical surface or supported on cable tray.		
3. Single core cables of the one circuit touching and installed clipped direct to a wall floor, ceiling or similar surface;		
4. Multi core cables with minimum spacing's in air **spaced** from a wall or vertical; supported on ladders, racks, perforated or unperforated trays, cleats or hangers:		

SCHEDULE OF INSTALLATION METHODS FOR CABLES DEEMED TO HAVE
THE SAME CURRENT-CARRYING CAPACITY AND CROSS-REFERENCES TO
APPLICABLE DERATING TABLES—UNENCLOSED IN AIR

A1

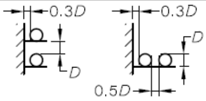
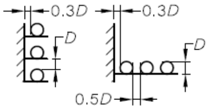
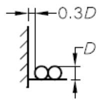
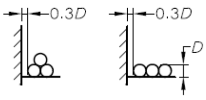
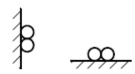
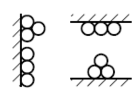
1	2	3	4	5	6
Item No.	**Cable details (see Note 2)**	**Reference drawing (see Note 3)**	**Current-carrying capacity table reference**	**Methods of installation for cables deemed to have the same current-carrying capacity (See Notes 4, 5 and 6)**	**Derating table**
1	Two single-core cables		Tables 4 and 5 Columns 2 to 4 Table 6 Columns 2 and 3	Cables with minimum cable separation in air as shown for horizontal and vertical mounting and installed— (a) spaced from a wall or vertical surface; (b) supported on ladders, racks, perforated trays, cleats or hanger; or	23
2	Three single-core cables		Tables 7 and 8 Columns 2 to 4 Table 9 Columns 2 and 3		
3				(c) suspended from a catenary wire.	22
4	Two single-core cables		Tables 4 and 5 (see Note 5) Columns 5 to 7 Table 6 Columns 2 and 3	Cables with minimum cable spacings in air as shown and installed— (a) spaced from a wall or vertical surface; (b) supported on ladders, racks, perforated or unperforated trays, cleats or hangers; (c) in a switchboard or similar enclosure; or	23
5	Three single-core cables		Tables 7 and 8 (see Note 5) Columns 5 to 7 Table 9 Columns 4 and 5		
6				(d) suspended from a catenary wire.	22
7	Two single-core cables		Tables 4 and 5 (see Note 4) Columns 8 to 10 Table 6 Columns 6 and 7	Cables of the one circuit touching and installed— (a) clipped direct to a wall, floor, ceiling or similar surface; (b) in a ventilated trench or open trunking; (c) buried directly in a plaster or render on a wall; or (d) in a switchboard or similar enclosure.	22
8	Three single-core cables		Tables 7 and 8 (see Note 4) Columns 8 to 10 Table 9 Columns 6 and 7.		

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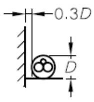
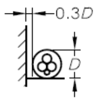
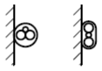
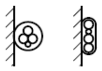
TABLE 3(1) *(continued)*

A1

1	2	3	4	5	6
Item No.	Cable details (see Note 2)	Reference drawing (see Note 3)	Current-carrying capacity table reference	Methods of installation for cables deemed to have the same current-carrying capacity (See Notes 4, 5 and 6)	Derating table
9	Two-core cables		Tables 10 and 11 (see Note 5) Columns 2 to 4 Table 12 Columns 2 and 3	Cables with minimum spacings in air as shown and installed— (a) spaced from a wall or vertical surface; (b) supported on ladders, racks, perforated or unperforated trays, cleats or hangers; (c) in a switchboard or similar enclosure; or	24
10	Three-core cables		Tables 13 and 14 (see Note 5) Columns 2 to 4 Table 15 Columns 2 and 3		
11				(d) suspended from a catenary or as a self-supported overhead cable.	22
12	Two-core cables		Tables 10 and 11 (see Note 4) Columns 5 to 7 Table 12 Columns 4 and 5	Cables installed— (a) clipped direct to a wall, floor, ceiling or similar surface; (b) buried directly in concrete or masonry above the ground or in plaster or render on a wall; (c) in a ventilated trench or open trunking; or (d) in a switchboard or similar enclosure	22
13	Three-core cables		Tables 13 and 14 (see Note 4) Columns 5 to 7 Table 15 Columns 4 and 5		

NOTES:

Activity - 2 - Installation conditions that cause de-rating.

Read AS 3008.1.1. sections 3.4 to 3.5	
	
List the "standard" conditions of installation and operation to avoid de-rating;	
1. Ambient **air** temperature	
2. Ambient **soil** temperature	
3. Depth of laying cable underground	
4. Soil thermal resistivity	
5. Cable grouping	
6. Harmonic distortion	
Read AS 3000 clause 2.5.3.1	
7. Circuit protection	

3.4 INSTALLATION CONDITIONS

3.4.1 General

The current-carrying capacity of a cable is dependent on the method of installation tomaintain the temperature of the cable within its operating limits.

Different methods ofinstallation vary the rate at which the heat generated by the current flow is dissipated to thesurrounding medium.

Specific conditions of installation are laid down in Clauses 3.4.2 to 3.4.5 for cables installed with or without wiring enclosures in air, in the ground or embedded in building materials. These conditions have been used to derive the current-carrying capacities tabulated in Section 3. Where a number of installation conditions exist along a cable run or variations to the specific conditions occur, reference shall be made to Clauses 3.4.6 and 3.5respectively.

3.4.2 Cables installed in air
For cables installed in free air, the current-carrying capacities shall be based on the
following conditions of installation and operation:
(a) Ambient temperature An ambient air temperature of 40°C.
(b) Unenclosed cables Cables installed as follows:
(i) Directly in air and, except for flexible cables as mentioned in Note 2 to Table 1
and aerial cables, not exposed to direct sunlight and where they are—
(A) lying on a horizontal surface;
(B) lying across ceiling joists;
(C) supported on perforated or unperforated cable trays, ladders, hangers or racks;
(D) clipped at intervals to a vertical or horizontal surface, such as a wall or beneath a ceiling;
(E) suspended from a catenary wire;
(F) lying in the bottom of open trunking; or
(G) in an enclosure such as a switchboard.
(ii) Directly embedded beneath the surface of plaster, cement render or masonry.
NOTE: Table 3(1) contains a reference to the appropriate current-carrying capacity table for cables installed unenclosed in air.
(c) Enclosed cables Cables installed as follows:
(i) In metallic or non-metallic wiring enclosure in—
(A) free air;
(B) a ventilated or enclosed trench;
(C) a concrete slab on or above the surface of the ground; or
(D) a concrete, plaster, cement rendered or masonry wall.
(ii) In closed trunking.
(iii) In an enclosed trench with removable covers.
(iv) Directly buried in concrete.

3.4.3 Cables installed in thermal insulation
For cables installed in thermal insulation the current-carrying capacities shall be based on
the following conditions of installation and operation:
(a) Ambient temperature An ambient temperature of the air surrounding the thermal insulation of 40°C.
(b) Unenclosed cables Cables installed without further enclosure—
(i) lying on a horizontal surface;
(ii) lying across ceiling joists;
(iii) supported on perforated or unperforated cable trays, ladders, hangers or racks;
(iv) clipped at intervals to a vertical or horizontal surface such as a wall or ceiling

joist; or
(v) lying in the bottom of open trunking.
(c) Enclosed cables Cables installed in—
(i) metallic or non-metallic wiring enclosure; or
(ii) closed trunking or ducts.
(d) Bulk thermal insulation Bulk thermal insulation installed as follows:
(i) Materials Building materials installed to provide a thermal insulation including—
(A) fibreglass or rockwool batts;
(B) cellulose fibre, paper, cork, seagrass or similar organic materials that are normally installed in a loose-fill form; or
(C) expanded synthetic foams such as polystyrene, ureaformaldehyde or polyurethane, which may be installed by pumping or injection as a wet foam.
NOTE: Reflective foil laminates are not considered to be bulk thermal insulation.
(ii) Completely surrounded installation An installation method where bulk thermal insulation surrounds, and is in contact with, unenclosed or enclosed cables.
(iii) Partially surrounded installation An installation method where bulk thermal insulation is prevented from completely surrounding unenclosed or enclosed cable, such as where an unenclosed or enclosed cable is clipped to a structural member or is lying on a ceiling

3.4.4 Cables buried direct in the ground
For cables buried direct in the ground, the current-carrying capacities shall be based on the
following conditions of installation and operation:
(a) Ambient temperature An ambient soil temperature of 25°C.

(b) Depth of laying A depth of laying of 0.5 m measured from the ground surface to the
centre of a cable, or to the centre of a trefoil group of cables.
(c) Thermal resistivity of soil A soil thermal resistivity of 1.2°C.m/W.
(d) Spacing of cables Cables are spaced as follows:
(i) Single-core cables Either—
(A) three single-core cables laid touching throughout in trefoil formation; or
(B) two or three single-core cables laid touching in flat formation.
(ii) Multicore cables Multicore cables laid singly.
NOTE: Table 3(3) contains a reference to the appropriate current-carrying capacity table for cables buried direct in the ground. See Clause 3.5.2.5 for spacing distances.
3.4.5 Cables installed in underground wiring enclosures
For cables installed in underground wiring enclosures, the current-carrying capacities shall
be based on the following conditions of installation and operation:
(a) Ambient temperature An ambient soil temperature of 25°C.
(b) Depth of laying A depth of laying of 0.5 m measured from the ground surface to the
centre of a wiring enclosure, or to the centre of a trefoil group of wiring enclosures.
(c) Thermal resistivity of soil A soil thermal resistivity of 1.2°C.m/W.
(d) Spacing of wiring enclosures Wiring enclosures shall be spaced as follows:
(i) Single-core cables in separate wiring enclosures with—
(A) two ducts side by side touching; or
(B) three ducts in trefoil, or in flat formation touching.
(ii) Single-core cables as a circuit in a single wiring enclosure.

(iii) Multicore cable in a single wiring enclosure.

NOTE: Table 3(4) contains a reference to the appropriate current-carrying capacity table for cables installed in underground wiring enclosures. See Clause 3.5.2.6 for spacing distances.

3.4.6 Variation of installation conditions along cable run

In situations where one method of installation is used for part of a cable run and other methods for the remainder, the current-carrying capacity of the cable run shall be limited to the lowest value of current determined for each method of installation employed, unless precautions to avoid cable overheating are taken.

3.5 EXTERNAL INFLUENCES ON CABLES

3.5.1 Application of rating factors

The current-carrying capacity of a cable will be affected by the presence of certain external influences as detailed in Clauses 3.5.2 to 3.5.8. Under such conditions the current-carrying capacity given in Tables 4 to 21 shall be corrected by the application of an appropriate rating factor or factors obtained from Tables 22 to 29.

3.5.2 Effect of grouping of cables

3.5.2.1 General

The current-carrying capacities given in Tables 4 to 21 relate to single circuits.

Where a number of circuits are installed in the same group in free air, on a surface, buried direct in the ground or within the same sheath or wiring enclosure, in such a way that they are not independently cooled by the ambient air or the ground, the appropriate derating factor shall be as given in Tables 26 to 30.

Specific guidance on the use of Tables 22 to 26 is given in Clauses 3.5.2.3 to 3.5.2.7 and Table 3.

NOTES:

1 The derating factors have been calculated on the basis of sustained operation of all cables within the group. In most instances the loading on all cables in the group will not occur simultaneously and as a result actual factors may vary from those in Tables 22 to 26. Actual values would need to be calculated according to loading.

2 Where cables of different temperature rating are grouped, they should be rated at the rating appropriate to the lowest temperature cable, unless adequate spacing is provided in accordance with Figure 1.

3.5.2.2 Installation conditions that avoid derating

The derating factors of Tables 22 to 26 are not applicable to the following conditions of grouped cables:

(a) MIMS cables MIMS cables without serving unless other types of cables are installed in close proximity or within the same wiring enclosure. The higher operating temperature achieved by grouping will not affect the mineral insulation of the unserved cable. However, care must be taken that the cable environment and means of support can withstand the higher temperatures.

NOTE: See Note 5 to Table 1.

(b) Limited length of grouping Groups of cables such as at a switchboard entry,

provided that the length of wiring enclosure does not exceed—
(i) for conductor sizes smaller than 300 mm_2 for aluminium or smaller than 150 mm_2 for copper: 1 m;
(ii) for conductor sizes of 300 mm_2 or larger for aluminium and 150 mm_2 or larger for copper: 3 m; or
(iii) half the length of the cable;
whichever is the shorter dimension.
(c) Groups of circuits in free air Groups of circuits installed unenclosed under the conditions and circuit arrangements depicted in Figure 1.
(d) Cables operating below current-carrying capacity Cables that, as a result of the conditions of operation of the installation or cable selection practices, are operating at
less than 35% of their current-carrying capacity (see Figure 1, Note 3).

3.5.2.3 Cables run horizontally

For cables installed horizontally the following shall apply:
(a) Unenclosed on cable tray, ladder support, rack hanger or cleat Where a single-core or multicore cable is installed horizontally in close proximity to a cable or cables of
another circuit and—
(i) it is on perforated or unperforated trays, ladder supports, racks, hangers or cleats; and
(ii) it is either—
(A) touching the other cable or cables; or
(B) in terms of its spacing from the other cable or cables, less than that specified in Clause 3.5.2.2(c) and Figure 1;
the appropriate derating factor shall be as given in Table 23 or Table 24.
(b) Enclosed, fixed to a surface, or bunched in free air Where a single-core or multicore cable is installed horizontally in close proximity to a cable or cables of another
circuit—
(i) within a wiring enclosure;
(ii) on a surface, wall, floor or ceiling, spaced or touching;
(iii) bunched in free air; or
(iv) suspended from a catenary;
the appropriate derating factor shall be as given in Table 22.

3.5.2.4 Cables run vertically

Where a cable is installed vertically, the appropriate current-carrying capacities and
derating factors shall be—
(a) obtained from Tables 22 to 24 as for cables run horizontally; and
(b) determined in accordance with Clause 3.5.3 using the highest ambient air temperature
up the cable run, if a barrier is not provided at intervals of 3.5 m or less to prevent the
vertical flow of air along the cable.

3.5.2.5 Cables buried direct in the ground

Where a single-core or multicore cable is buried directly in the ground and is separated by
not less than 2 m from a cable or cables of another circuit carrying substantial currents, no
derating factor need be applied. Where the circuits are separated by less than 2 m, the
appropriate derating factor shall be obtained from Table 25 or, for installation methods not

covered in this Standard, alternative specifications as recommended in Clause 1.3.

NOTE: The derating factors have been determined from the hottest cable in the group and assume that all cables are of the same thermal grade of insulation.

3.5.2.6 Cables in wiring enclosures

For cables in enclosures the following shall apply:

(a) Underground wiring enclosures Where a single-core or multicore cable is installed in an underground wiring enclosure and is separated by not less than 2 m from a cable or cables of another enclosed circuit carrying substantial currents, no derating factor need be applied. Where the enclosed circuits are separated by less than 2 m, the appropriate derating factor shall be as given in Table 26 or, for installation methods not covered in this Standard, alternative specifications as recommended in Clause 1.3.

(b) Other enclosures Where cables are installed in an enclosure such as a switchboard, the current-carrying capacity shall be determined from the unenclosed in air conditions in Tables 4 to 10 with due regard being given to the derating factors when circuits are bunched.

NOTE: The selection of the derating factor should be based on the number of circuits that would be loaded; for example, where nine circuits are bunched but only six are loaded at any one time, a derating factor of 0.57 from Table 22 would be applicable.

3.5.2.7 Conductors connected in parallel or passing more than once within a group or enclosure

In applying the derating factors of Tables 22 to 26 where—

(a) a group of conductors forming a circuit passes more than once through the same wiring enclosure, group of cables or group of enclosures; or

(b) groups of conductors are connected in parallel;

(a) each separate group of conductors shall be regarded as a separate circuit.

3.5.3 Effect of ambient temperature

The current-carrying capacities given in the tables of this Standard are based on a consistent ambient air temperature of 40°C and an ambient soil temperature of 25°C. Where other

(a) ambient temperatures apply, the appropriate rating factors shall be as given in Table 27

3.5.4 Effect of depth of laying

The current-carrying capacities given in the tables of this Standard are based on a depth of laying of 0.5 m as specified in Clauses 3.4.4 and 3.4.5. Where other depths of laying apply, the appropriate rating factors shall be as given in Table 28.

NOTE: The rating factors are based on the assumption that the effective thermal resistivity of the ground is constant from a depth of 0.5 m to 3 m. Above and below these respective limits it is considered that a reduction in effective thermal resistivity occurs due to the composition and moisture content of the soil.

3.5.5 Effect of thermal resistivity of soil

The current-carrying capacities given in the tables of this Standard are based on a soil thermal resistivity of 1.2°C.m/W.

Soil thermal resistivity varies greatly with soil composition, moisture retention qualities and
seasonal weather patterns as well as the variation in load carried by the cable. Higher
current-carrying capacities are obtained in clay or peat soils, which may have resistivities as
low as 0.8°C.m/W. Similarly, values as high as 2.5°C.m/W may be associated with well
drained sands for constantly loaded cables. The value of 1.2°C.m/W has been selected as an
average figure on the basis of soil types and assumes maximum thermal resistivity at times
of maximum load.
If possible the actual value should be measured along the cable route as it can greatly affect
the current-carrying capacity of the cable. Where values for soil resistivities other than

(a) 1.2°C.m/W apply, the appropriate rating factors may be obtained from Table 29.
(b) 3.5.6 Effect of varying loads
(c) The current-carrying capacities given in the tables of this Standard and the derating factors
(d) given in Clauses 3.5.2 to 3.5.5 are based on continuous loading on all conductors. Where it
(e) can be shown that intermittent load variations will occur or that all conductors cannot be
(f) loaded simultaneously, appropriate uprating factors may be applied.
(g) In many installations, groups of cables comprise a mixture of loaded and unloaded cables at
(h) any one time and the designer may justify the use of alternative derating factors to those
(i) specified in Tables 22 to 26, if the connected loads have a known diversity. If the diversity
(j) is unknown or unobtainable by experiment, the design may have to be based on worst-case
(k) analysis of the possible load combinations at any one time. Some information on the
(l) diversity of certain loads may be obtained from the determination of maximum demand in
(m) AS/NZS 3000.
(n) 3.5.7 Effect of thermal insulation
(o) Current-carrying capacities are given in Tables 4 to 15 of this Standard for unenclosed or
(p) enclosed cables surrounded by bulk thermal insulating materials that affect the rate of heat
(q) dissipation from the cables.
(r) The rate of heat dissipation varies with the type and thickness of material used. A
(s) comparative measure of the performance of different materials is known as the R-factor.
(t) The current-carrying capacity values in the tables are based upon typical installation
(u) conditions and a range of different materials as described in Clause 3.4.3. Where different

(v) materials or installation conditions are used such that the rate of heat dissipation is
(w) adversely or favourably affected, lower or higher current-carrying capacities may be
(x) obtained respectively.
(y) NOTES:
(z) 1 Where a length of cable not exceeding 150 mm passes through bulk thermal insulation,
(aa) e.g. for the connection of a lighting point, the cable need not be considered as being
(bb) surrounded by thermal insulation.
(cc) 2 A cable is considered to be affected by thermal insulation if it is embedded in, or surrounded
(dd) by, insulating material. Cables lying on top of suitably rigid material do not in general come
(ee) into this consideration.

3.5.8 Effect of direct sunlight

Current-carrying capacities are given in Tables 4 to 15, 20 and 21 for cables exposed to direct sunlight. For other types of cable installed in locations exposed to direct solar radiation it will be necessary to make some provision for the effects of the increased heating. This may be achieved by one of the following means:

(a) Provision of a shield, screen or enclosure that allows for the natural ventilation of the cable.

(b) Reduction of the current-carrying capacity of the cable by an appropriate amount in accordance with the higher air temperature. As a rule-of-thumb alternative to any recommendation from a cable manufacturer, a correction factor obtained from Table 27(1) for a temperature 20° higher than the ambient air temperature may be applied.

.5.9 Effect of harmonic currents on balanced three-phase systems

Where the neutral conductor carries current without a corresponding reduction in load of the phase conductors, the current flowing in the neutral conductor shall be taken into account in ascertaining the current-carrying capacity of the circuit.

This clause is intended to cover the situation where there is current flowing in the neutral of a balanced three-phase system. Such neutral currents are due to the line currents having a harmonic content that does not cancel in the neutral. The most significant harmonic that does not cancel in the neutral is usually the third harmonic. The magnitude of the neutral current due to the third harmonic may exceed the magnitude of the power frequency phase current. The neutral current will then have a significant effect on the current-carrying capacity of the cables in the circuit.

The reduction factors given in this Clause apply to balanced three-phase circuits; it is recognized that the situation is more onerous if only two of the three phases are loaded. In

this situation the neutral conductor will carry the harmonic currents in addition to the unbalanced current. Such a situation can lead to overloading of the neutral conductor.
Equipment likely to cause significant harmonic currents are, for example, fluorescent lighting banks and d.c. power supplies such as those found in computers.
The reduction factors given in Table 2 only apply to cables where the neutral conductor is within a four- or five-core cable and is of the same material and cross-sectional area as the phase conductors. These reduction factors have been calculated based on third harmonic currents. If significant, more than 10%, higher harmonics, 9_{th}, 12_{th}, etc. are expected then lower reduction factors are applicable. Where there is an unbalance between phases of more than 50% then lower reduction factors may be applicable.
The tabulated reduction factors, when applied to the current-carrying capacity of a cable with three loaded conductors, will give the current-carrying capacity of a cable with four loaded conductors where the current in the fourth conductor is due to harmonics. The reduction factors also take the heating effect of the harmonic current in the phase conductors into account.
Where the neutral current is expected to be higher than the phase current then the cable size should be selected on the basis of the neutral current.
Where the cable size selection is based on a neutral current that is not significantly higher than the phase current, it is necessary to reduce the tabulated current-carrying capacity for three loaded conductors.
If the neutral current is more than 135% of the phase current and the cable size is selected on the basis of the neutral current then the three-phase conductors will not be fully loaded.
The reduction in heat generated by the phase conductors offsets the heat generated by the neutral conductor to the extent that it is not necessary to apply any reduction factor to the current-carrying capacity for three loaded conductors.

3.5.10 Effect of parallel cables

Current-carrying capacities for circuits comprising parallel multicore cables or groups of single-core cables can be determined from the sum of the current-carrying capacity of the various cables provided that consideration is given to—
(a) grouping cables and the effect of cooling by the ambient air or the ground on each parallel cable or group; and

(b) load current sharing between each parallel cable or group so as to prevent overheating
of any cable or group.
Equal load current sharing is generally achieved by the selection and installation of cables
to give the same impedance, i.e. by using cables of the same conductor material and
construction installed over the same route. Mutual impedance is also affected by the
configuration of cables within and between each group.

NOTES:
1 Table D1 of Appendix D provides recommended circuit configurations for the installation of parallel single-core cables in electrically symmetric groups. The recommended method is to use trefoil groups containing each of the three-phase conductors and neutral in each group.
2 Unequal load current sharing between cables or groups may be permitted provided that the design current and overcurrent protection requirements for each cable or group are considered individually. IEC 60364-4-43 provides further information on the conditions under which this is permitted.

3.5.11 Effect of electromagnetic interference

Certain types of electrical installations, e.g. those containing sensitive electronic equipment
or systems, may require minimization of electromagnetic interference arising from magnetic
fields developed from current flowing in cables. This may be addressed by—
(a) selection of cables designed for low magnetic field emissions; or
(b) installation of cables in enclosures that contain or shield magnetic fields; or
(c) installation of cables in configurations that produce low magnetic fields.

NOTE: Table D1 of Appendix D provides recommended circuit configurations for the installation of parallel single-core cables in groups that produce reduced levels of magnetic field.

If cables are installed as described in activity 1, the cable will not be “de-rated”. If any variation to these installation conditions occurs the cable will have to be de-rated, this means its current carrying capacity will be lower, a larger cable c.s.a. may be required.

Topic 2 - De-rating Factors

Tables 2 and 22 to 29 of AS3008.1.1 show the de-rating factors that must be applied to cables if they have installation conditions that differ from Activity 2. The de-rating factor for grouping of circuits is listed in the final column of each table for tables 3(1) to 3(4) as shown in figures 2 and 3.

TABLE 3(1)

SCHEDULE OF INSTALLATION METHODS FOR CABLES DEEMED TO HAVE THE SAME CURRENT-CARRYING CAPACITY AND CROSS-REFERENCES TO APPLICABLE DERATING TABLES—UNENCLOSED IN AIR

1 Item No.	2 Cable details (see Note 2)	3 Reference drawing (see Note 3)	4 Current-carrying capacity table reference	5 Methods of installation for cables deemed to have the same current-carrying capacity (See Notes 4, 5 and 6)	6 Derating table for more than one circuit
1	Two single-core cables	0.3D, 0.3D, D, D, 0.5D	Tables 4 and 5 Columns 2 to 4 Table 6 Columns 2 and 3	Cables with minimum cable separation in air as shown for horizontal and vertical mounting and installed— (a) spaced from a wall or vertical surface; (b) supported on ladders, racks, perforated trays, cleats or hanger; or	23
2	Three single-core cables	0.3D, 0.3D, D, D, 0.5D	Tables 7 and 8 Columns 2 to 4 Table 9 Columns 2 and 3		
3				(c) suspended from a catenary wire.	22

figure 2.

Foot notes at the bottom tables 3(1) to 3(4) give guidance to which de-rating table to use for installation conditions other than the grouping of cables. As shown if figure 2.

figure 2.

Foot notes at the bottom tables 3(1) to 3(4) give guidance to which de-rating table to use for installation conditions other than the grouping of cables. As shown if figure 2.

			Columns 4 and 5	plaster or render on a wall;	22
13	Three-core cables		Tables 13 and 14 (see Note 4) Columns 5 to 7 Table 15 Columns 4 and 5	(c) in a ventilated trench or open trunking; or (d) in a switchboard or similar enclosure	

NOTES:

1 *D* equals the cable outside diameter or in the case of a flat multicore cable the maximum dimension of the cable.

2 Earthing conductors, lightly loaded neutral conductors of three-phase circuits and conductors subject only to momentary loading, such as control wiring, shall not be counted in the number of cable cores.

3 See column headings of Tables 4 to 15.

4 See Table 22 for the derating factor applicable to a single circuit fixed to the underside of a ceiling or similar horizontal surface.

5 See Tables 23 and 24 for the derating factors applicable to a single circuit fixed to perforated or unperforated trays.

6 See AS/NZS 3000 for the restricted installation conditions of certain types of cable, e.g. unarmoured cables in plaster or cement render on walls.

figure 3.

Do it yourself

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Activity - 3 - De-rating factors

Use AS 3008.1.1.

Read the suggested text or resource

Write a response

Determine the de-rating factor for	De-rating Factor	Table/Column
1. A single phase V75 T+E cable installed on perforated cable tray in a factory with a ambient air temperature of 55°C.		
2. A three phase V75 4 core +E cable installed in an underground conduit with a ambient soil temperature of 35°C.		
3. A three phase V75 4 core +E cable installed in an underground conduit at a depth of 0.6m.		
4. A three phase V75 4 core +E cable installed in an underground conduit with a soil thermal resistivity of 1.5°C.m/W		
5. A single phase V75 T+E cable installed on perforated cable tray in a factory		

If more than one de-rating factor is to be applied they are multiplied together e.g.
H.R.C. fuse = 0.9
Grouping of circuits = 0.8
Total de-rating applied to current carrying capacity of conductor
D.R. = 0.9 x 0.8 = 0.72

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When cables are secured to supports such as ladder or cable tray it is preferred to space the cables of different circuits from each other to allow the circulation of air around the conductors. If cables must be grouped it is better to group cables in small groups. If say 20 or more circuits are bunched on a surface or enclosed in the same conduit, they must be de-rated to 0.38 of their original current carrying capacity.

Activity - 4 - Installation conditions that avoid de-rating

Read AS3008.1.1 clause 3.5.2.2 (figure 1.)

Read the suggested

Write a response

1. Do unserved MIMS cables in the same wiring enclosure need to be de-rated due to grouping of cables? Y/N	
2. What is the maximum length of groups of copper cables that enter a switchboard if they are under 150mm^2?	
3. When installed in **free air**, and fixed to a wall, what horizontal distance is required between single core conductors of different circuits to avoid de-rating?	
4. When installed in **free air**, and fixed to a wall, what horizontal distance is required between multi core conductors of different circuits to avoid de-rating?	

3.5.2.2 Installation conditions that avoid derating

The derating factors of Tables 22 to 26 are not applicable to the following conditions of grouped cables:

(a) MIMS cables MIMS cables without serving unless other types of cables are installed in close proximity or within the same wiring enclosure. The higher operating temperature achieved by grouping will not affect the mineral insulation of the unserved cable. However, care must be taken that the cable environment and means of support can withstand the higher temperatures.

NOTE: See Note 5 to Table 1.

(b) Limited length of grouping Groups of cables such as at a switchboard entry, provided that the length of wiring enclosure does not exceed—

(i) for conductor sizes smaller than 300 mm^2 for aluminium or smaller than 150 mm^2 for copper: 1 m;

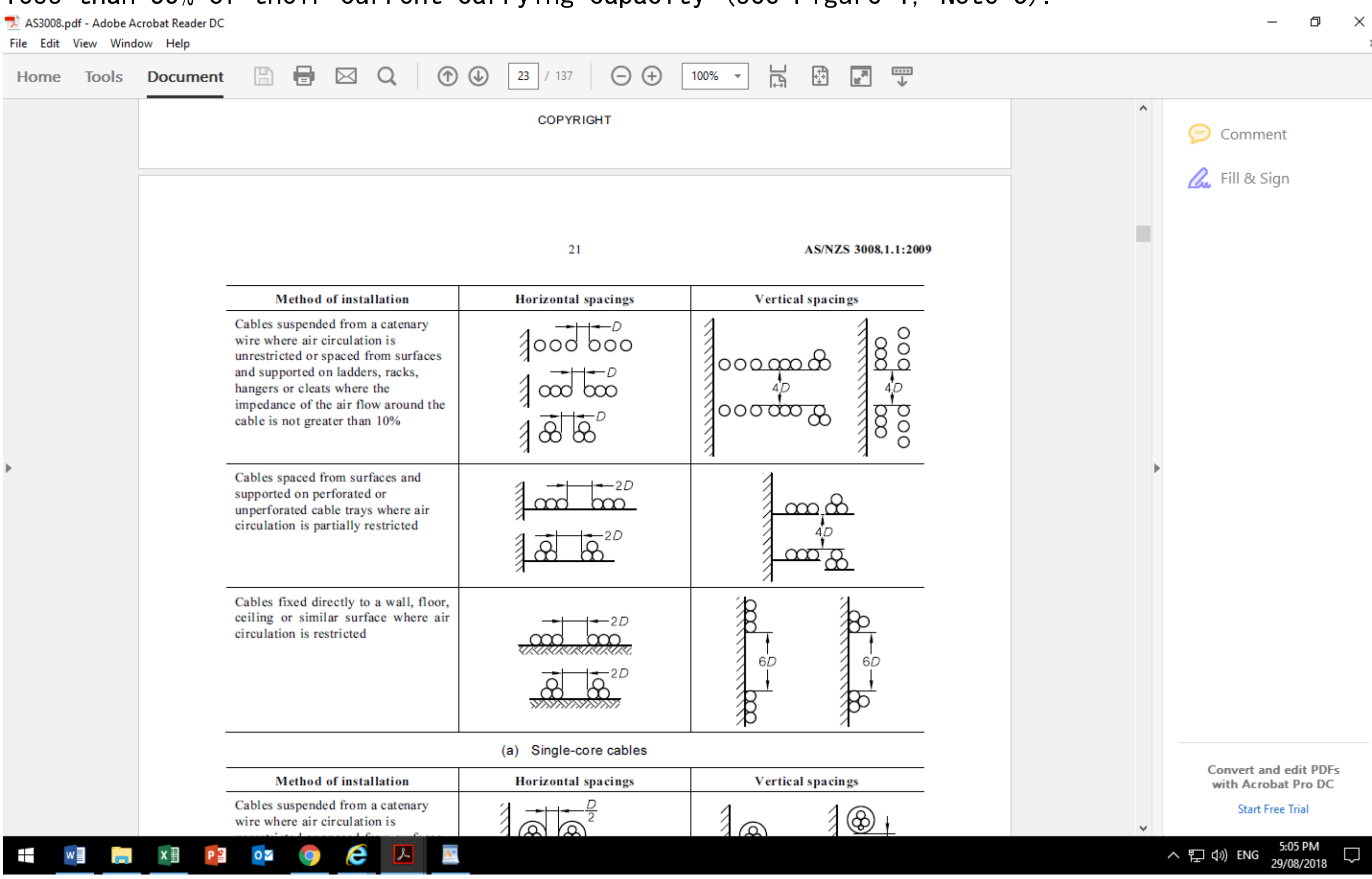
(ii) for conductor sizes of 300 mm^2 or larger for aluminium and 150 mm^2 or larger for copper: 3 m; or

(iii) half the length of the cable;

whichever is the shorter dimension.

(c) Groups of circuits in free air Groups of circuits installed unenclosed under the conditions and circuit arrangements depicted in Figure 1.

(d) Cables operating below current-carrying capacity Cables that, as a result of the conditions of operation of the installation or cable selection practices, are operating at less than 35% of their current-carrying capacity (see Figure 1, Note 3).



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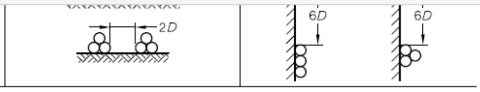
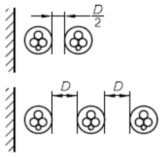
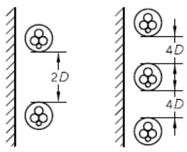
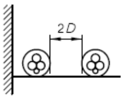
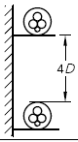
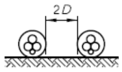
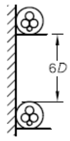


(a) Single-core cables

Method of installation	Horizontal spacings	Vertical spacings
Cables suspended from a catenary wire where air circulation is unrestricted or spaced from surfaces and supported on ladders, racks, hangers or cleats where the impedance of the air flow around the cable is not greater than 10%		
Cables spaced from surfaces and supported on perforated or unperforated cable trays where air circulation is partially restricted		
Cables fixed directly to a wall, floor, ceiling or similar surface where air circulation is restricted		

(b) Multicore cables

FIGURE 1 MINIMUM CABLE SPACINGS IN AIR TO AVOID DERATING

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How AS/NZS 3008.1.1 is organised.

Section	Purpose
Contents	Lists, sections, clause appendices tables and figures.
1	Scope, references and Section definitions.
2	Summary of cable selection procedure.
3	Cable selection based on current carrying capacity; includes Tables I to 29
4	Cable selection based on voltage drop; includes Tables 30 to 51.
5	Cable selection based on short circuit performance; includes Table 52 to 55
Appendices	Additional information to help apply the standard

Selecting Cable Size Based on Current Rating.

Selection of cable size based on current carrying capacity is based on;

$$I_B \leq I_N \leq I_Z$$

Determine the minimum current carrying capacity (I_Z) by:

- determining the current requirements, maximum demand (I_B) for the circuit;
- determine the current rating of the protective device (I_N) to be used. Table 8.1, 8.2 and B1 of AS 3000 shows standard protection device ratings up to 200A;
- decide which cable type and installation method to use;
- apply de-rating/rating factor from tables of AS/NZS 3008.1.1 for the installation environment conditions where applicable;

Determine the minimum current carrying capacity (I_Z) by:

- determining the current requirements, maximum demand (I_B) for the circuit;
- determine the current rating of the protective device (I_N) to be used. Table 8.1, 8.2 and B1 of AS 3000 shows standard protection device ratings up to 200A;
- decide which cable type and installation method to use;
- apply de-rating/rating factor from tables of AS/NZS 3008.1.1 for the installation environment conditions where applicable;

If a de-rating factor is to be used you will need to calculate a "look up current rating" or if you like a minimum current rating for the required cable to take to the tables as a reference to find cable size:-

$$I_{Z_{min}} = \frac{I_N}{\text{D.R. Factors}}$$

Select a minimum conductor size for the look up current rating (or next largest) from tables of AS/NZS 3008.1.1. The actual current rating of the cable under these conditions will be the current rating from the table times de-rating factor/s. If there is more than one de-rating factor the overall de-rating factor is the product of all de-rating factors that apply.

rating factors that apply.

Fabricate Assemble and Dismantle Utilities Industry Components Topic 1 Version 1 Page 149 of 374
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TAFE SWSi Section 5 – Cable selection based on current carrying capacity Miller College

Activity - 5 - Applying de-rating factors

A load has a maximum demand of 180A. The circuit will be protected by a 200A HRC fuse. Determine the minimum current carrying capacity of the cable.	Write a response
1.	
2. Is the statement $I_B \leq I_N \leq I_Z$ true? Y/N	

Current Carrying Capacities of Cables

The current carrying capacities for various types of commonly used cables and installation methods are given in Tables 4 to 21

TABLE 8.1

MAXIMUM VALUES OF EARTH FAULT-LOOP IMPEDANCE FOR THE TOTAL CIRCUIT INCLUDING THE SUPPLY TRANSFORMER (Z_s AT 230 V) VALUES RELATING TO OPERATION OF PROTECTIVE DEVICES ON THE FINAL SUBCIRCUIT

Protective device rating Amps	MCBs on the final subcircuit			Fuses on the final subcircuit	
	Type B	Type C	Type D		
	Disconnection times				
	0.4 s			0.4 s	5 s
	Maximum earth fault-loop impedance Z_s Ω				
6	9.6	5.1	3.1	11.5	15.3
10	5.8	3.1	1.8	6.4	9.2
16	3.6	1.9	1.2	3.1	5.0
20	2.9	1.5	0.9	2.1	3.6
25	2.3	1.2	0.7	1.6	2.7
32	1.8	1.0	0.6	1.3	2.2
40	1.4	0.8	0.5	1.0	1.6
50	1.2	0.6	0.4	0.7	1.3
63	0.9	0.5	0.3	0.6	0.9
80	0.7	0.4	0.2	0.4	0.7
100	0.6	0.3	0.2	0.3	0.5
125	0.5	0.2	0.1	0.2	0.4
160	0.4	0.2	0.1	0.2	0.3
200	0.3	0.2	0.1	0.1	0.2

NOTES:

* 1 Refer to AS/NZS 3017 for EFL tester tolerances. Refer to Table B1 for circuit route lengths of final subcircuits up to 200 A.

* 2 Refer to Paragraph B4.5 for MCB data used in these calculations.

* 3 MCB selection is based on instantaneous (0.1 s max) operation using the mean of the tripping value.

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									
	Active mm²	Earth mm²	0.4 s				0.4 s		5 s			
			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.

* 4 In addition, Table B1 also includes final subcircuit route length for voltage drops complying with Clause 3.6.2.

* 5 To comply with both earth fault loop and voltage drop route length the shortest route length is required.

8.3.10 Operation of RCDs

TABLE B1

CIRCUIT ROUTE LENGTHS BASED ON EARTH FAULT LOOP IMPEDANCE ASSUMING Z_{int} = 80% Z_s AND VOLTAGE DROP ON FINAL SUBCIRCUITS WITH A MAXIMUM DEMAND/DIVERSITY CURRENT OF 0.8I_N

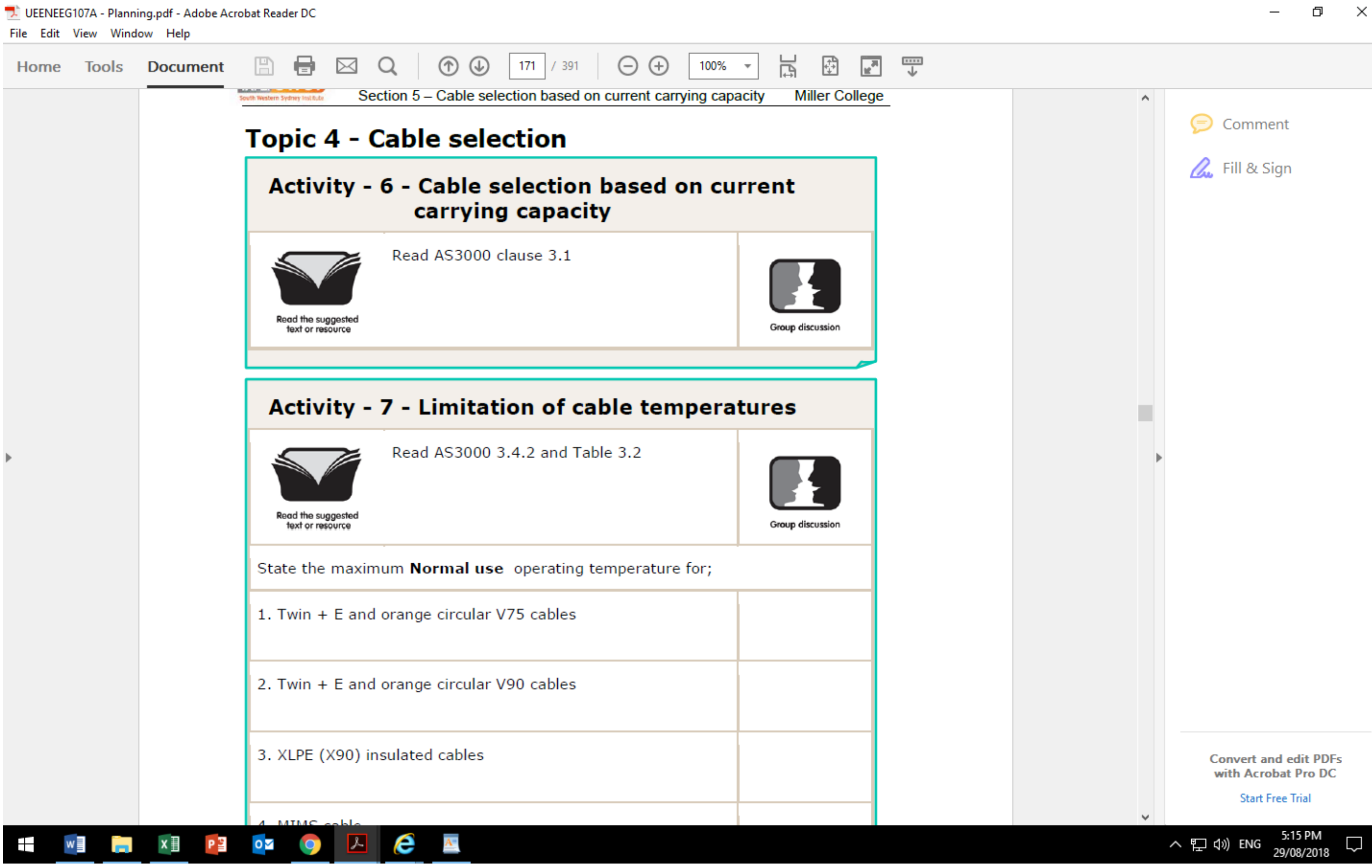
1	2	3	4	5	6	7	8	9	10	11	12
Final subcircuit route lengths based on earth fault loop impedance and voltage drop											
Copper conductor area, (mm²)		Circuit-breaker or fuse rated current I_N, (A)	Earth fault loop route length for Z_{int}, I_N, MCB C curve, (m)(1,2)	Final subcircuit route length to comply with voltage drop for a maximum demand current 0.8 × I_N(3,4)							Fuses to IEC 60269 (BS88 type for industrial use)
Active and neutral	Earth			V_c Table 41 AS/NZS 3008 at 60°C mV/A.m 3 phase(3)	Route length single phase (m)			Route length three phase (m)			Earth fault loop route length for Z_{int}, I_N based on mean operating current for ≤0.4 s
					2.5% voltage drop	3% voltage drop	4% voltage drop	2.5% voltage drop	3% voltage drop	4% voltage drop	
1	1	6	*91*	42.5	24	29	39	28	34	45	204
1	1	10	*55*	42.5	15	18	23	17	20	27	114
1.5	1.5	10	*82*	27.3	23	27	36	26	32	42	170
1.5	1.5	16	*51*	27.3	14	17	23	16	20	26	82
2.5	2.5	16	*85*	14.9	26	31	42	30	36	48	136
2.5	2.5	20	*68*	14.9	21	25	33	24	29	39	93
4	2.5	25	*67*	9.24	27	32	43	31	37	50	90
4	2.5	32	*52*	9.24	21	25	34	24	29	39	70
6	2.5	32	*60*	6.18	31	38	50	36	44	58	75
6	2.5	40	*48*	6.18	25	30	40	29	35	47	60
10	4	50	*62*	3.68	34	41	54	39	47	63	73
16	6	63	*76*	2.32	43	51	68	49	59	79	85

(continued)

200A HRC Fuse so earthfault impedance maximum is 0.1 ohm

TABLE B1 *(continued)*

1	2	3	4	5	6	7	8	9	10	11	12
Final subcircuit route lengths based on earth fault loop impedance and voltage drop											
Copper conductor area, (mm²)		Circuit-breaker or fuse rated current I_N, (A)	Earth fault loop route length for Z_{int}, I_N, MCB C curve, (m)(1,2)	Final subcircuit route length to comply with voltage drop for a maximum demand current 0.8 × I_N(3,4)							Fuses to IEC 60269 (BS88 type for industrial use)
Active and neutral	Earth			V_c Table 41 AS/NZS 3008 at 60°C mV/A.m 3 phase(3)	Route length single phase (m)			Route length three phase (m)			Earth fault loop route length for Z_{int}, I_N based on mean operating current for ≤0.4 s
					2.5% voltage drop	3% voltage drop	4% voltage drop	2.5% voltage drop	3% voltage drop	4% voltage drop	
16	6	80	*59*	2.32	34	40	54	39	46	62	59
25	6	80	*66*	1.47	53	63	85	61	73	98	66
25	6	100	*53*	1.47	42	51	68	49	59	78	47
35	10	100	*85*	1.07	58	70	93	67	81	107	75
35	10	125	*68*	1.07	47	56	74	54	64	86	58
50	16	125	*106*	0.801	62	75	99	72	86	115	90
50	16	160	*83*	0.801	49	58	78	56	67	90	71
70	25	160	*126*	0.571	68	82	109	79	94	126	108
70	25	200	*100*	0.571	54	65	87	63	76	101	84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Section 5 – Cable selection based on current carrying capacity   Miller College

Topic 4 - Cable selection

Activity - 6 - Cable selection based on current carrying capacity

Read the suggested text or resource | Read AS3000 clause 3.1 | Group discussion

Activity - 7 - Limitation of cable temperatures

Read the suggested text or resource | Read AS3000 3.4.2 and Table 3.2 | Group discussion

State the maximum **Normal use** operating temperature for;

1. Twin + E and orange circular V75 cables	
2. Twin + E and orange circular V90 cables	
3. XLPE (X90) insulated cables	
4. MIMS cable	

3.1 GENERAL

3.1.1 Application

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

3.1.2 Selection and installation

Wiring systems shall be selected and installed to perform the following functions or have the following features:

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

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

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

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

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

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

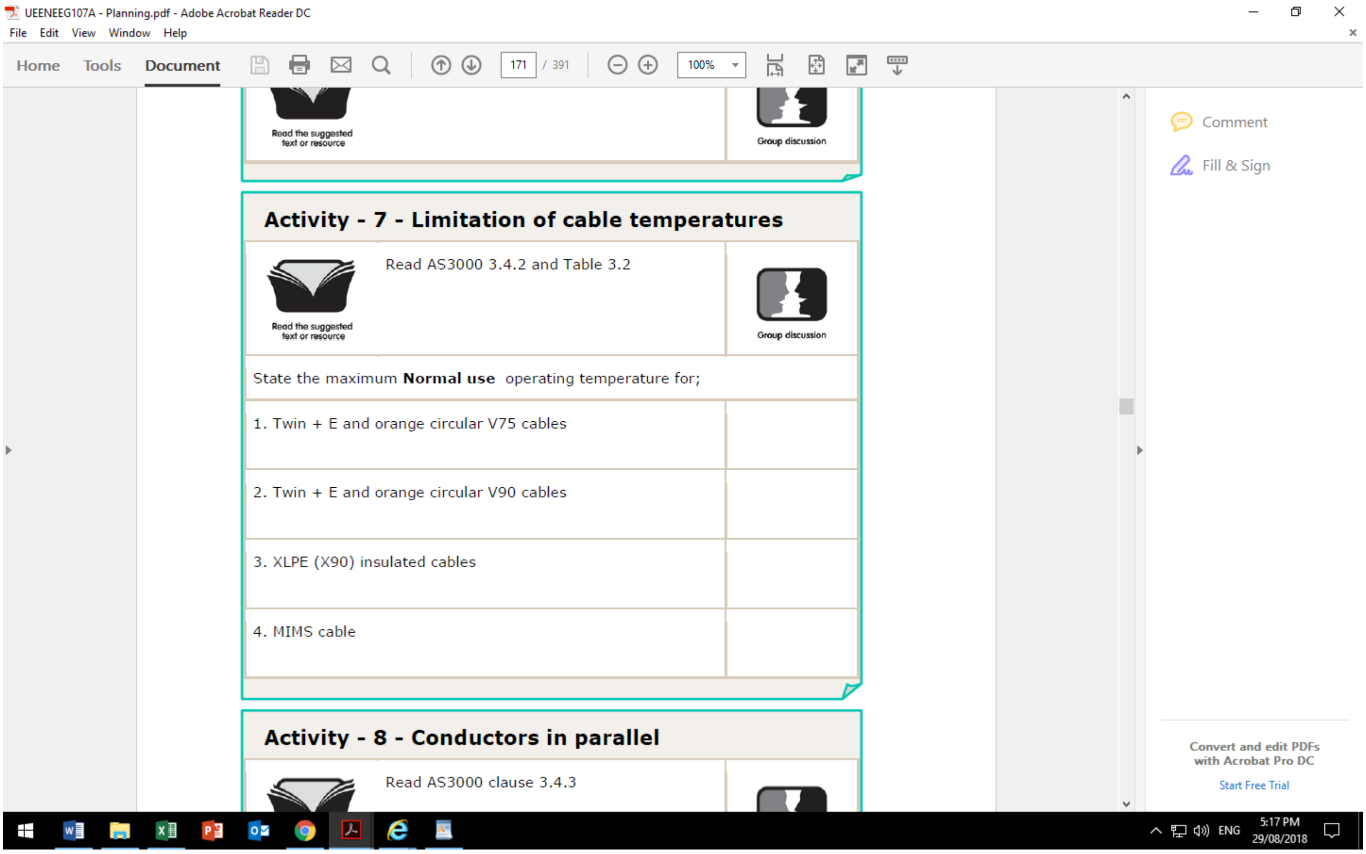
(g) Installed in accordance with the requirements of this Section and the additional requirements as specified in the manufacturer's instructions.

3.2 TYPES OF WIRING SYSTEMS

The type of wiring system and method of installation used shall either—

(a) comply with Table 3.1; or

(b) have a degree of safety equivalent to that given in Table 3.1.



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Read the suggested text or resource | Group discussion

Activity - 7 - Limitation of cable temperatures

Read the suggested text or resource	Read AS3000 3.4.2 and Table 3.2	Group discussion

State the maximum **Normal use** operating temperature for;

1. Twin + E and orange circular V75 cables	
2. Twin + E and orange circular V90 cables	
3. XLPE (X90) insulated cables	
4. MIMS cable	

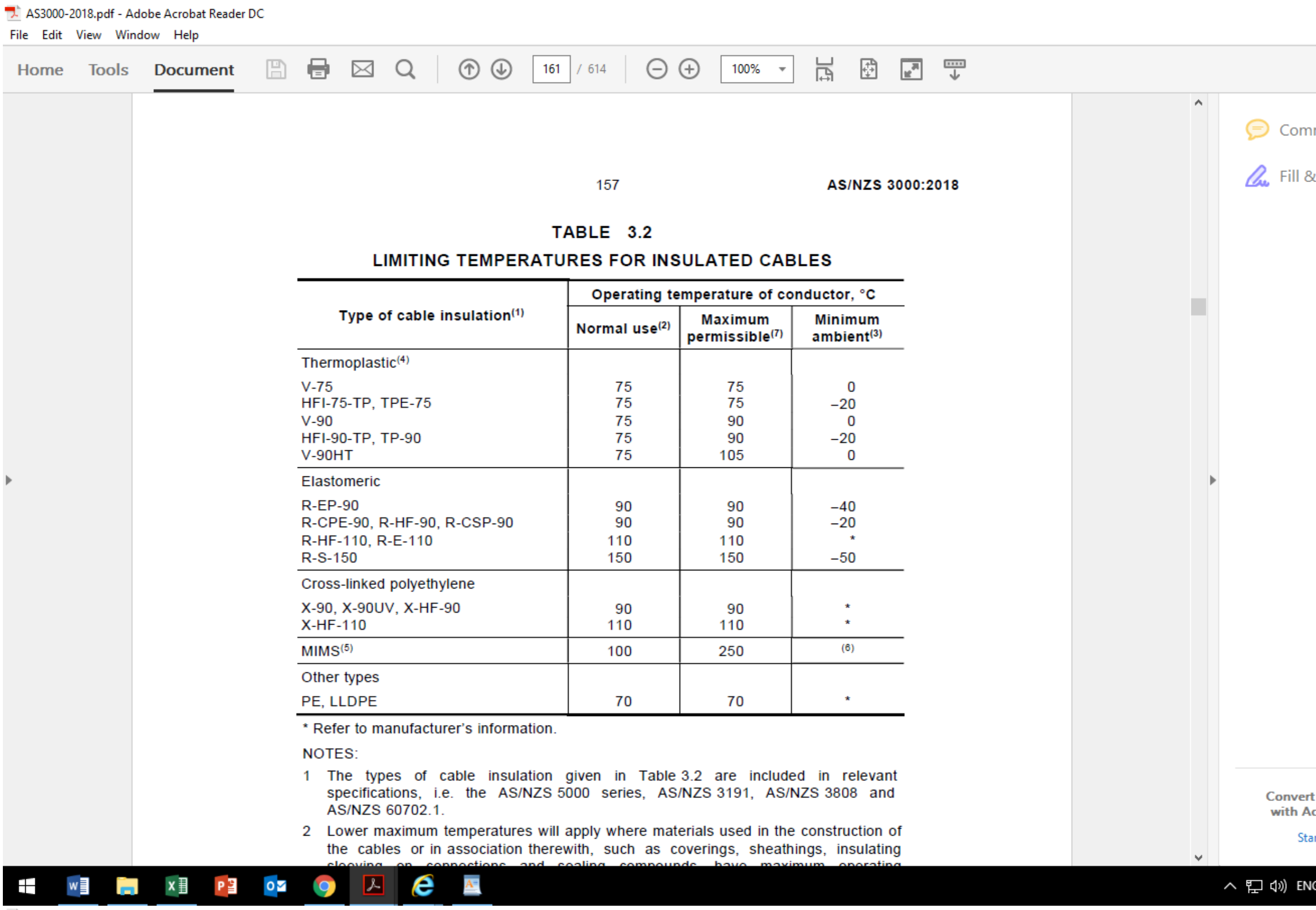
Activity - 8 - Conductors in parallel

Read AS3000 clause 3.4.3

3.4.2 Operating temperature limits

The operating temperatures of conductors shall not exceed the limits given in Table 3.2.

Polymeric cables with normal use temperatures below 75° C (see Notes to Table 3.2) are deemed not suitable for Australian or New Zealand conditions.



157 AS/NZS 3000:2018

TABLE 3.2

LIMITING TEMPERATURES FOR INSULATED CABLES

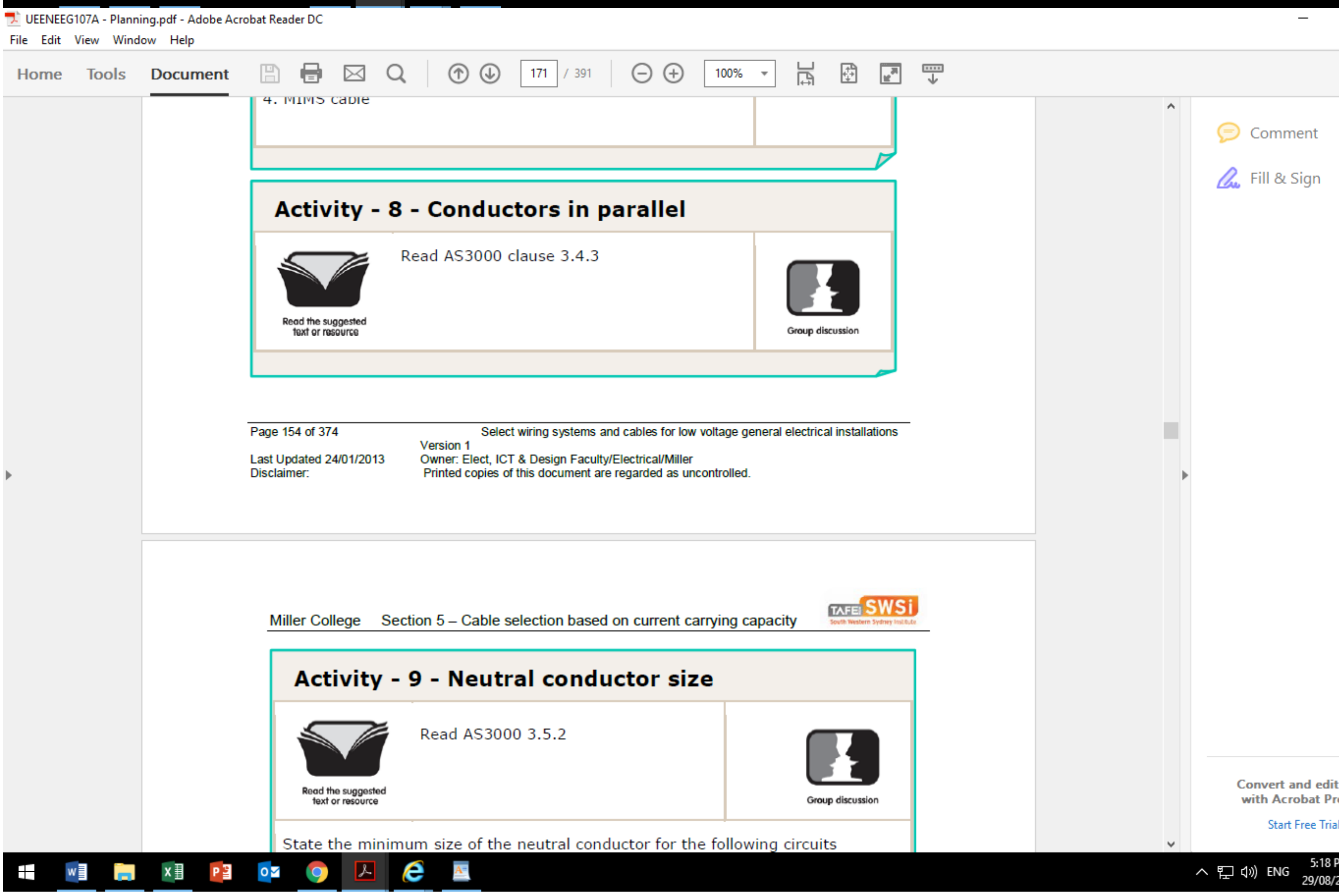
Type of cable insulation[1]	Operating temperature of conductor, °C Normal use[2]	Maximum permissible[7]	Minimum ambient[3]
Thermoplastic[4]			
V-75	75	75	0
HFI-75-TP, TPE-75	75	75	−20
V-90	75	90	0
HFI-90-TP, TP-90	75	90	−20
V-90HT	75	105	0
Elastomeric			
R-EP-90	90	90	−40
R-CPE-90, R-HF-90, R-CSP-90	90	90	−20
R-HF-110, R-E-110	110	110	*
R-S-150	150	150	−50
Cross-linked polyethylene			
X-90, X-90UV, X-HF-90	90	90	*
X-HF-110	110	110	*
MIMS[5]	100	250	(6)
Other types			
PE, LLDPE	70	70	*

* Refer to manufacturer's information.

NOTES:

1 The types of cable insulation given in Table 3.2 are included in relevant specifications, i.e. the AS/NZS 5000 series, AS/NZS 3191, AS/NZS 3808 and AS/NZS 60702.1.

2 Lower maximum temperatures will apply where materials used in the construction of the cables or in association therewith, such as coverings, sheathings, insulating



Activity - 8 - Conductors in parallel

Read AS3000 clause 3.4.3

Read the suggested text or resource

Group discussion

Page 154 of 374 Select wiring systems and cables for low voltage general electrical installations

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Miller College Section 5 – Cable selection based on current carrying capacity

Activity - 9 - Neutral conductor size

Read AS3000 3.5.2

Read the suggested text or resource

Group discussion

State the minimum size of the neutral conductor for the following circuits

3.4.3 Conductors in parallel

Current-carrying capacities for circuits comprising parallel multi-core cables or groups of single-core cables may be determined from the sum of the current-carrying capacity of the various cables connected in parallel provided that the following requirements are met:

(a) Cables shall be not less than 4 mm^2.
(b) Grouping of cables shall not affect the cooling of each parallel cable, or group, by the ambient air or the ground.
(c) The load current sharing between each parallel cable or group shall be sufficient to prevent overheating of any cable or group.
Example:
Equal load current sharing may be achieved by the selection and installation of cables to give the same impedance for each cable in the group. This condition is satisfied when—
(i) conductors are of the same material and cross-sectional area with a minimum size of 4 mm^2;
(ii) cables follow the same route and achieve the same length;

3.5.2 Neutral conductor
The minimum size of the neutral conductor shall be as follows:
(a) Single-phase two-wire circuit The neutral conductor or conductors of a single-phase consumer main, submain or final subcircuit shall have a current-carrying capacity not less than—
(i) the current-carrying capacity of the associated active conductor; or
(ii) the total current to be carried, where there is more than one active conductor.
(b) Multiphase circuit The current-carrying capacity of the neutral conductor of a multiphase circuit shall not be less than that determined in accordance with the following:
(i) Harmonic currents Where a consumer main, submain or final subcircuit supplies a substantial load that generates harmonic currents, e.g. fluorescent lighting, computers, soft starters, variable speed devices or other electronic devices, the third and any higher order harmonic current generated in the equipment

Activity - 10 - Protective earthing conductor size

Read AS3000 5.3.3.1.2

Read the suggested text or resource

Group discussion

State the minimum size of the protective earthing /main earthing conductor for the following circuits;

1. 2.5 mm² TPI copper active conductors enclosed in L.D. PVC conduit.	
2. 1.0 mm² TPI copper active conductors enclosed in L.D. PVC conduit.	
3. 1.0 mm² TPI copper active conductors in a V90 T+E cable.	
4. A 10mm² copper, 3 phase XLPE single core final sub-circuit installed on cable tray.	
5. A main earthing conductor, if the consumers mains are single phase 16mm² copper XLPE cables.	
6. Sub-mains are 3 phase 95mm² copper XLPE single core cables installed in underground enclosures.	
7. Sub-mains are 3 phase 95mm² Aluminium XLPE single core cables installed in underground enclosures.	
8. A main earthing conductor, if the consumers mains are 3 phase 240mm² copper XLPE cables.	
9. A main earthing conductor, if the consumers mains are 3 phase 240mm² aluminium XLPE cables.	

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.

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

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

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

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Activity - 11 - Cable selection

Write a response

Using AS3008.1.1:2009 determine the minimum allowable cable size.

The maximum demand current of a submain cable, has been calculated to be 172 amperes. The type of cable to be used is a 4 core, non armoured, V75 insulated and sheathed circular cable with copper conductors. The cable is to be clipped directly to a vertical surface, open to the air and is to be protected by a circuit breaker with fixed current setting.

Minimum Circuit Breaker Rating that could be used	
Table Number 3(?) / Item Number	
Table Number / Column Number	
Cable Size	
Protective earthing conductor cable size	
Coordination between conductors and protective devices (AS3000 2.5.3.1)	
I_B = Maximum demand current	
I_N = Nominal current rating of the selected protective device	
I_Z = Current Carrying Capacity of the selected cable after any de-rating has been considered.	
Is $I_B \le I_N \le I_Z$?	
Would the cable need to be upgraded?	
If so, select the new cable size.	

Do it yourself

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Activity - 12 - Cable selection

Using AS3008.1.1:2009 determine the minimum allowable cable size.

The maximum demand current for the sub-mains of a non-domestic installation has been calculated to be 135 amperes. The type of cable to be used is four single core, non-armoured, XLPE insulated, sheathed copper cables laid touching in open trunking. The cables are to be protected by a circuit breaker.

Minimum Circuit Breaker Rating that could be used	
Table Number 3(?) / Item Number	
Table Number / Column Number	
Cable Size / Current rating from table	
Protective earthing conductor cable size	
Coordination between conductors and protective devices (AS3000 2.5.3.1)	
I_B = Maximum demand current	
I_N = Nominal current rating of the selected protective device	
I_Z = Current Carrying Capacity of the selected cable after any de-rating has been considered.	
Is $I_B \leq I_N \leq I_Z$?	
Would the cable need to be upgraded?	
If so, select the new cable size.	

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Activity - 13 - Cable selection

Using AS3008.1.1:2009 determine the minimum allowable cable size.

One circuit, consisting of three single core V75 insulated, unsheathed non-armoured cables with copper conductors is to carry 155 amperes and be enclosed in non-metallic pipe buried in the ground to a depth of 1.25 metres below the ground surface in an ambient soil temperature of 25 degrees Celsius. Protection for the circuit is via circuit breakers. Determine the minimum permissible cable size of the circuit.

Minimum Circuit Breaker Rating	
Table Number 3(?) / Item Number	
Table Number / Column Number	
Cable Size / Current rating from table	
Protective earthing conductor cable size	
Coordination between conductors and protective devices (AS3000 2.5.3.1)	
I_B = Maximum demand current	
I_N = Nominal current rating of the selected protective device	
I_Z = Current Carrying Capacity of the selected cable after any de-rating has been considered.	
Is $I_B \leq I_N \leq I_Z$?	
Would the cable need to be upgraded?	
If so, select the new cable size.	

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Activity - 14 - Cable selection

Write a response

Using AS3008.1.1:2009 determine the minimum allowable cable size.

Find the minimum size served MIMS single core cable to supply a distribution board for safety services with a maximum demand of 80A per phase. The cables are laid in trefoil on perforated cable tray spaced from other conductors. The serving of the cable is suitable for a copper sheath temperature of 105° C. Circuit protection is C.B.

Minimum Circuit Breaker Rating	
Table Number 3(?) / Item Number	
Table Number / Column Number	
Cable Size / Current rating from table	
Protective earthing conductor cable size	
Coordination between conductors and protective devices (AS3000 2.5.3.1)	
I_B = Maximum demand current	
I_N = Nominal current rating of the selected protective device	
I_Z = Current Carrying Capacity of the selected cable after any de-rating has been considered.	
Is $I_B \leq I_N \leq I_Z$?	
Would the cable need to be upgraded?	
If so, select the new cable size.	

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Activity - 15 - Cable Current Carrying Capacity

Write a response

Using AS3008.1.1:2009 determine the maximum allowable cable current carrying capacity.

A C.B. protected 4 core + E, 10 mm² V75 orange circular cable laid flat touching two other circuits on perforated cable tray.

Table Number 3(?) / Item Number	
Initial Current Carrying Capacity	
Table Numbers / Column Numbers	
De-rating factors	
Table Numbers / Column Numbers	
Current Carrying Capacity after de-rating	
Maximum Circuit Breaker Rating	
Coordination between conductors and protective devices (AS3000 2.5.3.1)	
I_B = Maximum demand current	
I_N = Nominal current rating of the selected protective	
I_Z = Current Carrying Capacity of the selected cable	
Is $I_B \leq I_N \leq I_Z$?	

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Activity - 16 - Cable Current Carrying Capacity

Write a response	Using AS3008.1.1:2009 determine the maximum allowable cable current carrying capacity.

A H.R.C. fuse protected 4 core + E, 16 mm² Aluminium XLPE circular cable laid flat touching one other circuit on perforated cable tray.

Table Number 3(?) / Item Number	
Initial Current Carrying Capacity	
Table Numbers / Column Numbers	
De-rating factors	
Table Numbers / Column Numbers	
Current Carrying Capacity after de-rating	
Maximum H.R.C. fuse Rating	
Coordination between conductors and protective devices (AS3000 2.5.3.1)	
I_B = Maximum demand current	
I_N = Nominal current rating of the selected protective	
I_Z = Current Carrying Capacity of the selected cable	
Is $I_B \le I_N \le I_Z$?	

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Activity - 17 - Cable Current Carrying Capacity

Write a response	Using AS3008.1.1:2009 determine the maximum allowable cable current carrying capacity.

Two single core, 4 mm² V75 TPI conductors enclosed in medium duty conduit in a concrete slab above the ground with three other circuits. C.B. protected

Table Number 3(?) / Item Number	
Initial Current Carrying Capacity	
Table Numbers / Column Numbers	
De-rating factors	
Table Numbers / Column Numbers	
Current Carrying Capacity after de-rating	
Maximum Circuit Breaker Rating	
Coordination between conductors and protective devices (AS3000 2.5.3.1)	
I_B = Maximum demand current	
I_N = Nominal current rating of the selected protective	
I_Z = Current Carrying Capacity of the selected cable	
Is $I_B \le I_N \le I_Z$?	

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Activity - 18 - Cable Current Carrying Capacity

Write a response

Using AS3008.1.1:2009 determine the maximum allowable cable current carrying capacity.

A submain to an out building is installed burried direct in the ground, single core XLPE 120 mm² Aluminium cables laid in trefoil spaced from another circuit by 300 mm at a depth of 0.5m. The cable is C.B. protected.

Table Number 3(?) / Item Number	
Initial Current Carrying Capacity	
Table Numbers / Column Numbers	
De-rating factors	
Table Numbers / Column Numbers	
Current Carrying Capacity after de-rating	
Maximum Circuit Breaker Rating	
Coordination between conductors and protective devices (AS3000 2.5.3.1)	
I_B = Maximum demand current	
I_N = Nominal current rating of the selected protective	
I_Z = Current Carrying Capacity of the selected cable	
Is $I_B \leq I_N \leq I_Z$?	

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Activity - 19 - Cable Current Carrying Capacity

Write a response

Using AS3008.1.1:2009 determine the maximum allowable cable current carrying capacity.

A single phase submain consisting of two single core 16mm² V75 Cu cables installed in an underground enclosure. The enclosure is buried at a depth of 0.5m and touches two other circuits. All circuits are in separate enclosures. The cable is C.B. protected.

Table Number 3(?) / Item Number	
Initial Current Carrying Capacity	
Table Numbers / Column Numbers	
De-rating factors	
Table Numbers / Column Numbers	
Current Carrying Capacity after de-rating	
Maximum Circuit Breaker Rating	
Coordination between conductors and protective devices (AS3000 2.5.3.1)	
I_B = Maximum demand current	
I_N = Nominal current rating of the selected protective	
I_Z = Current Carrying Capacity of the selected cable	
Is $I_B \leq I_N \leq I_Z$?	

Adjustable Circuit Breakers (200A - 400A)

When a circuit requires a protection device larger than 200A an adjustable circuit breaker may be used to match the setting of the breaker to the capacity of the cable. This way no capacity between the preset size of the breaker and the cable is lost.

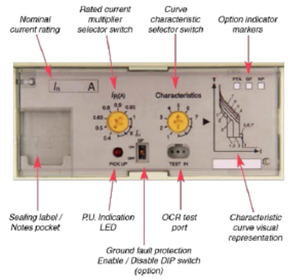

figure 10. - www.nhp.com.au

Figure 10 shows how the current rating of the device can be adjusted between 100 to 40% of its rated value. Nominal ratings of adjustable circuit breakers are typically 250 and 400A.

Setting $$\% = \frac{I_Z}{I_N} \times \frac{100}{1}$$

Circuit Breaker Increment Settings

1.0 **0.95** 0.9 0.8 0.63 0.5 0.4

Example 1

Four single core 70 mm² XLPE copper cables are installed laid flat touching as a single circuit on cable ladder. What size and current setting of an adjustable C.B. will allow the full optimisation of the cable current carrying capacity.

Table 3(1) Item 5 Tables 8 column 5 to 7 CCC = 240A

Setting $$\% = \frac{I_Z}{I_N} \times \frac{100}{1} = \frac{240}{250} \times \frac{100}{1} = 96\ \%$$

A 250 C.B. is now set to **95%** of its rated value to match the protection device to the cable rating. Had a preset C.B. been used a 95mm² cable would have been required.

Activity - 20 - Adjustable circuit breakers

Write a response

Using AS3008.1.1:2009 determine the maximum allowable cable current carrying capacity.

A 150 mm² Aluminium XLPE 4 core + E cable is installed burried direct in the ground at depth of 0.5 m, as a single circuit. Select a suitable size and current setting for a C.B to protect the cable.

Table Number 3(?) / Item Number	
Initial Current Carrying Capacity	
Table Numbers / Column Numbers	
De-rating factors	
Table Numbers / Column Numbers	
Current Carrying Capacity after de-rating	
Maximum Circuit Breaker Rating	
Circuit Breaker setting	
Coordination between conductors and protective devices (refer to clause 2.5.3.1)	
I_B = Maximum demand current	
I_N = Nominal current rating of the selected protective	
I_Z = Current Carrying Capacity of the selected cable	
Is $I_B \le I_N \le I_Z$?	

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Activity - 21 - Adjustable circuit breakers

Write a response

Using AS3008.1.1:2009 determine the maximum allowable cable current carrying capacity.

Four 120 mm² copper XLPE single core cables are installed in trefoil touching one other circuit on a single tier cable ladder. Select a suitable size and setting for a C.B to protect the cable.

Table Number 3(?) / Item Number	
Initial Current Carrying Capacity	
Table Numbers / Column Numbers	
De-rating factors	
Table Numbers / Column Numbers	
Current Carrying Capacity after de-rating	
Maximum Circuit Breaker Rating	
Circuit Breaker setting	
Coordination between conductors and protective devices (refer to clause 2.5.3.1)	
I_B = Maximum demand current	
I_N = Nominal current rating of the selected protective	
I_z = Current Carrying Capacity of the selected cable	
Is $I_B \leq I_N \leq I_Z$?	

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Paralleling Cables

To increase the current carrying capacity of a circuit, the conductors may be run in parallel. Smaller conductors are used allowing a tighter radius when bending, and easier installation, than one single larger conductor. The cables used in parallel must be identical in material, c.s.a. and root length. The current rating of the parallel group is; 2 x the single cable current rating x any de-rating applicable including grouping.

Activity - 22 - Conductors in parallel

Read AS 3000 clause 3.4.3 Read the suggested text or resource	Write a response
What is the minimum size of a cable that can be connected in a parallel group?	

Example 2

Determine the current carrying capacity of two sets of 70mm² copper single core XLPE cables laid in trefoil on cable ladder. Each set is touching the other. Protection is by H.R.C. fuse.

Table 3(1) Item 5	Tables 8	column 5	CCC = 240A
D.R. Gouping	Table 23	column 7	2 circuits = 0.95
D.R. H.R.C. fuse	0.9		

I_Z = 2 x 240 x 0.95 x 0.9 = 410A

Select a 400A H.R.C. fuse as protection device

I_B = 400A

I_N = 400A

I_Z = 410A

Is $I_B \leq I_N \leq I_Z$? Yes

3.4.3 Conductors in parallel

Current-carrying capacities for circuits comprising parallel multi-core cables or groups of single-core cables may be determined from the sum of the current-carrying capacity of the various cables connected in parallel provided that the following requirements are met:

(a) Cables shall be not less than 4 mm2.

(b) Grouping of cables shall not affect the cooling of each parallel cable, or group, by the ambient air or the ground.
(c) The load current sharing between each parallel cable or group shall be sufficient to prevent overheating of any cable or group.

Example:

Equal load current sharing may be achieved by the selection and installation of cables to give the same impedance for each cable in the group. This condition is satisfied when–

(i) conductors are of the same material and cross-sectional area with a minimum size of 4 mm^2;

(ii) cables follow the same route and achieve the same length;

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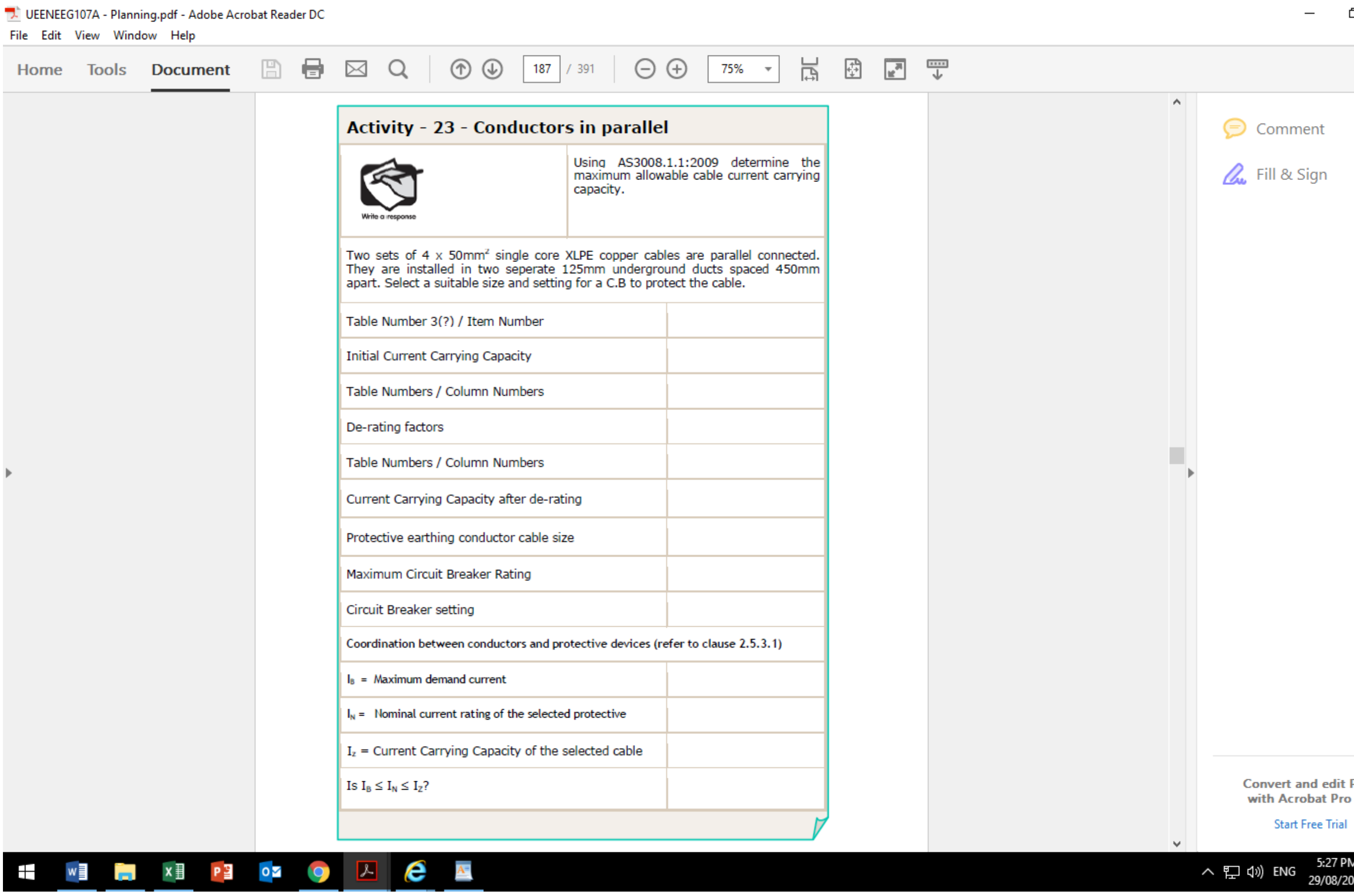
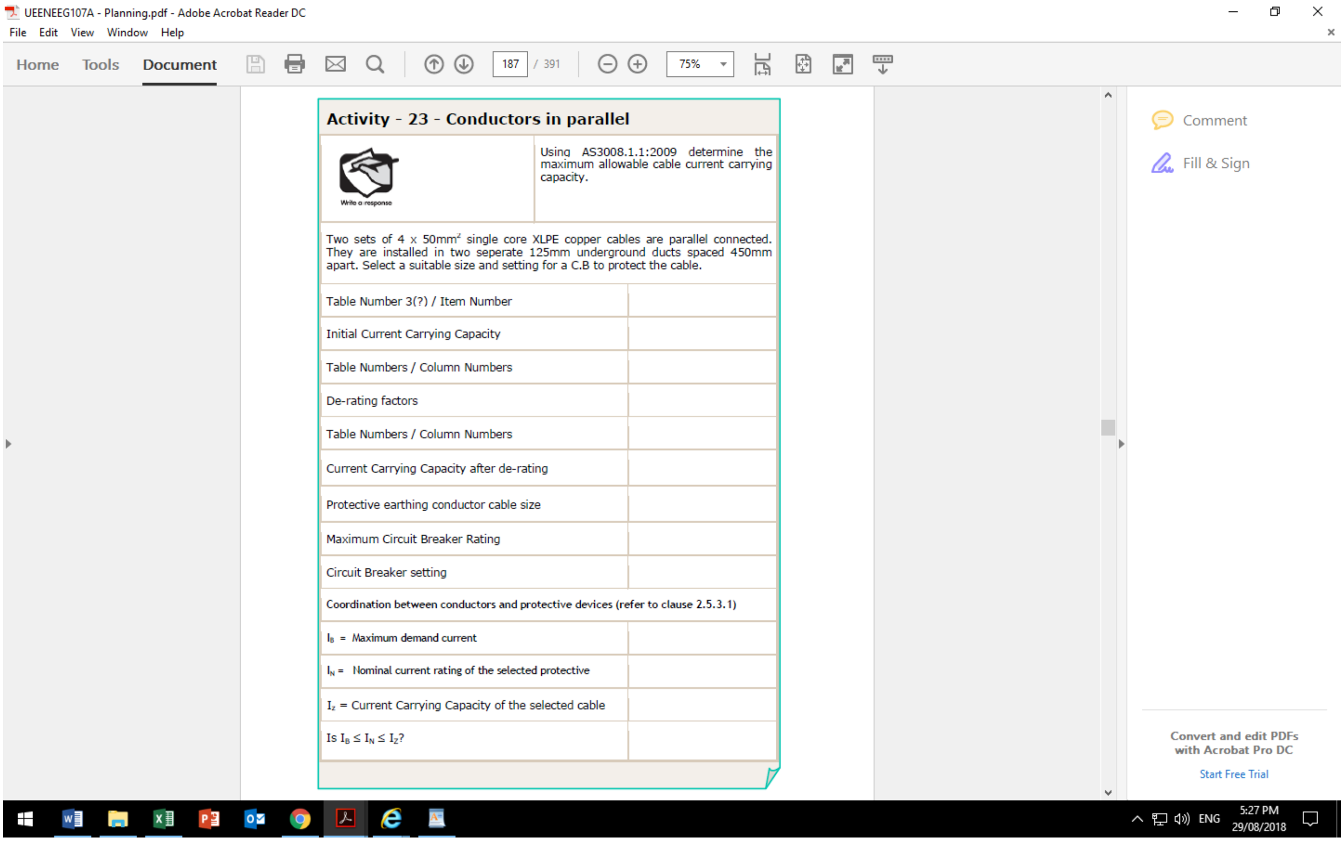


Activity - 23 - Conductors in parallel

Using AS3008.1.1:2009 determine the maximum allowable cable current carrying capacity.

Two sets of 4 x 50mm² single core XLPE copper cables are parallel connected. They are installed in two seperate 125mm underground ducts spaced 450mm apart. Select a suitable size and setting for a C.B to protect the cable.

Table Number 3(?) / Item Number	
Initial Current Carrying Capacity	
Table Numbers / Column Numbers	
De-rating factors	
Table Numbers / Column Numbers	
Current Carrying Capacity after de-rating	
Protective earthing conductor cable size	
Maximum Circuit Breaker Rating	
Circuit Breaker setting	
Coordination between conductors and protective devices (refer to clause 2.5.3.1)	
I_B = Maximum demand current	
I_N = Nominal current rating of the selected protective	
I_Z = Current Carrying Capacity of the selected cable	
Is $I_B \leq I_N \leq I_Z$?	



Activity - 23 - Conductors in parallel

Write a response

Using AS3008.1.1:2009 determine the maximum allowable cable current carrying capacity.

Two sets of 4 x 50mm² single core XLPE copper cables are parallel connected. They are installed in two seperate 125mm underground ducts spaced 450mm apart. Select a suitable size and setting for a C.B to protect the cable.

Table Number 3(?) / Item Number	
Initial Current Carrying Capacity	
Table Numbers / Column Numbers	
De-rating factors	
Table Numbers / Column Numbers	
Current Carrying Capacity after de-rating	
Protective earthing conductor cable size	
Maximum Circuit Breaker Rating	
Circuit Breaker setting	
Coordination between conductors and protective devices (refer to clause 2.5.3.1)	
I_B = Maximum demand current	
I_N = Nominal current rating of the selected protective	
I_Z = Current Carrying Capacity of the selected cable	
Is $I_B \leq I_N \leq I_Z$?	

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.

The value of current used for the calculation of voltage drop on a circuit need not exceed the—

(a) total of the connected load supplied through the circuit;

(b) maximum demand of the circuit; or

(c) current rating of the circuit protective device.

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$$V_{DROP} = I \times R_{cable}$$

Factors that determine the voltage drop in a cable are the;

- length of the cable.
- c.s.a. of the cable.
- current flowing in the cable.
- type of material of the cable (copper or aluminium).
- operating temperature of the cable and ability to dissipate heat
- installation method of the cable. (trefoil, laid flat or in a multi-core cable).

The voltage drop on any given combination of the above can be predicted before the cable is selected and installed by using tables 40 t0 51 of Section 4 of AS3008.1.1 (2009).

Section	Purpose
Contents	Lists, sections, clause appendices tables and figures.
1	Scope, references and Section definitions.
2	Summary of cable selection procedure.
3	Cable selection based on current carrying capacity; includes Tables I to 29
4	Cable selection based on voltage drop; includes Tables 30 to 51.
5	Cable selection based on short circuit performance; includes Table 52 to 55
Appendices	Additional information to help apply the standard

table 1

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4.2 DETERMINATION OF VOLTAGE DROP FROM MILLIVOLTS PER AMPERE METRE

The voltage drop (mV/A.m) values given in Tables 40 to 50 are for various cable types and configurations and maximum operating temperatures.

In applying these voltage drop values, the smallest permissible conductor is the smallest that satisfies the following equations:

$$V_c = \frac{1000 V_d}{L \times I} \qquad \ldots 4.2(1)$$

$$V_d = \frac{L \times I \times V_c}{1000} \qquad \ldots 4.2(2)$$

$V_p \geq$ sum of V_d on circuit run

where

V_c = the millivolt drop per ampere-metre route length of circuit, as shown in the tables for various conductors, in millivolts per ampere metre (mV/A.m)

NOTES:

1 To convert single-phase voltage drop (mV/A.m) values to three-phase values, multiply the single-phase values by 0.866 $\left(\frac{\sqrt{3}}{2}\right)$. To convert three-phase values to single-phase values, multiply the three-phase values by 1.155 $\left(\frac{2}{\sqrt{3}}\right)$.

2 Paragraph C4 and C7 of AS/NZS 3000:2007 details a simplified method of calculating the voltage drop for PVC cables up to 95 mm^2, operating at 75°C with maximum values of V_c. The method allows the addition of single phase and three phase percentages.

V_d = actual voltage drop, in volts

V_p = permissible voltage drop on the circuit run, e.g. 5% of supply voltage, in volts

L = route length of circuit, in metres

I = the current to be carried by the cable, in amperes.

A characteristic of a 3 phase circuit is that it has lower 'losses', than a single phase circuit of the same material, length and c.s.a. Voltage drop is a loss. The 3 phase V_c for an equivalent conductor is always smaller than the V_c of single phase circuit.

Activity - 2 - Values of V_c

Use AS 3008.1.1 **Table 40**

1. For the following copper conductor sizes, operating temperature of 75° C, covert the **3 phase values of Vc to 1 phase.**

a) 1 mm²	
b) 4 mm²	
c) 16 mm²	

2. Convert the following values of **single phase V_c, to 3 phase** values of V_c and determine the copper conductor sizes, at a operating temperature of 75° C.

a) 0.96327 mV/A.m	
b) 0.68295 mV/A.m	
c) 0.255255 mV/A.m	

Topic 2 - Voltage drop calculations using AS3008.1.1

TABLE 40

THREE-PHASE VOLTAGE DROP (V_c) AT 50 Hz

CABLE TYPES: SINGLE-CORE INSULATED AND SHEATHED COPPER CONDUCTORS LAID IN TREFOIL

1	2	3	4	5	6	7	8	9	10	11
Conductor size	Three-phase voltage drop (V_c) at 50 Hz, mV/A.m									
	Conductor temperature, °C									
	45		60		75		90		110	
mm²	Max.	0.8 p.f.	Max.	0.8 p.f.	Max.	0.8 p.f.	Max.	0.8 p.f.	Max.	0.8 p.f.
1	40.3	—	42.5	—	44.7	—	46.8	—	49.7	—
1.5	25.9	—	27.3	—	28.6	—	30.0	—	31.9	—
2.5	14.1	—	14.9	—	15.6	—	16.4	—	17.4	—
4	8.77	—	9.24	—	9.71	—	10.2	—	10.8	—
6	5.86	—	6.18	—	6.49	—	6.81	—	7.23	—
10	3.49	—	3.67	—	3.86	—	4.05	—	4.30	—
16	2.20	—	2.31	—	2.43	—	2.55	—	2.70	—
25	1.40	—	1.47	—	1.54	—	1.62	—	1.72	—
35	1.01	—	1.07	—	1.12	—	1.17	—	1.24	—
50	0.757	—	0.795	—	0.834	—	0.872	—	0.924	—
70	0.537	—	0.563	—	0.589	—	0.615	—	0.650	—
95	0.402	—	0.420	—	0.439	—	0.457	—	0.481	—
120	0.332	—	0.345	—	0.359	—	0.373	—	0.392	—
150	0.284	—	0.295	—	0.305	—	0.316	—	0.331	—
185	0.245	0.245	0.253	0.253	0.261	—	0.269	—	0.280	—
240	0.211	0.208	0.216	0.214	0.221	0.220	0.227	0.226	0.235	0.234
300	0.191	0.185	0.195	0.190	0.198	0.195	0.202	0.199	0.208	0.206
400	0.175	0.166	0.178	0.169	0.181	0.173	0.183	0.176	0.187	0.181
500	0.165	0.150	0.166	0.153	0.168	0.156	0.170	0.158	0.172	0.162
630	0.155	0.138	0.156	0.140	0.157	0.142	0.159	0.144	0.160	0.146

NOTE: These V_c values apply to a balanced three-phase circuit in which no current flows in the neutral conductor. To determine the single phase V_c the current in the neutral conductor needs to be considered by multiplying the three-phase value by $\frac{2}{\sqrt{3}} = 1.155$.

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$$V_d = \frac{L \times I \times V_c}{1000} \qquad \ldots 4.2(2)$$

$V_p \geq$ sum of V_d on circuit run

where

V_c = the millivolt drop per ampere-metre route length of circuit, as shown in the tables for various conductors, in millivolts per ampere metre (mV/A.m)

NOTES:

1 To convert single-phase voltage drop (mV/A.m) values to three-phase values, multiply the single-phase values by 0.866 $\left(\frac{\sqrt{3}}{2}\right)$. To convert three-phase values to single-phase values, multiply the three-phase values by 1.155 $\left(\frac{2}{\sqrt{3}}\right)$.

2 Paragraph C4 and C7 of AS/NZS 3000:2007 details a simplified method of calculating the voltage drop for PVC cables up to 95 mm^2, operating at 75°C with maximum values of V_c. The method allows the addition of single phase and three phase percentages.

V_d = actual voltage drop, in volts

V_p = permissible voltage drop on the circuit run, e.g. 5% of supply voltage, in volts

L = route length of circuit, in metres

I = the current to be carried by the cable, in amperes.

The voltage drop values in Tables 40 to 50 may not be applicable under the following conditions:

Do it yourself

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To determine the **actual voltage drop** for a given cable size, use the equation;

where

V_d = the actual voltage drop, in volts

V_c = the value found from AS3008.1.1 tables in mV/A.m

L = the route length of circuit, in metres

I = the current to be carried by the cable, in amperes.

Activity - 3 - Calculating voltage drop (V_d)

Use AS 3008.1.1

Calculate the voltage drop on a 6mm² V90 3 phase multicore copper cable, if protected by a 32A C.B. with a length of 30m.

To find the total voltage drop for an entire installation the voltage drops of the consumer's mains and final sub-circuits are added together.

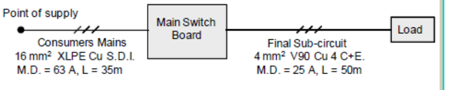
Activity - 4 - Calculating voltage drop (V_d)

Use AS 3008.1.1

Read the suggested text or resource

Write a response

Calculate the voltage drop for the installation.



Does the installation comply with AS3000 clause 3.6.2 (Y / N)

Why ?

When an installation contains single phase circuits the values of V_c must be converted to single phase values and then used in the voltage drop equation.

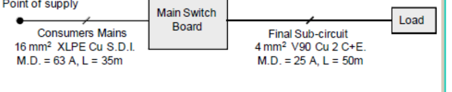
Activity - 5 - Calculating voltage drop (V_d)

Use AS 3008.1.1

Read the suggested text or resource

Write a response

Calculate the voltage drop for the installation.



Does the installation comply with AS3000 clause 3.6.2 (Y / N)

Why ?

Three phase installations with single phase circuits

If an installation is supplied by three phase and has single phase circuits within the installation, both 3 and 1 phase voltage drops must be converted to a common unit value so they can be added together. Both values can be converted to a percentage of their nominal value, or the 3 phase V_d may be converted to a single phase V_d, by dividing it by √3, in the same way a line voltage (V_L) of 400V is converted to a phase voltage (V_P) of 230V.

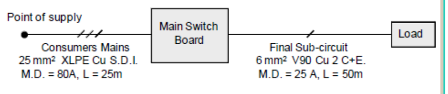
Activity - 6 - Calculating voltage drop (V_d) %

Use AS 3008.1.1

Read the suggested text or resource

Write a response

Calculate the voltage drop for the installation using the percentage method



Does the installation comply with AS3000 clause 3.6.2 (Y / N)

Why ?

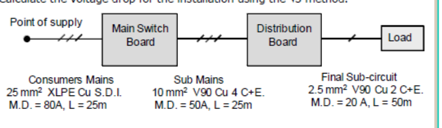
Activity - 7 – Calculating Values of V_d (√3)

Use AS 3008.1.1

Read the suggested text or resource

Write a response

Calculate the voltage drop for the installation using the √3 method.



Does the installation comply with AS3000 clause 3.6.2 (Y / N)

Why ?

L = the route length of circuit, in metres
I = the current to be carried by the cable, in amperes.

Activity - 8 - Calculating Values of V_c

Use AS 3008.1.1

Read the suggested text or resource

Write a response

1. Calculate the maximum permissible value of V_c for a 3 phase V90 copper multi-core cable, if the permissible voltage drop is 14V, the length of the cable run is 45m and the maximum demand is 25A.

2. Determine the minimum cable size

Section 6 – Cable selection based on voltage drop Miller College

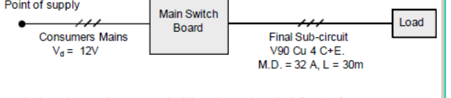
Activity - 9 - Cable selection based on voltage drop

Use AS 3008.1.1

Read the suggested text or resource

Write a response

For the installation bellow



1. Calculate the maximum permissible voltage drop (V_p) for the f.s.c.

2. Calculate the maximum permissible value of V_c

3. Determine the minimum cable size

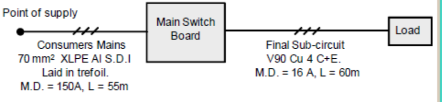
Activity - 10 - Cable selection based on voltage drop

Use AS 3008.1.1

Read the suggested text or resource

Write a response

For the installation bellow



1. Calculate the voltage drop (V_d) on the consumers mains

2. Calculate the maximum permissible voltage drop (V_P) for the f.s.c.

3. Calculate the maximum permissible value of V_C for the f.s.c.

4. Determine the minimum cable size for the f.s.c.

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Single phase installations

When an installation contains single phase circuits, values of V_C must be calculated using the single phase permissible voltage drop (V_P). The calculated single phase V_C is then converted to a 3 phase value by multiplying it by **0.866**. The cable size can then be selected using the appropriate operating temperature for the cable.

Activity - 11 - Calculating Values of V_c

Use AS 3008.1.1

Read the suggested text or resource

Write a response

1. Calculate the maximum permissible value of V_C for a 230V 1 phase V90 copper multi-core cable, if the permissible voltage drop is 8V, the length of the cable run is 45m and the maximum demand is 25A.

2. Determine the minimum cable size

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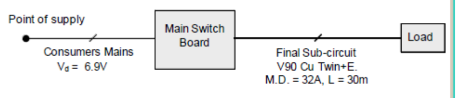
Activity - 12 - Cable selection based on voltage drop

Use AS 3008.1.1

Read the suggested text or resource

Write a response

For the installation bellow



1. Calculate the maximum permissible voltage drop (V_p) for the f.s.c.

2. Calculate the maximum permissible value of V_c

3. Determine the minimum cable size.

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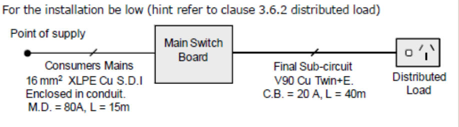
Activity - 13 - Cable selection based on voltage drop

Use AS 3008.1.1

Read the suggested text or resource

Write a response

For the installation be low (hint refer to clause 3.6.2 distributed load)



1. Calculate the voltage drop (V_d) on the consumer's mains

2. Calculate the maximum permissible voltage drop (V_p) for the f.s.c.

3. Calculate the maximum permissible value of V_c for the f.s.c.

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Three phase installations with single phase circuits

1. As discussed in topic 2 of this section, the 3 phase V_d is calculated and then must be converted to a single phase V_d. This done either converting both 3 phase and 1 phase voltage drops to a percentage, or by dividing the 3 phase V_d by √3. A single phase V_p is then found and used to calculate a single phase V_c This is then converted back to a three phase V_c so that the cable size can be determined by looking up the table.

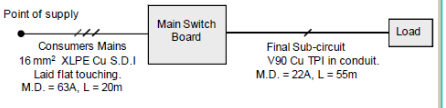
Activity - 14 - Cable selection based on voltage drop

Use AS 3008.1.1

Read the suggested text or resource

Write a response

For the installation bellow



1. Calculate the voltage drop (V_d) on the consumer's mains

2. Calculate the maximum permissible voltage drop (V_p) for the f.s.c.

3. Calculate the maximum permissible value of V_c for the f.s.c.

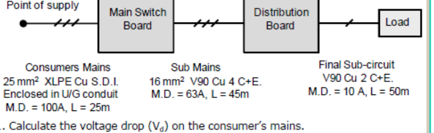
Activity - 15 - Cable selection based on voltage drop

Use AS 3008.1.1

Read the suggested text or resource

Write a response

For the installation bellow



1. Calculate the voltage drop (V_d) on the consumer's mains.

2. Calculate the voltage drop (V_d) on the sub mains.

3. Calculate the maximum permissible voltage drop (V_p) for the f.s.c.

3. Calculate the maximum permissible value of V_c for the f.s.c.

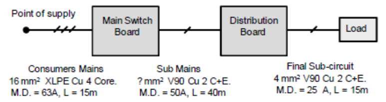
Activity - 16 - Cable selection based on voltage drop

Use AS 3008.1.1

Read the suggested text or resource

Write a response

For the installation bellow



1. Calculate the voltage drop (V_d) on the consumer's mains.

2. Calculate the voltage drop (V_d) on the f.s.c.

3. Calculate the maximum permissible voltage drop (V_P) for the sub-main.

3. Calculate the maximum permissible value of V_C for the sub-main.

4. Determine the minimum cable size for the sub-main.

14. For the installation of figure 5 determine;

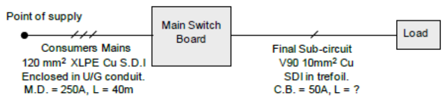


figure 5.

(a) Consumer's Mains V_d

(b) Final sub-circuit maximum length.

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(c) Final Sub Circuit

$$V_p = \frac{5\% \times 400 - (V_{CM} + V_{SM})}{\sqrt{3}} = \frac{20 - (4.99 + 6)}{\sqrt{3}} = 5.2V$$

$$V_c = \frac{1000 \times V_d}{L \times I} = \frac{1000 \times 5.2}{40 \times 32} = 4.06mV/A.m$$

C.S.A. = $10mm^2$ (3.86mV/A.m) T42C6

14.

(a) Consumer's Mains

V_c = 0.385mV/A.m (T41C8)

$$V_d = \frac{L \times I \times V_c}{1000} = \frac{55 \times 400 \times 0.385}{1000} = 3.85V$$

(b) Final Sub Circuit length

Vc = 3.86 1.155 = 4.4583mV/A.m (T40C6)

$$V_p = \frac{5\% \times 400 - V_{CM}}{\sqrt{3}} = \frac{20 - 3.85}{\sqrt{3}} =$$

$$V_d = \frac{L \times I \times V_c}{1000} \therefore V_d \times 1000 = L \times I \times V_c$$

$$\therefore L = \frac{V_d \times 1000}{I \times V_c} = \frac{9.32 \times 1000}{50 \times 4.4583} = 41.8m$$

15.

Consumer's Mains – use 0.5 x of maximum demand (I) because of parallel

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Do it yoouself

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I = the current to be carried by the cable, in amperes.

Activity - 17 – Calculating maximum length of cable

Use AS 3008.1.1

Calculate the maximum length of a 3 phase $2.5mm^2$ V75 multicore copper cable protected by a 20A C.B, if the permissible voltage drop is 12V.

Activity - 18 - Calculating maximum length of cable

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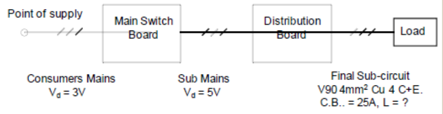
Activity - 18 - Calculating maximum length of cable

Use AS 3008.1.1

Read the suggested text or resource

Write a response

For the installation bellow



1. Determine the maximum permissible voltage drop (V_P) for the f.s.c.

2. Determine the value of V_C for the f.s.c.

3. Calculate the maximum permissible length for the f.s.c.

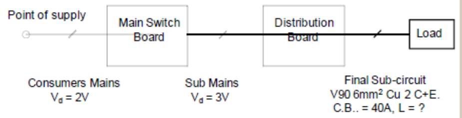
Activity - 19 - Calculating maximum length of cable

Use AS 3008.1.1

Read the suggested text or resource

Write a response

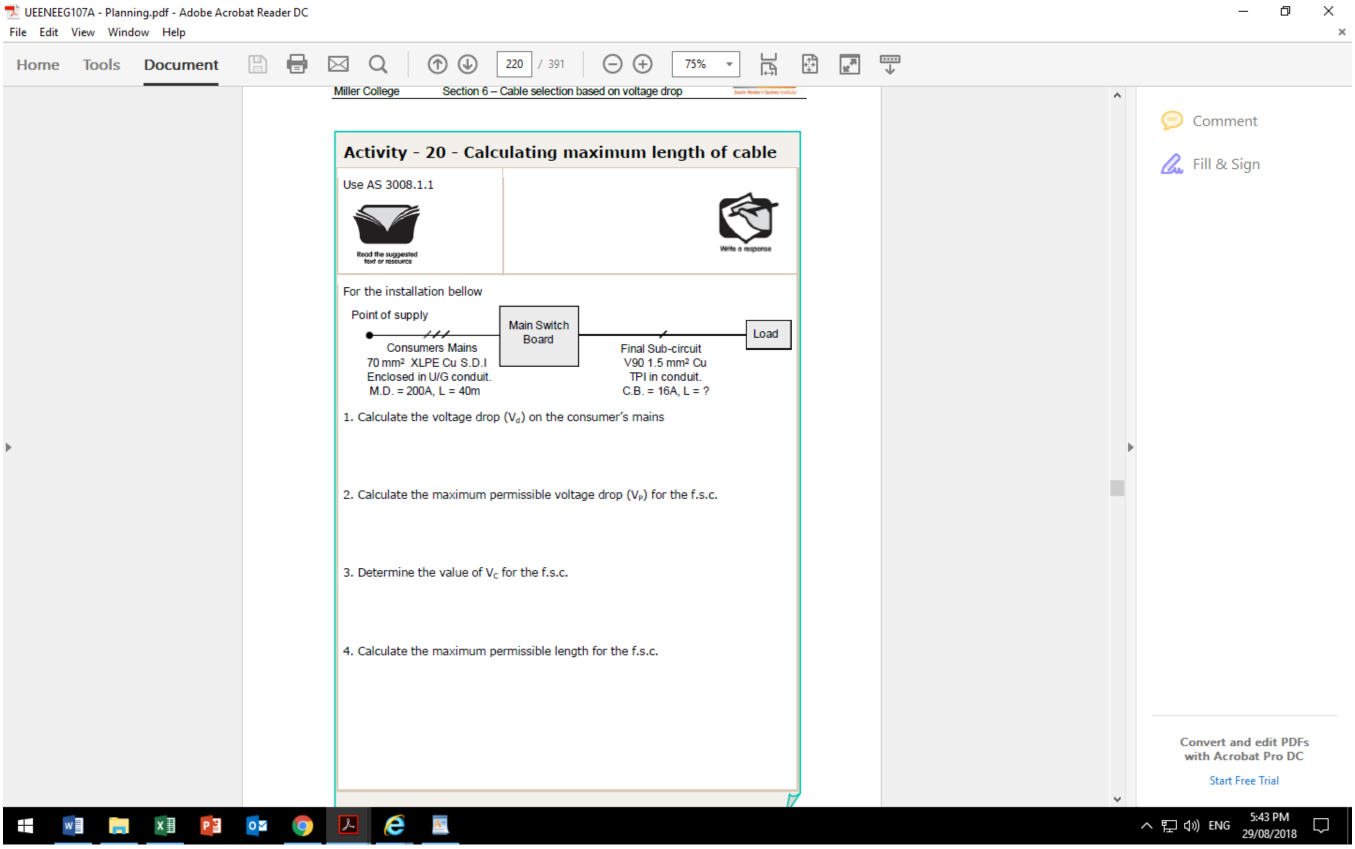
For the installation bellow



1. Determine the maximum permissible voltage drop (V_P) for the f.s.c.

2. Determine the value of V_C for the f.s.c.

3. Calculate the maximum permissible length for the f.s.c.



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Miller College Section 6 – Cable selection based on voltage drop

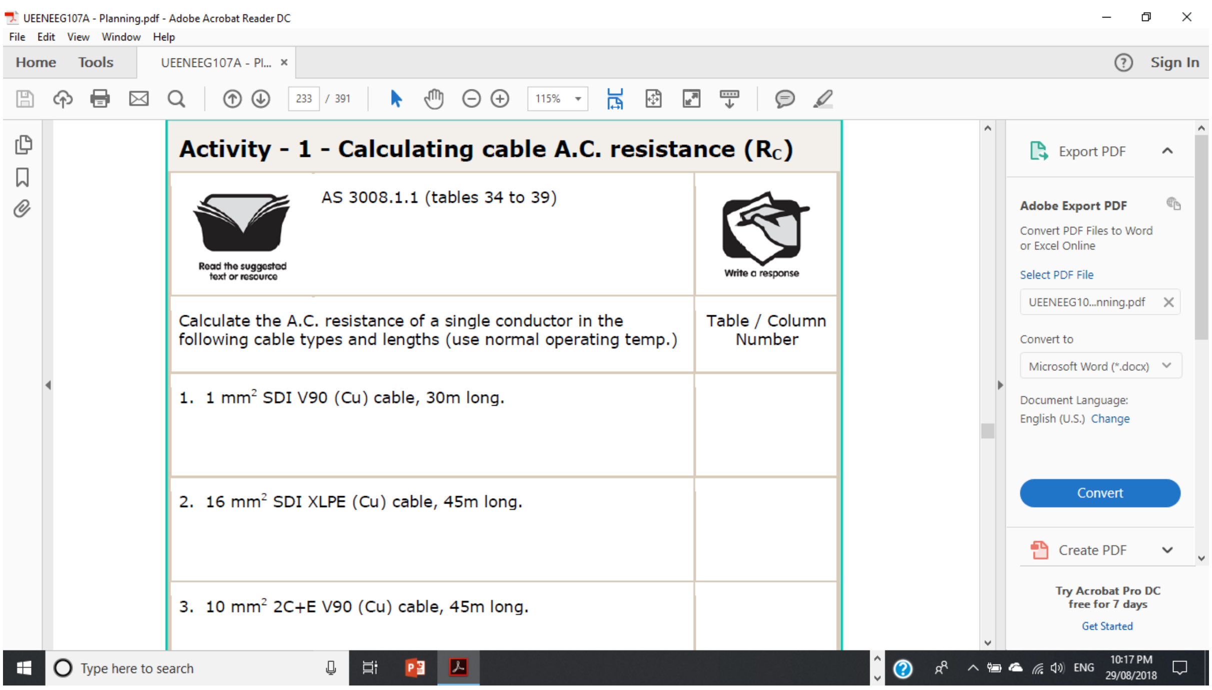
Activity - 20 - Calculating maximum length of cable

Use AS 3008.1.1

For the installation bellow

1. Calculate the voltage drop (V_d) on the consumer's mains
2. Calculate the maximum permissible voltage drop (V_P) for the f.s.c.
3. Determine the value of V_C for the f.s.c.
4. Calculate the maximum permissible length for the f.s.c.

Page 230



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Activity - 1 - Calculating cable A.C. resistance (R_C)

AS 3008.1.1 (tables 34 to 39)

Calculate the A.C. resistance of a single conductor in the following cable types and lengths (use normal operating temp.)	Table / Column Number
1. 1 mm² SDI V90 (Cu) cable, 30m long.	
2. 16 mm² SDI XLPE (Cu) cable, 45m long.	
3. 10 mm² 2C+E V90 (Cu) cable, 45m long.	

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TABLE 34

a.c. RESISTANCE (R_c) AT 50 Hz

CABLE TYPE: SINGLE-CORE

A1

1	2	3	4	5	6	7	8	9	10
Conductor size	a.c. resistance (R_c) at 50 Hz, Ω/km								
	Copper*					Aluminium			
	Conductor temperature, °C					Conductor temperature, °C			
mm²	45	60	75	90	110	45	60	75	90
1	23.3	24.5	25.8	27.0	28.7	—	—	—	—
1.5	14.9	15.7	16.5	17.3	18.4	—	—	—	—
2.5	8.14	8.57	9.01	9.45	10.0	—	—	—	—
4	5.06	5.33	5.61	5.88	6.24	—	—	—	—
6	3.38	3.56	3.75	3.93	4.17	—	—	—	—
10	2.01	2.12	2.23	2.33	2.48	—	—	—	—
16	1.26	1.33	1.40	1.47	1.56	2.10	2.22	2.33	2.45
25	0.799	0.842	0.884	0.927	0.984	1.32	1.39	1.47	1.54
35	0.576	0.607	0.638	0.668	0.710	0.956	1.01	1.06	1.11
50	0.426	0.448	0.471	0.494	0.524	0.706	0.745	0.783	0.822
70	0.295	0.311	0.327	0.342	0.363	0.488	0.515	0.542	0.568
95	0.213	0.225	0.236	0.247	0.262	0.353	0.372	0.392	0.411
120	0.170	0.179	0.188	0.197	0.208	0.279	0.295	0.310	0.325
150	0.138	0.145	0.153	0.160	0.169	0.228	0.240	0.253	0.265
185	0.111	0.117	0.123	0.129	0.136	0.182	0.192	0.202	0.212
240	0.0862	0.0905	0.0948	0.0991	0.105	0.140	0.147	0.155	0.162

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Reactance may generally be ignored for conductors of 35 mm² or less where the active and earthing conductors are in close proximity to one another. Thus, for such circuits, the current I_A may be calculated using only conductor resistance by—

$$I_A = U_0/(R_{PE} + R_L) \quad \ldots B1$$

where

U_0 = the nominal a.c. r.m.s. voltage to earth

R_{PE} = the resistance of the protective earthing conductor from the reference point to the exposed conductive part

R_L = the resistance of the phase (active) conductor from the reference point to the exposed conductive part

A study was made of the influence of the variations in the different parameters on the value of the prospective touch voltage and the corresponding disconnection time.

These parameters are as follows:

(1) The factor c that represents the proportion of the supply voltage available at the reference point during operation of the protective device. Depending on the circuit considered, this may vary between 0.6, e.g. a circuit very far from the source, and 1.0, e.g. a circuit supplied directly from the source.

(2) The value m is the ratio of the cross-sectional area of the phase conductor compared to the cross-sectional area of the protective earthing conductor in the circuit considered.

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a.c. RESISTANCE (R_c) AT 50 Hz

CABLE TYPE: MULTICORE WITH CIRCULAR CONDUCTORS

1	2	3	4	5	6	7	8	9	10
Conductor size	a.c. resistance (R_c) at 50 Hz, Ω/km								
	Copper*					Aluminium			
	Conductor temperature, °C					Conductor temperature, °C			
mm²	45	60	75	90	110	45	60	75	90
1	23.3	24.5	25.8	27.0	28.7	—	—	—	—
1.5	14.9	15.7	16.5	17.3	18.4	—	—	—	—
2.5	8.14	8.57	9.01	9.45	10.0	—	—	—	—
4	5.06	5.33	5.61	5.88	6.24	—	—	—	—
6	3.38	3.56	3.75	3.93	4.17	—	—	—	—
10	2.01	2.12	2.23	2.33	2.48	—	—	—	—
16	1.26	1.33	1.40	1.47	1.56	2.10	2.22	2.33	2.45
25	0.799	0.842	0.884	0.927	0.984	1.32	1.39	1.47	1.54
35	0.576	0.607	0.638	0.669	0.710	0.956	1.01	1.06	1.11
50	0.426	0.449	0.471	0.494	0.524	0.706	0.745	0.784	0.822
70	0.295	0.311	0.327	0.343	0.364	0.488	0.515	0.542	0.569
95	0.214	0.225	0.236	0.248	0.262	0.353	0.373	0.392	0.411
120	0.170	0.179	0.188	0.197	0.209	0.280	0.295	0.310	0.325
150	0.139	0.146	0.153	0.160	0.170	0.228	0.241	0.253	0.265
185	0.112	0.118	0.123	0.129	0.136	0.182	0.192	0.202	0.212
240	0.0870	0.0912	0.0955	0.0998	0.105	0.140	0.148	0.155	0.162
300	0.0712	0.0745	0.0778	0.0812	0.0852	0.113	0.119	0.125	0.131
400	0.0580	0.0605	0.0630	0.0656	0.0685	0.0897	0.0943	0.0988	0.103
500	0.0486	0.0506	0.0525	0.0544	0.0565	0.0730	0.0765	0.0800	0.0835

TABLE 36

a.c. RESISTANCE (R_c) AT 50 Hz

CABLE TYPE: MULTICORE WITH SHAPED CONDUCTORS

1	2	3	4	5	6	7	8	9
Conductor size	a.c. resistance (R_c) at 50 Hz, Ω/km							
	Copper*				Aluminium			
	Conductor temperature, °C				Conductor temperature, °C			
mm²	45	60	75	90	45	60	75	90
16	1.26	1.33	1.40	1.47	2.10	2.22	2.33	2.45
25	0.799	0.842	0.884	0.927	1.32	1.39	1.47	1.54
35	0.576	0.607	0.638	0.669	0.956	1.01	1.06	1.11
50	0.426	0.448	0.471	0.494	0.706	0.745	0.783	0.822
70	0.295	0.311	0.327	0.342	0.488	0.515	0.542	0.568
95	0.213	0.224	0.236	0.247	0.353	0.372	0.392	0.411
120	0.170	0.179	0.187	0.196	0.279	0.295	0.310	0.325
150	0.138	0.145	0.153	0.160	0.228	0.240	0.253	0.265
185	0.111	0.117	0.123	0.128	0.182	0.192	0.202	0.211
240	0.0859	0.0902	0.0945	0.0988	0.139	0.147	0.154	0.162
300	0.0698	0.0732	0.0766	0.0800	0.112	0.118	0.124	0.130
400	0.0563	0.0589	0.0615	0.0641	0.0886	0.0932	0.0978	0.102
500	0.0466	0.0486	0.0506	0.0526	0.0716	0.0752	0.0788	0.0824

* For the a.c. resistance of tinned copper conductor, multiply copper value by 1.01.

TABLE 37

a.c. RESISTANCE (R_c) AT 50 Hz

CABLE TYPES: FLEXIBLE CORDS AND FLEXIBLE CABLES WITH COPPER CONDUCTORS*

1	2	3	4	5	6	7	8	9	10	11
Conductor size	a.c. resistance (R_c) at 50 Hz, Ω/km									
	Single-core					Multicore				
	Conductor temperature, °C					Conductor temperature, °C				
mm²	45	60	75	90	110	45	60	75	90	110
0.5	42.8	45.1	47.4	49.7	52.8	42.8	45.1	47.4	49.7	52.8
0.75	28.6	30.1	31.6	33.2	35.2	28.6	30.1	31.6	33.2	35.2
1	21.4	22.6	23.7	24.9	26.4	21.4	22.6	23.7	24.9	26.4
1.5	14.6	15.4	16.2	17.0	18.0	14.6	15.4	16.2	17.0	18.0
2.5	8.76	9.23	9.70	10.2	10.8	8.76	9.23	9.70	10.2	10.8
4	5.44	5.73	6.02	6.31	6.70	5.44	5.73	6.02	6.31	6.70
6	3.62	3.82	4.01	4.21	4.47	3.62	3.82	4.01	4.21	4.47
10	2.10	2.21	2.32	2.44	2.59	2.10	2.21	2.32	2.44	2.59
16	1.33	1.40	1.47	1.54	1.64	1.33	1.40	1.47	1.54	1.64
25	0.857	0.903	0.949	0.995	1.06	0.857	0.903	0.949	0.995	1.06
35	0.609	0.641	0.674	0.707	0.750	0.609	0.642	0.674	0.707	0.750
50	0.424	0.447	0.470	0.493	0.523	0.425	0.447	0.470	0.493	0.523
70	0.300	0.316	0.332	0.348	0.369	0.300	0.316	0.332	0.348	0.369
95	0.227	0.240	0.252	0.264	0.280	0.228	0.240	0.252	0.264	0.280
120	0.178	0.188	0.197	0.207	0.219	0.179	0.188	0.198	0.207	0.219
150	0.144	0.151	0.159	0.166	0.176	0.144	0.152	0.159	0.167	0.176

TABLE 38

a.c. RESISTANCE (R_c) AT 50 Hz

CABLE TYPE: MIMS

1	2	3	4	5	6	7
Conductor size	a.c. resistance (R_c) at 50 Hz, Ω/km					
	Conductor temperature, °C					
mm²	45	60	75	90	100	105
1	18.9	19.9	20.9	21.9	22.6	22.9
1.5	12.7	13.3	14.0	14.7	15.2	15.4
2.5	7.61	8.02	8.43	8.83	9.11	9.24
4	4.76	5.02	5.27	5.53	5.70	5.78
6	3.16	3.33	3.50	3.67	3.79	3.84
10	1.89	1.99	2.09	2.20	2.26	2.30
16	1.19	1.25	1.31	1.38	1.42	1.44
25	0.758	0.799	0.840	0.880	0.907	0.921
35	0.541	0.570	0.599	0.628	0.647	0.657
50	0.379	0.400	0.420	0.440	0.454	0.460
70	0.271	0.286	0.300	0.315	0.325	0.329
95	0.201	0.211	0.222	0.233	0.240	0.243
120	0.160	0.168	0.176	0.185	0.190	0.193
150	0.129	0.135	0.142	0.149	0.153	0.155
185	0.105	0.110	0.116	0.121	0.125	0.127
240	0.0825	0.0866	0.0906	0.0947	0.0975	0.0988
300	0.0674	0.0706	0.0739	0.0771	0.0792	0.0803
400	0.0527	0.550	0.0574	0.0597	0.0613	0.0621

TABLE 39

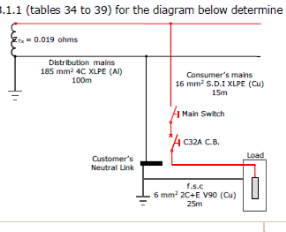
a.c. RESISTANCE (R_c) AT 50 Hz

CABLE TYPE: SINGLE-CORE AERIAL WITH BARE OR INSULATED CONDUCTORS

1	2	3	4	5	6	7	8	9
Conductor size (mm²) or stranding (No./mm)	a.c. resistance (R_c) at 50 Hz, Ω/km*							
	Copper				Aluminium			
	Conductor temperature, °C				Conductor temperature, °C			
	45	60	75	80	45	60	75	80
7/1.00	3.57	3.76	3.95	4.02	—	—	—	—
6	3.48	3.67	3.86	3.92	—	—	—	—
7/1.25	2.30	2.42	2.54	2.58	—	—	—	—
10	2.06	2.18	2.29	2.32	—	—	—	—
16	1.30	1.37	1.44	1.46	2.10	2.21	2.32	2.36
7/1.75	1.16	1.23	1.29	1.31	—	—	—	—
7/2.00	0.895	0.943	0.991	1.01	—	—	—	—
25	0.823	0.867	0.911	0.926	1.32	1.39	1.46	1.48
35	0.593	0.625	0.657	0.667	0.953	1.00	1.06	1.07
7/2.50	—	—	—	—	0.915	0.964	1.01	1.03
7/2.75	0.476	0.501	0.527	0.535	0.757	0.797	0.838	0.852
50	0.438	0.462	0.485	0.493	0.704	0.742	0.780	0.792
19/1.75	0.434	0.457	0.481	0.488	—	—	—	—
7/3.00	—	—	—	—	0.636	0.670	0.704	0.716
19/2.00	0.333	0.351	0.369	0.375	—	—	—	—
70	0.303	0.320	0.336	0.341	0.487	0.513	0.539	0.548
7/3.50	0.295	0.310	0.326	0.331	—	—	—	—
7/3.75	0.256	0.270	0.284	0.288	0.407	0.428	0.450	0.457

Activity - 2 – Total earth fault loop impedances (Z_S)

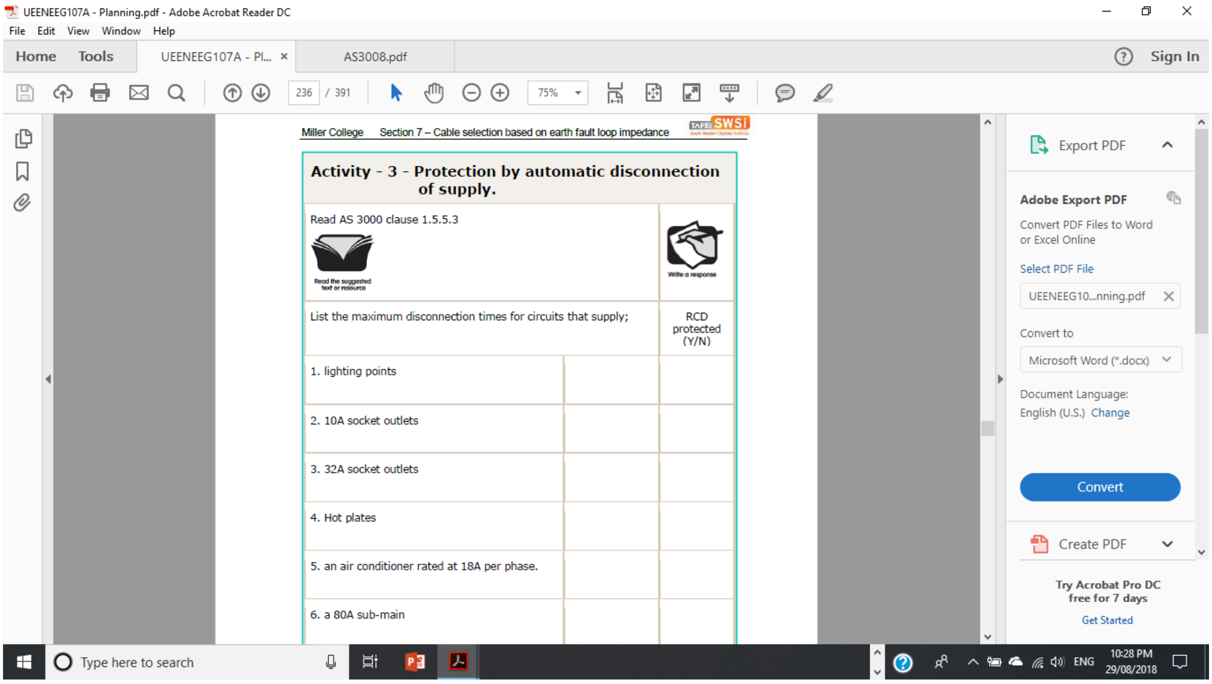
Using AS 3008.1.1 (tables 34 to 39) for the diagram below determine the;



1. Impedance of the distribution mains.

2. Impedance of the consumer's mains.

3. Impedance of the final sub-circuit.


Miller College Section 7 – Cable selection based on earth fault loop impedance

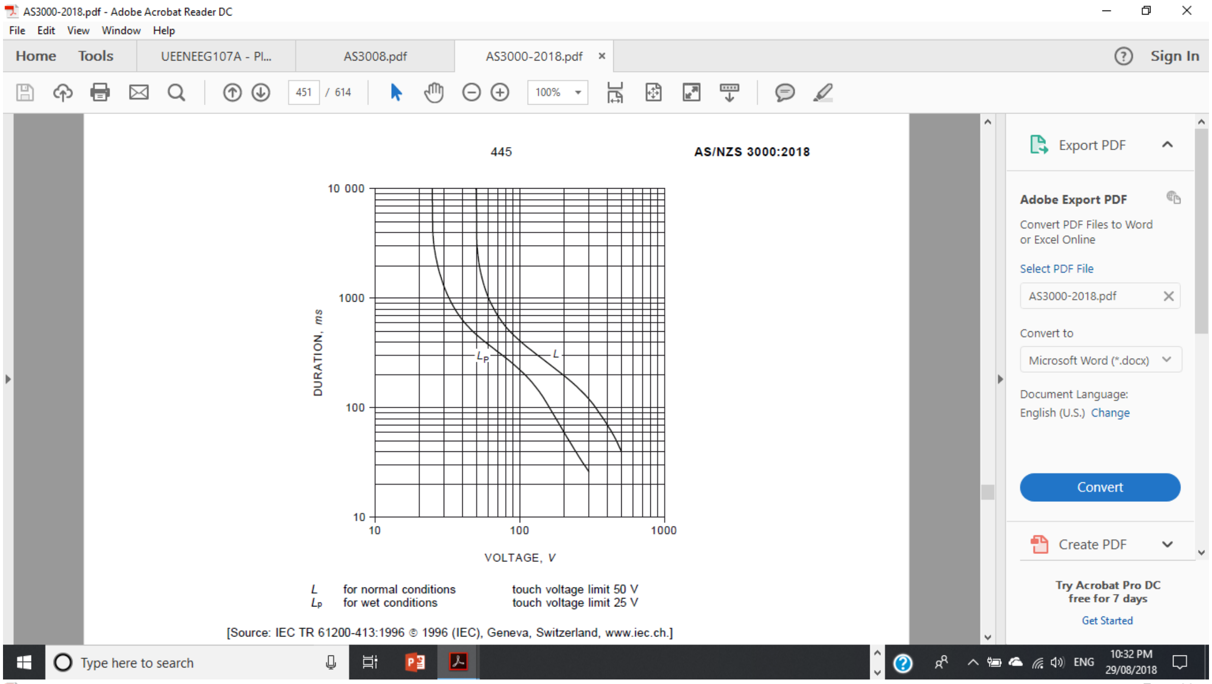
Activity - 3 - Protection by automatic disconnection of supply.		
Read AS 3000 clause 1.5.5.3		Write a response
List the maximum disconnection times for circuits that supply;		RCD protected (Y/N)
1. lighting points		
2. 10A socket outlets		
3. 32A socket outlets		
4. Hot plates		
5. an air conditioner rated at 18A per phase.		
6. a 80A sub-main		

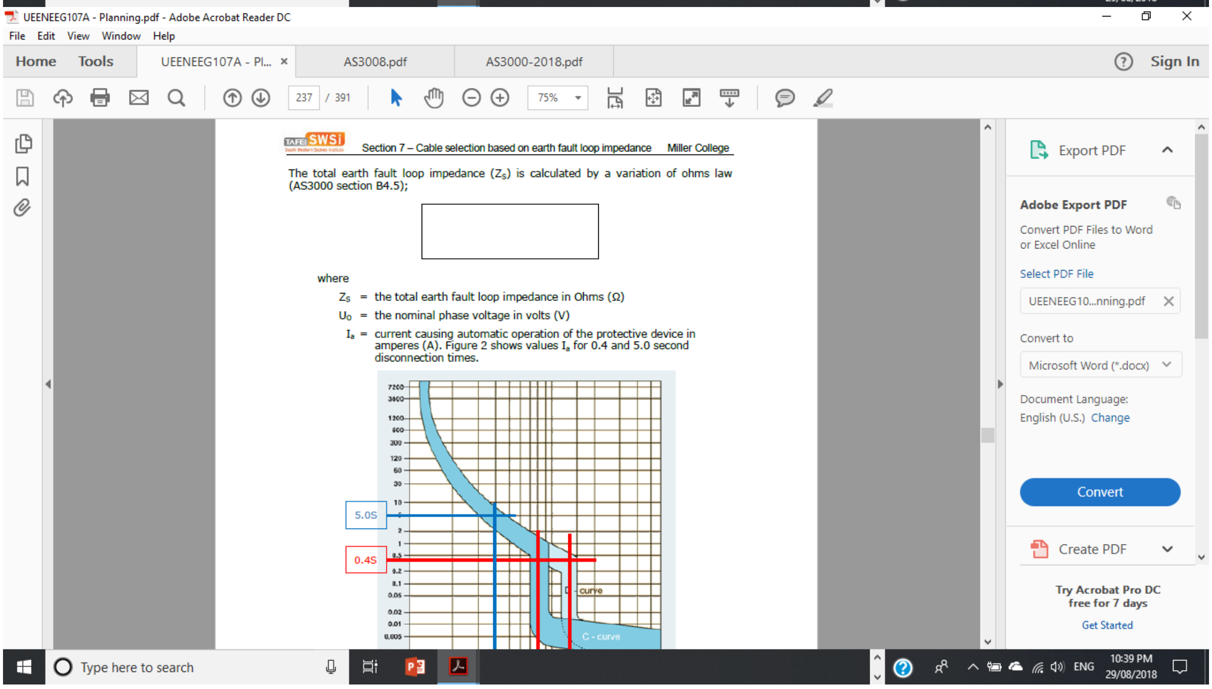
1.5.5.3 Protection by automatic disconnection of supply
The following applies:
(a) Automatic disconnection of supply is intended to limit the prospective touch voltage arising between simultaneously accessible conductive parts in the event of a fault between a live part and exposed conductive parts or 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.
(c) Earthing system impedance (earth fault-loop impedance) The characteristics of protective devices and the earthing system impedance shall be such that, if a fault of negligible impedance occurs anywhere in the electrical installation between an active conductor and a protective earthing conductor or exposed conductive part, automatic disconnection of the supply will occur within the specified time.
(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

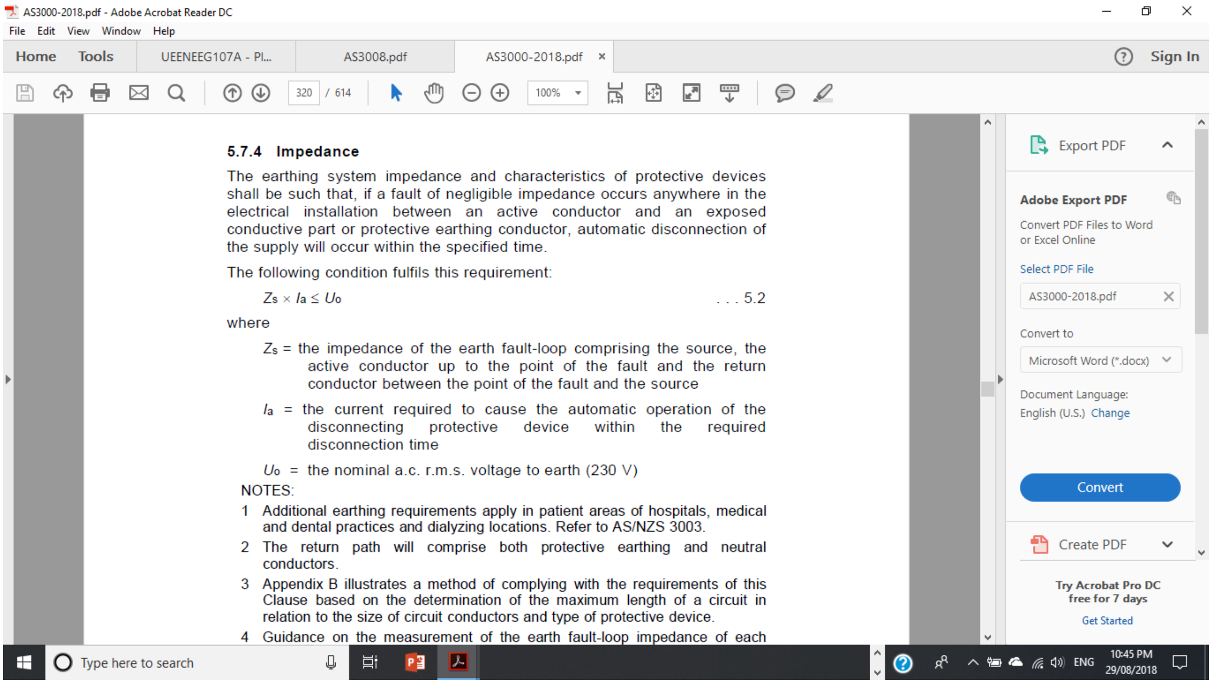
(C) portable equipment intended for manual movement during use.

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

NOTE: Maximum disconnection times will vary for other voltages and installation conditions. Appendix B provides further guidance regarding disconnection times.







5.7.4 Impedance

The earthing system impedance and characteristics of protective devices shall be such that, if a fault of negligible impedance occurs anywhere in the electrical installation between an active conductor and an exposed conductive part or protective earthing conductor, automatic disconnection of the supply will occur within the specified time.

The following condition fulfils this requirement:

$$Z_s \times I_a \leq U_o \quad \ldots 5.2$$

where

Z_s = the impedance of the earth fault-loop comprising the source, the active conductor up to the point of the fault and the return conductor between the point of the fault and the source

I_a = the current required to cause the automatic operation of the disconnecting protective device within the required disconnection time

U_o = the nominal a.c. r.m.s. voltage to earth (230 V)

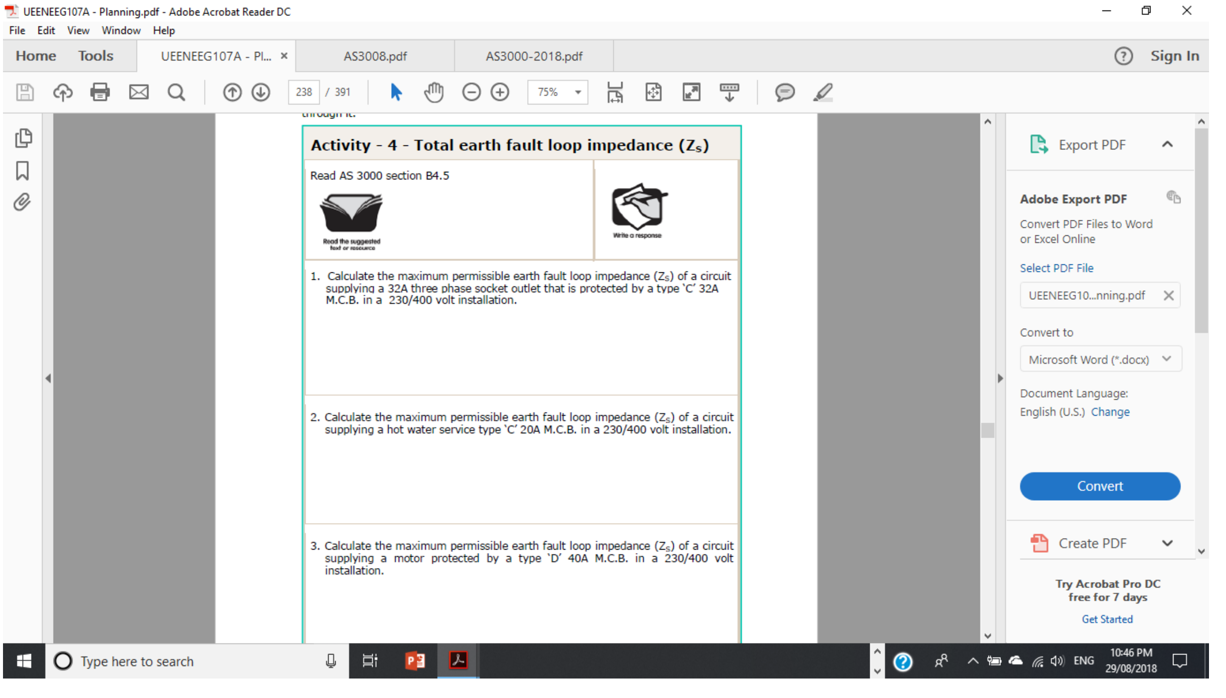
NOTES:

1 Additional earthing requirements apply in patient areas of hospitals, medical and dental practices and dialyzing locations. Refer to AS/NZS 3003.

2 The return path will comprise both protective earthing and neutral conductors.

3 Appendix B illustrates a method of complying with the requirements of this Clause based on the determination of the maximum length of a circuit in relation to the size of circuit conductors and type of protective device.

4 Guidance on the measurement of the earth fault-loop impedance of each



Activity - 4 - Total earth fault loop impedance (Z_s)

Read AS 3000 section B4.5

1. Calculate the maximum permissible earth fault loop impedance (Z_s) of a circuit supplying a 32A three phase socket outlet that is protected by a type 'C' 32A M.C.B. in a 230/400 volt installation.

2. Calculate the maximum permissible earth fault loop impedance (Z_s) of a circuit supplying a hot water service type 'C' 20A M.C.B. in a 230/400 volt installation.

3. Calculate the maximum permissible earth fault loop impedance (Z_s) of a circuit supplying a motor protected by a type 'D' 40A M.C.B. in a 230/400 volt installation.

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B4.5 Calculation of earth fault-loop impedance

Table 8.1 contains calculated examples of the maximum values of earth fault-loop impedance, Z_S, using approximate mean tripping currents, which may be taken as I_A for a limited range of MCBs (taken from the AS/NZS 60898 series and manufacturers' time/current characteristic curves) and fuses (taken from IEC 60269.1) and the appropriate disconnection time.

NOTES:

1 The appropriate tolerances permitted by the product Standard should be taken into consideration. Therefore, as part of the simplification process, approximate mean tripping currents have been used.

2 See Figure B6 for typical time/current curves for a circuit-breaker and a fuse.

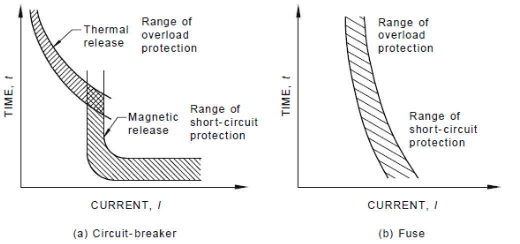

FIGURE B6 TYPICAL TIME/CURRENT CURVES FOR CIRCUIT-BREAKERS AND FUSES

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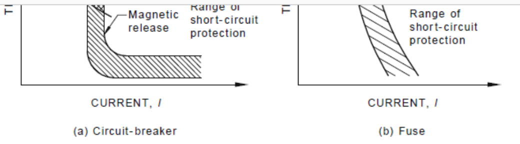

FIGURE B6 TYPICAL TIME/CURRENT CURVES FOR CIRCUIT-BREAKERS AND FUSES

The values of Z_S in Table 8.1 were calculated using the following equation:

$$Z_S = U_0 / I_a \qquad \ldots B4$$

where

Z_S = earth fault-loop impedance

U_0 = nominal phase voltage (230 V)

I_a = current causing automatic operation of the protective device, as follows:

I_a for circuit-breakers is the mean tripping current as follows:

Type B = 4 × rated current

Type C = 7.5 × rated current

Type D = 12.5 × rated current

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The maximum value of total earth fault loop impedance (Z_S) can also be found using table 8.1 of AS3000. Only 0.4 second disconnection times are shown for circuit breakers. If a earth fault loop impedance is required for a fixed or stationary appliance with a 5 second disconnection time it will have to be calculated.

Activity - 5 - Total earth fault loop impedance (Z_S)

Use Table 8.1 of AS3000.

Determine the total earth fault loop impedance for the following circuits.	
1. A 25A socket outlet in data room protected b a 25A type C circuit breaker.	
2. A phase 63 A socket outlet for a welder protected by a 63A type C circuit breaker.	
3. A range circuit protected by a 20A H.R.C. fuse.	
4. A sub main protected by a 100A H.R.C. fuse.	

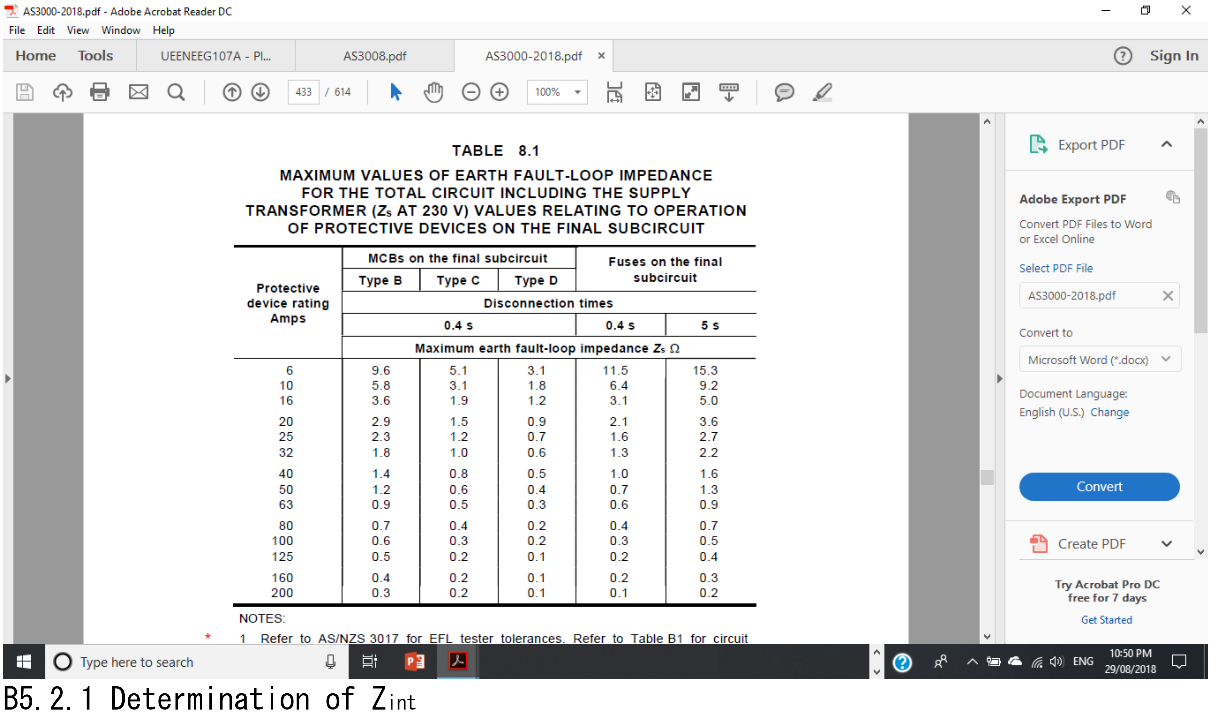


TABLE 8.1

MAXIMUM VALUES OF EARTH FAULT-LOOP IMPEDANCE FOR THE TOTAL CIRCUIT INCLUDING THE SUPPLY TRANSFORMER (Z_s AT 230 V) VALUES RELATING TO OPERATION OF PROTECTIVE DEVICES ON THE FINAL SUBCIRCUIT

Protective device rating Amps	MCBs on the final subcircuit			Fuses on the final subcircuit	
	Type B	Type C	Type D		
	Disconnection times				
	0.4 s			0.4 s	5 s
	Maximum earth fault-loop impedance Z_s Ω				
6	9.6	5.1	3.1	11.5	15.3
10	5.8	3.1	1.8	6.4	9.2
16	3.6	1.9	1.2	3.1	5.0
20	2.9	1.5	0.9	2.1	3.6
25	2.3	1.2	0.7	1.6	2.7
32	1.8	1.0	0.6	1.3	2.2
40	1.4	0.8	0.5	1.0	1.6
50	1.2	0.6	0.4	0.7	1.3
63	0.9	0.5	0.3	0.6	0.9
80	0.7	0.4	0.2	0.4	0.7
100	0.6	0.3	0.2	0.3	0.5
125	0.5	0.2	0.1	0.2	0.4
160	0.4	0.2	0.1	0.2	0.3
200	0.3	0.2	0.1	0.1	0.2

NOTES:

* 1 Refer to AS/NZS 3017 for EFL tester tolerances. Refer to Table B1 for circuit

B5.2.1 Determination of Z_{int}

As stated in Paragraph B4.4, $Z_s = Z_{ext} + Z_{int}$.

When an electrical installation is being designed, Z_{ext} may or may not be available (it will depend on the electricity distributor's transformer and supply cables). If it is not available, Z_{int} may be determined by either of the following methods:

(a) When the length and cross-sectional area of conductors are known—

$Z_{int} = Z_{CD} + Z_{EF}$

Z_{CD} = impedance of the active conductors (C to D in Figure B5)

Z_{EF} = impedance of the protective earthing conductors (E to F in Figure B5)

NOTES:

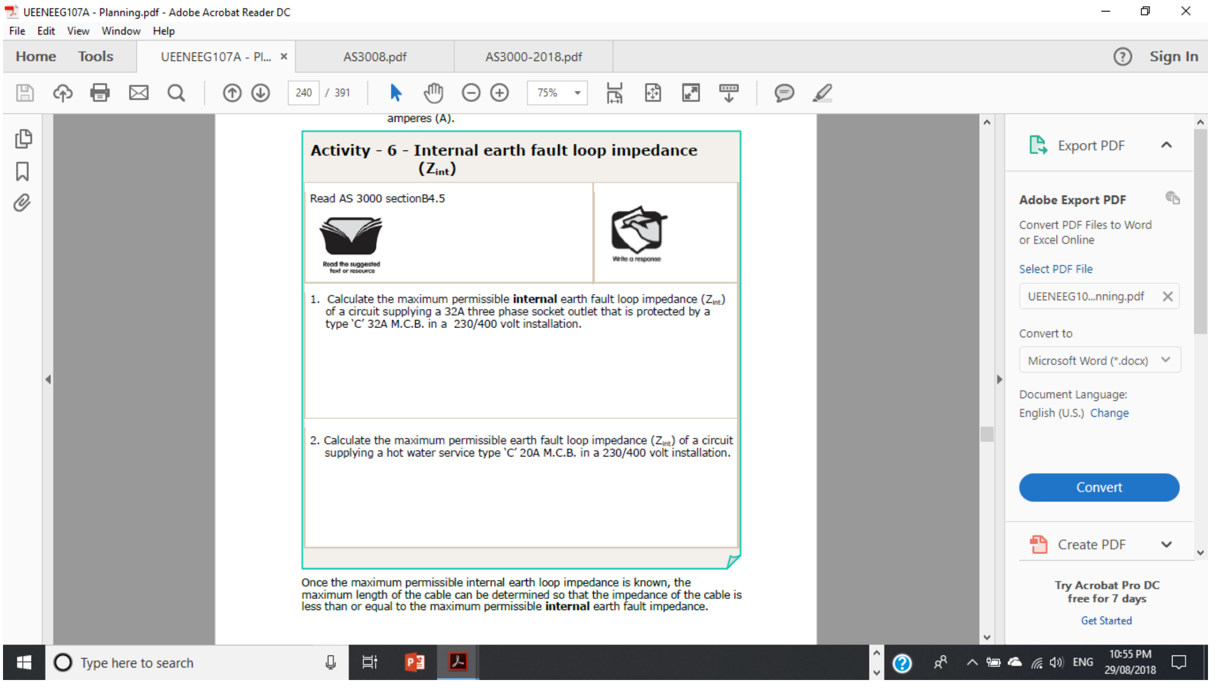
1 Consumer mains (Z_{BC} and Z_{FG}) form part of Z_{ext}.

2 Impedances for conductors are given in the AS/NZS 3008.1 series.

(b) When the length and cross-sectional area of the supply conductors are not known, it may be assumed that there will always be 80% or more of the nominal phase voltage available at the position of the circuit protective device. Therefore, Z_{int} should be not greater than 0.8 Z_s.

This may be expressed as follows:

$Z_{int} = 0.8\ U_o/I_a$



amperes (A).

Activity - 6 - Internal earth fault loop impedance (Z_{int})

Read AS 3000 sectionB4.5

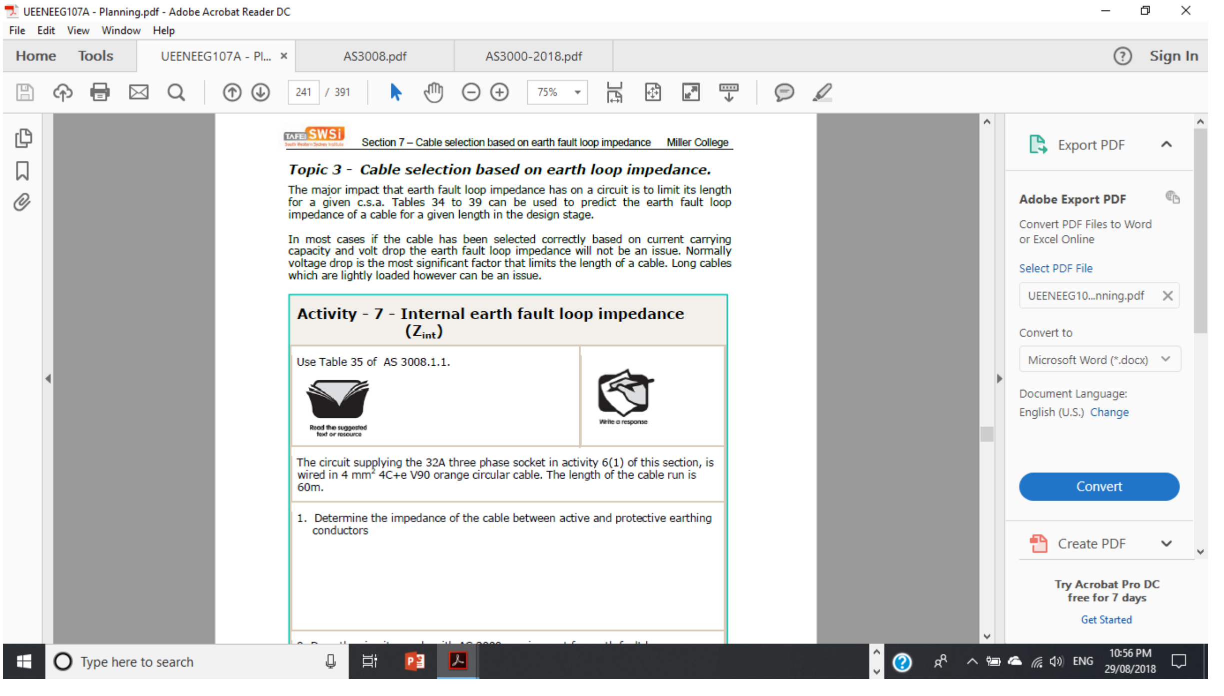
Read the suggested text or resource

Write a response

1. Calculate the maximum permissible **internal** earth fault loop impedance (Z_{int}) of a circuit supplying a 32A three phase socket outlet that is protected by a type 'C' 32A M.C.B. in a 230/400 volt installation.

2. Calculate the maximum permissible earth fault loop impedance (Z_{int}) of a circuit supplying a hot water service type 'C' 20A M.C.B. in a 230/400 volt installation.

Once the maximum permissible internal earth loop impedance is known, the maximum length of the cable can be determined so that the impedance of the cable is less than or equal to the maximum permissible **internal** earth fault impedance.



Topic 3 - Cable selection based on earth loop impedance.

The major impact that earth fault loop impedance has on a circuit is to limit its length for a given c.s.a. Tables 34 to 39 can be used to predict the earth fault loop impedance of a cable for a given length in the design stage.

In most cases if the cable has been selected correctly based on current carrying capacity and volt drop the earth fault loop impedance will not be an issue. Normally voltage drop is the most significant factor that limits the length of a cable. Long cables which are lightly loaded however can be an issue.

Activity - 7 - Internal earth fault loop impedance (Z_{int})

Use Table 35 of AS 3008.1.1.

Read the suggested text or resource

Write a response

The circuit supplying the 32A three phase socket in activity 6(1) of this section, is wired in 4 mm^2 4C+e V90 orange circular cable. The length of the cable run is 60m.

1. Determine the impedance of the cable between active and protective earthing conductors

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TABLE 35

a.c. RESISTANCE (R_c) AT 50 Hz

CABLE TYPE: MULTICORE WITH CIRCULAR CONDUCTORS

1	2	3	4	5	6	7	8	9	10
Conductor size	a.c. resistance (R_c) at 50 Hz, Ω/km								
	Copper*					Aluminium			
	Conductor temperature, °C					Conductor temperature, °C			
mm²	45	60	75	90	110	45	60	75	90
1	23.3	24.5	25.8	27.0	28.7	—	—	—	—
1.5	14.9	15.7	16.5	17.3	18.4	—	—	—	—
2.5	8.14	8.57	9.01	9.45	10.0	—	—	—	—
4	5.06	5.33	5.61	5.88	6.24	—	—	—	—
6	3.38	3.56	3.75	3.93	4.17	—	—	—	—
10	2.01	2.12	2.23	2.33	2.48	—	—	—	—
16	1.26	1.33	1.40	1.47	1.56	2.10	2.22	2.33	2.45
25	0.799	0.842	0.884	0.927	0.984	1.32	1.39	1.47	1.54
35	0.576	0.607	0.638	0.669	0.710	0.956	1.01	1.06	1.11
50	0.426	0.449	0.471	0.494	0.524	0.706	0.745	0.784	0.822
70	0.295	0.311	0.327	0.343	0.364	0.488	0.515	0.542	0.569
95	0.214	0.225	0.236	0.248	0.262	0.353	0.373	0.392	0.411
120	0.170	0.179	0.188	0.197	0.209	0.280	0.295	0.310	0.325
150	0.139	0.146	0.153	0.160	0.170	0.228	0.241	0.253	0.265
185	0.112	0.118	0.123	0.129	0.136	0.182	0.192	0.202	0.212
240	0.0870	0.0912	0.0955	0.0998	0.105	0.140	0.148	0.155	0.162
300	0.0712	0.0745	0.0778	0.0812	0.0852	0.113	0.119	0.125	0.131
400	0.0580	0.0605	0.0630	0.0656	0.0685	0.0897	0.0943	0.0988	0.103

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Activity - 8 - Internal earth fault loop impedance (Z_{int})

Use Table 35 of AS 3008.1.1.


Read the suggested text or resource


Write a response

The circuit supplying the hot water system in activity 6(2) of this section, is wired in 2.5 mm² 2C+e V90 orange circular cable. The length of the cable run is 60m.

1. Determine the impedance of the cable between active and protective earthing conductors
2. Does the circuit comply with AS 3000 requirement for earth fault loop impedance (Y/N) and why?
3. Calculate the voltage drop on this section of cable.

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TABLE B1

CIRCUIT ROUTE LENGTHS BASED ON EARTH FAULT LOOP IMPEDANCE ASSUMING Z_{int} = 80% Z_s AND VOLTAGE DROP ON FINAL SUBCIRCUITS WITH A MAXIMUM DEMAND/DIVERSITY CURRENT OF $0.8I_N$

1	2	3	4	5	6	7	8	9	10	11	12
Final subcircuit route lengths based on earth fault loop impedance and voltage drop											
Copper conductor area, (mm²)		Circuit-breaker or fuse rated current I_N, (A)	Earth fault loop route length for Z_{int}, I_N, MCB C curve, (m)(1,2)	Final subcircuit route length to comply with voltage drop for a maximum demand current $0.8 \times I_N$(3,4)							Fuses to IEC 60269 (BS88 type for industrial use)
Active and neutral	Earth			V_c Table 41 AS/NZS 3008 at 60°C mV/A.m 3 phase(3)	Route length single phase (m)			Route length three phase (m)			Earth fault loop route length for Z_{int}, I_N based on mean operating current for ≤0.4 s
					2.5% voltage drop	3% voltage drop	4% voltage drop	2.5% voltage drop	3% voltage drop	4% voltage drop	
1	1	6	*91*	42.5	24	29	39	28	34	45	204
1	1	10	*55*	42.5	15	18	23	17	20	27	114
1.5	1.5	10	*82*	27.3	23	27	36	26	32	42	170
1.5	1.5	16	*51*	27.3	14	17	23	16	20	26	82
2.5	2.5	16	*85*	14.9	26	31	42	30	36	48	136
2.5	2.5	20	*68*	14.9	21	25	33	24	29	39	93
4	2.5	25	*67*	9.24	27	32	43	31	37	50	90
4	2.5	32	*52*	9.24	21	25	34	24	29	39	70
6	2.5	32	*60*	6.18	31	38	50	36	44	58	75
6	2.5	40	*48*	6.18	25	30	40	29	35	47	60
10	4	50	*62*	3.68	34	41	54	39	47	63	73
16	6	63	*76*	2.32	43	51	68	49	59	79	85

(continued)

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The circuits in the examples of activity 9 are of a type that are typically not R.C.D. protected and will have a 0.4 disconnection time.

Activity – 9 – Maximum length of conductors

Use Table B1 of AS 3000 Read the suggested text or resource	Write a response
Determine the maximum route lengths based on earth fault loop impedance for the following circuits in a 230/400 volt installation.	
1. A $4mm^2$ Cu 4C+e V90 circuit supplying a 32A three phase **socket outlet** that is protected by a type 'C' 32A M.C.B.	
2. A 25A **socket outlet** in data room protected b a 25A type 'C' circuit breaker wired in 4.0 mm^2 Cu V75 twin + E.	
3. A phase 63 A **socket outlet** for a welder protected by a 63A type 'D' circuit breaker wired in $16mm^2$ Cu 4C+E	

Calculation of maximum length of conductors based on earth fault loop impedance.

If a cable / circuit breaker combination not listed in table B1 of AS3000 or the circuit supplied has a 5 second disconnection time the earth fault loop impedance must be calculated.

The **maximum route length** based on earth fault loop impedance (L_{max}) is calculated by (AS3000 section B5.2.2);

where

- L_{max} = maximum route length in metres
- U_0 = the nominal phase voltage in volts (V)
- ρ = resistivity at normal working temperature in Ω-mm²/m
  - = 22.5×10^{-3} for copper
  - = 36×10^{-3} for aluminium
- I_a = current causing instantaneous operation of the protective device in amperes (A).
  - = the current that assures operation of the protective fuse concerned, in the specified time
- S_{ph} = cross sectional area of the active conductor of the circuit concerned in mm^2
- S_{pe} = cross sectional area of the protective earthing conductor concerned in mm^2

This calculation was used to determine the maximum lengths of cables in table B1 of AS3000. If a circuit has a disconnection time of 5 seconds the mean tripping current of the protection device must be found from manufactures data (figures 2 to 6). The

Equation B6 may be expressed in terms of circuit length by considering conductor sizes (active and earth) and protective device tripping current (see Note 1). This gives rise to the following equation:

$$L_{max} = \frac{0.8 U_o S_{ph} S_{pe}}{I_a \rho (S_{ph} + S_{pe})} \quad \ldots B7$$

where

- L_{max} = maximum route length, in metres (see Table B1)
- U_0 = nominal phase volts (230 V)
- ρ = resistivity at normal working temperature, in Ω-mm²/m
  - = 22.5×10^{-3} for copper
  - = 36×10^{-3} for aluminium
- I_a = trip current setting for the instantaneous operation of a circuit-breaker *or*
  - = the current that assures operation of the protective fuse concerned, in the specified time
- S_{ph} = cross-sectional area of the active conductor of the circuit concerned, in mm^2
- S_{pe} = cross-sectional area of the protective earthing conductor concerned, in mm^2

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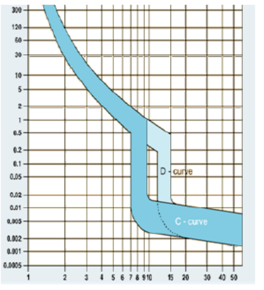


figure 3 - www.clipsal.com

Activity – 10 – Maximum length of conductors

Use Section B5.2.2 of AS 3000 to calculate the maximum route length based on earth fault loop impedance for A 4mm² 2C+e V90 circuit supplying a cook top protected by a C25A Clipsal M.C.B. in a 230/400 volt installation.

1. Maximum disconnection time	
2. Determine from manufactures data (figure 3) the current I_a	
3. Calculate the maximum length of the circuit based on earth fault loop impedance.	

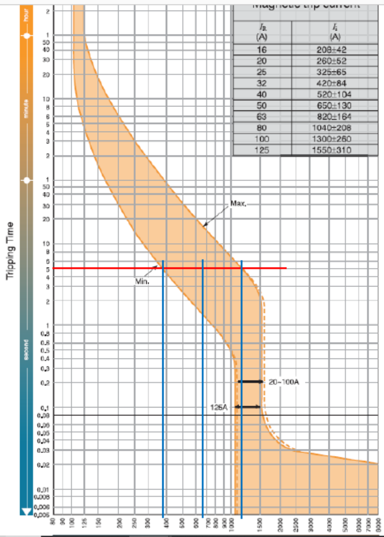
multiples of In

figure 4 – www.hagerbr.com.au

Activity – 11 – Maximum length of conductors

Use Section B5.2.2 of AS 3000 to calculate the maximum route length based on earth fault loop impedance for A 6mm² 4C+e V90 circuit supplying a 32A three phase **socket outlet** that is protected by a Hager C32A M.C.B. in a 230/400 volt installation.

1. Maximum disconnection time	
2. Determine from manufactures data (figure 4) the current I_a	
3. Calculate the maximum length of the circuit based on earth fault loop impedance.	



Magnetic trip current	
I_R (A)	I_i (A)
16	208±42
20	260±52
25	325±65
32	420±84
40	520±104
50	650±130
63	820±164
80	1040±208
100	1300±260
125	1550±310

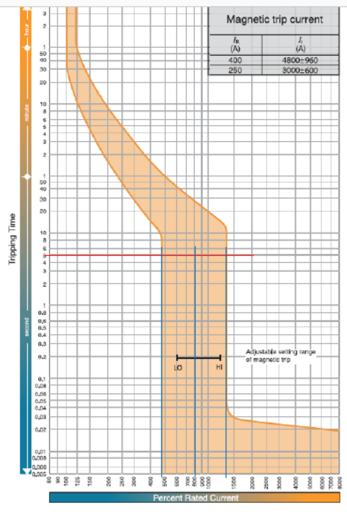
Activity – 12 – Maximum length of conductors

Read the suggested text or resource

Use Section B5.2.2 of AS 3000 to calculate the maximum route length based on earth fault loop impedance for a 16 mm² 2C+E V90 circuit, supplying a single phase sub main protected by a single pole 63A Tembreak 2 C.B. in a 230/400 volt installation.

Write a response

1. Maximum disconnection time	
2. Determine from manufactures data (figure 5) the current I_a	
3. Calculate the maximum length of the circuit based on earth fault loop impedance.	



Magnetic trip current	
I_R (A)	I_i (A)
400	4800±960
250	3000±600

figure 6 – www.nhp.com.au/tembreak2/manuals/asp

Activity – 13 – Maximum length of conductors

Read the suggested text or resource	Use Section B5.2.2 of AS 3000 to Determine the maximum route length based on earth fault loop impedance for a 150 mm² single core XLPE circuit, supplying a three phase sub main protected by a 400A type 'C' M.C.B. in a 230/400 volt installation.	Write a response
	1. Maximum disconnection time	
	2. Determine from manufactures data (figure 6) the current I_a	
	3. Calculate the maximum length of the circuit based on earth fault loop impedance.	

The situation can arise, on a long run of cable, where cable size has been increased to compensate for voltage drop, the maximum demand (I_B) will be much lower than the current carrying capacity of the cable (I_Z). Figure 7 below shows a scenario where both current carrying capacity and voltage drop comply with AS3000 requirements, but the earth fault loop impedance does not.

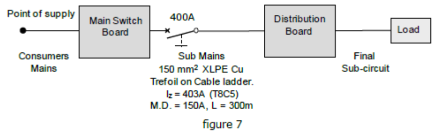


figure 7

Clause 2.5.3.1 AS3000 Protection against overload $I_B \leq I_N \leq I_Z$.

In this case I_B (150A) is less than I_N (400A) and I_N is less than I_Z (403A), so protection against overload is provided.

Clause 3.6.2 AS3000 Voltage drop should not exceed 5% of nominal supply voltage.

When calculating voltage drop it is permitted to use the lower maximum demand current rather than the rating of the circuit breaker.

$$Vd = \frac{L \times I \times V_c}{1000} = \frac{300 \times 150 \times 0.316}{1000} = 14.22V$$

The voltage drop on the circuit is not excessive and complies with AS3000 requirements. While a 150A would be a more suitable rating of a circuit breaker, than the 400A device, it still complies with AS3000 requirements for overload protection and voltage drop.

Clause 1.5.5.3 AS300 Protection by automatic disconnection of supply

Circuits under fault conditions between active and earth must be automatically disconnected from the supply with the specified time. In this case for a sub-main, the required disconnection time is 5 seconds .

In this case I_B (150A) is less than I_N (400A) and I_N is less than I_Z (403A), so protection against overload is provided.

Clause 3.6.2 AS3000 Voltage drop should not exceed 5% of nominal supply voltage.

When calculating voltage drop it is permitted to use the lower maximum demand current rather than the rating of the circuit breaker.

$$Vd = \frac{L \times I \times V_c}{1000} = \frac{300 \times 150 \times 0.316}{1000} = 14.22V$$

The voltage drop on the circuit is not excessive and complies with AS3000 requirements. While a 150A would be a more suitable rating of a circuit breaker, than the 400A device, it still complies with AS3000 requirements for overload protection and voltage drop.

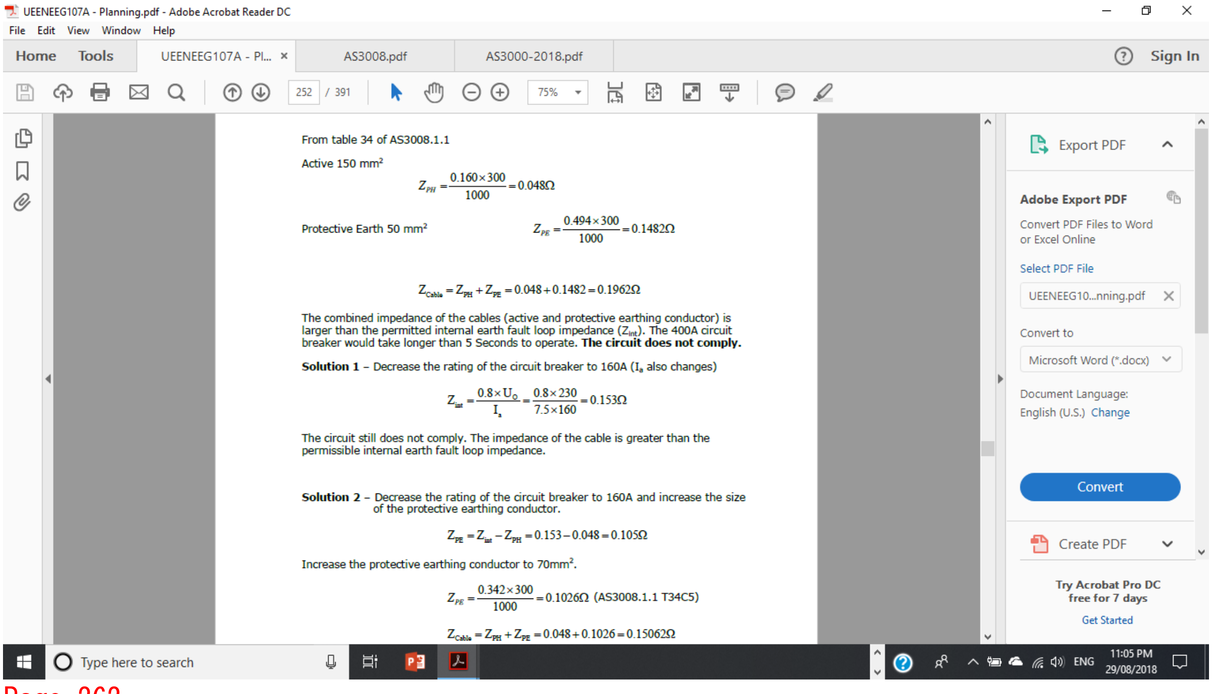
Clause 1.5.5.3 AS300 Protection by automatic disconnection of supply

Circuits under fault conditions between active and earth must be automatically disconnected from the supply with the specified time. In this case for a sub-main, the required disconnection time is 5 seconds .

Clause 5.2.1 AS3000 Determination of maximum length $Z_{int} = \frac{0.8 \times U_o}{I_a}$

From manufactures data such as the graph shown in figure 6 of this section, the current required to operate the 400A C.B. in 5 seconds would be 8 x 400A which equals 3200A.

$$Z_{int} = \frac{0.8 \times U_o}{I_a} = \frac{0.8 \times 230}{8 \times 400} = 0.0575\Omega$$



From table 34 of AS3008.1.1

Active 150 mm²

$$Z_{PH} = \frac{0.160 \times 300}{1000} = 0.048\Omega$$

Protective Earth 50 mm²

$$Z_{PE} = \frac{0.494 \times 300}{1000} = 0.1482\Omega$$

$$Z_{Cable} = Z_{PH} + Z_{PE} = 0.048 + 0.1482 = 0.1962\Omega$$

The combined impedance of the cables (active and protective earthing conductor) is larger than the permitted internal earth fault loop impedance (Z_{int}). The 400A circuit breaker would take longer than 5 Seconds to operate. **The circuit does not comply.**

Solution 1 – Decrease the rating of the circuit breaker to 160A (I_a also changes)

$$Z_{int} = \frac{0.8 \times U_0}{I_a} = \frac{0.8 \times 230}{7.5 \times 160} = 0.153\Omega$$

The circuit still does not comply. The impedance of the cable is greater than the permissible internal earth fault loop impedance.

Solution 2 – Decrease the rating of the circuit breaker to 160A and increase the size of the protective earthing conductor.

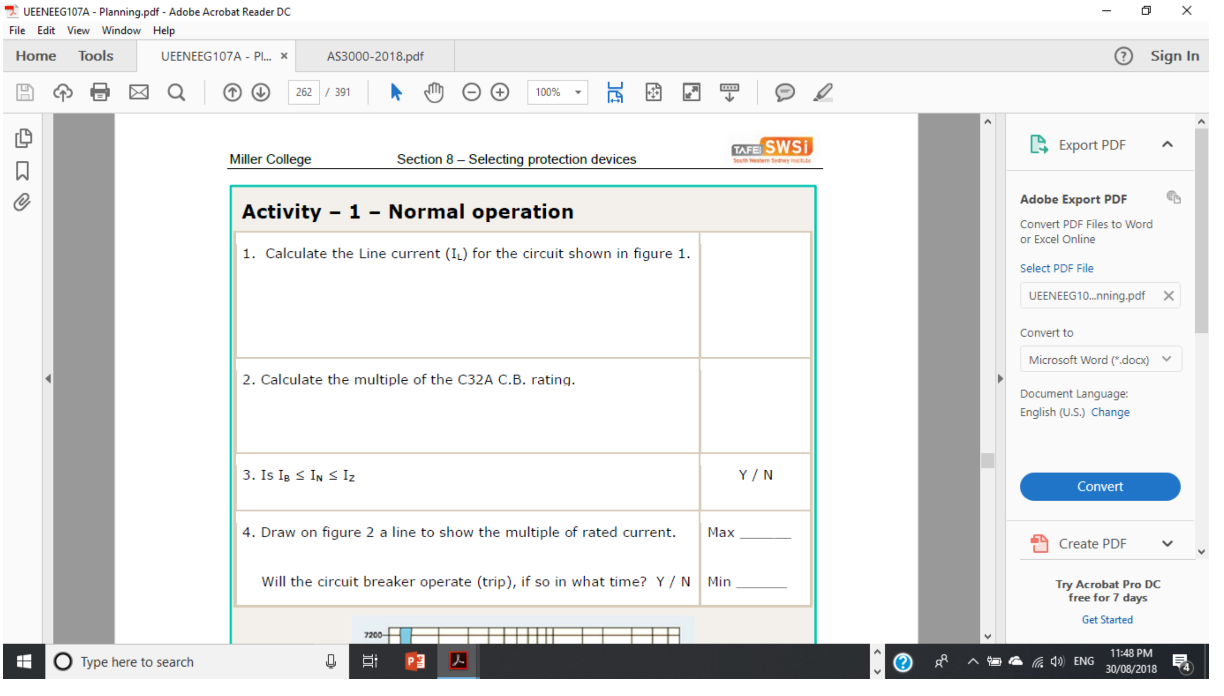
$$Z_{PE} = Z_{int} - Z_{PH} = 0.153 - 0.048 = 0.105\Omega$$

Increase the protective earthing conductor to 70mm².

$$Z_{PE} = \frac{0.342 \times 300}{1000} = 0.1026\Omega \text{ (AS3008.1.1 T34C5)}$$

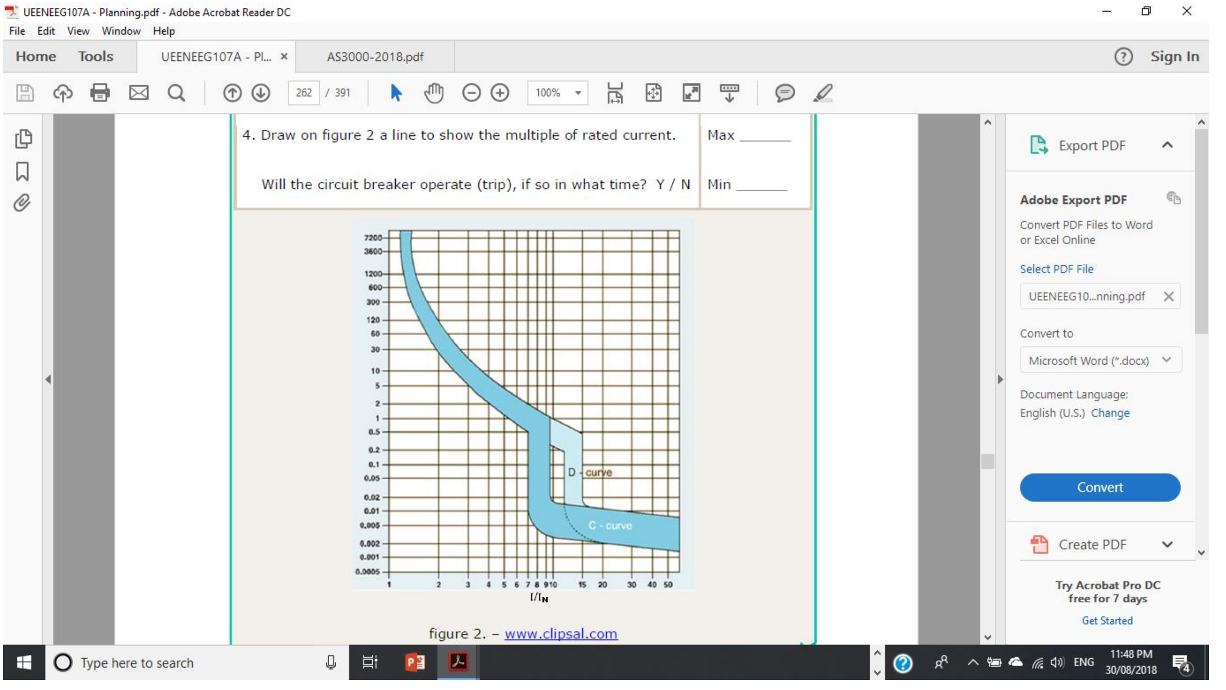
$$Z_{Cable} = Z_{PH} + Z_{PE} = 0.048 + 0.1026 = 0.15062\Omega$$

Page 262



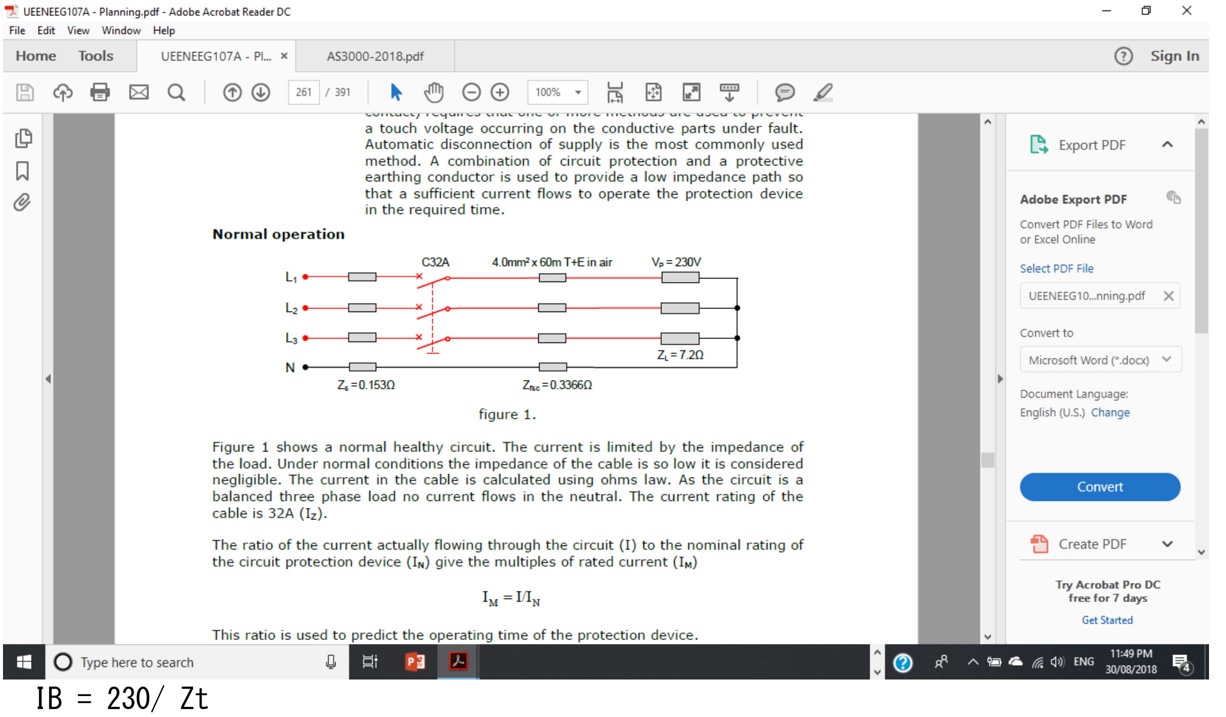
Activity – 1 – Normal operation

1. Calculate the Line current (I_L) for the circuit shown in figure 1.	
2. Calculate the multiple of the C32A C.B. rating.	
3. Is $I_B \le I_N \le I_Z$	Y / N
4. Draw on figure 2 a line to show the multiple of rated current. Will the circuit breaker operate (trip), if so in what time? Y / N	Max ______ Min ______



4. Draw on figure 2 a line to show the multiple of rated current.	Max ______
Will the circuit breaker operate (trip), if so in what time? Y / N	Min ______

figure 2. – www.clipsal.com



a touch voltage occurring on the conductive parts under fault. Automatic disconnection of supply is the most commonly used method. A combination of circuit protection and a protective earthing conductor is used to provide a low impedance path so that a sufficient current flows to operate the protection device in the required time.

Normal operation

figure 1.

Figure 1 shows a normal healthy circuit. The current is limited by the impedance of the load. Under normal conditions the impedance of the cable is so low it is considered negligible. The current in the cable is calculated using ohms law. As the circuit is a balanced three phase load no current flows in the neutral. The current rating of the cable is 32A (I_Z).

The ratio of the current actually flowing through the circuit (I) to the nominal rating of the circuit protection device (I_N) give the multiples of rated current (I_M)

$$I_M = I/I_N$$

This ratio is used to predict the operating time of the protection device.

IB = 230/ Zt

Iz= See AS3008 Table

In = CB rating Table C9

AS3000 rule 2.5.3.1 must be met.

Activity - 2 - AS3000 requirements - Overload

Read AS 3000 clause 2.5.3	
Read the suggested text or resource	Group discussion

If the following equations are true the circuit will operate correctly under normal conditions and the circuit protection will operate in the required time if the circuit is overloaded.

$$I_B \leq I_N \leq I_Z$$

where

I_B = the maximum demand of the circuit in Amperes

I_N = the current rating of the circuit protection device (fuse or C.B.) in Amperes.

I_Z = the current rating of the conductor after all applicable de-ratings have been applied.

and

$$I_2 \leq 1.45 \times I_Z$$

where

---

rewireable fuse-carriers, such circuit-breakers should be rated at not more 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:

$I_B \leq I_N \leq I_Z$ . . . 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

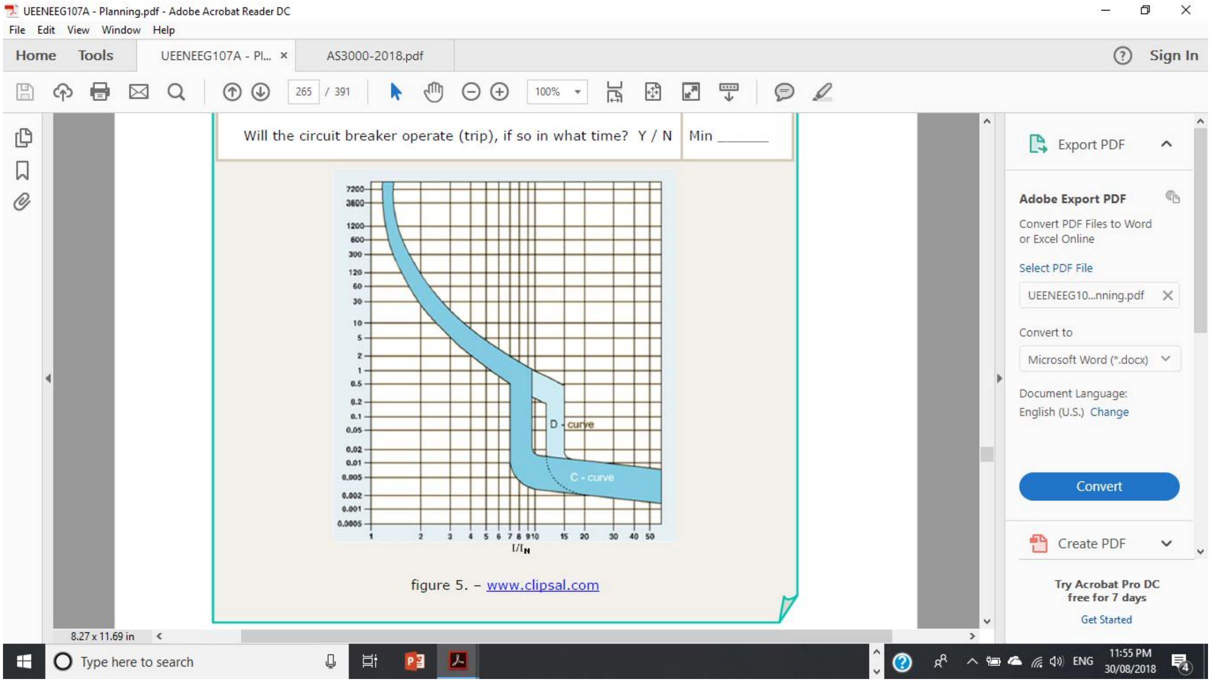
(b) the fusing current in conventional time for fuses (1.6 I_N for fuses in accordance with the IEC 60269 series).

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—

Activity – 3 – Overload condition

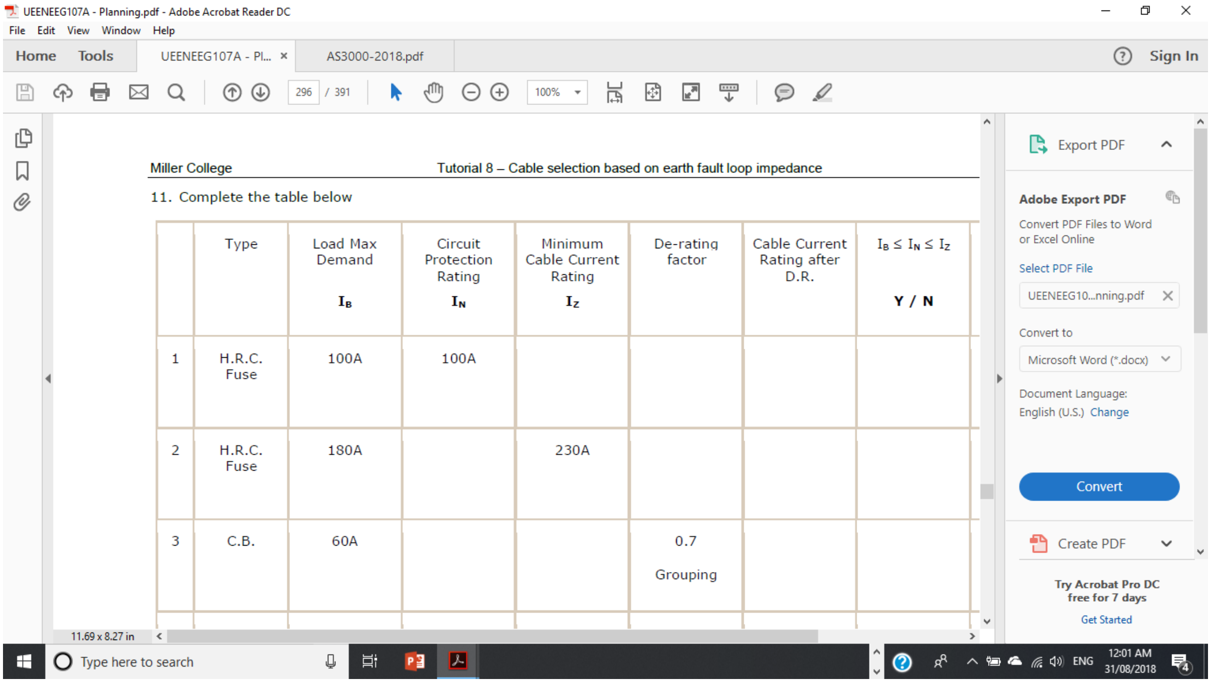
1. Calculate the Line current (I_L) for the circuit shown in figure 3.	
2. Calculate the multiple of the C32A C.B. rating.	
3. Is $I_B \leq I_N \leq I_Z$	Y / N
4. Draw on figure 5 a line to show the multiple of rated current. Will the circuit breaker operate (trip), if so in what time? Y / N	Max ______ Min ______



Will the circuit breaker operate (trip), if so in what time? Y / N | Min ______

figure 5. – www.clipsal.com

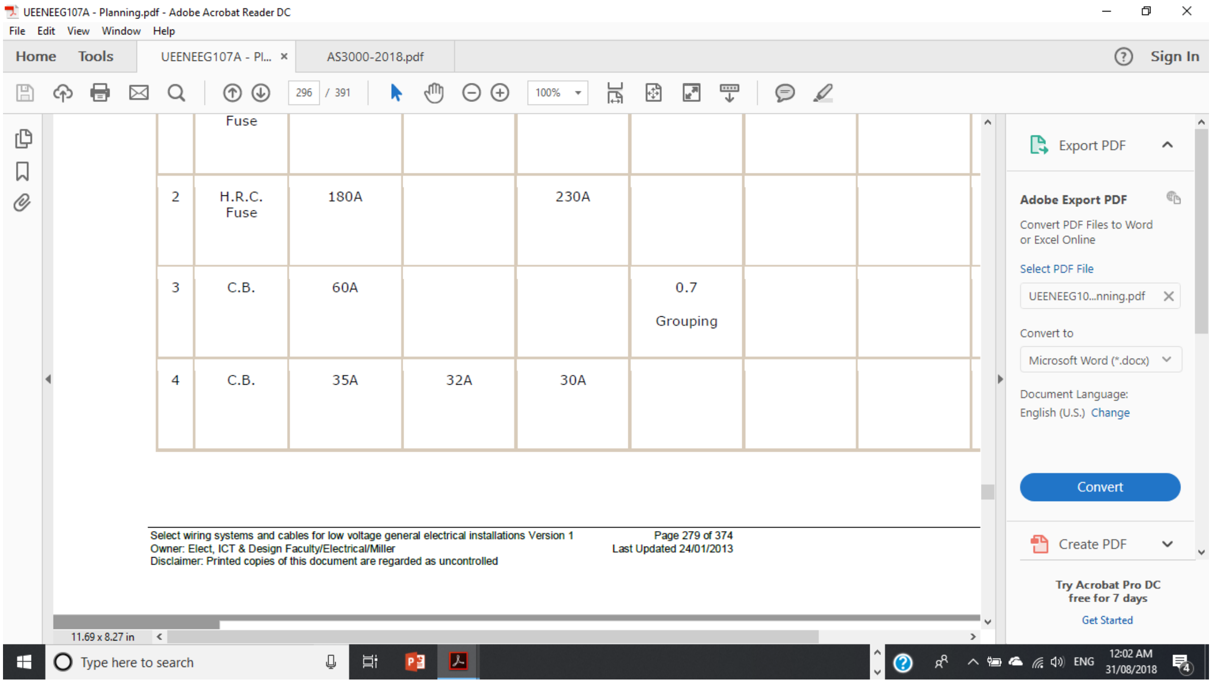
Do it yourself



Miller College Tutorial 8 – Cable selection based on earth fault loop impedance

11. Complete the table below

	Type	Load Max Demand I_B	Circuit Protection Rating I_N	Minimum Cable Current Rating I_Z	De-rating factor	Cable Current Rating after D.R.	$I_B \le I_N \le I_Z$ Y / N
1	H.R.C. Fuse	100A	100A				
2	H.R.C. Fuse	180A		230A			
3	C.B.	60A			0.7 Grouping		



	Fuse						
2	H.R.C. Fuse	180A		230A			
3	C.B.	60A			0.7 Grouping		
4	C.B.	35A	32A	30A			

Select wiring systems and cables for low voltage general electrical installations Version 1 — Page 279 of 374
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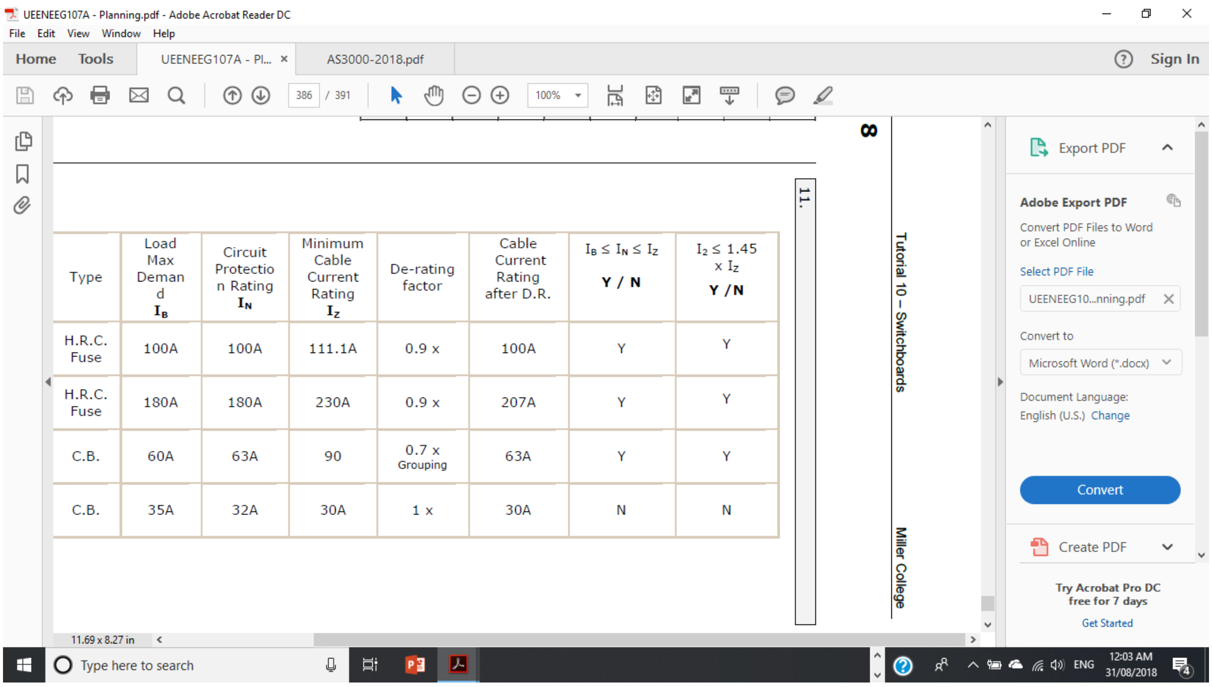


Type	Load Max Demand I_B	Circuit Protection Rating I_N	Minimum Cable Current Rating I_Z	De-rating factor	Cable Current Rating after D.R.	$I_B \le I_N \le I_Z$ Y / N	$I_2 \le 1.45 \times I_Z$ Y / N
H.R.C. Fuse	100A	100A	111.1A	0.9 x	100A	Y	Y
H.R.C. Fuse	180A	180A	230A	0.9 x	207A	Y	Y
C.B.	60A	63A	90	0.7 x Grouping	63A	Y	Y
C.B.	35A	32A	30A	1 x	30A	N	N

11.

8

Tutorial 10 – Switchboards

Miller College

Activity - 4 – Over load protection

Read the suggested text or resource

Where possible, complete the following table using minimum possible current ratings.

Use AS 3000 Tables 8.1, 8.2 or B1 as a guide to preferred protection device ratings.

Write a response

	Type	Load Max Demand I_B	Circuit Protection Rating I_N	Minimum Cable Current Rating I_Z	De-rating factor	Cable Current Rating after D.R.	$I_B \le I_N \le I_Z$ Y / N	$I_2 \le 1.45 \times I_Z$ Y / N
1	C.B.	20A	20A	20A				
2	H.R.C. Fuse	20A	20A	20A				

TABLE 8.1

MAXIMUM VALUES OF EARTH FAULT-LOOP IMPEDANCE FOR THE TOTAL CIRCUIT INCLUDING THE SUPPLY TRANSFORMER (Z_s AT 230 V) VALUES RELATING TO OPERATION OF PROTECTIVE DEVICES ON THE FINAL SUBCIRCUIT

Protective device rating Amps	MCBs on the final subcircuit			Fuses on the final subcircuit	
	Type B	Type C	Type D		
	Disconnection times				
	0.4 s			0.4 s	5 s
	Maximum earth fault-loop impedance Z_s Ω				
6	9.6	5.1	3.1	11.5	15.3
10	5.8	3.1	1.8	6.4	9.2
16	3.6	1.9	1.2	3.1	5.0
20	2.9	1.5	0.9	2.1	3.6
25	2.3	1.2	0.7	1.6	2.7
32	1.8	1.0	0.6	1.3	2.2
40	1.4	0.8	0.5	1.0	1.6
50	1.2	0.6	0.4	0.7	1.3
63	0.9	0.5	0.3	0.6	0.9
80	0.7	0.4	0.2	0.4	0.7
100	0.6	0.3	0.2	0.3	0.5
125	0.5	0.2	0.1	0.2	0.4
160	0.4	0.2	0.1	0.2	0.3
200	0.3	0.2	0.1	0.1	0.2

NOTES:

* 1 Refer to AS/NZS 3017 for EFL tester tolerances. Refer to Table B1 for circuit route lengths of final subcircuits up to 200 A.

TABLE 8.2

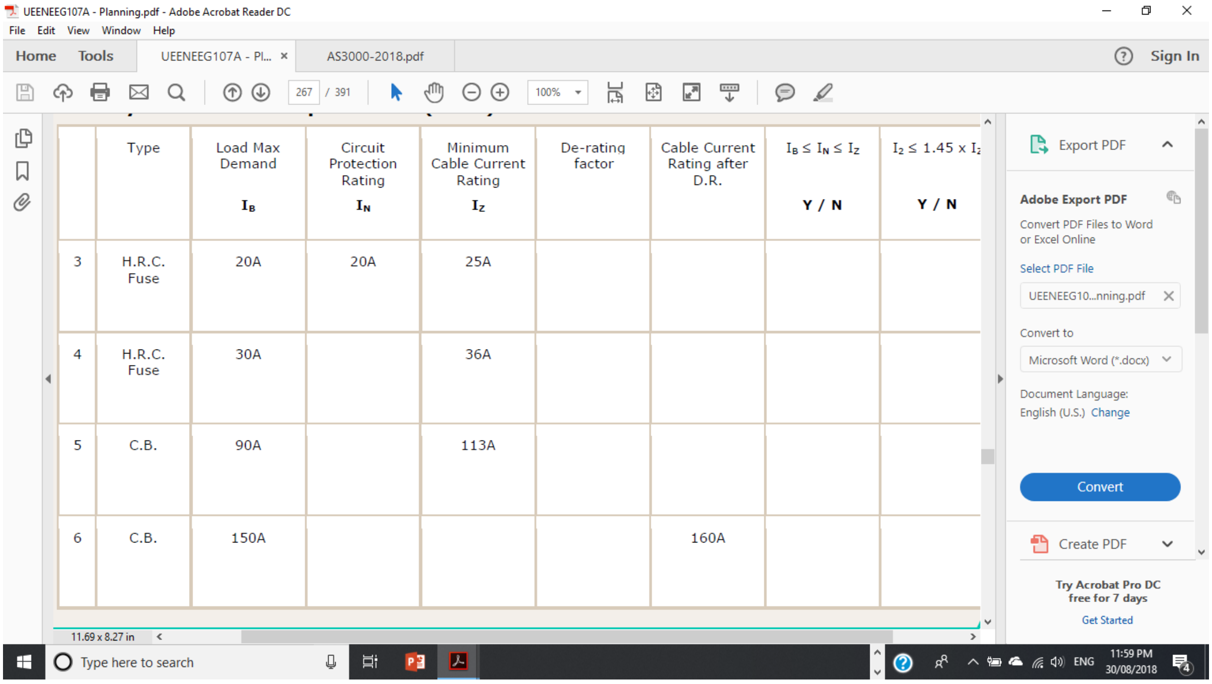
MAXIMUM VALUES OF RESISTANCE OF FINAL SUBCIRCUITS AT 80% RATED CURRENT RELATING TO Z_s IMPEDANCE VALUES IN TABLE 8.1

Protective device rating, amps	Conductor size		Circuit breakers						Fuses			
			Disconnection times									
	Active mm^2	Earth mm^2	0.4 s				0.4 s		5 s			
			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:

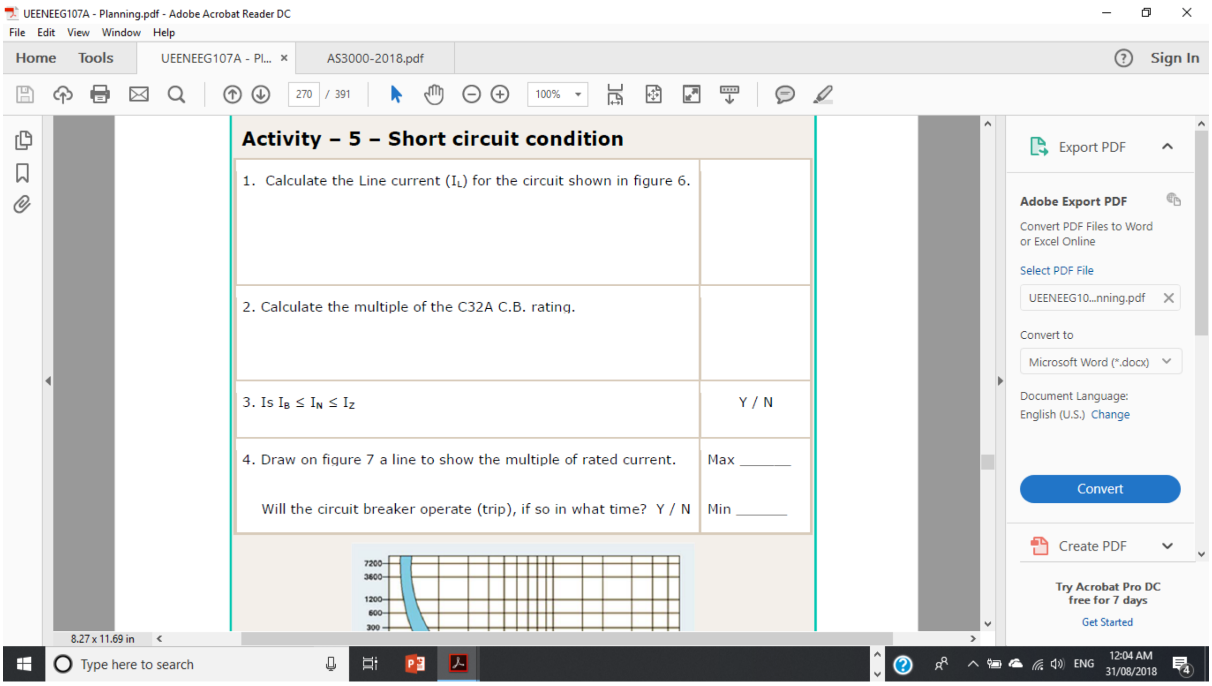
* 1 The values, which have been rounded to one decimal place, are calculated using R_{phe} as 64% × Z_s in Table 8.1.

* 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).



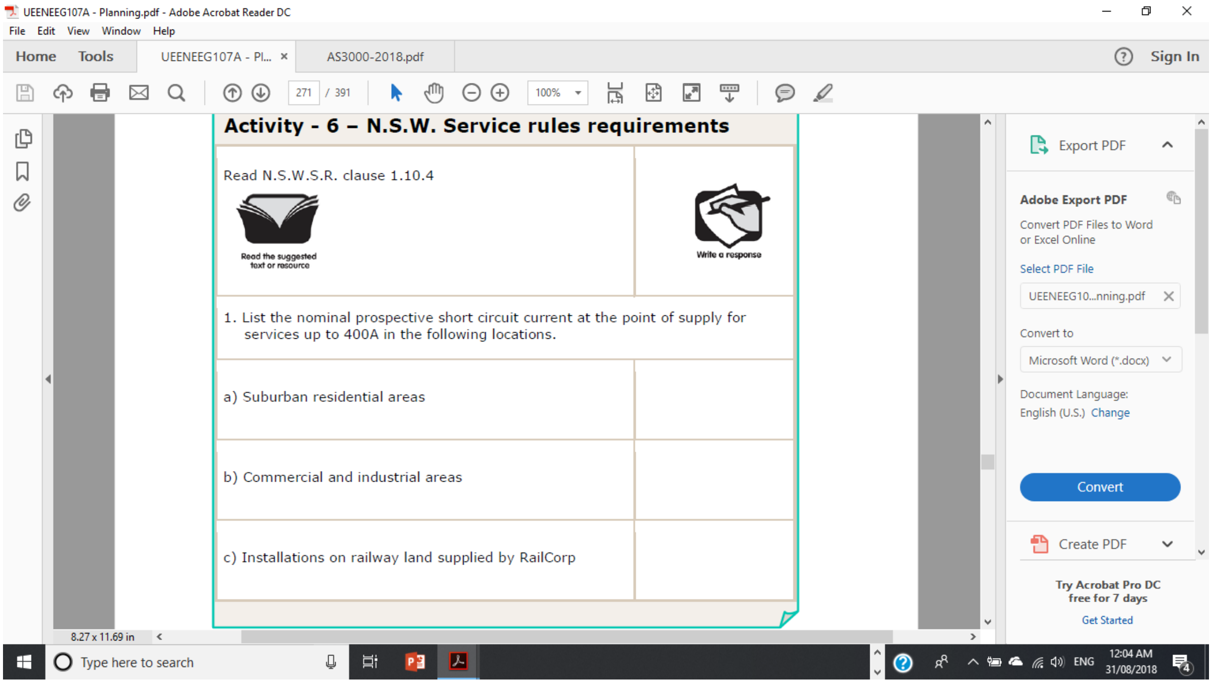
	Type	Load Max Demand I_B	Circuit Protection Rating I_N	Minimum Cable Current Rating I_Z	De-rating factor	Cable Current Rating after D.R.	$I_B \le I_N \le I_Z$ Y / N	$I_2 \le 1.45 \times I_Z$ Y / N
3	H.R.C. Fuse	20A	20A	25A				
4	H.R.C. Fuse	30A		36A				
5	C.B.	90A		113A				
6	C.B.	150A				160A		

Do it yourself



Activity – 5 – Short circuit condition

1. Calculate the Line current (I_L) for the circuit shown in figure 6.	
2. Calculate the multiple of the C32A C.B. rating.	
3. Is $I_B \le I_N \le I_Z$	Y / N
4. Draw on figure 7 a line to show the multiple of rated current. Will the circuit breaker operate (trip), if so in what time? Y / N	Max ______ Min ______



Activity - 6 – N.S.W. Service rules requirements

Read N.S.W.S.R. clause 1.10.4 (Read the suggested text or resource)	Write a response
1. List the nominal prospective short circuit current at the point of supply for services up to 400A in the following locations.	
a) Suburban residential areas	
b) Commercial and industrial areas	
c) Installations on railway land supplied by RailCorp	

1.10.4 Protection from prospective short circuit currents

The electrical installation must be designed and installed so that it will perform satisfactorily under all fault conditions.

In determining the suitability of equipment for use at 230/400 volts supplied from a distribution system, the nominal prospective short circuit current at the connection point for services up to 400A will be as follows:

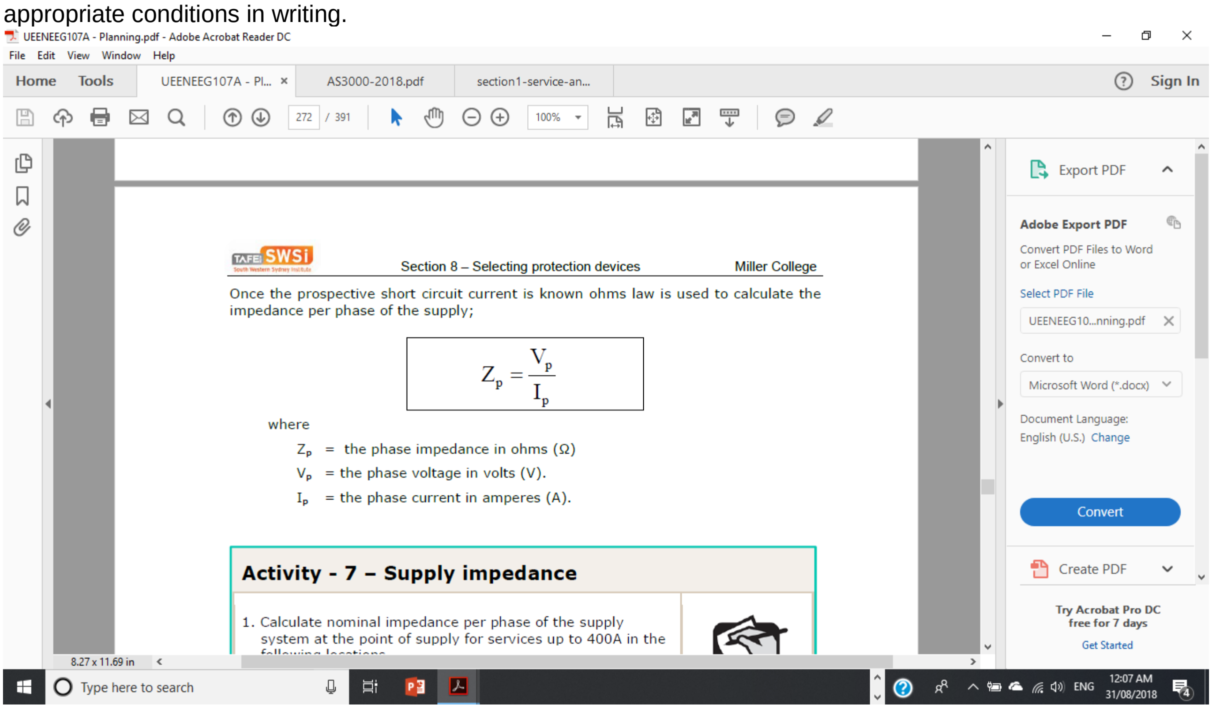
(a) Suburban residential areas: 10 kA.

(b) Commercial and industrial areas: 25 kA.

(c) Installations on railway land supplied by RailCorp: 6 kA.

For switchboards greater than 400A refer to clause 4.17.2.

In certain circumstances lower or higher values may apply eg, rural areas and direct connection at a substation. In these cases, and in the case of supply at high voltage, the electricity distributor will advise the customer on the appropriate conditions in writing.



TAFE SWSi — Section 8 – Selecting protection devices — Miller College

Once the prospective short circuit current is known ohms law is used to calculate the impedance per phase of the supply;

$$Z_p = \frac{V_p}{I_p}$$

where

Z_p = the phase impedance in ohms (Ω)

V_p = the phase voltage in volts (V).

I_p = the phase current in amperes (A).

Activity - 7 – Supply impedance

1. Calculate nominal impedance per phase of the supply system at the point of supply for services up to 400A in the following locations...

Zp = V/ IP

Fault levels are effectively the apparent power supplied to the circuit under short circuit conditions. Recall the equation for Apparent power (S).

$$S = \sqrt{3} \times V_L \times I_L$$

where

S = the Apparent power in Volt Amps (VA)

V_L = the line voltage in volts (V)

I_L = the line current in amperes (A)

The equation above is used to calculate apparent power supplied by devices such as alternators and transformers. It can be transposed to find the line current supplied by such devices under normal operating conditions. The Apparent power output of supply authority transformers in usually given in kVA.

$$I_L = \frac{S}{\sqrt{3} \times V_L}$$

Activity - 8 – Line current under normal conditions

1. Calculate maximum rated line current (I_L) for a 500kVA 400V supply authority distribution transformer.	Write a response

The same equation is used to express prospective short circuit values as VA rather than amperes. As the line current is extremely high in short circuit faults the fault level is also extremely high and usually specified in MVA rather than kVA.

$$I_{SC} = \frac{MVA \times 10^6}{\sqrt{3} \times V_L}$$

where

MVA = the Fault Level (Apparent power) in Mega Volt Amps (MVA)

V_L = the line voltage in volts (V)

$I_{S/C}$ = the prospective short circuit current (line current) in amperes (A)

Activity - 9 – Prospective short circuit current

1. Calculate the prospective short circuit current for a 500kVA 400V supply authority distribution transformer with a fault level of 10MVA.	Write a response

The prospective short circuit current can be calculated using the equation;

$$I_{SC} = \frac{100 \text{ x kVA} \times 10^3}{Z\% \times \sqrt{3} \times V_L}$$

where

$I_{S/C}$ = the prospective short circuit current (line current) in amperes (A)

kVA = the maximum rated output (Apparent) power in kilo Volt Amps (kVA)

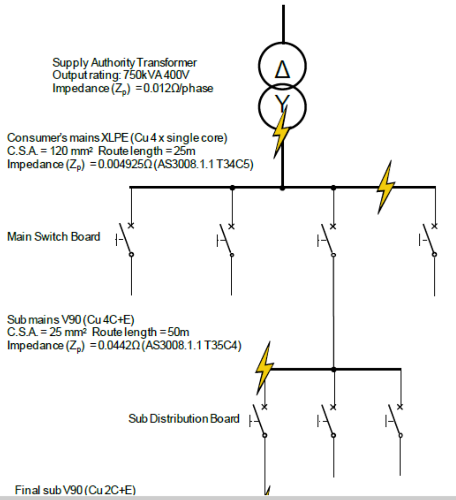
V_L = the line voltage in volts (V)

Activity - 10 – Prospective short circuit current

1. Calculate the prospective short circuit current for a 500kVA 400V supply authority distribution transformer with percentage impedance of 5%.

Write a response

fault current may be calculated:-



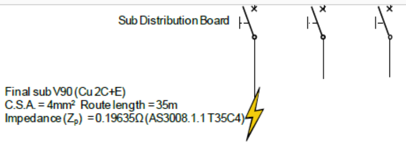


figure 8

Figure 8 show 4 short circuit faults at various locations in an industrial installation

Prospective short circuit current at transformer

$$I_{SC} = \frac{V_P}{Z_P} = \frac{230}{0.012} = 19166.6\text{A} = \mathbf{19.166kA}$$

Prospective short circuit current at Main Switch Board

$$I_{SC} = \frac{V_P}{Z_P} = \frac{230}{0.012 + 0.004925} = 13589.3\text{A} = \mathbf{13.589kA}$$

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Prospective short circuit current at sub distribution board

$$I_{SC} = \frac{V_P}{Z_P} = \frac{230}{0.012 + 0.004925 + 0.0442} = 5196.6A = \mathbf{5.196kA}$$

Prospective short circuit current at the end of the final sub-circuit.

$$I_{SC} = \frac{V_P}{Z_P} = \frac{230}{0.012 + 0.004925 + 0.0442 + 0.19635} = \mathbf{893A}$$

The worked example above shows how as the prospective short circuit (P.S.C.) decreases as the location at which the fault occurs moves away from the supply transformer. The greater the distance from the supply transformer, the higher the impedance of the cable and the lower the prospective short circuit current that can flow at that location.

When selecting short circuit protection devices, the devices breaking capacity or "kA" rating, must be higher than the prospective short circuit current; otherwise the device

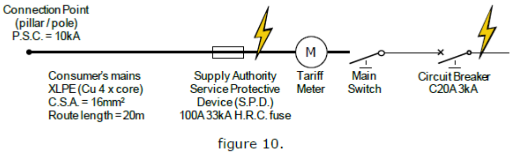


figure 10.

The P.S.C. determined in activity 11 is not the worst case example. Had the cable been unloaded, the cable would be at lower operating temperature than 75°C, say an ambient temperature of 20°C, the cable impedance would have been approximately 80% of the stated value. This in turn would have resulted in a larger P.S.C. To maintain consistency with **HB-301 "Designing to the Australian wiring rules"** (Appendix A and B) the initial cable temperature is assumed to be the cables maximum "Normal use" operating temperature.

Fault Current Limiters

A Fault Current Limiter (F.C.L.) is a device which limits the prospective fault current when a fault occurs. A suitably rated H.R.C. fuse or fault current limiting circuit breaker is placed "upstream" in series with protection devices which have a lower fault

Activity - 11 – Selection of device

1. Calculate the impedance of the supply at the point of supply shown in figure 10.	Write a response
2. Calculate the impedance of the active conductor of the consumers mains in figure 10 using table 35 of AS3008.1.1 (use 90°C temperature)	
3. Calculate the prospective fault current at the Service protection device.	

C

TABLE 35

a.c. RESISTANCE (R_c) AT 50 Hz

CABLE TYPE: MULTICORE WITH CIRCULAR CONDUCTORS

1	2	3	4	5	6	7	8	9	10
Conductor size	a.c. resistance (R_c) at 50 Hz, Ω/km								
	Copper*					Aluminium			
	Conductor temperature, °C					Conductor temperature, °C			
mm²	45	60	75	90	110	45	60	75	90
1	23.3	24.5	25.8	27.0	28.7	—	—	—	—
1.5	14.9	15.7	16.5	17.3	18.4	—	—	—	—
2.5	8.14	8.57	9.01	9.45	10.0	—	—	—	—
4	5.06	5.33	5.61	5.88	6.24	—	—	—	—
6	3.38	3.56	3.75	3.93	4.17	—	—	—	—
10	2.01	2.12	2.23	2.33	2.48	—	—	—	—
16	1.26	1.33	1.40	1.47	1.56	2.10	2.22	2.33	2.45
25	0.799	0.842	0.884	0.927	0.984	1.32	1.39	1.47	1.54
35	0.576	0.607	0.638	0.669	0.710	0.956	1.01	1.06	1.11
50	0.426	0.449	0.471	0.494	0.524	0.706	0.745	0.784	0.822
70	0.295	0.311	0.327	0.343	0.364	0.488	0.515	0.542	0.569
95	0.214	0.225	0.236	0.248	0.262	0.353	0.373	0.392	0.411
120	0.170	0.179	0.188	0.197	0.209	0.280	0.295	0.310	0.325
150	0.139	0.146	0.153	0.160	0.170	0.228	0.241	0.253	0.265
185	0.112	0.118	0.123	0.129	0.136	0.182	0.192	0.202	0.212
240	0.0870	0.0912	0.0955	0.0998	0.105	0.140	0.148	0.155	0.162
300	0.0712	0.0745	0.0778	0.0812	0.0852	0.113	0.119	0.125	0.131
400	0.0580	0.0605	0.0630	0.0656	0.0685	0.0897	0.0943	0.0988	0.103
500	0.0486	0.0506	0.0525	0.0544	0.0565	0.0730	0.0765	0.0800	0.0835

* For the a.c. resistance of tinned copper conductor, multiply copper value by 1.01.

TABLE 36

a.c. RESISTANCE (R_c) AT 50 Hz

CABLE TYPE: MULTICORE WITH SHAPED CONDUCTORS

1	2	3	4	5	6	7	8	9
Conductor size	a.c. resistance (R_c) at 50 Hz, Ω/km							
	Copper*				Aluminium			

Activity - 12 – Selection of devices

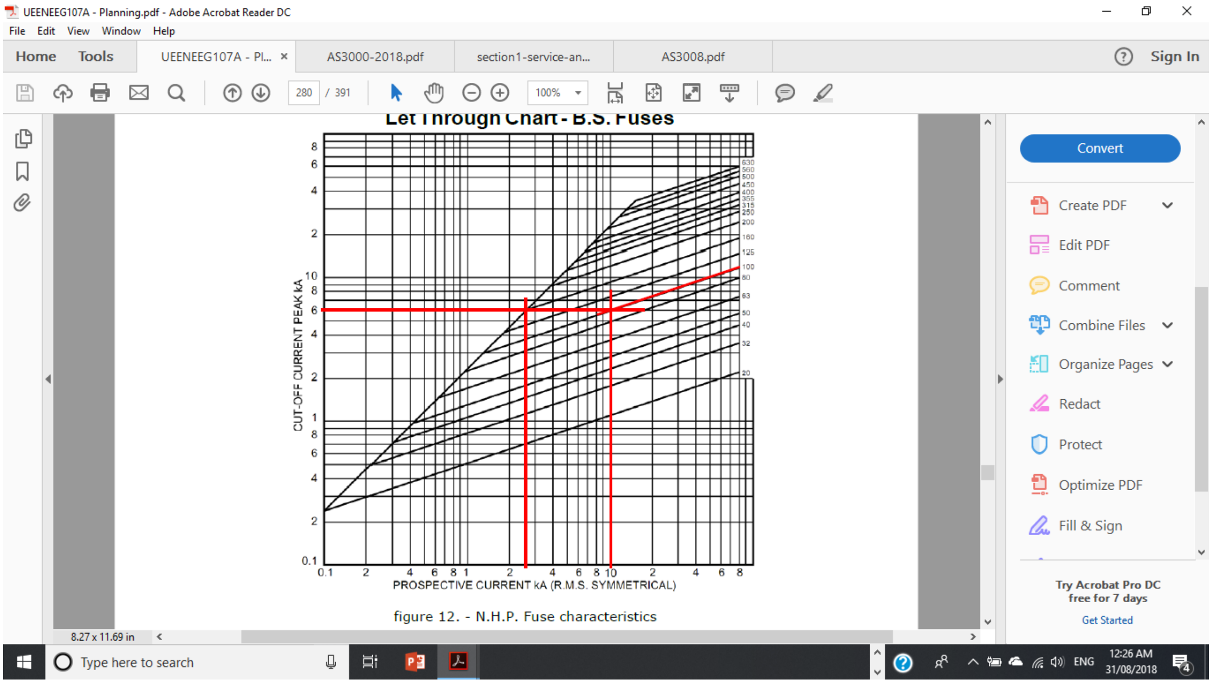
Read the suggested text or resource

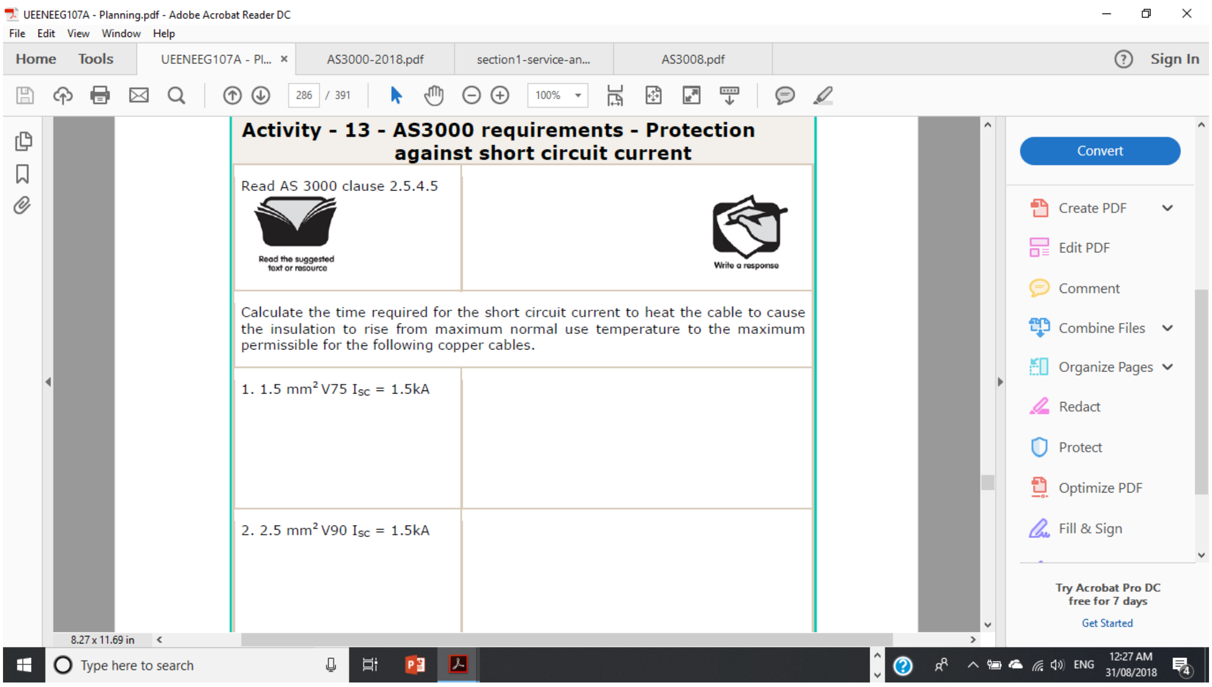
Use figure 12 to determine;

Write a response

1. The minimum breaking capacity of a M.C.B protected against a 10kA P.S.C. by a 160A H.R.C. fuse

2. The minimum breaking capacity of a M.C.B protected against a 25kA P.S.C. by a 160A H.R.C. fuse




Activity - 13 - AS3000 requirements - Protection against short circuit current

Read AS 3000 clause 2.5.4.5

Read the suggested text or resource

Write a response

Calculate the time required for the short circuit current to heat the cable to cause the insulation to rise from maximum normal use temperature to the maximum permissible for the following copper cables.

1. 1.5 mm^2 V75 I_{SC} = 1.5kA

2. 2.5 mm^2 V90 I_{SC} = 1.5kA

2.5.4.5 Omission of devices for short-circuit protection

Devices for protection against short-circuit current may be omitted under the following conditions:

(a) Where unexpected opening of the circuit could cause a danger greater than short-circuit, devices for protection against short-circuit shall be omitted, in accordance with Clause 2.5.1.4.

(b) Consumer mains constructed in accordance with Clause 3.9.7.1 need not be provided with short-circuit protection.

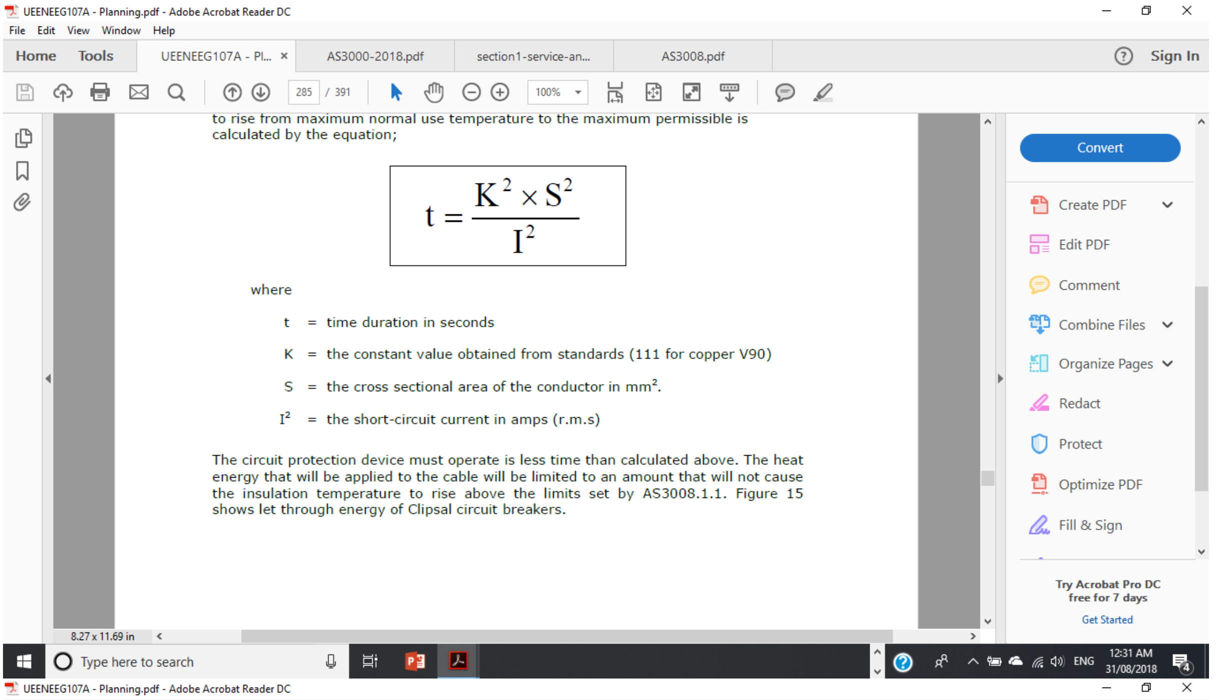
(c) Conductors connecting generators, transformers, rectifiers or batteries to their associated switchboards need not be provided with shortcircuit protection provided that—

(i) the wiring is carried out in such a way as to reduce the risk of a short-circuit to a minimum; and

(ii) the wiring is not placed close to flammable material; and

(iii) the short-circuit protective devices for the remainder of the circuit are placed on the associated switchboard.

NOTE: Examples of the omission of devices for short-circuit protection are shown in Figures 2.3 and 2.9.



to rise from maximum normal use temperature to the maximum permissible is calculated by the equation;

$$t = \frac{K^2 \times S^2}{I^2}$$

where

- t = time duration in seconds
- K = the constant value obtained from standards (111 for copper V90)
- S = the cross sectional area of the conductor in mm².
- I^2 = the short-circuit current in amps (r.m.s)

The circuit protection device must operate is less time than calculated above. The heat energy that will be applied to the cable will be limited to an amount that will not cause the insulation temperature to rise above the limits set by AS3008.1.1. Figure 15 shows let through energy of Clipsal circuit breakers.

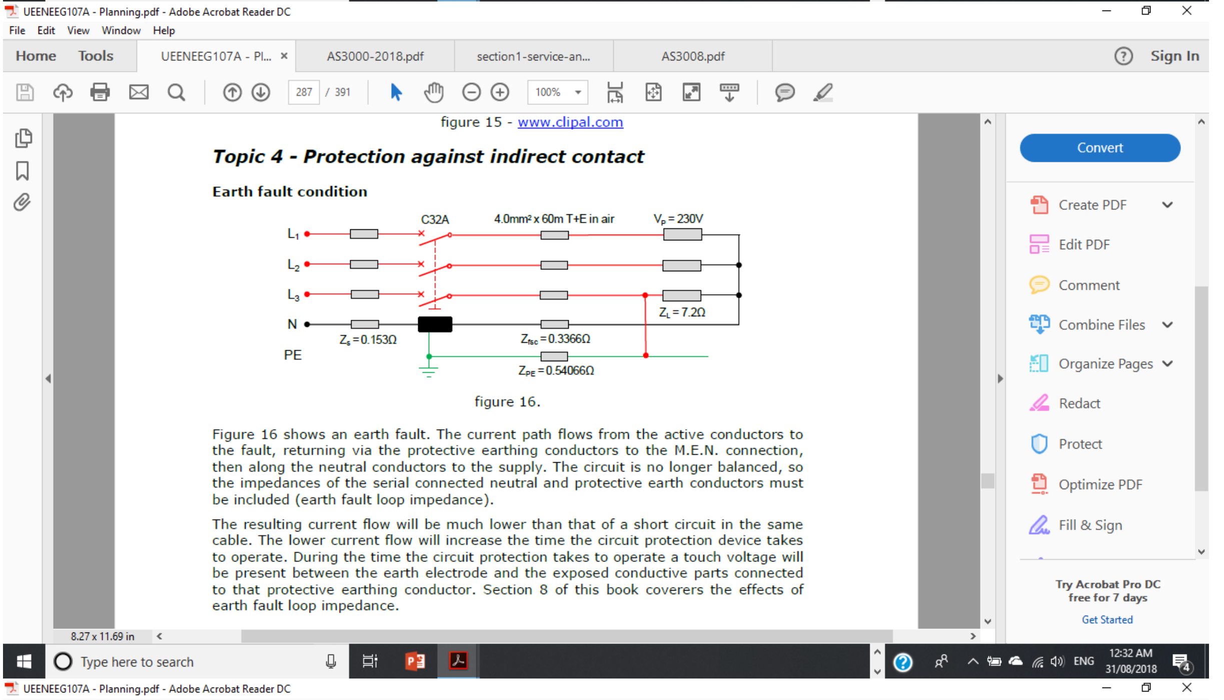


figure 15 - www.clipal.com

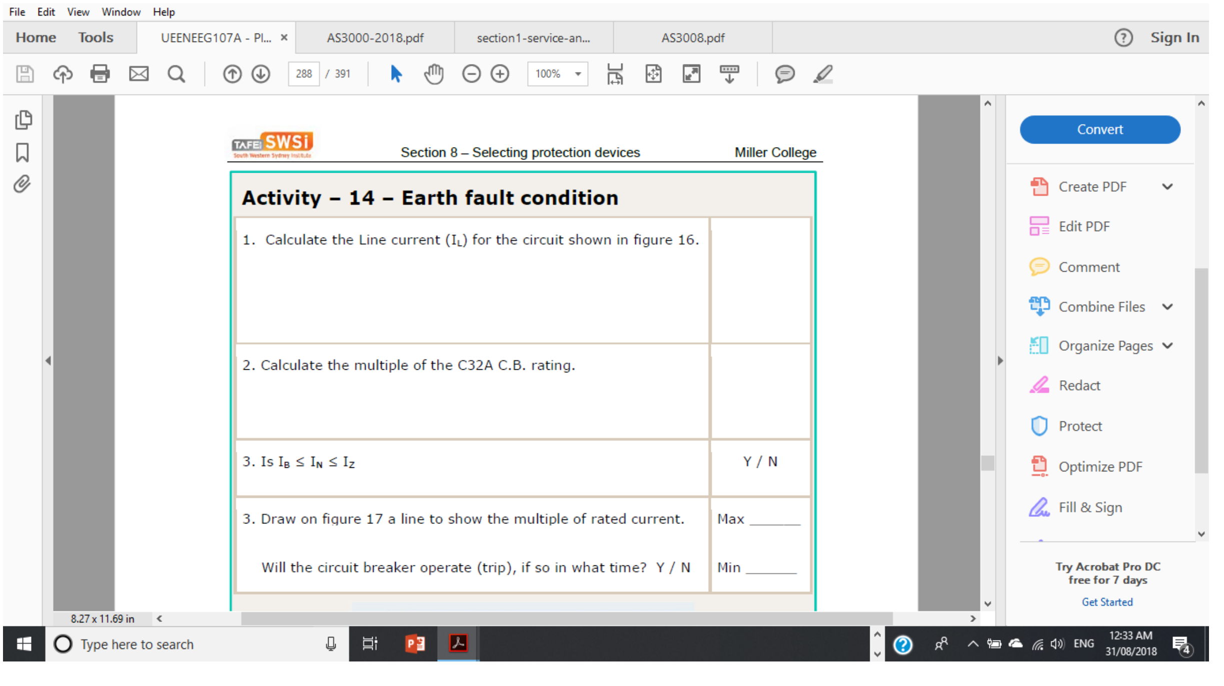
Topic 4 - Protection against indirect contact

Earth fault condition

figure 16.

Figure 16 shows an earth fault. The current path flows from the active conductors to the fault, returning via the protective earthing conductors to the M.E.N. connection, then along the neutral conductors to the supply. The circuit is no longer balanced, so the impedances of the serial connected neutral and protective earth conductors must be included (earth fault loop impedance).

The resulting current flow will be much lower than that of a short circuit in the same cable. The lower current flow will increase the time the circuit protection device takes to operate. During the time the circuit protection takes to operate a touch voltage will be present between the earth electrode and the exposed conductive parts connected to that protective earthing conductor. Section 8 of this book coverers the effects of earth fault loop impedance.



Section 8 – Selecting protection devices Miller College

Activity – 14 – Earth fault condition

1. Calculate the Line current (I_L) for the circuit shown in figure 16.	
2. Calculate the multiple of the C32A C.B. rating.	
3. Is $I_B \leq I_N \leq I_Z$	Y / N
3. Draw on figure 17 a line to show the multiple of rated current. Will the circuit breaker operate (trip), if so in what time? Y / N	Max ______ Min ______

V

Nominal conductor csa (mm^2)	Nominal conductor resistance at 20°C (Ohm per metre)	Length of cable (m) 5	10	15	20	25	30	40	50
1	0.0177	0.0885	0.1770						
1.5	0.0119	0.0595	0.1190	0.1785					
2.5	0.0072	0.0360	0.0720	0.1080	0.1440	0.1800			
4	4.52×10^{-3}	0.0226	0.0452	0.0678	0.0904	0.1130	0.1356	0.1808	
6	3.02×10^{-3}	0.0151	0.0302	0.0453	0.0604	0.0755	0.0906	0.1208	0.1510
10	1.79×10^{-3}	0.0090	0.0179	0.0269	0.0358	0.0448	0.0537	0.0716	0.0895
16	1.13×10^{-3}	0.0057	0.0113	0.0170	0.0226	0.0283	0.0339	0.0452	0.0565

values above this line reduce fault currents to less than 2kA

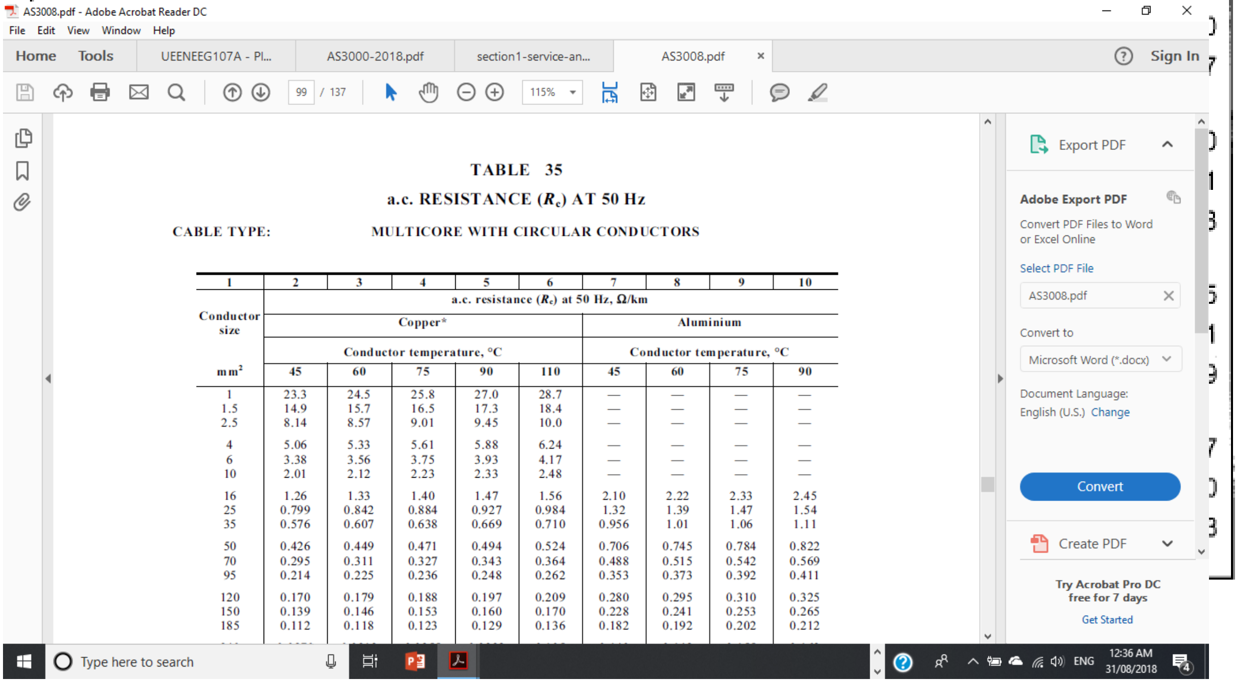
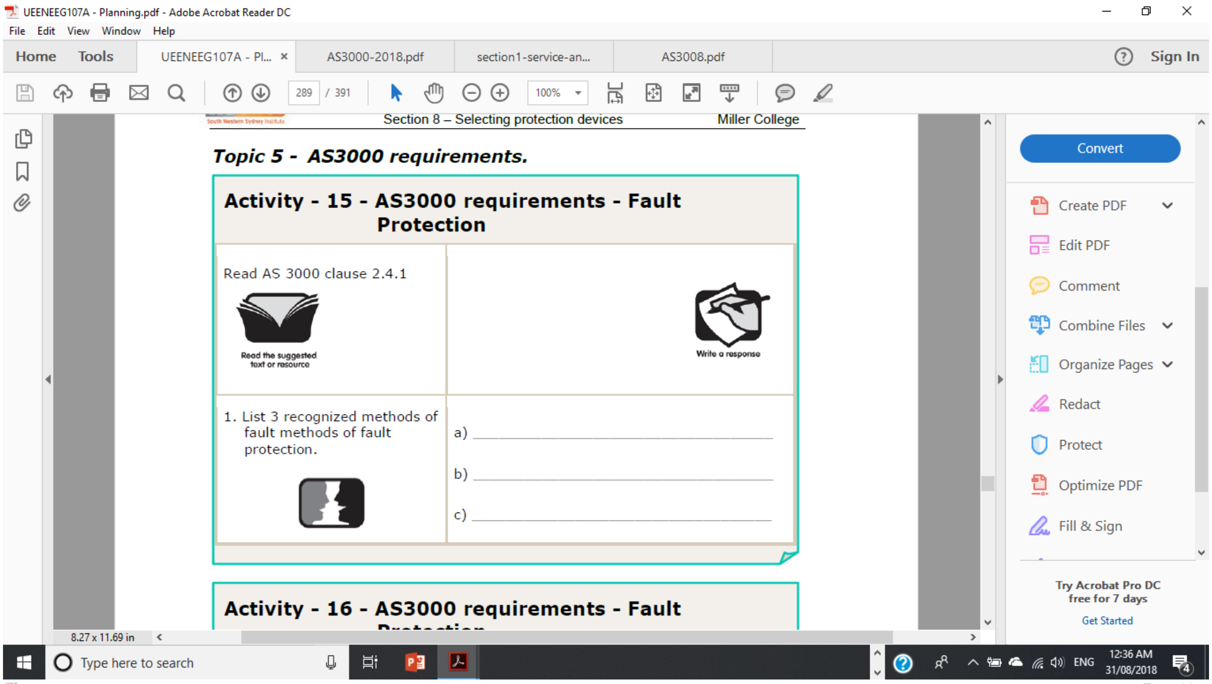


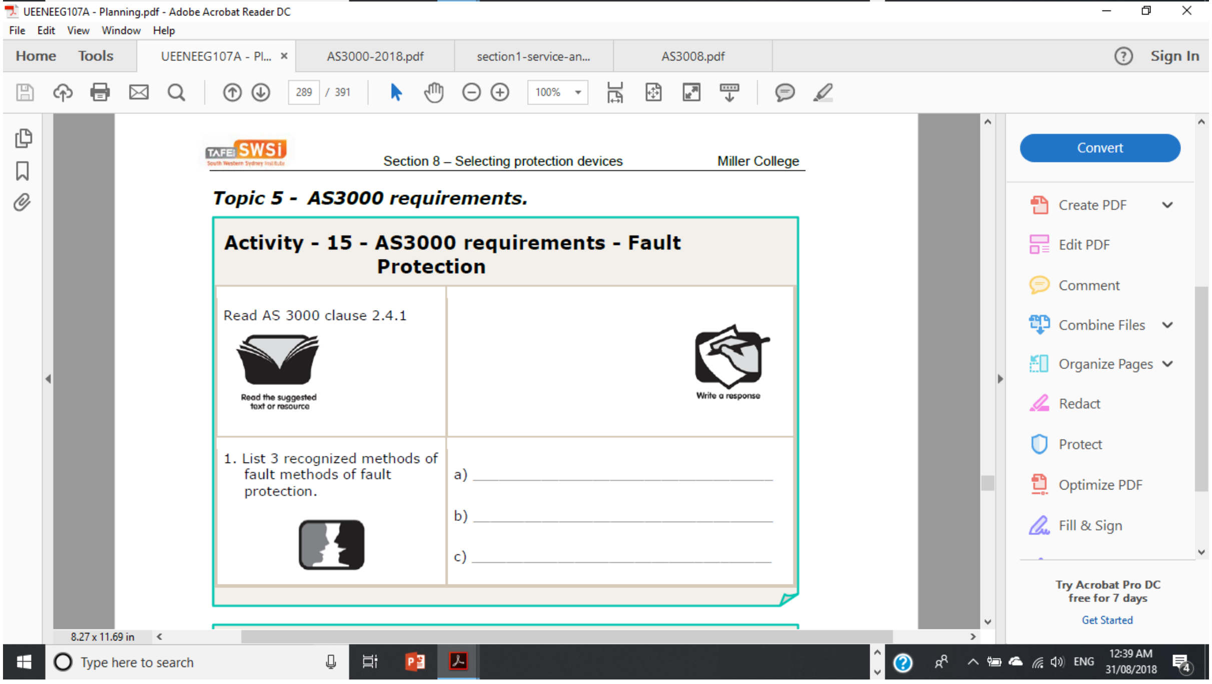
TABLE 35

a.c. RESISTANCE (R_c) AT 50 Hz

CABLE TYPE: MULTICORE WITH CIRCULAR CONDUCTORS

1	2	3	4	5	6	7	8	9	10
Conductor size	a.c. resistance (R_c) at 50 Hz, Ω/km								
	Copper*					Aluminium			
	Conductor temperature, °C					Conductor temperature, °C			
mm^2	45	60	75	90	110	45	60	75	90
1	23.3	24.5	25.8	27.0	28.7	—	—	—	—
1.5	14.9	15.7	16.5	17.3	18.4	—	—	—	—
2.5	8.14	8.57	9.01	9.45	10.0	—	—	—	—
4	5.06	5.33	5.61	5.88	6.24	—	—	—	—
6	3.38	3.56	3.75	3.93	4.17	—	—	—	—
10	2.01	2.12	2.23	2.33	2.48	—	—	—	—
16	1.26	1.33	1.40	1.47	1.56	2.10	2.22	2.33	2.45
25	0.799	0.842	0.884	0.927	0.984	1.32	1.39	1.47	1.54
35	0.576	0.607	0.638	0.669	0.710	0.956	1.01	1.06	1.11
50	0.426	0.449	0.471	0.494	0.524	0.706	0.745	0.784	0.822
70	0.295	0.311	0.327	0.343	0.364	0.488	0.515	0.542	0.569
95	0.214	0.225	0.236	0.248	0.262	0.353	0.373	0.392	0.411
120	0.170	0.179	0.188	0.197	0.209	0.280	0.295	0.310	0.325
150	0.139	0.146	0.153	0.160	0.170	0.228	0.241	0.253	0.265
185	0.112	0.118	0.123	0.129	0.136	0.182	0.192	0.202	0.212





2.4.1 General

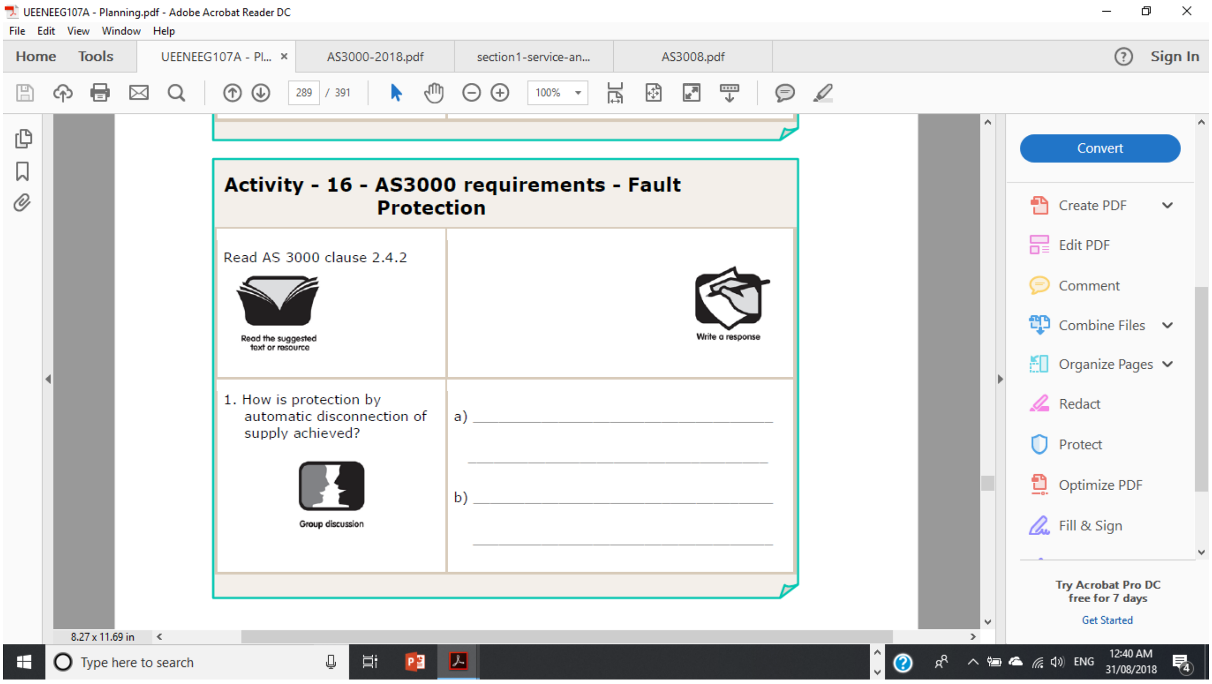
The following methods of fault protection are recognized in this Standard:

* (a) Automatic disconnection of supply, in accordance with Clause 1.5.5.3 and Clause 5.7.

(b) The use of Class II equipment or equivalent insulation, in accordance with Clause 1.5.5.4.

(c) Electrical separation, in accordance with Clauses 1.5.5.5 and 7.4.

The requirements for protection by means of automatic disconnection of supply are set out in Clauses 2.4.2, 2.4.3, 2.5 and 2.6



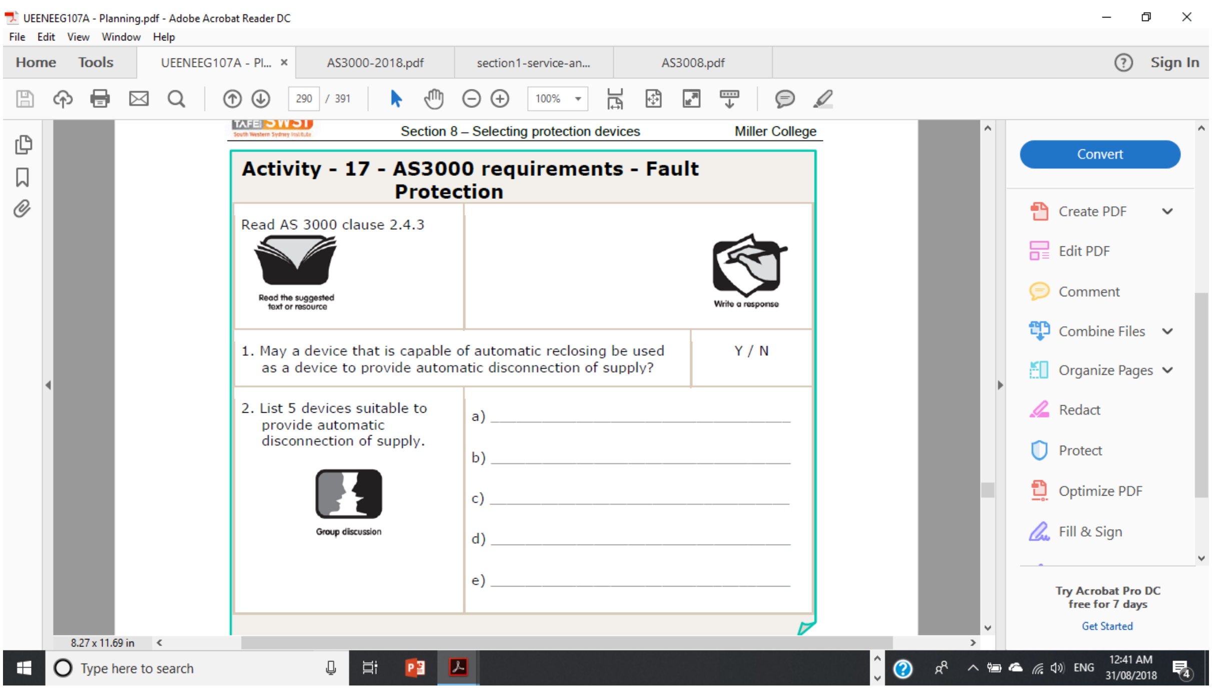
2.4.2 Protection by automatic disconnection of supply

Protection by means of 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 protection shall be achieved by—

(a) provision of a system of earthing in which exposed conductive parts are connected to a protective earthing conductor, in accordance with Section 5; and

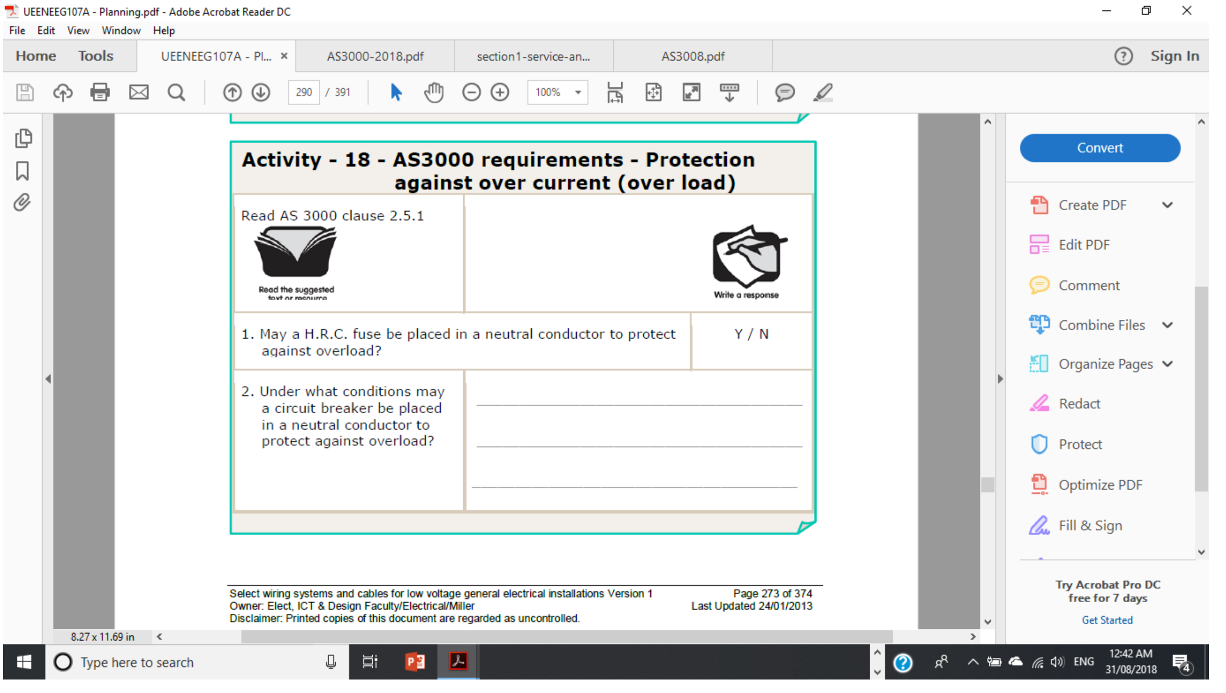
(b) disconnection of the fault by an overcurrent protective device or an RCD.



2.4.3 Types of devices

A device used for protection by automatic disconnection of supply shall not be capable of automatically re-closing. The following types of devices may be employed to provide automatic disconnection of supply:

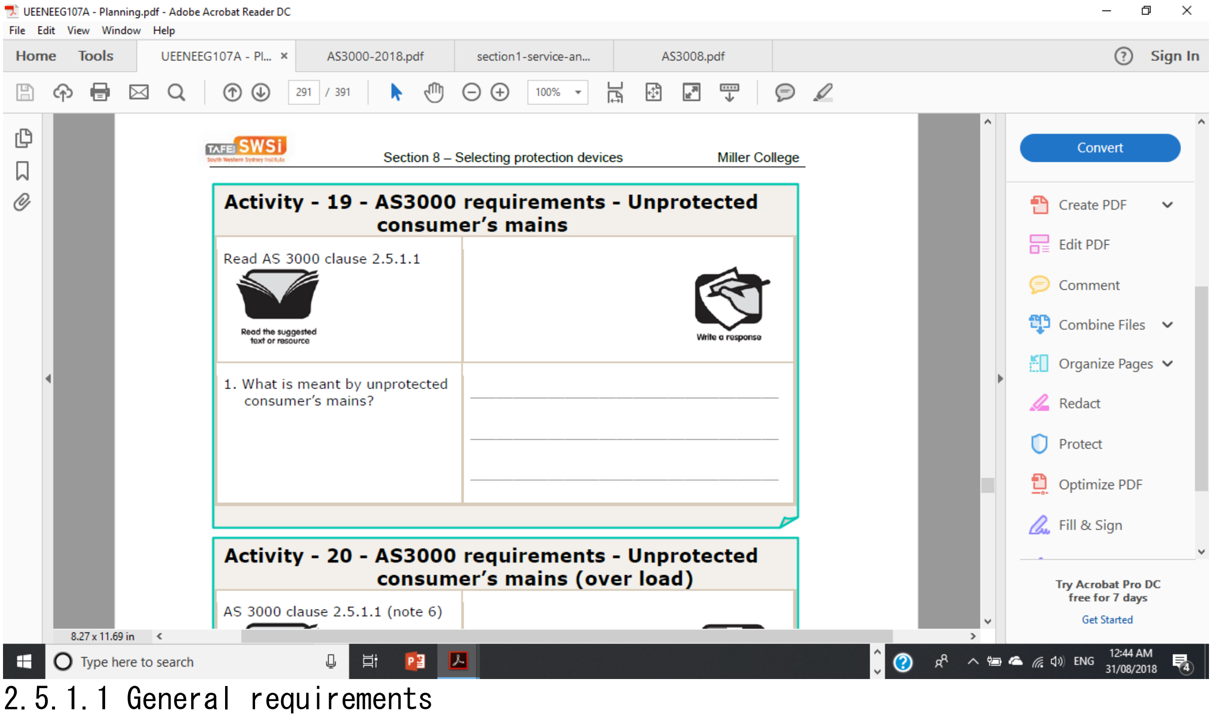
(a) Enclosed fuse-links complying with the appropriate part(s) of the IEC 60269 series.
(b) Miniature overcurrent circuit-breakers complying with AS/NZS 60898 series or AS/NZS 3111.
(c) Moulded-case circuit-breakers complying with AS/NZS IEC 60947.2.
(d) Fixed setting RCDs complying with AS/NZS 3190, AS/NZS 61008.1 or AS/NZS 61009.1.
(e) Other devices, with no automatic reclose function, having characteristics similar to any of the devices listed in Items (a) to (d).



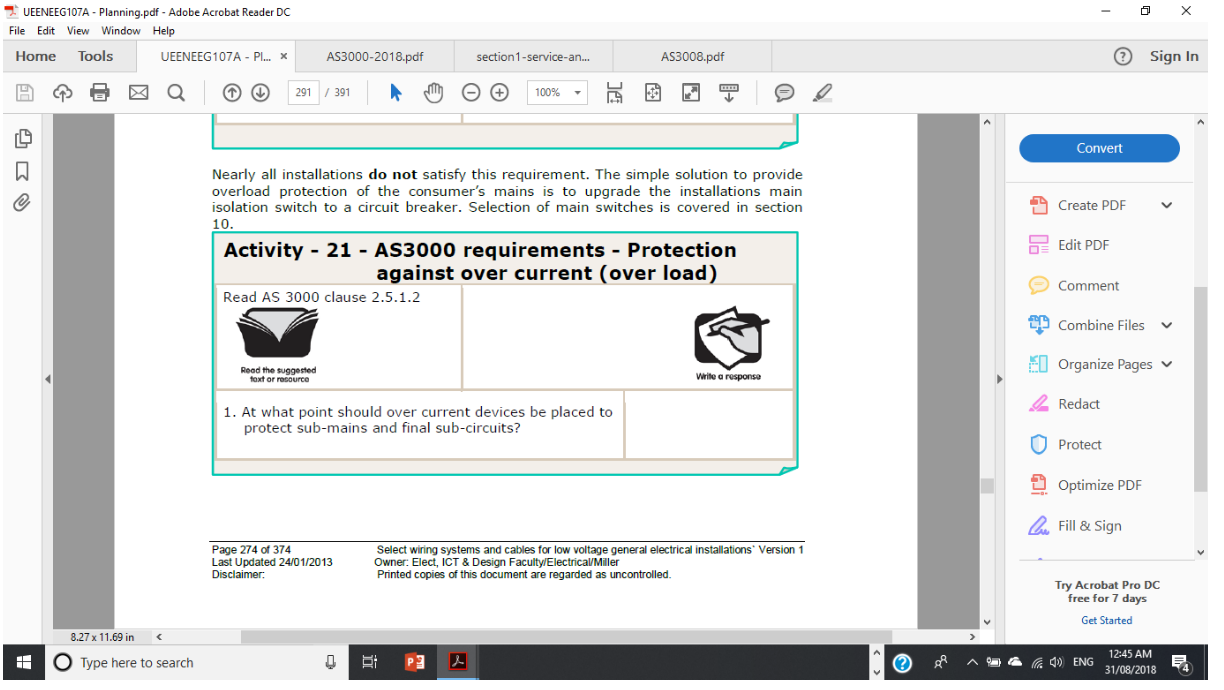
2.5 PROTECTION AGAINST OVERCURRENT
2.5.1 General
* 2.5.1.1 General requirements
Active conductors shall be protected by one or more devices that automatically disconnect the supply in the event of overcurrent, before such overcurrent attains a magnitude or duration that could cause injury to persons or livestock or damage because of excessive temperatures or electromechanical stresses in the electrical installation.
No fuse shall be inserted in a neutral conductor. Protective devices that incorporate a switching function in the neutral conductor shall comply with the requirements of Clause 2.3.2.1.2(b).
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.
Protection against overload current and short-circuit current shall be coordinated, in accordance with Clause 2.5.6.
NOTES:
1 Overcurrent protection is inseparably linked to the current-carrying capacity and temperature limits of the protected cable.
* Reduction in current-carrying capacity of conductors may occur by a change in cross-sectional area, method of installation, or type of cable or conductor.
2 Appendix I provides guidance on the ratings of overload protective devices where alterations or repairs involve the use of existing imperial 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.



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.
No fuse shall be inserted in a neutral conductor. Protective devices that incorporate a switching function in the neutral conductor shall comply with the requirements of Clause 2.3.2.1.2(b).
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.
Protection against overload current and short-circuit current shall be coordinated, in accordance with Clause 2.5.6.



Nearly all installations **do not** satisfy this requirement. The simple solution to provide overload protection of the consumer's mains is to upgrade the installations main isolation switch to a circuit breaker. Selection of main switches is covered in section 10.

Activity - 21 - AS3000 requirements - Protection against over current (over load)

Read AS 3000 clause 2.5.1.2

Read the suggested text or resource

Write a response

1. At what point should over current devices be placed to protect sub-mains and final sub-circuits?

Page 274 of 374 Select wiring systems and cables for low voltage general electrical installations' Version 1
Last Updated 24/01/2013 Owner: Elect, ICT & Design Faculty/Electrical/Miller
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2.5.1.2 Consumer mains

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

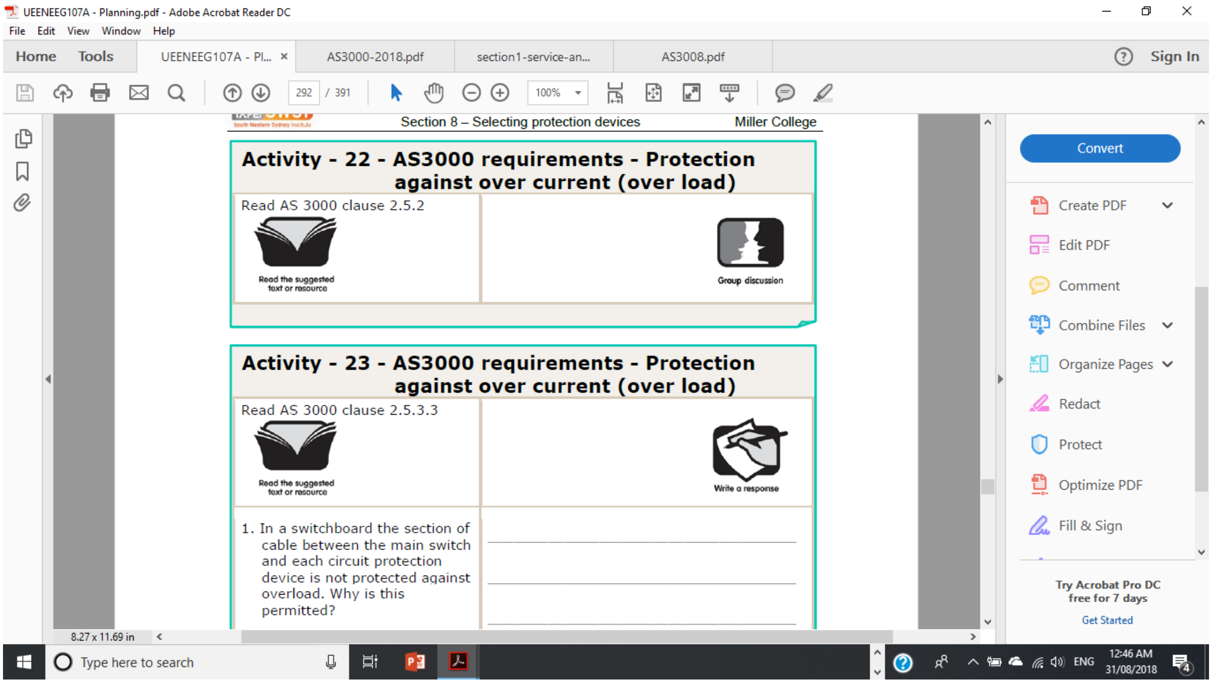
(a) Short-circuit protection and overload protection shall be provided at the origin of the consumer mains (the point of supply) (see Notes 1 and 2).

(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.



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:

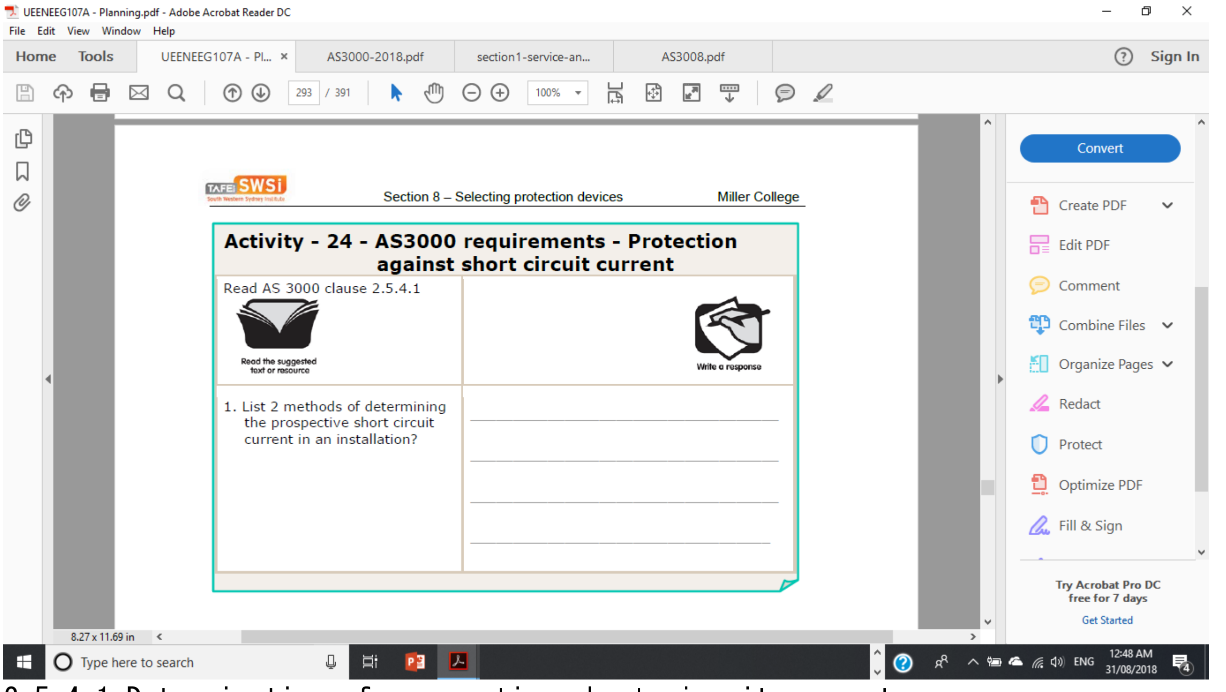
(a) Circuit-breakers incorporating short-circuit and overload releases.
(b) Fuse-combination units (CFS units).
(c) Fuses having enclosed fuse-links (HRC fuses).
(d) Circuit-breakers in conjunction with fuses.

Semi-enclosed rewireable fuses shall not be used.

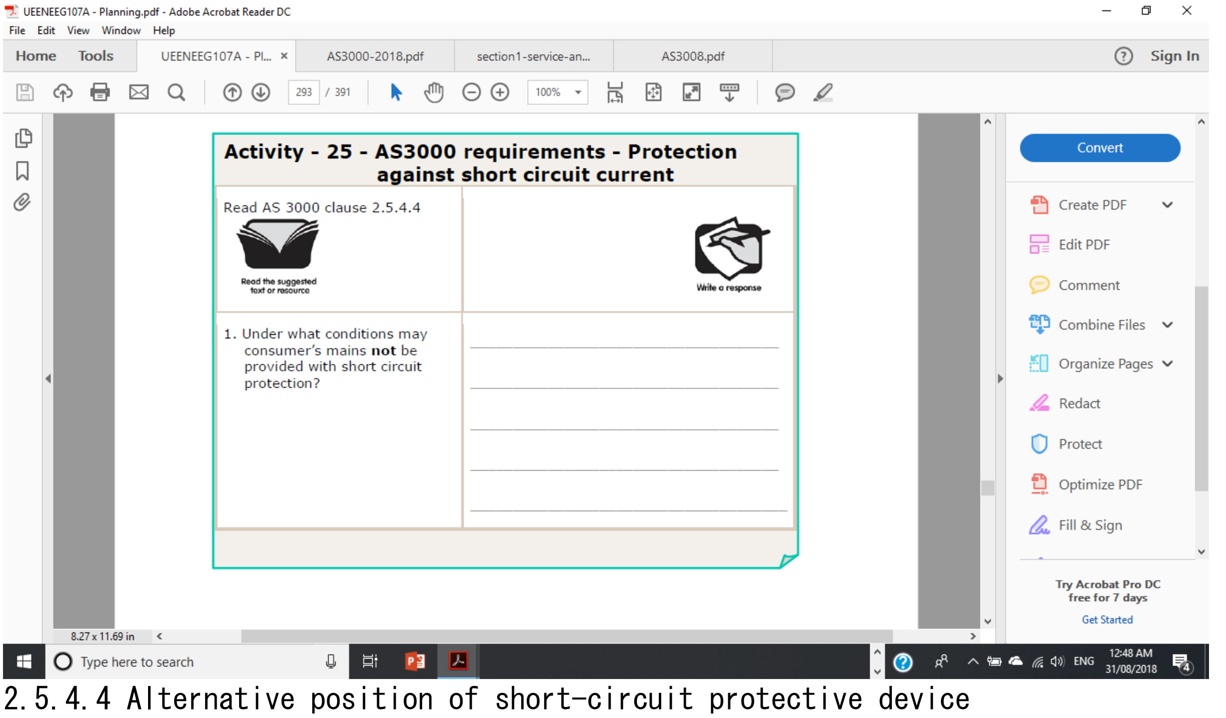
2.5.3.3 Alternative position of overload protective device

A device providing protection of a conductor against overload current may be placed at a point other than the origin of the circuit provided that—

(a) the conductor has no branch circuits or socket-outlets connected between the origin of the conductor and the overload protective device; or
(b) the conductor supplies one or more circuits that are individually protected against overload, such as within a switchboard or busway, and the sum of the current ratings of the circuit protective devices supplied by the conductor does not exceed the current-carrying capacity of the conductor.



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.



2.5.4.4 Alternative position of short-circuit protective device
2.5.4.4.1 General
A device providing protection against short-circuit current may be placed at another point in the circuit under the conditions of Clauses 2.5.4.4.2 or 2.5.4.4.3.
* 2.5.4.4.2 Condition 1
The part of the conductor between the point of reduction of cross-sectional area or other change and the position of the protective device shall be such that—
(a) its length does not exceed three metres; and
(b) it is protected mechanically or otherwise so that the risk of short-circuit
is reduced to a minimum; and

c) it is installed in such a manner as to reduce to a minimum the risk of fire or other danger to persons, livestock and property.

NOTES:

1 Insulated conductors in a metallic wiring enclosure are considered to comply with this requirement.

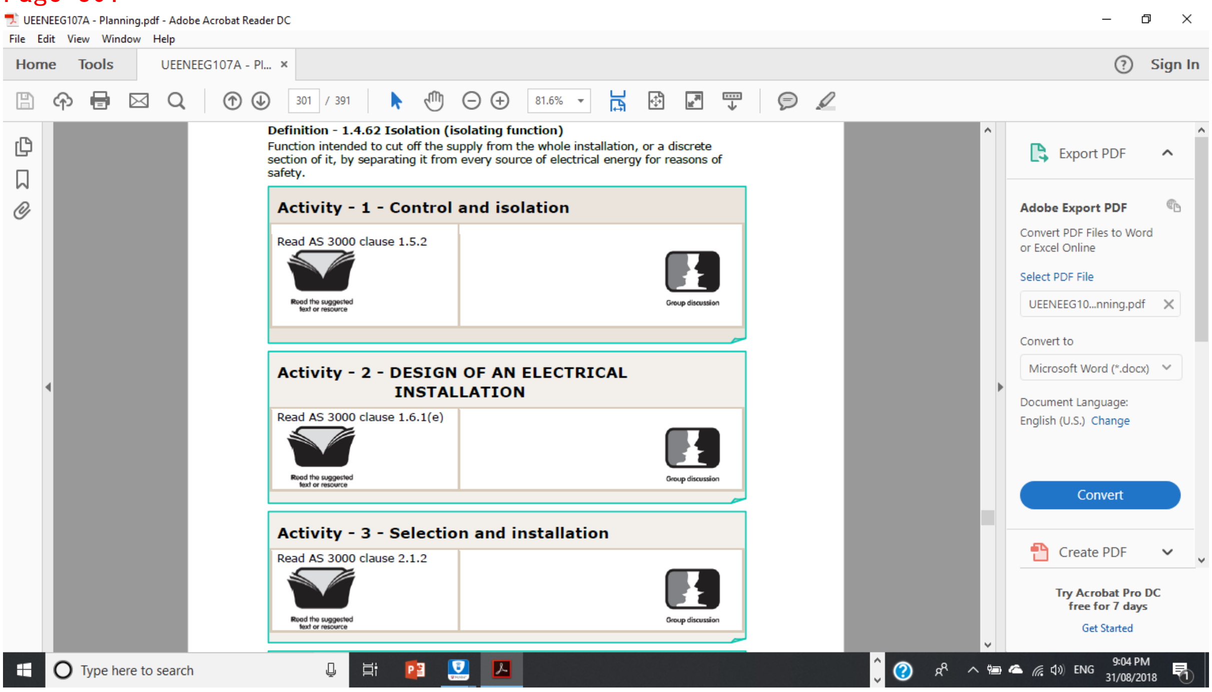
2 An example of the alternative position of a short-circuit protective device is shown at Figure 2.8.

2.5.4.4.3 Condition 2

A protective device may be placed on the supply side of the reduced crosssectional
area or other change, provided that it possesses an operating characteristic such that it protects the circuit situated on the load side against short-circuit, in accordance with Clause 2.5.4.5.

NOTE: This may be verified by comparing the short-circuit current level just before the branch device with the performance characteristics of the preceding device.

Page 301



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.

This may incorporate a device that effectively isolates the equipment from all sources of supply external to the equipment.

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 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.

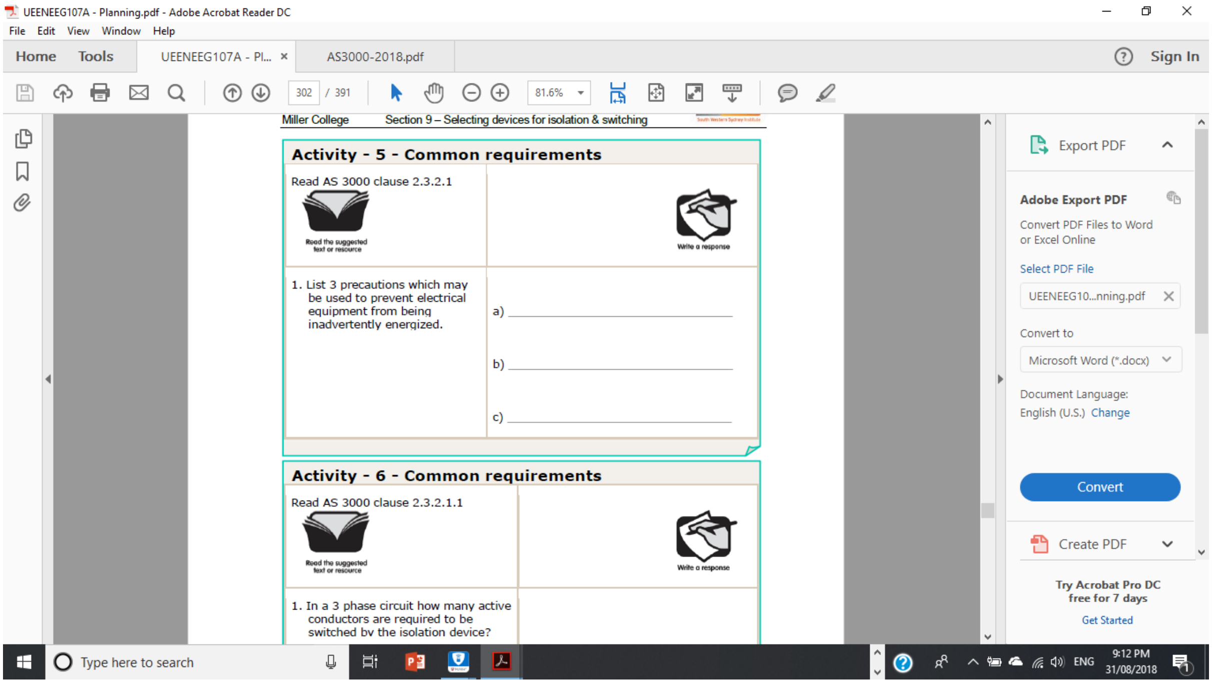
An isolation device or switch shall not interrupt an earthing conductor or a combined protective earthing and neutral (PEN) conductor.

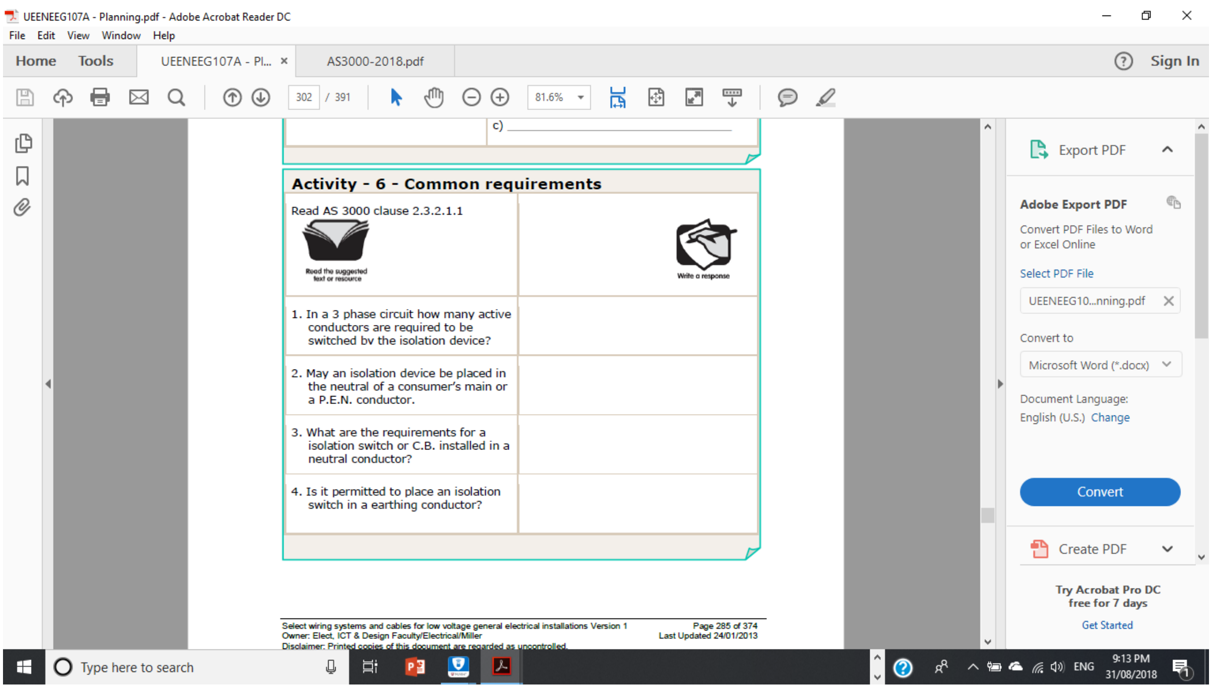
1.6 DESIGN OF AN ELECTRICAL INSTALLATION

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.
WE

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.

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.





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.

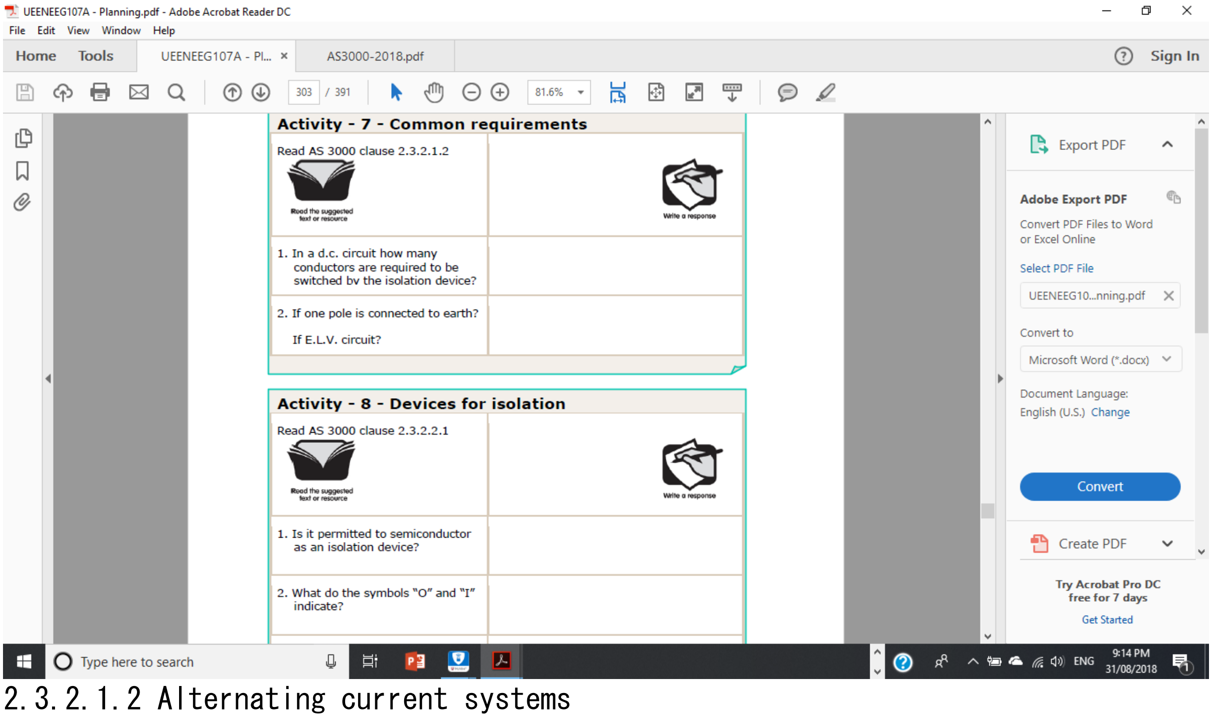
NOTE: Such precautions may include one or more of the following measures:

(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.

Where an item of equipment or enclosure contains live parts connected to more than one supply, a notice shall be placed in such a position that any person gaining access to live parts will be warned of the need to isolate those parts from the various supplies.



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.

NOTE: This requirement applies to situations such as an earth sheath return (ESR) system or a submain neutral used for earthing of an electrical installation in an outbuilding in accordance with Clause 5.5.3.1.

(ii) A switch or circuit-breaker may operate in the neutral conductor of circuits other than those in Item (i) where—

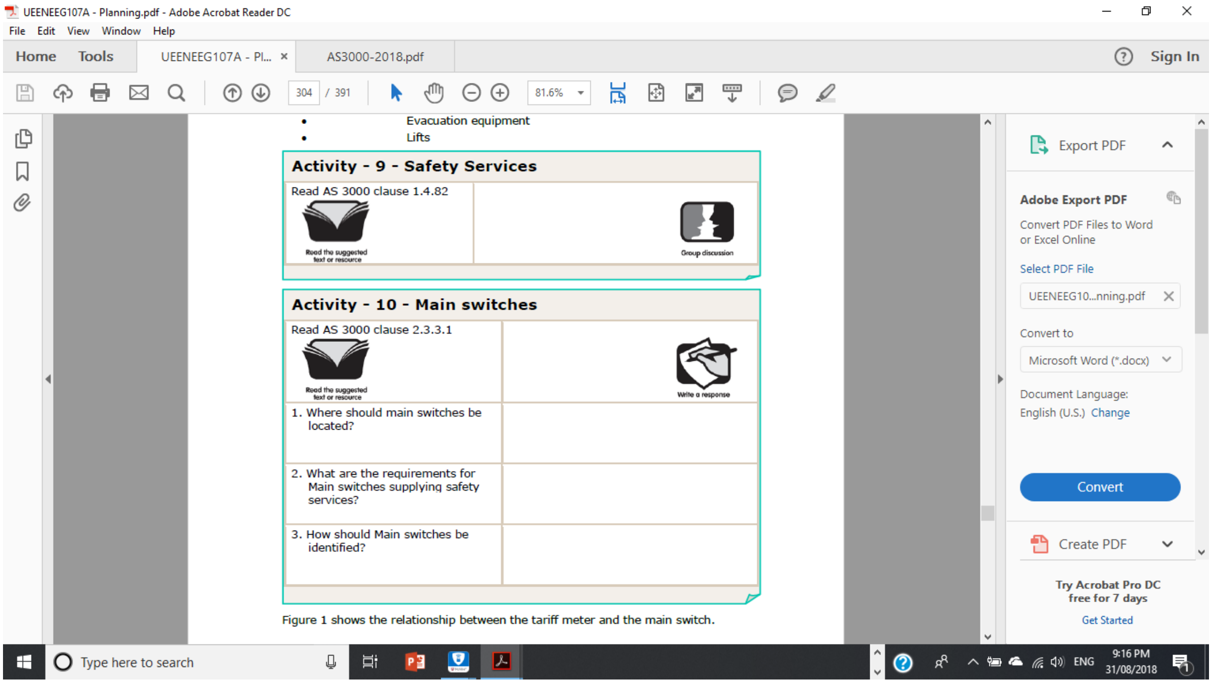
(A) the neutral pole of a multi-pole switch or circuit-breaker, having an appropriate short-circuit breaking and making capacity, is linked and arranged to switch substantially together with all active poles; or

(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).
(iii) Where an item of switchgear is required to disconnect all live conductors of a circuit, it shall be of a type such that the neutral conductor cannot be disconnected or reconnected without the respective active conductors also being disconnected or reconnected.
* NOTE: The manual disconnection and connection of neutral conductors should be as follows:
(a) The active conductors should be disconnected before the neutral conductors.
(b) The neutral conductors should be connected before the active conductors.
Refer to AS/NZS 4836 for safe work practices.
(iv) A switch in the control circuit of a fire pump shall operate in the neutral conductor in accordance with Clause 7.2.5.6.4.
In accordance with Clause 2.5.1.1, no fuse shall be inserted in a neutral conductor.
(c) Switching of earthing conductor prohibited An earthing conductor shall not be isolated or switched.
A conductor used as a combined protective earthing and neutral (PEN) conductor shall not be isolated or switched.

2.3.2.2.1 General
* Devices for isolation shall effectively isolate all active conductors from the
circuit.
A semiconductor (solid-state) device shall not be used for isolation purposes.
A device for isolation—
(a) shall be capable of withstanding an impulse voltage likely to occur at the point of installation, or shall have an appropriate contact gap;
(b) shall not be able to falsely indicate that the contacts are open;
(c) shall clearly and reliably indicate the isolating position of the device;
NOTE: The symbols ‘O’ (OFF) and ‘I’ (ON) are deemed to satisfy this requirement.
(d) shall be designed and installed so as to prevent unintentional closure, such as might be caused by impact, vibration or the like;
(e) shall be a device that disconnects all active conductors of the relevant supply; and
NOTE: Single-pole devices situated adjacent to one another may be used.
(f) shall be readily available.



1.4.82 Main switch

* A switch, the primary function of which is the isolation of a supply of electricity to the electrical installation. This device may

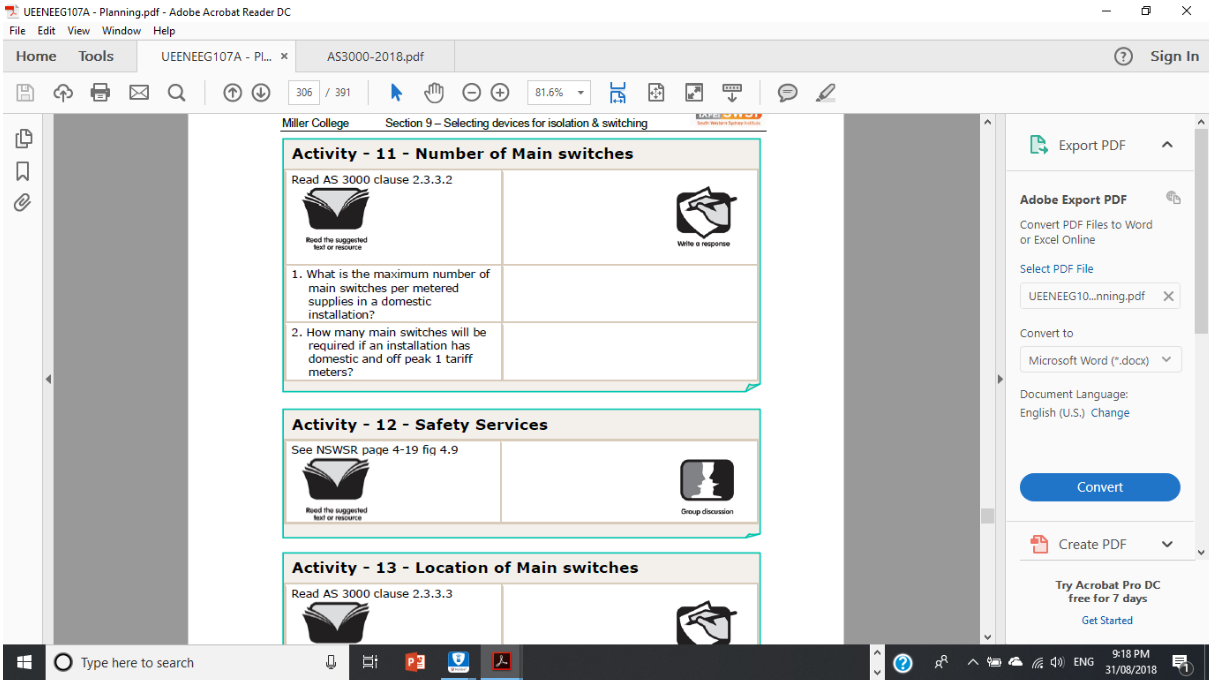
2.3.3 Main switches

* 2.3.3.1 Introduction

The following requirements are intended to provide for the—

(a) efficient and effective isolation of electricity supply from the electrical
installation, or part thereof, by persons, including emergency services personnel, in the event of an emergency arising that requires prompt isolation; and

(b) maintenance of supply to safety services during an emergency that may require, or result in, isolation of supply from other portions of the electrical installation.

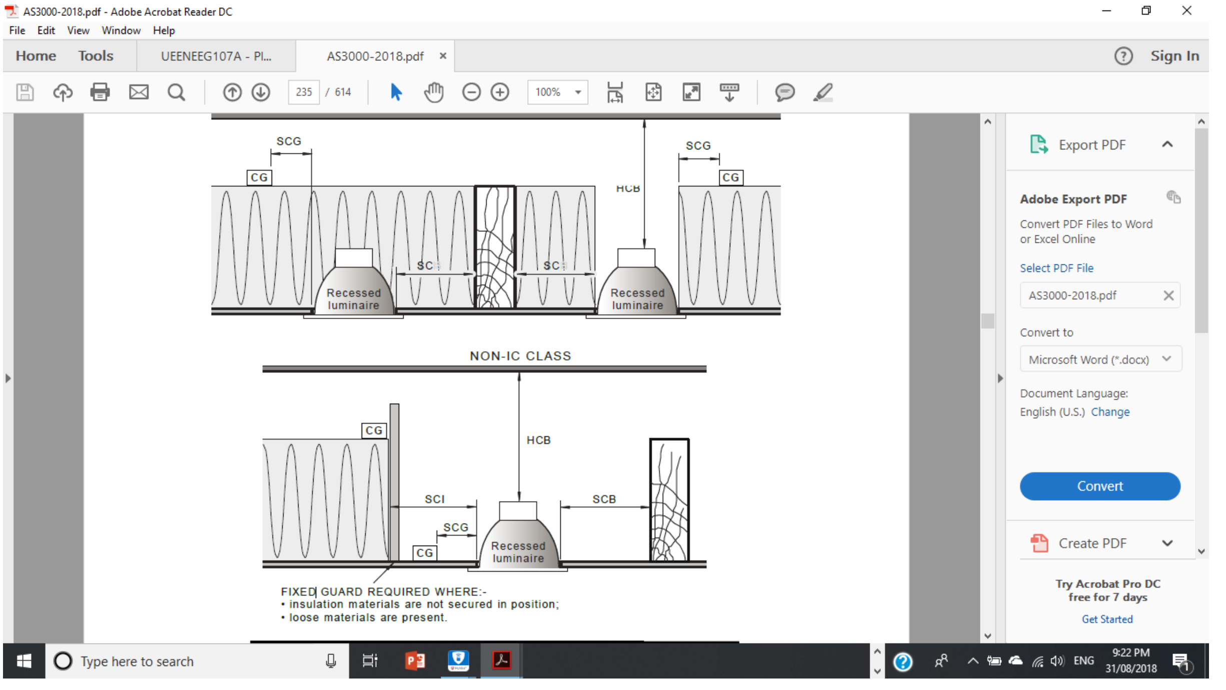


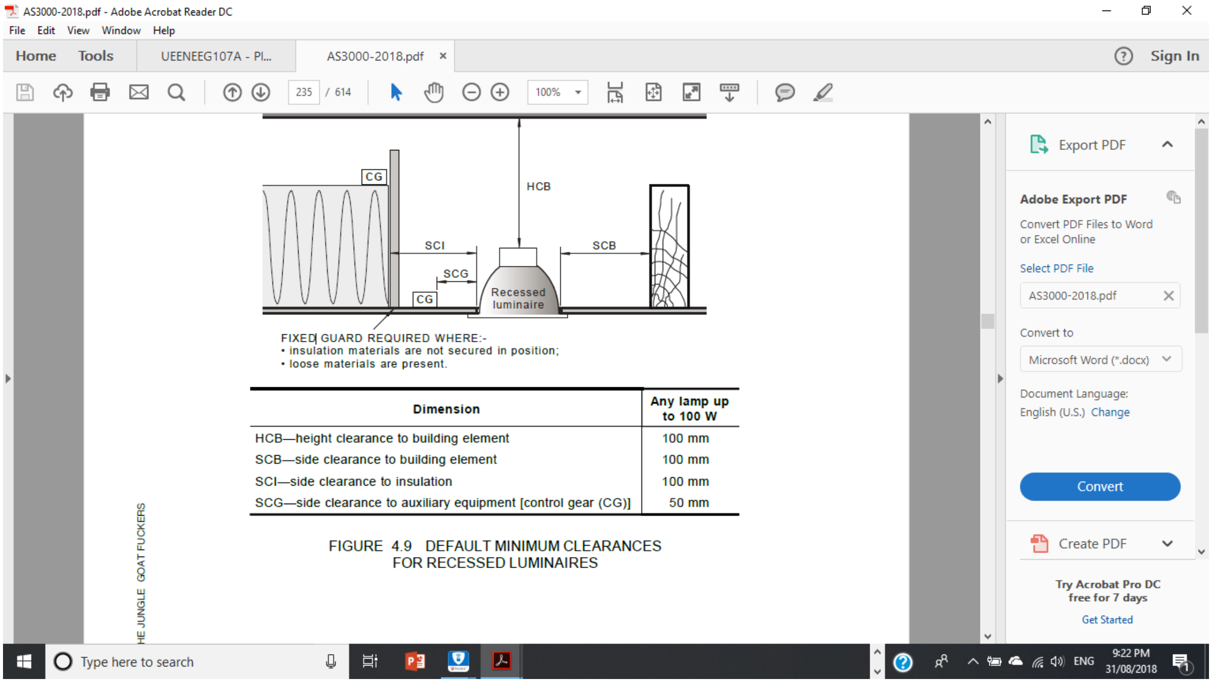
2.3.3.2 General
The supply to every electrical installation shall be controlled on the main switchboard by a main switch or switches that control the whole of the electrical installation.
Where multiple supplies are provided, each supply shall be controlled by a main switch or switches on the main switchboard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

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.

4.19 AIRCONDITIONING AND HEAT PUMP SYSTEMS
Airconditioning and heat pump systems incorporating a compressor shall be provided with an isolating switch (lockable) in accordance with Clause 2.3.2.2, installed adjacent to but not on the unit, which isolates all parts of the system, including ancillary equipment, such as head units, from the same location.
For split system airconditioning units, where the manufacturer requires the airconditioning system to be connected to the electricity supply by means of a plug and socket at the internal unit, the isolating switch installed at the external unit shall control the socket-outlet located at the internal unit.
* For airconditioning systems (including room heaters incorporating a compressor) where the internal unit (or units) are supplied from a circuit separate to that of the compressor, a warning sign shall be permanently fixed on or adjacent to the compressor isolator indicating that the isolator does not isolate the ancillary equipment. Where the internal unit (or units)

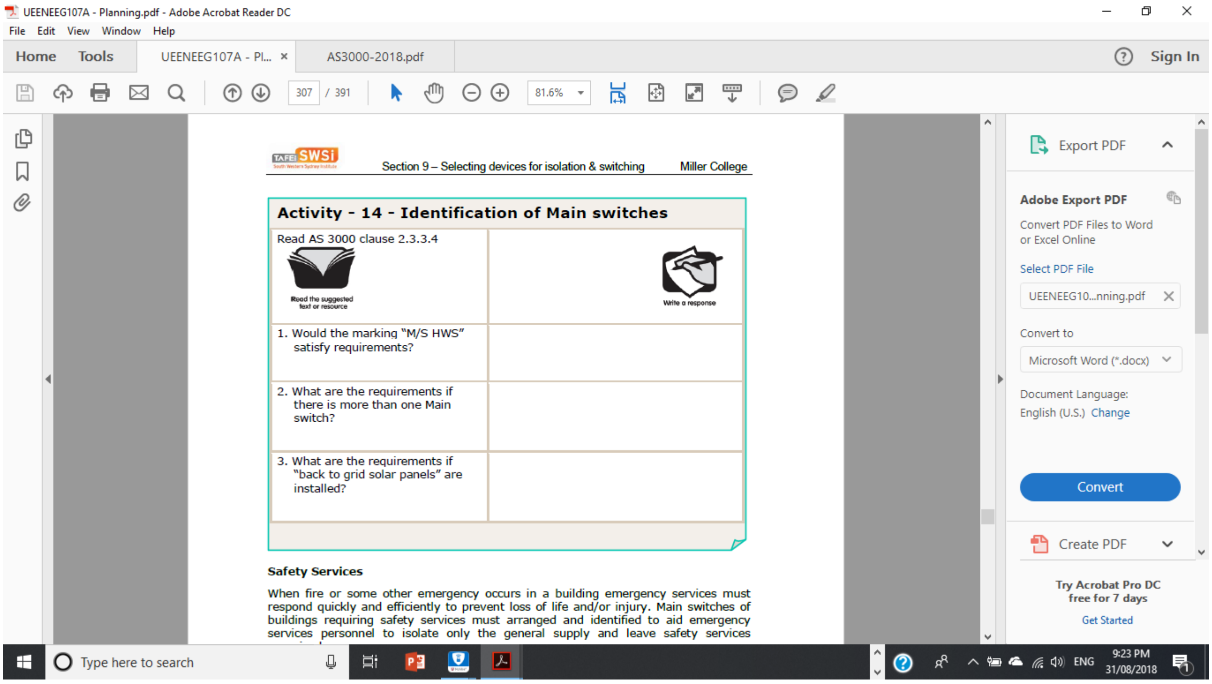
are not connected by plug and socket, an independent isolating switch (lockable) in accordance with Clause 2.3.2.2 shall also be installed adjacent to each separately supplied internal unit (or units).





Dimension	Any lamp up to 100 W
HCB—height clearance to building element	100 mm
SCB—side clearance to building element	100 mm
SCI—side clearance to insulation	100 mm
SCG—side clearance to auxiliary equipment [control gear (CG)]	50 mm

FIGURE 4.9 DEFAULT MINIMUM CLEARANCES FOR RECESSED LUMINAIRES



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.

Exception: A main switch need not be located on a switchboard nor be readily accessible where unauthorized operation may impair safety and the electrical installation is—

(i) located on public land; and

(ii) associated with telephone cabinets, traffic control signals and street furniture, such as bus shelters, and the like; and

(iii) otherwise controlled and protected in accordance with the requirements of this Standard.

* (b) Operating handles or controls associated with a main switch shall be manually operated, single action and mechanical. They shall consist of a handle, lever, push-buttons or similar device. Electronic touch screens, programmable control systems or the like shall not be used as a means of operating main switches.

Electronic touch screens may be used for remote control of main switch/s as per Clause 2.3.3.6.

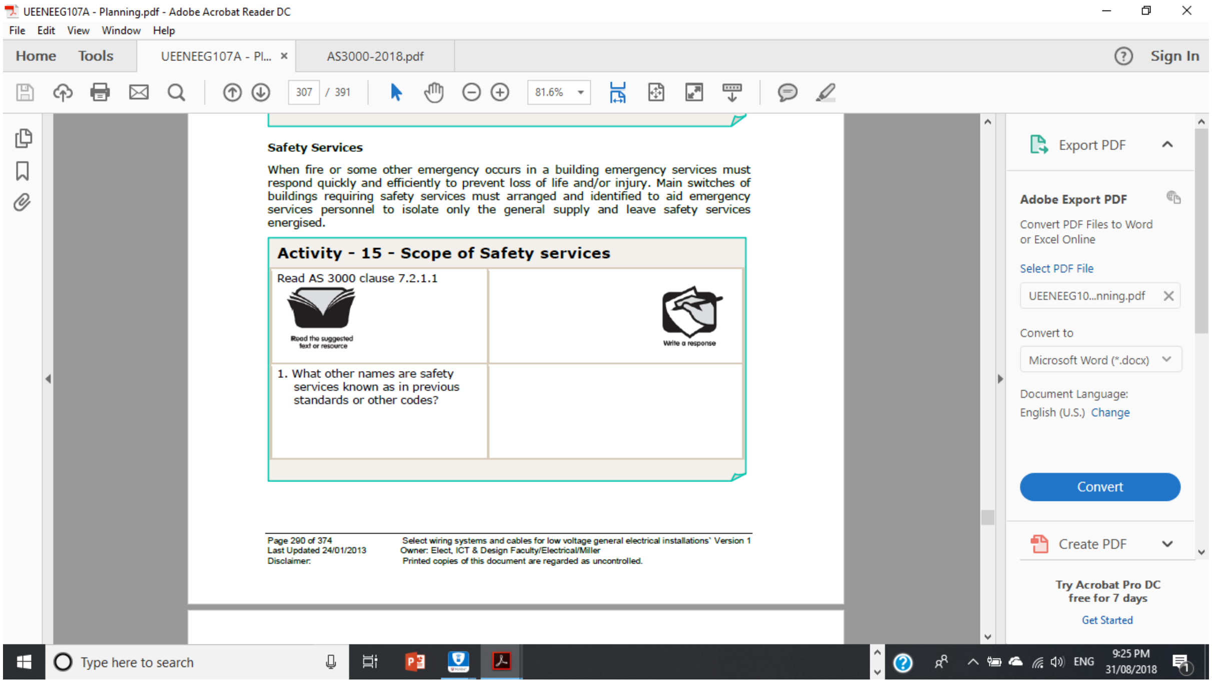
(c) Electrical installations with more than one occupier Each individual occupier shall have readily available access to an isolating switch or switches that isolate that occupier's portion of the electrical installation.

The isolating switch or switches need not control the submains supplying that portion of the electrical installation but shall be mounted on a switchboard located either in the individual portion of the electrical installation or within easy access from an entrance to the individual premises.

The number of such switches shall be in accordance with

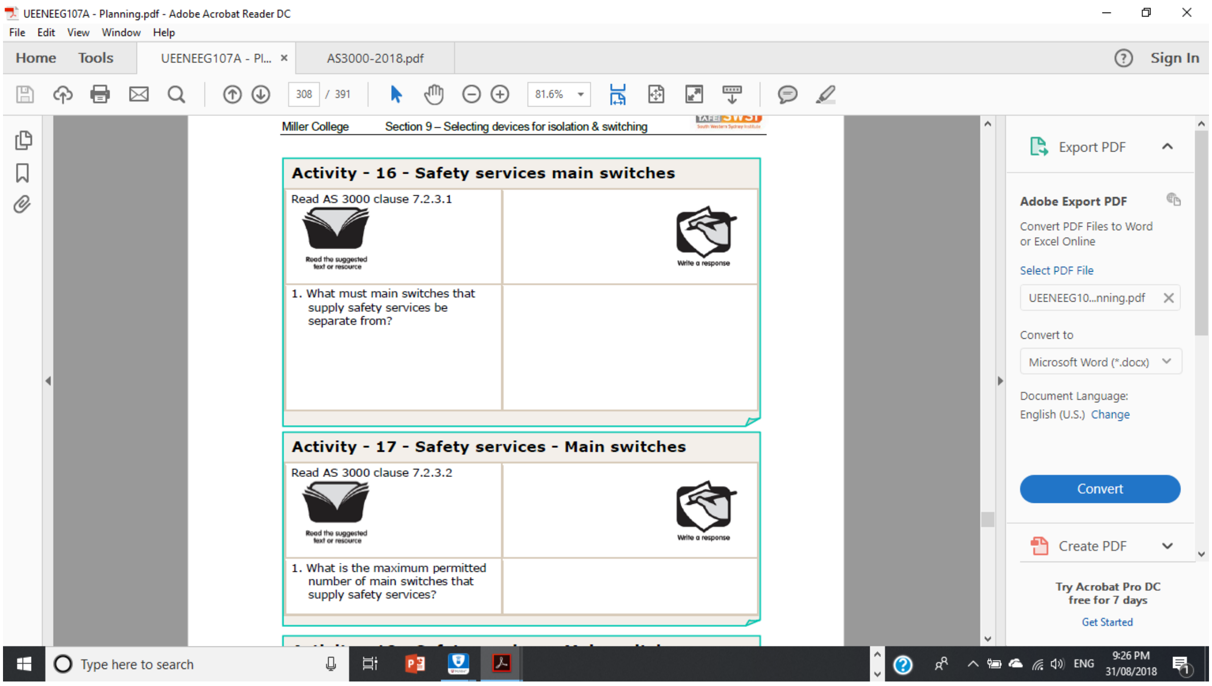
Clause 2.3.3.3 for main switches.

Exception: This requirement need not apply where the main switch or switches for the electrical installation are readily accessible to the individual occupier.



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.



7.2.3 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

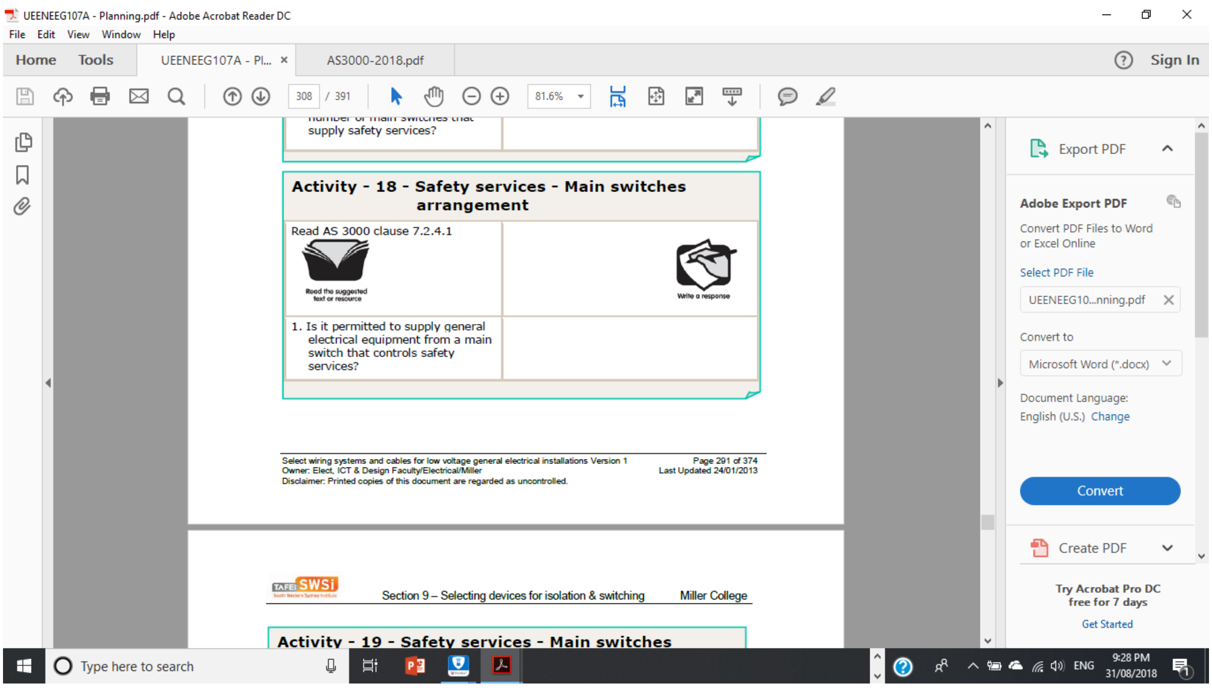
(b) other types of safety services.

Main switchboards shall be installed in accordance with Clause 2.10 and

the National Construction Code or the New Zealand Building Code.
NOTE: Typical examples of main switchboards with one and two normal supplies are shown in Figures 7.2(A) and 7.2(B) respectively.

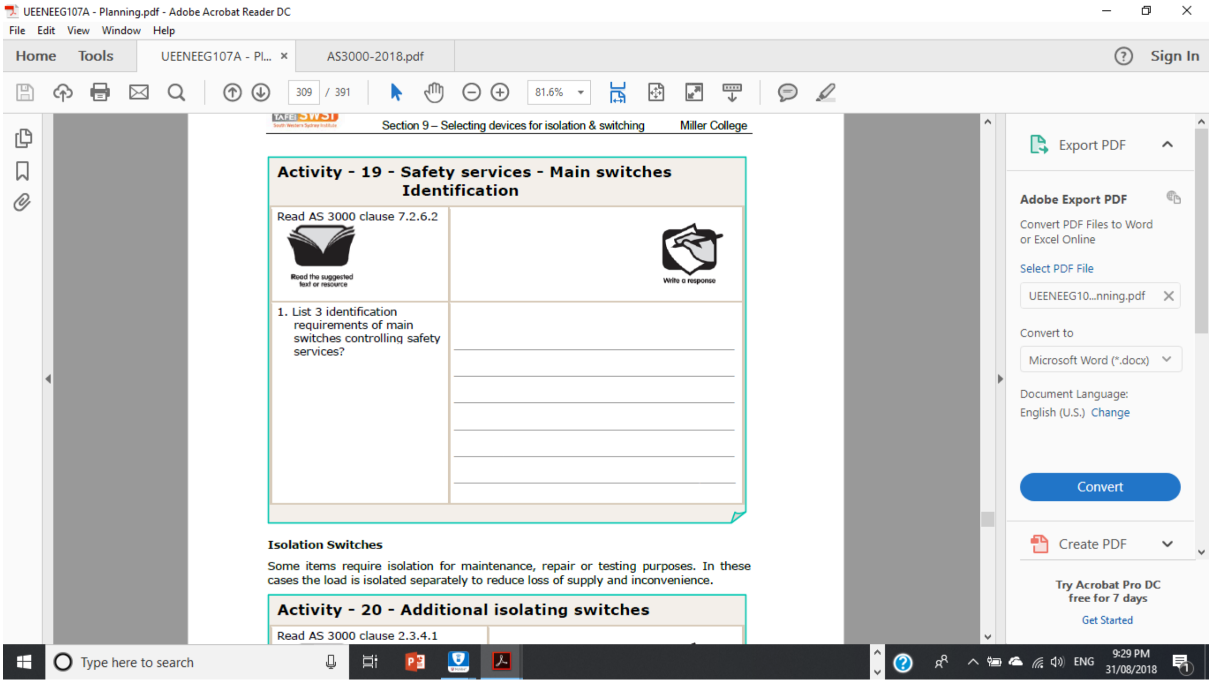
7.2.3.2 Switchgear

Where safety services are installed, all switchboards that are required to sustain supply to safety services shall be constructed so that the safety services switchgear is separated from general switchgear by metal partitions designed to minimize the spread of a fault from the general switchgear to the safety services switchgear.
NOTE: A non-metallic case switchboard does not comply with this Clause.

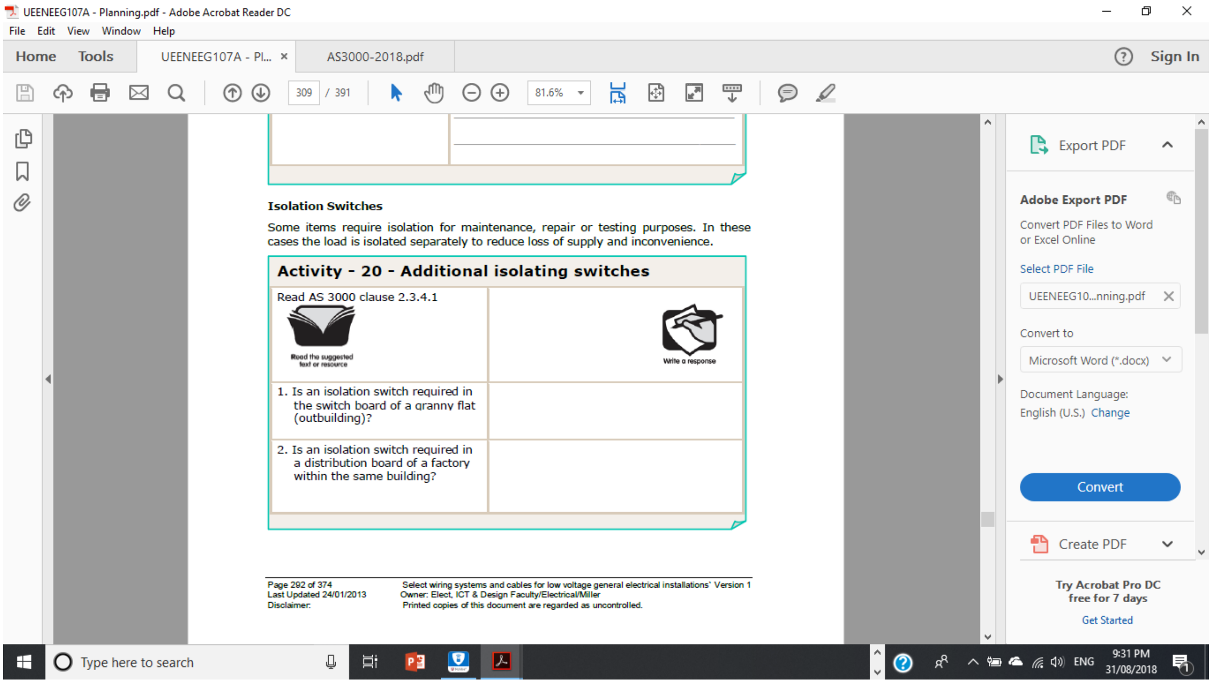


7.2.4.1 General

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.
Main switches shall be selected such that—
(i) a fault on one safety service will not result in loss of supply to other safety services; and
(ii) a fault on the general electrical installation will not result in loss of supply to safety services.
There is no limit to the number of main switches installed for the control of safety services.
An auto transfer switch (ATS) may be used as a main switch provided the ATS meets the requirements of Clause 2.3.3.
Fault-current limiters used to protect safety services shall not be used to provide protection to any part of the general electrical installation.



7.2.6.2 Wiring systems for fire detection and alarm systems
7.2.6.2.1 Types of wiring systems for fire detection and alarm systems
Wiring systems supplying fire detection and alarm systems shall comply with AS/NZS 3013 with a WS classification as specified by the Standard relevant to the installation of such equipment.
NOTE: See Appendix H for further information regarding the application of the WS classification system.
Where the relevant Standard does not specify a WS classification, the wiring system shall be of a type that is—
(a) capable of maintaining supply to the equipment when exposed to either fire or mechanical damage; or
(b) capable of maintaining supply to the equipment when exposed to fire and protected against mechanical damage by—
(i) installation in an effective enclosure; or
(ii) installation in a location where the system will not be exposed to mechanical damage.



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

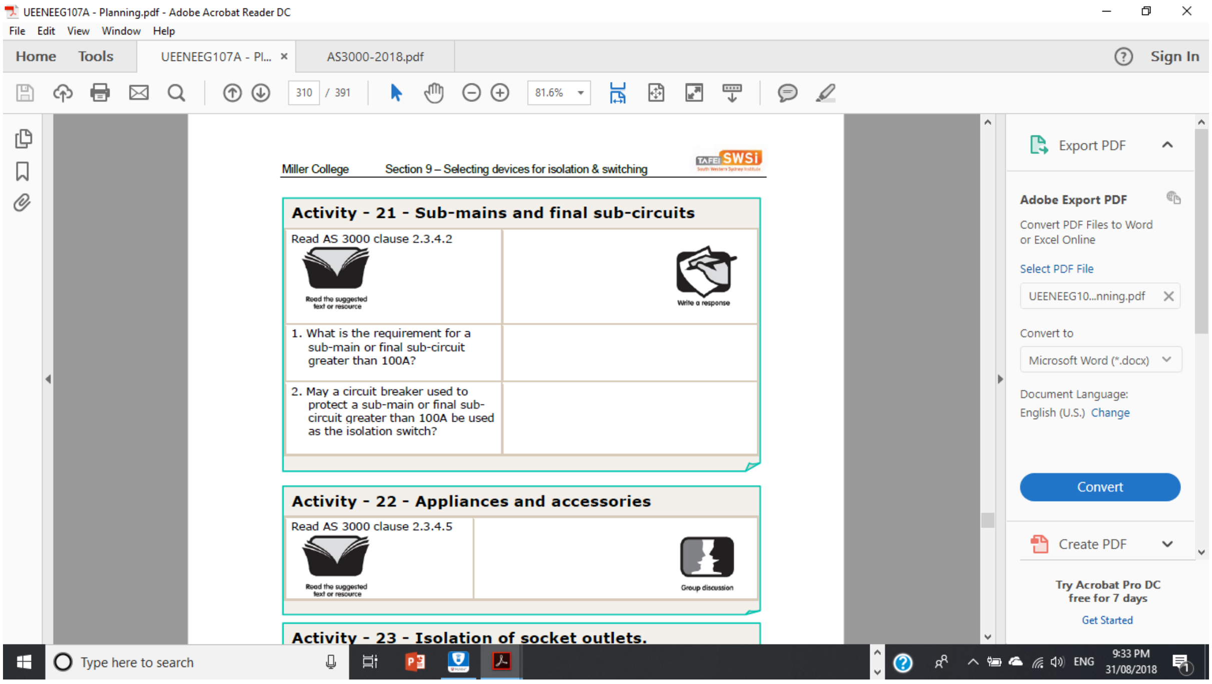
(ii) is provided with a switchboard

(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.

(ii) Supply by more than one submain Where the electrical installation in the outbuilding is supplied through more than one submain, the supply through each such submain shall be controlled by a main switch or switches, in accordance with Item (b)(i).

The main switch or switches associated with each submain need not be mounted on the same switchboard as those associated with other submains, provided that the location of all other main switches within the outbuilding is indicated on a prominent and indelible notice adjacent to each main switch or group of switches.

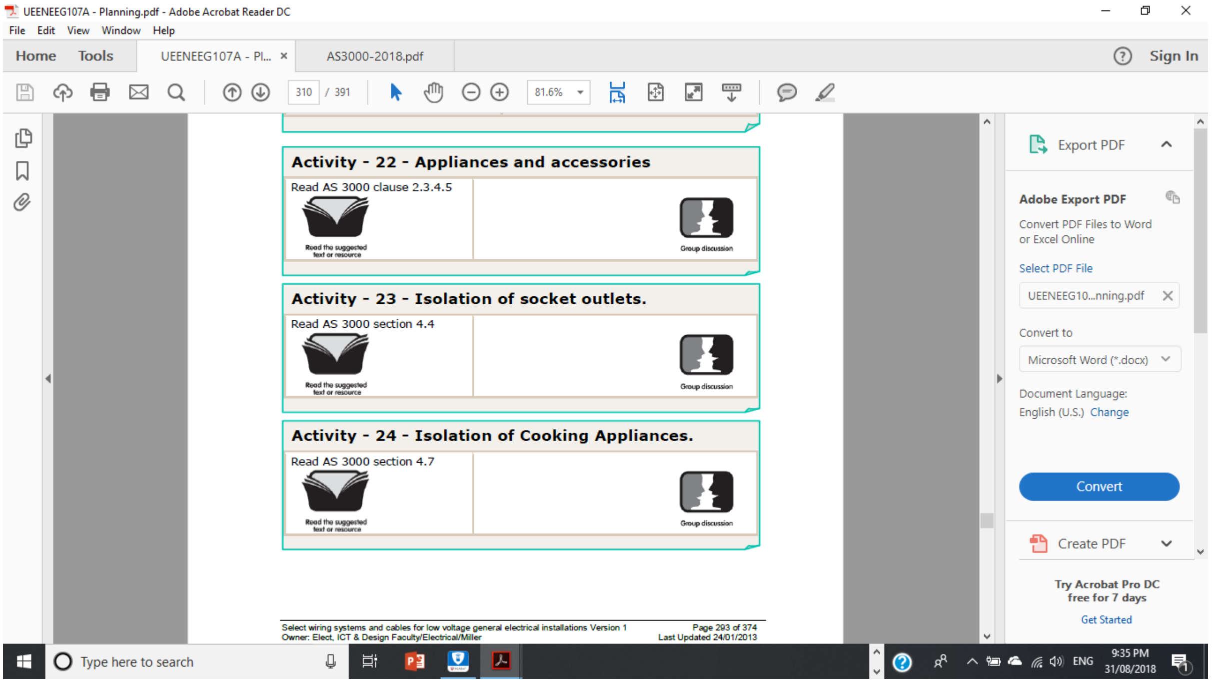


2.3.4.2 Submains and final subcircuits greater than 100 A
Every submain and final subcircuit having a rating exceeding 100 A per phase shall be controlled by a separate isolating switch on the switchboard at which the circuit originates.
Exception: This requirement need not apply where fault-current limiters or fuses protect small submains that are teed off larger submains, e.g. teeing off large rising submains at each floor.

2.3.4.5 Appliances and accessories
Appliances and accessories, including motors, shall be provided with devices for isolation and switching, in accordance with relevant clauses of Sections 4 and 7
These clauses include the following:
(a) Socket-outlets.. Clause 4.4.
(b) Cooking appliances .... Clause 4.7.
(c) Water heaters .... Clause 4.8.
(d) Room heaters .... Clause 4.9.
(e) Electric heating cables for floors and ceilings and trace heating appliances .... Clause 4.10.
(f) Electricity converters .... Clause 4.12.
(g) Motors .... Clause 4.13.
(h) Capacitors .... Clause 4.15.

* (i) Gas appliances and equipment
....Clause 4.18.
(j)
Airconditioners...
...Clause 4.19.
(k) Lifts

....
....Clause 4.20.
(l) Safety services
.... Clause 7.2.
(m) Electricity generation systems...
Clause 7.3.



4.4 SOCKET-OUTLETS
4.4.1 Types
4.4.1.1 General
4.4.1.1.1 Socket-outlets—Application
Socket-outlets shall be suitable for the intended application and location of installation and shall comply with the requirements of the following Standards or Standards equivalent thereto:
* (a) AS/NZS 3112 or AS/NZS 60884.1.
(b) AS/NZS 3123.
(c) IEC 60309.
(d) AS/NZS 3131.
* 4.4.1.1.2 Socket-outlets—Alternative pin configurations
Socket-outlets with alternative pin configurations, e.g. UK, French, German and USA types, shall only be used under the following conditions:
(a) The socket-outlet shall be of the single set of apertures with an earthing contact and comply with the national Standard of the country, as shown in IEC/TR 60083. Single set of pin apertures of socketoutlets that accept multiple pin configurations shall not be used.
Exception: Shaver socket-outlets complying with AS/NZS 3194.
(b) The installation of the socket-outlet shall comply with Clause 4.4.4.

(c) The socket-outlet shall be rated at the voltage of the electrical installation, unless supplied at a lower voltage, in which case it may be rated at that lower voltage.
(d) Socket-outlets with alternative pin configurations normally supplying a voltage less than that of the electrical installation shall be supplied at that lower voltage.
(e) The socket-outlet shall have been tested to the equivalent of the requirements of the Standards listed in Clause 4.4.1.1.1, Items (a), (b),

(c) and (d) above.
(d) In New Zealand only, the following additional provisions apply.
(e) (i) Socket-outlets with alternative pin aperture configurations shall be
(f) used only in—
(g) (A) facilities directly associated with an international airport; or
(h) (B) residential areas of non-domestic electrical installations providing
(i) accommodation for international visitors or guests.
(j) (ii) Socket-outlets with alternative pin configurations detailed in
(k) IEC TR 60083 as requiring a nominal voltage of 230 V supply, shall be
(l) protected by an RCD with a maximum rated residual current of 10 mA
(m) and by an AFDD.
(n) NOTES:
(o) 1 These RCDs need not be Type 1 as used for electrical medical devices.
(p) 2 Requirements for installation of AFDDs are in Clause 2.9, and further
(q) guidance is in Appendix O.
(r) (iii) Socket-outlets with alternative pin configurations detailed in
(s) IEC TR 60083 as requiring a nominal voltage of 110 V supply shall be
(t) supplied at reduced low voltage.
(u) NOTE: Reduced low voltage is defined in Clause 2.6.3.3.2.
(v) * 4.4.1.1.3 Low voltage fixed socket-outlet
(w) A low voltage fixed switch or socket-outlet, or its faceplate, shall not
(x) incorporate a connecting device for telecommunications, data, television,
(y) radio or other similar wiring systems.
(z) NOTE: USB charging socket-outlets on the faceplate are acceptable.
(aa) 4.4.1.2 Different systems
(bb) Where an ELV electrical installation and an electrical installation of greater
(cc) than ELV are in the same premises, all socket-outlets supplied at ELV
(dd) shall—
(ee) (a) have their voltage conspicuously marked; and
(ff) (b) be of a form that will prevent insertion of an ELV plug into a socketoutlet
(gg) connected to a circuit of greater than extra-low voltage.
(hh) NOTE: AS/NZS 3112 contains a specific plug and socket-outlet arrangement
(ii) recommended for ELV applications.
(jj) Plugs and socket-outlets for SELV and PELV systems shall not be provided
(kk) with an earthing contact or pin and shall comply with Clause 7.5.10.

(ll) * 4.4.1.3 Socket-outlets for electric vehicle charging
(mm) NOTE: Information for the installation and location of socket-outlets for electric
(nn) vehicle charging stations is provided in Appendix P.
(oo) In New Zealand only, requirements for the installation and location of
(pp) socket-outlets for electric vehicle charging stations are provided in
(qq) Clause 7.9.

4.4.2 Location
4.4.2.1 Accessibility
Each socket-outlet shall be installed so that any plug intended to be used with the socket-outlet can be conveniently inserted and withdrawn and not cause damage to any flexible cord or cable connected to the plug.
Socket-outlets shall not be installed where the withdrawal of a plug from the socket-outlet is restricted by a permanent fixture or fitting within the installation.
The AS/NZS 5601 series requires that the means of electrical isolation for a gas appliance is accessible with the appliance installed.
4.4.2.2 Protection of socket-outlets
Socket-outlets shall be installed so that they will not be subjected to undue mechanical stress or damage in normal service.
In addition, the following applies:
(a) Where installed in a floor or other horizontal surface, socket-outlets shall be designed or arranged to prevent the accumulation of dust or water therein.
* NOTE: AS/NZS 3112 and AS/NZS 60884.1 contain requirements for socketoutlets intended to be mounted in a floor.
(b) Where installed within 75 mm of a floor, socket-outlets shall be installed so that any plug used with the socket-outlet is withdrawn in the horizontal plane.
Exception: This requirement does not apply to a socket-outlet that complies with Items (a) and (d).
(c) Socket-outlets shall be so installed that a plug is not likely to become loose or to malfunction because of gravity, vibration or the weight of the flexible cord or cable.
(d) Where installed in a location that is not readily accessible for the connection of a fixed or stationary appliance or a luminaire, the socket-outlet shall be securely fixed to a structure or support to ensure that no mechanical strain is placed on the installation wiring connections when inserting or removing a plug from the socket-outlet.
Exceptions: The socket-outlet need not be fixed in position where the installation meets the following conditions:
1 Cable connections are not subject to undue mechanical stress on any connection in accordance with Clause 3.7.2.6.
2 The wiring system, where likely to be disturbed, is supported in accordance with Clause 3.9.3.3.
3 The wiring system, where installed in a suspended ceiling, is supported in accordance with Clause 3.9.3.2.

4 Conductors are flexible or stranded type.

5 Insulated, unsheathed cables, including exposed cores where sheathing is removed, are enclosed in accordance with Clause 3.10.1.1.

(e) The use and location of socket-outlets is restricted in a number of particular situations, including adjacent to damp situations, in accordance with Section 6 and hazardous areas and other situations, in accordance with Section 7.

(f) Where socket-outlets are installed in building surfaces that are required to provide fire-resistance or acoustic properties, measures shall be taken to ensure that these properties are maintained.

NOTE: Clause 4.2.2.6 and the national building codes have requirements for the installation of socket-outlets in building surfaces providing fire-resistance or acoustic properties.

4.4.3 Earthing contacts

Every socket-outlet shall be provided with an earthing contact.

NOTE: See Clause 5.4.2 for earthing requirements.

Exception: In accordance with Clause 7.5.10, socket-outlets for SELV and PELV systems shall not be provided with an earthing contact.

4.4.4 Switching device

4.4.4.1 General

Each socket-outlet shall be individually controlled by a separate switch that complies with either AS/NZS 3133, AS/NZS 60669.1 or AS/NZS 60947.3 and operates in all active conductors.

Switches controlling socket-outlets shall comply with Clauses 4.4.4.2 and 4.4.4.3.

Exceptions:

1 A single switch may be used for the control of two socket-outlets located immediately adjacent to each other.

2 A socket-outlet that is rated at not more than 10 A, installed for the connection of a fixed or stationary appliance or a luminaire and that is not readily accessible for other purposes, need not be controlled by a switch.

3 A socket-outlet that is switched by the insertion and withdrawal of the plug is deemed to meet the requirements of this Clause.

4.4.4.2 Rating

Each switch shall have a current rating, at its operating voltage, not less than the current rating of the socket-outlet it controls.

Where a single switch is used to control two socket-outlets, as permitted by Exception 1 to Clause 4.4.4.1, the current rating of the switch shall be not less than—

(a) the total current rating of the socket-outlets; or

(b) the current rating of the overcurrent protective device on the circuit,

whichever is the lesser value.

4.4.4.3 Location and marking

Each switch, or means of operating the switch, for a socket-outlet shall be—

(a) as close as practicable to the socket-outlet; and

(b) marked to indicate the socket-outlet(s) or the connected electrical equipment that it controls.

Exception: Marking is not required where the socket-outlet controlled is obvious because of the location of the switch.

Where the switch is located remote from the socket-outlet—
(i) it shall be installed in a convenient and readily accessible position as close as practicable to the socket-outlet;
(ii) the location of the switch shall be clearly and permanently marked at the socket-outlet; and
(iii) both the switch and the socket-outlet shall be provided with legible, indelible and uniform labels indicating their relationship.
Exception: Marking is not required where the socket-outlet is—
(a) located more than 2.5 m above the ground, floor or platform; and
(b) provided for the connection of a specific lamp, luminaire or appliance; and
(c) not accessible for general use.

4.4.4.4 Pendant-type socket-outlet

A switch incorporated in a pendant-type socket-outlet attached to a flexible cord shall interrupt all live (active and neutral) conductors.
Exception: Pendant-type multiphase outlets with switching only in the active conductors may be used where—
(a) the outlet is not dependent on the supply cable for support; and
(b) additional mechanical protection is provided where necessary; and
(c) the supply cable or cord is selected to take into account any likelihood of vibration and movement expected during operation.

4.4.5 Polarization and phase sequence

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

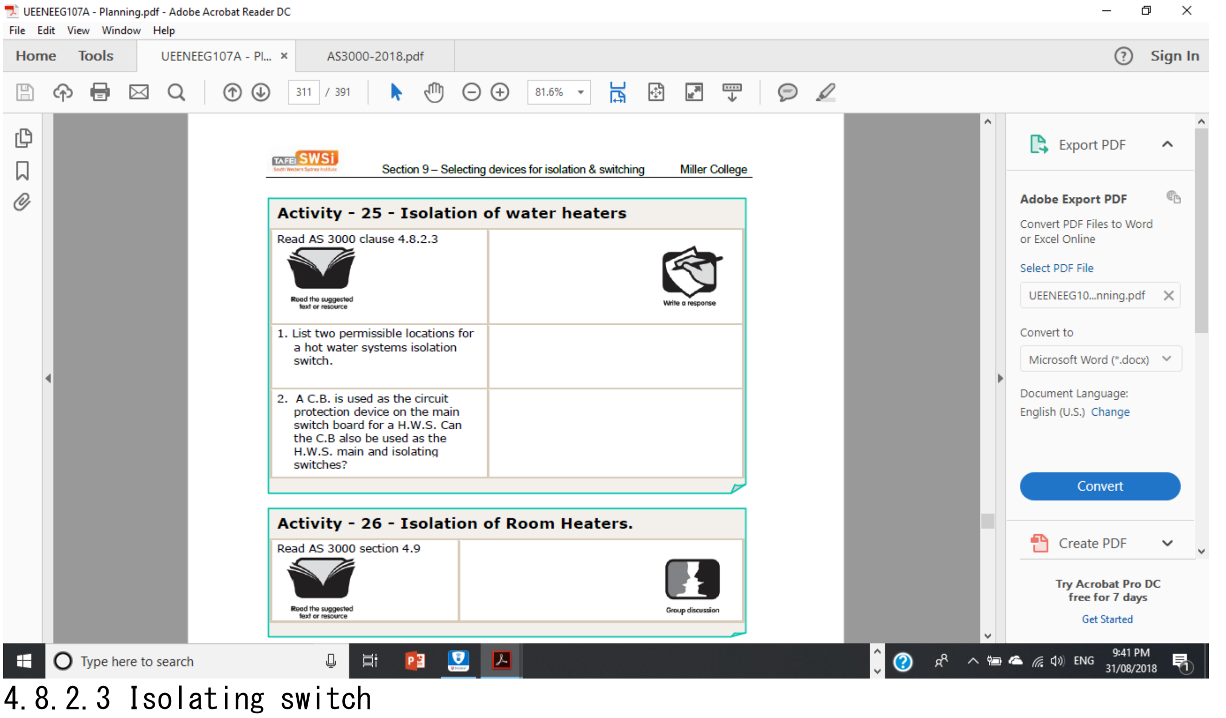
4.7 COOKING APPLIANCES

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.



4.8.2.3 Isolating switch
Every water heater that is fixed wired shall be provided with an independent, isolating switch (lockable) in accordance with Clause 2.3.2.2.
The isolating switch shall be—
(a) additional to any automatic switch incorporated in the heater structure; and
(b) installed adjacent to but not on the water heater.
Where a water heater is supplied by two or more final subcircuits, all of the final subcircuits for that water heater shall be capable of being isolated by a
single isolating switch.
4.9 ROOM HEATERS

4.9.1 General

Where a permanently connected room heater, or a number of permanently connected room heaters, are installed in one room, an individual isolating switch and an individual functional switch shall be provided for each room heater or for each group of room heaters.

Where a number of permanently connected room heaters are installed in one room and are supplied by the one final subcircuit, a single isolating switch may be used for the room heaters in that room.

4.9.2 Isolating switches

In accordance with Clause 2.3.2.2, isolating switches shall be—

(a) installed immediately adjacent to an entrance to, or within, the room where the room heater is located; or

(b) installed on the switchboard at which the room heater final subcircuit originates.

Isolating switches may be incorporated in temperature-control devices, provided that they have a definite ‘OFF’ position.

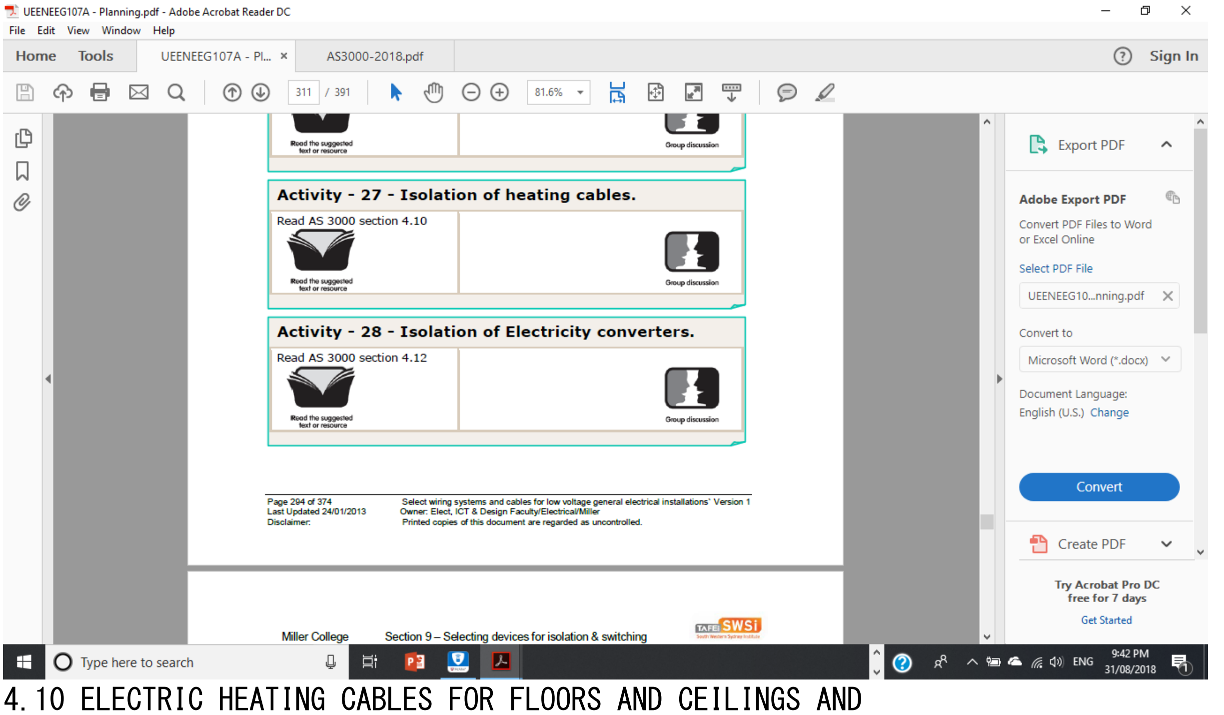
4.9.3 Functional switches

In accordance with Clause 2.3.7, functional switches shall be installed in a readily accessible position in the same room, or immediately adjacent to an entrance to the room, in which the room heater or room heaters are located.

A functional switch may be—

(a) an appliance switch or switches with an ‘OFF’ position incorporated within the room heater; or

(b) an isolating switch provided in accordance with Clause 4.9.2(a).



4.10 ELECTRIC HEATING CABLES FOR FLOORS AND CEILINGS AND TRACE HEATING APPLICATIONS

4.10.1 General

Cables for electric heating systems in floors and ceilings and trace heating applications shall be of a type specifically designed for the purpose. The heating equipment shall be installed in accordance with the manufacturer’s instructions.

4.10.2 Heating cables

Heating cables shall be so installed that they are not in contact with

flammable materials and where designed to be embedded—
(a) are completely and adequately embedded in the substance they are intended to heat; and
(b) do not suffer any detrimental effect because of flexing or movement of the substance in which they are embedded.

Alternatively, where designed as trace heating cables, heating cables shall provide adequate heat transfer to the surface or material to which they are fixed.

4.10.3 Isolating switches

Cables or groups of cables that comprise the heating system shall be provided with an isolating switch or switches in accordance with Clause 2.3.2.2.

Isolating switches may be incorporated in temperature-control devices, provided that they have a definite 'OFF' position.

Isolating switches shall be—
(a) installed immediately adjacent to an entrance to, or within, the room or area in which the heating system is located; or
(b) installed on the switchboard at which the heating system final subcircuit originates.

Exception: Where the heating system is provided for trace heating applications, the isolating switch need not be located as specified in this Clause.

4.10.4 Functional switches

Cables or groups of cables that comprise the heating system shall be provided with a functional switch or switches, in accordance with Clause 2.3.7.

Functional switches shall be installed in a readily accessible position immediately adjacent to an entrance to, or within, the room or area in which the heating system is located.

A functional switch may be an isolating switch in accordance with Clause 4.10.3(a).

Exception: Where the heating system is provided for trace heating applications, the functional switch need not be located as specified in this Clause.

4.10.5 Additional protection

All heating cables shall be provided with additional protection by an RCD with a fixed rated residual current not exceeding 30 mA, and—
(a) in the case of heating units fitted with a conductive covering, this covering shall be earthed;
(b) in the case of under-floor heating units without a conductive covering, an earthed metallic grid with a spacing not exceeding 30 mm shall be provided above the under-floor heating cable; and
(c) heating units shall be provided with adequate mechanical protection to prevent damage.

4.10.6 Signs

Where heating cables are installed, suitable signs drawing attention to their existence shall be provided in each location.

Where appropriate, signs warning of the danger of covering embedded heating equipment with furnishings or building materials that might cause excessive temperatures shall be provided.

This requirement may be satisfied by—

(a) clearly and permanently marking the functional switch or switches in the heated room or area; or
(b) providing suitable labelling at the relevant distribution board.
4.11

4.12 ELECTRICITY CONVERTERS

4.12.1 General

For the purpose of this Clause, an electricity converter includes both static and dynamic equipment designed to stabilize the supply voltage, or to change the voltage or frequency of an electricity supply, or to maintain a continuous electricity supply for a limited period of time when the primary source of electricity supply is interrupted.

Examples include the following:

(a) Uninterruptible power systems (UPS).
(b) Semiconductor power converters (and inverters).
(c) Voltage stabilizers.
(d) Motor-generator sets.
(e) Rotary converters.

Transformers and engine-driven generating sets that comply with AS/NZS 3010 shall not be considered as electricity converters.

4.12.2 Selection and installation

NOTE: Guidance on the selection and installation of electricity converters is contained in—
(a) for uninterruptible power systems (UPS).................... AS/NZS 62040 series;
(b) for semiconductor power converters .... AS 60146 series;
WELCOME

(c) for batteries... AS 3011 series; and
* (d) for rotating electrical machines .... AS 60034 series.

4.12.3 Control

Where an electrical installation, or part thereof, is supplied through an electricity converter, the converted supply shall be controlled by an isolating switch, or switches, at the output of the converter, or at the switchboard to which the output is connected.

Each electricity converter shall be controlled by switches or devices suitable for starting and stopping the converter. Where there is more than one switch or device for this purpose, they shall be grouped together and clearly identified.

An electricity converter shall be so arranged that it cannot supply energy upstream of the point of connection to the installation either directly or indirectly.

Exception: Electricity converters may be arranged to supply energy upstream of the point of connection to the installation subject to any additional conditions required by the electricity distributor.

Provision shall be made to ensure that all necessary connections for protection in the installation remain intact when supply is available from the output of the electricity converter.

4.12.4 Isolation

4.12.4.1 General

Each electricity converter shall be provided with an independent isolating switch in accordance with Clause 2.3.2.2.

The isolating switch shall—

(a) be installed adjacent to or on the electricity converter so that a person operating the switch has a clear view of any person working on the converter;

* (b) be provided with a means of securing the device in the isolated position that requires a deliberate action to engage or disengage it;

(c) comply with Clause 4.13 when the electricity converter incorporates an electric motor;

(d) be under manual control only; and

(e) not be capable of being overridden or bypassed by programmable control systems or the like.

4.12.4.2 Electricity converters incorporating batteries

Where batteries are incorporated in an electricity converter, a switch capable of interrupting the supply from such batteries shall be installed adjacent to the batteries and shall be clearly identified to indicate its purpose.

A single switch that incorporates both a.c. and d.c. switching functions outlined in Clause 4.12.4.1 and this Clause may be used.

4.12.5 Overcurrent protection

4.12.5.1 Electricity converter protection

Electricity converters shall be provided with overcurrent protection.

Exception: Overcurrent protective devices shall not be provided where the unexpected interruption of the supply could cause a greater danger than overcurrent.

Overcurrent protective devices shall be located as close as practicable to the output terminals of the electricity converter so that the unprotected interconnecting conductors are as short as practicable and, in no case, exceed 15 m in length.

The unprotected interconnecting conductors shall be completely enclosed by metal or other material that is not flammable.

Exception: Overcurrent protection may be provided by—

(a) an overcurrent protective device within the electricity converter itself; or

(b) the characteristics of the electricity converter being unable to support the fault current.

Where an electricity converter is intended to operate in parallel with a network or other source, circulating harmonic currents shall be limited so that the current-carrying capacity of conductors is not exceeded.

NOTE: The effects of circulating harmonic currents may be limited as follows:

(a) The selection of generating sets with compensated windings.

(b) The provision of a suitable impedance in the connection to generator star points.

(c) The provision of switches that interrupt the circulatory circuit but that are interlocked so that at all times fault protection is not impaired.

(d) The provision of filtering equipment.

(e) Other suitable means.

4.12.5.2 Circuit protection

＊ 4.12.5.2.1 General
Every submain or final subcircuit outgoing from an electricity converter shall be individually protected in accordance with Clause 2.5 and shall also include additional protection, where required, by Clause 2.6.
Exceptions:
1 This requirement need not apply where protection on the incoming side (if any) provides protection against an overcurrent condition on the outgoing side.

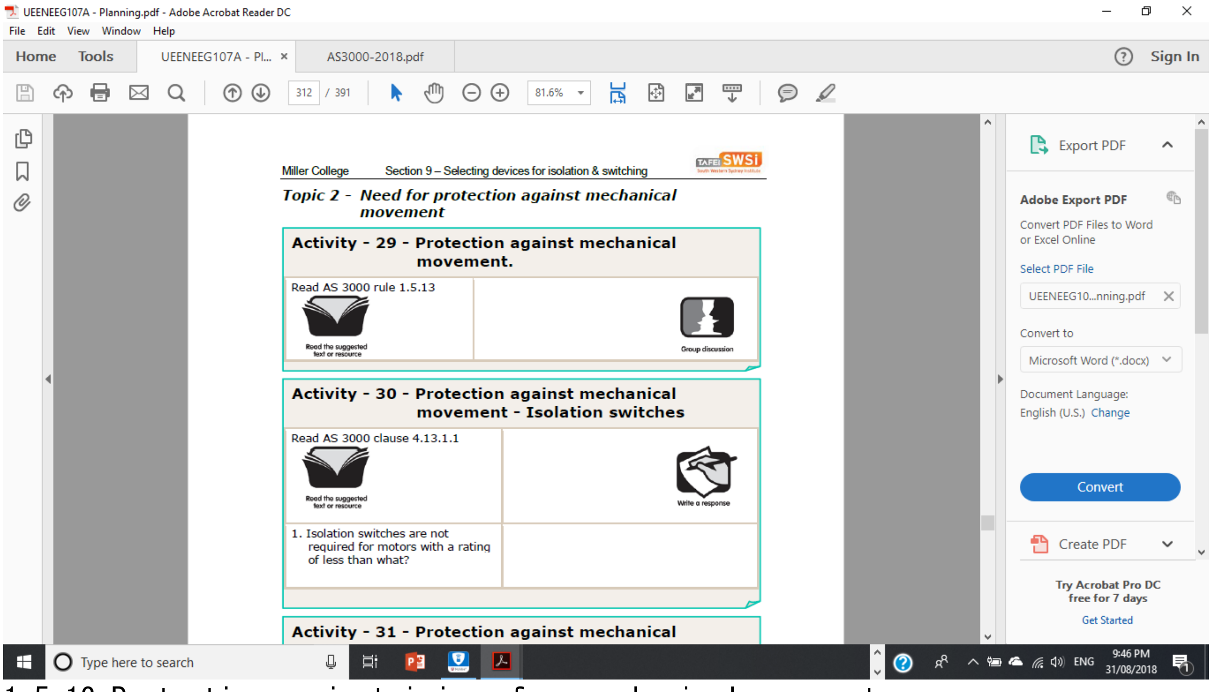
Overcurrent protective devices shall not be provided where the unexpected interruption of the supply could cause a greater danger than overcurrent.

＊ 4.12.5.2.2 RCDs
The possible waveform of a fault current to earth can affect the operation of RCDs and shall be taken into account for the selection of the type of RCD.
Where an electricity converter includes an inverter, the RCD shall be of a type suitable for the waveform of the particular inverter, and in accordance with the inverter manufacturer’s recommendations.
NOTE: Requirements for types of RCDs are set out in Clause 2.6.2.2.

4.12.6 Earthing
The output of an electricity converter shall be provided with the same type of earthing system used for the associated electrical installation.
Protective earthing conductors shall not be switched.
Provision shall be made to ensure that all necessary connections for protection, such as the MEN connection, remain intact when supply is available from the output of the system.
NOTE: See Clause 4.12.2 for information regarding Standards applicable to various devices.

4.12.7 Neutral continuity
Electricity converters, particularly static converters, such as UPS, shall be arranged to ensure that the continuity of the neutral conductor to the load is not interrupted during bypass or maintenance switching.

4.12.8 Electrical equipment connected to output
All electrical equipment connected to the output side of an electricity converter shall be suitable for the voltage, current and frequency of the output of the unit.
NOTES:
1 The values of current-carrying capacity and voltage drop specified in the AS/NZS 3008.1 series are only valid for conductors operating at 50 Hz.
2 For the type of RCD to be used where additional protection is required for circuits or equipment supplied by an electricity converter, refer to Clause 2.6.2.2.


Miller College Section 9 – Selecting devices for isolation & switching

Topic 2 - Need for protection against mechanical movement

Activity - 29 - Protection against mechanical movement.

Read AS 3000 rule 1.5.13

Read the suggested text or resource

Group discussion

Activity - 30 - Protection against mechanical movement - Isolation switches

Read AS 3000 clause 4.13.1.1

Read the suggested text or resource

Write a response

1. Isolation switches are not required for motors with a rating of less than what?

Activity - 31 - Protection against mechanical

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.

4.13 MOTORS

4.13.1 Protection against injury from mechanical movement

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.

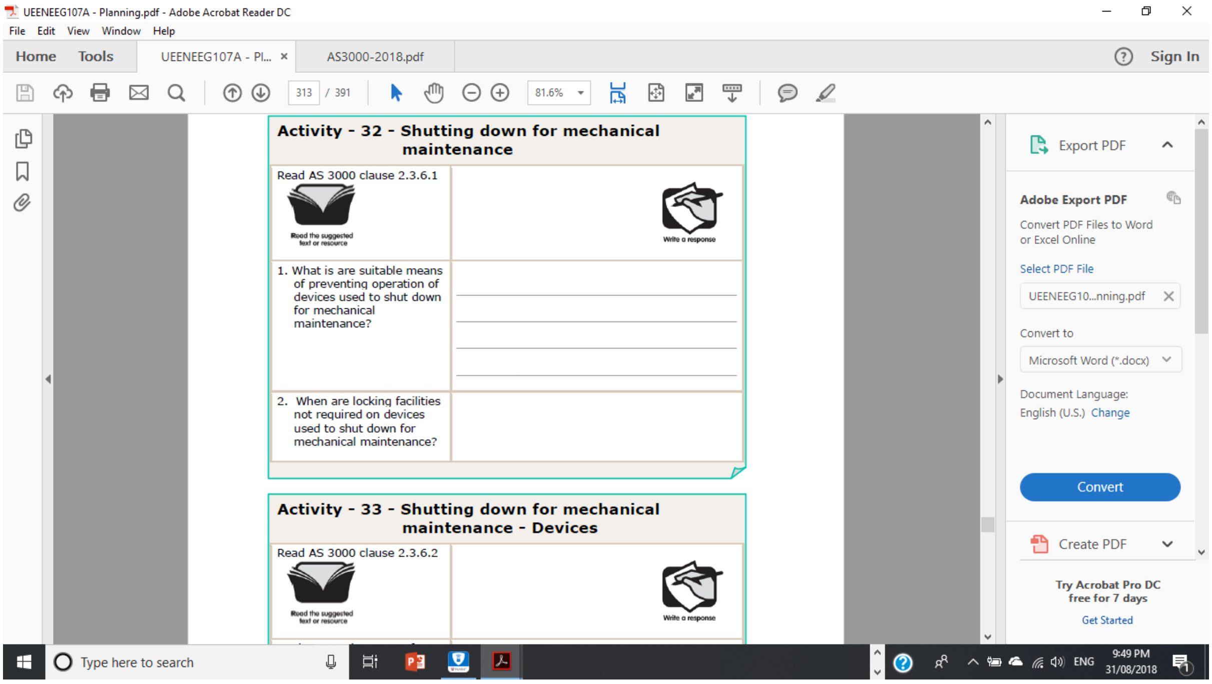
(c) Isolating the motor for mechanical maintenance, in accordance with Clause 2.3.6.

Exceptions:

1 Where a number of motors are required to function as a group, or operate in a coordinated manner, e.g. a split system airconditioning unit, a single switching device may be used to control more than one motor.

2 A switch suitable for disconnection of supply in accordance with Item (c) need not be provided for motors that are—

- connected by a plug and socket-outlet; or
- incorporated in an appliance having no exposed moving parts; or
- rated at not greater than 150 VA.



2.3.6.1 General

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.

Suitable means, such as facilities for locking the means of shutting down in the open position, the enclosure of the means of shutting down in a lockable enclosure or facilities for the attachment of a warning notice or notices, shall be provided to prevent operation of the means of shutting down and electrically powered equipment from being inadvertently started during mechanical maintenance.

Exception: Locking facilities or a lockable enclosure need not be provided where the means of shutting down is continuously under the control of the person performing such maintenance.

2.3.6.2 Devices for shutting down

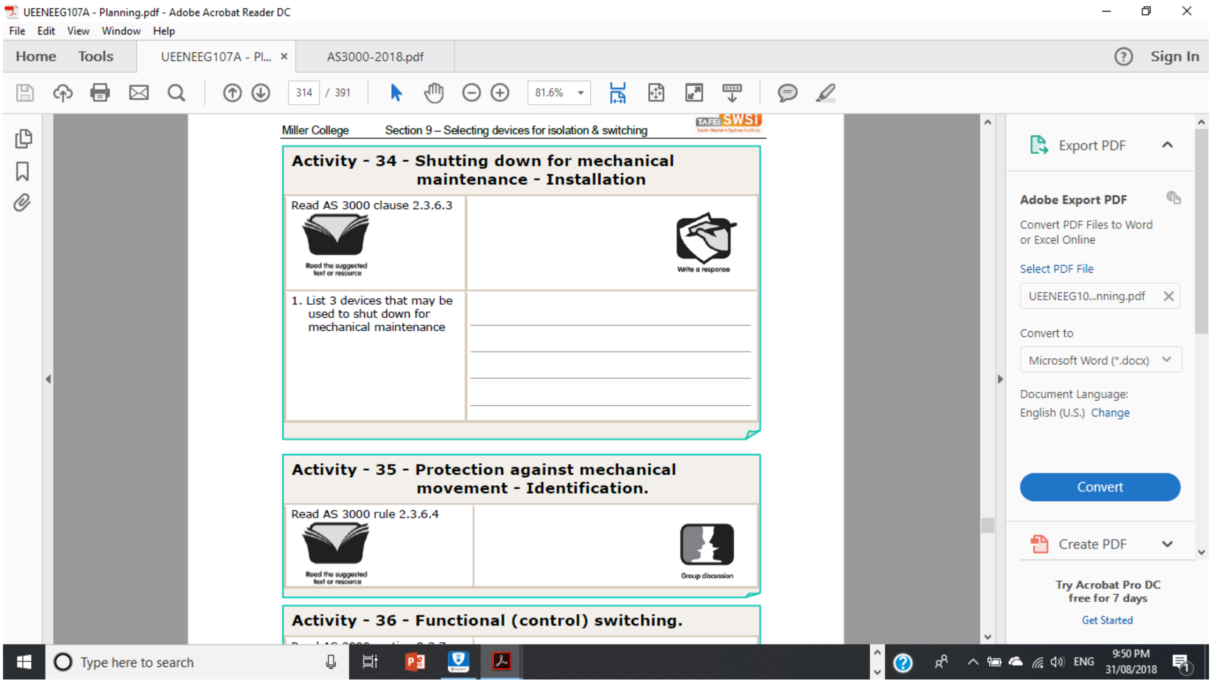
Devices for shutting down for mechanical maintenance shall—

(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.

NOTE: Such closure might be caused by impact, vibration or the like.



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.

Exception: Interruption of the control circuit of a drive or the like may occur

where—

(a) supplementary safeguards, such as mechanical restrainers are provided; or

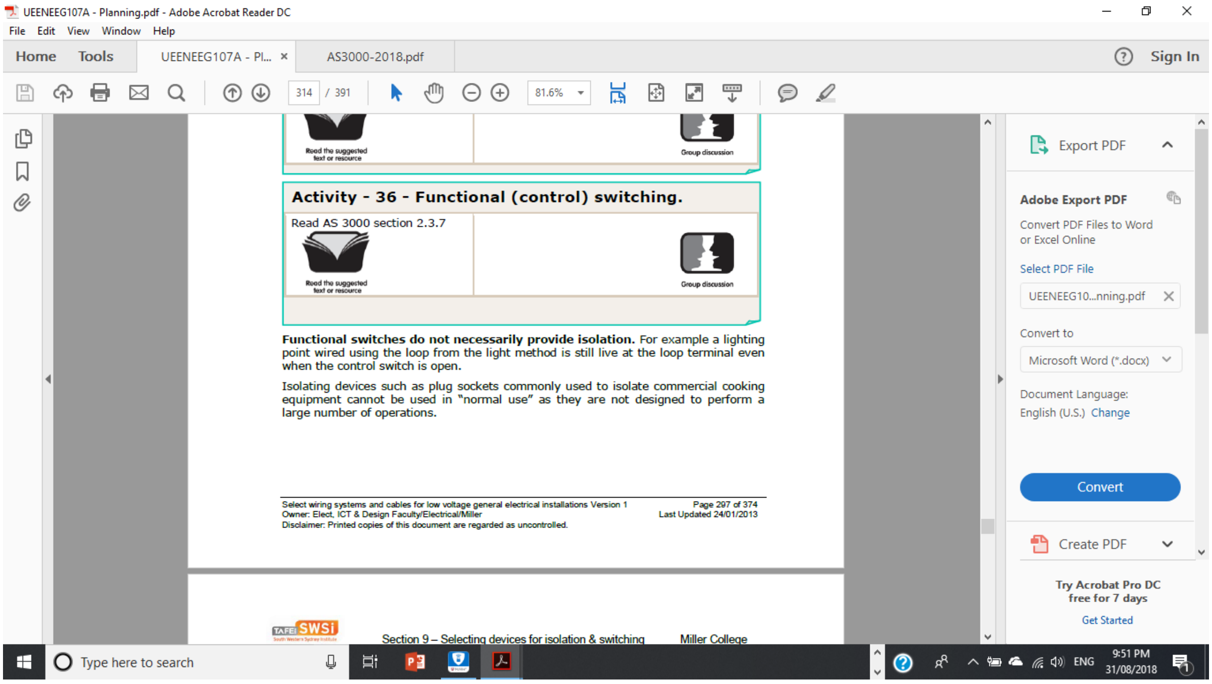
(b) direct interruption of the main supply is achieved by another means.

NOTE: Shutting down for mechanical maintenance may be achieved by devices, such as switches, circuit-breakers or plugs and sockets.

A device located remotely from the electrical equipment it controls, which is used for shutting down for mechanical maintenance, shall be provided with facilities for securing it in the open position.

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.


Activity - 36 - Functional (control) switching.

Read AS 3000 section 2.3.7

Read the suggested text or resource

Group discussion

Functional switches do not necessarily provide isolation. For example a lighting point wired using the loop from the light method is still live at the loop terminal even when the control switch is open.

Isolating devices such as plug sockets commonly used to isolate commercial cooking equipment cannot be used in "normal use" as they are not designed to perform a large number of operations.

Select wiring systems and cables for low voltage general electrical installations Version 1 Page 297 of 374
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Section 9 – Selecting devices for isolation & switching Miller College

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.

NOTE: Functional switching devices may be switches, semiconductor (solidstate) devices, or contactors.

A functional switching device shall be provided for each part of a circuit or item of apparatus that may be required to be controlled independently of other parts of the electrical installation or apparatus.

A single functional switching device may control several items of apparatus intended to operate simultaneously.

NOTE: The switching device may form part of the apparatus.

2.3.7.2 Functional switching devices

Disconnectors, fuses or links shall not be used for functional switching.

Functional switching devices shall be suitable for the most onerous of the duties that they might be required to perform.

NOTE: The type of loading, the frequency of operation, and the anticipated number of operations should be taken into account when assessing the most onerous duty. (Systems of duty classification are found in the Standards relevant to the electrical equipment concerned, or in the switch manufacturer's information.)

Functional switching devices need not switch all live conductors of a circuit.

WELCOME

Functional switching devices controlling loads having a significantly low power factor, such as motors or fluorescent lighting, shall be subject to an appropriate de-rating factor.

Exception: No de-rating factor need apply where the device has been designed for the purpose, e.g. switches having a utilization category of AC23A in accordance with AS/NZS IEC 60947.3, used to control circuits of fluorescent lighting are deemed to be designed for the purpose.

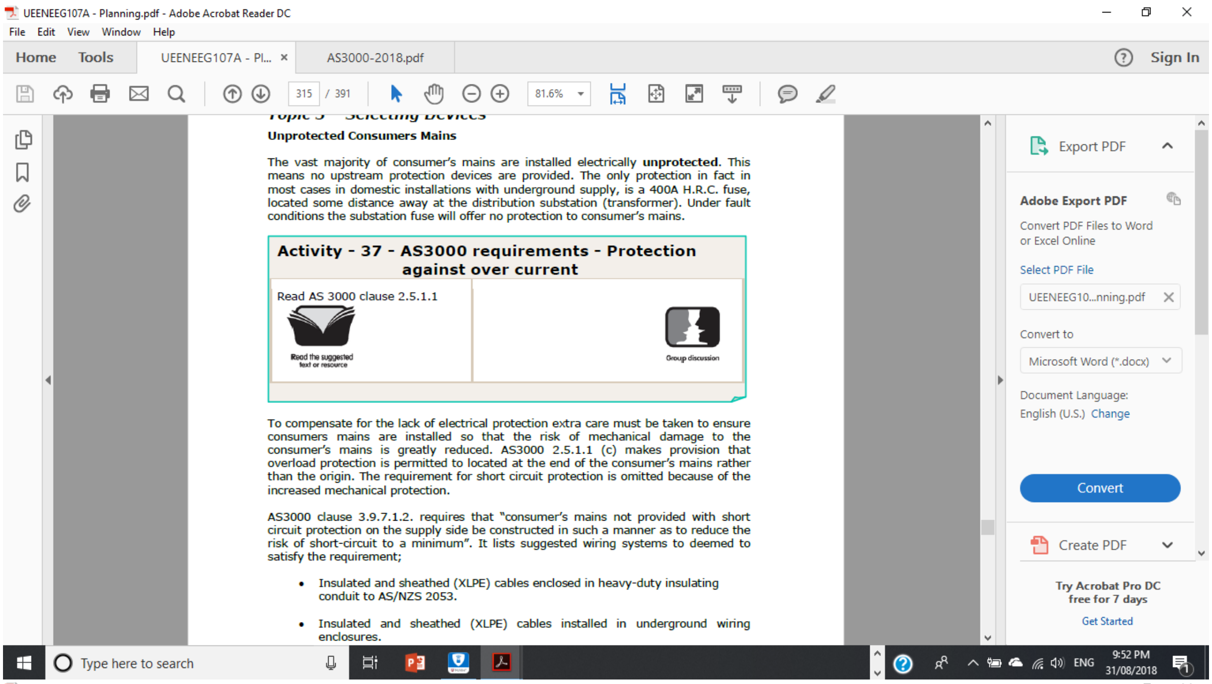
2.3.7.3 Identification

Functional switching devices need not be identified to indicate the 'ON' or 'OFF' position.

Exception: Appliance switches shall be identified to include the 'OFF' position, in accordance with AS/NZS 61058.1.

2.3.7.4 Control circuits

Control circuits shall be designed, arranged and protected to limit dangers resulting from a fault between the control circuit and other conductive parts liable to cause malfunction, e.g. inadvertent operations of the controlled apparatus.



Unprotected Consumers Mains

The vast majority of consumer's mains are installed electrically **unprotected**. This means no upstream protection devices are provided. The only protection in fact in most cases in domestic installations with underground supply, is a 400A H.R.C. fuse, located some distance away at the distribution substation (transformer). Under fault conditions the substation fuse will offer no protection to consumer's mains.

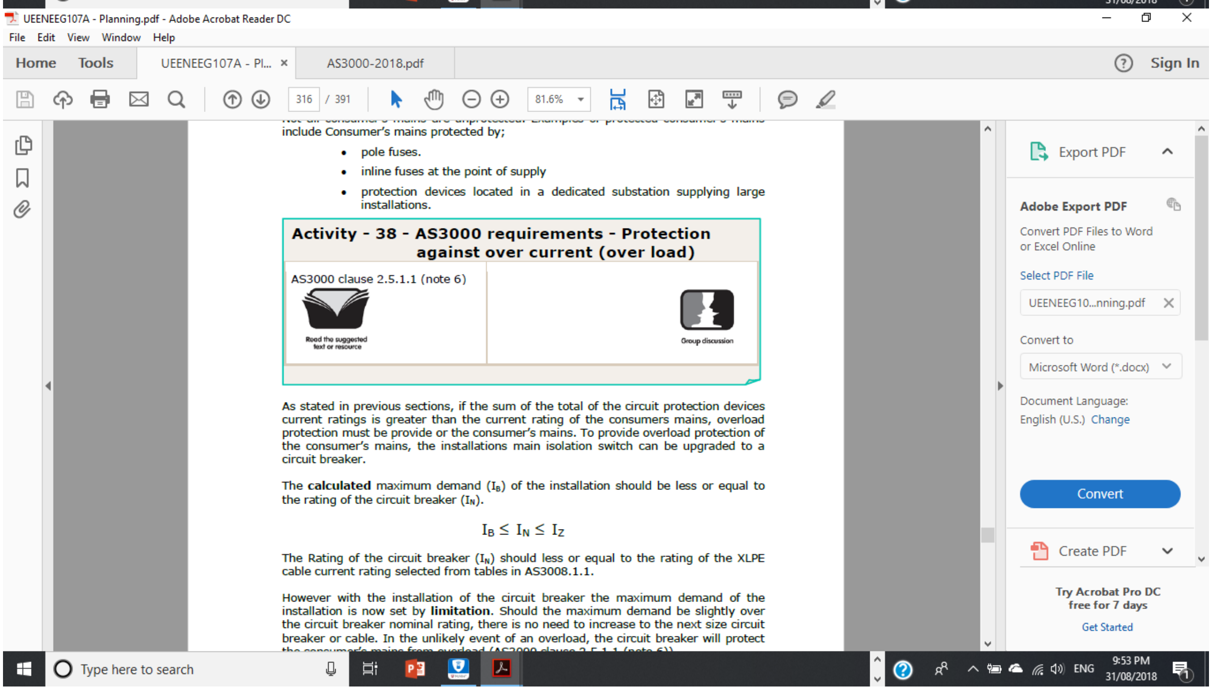
Activity - 37 - AS3000 requirements - Protection against over current

Read AS 3000 clause 2.5.1.1

To compensate for the lack of electrical protection extra care must be taken to ensure consumers mains are installed so that the risk of mechanical damage to the consumer's mains is greatly reduced. AS3000 2.5.1.1 (c) makes provision that overload protection is permitted to located at the end of the consumer's mains rather than the origin. The requirement for short circuit protection is omitted because of the increased mechanical protection.

AS3000 clause 3.9.7.1.2. requires that "consumer's mains not provided with short circuit protection on the supply side be constructed in such a manner as to reduce the risk of short-circuit to a minimum". It lists suggested wiring systems to deemed to satisfy the requirement;

- Insulated and sheathed (XLPE) cables enclosed in heavy-duty insulating conduit to AS/NZS 2053.
- Insulated and sheathed (XLPE) cables installed in underground wiring enclosures.



include Consumer's mains protected by;

- pole fuses.
- inline fuses at the point of supply
- protection devices located in a dedicated substation supplying large installations.

Activity - 38 - AS3000 requirements - Protection against over current (over load)

AS3000 clause 2.5.1.1 (note 6)

As stated in previous sections, if the sum of the total of the circuit protection devices current ratings is greater than the current rating of the consumers mains, overload protection must be provide or the consumer's mains. To provide overload protection of the consumer's mains, the installations main isolation switch can be upgraded to a circuit breaker.

The **calculated** maximum demand (I_B) of the installation should be less or equal to the rating of the circuit breaker (I_N).

$$I_B \leq I_N \leq I_Z$$

The Rating of the circuit breaker (I_N) should less or equal to the rating of the XLPE cable current rating selected from tables in AS3008.1.1.

However with the installation of the circuit breaker the maximum demand of the installation is now set by **limitation**. Should the maximum demand be slightly over the circuit breaker nominal rating, there is no need to increase to the next size circuit breaker or cable. In the unlikely event of an overload, the circuit breaker will protect

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.

No fuse shall be inserted in a neutral conductor. Protective devices that incorporate a switching function in the neutral conductor shall comply with the requirements of Clause 2.3.2.1.2(b).

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.

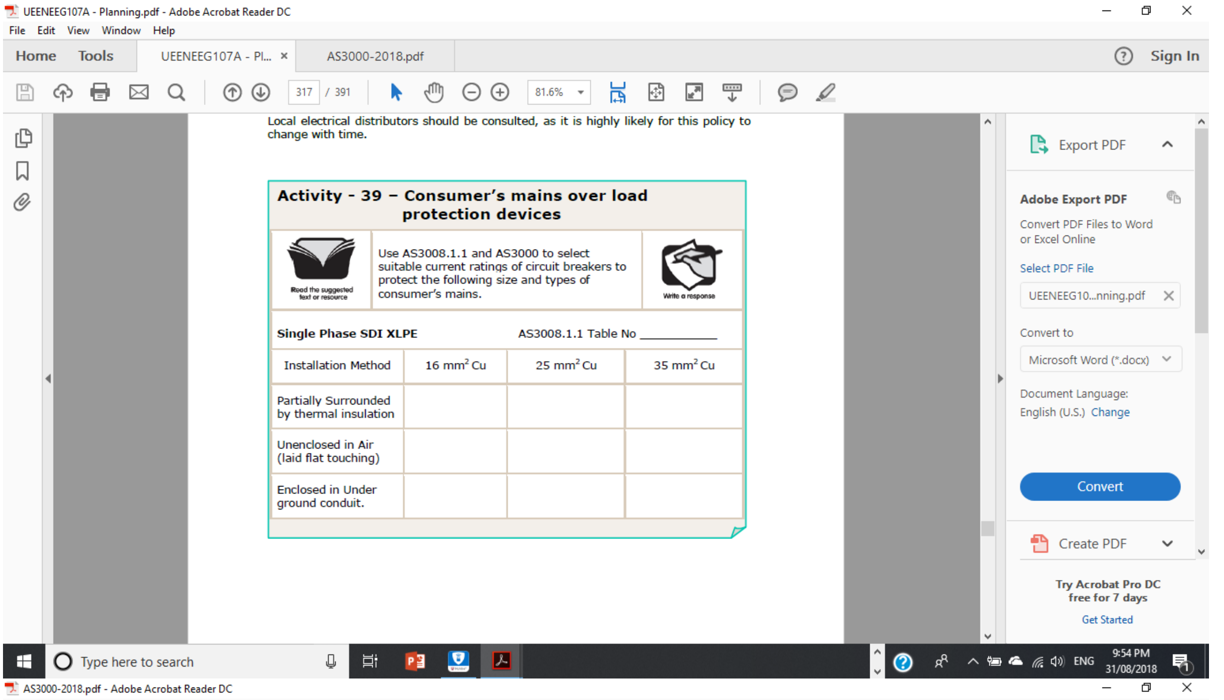
Protection against overload current and short-circuit current shall be coordinated, in accordance with Clause 2.5.6.

NOTES:

1 Overcurrent protection is inseparably linked to the current-carrying capacity and temperature limits of the protected cable.

* Reduction in current-carrying capacity of conductors may occur by a change in cross-sectional area, method of installation, or type of cable or conductor.

2 Appendix I provides guidance on the ratings of overload protective devices where alterations or repairs involve the use of existing imperial conductors.



Local electrical distributors should be consulted, as it is highly likely for this policy to change with time.

Activity - 39 – Consumer's mains over load protection devices

Read the suggested text or resource

Use AS3008.1.1 and AS3000 to select suitable current ratings of circuit breakers to protect the following size and types of consumer's mains.

Write a response

Single Phase SDI XLPE AS3008.1.1 Table No ___________

Installation Method	16 mm² Cu	25 mm² Cu	35 mm² Cu
Partially Surrounded by thermal insulation			
Unenclosed in Air (laid flat touching)			
Enclosed in Under ground conduit.			

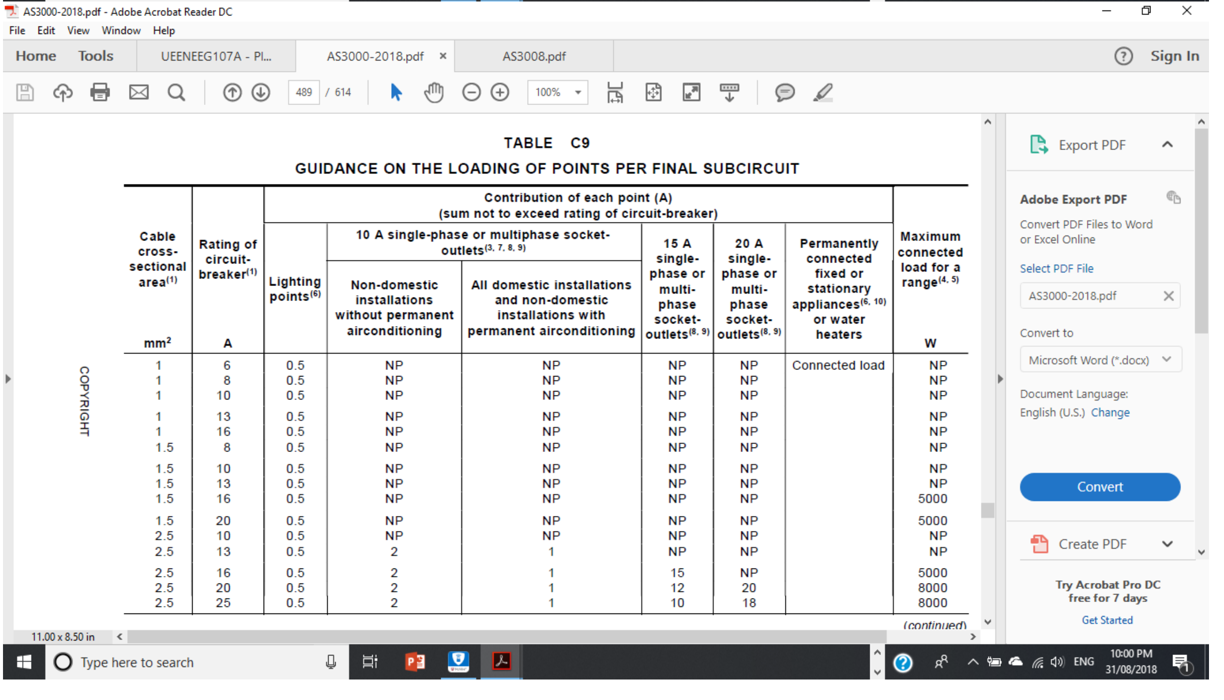


TABLE C9

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)

TABLE C9 *(continued)*

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
2.5	32	0.5	2	1	8	16		10 000
4	16	0.5	2	1	15	NP		5000
4	20	0.5	2	1	12	20		8000
4	25	0.5	2	1	10	18		10 000
4	32	0.5	2	1	8	16		10 000
6[2]	20	0.5	2	1	12	20		10 000
6[2]	25	0.5	2	1	10	18		10 000
6[2]	32	0.5	2	1	8	16		13 000
10[2]	32	0.5	2	1	8	16		13 000
10[2]	40	0.5	2	1	8	16		>13 000

NP = denotes socket-outlets not permitted on these circuits

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TABLE 3(1)

SCHEDULE OF INSTALLATION METHODS FOR CABLES DEEMED TO HAVE THE SAME CURRENT-CARRYING CAPACITY AND CROSS-REFERENCES TO APPLICABLE DERATING TABLES—UNENCLOSED IN AIR

A1

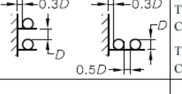
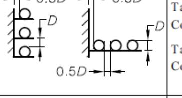
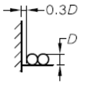
1 Item No.	2 Cable details (see Note 2)	3 Reference drawing (see Note 3)	4 Current-carrying capacity table reference	5 Methods of installation for cables deemed to have the same current-carrying capacity (See Notes 4, 5 and 6)	6 Derating table
1	Two single-core cables		Tables 4 and 5 Columns 2 to 4 Table 6 Columns 2 and 3	Cables with minimum cable separation in air as shown for horizontal and vertical mounting and installed— (a) spaced from a wall or vertical surface; (b) supported on ladders, racks, perforated trays, cleats or hanger; or	23
2	Three single-core cables		Tables 7 and 8 Columns 2 to 4 Table 9 Columns 2 and 3		
3				(c) suspended from a catenary wire.	22
4	Two single-core cables		Tables 4 and 5 (see Note 5) Columns 5 to 7 Table 6 Columns 2 and 3	Cables with minimum cable spacings in air as shown and installed— (a) spaced from a wall or vertical surface; (b) supported on ladders, racks,	23

TABLE 3(2)

SCHEDULE OF INSTALLATION METHODS FOR CABLES DEEMED TO HAVE THE SAME CURRENT-CARRYING CAPACITY AND CROSS-REFERENCES TO APPLICABLE DERATING TABLES—ENCLOSED

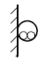
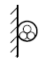
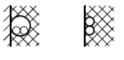
1	2	3	4	5	6
Item No.	**Cable details (see Note 1)**	**Reference drawing (see Note 2)**	**Current-carrying capacity table reference**	**Methods of installation for cables deemed to have the same current-carrying capacity (See Note 3)**	**Derating table for more than one circuit**
1	Two single-core cables		Tables 4 and 5 Columns 15 to 17 Table 6 Columns 11 and 12	Cables in wiring enclosures installed in— (a) air; (b) plaster, cement render, masonry or concrete in a wall or floor; (c) a concrete slab on or above the surface of the ground; or (d) a ventilated trench. Cables installed in— (a) a wiring enclosure on a wall; or (b) an enclosed trench with a removable cover.	22
2	Three single-core cables		Tables 7 and 8 Columns 15 to 17 Table 9 Columns 11 and 12		
3	Two single-core cables		Tables 4 and 5 Columns 18 and 19 Table 6 Column 13	Cables enclosed or unenclosed— (a) partially surrounded by thermal insulation material; or (b) in an enclosed trench.	

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TABLE 3(3)

SCHEDULE OF INSTALLATION METHODS FOR CABLES DEEMED TO HAVE THE SAME CURRENT-CARRYING CAPACITY AND CROSS-REFERENCES TO APPLICABLE DERATING TABLES—BURIED DIRECT IN THE GROUND

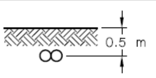
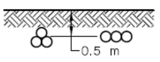
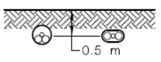
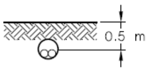
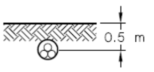
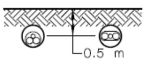
1	2	3	4	5	6
Item No.	**Cable details (see Note 1)**	**Reference drawing (see Note 2)**	**Current-carrying capacity table reference**	**Methods of installation for cables deemed to have the same current-carrying capacity (see Note 3)**	**Derating table for more than one circuit**
1	Two single-core cables		Tables 4 and 5 Columns 22 and 23 Table 6 Column 15	Cables with a minimum depth of laying of— (a) 0.3 m under continuous concrete paved areas; or (b) 0.5 m in other locations.	25(1)
2	Three single-core cables		Tables 7 and 8 Columns 22 and 23 Table 9 Column 15		
3	Two-core cables		Tables 10 and 11 Columns 23 and 24 Table 12 Column 13		25(2)
4	Three-core cables		Tables 13 and 14 Columns 23 and 24		

TABLE 3(4)

SCHEDULE OF INSTALLATION METHODS FOR CABLES DEEMED TO HAVE THE SAME CURRENT-CARRYING CAPACITY AND CROSS-REFERENCES TO APPLICABLE DERATING TABLES—UNDERGROUND WIRING ENCLOSURES

1	2	3	4	5	6	
Item No.	Cable details (see Note 1)	Reference drawing (see Note 2)	Current-carrying capacity table reference	Methods of installation for cables deemed to have the same current-carrying capacity (see Note 3)	Derating table for more than one circuit	
					in same enclosure	in separate enclosures
1	Two single-core cables		Tables 4 and 5 Columns 24 to 26 Table 6 Columns 16 and 17	Cables in a single enclosure laid— (a) a minimum of 0.5 m below continuous concrete paved areas; or (b) minimum 0.5 m in other locations.		26(2)
2	Three single-core cables		Tables 7 and 8 Columns 24 to 26 Table 9 Columns 16 and 17			
3	One two-core cable		Tables 10 and 11 Columns 25 to 27 Table 12 Columns 14 and 15			
4	One three-		Tables 13 and 14			

Activity - 43 - Selection of Isolation switches.

Use figures 4, 5 and 6 to select a suitable isolation switch for the following situations. Specify the; • number of poles • current rating. • type of device C.B. or Isolator • utilisation Category	Write a response
1 An isolation switch for a distribution board in garage of a single phase domestic installation with a maximum demand of 33A.	
2 An main switch for a three phase domestic installation with a maximum demand of 50A per phase.	
3 The isolation switch in the distribution board of a single phase town house with a maximum demand of 55A.	

demand of that circuit. Isolators for motors need to break the locked rotor current of the motor. Figure 3 shows examples and current ratings of isolators up to 100A.

Current (A)	Catalogue Number	Current (A)	Catalogue Number	Current (A)	Catalogue Number
40	4PSW140	40	4PSW240	40	4PSW340
80	4PSW180	80	4PSW280	80	4PSW380
100	4PSW1100	100	4PSW2100	100	4PSW3100

figure 4 - www.clipsal.com.au

In larger isolations switches the utilization category is also specified to match the isolator to the correct use. Figures 5 and 6 show further examples and technical data of larger isolators up to 1600A.

Load Break Vs Off Load disconnectors

Some large isolators are not rated to break the load current they can carry. They are given a Utilization Category of AC-20. Downstream circuit breakers must be opened first to interrupt the flow of current before the "disconnector" is opened.

A true isolator is given a Utilization Category of AC-21 or higher. Refer to figure 5 for more information relating to Utilization Categories

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HA302

HA307

HA354

description	width in 17.5 mm	characteristics	module mm	cat. ref	$ ex-GST	$ incl-GST
3 pole isolator 690V~	2	In 40A	36	**HA302**	75.50	83.05
	3	In 63A	54	**HA303**	102.60	112.86
3 pole isolator 400V~	6	In 80A	108	**HA304**	114.90	126.39
	6	In 100A	108	**HA305**	133.20	146.52
	6	In 125A	108	**HA306**	133.20	146.52
	8.5	In 160A	142	**HA307**	172.70	189.97
	8.5	In 200A	142	**HA308**	401.50	441.65
	8.5	In 250A	142	**HA309M**	410.00	451.00
3 pole isolator 400V~	-	In 250A	-	**HA354**	504.40	554.84
	-	In 400A	-	**HA356**	764.00	840.40
	-	In 630A	-	**HA358**	1188.10	1306.91
	-	In 800A	-	**HA360**	1477.90	1625.69
	-	In 1250A	-	**HA362**	2449.70	2694.67
	-	In 1600A	-	**HA364**	3094.90	3404.39
4 pole isolator 400V~	6	In 125A	108	**HA406**	390.90	429.99
	8.5	In 200A	142	**HA408**	459.20	505.12

http://www.hagerbr.com.au/

cat ref	HA302	HA303	HA304	HA305	HA306	HA307	HA308	HA309M	HA354	HA356	HA358	HA360	HA362	HA364
thermal current Ith	40	63	80	100	125	160	200	250	250	400	630	800	1250	1600
insulation voltage Ui (V)	800	800	800	800	800	800	800	800	800	1000	1000	1000	1000	1000
impulse withstand voltage Uimp (kV)	8	8	8	8	8	8	8	8	8	12	12	12	12	12
rated operation current (A)	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B
400VAC(1) AC-21A / AC-21B	40/40	63/63	80/80	100/100	125/125	160/160	200/200	200/250	250/250	400/400	630/630	800/800	1250/1250	1600/1600
AC-22A / AC-22B	40/40	63/63	80/80	100/100	125/125	160/160	200/200	200/200	250/250	400/400	630/630	800/800	1250/1250	1600/1600
AC-23A / AC-23B	32/32	63/63	80/80	100/100	125/125	160/160	200/200	200/200	250/250	400/400	500/630	800/800	1250/1250	1250/1250
690VAC(2) AC-20A / AC-20B	40/40	63/63	80/80	100/100	125/125	160/160	200/200	200/250	250/250	400/400	630/630	800/800	1250/1250	1600/1600
AC-22A / AC-22B	40/40	63/63	40/40	40/40	40/40	160/160	160/160	160/160	200/250	400/400	500/500	800/800	1000/1000	1000/1000
AC-23A / AC-23	20/20	50/50	25/25	25/25	25/25	63/80	63/80	63/80	125/160	250/315	315/315	800/800	1000/1000	1000/1000
220VDC DC-20A / DC-20B	40/40	63/63	80/80	100/100	125/125	160/160	200/200	200/250	250/250	400/400	630/630	800/800	1250/1250	1600/1600
operational power (kW)														
400 VAC	11	18	40	51	63	80	100	100	132/132	220/220	280/280	450/450	710/710	710/710
690 VAC	11	18	33	33	33	150	150	150	90/110	150/185	150/185	185/220	475/475	475/475
short time withstand current 1 sec (kA rms)	1.25	1.5	2.5	2.5	2.5	4	4	4	9	13	13	26	50	50
short circuit making capacity (kA peak)	6	10	12	12	12	16	16	16	30	45	45	55	110	110
connection														
max cable section (mm)	16	50	50	50	50	95	95	95	150	240	2X300	2X300	4X185	6X185
max busbar width (mm)	-	-	-	-	-	20	20	20	32	40	50	63	100	100

(1) A/B = category with index - A = frequent operation / B = infrequent operation

(2) with terminal shrouds or phase barriers

Application condition & utilisation category, according to IEC 60947-3

Utilisation category		Use	Application
AC	DC		
AC20	DC20	off-load making & breaking	disconnector
AC21	DC21	resistive loads including moderate overloads	switches at installation head or for resistive circuits (lighting)
AC22	DC22	inductive & resistive mixed loads including moderate overloads	switches in secondary circuits or reactive circuits (capacitor banks)
AC23	DC23	loads made of motors or other hightly inductive loads	switches feeding one or serveral motor or inductive circuits (series motors, magnetic brakes)

figure 6 - www.hagerbr.com.au

Activity - 43 - Selection of Isolation switches.

Use figures 4, 5 and 6 to select a suitable isolation switch for the following situations. Specify the;

- number of poles
- current rating.
- type of device C.B. or Isolator
- utilisation Category

Write a response

1 An isolation switch for a distribution board in garage of a single phase domestic installation with a maximum demand of 33A.

2 An main switch for a three phase domestic installation with a maximum demand of 50A per phase.

2 An main switch for a three phase domestic installation with a maximum demand of 50A per phase.

3 The isolation switch in the distribution board of a single phase town house with a maximum demand of 55A.

4 The isolation switch in the distribution board of a three phase factory unit with a maximum demand of 100A per phase.

5 The main switch for a factory unit complex with a maximum demand of 370A per

Activity - 44 - Selection of Isolation switches.

Use figures 11 & 6 to select a suitable isolation switch for the following situations. Specify the; • number of poles • current rating. • Utilisation Category	Write a response
1 An isolation switch for a 230V hot water system, current rated at 20A.	
2 An isolation switch for a shops 230V neon sign with a primary current of 8A	
3 The isolation switch for a group of 3 phase 400V Metal Halide flood lights with a line current of 25A per phase.	

insulation voltage Ui (V)	800	800	800	800	800	800	800	800	800	1000	1000	1000	1000	1000
impulse withstand voltage Uimp (kV)	8	8	8	8	8	8	8	8	8	12	12	12	12	12
rated operation current (A)	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B
400VAC(1) AC-21A / AC-21B	40/40	63/63	80/80	100/100	125/125	160/160	200/200	200/250	250/250	400/400	630/630	800/800	1250/1250	1600/1600
AC-22A / AC-22B	40/40	63/63	80/80	100/100	125/125	160/160	200/200	200/200	250/250	400/400	630/630	800/800	1250/1250	1600/1600
AC-23A / AC-23B	32/32	63/63	80/80	100/100	125/125	160/160	200/200	200/200	250/250	400/400	500/630	800/800	1250/1250	1250/1250
690VAC(2) AC-20A / AC-20B	40/40	63/63	80/80	100/100	125/125	160/160	200/200	200/250	250/250	400/400	630/630	800/800	1250/1250	1600/1600
AC-22A / AC-22B	40/40	63/63	40/40	40/40	40/40	160/160	160/160	160/160	200/250	400/400	500/500	800/800	1000/1000	1000/1000
AC-23A / AC-23	20/20	50/50	25/25	25/25	25/25	63/80	63/80	63/80	125/160	250/315	315/315	800/800	1000/1000	1000/1000
220VDC DC-20A / DC-20B	40/40	63/63	80/80	100/100	125/125	160/160	200/200	200/250	250/250	400/400	630/630	800/800	1250/1250	1600/1600
operational power (kW)														
400 VAC	11	18	40	51	63	80	100	100	132/132	220/220	280/280	450/450	710/710	710/710
690 VAC	11	18	33	33	33	150	150	150	90/110	150/185	150/185	185/220	475/475	475/475
short time withstand current 1 sec (kA rms)	1.25	1.5	2.5	2.5	2.5	4	4	4	9	13	13	26	50	50
short circuit making capacity (kA peak)	6	10	12	12	12	16	16	16	30	45	45	55	110	110
connection														
max cable section (mm)	16	50	50	50	50	95	95	95	150	240	2X300	2X300	4X185	6X185
max busbar width (mm)	-	-	-	-	-	20	20	20	32	40	50	63	100	100

(1) A/B = category with index - A = frequent operation / B = infrequent operation

(2) with terminal shrouds or phase barriers

Application condition & utilisation category, according to IEC 60947-3

Utilisation category		Use	Application
AC	DC		
AC20	DC20	off-load making & breaking	disconnector
AC21	DC21	resistive loads including moderate overloads	switches at installation head or for resistive circuits (lighting)
AC22	DC22	inductive & resistive mixed loads including moderate overloads	switches in secondary circuits or reactive circuits (capacitor banks)

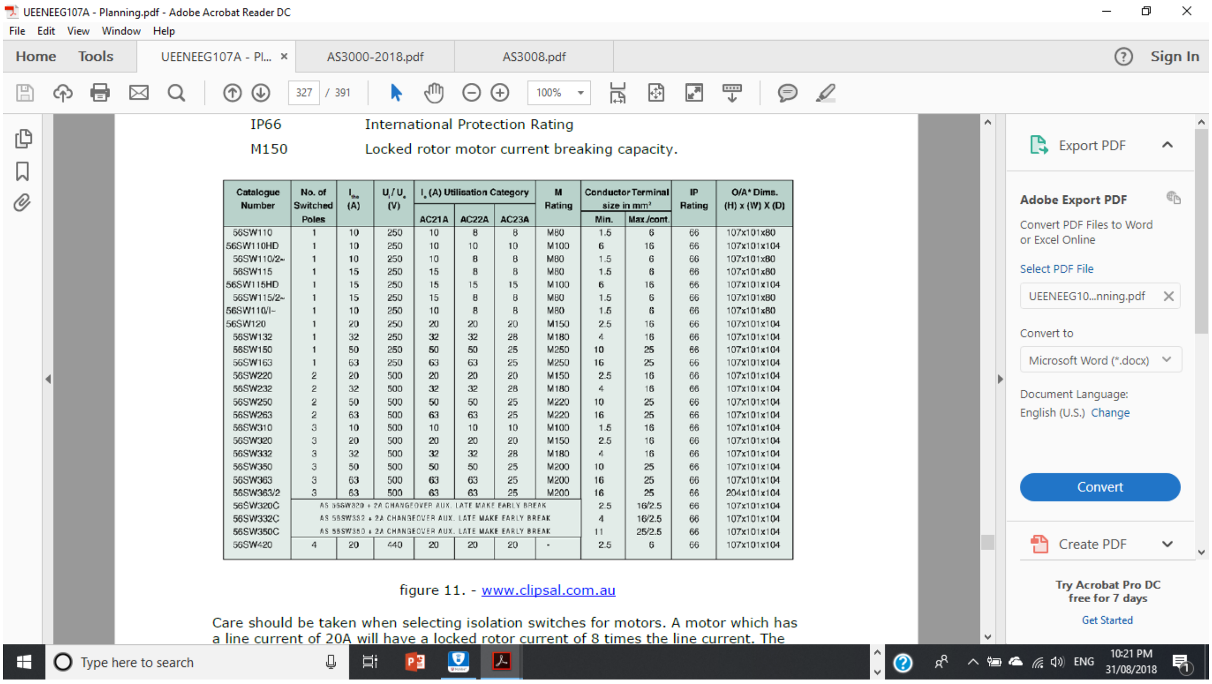
20 AMP

50Hz
500V
IP66
M150

figure 10.

20 AMP	Indicates current that the switch can carry under normal use for a prolonged period of time. The current rating is limited by the build up of heat over time.
50Hz	Rated Frequency
500V	Voltage Rating
IP66	International Protection Rating
M150	Locked rotor motor current breaking capacity.

Catalogue Number	No. of Switched Poles	I_{the} (A)	U_i / U_e (V)	I_e (A) Utilisation Category			M Rating	Conductor Terminal size in mm²		IP Rating	O/A* Dims. (H) x (W) X (D)
				AC21A	AC22A	AC23A		Min.	Max./cont.		
56SW110	1	10	250	10	8	8	M80	1.5	6	66	107x101x80
56SW110HD	1	10	250	10	10	10	M100	6	16	66	107x101x104
56SW110/2~	1	10	250	10	8	8	M80	1.5	6	66	107x101x80
56SW115	1	15	250	15	8	8	M80	1.5	6	66	107x101x80
56SW115HD	1	15	250	15	15	15	M100	6	16	66	107x101x104
56SW115/2~	1	15	250	15	8	8	M80	1.5	6	66	107x101x80
56SW110/I~	1	10	250	10	8	8	M80	1.5	6	66	107x101x80
56SW120	1	20	250	20	20	20	M150	2.5	16	66	107x101x104
56SW132	1	32	250	32	32	28	M180	4	16	66	107x101x104



IP66 International Protection Rating

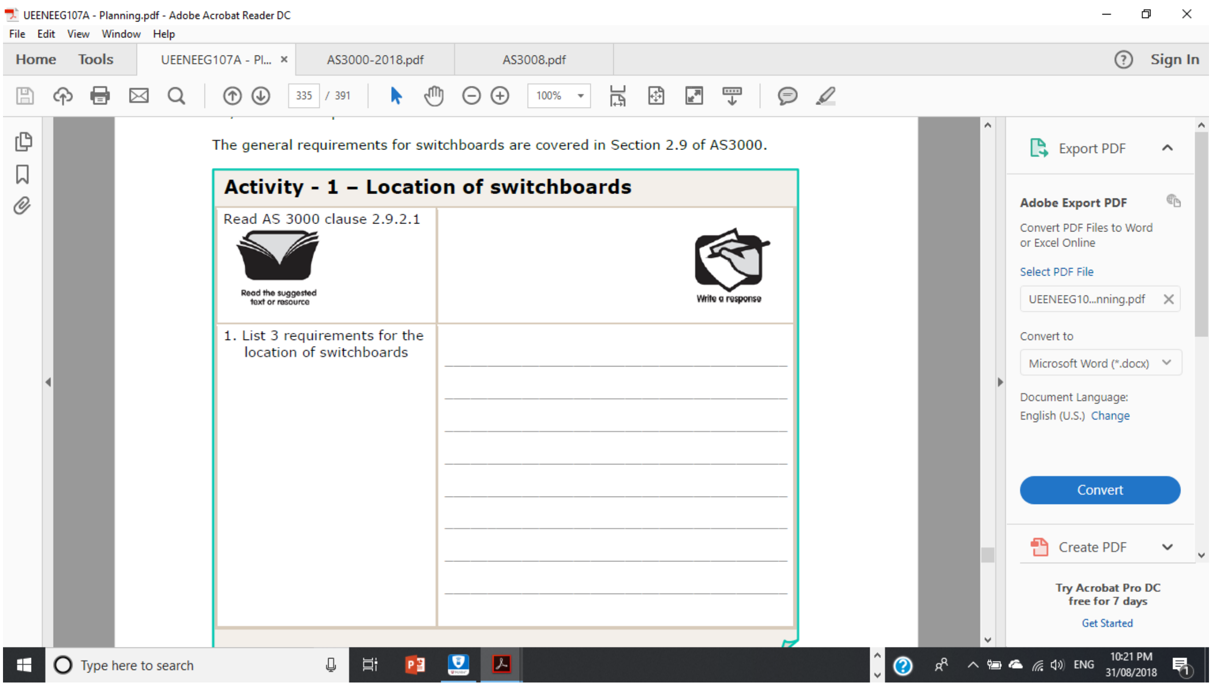
M150 Locked rotor motor current breaking capacity.

Catalogue Number	No. of Switched Poles	I_{the} (A)	U_i / U_e (V)	I_e (A) Utilisation Category AC21A	AC22A	AC23A	M Rating	Conductor Terminal size in mm² Min.	Max./cont.	IP Rating	O/A* Dims. (H) x (W) X (D)
56SW110	1	10	250	10	8	8	M80	1.5	6	66	107x101x80
56SW110HD	1	10	250	10	10	10	M100	6	16	66	107x101x104
56SW110/2~	1	10	250	10	8	8	M80	1.5	6	66	107x101x80
56SW115	1	15	250	15	8	8	M80	1.5	6	66	107x101x80
56SW115HD	1	15	250	15	15	15	M100	6	16	66	107x101x104
56SW115/2~	1	15	250	15	8	8	M80	1.5	6	66	107x101x80
56SW110/I~	1	10	250	10	8	8	M80	1.5	6	66	107x101x80
56SW120	1	20	250	20	20	20	M150	2.5	16	66	107x101x104
56SW132	1	32	250	32	32	28	M180	4	16	66	107x101x104
56SW150	1	50	250	50	50	25	M250	10	25	66	107x101x104
56SW163	1	63	250	63	63	25	M250	16	25	66	107x101x104
56SW220	2	20	500	20	20	20	M150	2.5	16	66	107x101x104
56SW232	2	32	500	32	32	28	M180	4	16	66	107x101x104
56SW250	2	50	500	50	50	25	M220	10	25	66	107x101x104
56SW263	2	63	500	63	63	25	M220	16	25	66	107x101x104
56SW310	3	10	500	10	10	10	M100	1.5	16	66	107x101x104
56SW320	3	20	500	20	20	20	M150	2.5	16	66	107x101x104
56SW332	3	32	500	32	32	28	M180	4	16	66	107x101x104
56SW350	3	50	500	50	50	25	M200	10	25	66	107x101x104
56SW363	3	63	500	63	63	25	M200	16	25	66	107x101x104
56SW363/2	3	63	500	63	63	25	M200	16	25	66	204x101x104
56SW320C	AS 56SW320 + 2A CHANGEOVER AUX. LATE MAKE EARLY BREAK							2.5	16/2.5	66	107x101x104
56SW332C	AS 56SW332 + 2A CHANGEOVER AUX. LATE MAKE EARLY BREAK							4	16/2.5	66	107x101x104
56SW350C	AS 56SW350 + 2A CHANGEOVER AUX. LATE MAKE EARLY BREAK							11	25/2.5	66	107x101x104
56SW420	4	20	440	20	20	20	-	2.5	6	66	107x101x104

figure 11. - www.clipsal.com.au

Care should be taken when selecting isolation switches for motors. A motor which has a line current of 20A will have a locked rotor current of 8 times the line current. The

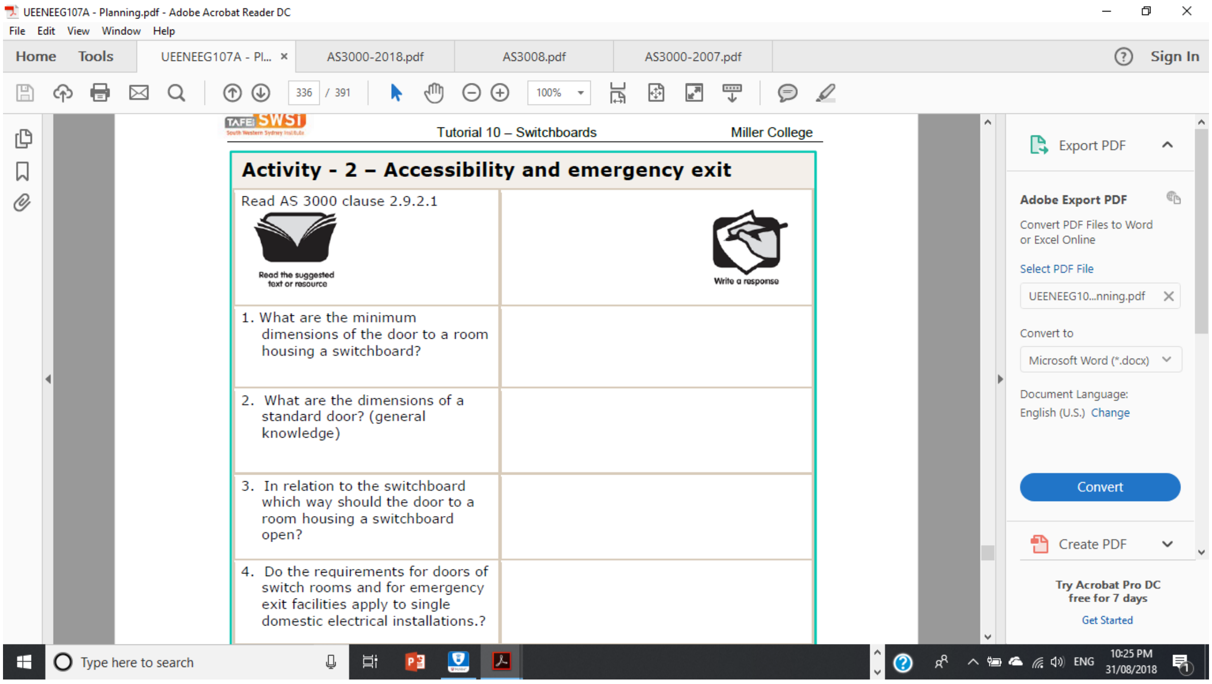
Page 335



The general requirements for switchboards are covered in Section 2.9 of AS3000.

Activity - 1 – Location of switchboards

Read AS 3000 clause 2.9.2.1	
1. List 3 requirements for the location of switchboards	



Tutorial 10 – Switchboards Miller College

Activity - 2 – Accessibility and emergency exit

Read AS 3000 clause 2.9.2.1	
1. What are the minimum dimensions of the door to a room housing a switchboard?	
2. What are the dimensions of a standard door? (general knowledge)	
3. In relation to the switchboard which way should the door to a room housing a switchboard open?	
4. Do the requirements for doors of switch rooms and for emergency exit facilities apply to single domestic electrical installations.?	

2.9.2 Location of switchboards

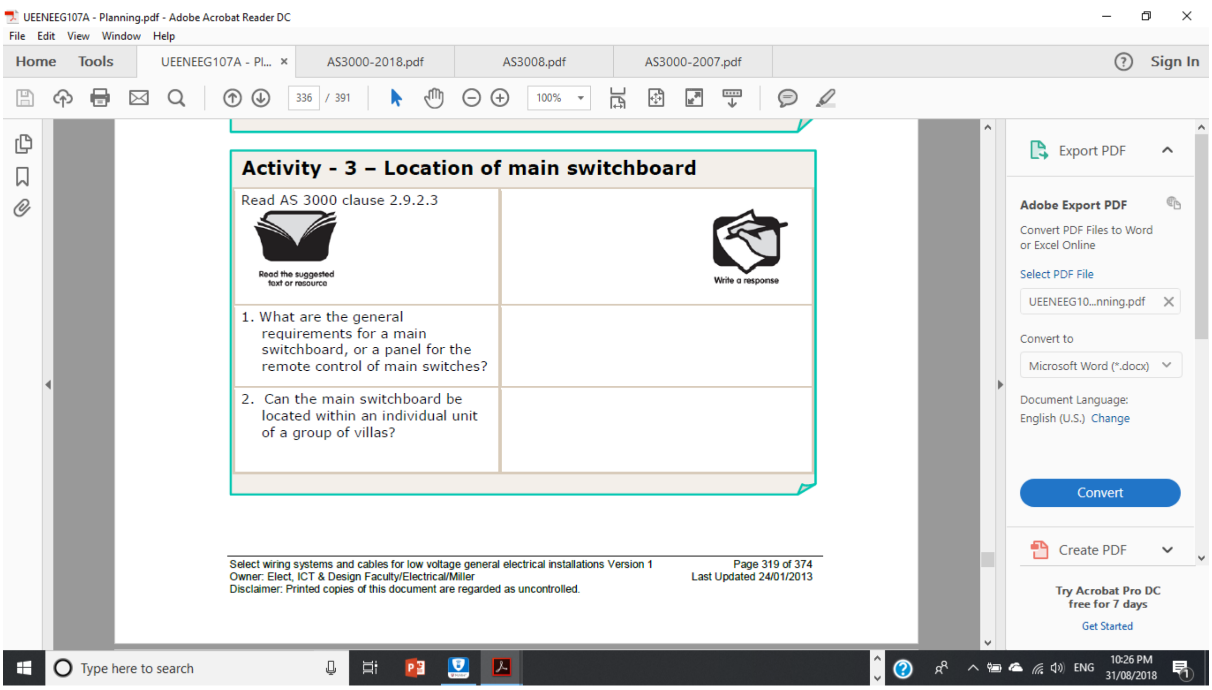
2.9.2.1 General

Switchboards shall be—

(a) installed in suitable well-ventilated places: and

(b) protected against the effects of moisture to which they may be exposed; and

(c) arranged so as to provide sufficient space for the initial installation and later replacement of individual items of the control and protective devices and accessibility for operation, testing, inspection, maintenance and repair.



Activity - 3 – Location of main switchboard

Read AS 3000 clause 2.9.2.3	
1. What are the general requirements for a main switchboard, or a panel for the remote control of main switches?	
2. Can the main switchboard be located within an individual unit of a group of villas?	

Select wiring systems and cables for low voltage general electrical installations Version 1 Page 319 of 374
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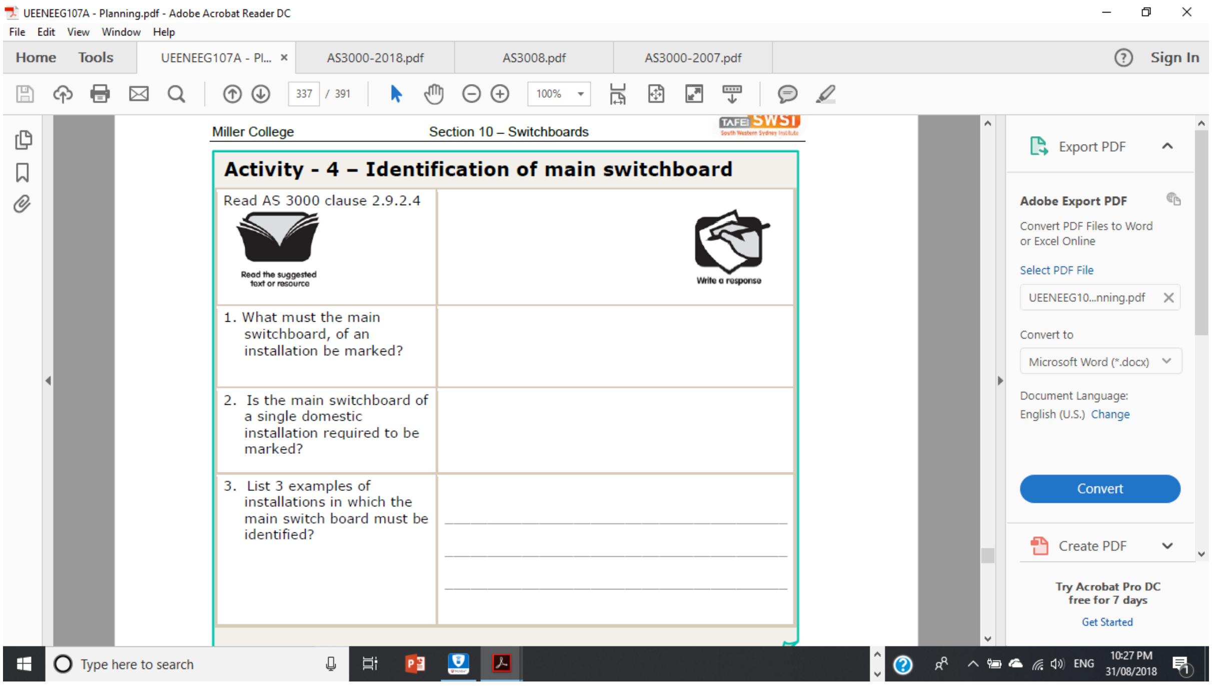
2.9.2.3 Location of main switchboard

(a) General The main switchboard shall be readily accessible. The main switchboard, or a panel for the remote control of main switches in accordance with Clause 2.3.3.5, shall be located within easy access of an entrance to the building.

(b) Multiple electrical installations In multiple electrical installations the main switchboard shall not be located within any tenancy or single electrical installation of a multiple premise, either domestic or nondomestic.



2.9.2.4 Identification of main switchboard

The main switchboard shall be legibly and permanently marked 'MAIN SWITCHBOARD'.

Where a main switchboard is located within a room or enclosure, any door required for immediate personal access shall be prominently and permanently marked to identify the room or enclosure in which the main switchboard is located.

The location of the main switchboard shall be legibly and permanently indicated by a conspicuous notice at each entry to the building that may be used by emergency services personnel.

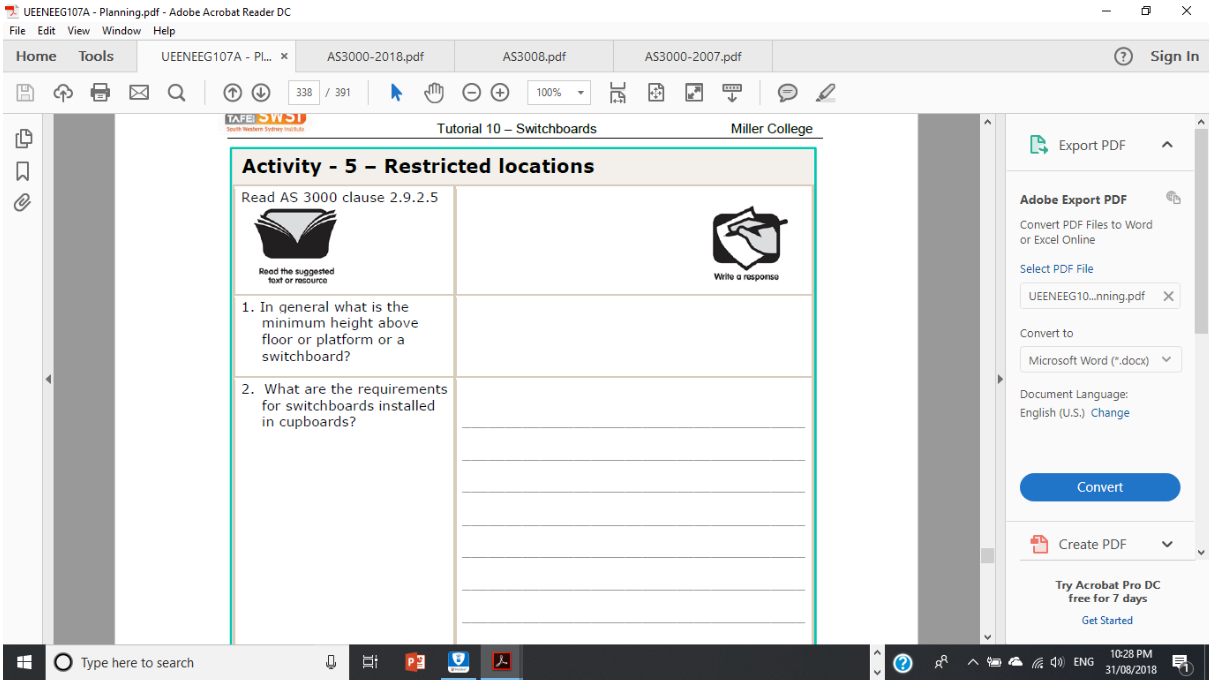
Notices indicating the location of the main switchboard shall be of permanent construction and shall incorporate the term 'MAIN SWITCHBOARD' in contrasting colours.

Exceptions:

1 Identification of the main switchboard and its room or enclosure need not apply in a single domestic electrical installation.

2 The location of the main switchboard need not be marked at an entry to a building where the location is clearly indicated at a Fire Indicator Panel.

3 The location of the main switchboard need not be marked where the location can be readily determined, e.g. where it is clearly visible from the main entrance to the electrical installation.



2.9.2.5 Restricted locations

Restricted locations for switchboards are as follows:

(a) Height above ground, floor or platform A switchboard shall not be located within 1.2 m of the ground, floor or platform.

Exception: A switchboard may be located within 1.2m of the ground, floor or platform if access to live parts is arranged, in accordance with the requirements of Clause 2.9.3.1.

(b) Water containers and fixed or stationary cooking appliances A switchboard shall not be installed above open water containers or fixed or stationary cooking appliances.

Exception: A switchboard may be located in an area that may be affected by water splashing or by steam, provided that the switchboard is provided with a suitable enclosure or is installed in a cupboard with close-fitting doors.

(c) In cupboards A switchboard installed in a cupboard or similar enclosure shall only be installed in an area set aside for the purpose. The provisions of Clause 2.9.2.2 require that the switchboard be designed and located to provide ready access thereto for the purposes of operation and maintenance of equipment mounted on the switchboard. The following restrictions shall be applied to all switchboards, in particular, main switchboards.

The switchboard shall be—

(i) installed in a section of the cupboard separated from other sections; and

(ii) installed at the front of the switchboard section of the cupboard; and

(iii) facing the cupboard access door with insufficient unused space between the switchboard and the cupboard door, when closed, to store extraneous objects in front of the switchboard; and

(iv) arranged so that below the area of the switchboard panel or enclosure, there are no projections that obstruct access for the operation and maintenance of the switchboard.

(d) Near baths and showers A switchboard shall not be installed within any zone classified in accordance with Clause 6.2.2 for a bath or shower.

NOTE: Areas in the proximity of a shower are deemed unsuitable for switchboards because of the prevalence of high humidity and condensation.

(e) Near swimming pools, spas or saunas A switchboard shall not be installed within or above any zone classified in accordance with Clause 6.3.2 for a swimming pool or spa pool.

A switchboard shall not be installed within a sauna.

(f) Refrigeration rooms A switchboard shall not be installed within a refrigeration room.

(g) Sanitization or general hosing-down operations Switchboards installed in classified zones in locations subject to sanitization or hosing-down operations shall be provided with a minimum degree of protection of IPX6.

(h) Fire exits and egress paths Switchboards shall be located or arranged to minimize the impact of any smoke generated from a fault in the switchboard affecting egress from the building.

A switchboard shall not be installed within a fire-isolated stairway, passageway or ramp.

A switchboard may be installed within a cupboard, or similar compartment, in other forms of required exit, or in any corridor, hallway, lobby or the like leading to such an exit, provided that the cupboard or compartment doors are sealed against the spread of smoke from the switchboard.

NOTES:

1 The compartment may be the switchboard enclosure, provided that the enclosure provides a seal to the ingress of dust to at least IP5X and is provided with a facility to be kept locked in normal service.

2 These restrictions are based on the provisions of National Building Codes to which reference should be made for definition of the terms and for exceptions that may apply.

(i) Near fire-hose reels A switchboard shall not be installed within a cupboard containing a fire-hose reel.

NOTE: Information on the installation of fire hydrants and fire-hose reels in buildings is given in National Building Codes and AS 2419 series or NZS 4510 and AS 2441.

(j) Near automatic fire-sprinklers The following types of switchboards shall not be installed in the vicinity of an automatic fire-sprinkler system:

(i) Main switchboards.

(ii) Switchboards from which safety services originate in accordance with Clause 7.2.

Exception: A switchboard may be installed in the vicinity of an automatic fire sprinkler system if at least one of the following conditions is satisfied:

(A) The switchboard is provided with degree of protection IPX4, in accordance with AS 60529.

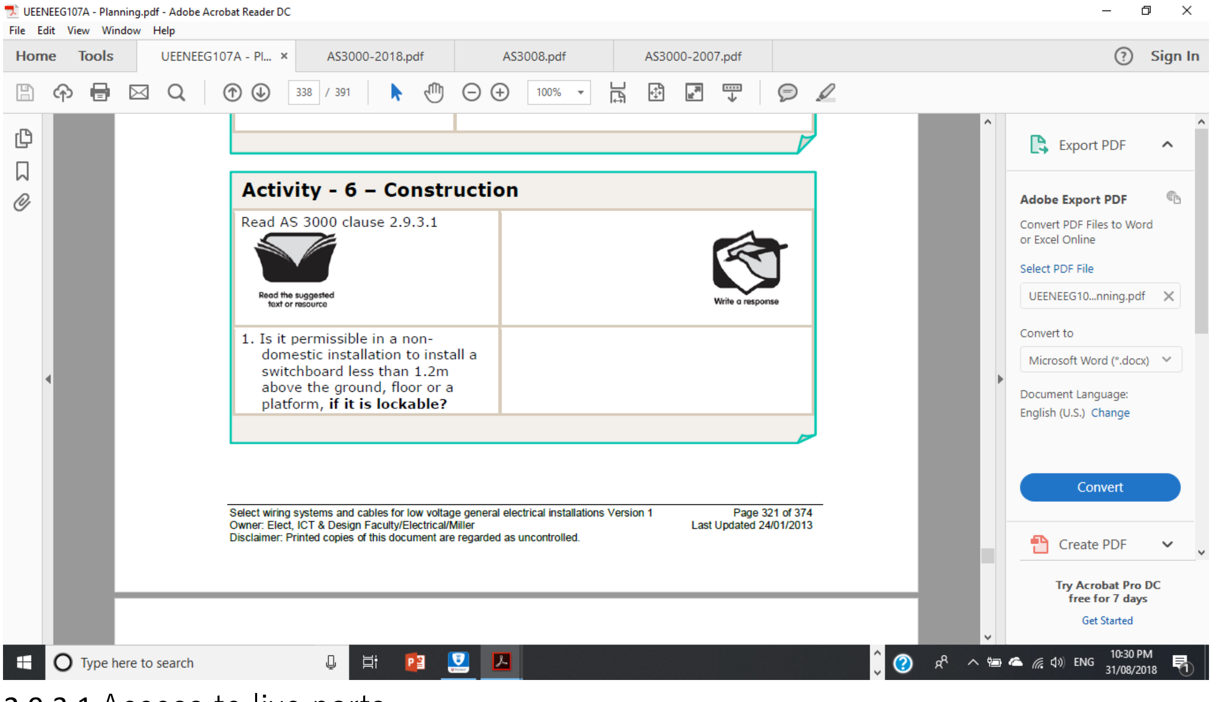
(B) The switchboard is provided with a shield to prevent water spraying on it.

(C) Sprinkler heads that could project water on the switchboard are provided with suitable deflectors.

(D) Sprinkler heads are of the dry type.

(k) Hazardous areas **Switchboards shall not be installed in hazardous areas as defined in AS/NZS 60079.10.1 or AS/NZS 60079.10.2.**

Exception: Switchboards constructed in accordance with AS/NZS 60079.14 may be installed within a hazardous area for which they are specifically designed.



2.9.3.1 Access to live parts

Live parts shall be arranged so that basic protection is provided by enclosures, in accordance with the provisions of Clause 1.5.4.

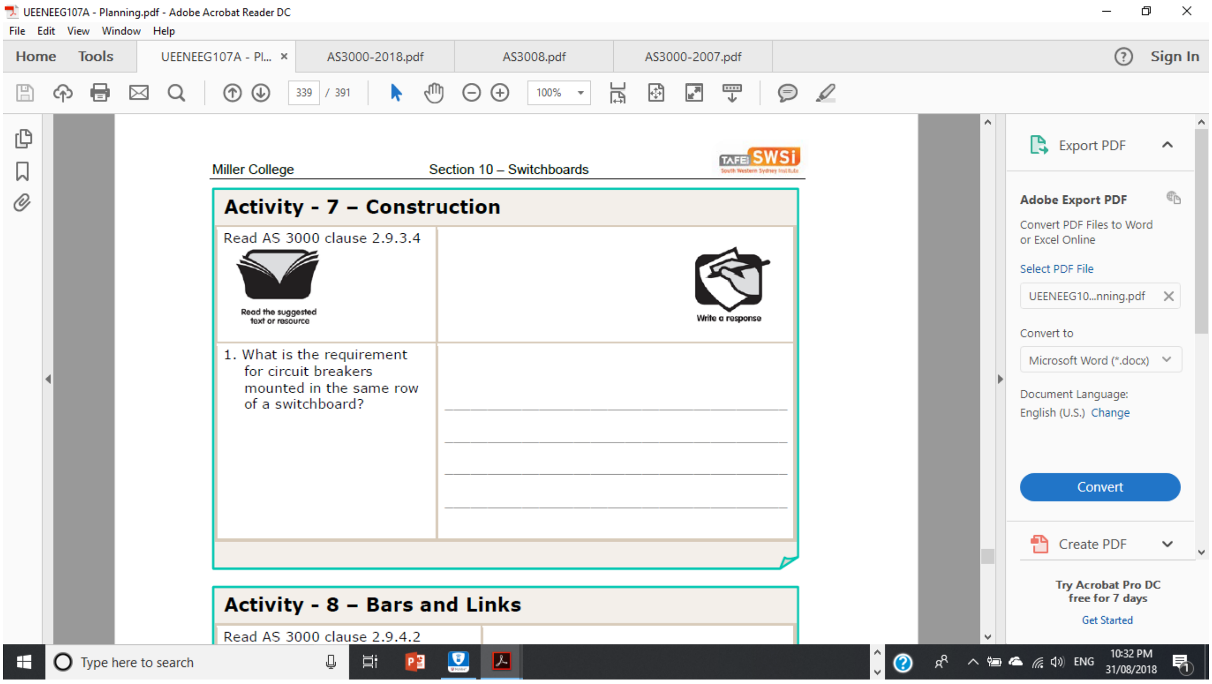
Exception: Live parts may be exposed in a non- domestic electrical installation provided that—

1 the live parts are arranged so that basic protection is provided by barriers in accordance with the provisions of Clause 1.5.4.4; or

2 the switchboard is installed in an area that is accessible only to authorized persons and the means of access to such areas is provided with facilities for locking.

In situations where the removal of covers and the like exposes live parts such covers shall be identified in accordance with AS/NZS 3439.

Exception: This requirement does not apply to domestic switchboards.



Miller College Section 10 – Switchboards

Activity - 7 – Construction

Read AS 3000 clause 2.9.3.4 Read the suggested text or resource	Write a response
1. What is the requirement for circuit breakers mounted in the same row of a switchboard?	

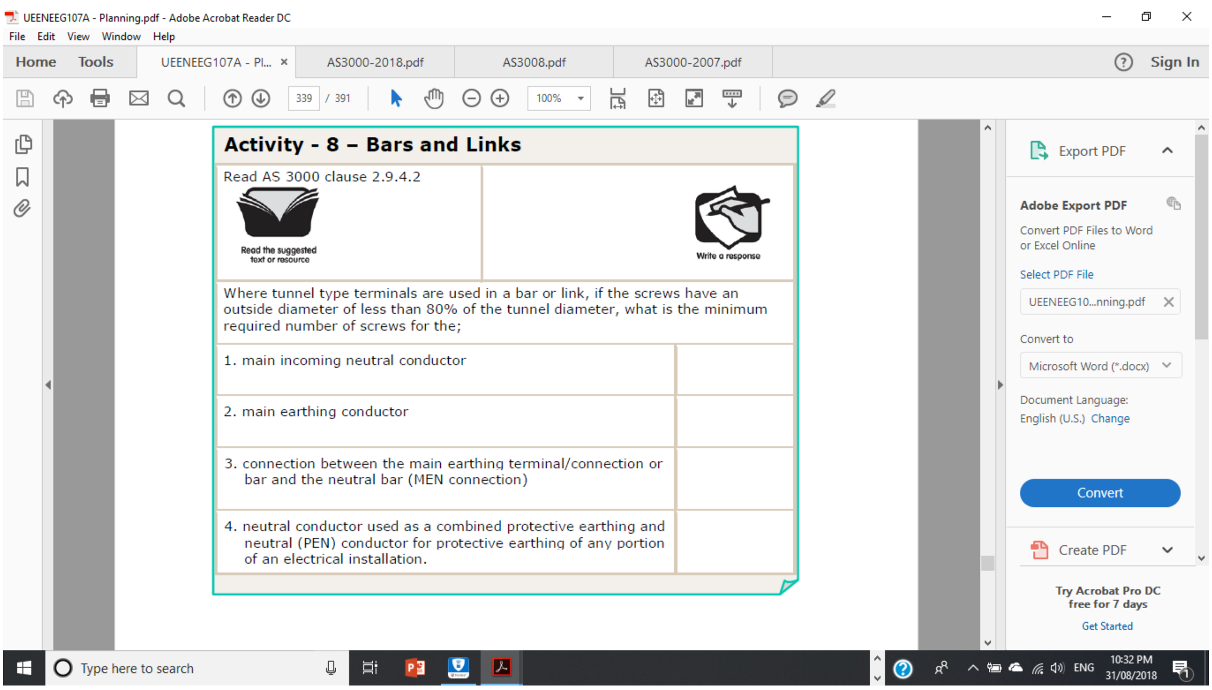
Activity - 8 – Bars and Links

Read AS 3000 clause 2.9.4.2

2.9.3.4 Orientation of circuit-breakers

Where two or more circuit-breakers are mounted in the same row, the operating mechanism of each shall cause the circuit to open when the operating means are orientated in one general direction.

Exception: Other arrangements are permitted where the open circuit condition of each device is obvious or where each device is clearly marked to indicate the off position.



Activity - 8 – Bars and Links

Read AS 3000 clause 2.9.4.2 Read the suggested text or resource	Write a response

Where tunnel type terminals are used in a bar or link, if the screws have an outside diameter of less than 80% of the tunnel diameter, what is the minimum required number of screws for the;

1. main incoming neutral conductor	
2. main earthing conductor	
3. connection between the main earthing terminal/connection or bar and the neutral bar (MEN connection)	
4. neutral conductor used as a combined protective earthing and neutral (PEN) conductor for protective earthing of any portion of an electrical installation.	

2.9.4.2 Tunnel-type terminals

All screws that are in direct contact with conductors in tunnel-type terminals shall be of the type designed not to cut the conductor.

Where tunnel-type terminals having clamping screws that are in direct contact with the conductors are provided for connection of—

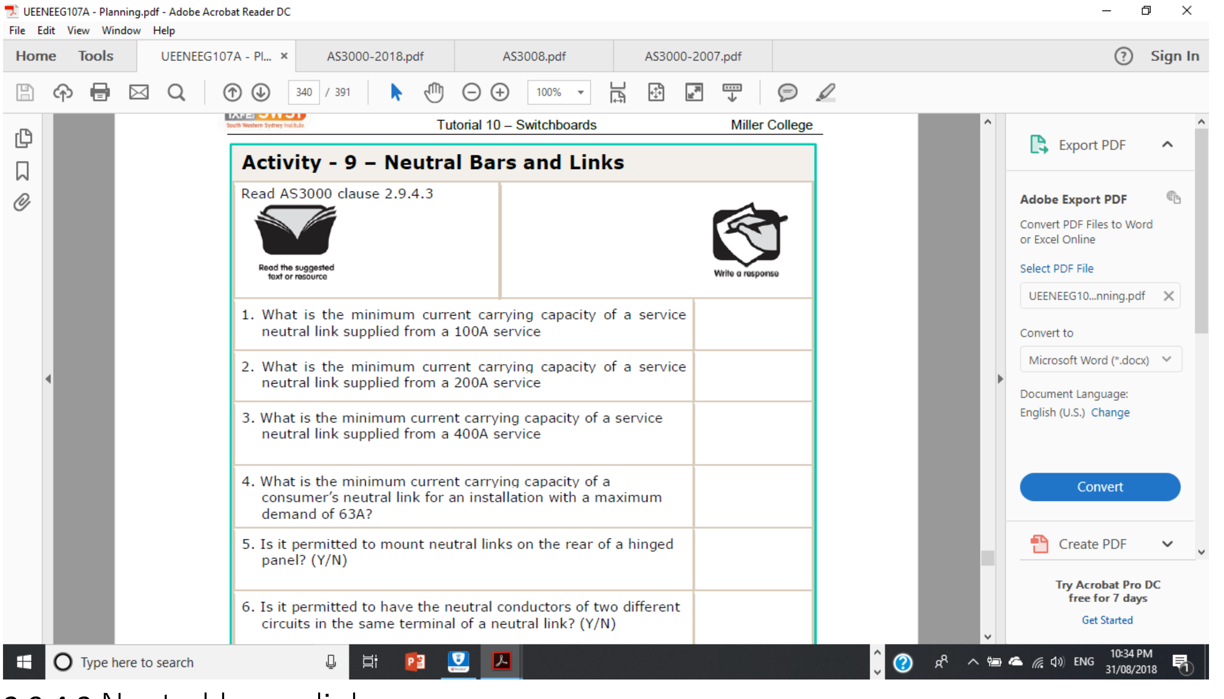
(a) the main incoming neutral conductor; or

(b) the main earthing conductor; or

(c) the connection between the main earthing terminal/connection or bar

and the neutral bar (MEN connection); or
(d) a neutral conductor used as a combined protective earthing and neutral (PEN) conductor for protective earthing of any portion of an electrical installation,
the terminal shall be of a type having—

(i) two screws; or
(ii) (ii) one screw with an outside diameter not less than 80% of the tunnel
(iii) diameter.
(iv) NOTE: This requirement does not apply to connections arranged so that the
(v) conductor is clamped by suitable ferrules or plates in direct contact with the
(vi) conductor.



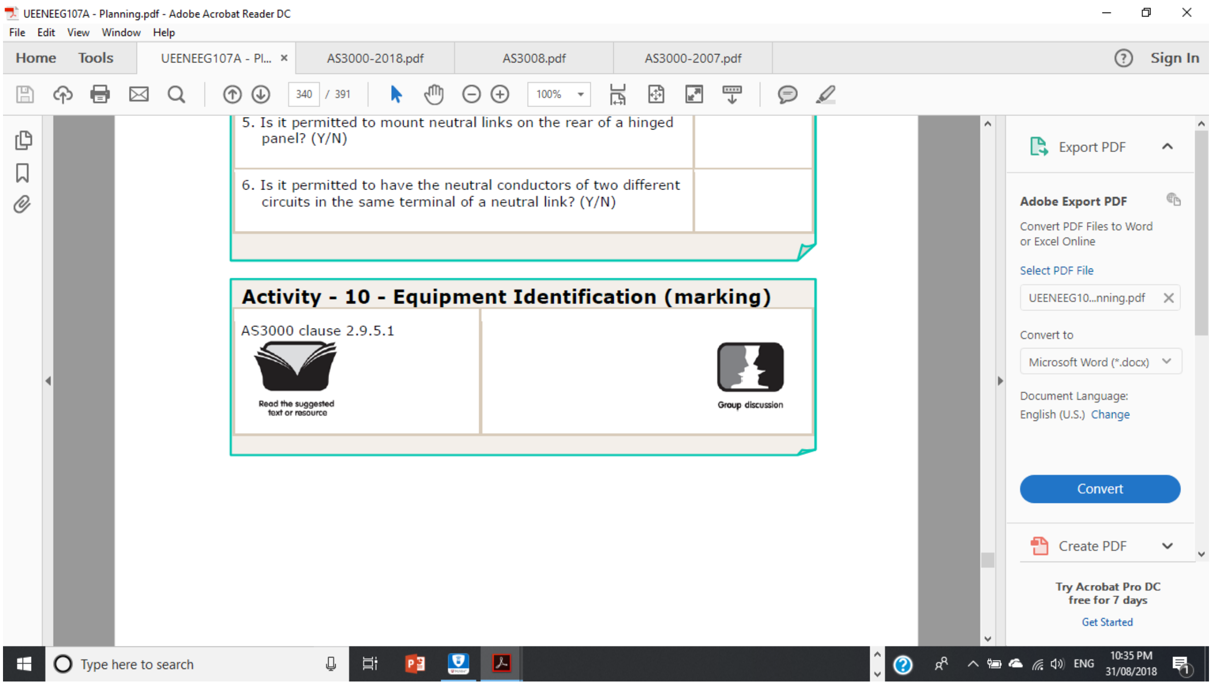
Tutorial 10 – Switchboards Miller College

Activity - 9 – Neutral Bars and Links	
Read AS3000 clause 2.9.4.3 (Read the suggested text or resource)	Write a response
1. What is the minimum current carrying capacity of a service neutral link supplied from a 100A service	
2. What is the minimum current carrying capacity of a service neutral link supplied from a 200A service	
3. What is the minimum current carrying capacity of a service neutral link supplied from a 400A service	
4. What is the minimum current carrying capacity of a consumer's neutral link for an installation with a maximum demand of 63A?	
5. Is it permitted to mount neutral links on the rear of a hinged panel? (Y/N)	
6. Is it permitted to have the neutral conductors of two different circuits in the same terminal of a neutral link? (Y/N)	

2.9.4.3 Neutral bar or link

Every switchboard, to which a neutral conductor is connected, shall be provided with a neutral bar or link that is—
(a) of adequate current-carrying capacity; and
NOTE: The current-carrying capacity of the incoming neutral conductor may be used as a guide.
(b) located in an accessible position to allow all conductors to be safely connected without moving other cables or isolating the supply to the switchboard; and
(c) designed such that the incoming neutral conductor cannot be inadvertently disconnected from the bar or link; and
(d) provided with a separate terminal for—
(i) the incoming neutral conductor terminating at the switchboard; and
(ii) the neutral conductor(s) associated with each outgoing circuit originating at the switchboard.
Where tunnel-type terminals are provided, the provisions of Clause 2.9.4.2 shall apply.
A neutral conductor or busbar connection may be used between the neutral bar or link and a number of multi-pole devices mounted on the switchboard. Where such an arrangement is used the connection device shall comply with Clause 2.9.4.1 and, where appropriate, Clause 2.9.4.2.
Exception: Where the connection is made at a terminal of switchgear

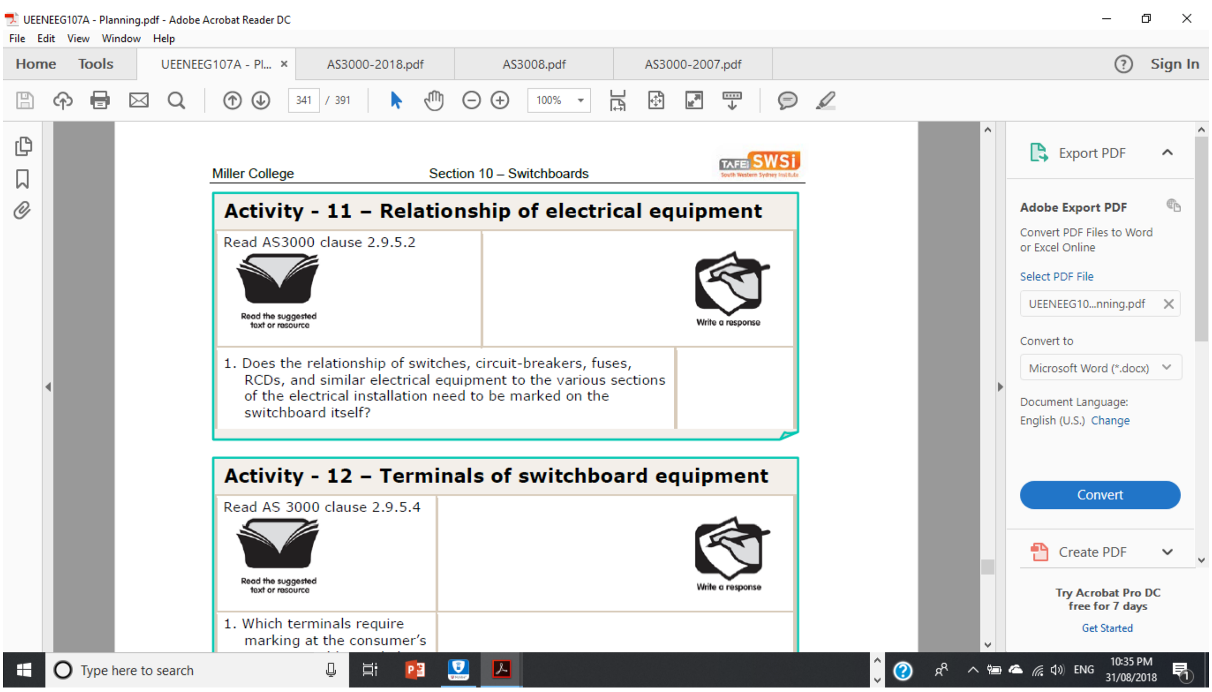
in accordance with the manufacturer's specifications, the provisions of Clauses 2.9.4.1 and 2.9.4.2 need not apply



2.9.5.1 General

All equipment installed on a switchboard shall be legibly and indelibly identified in the English language in accordance with the requirements of Clauses 2.9.5.2 to 2.9.5.6.

NOTE: See Clauses 2.3.3 and 2.3.4 for the marking requirements of main switches and additional isolating switches.



2.9.5.2 Relationship of electrical equipment

The relationship of switches, circuit-breakers, fuses, RCDs, and similar electrical equipment to the various sections of the electrical installation shall be marked on or adjacent to the switchboard.

2.9.5.4 Terminals of switchboard equipment

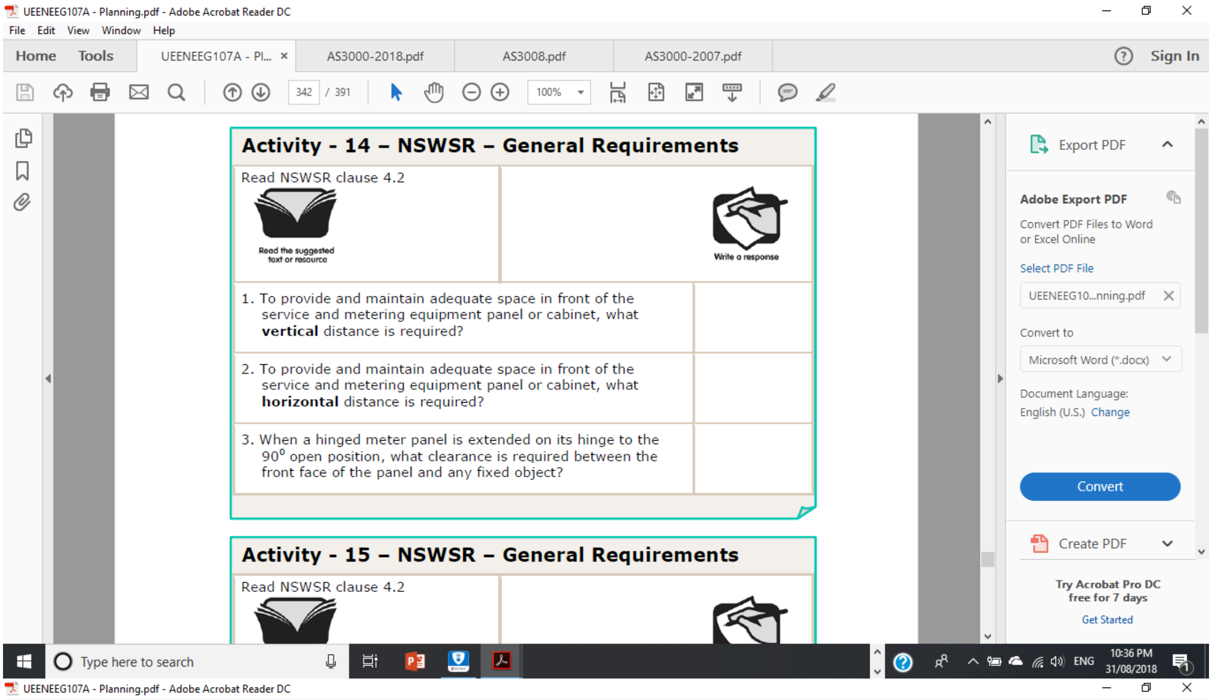
Terminals of bars, links, circuit-breakers, fuses and other electrical equipment mounted on a switchboard shall be marked or arranged to identify the corresponding active and neutral connection for each circuit. The terminals for the connection of the MEN connection and for the main neutral conductor shall be legibly and indelibly marked at the main neutral bar or link.

Exception: This marking is not necessary where—

1 the MEN connection is made at a terminal at one extremity of the bar or link; and

2 the main neutral conductor is connected to the next adjacent terminal of the bar or link.

Where the MEN connection is made at another location, such as a substation, in accordance with Clause 5.3.5.1, the location of the connection shall be legibly and indelibly marked at the main switchboard.

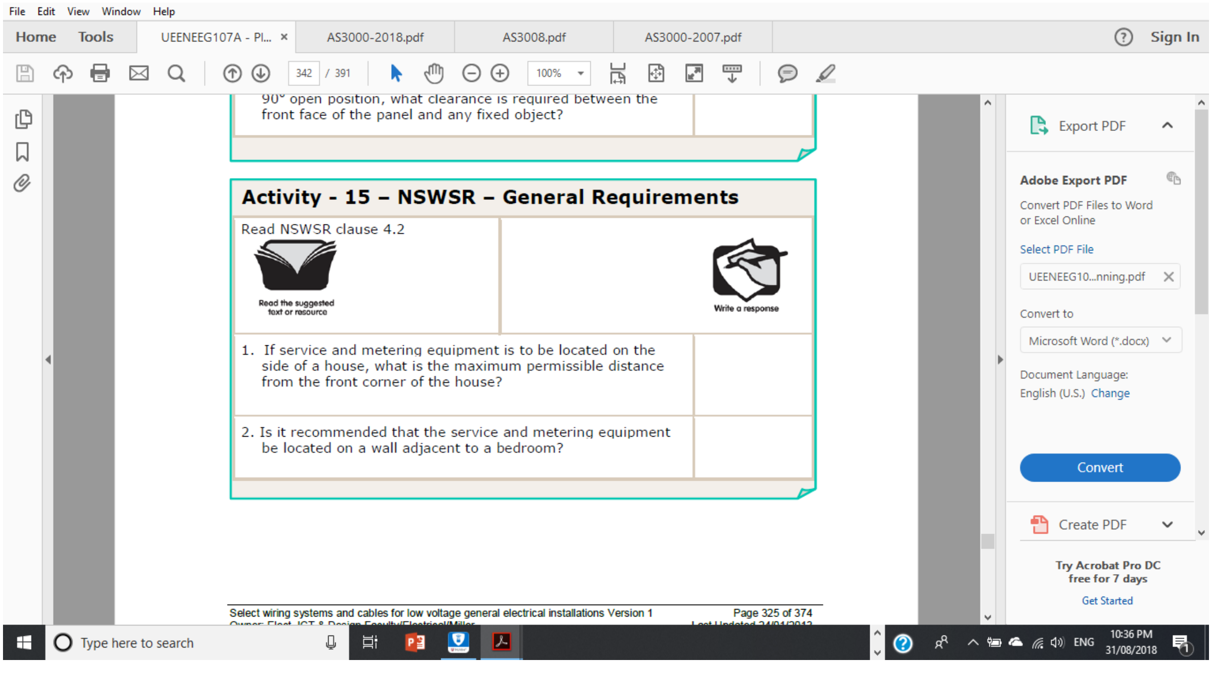


Activity - 14 – NSWSR – General Requirements

Read NSWSR clause 4.2	
1. To provide and maintain adequate space in front of the service and metering equipment panel or cabinet, what **vertical** distance is required?	
2. To provide and maintain adequate space in front of the service and metering equipment panel or cabinet, what **horizontal** distance is required?	
3. When a hinged meter panel is extended on its hinge to the 90° open position, what clearance is required between the front face of the panel and any fixed object?	

Activity - 15 – NSWSR – General Requirements

Read NSWSR clause 4.2



Activity - 15 – NSWSR – General Requirements

Read NSWSR clause 4.2	
1. If service and metering equipment is to be located on the side of a house, what is the maximum permissible distance from the front corner of the house?	
2. Is it recommended that the service and metering equipment be located on a wall adjacent to a bedroom?	

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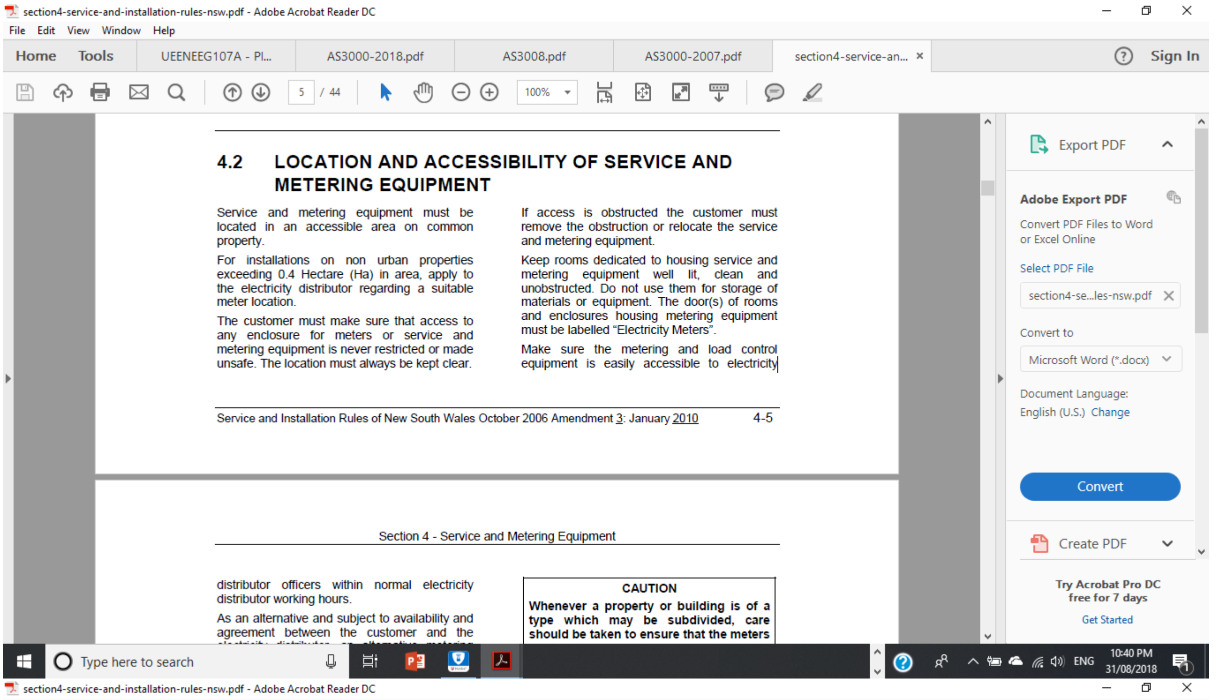


4.2 LOCATION AND ACCESSIBILITY OF SERVICE AND METERING EQUIPMENT

Service and metering equipment must be located in an accessible area on common property.

For installations on non urban properties exceeding 0.4 Hectare (Ha) in area, apply to the electricity distributor regarding a suitable meter location.

The customer must make sure that access to any enclosure for meters or service and metering equipment is never restricted or made unsafe. The location must always be kept clear.

If access is obstructed the customer must remove the obstruction or relocate the service and metering equipment.

Keep rooms dedicated to housing service and metering equipment well lit, clean and unobstructed. Do not use them for storage of materials or equipment. The door(s) of rooms and enclosures housing metering equipment must be labelled "Electricity Meters".

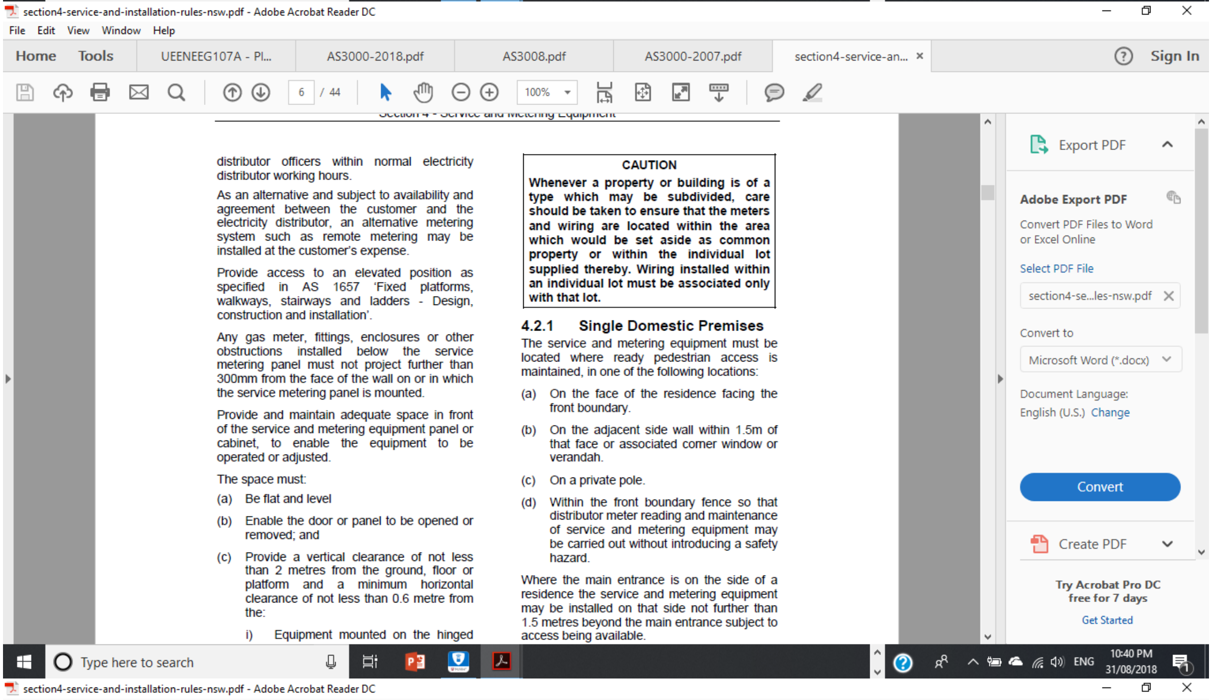
Make sure the metering and load control equipment is easily accessible to electricity

distributor officers within normal electricity distributor working hours.

As an alternative and subject to availability and agreement between the customer and the

CAUTION

Whenever a property or building is of a type which may be subdivided, care should be taken to ensure that the meters



distributor officers within normal electricity distributor working hours.

As an alternative and subject to availability and agreement between the customer and the electricity distributor, an alternative metering system such as remote metering may be installed at the customer's expense.

Provide access to an elevated position as specified in AS 1657 'Fixed platforms, walkways, stairways and ladders - Design, construction and installation'.

Any gas meter, fittings, enclosures or other obstructions installed below the service metering panel must not project further than 300mm from the face of the wall on or in which the service metering panel is mounted.

Provide and maintain adequate space in front of the service and metering equipment panel or cabinet, to enable the equipment to be operated or adjusted.

The space must:

(a) Be flat and level

(b) Enable the door or panel to be opened or removed; and

(c) Provide a vertical clearance of not less than 2 metres from the ground, floor or platform and a minimum horizontal clearance of not less than 0.6 metre from the:

i) Equipment mounted on the hinged

CAUTION

Whenever a property or building is of a type which may be subdivided, care should be taken to ensure that the meters and wiring are located within the area which would be set aside as common property or within the individual lot supplied thereby. Wiring installed within an individual lot must be associated only with that lot.

4.2.1 Single Domestic Premises

The service and metering equipment must be located where ready pedestrian access is maintained, in one of the following locations:

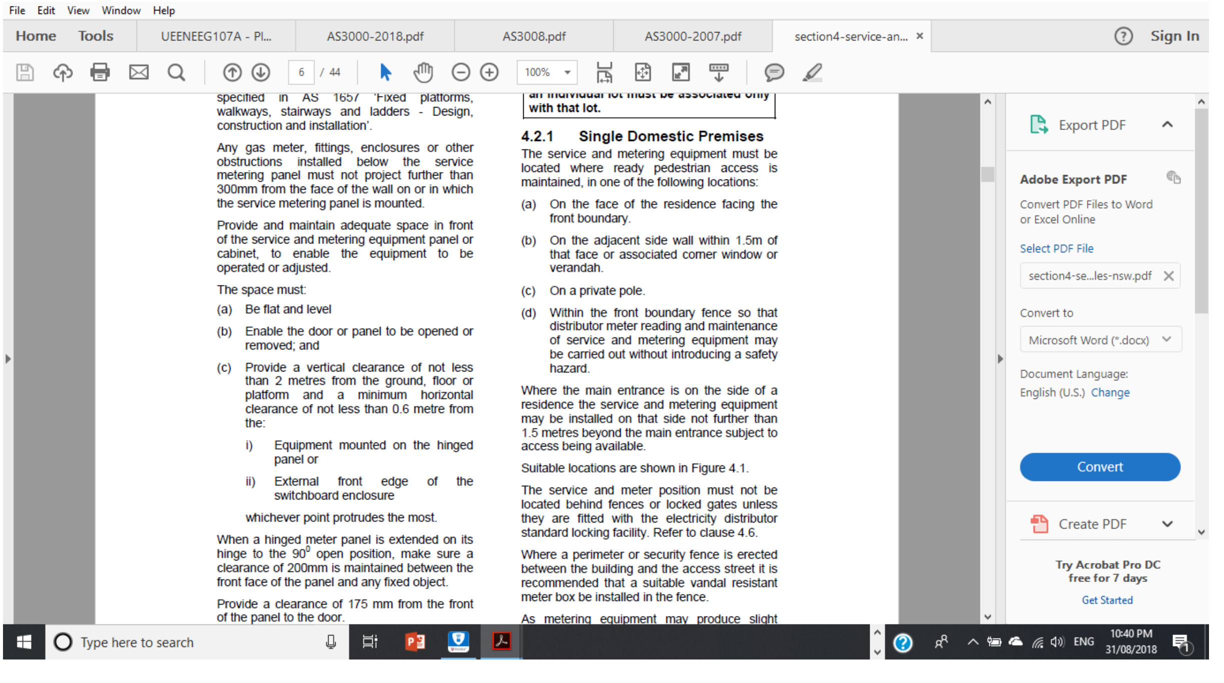
(a) On the face of the residence facing the front boundary.

(b) On the adjacent side wall within 1.5m of that face or associated corner window or verandah.

(c) On a private pole.

(d) Within the front boundary fence so that distributor meter reading and maintenance of service and metering equipment may be carried out without introducing a safety hazard.

Where the main entrance is on the side of a residence the service and metering equipment may be installed on that side not further than 1.5 metres beyond the main entrance subject to access being available.



specified in AS 1657 'Fixed platforms, walkways, stairways and ladders - Design, construction and installation'.

Any gas meter, fittings, enclosures or other obstructions installed below the service metering panel must not project further than 300mm from the face of the wall on or in which the service metering panel is mounted.

Provide and maintain adequate space in front of the service and metering equipment panel or cabinet, to enable the equipment to be operated or adjusted.

The space must:

(a) Be flat and level

(b) Enable the door or panel to be opened or removed; and

(c) Provide a vertical clearance of not less than 2 metres from the ground, floor or platform and a minimum horizontal clearance of not less than 0.6 metre from the:

i) Equipment mounted on the hinged panel or

ii) External front edge of the switchboard enclosure

whichever point protrudes the most.

When a hinged meter panel is extended on its hinge to the 90° open position, make sure a clearance of 200mm is maintained between the front face of the panel and any fixed object.

Provide a clearance of 175 mm from the front of the panel to the door.

with that lot.

4.2.1 Single Domestic Premises

The service and metering equipment must be located where ready pedestrian access is maintained, in one of the following locations:

(a) On the face of the residence facing the front boundary.

(b) On the adjacent side wall within 1.5m of that face or associated corner window or verandah.

(c) On a private pole.

(d) Within the front boundary fence so that distributor meter reading and maintenance of service and metering equipment may be carried out without introducing a safety hazard.

Where the main entrance is on the side of a residence the service and metering equipment may be installed on that side not further than 1.5 metres beyond the main entrance subject to access being available.

Suitable locations are shown in Figure 4.1.

The service and meter position must not be located behind fences or locked gates unless they are fitted with the electricity distributor standard locking facility. Refer to clause 4.6.

Where a perimeter or security fence is erected between the building and the access street it is recommended that a suitable vandal resistant meter box be installed in the fence.

As metering equipment may produce slight

4.3 UNSUITABLE LOCATIONS

Service and metering equipment must not be installed behind locked gates or doors unless they are fitted with the electricity distributor's locking systems.

In addition the following locations are considered unsuitable for mounting service and metering equipment:

(a) Over stairways or ramps, in narrow passageways, or in confined spaces.

(b) In vehicle docks, driveways, factory passageways where the equipment or a person working on it would not be effectively protected.

(c) In close proximity to, or over, machinery or open type switchgear.

(d) Locations which are liable to be affected by fumes, vibration, dampness, or dust, which may cause deterioration of equipment or unsatisfactory working conditions.

(e) In hazardous or prohibited switchboard locations as defined in the AS/NZS 3000.

(f) Where the normal ambient temperature exceeds 50°C.

(g) Where there is insufficient light.

(h) Where exposed to direct sunlight.

(i) Where the use of a ladder would be

(j) Where projections at head height are a hazard.

(k) In pool or spa areas.

(l) In carports, unless with the prior permission of the electricity distributor.

(m) On enclosed verandahs.

(n) In areas enclosing dogs.

(o) In areas to which access is normally restricted - for security, health or other reasons. (This would include areas in which animals are kept for security reasons).

(p) Behind a fence without a gate.

(q) Within gas emitting devices exclusion zone, refer to AS 5601.

(r) Within LPG cylinder minimum clearance to ignition sources refer to AS 5601.

(s) In fire isolated stairways, passageways or corridors.

(t) Where access is restricted by vegetation.

(u) On the electricity distributor's asset.

See AS/NZS 2430.3.4 'Classification of hazardous areas Part 3.4 - Examples of area classification - Flammable gases'.

Activity - 17 – Service Protective Devices

AS3000 clause 4.5.9

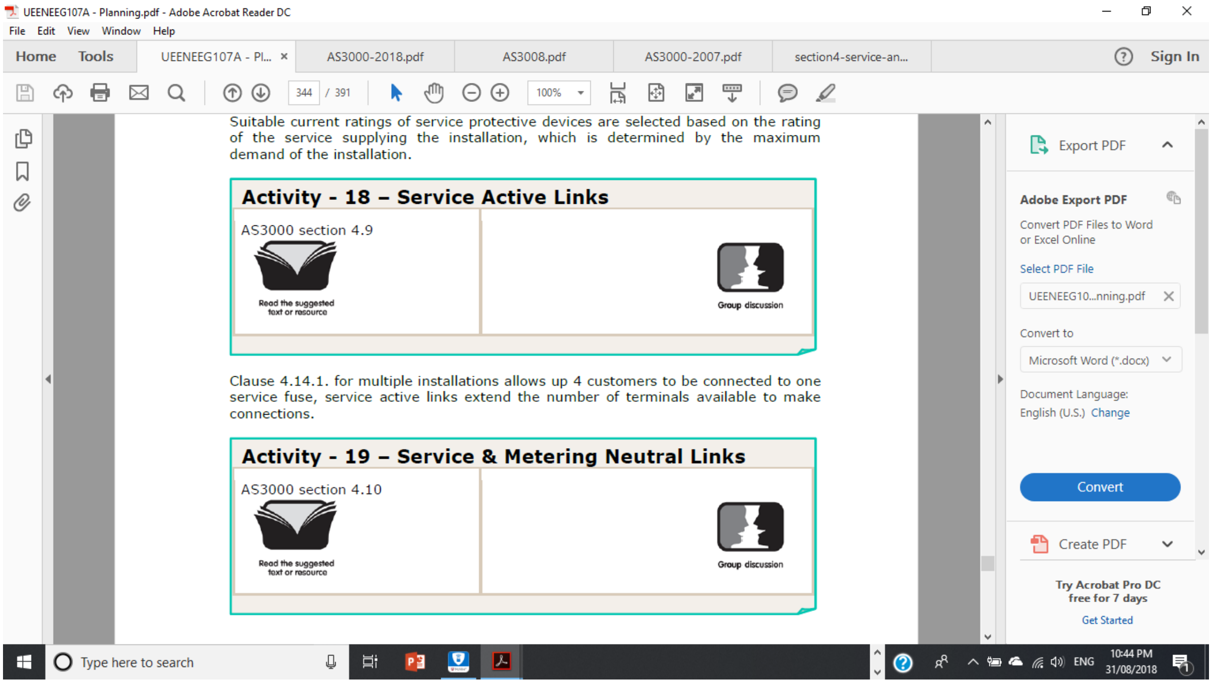
Read the suggested text or resource

Group discussion

Service Protective Devices (S.P.D.) are provided at the end of the consumers mains to provide

- Prospective short circuit current protection.
- An isolation point.
- Overload protection of whole current metering.

The current ratings of service protective devices are given in table 4.1 of the NSWSR. Suitable current ratings of service protective devices are selected based on the rating


Suitable current ratings of service protective devices are selected based on the rating of the service supplying the installation, which is determined by the maximum demand of the installation.

Activity - 18 – Service Active Links

AS3000 section 4.9

Read the suggested text or resource

Group discussion

Clause 4.14.1. for multiple installations allows up 4 customers to be connected to one service fuse, service active links extend the number of terminals available to make connections.

Activity - 19 – Service & Metering Neutral Links

AS3000 section 4.10

Read the suggested text or resource

Group discussion

4.9 ROOM HEATERS

4.9.1 General

Where a permanently connected room heater, or a number of permanently connected room heaters, are installed in one room, an individual isolating switch and an individual functional switch shall be provided for each room heater or for each group of room heaters.

Where a number of permanently connected room heaters are installed in one room and are supplied by the one final subcircuit, a single isolating switch may be used for the room heaters in that room.

4.9.2 Isolating switches

In accordance with Clause 2.3.2.2, isolating switches shall be—

(a) installed immediately adjacent to an entrance to, or within, the room where the room heater is located; or

(b) installed on the switchboard at which the room heater final subcircuit originates.

Isolating switches may be incorporated in temperature-control devices, provided that they have a definite 'OFF' position.

4.9.3 Functional switches

In accordance with Clause 2.3.7, functional switches shall be installed in a readily accessible position in the same room, or immediately adjacent to an entrance to the room, in which the room heater or room heaters are located.

A functional switch may be—

(a) an appliance switch or switches with an 'OFF' position incorporated within the room heater; or

(b) an isolating switch provided in accordance with Clause 4.9.2(a).

4.10 ELECTRIC HEATING CABLES FOR FLOORS AND CEILINGS AND TRACE HEATING APPLICATIONS

4.10.1 General

Cables for electric heating systems in floors and ceilings and trace heating applications shall be of a type specifically designed for the purpose. The heating equipment shall be installed in accordance with the manufacturer's instructions.

4.10.2 Heating cables

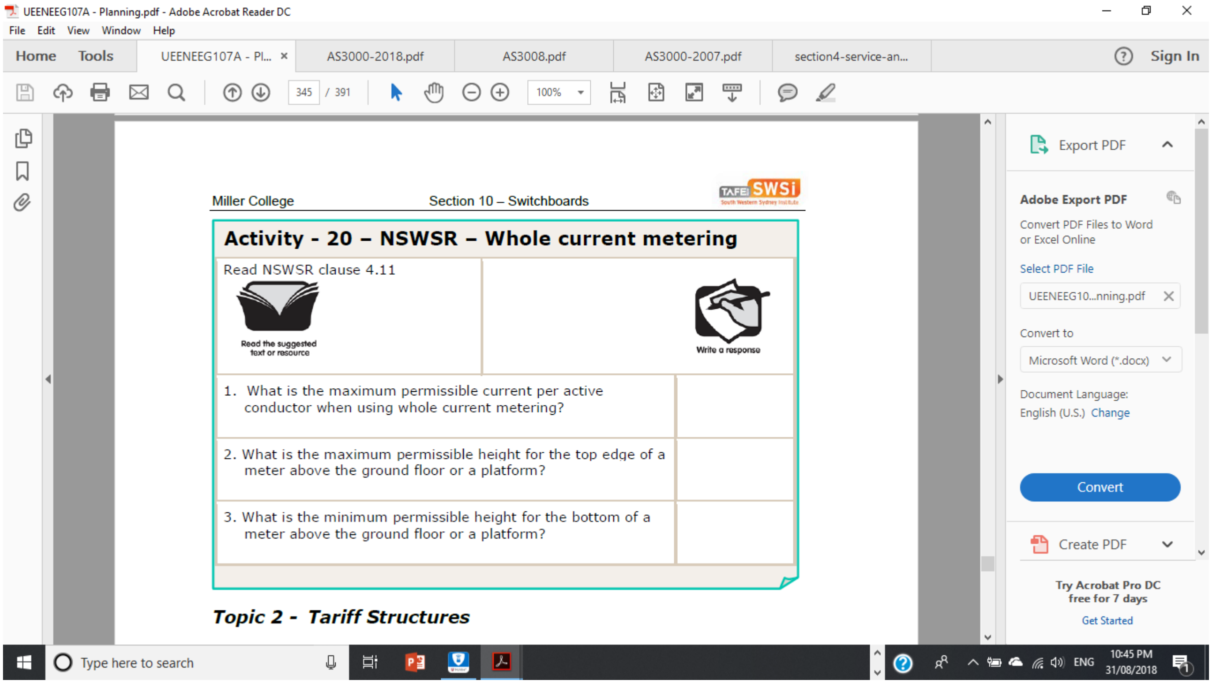
Heating cables shall be so installed that they are not in contact with flammable materials and where designed to be embedded—

(a) are completely and adequately embedded in the substance they are intended to heat; and

(b) do not suffer any detrimental effect because of flexing or movement of the substance in which they are embedded.

Alternatively, where designed as trace heating cables, heating cables shall provide adequate heat transfer to the surface or material to which they are fixed.

* In New Zealand only, in-floor and ceiling heating cables shall be installed in
accordance with NZS 6110.



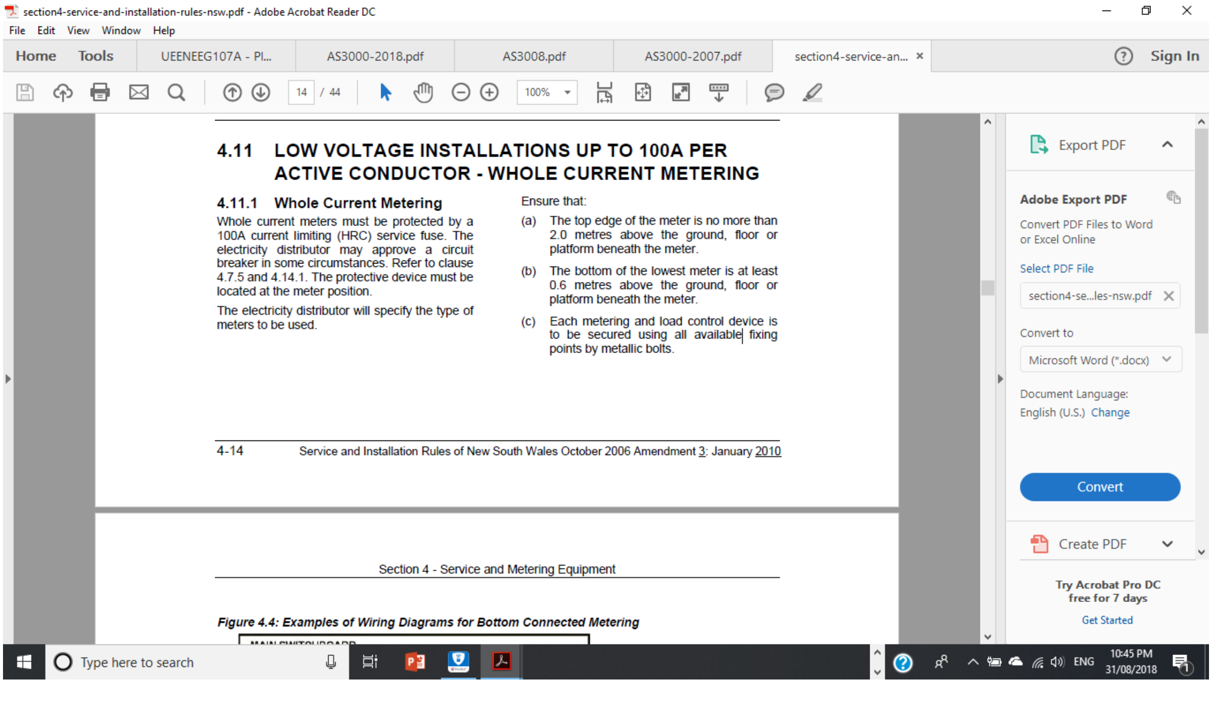
Miller College Section 10 – Switchboards

Activity - 20 – NSWSR – Whole current metering

Read NSWSR clause 4.11

1. What is the maximum permissible current per active conductor when using whole current metering?	
2. What is the maximum permissible height for the top edge of a meter above the ground floor or a platform?	
3. What is the minimum permissible height for the bottom of a meter above the ground floor or a platform?	

Topic 2 - Tariff Structures



4.11 LOW VOLTAGE INSTALLATIONS UP TO 100A PER ACTIVE CONDUCTOR - WHOLE CURRENT METERING

4.11.1 Whole Current Metering

Whole current meters must be protected by a 100A current limiting (HRC) service fuse. The electricity distributor may approve a circuit breaker in some circumstances. Refer to clause 4.7.5 and 4.14.1. The protective device must be located at the meter position.

The electricity distributor will specify the type of meters to be used.

Ensure that:

(a) The top edge of the meter is no more than 2.0 metres above the ground, floor or platform beneath the meter.

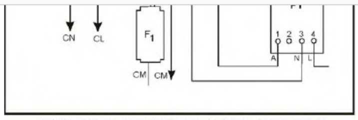
(b) The bottom of the lowest meter is at least 0.6 metres above the ground, floor or platform beneath the meter.

(c) Each metering and load control device is to be secured using all available fixing points by metallic bolts.

4-14 Service and Installation Rules of New South Wales October 2006 Amendment 3: January 2010

Section 4 - Service and Metering Equipment

Figure 4.4: Examples of Wiring Diagrams for Bottom Connected Metering



EXAMPLE SINGLE PHASE AND OFF-PEAK INSTALLATION BOTTOM CONNECTED DEVICES

4.11.2 Bottom Connected Meters

For bottom connected meters, the contractor must:

(a) Pre drill the meter panel, as per the electricity distributor's drilling templates.

(b) Provide the necessary cables in position.

(c) Leave a free length of 75mm through the pre-drilled holes.

(d) Remove 20mm of insulation from the end of the cable so it is ready for connection.

Where bottom connected metering exists, any additional meter/control equipment will also be bottom connected.

Note: Care should be taken when stripping the cable to ensure the conductor strands are not damaged.

An example layout of bottom connected metering equipment and associated service equipment is shown in Figure 4.5.

Note: 1. The Service Neutral link may be mounted in any suitable location either on the front as shown or on the rear of a hinged panel.

2. All equipment must be mounted no closer than 32mm from the hinged edge of the panel.

4.11.3 Load Control Equipment

Where electricity is to be supplied only during certain hours in accordance with the provisions of a published tariff, the electricity distributor may require the customer to provide and install a single pole load control device to directly control the load supplied under that tariff.

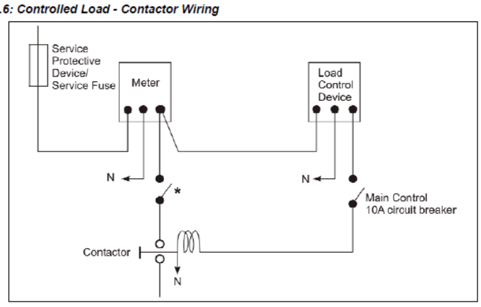
The electricity distributor will either provide or specify the type of load control device to be used.

Unless approved by the electricity distributor, controlled load must not exceed 25A single phase. Where the load exceeds 25A single phase or is inductive, the customer must provide, install and wire a contactor so that it is operated by the load control device. The contactor must be a non-latching type with provision for sealing and be installed at the metering position.

The contactor control circuit must be controlled and protected by a 10A circuit breaker which must be sealable. Refer to Figure 4.6. The neutral conductor for the contactor coil must be terminated in the service neutral link.

Other methods may be acceptable, apply to the electricity distributor.

Figure 4.6: Controlled Load - Contactor Wiring

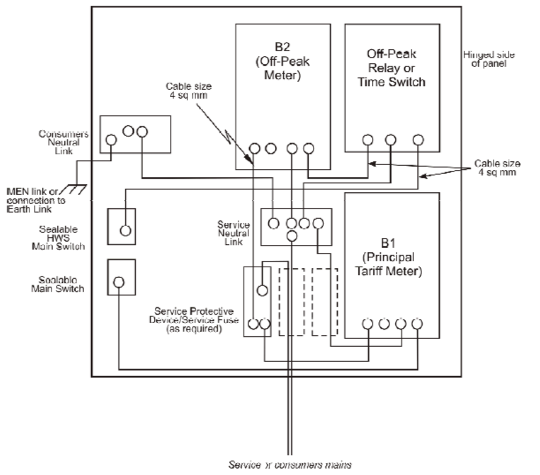


Note:

1. The customer is required to install a contactor and associated wiring where the controlled load exceeds 25A or involves the switching of more than one phase of supply.
2. The contactor must be located at the meter position with a switch controlling the contactor coil.
3. The circuit breaker and contactor covers are to be sealable.
4. Single phase shown for clarity.

* An alternate location for the main switch may be on the load side of the contactor.

Example shown is for a single phase customer with Off Peak



Note: 1. The Service Neutral link may be mounted in any suitable location either on the front as shown or on

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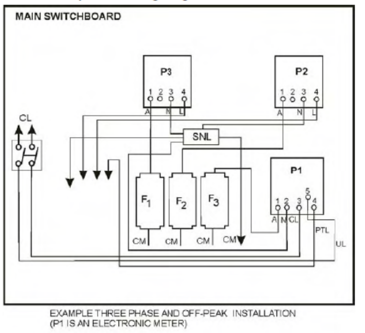
Figure 4.4: Examples of Wiring Diagrams for Bottom Connected Metering



EXAMPLE THREE PHASE AND OFF-PEAK INSTALLATION
(P1 IS AN ELECTRONIC METER)

LEGEND

A	Active terminal
C	Load-control device
F	Service Protective Device
L	Load terminal
M	Meter
MC	Controlled load meter
N	Neutral terminal
SNL	Service neutral link on back of panel
P	Positions
PTL	Principal Tariff Load
P1	First position used in each layout
CL	Connection to controlled-load main switch or contactor
CM	consumers mains/underground service mains
UL	Uncontrolled Load

Note:
1. Panels hinged on the right hand side

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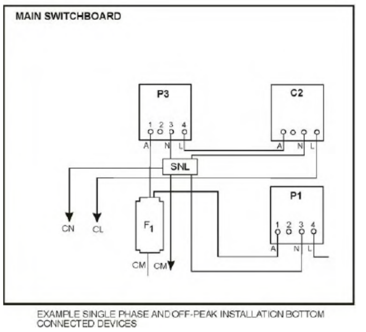
EXAMPLE THREE PHASE AND OFF-PEAK INSTALLATION
(P1 IS AN ELECTRONIC METER)
CL Connection to controlled-load main switch or contactor
CM consumers mains/underground service mains
UL Uncontrolled Load
Note:
1. Panels hinged on the right hand side

2. The diagram indicates the line side as the bottom of the service protective device, therefore they must be labelled 'LINE SIDE' refer clause 4.7.6



EXAMPLE SINGLE PHASE AND OFF-PEAK INSTALLATION BOTTOM CONNECTED DEVICES

4.11.2 Bottom Connected Meters

For bottom connected meters, the contractor must:

Where bottom connected metering exists, any additional meter/control equipment will also be bottom connected.

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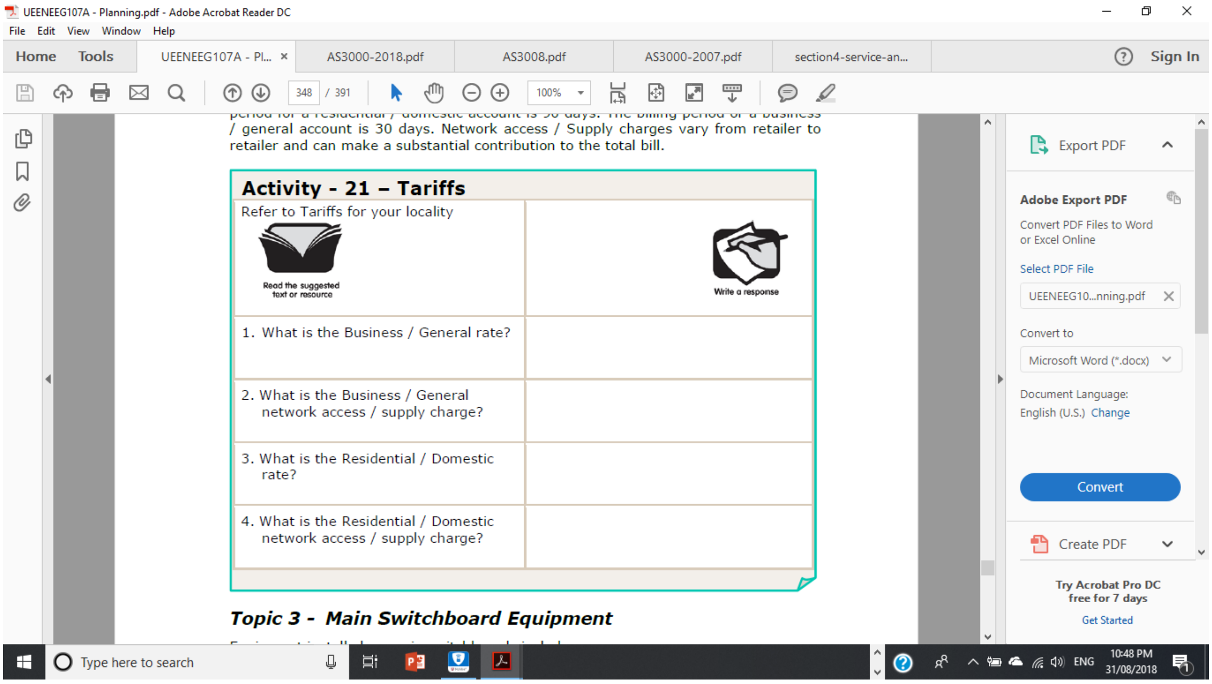


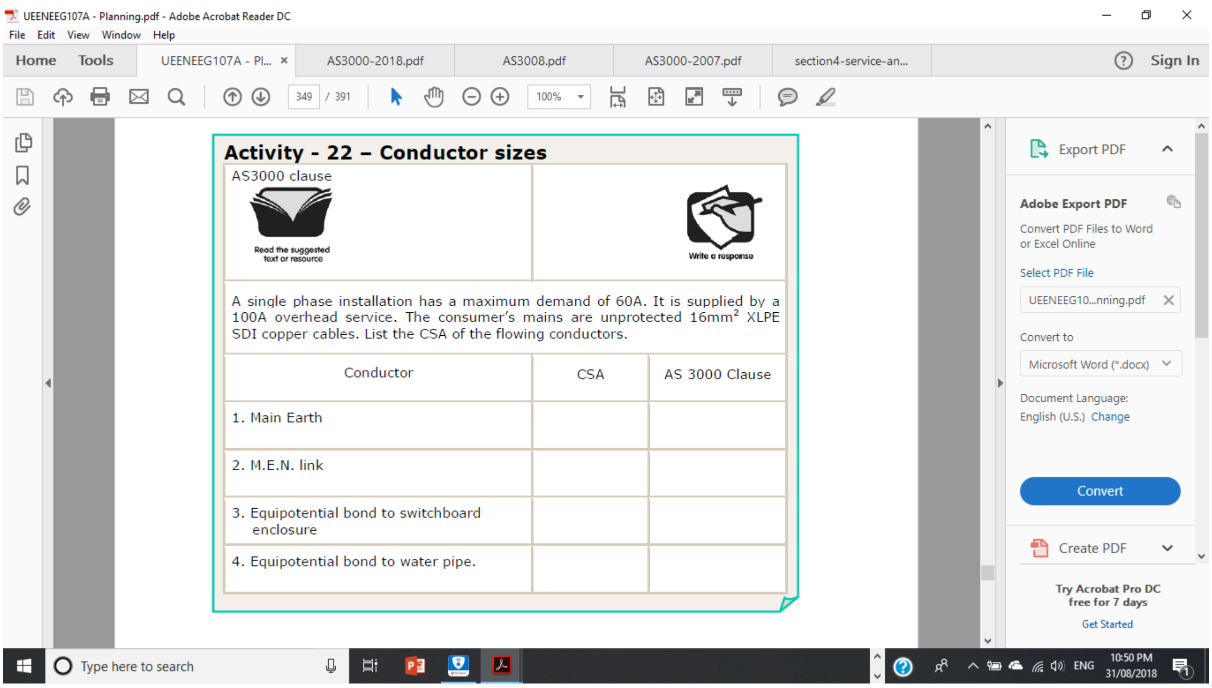
/ general account is 30 days. Network access / Supply charges vary from retailer to retailer and can make a substantial contribution to the total bill.

Activity - 21 – Tariffs

Refer to Tariffs for your locality Read the suggested text or resource	Write a response
1. What is the Business / General rate?	
2. What is the Business / General network access / supply charge?	
3. What is the Residential / Domestic rate?	
4. What is the Residential / Domestic network access / supply charge?	

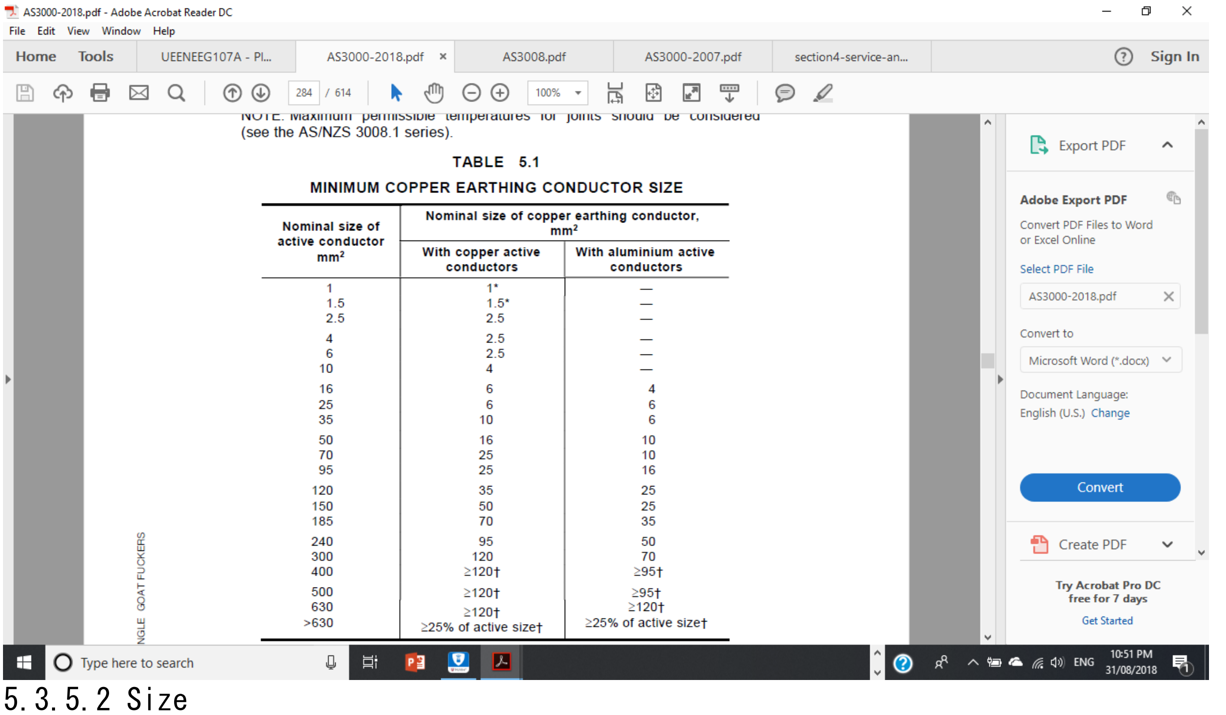
Topic 3 - Main Switchboard Equipment

There are **usage** charges and supply charges. **Usage** charges: These charges reflect the cost of electricity a property has used. A property is charged for each Kilowatt Hour (kWh) of electricity consumed, with **costs** varying anywhere from 10c to 55c depending on the tariff, retailer and **network**.



Activity - 22 – Conductor sizes

AS3000 clause Read the suggested text or resource	Write a response	
A single phase installation has a maximum demand of 60A. It is supplied by a 100A overhead service. The consumer's mains are unprotected 16mm² XLPE SDI copper cables. List the CSA of the flowing conductors.		
Conductor	CSA	AS 3000 Clause
1. Main Earth		
2. M.E.N. link		
3. Equipotential bond to switchboard enclosure		
4. Equipotential bond to water pipe.		



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†

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.

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.

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.

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 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 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

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Activity - 23 – Conductor sizes

AS3000 clause

Read the suggested text or resource

Write a response

A three phase installation has a maximum demand of 320A. It is supplied by a 400A underground service. The consumer's mains are protected $240mm^2$ XLPE 4 core aluminium cables. List the CSA of the flowing conductors.

Conductor	CSA	AS 3000 Clause
1. Main Earth		
2. M.E.N. link		
3. Equipotential bond to switchboard enclosure		
4. Equipotential bond to water pipe.		

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3. Equipotential bond to switchboard enclosure		
4. Equipotential bond to water pipe.		

Topic 4 - Layout Diagrams for Whole Current Metering

Activity - 24 – Whole Current Metering Layouts

NSWSR Figures 4.4 to 4.6

Read the suggested text or resource

Group discussion

section4-service-and-installation-rules-nsw.pdf - Adobe Acrobat Reader DC

(f) Where the normal ambient temperature exceeds 50°C.

(g) Where there is insufficient light.

(h) Where exposed to direct sunlight.

(i) Where the use of a ladder would be necessary.

(t) Where access is restricted by vegetation.

(u) On the electricity distributor's asset.

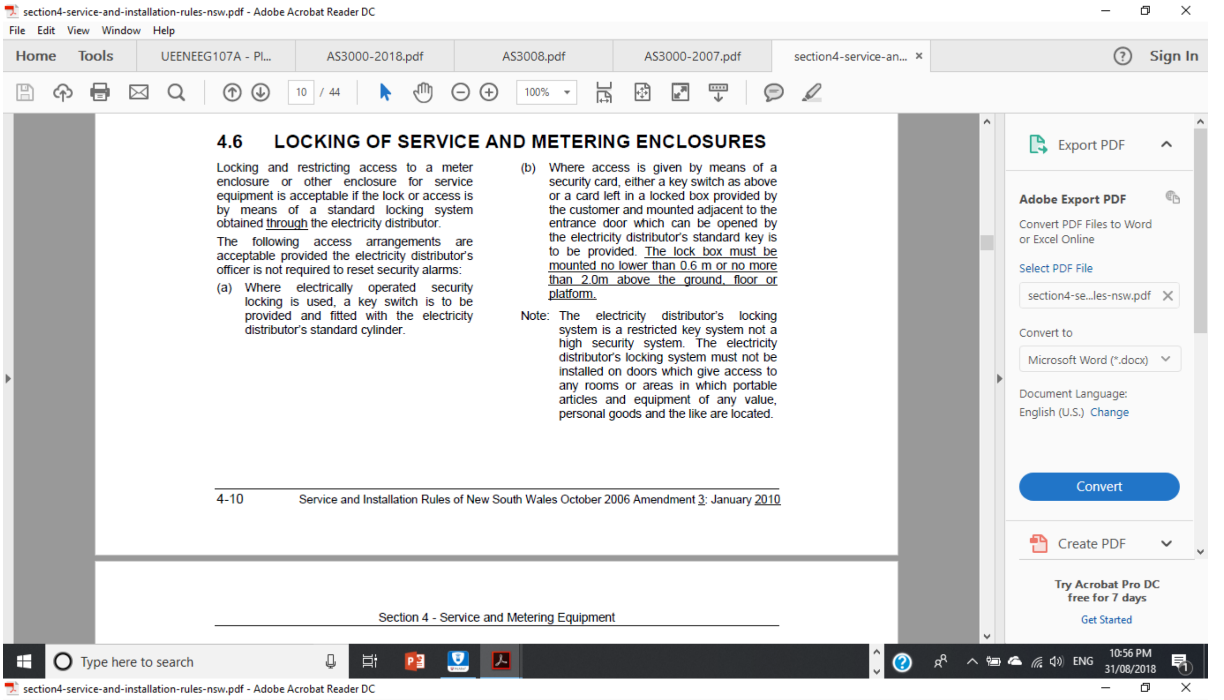
See AS/NZS 2430.3.4 'Classification of hazardous areas Part 3.4 - Examples of area classification - Flammable gases'.

4.4 HAZARDS OF EXISTING METER AND SWITCHBOARD PANELS THAT MAY CONTAIN ASBESTOS

Accredited Service Providers and electrical contractors should not carry out work that disturbs the integrity (eg drilling) of existing meter or switchboard panels that may contain asbestos, within electrical installations, without taking suitable precautions. Information in this regard is available from the WorkCover website (www.workcover.nsw.gov.au) which lists relevant industry safety guidelines and model procedures.

WARNING - ASBESTOS

Historically, asbestos has been used in switchboard panels used in electrical installations. All electrical personnel who work on switchboard panels need to identify if this hazard may be present, and if necessary adopt approved industry procedures, when working with switchboard panels.



4.6 LOCKING OF SERVICE AND METERING ENCLOSURES

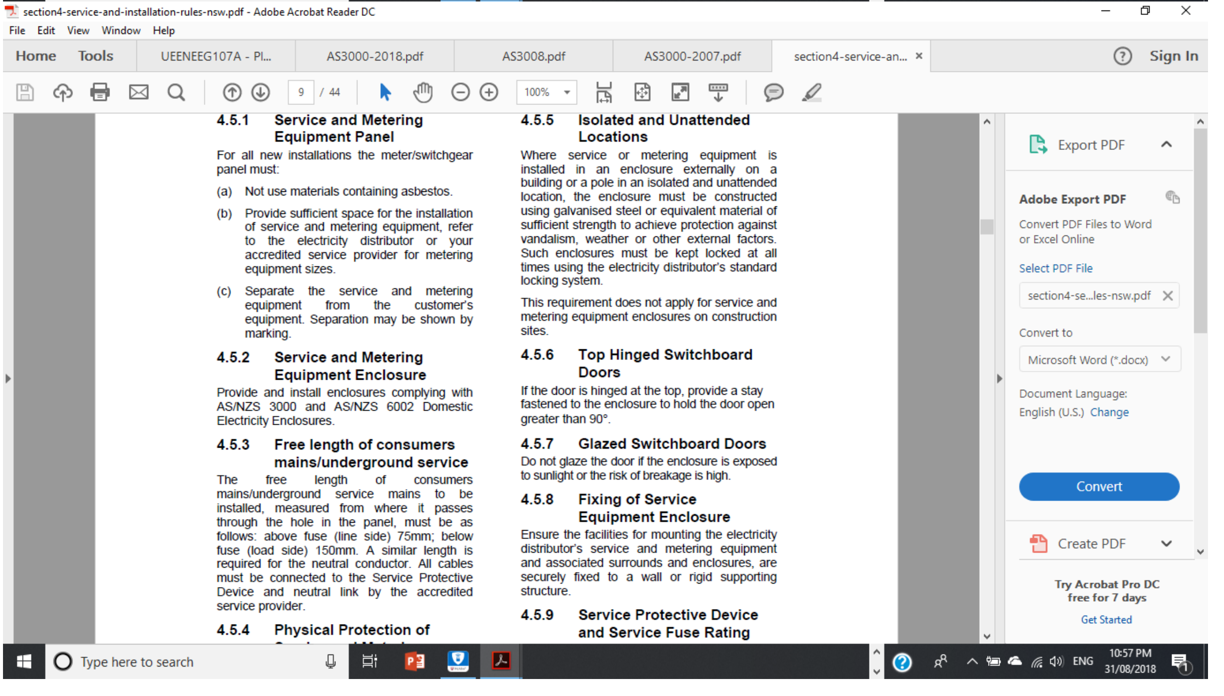
Locking and restricting access to a meter enclosure or other enclosure for service equipment is acceptable if the lock or access is by means of a standard locking system obtained through the electricity distributor.

The following access arrangements are acceptable provided the electricity distributor's officer is not required to reset security alarms:

(a) Where electrically operated security locking is used, a key switch is to be provided and fitted with the electricity distributor's standard cylinder.

(b) Where access is given by means of a security card, either a key switch as above or a card left in a locked box provided by the customer and mounted adjacent to the entrance door which can be opened by the electricity distributor's standard key is to be provided. The lock box must be mounted no lower than 0.6 m or no more than 2.0m above the ground, floor or platform.

Note: The electricity distributor's locking system is a restricted key system not a high security system. The electricity distributor's locking system must not be installed on doors which give access to any rooms or areas in which portable articles and equipment of any value, personal goods and the like are located.



4.5.1 Service and Metering Equipment Panel

For all new installations the meter/switchgear panel must:

(a) Not use materials containing asbestos.

(b) Provide sufficient space for the installation of service and metering equipment, refer to the electricity distributor or your accredited service provider for metering equipment sizes.

(c) Separate the service and metering equipment from the customer's equipment. Separation may be shown by marking.

4.5.2 Service and Metering Equipment Enclosure

Provide and install enclosures complying with AS/NZS 3000 and AS/NZS 6002 Domestic Electricity Enclosures.

4.5.3 Free length of consumers mains/underground service

The free length of consumers mains/underground service mains to be installed, measured from where it passes through the hole in the panel, must be as follows: above fuse (line side) 75mm; below fuse (load side) 150mm. A similar length is required for the neutral conductor. All cables must be connected to the Service Protective Device and neutral link by the accredited service provider.

4.5.4 Physical Protection of

4.5.5 Isolated and Unattended Locations

Where service or metering equipment is installed in an enclosure externally on a building or a pole in an isolated and unattended location, the enclosure must be constructed using galvanised steel or equivalent material of sufficient strength to achieve protection against vandalism, weather or other external factors. Such enclosures must be kept locked at all times using the electricity distributor's standard locking system.

This requirement does not apply for service and metering equipment enclosures on construction sites.

4.5.6 Top Hinged Switchboard Doors

If the door is hinged at the top, provide a stay fastened to the enclosure to hold the door open greater than 90°.

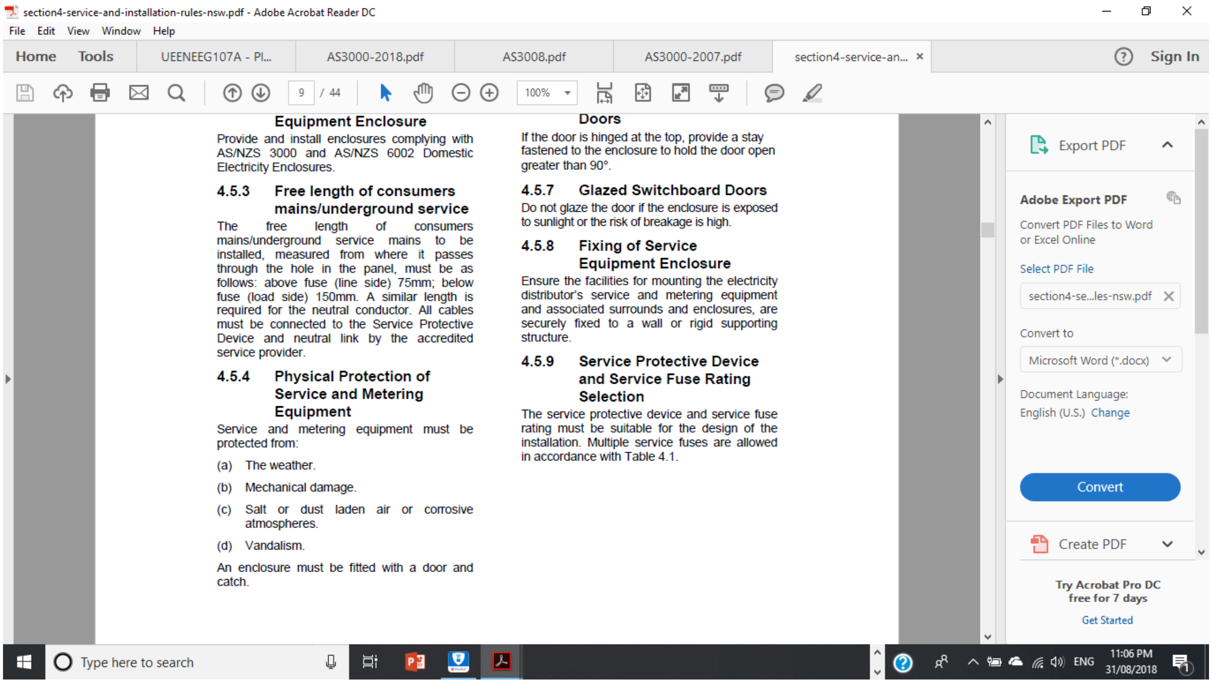
4.5.7 Glazed Switchboard Doors

Do not glaze the door if the enclosure is exposed to sunlight or the risk of breakage is high.

4.5.8 Fixing of Service Equipment Enclosure

Ensure the facilities for mounting the electricity distributor's service and metering equipment and associated surrounds and enclosures, are securely fixed to a wall or rigid supporting structure.

4.5.9 Service Protective Device and Service Fuse Rating



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Equipment Enclosure

Provide and install enclosures complying with AS/NZS 3000 and AS/NZS 6002 Domestic Electricity Enclosures.

4.5.3 Free length of consumers mains/underground service

The free length of consumers mains/underground service mains to be installed, measured from where it passes through the hole in the panel, must be as follows: above fuse (line side) 75mm; below fuse (load side) 150mm. A similar length is required for the neutral conductor. All cables must be connected to the Service Protective Device and neutral link by the accredited service provider.

4.5.4 Physical Protection of Service and Metering Equipment

Service and metering equipment must be protected from:

(a) The weather.

(b) Mechanical damage.

(c) Salt or dust laden air or corrosive atmospheres.

(d) Vandalism.

An enclosure must be fitted with a door and catch.

Doors

If the door is hinged at the top, provide a stay fastened to the enclosure to hold the door open greater than 90°.

4.5.7 Glazed Switchboard Doors

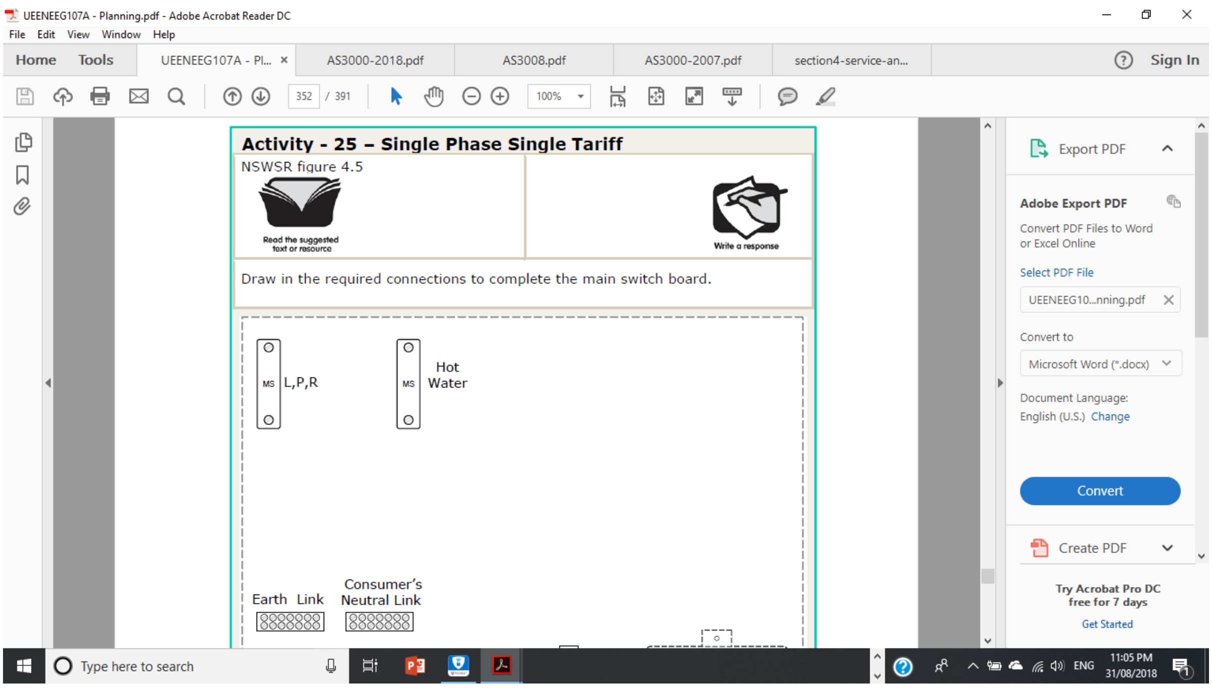
Do not glaze the door if the enclosure is exposed to sunlight or the risk of breakage is high.

4.5.8 Fixing of Service Equipment Enclosure

Ensure the facilities for mounting the electricity distributor's service and metering equipment and associated surrounds and enclosures, are securely fixed to a wall or rigid supporting structure.

4.5.9 Service Protective Device and Service Fuse Rating Selection

The service protective device and service fuse rating must be suitable for the design of the installation. Multiple service fuses are allowed in accordance with Table 4.1.



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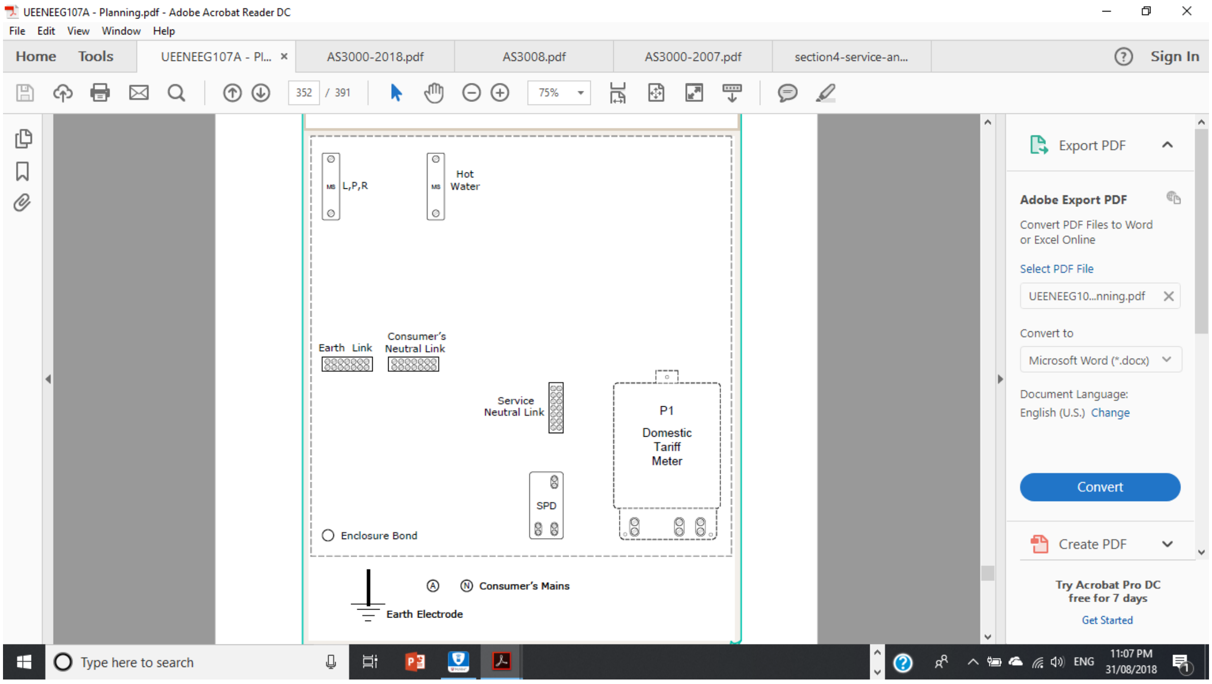
Activity - 25 – Single Phase Single Tariff

NSWSR figure 4.5

Draw in the required connections to complete the main switch board.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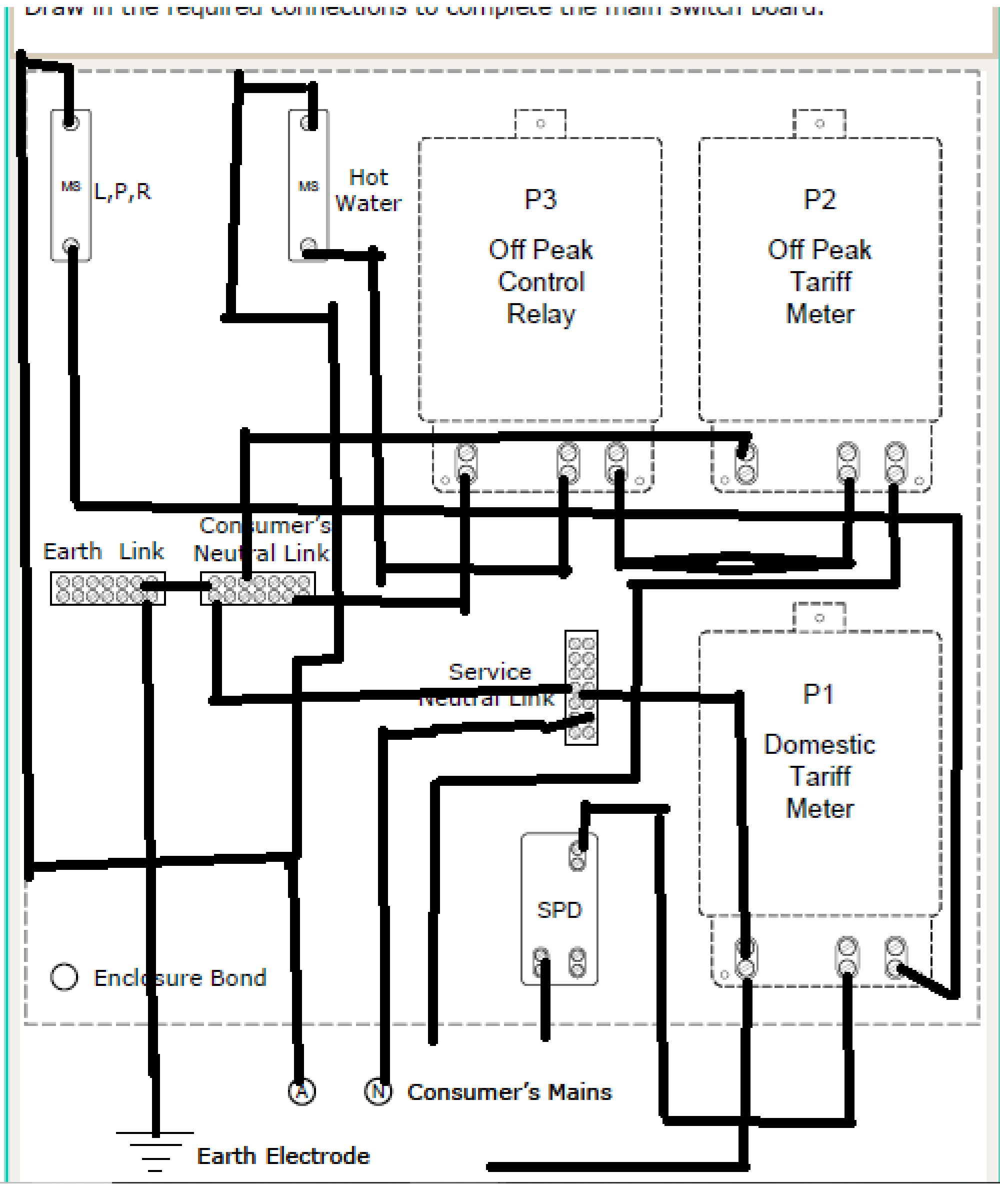
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MS
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P3
Off Peak Control Relay
P2
Off Peak Tariff Meter
Earth Link
Consumer's Neutral Link
Service Neutral Link
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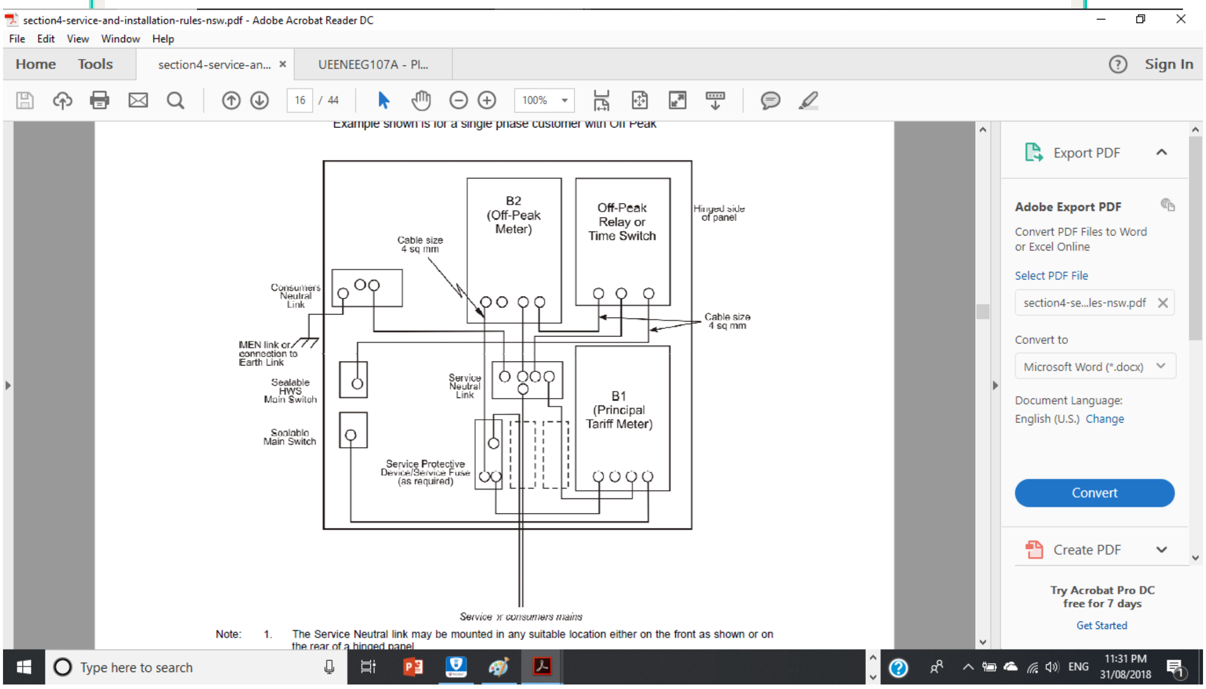
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Example shown is for a single phase customer with Off Peak
B2 (Off-Peak Meter)
Off-Peak Relay or Time Switch
Hinged side of panel
Cable size 4 sq mm
Consumers Neutral Link
MEN link or connection to Earth Link
Sealable HWS Main Switch
Sealable Main Switch
Service Neutral Link
Service Protective Device/Service Fuse (as required)
B1 (Principal Tariff Meter)
Service & consumers mains
Note: 1. The Service Neutral link may be mounted in any suitable location either on the front as shown or on the rear of a hinged panel
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Tutorial 10 – Switchboards Miller College

Activity - 27 – Three Phase Single Tariff E1 Meters

NSWSR figure 4.4

Read the suggested text or resource

Write a response

Draw in the required connections to complete the main switch board.

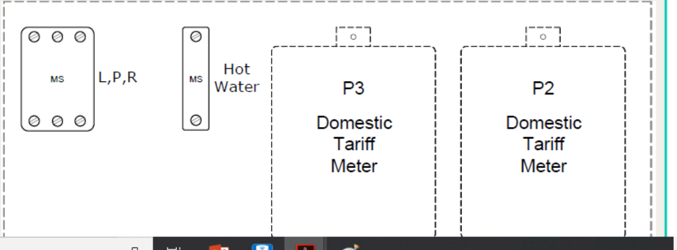
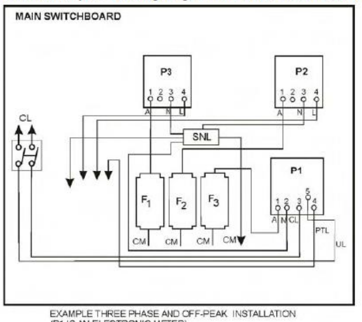


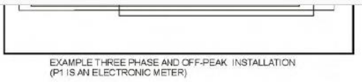
Figure 4.4: Examples of Wiring Diagrams for Bottom Connected Metering



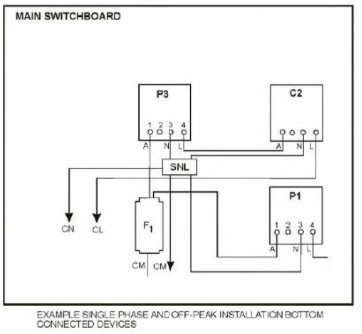
EXAMPLE THREE PHASE AND OFF-PEAK INSTALLATION (P1 IS AN ELECTRONIC METER)

LEGEND

A	Active terminal
C	Load-control device
F	Service Protective Device
L	Load terminal
M	Meter
MC	Controlled load meter
N	Neutral terminal
SNL	Service neutral link on back of panel
P	Positions
PTL	Principal Tariff Load
P1	First position used in each layout
CL	Connection to controlled-load main switch or contactor
CM	consumers mains/underground service mains
UL	Uncontrolled Load



EXAMPLE THREE PHASE AND OFF-PEAK INSTALLATION (P1 IS AN ELECTRONIC METER)



EXAMPLE SINGLE PHASE AND OFF-PEAK INSTALLATION BOTTOM CONNECTED DEVICES

Note:

1. Panels hinged on the right hand side
2. The diagram indicates the line side as the bottom of the service protective device, therefore they must be labelled 'LINE SIDE' refer clause 4.7.6

4.11.2 Bottom Connected Meters

For bottom connected meters, the contractor must:

Where bottom connected metering exists, any additional meter/control equipment will also be bottom connected.

Note: Care should be taken when stripping the

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figure 6.

Figure 6 shows single phase single tariff multiple domestic installation, only one phase is show to keep the drawing simple.

Switchboards for multiple domestic installations are usually constructed on banks of 600 x 600 mm hinged or fixed standard panels. Alternately custom built switchboards can be installed. Distribution boards in each unit are usually self contained load centres.

Activity - 27 – C.T. Metering Layouts

NSWSR Section 4.17	
Read the suggested text or resource	Group discussion

section4-service-and-installation-rules-nsw.pdf - Adobe Acrobat Reader DC

4.17 LV INSTALLATION IN EXCESS OF 100A PER PHASE - LV CURRENT TRANSFORMER METERING

Where the assessed load of an installation or portion of an installation to be separately metered exceeds 100A per phase the electricity distributor will require that the meter be a current transformer (CT) type

The customer must provide the facilities for the mounting and connection of the current transformers, meters and associated equipment in accordance with these Rules.

The customer is responsible for the provision and installation of:

(a) All equipment mounting facilities.

(b) Meter panels pre-drilled and installed.

(c) Voltage circuit fuses (10A current limiting (HRC)) suitable for sealing.

(d) Meter links - used for metering purposes where the service neutral link cannot accommodate all the neutral cables associated with metering.

(e) All cabling to the specified identification code fully connected to the equipment.

(f) The CTs.

(g) The meter test block - used to allow in circuit testing of CT metering systems.

(h) The meters and their connection.

The electricity distributor will specify:

(a) The type of CTs.

principles of this document be applied to these switchboards.

4.17.2 Prospective Short Circuit Current

Clause 1.10.4 of these Rules states that the electrical installation must be capable of withstanding, without damage, the nominated prospective short circuit current.

Switchboards and equipment rated greater than 400A must be rated for the nominal prospective short circuit current for 1 second. The electricity distributor will provide values not specified in these Rules upon application.

4.17.3 Protection Grading

Select and arrange your main circuit breakers or fuses so that they will interrupt the fault current in the event of a fault on the portion of the installation they protect. They must interrupt the fault current rapidly enough to ensure that the electricity distributor's protection devices do not operate.

The electricity distributor will provide information on the characteristics of the electricity distributor's protection equipment.

WARNING

Where a single customer is supplied direct from a substation the electricity distributor generally protects its equipment by the

section4-service-and-installation-rules-nsw.pdf - Adobe Acrobat Reader DC

(h) The meters and their connection.

The electricity distributor will specify:

(a) The type of CTs.

(b) The meter test block.

(c) The meter equipment to be provided.

4.17.1 Submission of Design

The customer must submit full details of the proposed installation for examination before the relevant work proceeds to prevent possible delays in the connection of electricity.

The submission must include:

(a) The proposed load details.

(b) The design of the CT enclosure.

(c) A single line schematic diagram.

(d) Power Factor correction **where applicable**.

The electricity distributor will not normally comment on the design of an electrical installation unless a fee is paid by the customer. Check with the electricity distributor.

The design will be assessed for tariff and metering requirements.

Note: Not all of the requirements of this section apply to low voltage switchboards installed in installations supplied and metered at high voltage. However, it is recommended that the

WARNING

Where a single customer is supplied direct from a substation the electricity distributor generally protects its equipment by the installation of a circuit breaker or fuse in each out going LV circuit.

Unless the customer's protective devices are correctly selected to discriminate with the electricity distributor's device, a fault within the electrical installation may cause the device to operate.

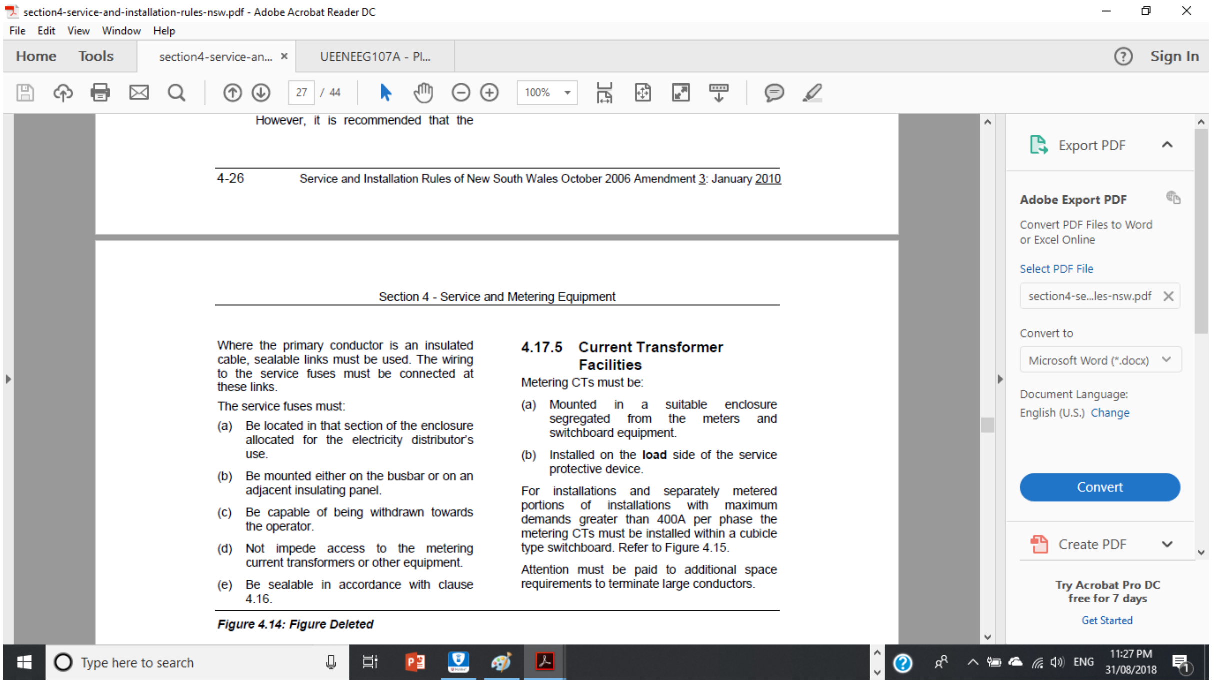
The implications of this are as follows:

Supply to smoke and fire control and emergency evacuation equipment and lifts may be interrupted. It is common for such faults to occur during fires when the need for emergency supply is paramount.

Resetting of 'tripped' equipment can only be carried out by the electricity distributor's specialised staff and this may cause considerable delay to the reconnection of supply. It may also incur a charge.

4.17.4 Whole Current Metering

Where it is necessary to meter other sections of the premises using whole current meters, the take-off connection point to the service fuses must be on the line side of the CT metering. It is not permitted to have the connection point on the load side of a CT and pass cables through the CT in the reverse direction.



However, it is recommended that the

Where the primary conductor is an insulated cable, sealable links must be used. The wiring to the service fuses must be connected at these links.

The service fuses must:

(a) Be located in that section of the enclosure allocated for the electricity distributor's use.

(b) Be mounted either on the busbar or on an adjacent insulating panel.

(c) Be capable of being withdrawn towards the operator.

(d) Not impede access to the metering current transformers or other equipment.

(e) Be sealable in accordance with clause 4.16.

4.17.5 Current Transformer Facilities

Metering CTs must be:

(a) Mounted in a suitable enclosure segregated from the meters and switchboard equipment.

(b) Installed on the **load** side of the service protective device.

For installations and separately metered portions of installations with maximum demands greater than 400A per phase the metering CTs must be installed within a cubicle type switchboard. Refer to Figure 4.15.

Attention must be paid to additional space requirements to terminate large conductors.

Figure 4.14: Figure Deleted

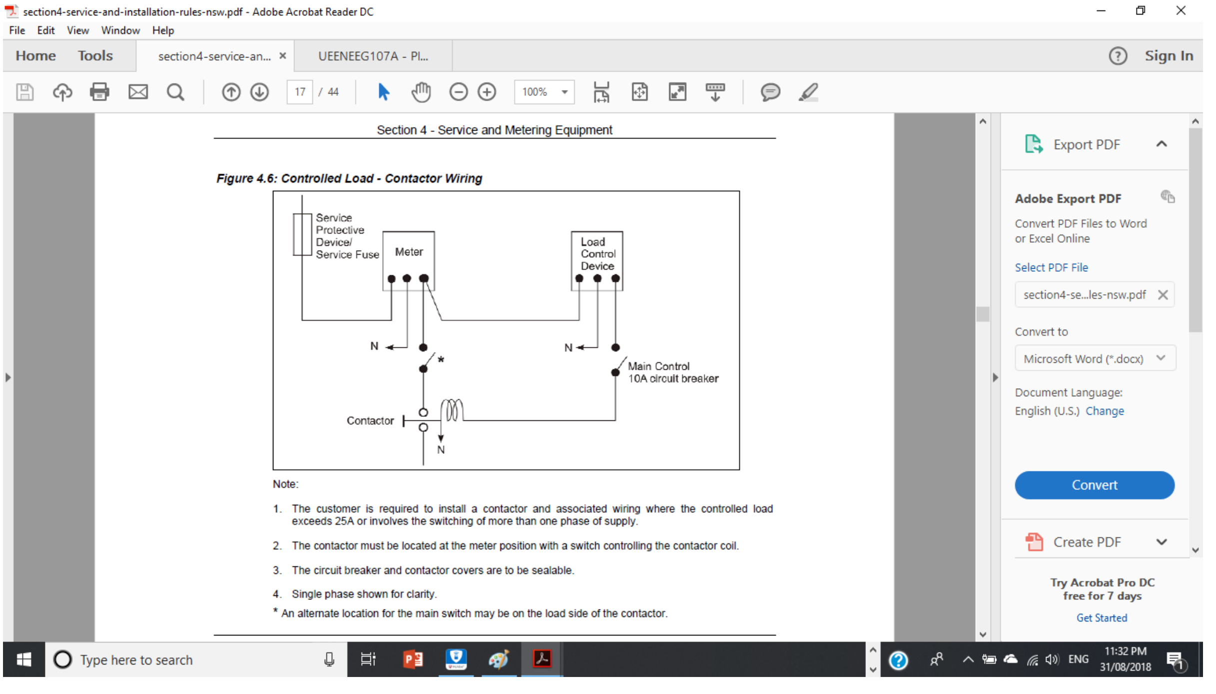
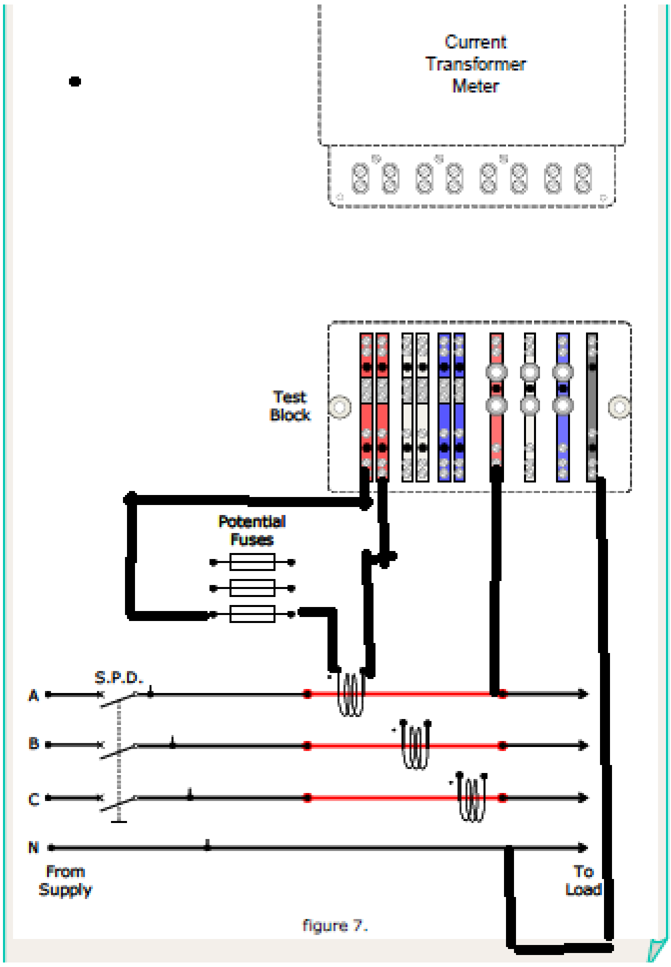


Figure 4.6: Controlled Load - Contactor Wiring

Note:

1. The customer is required to install a contactor and associated wiring where the controlled load exceeds 25A or involves the switching of more than one phase of supply.
2. The contactor must be located at the meter position with a switch controlling the contactor coil.
3. The circuit breaker and contactor covers are to be sealable.
4. Single phase shown for clarity.

* An alternate location for the main switch may be on the load side of the contactor.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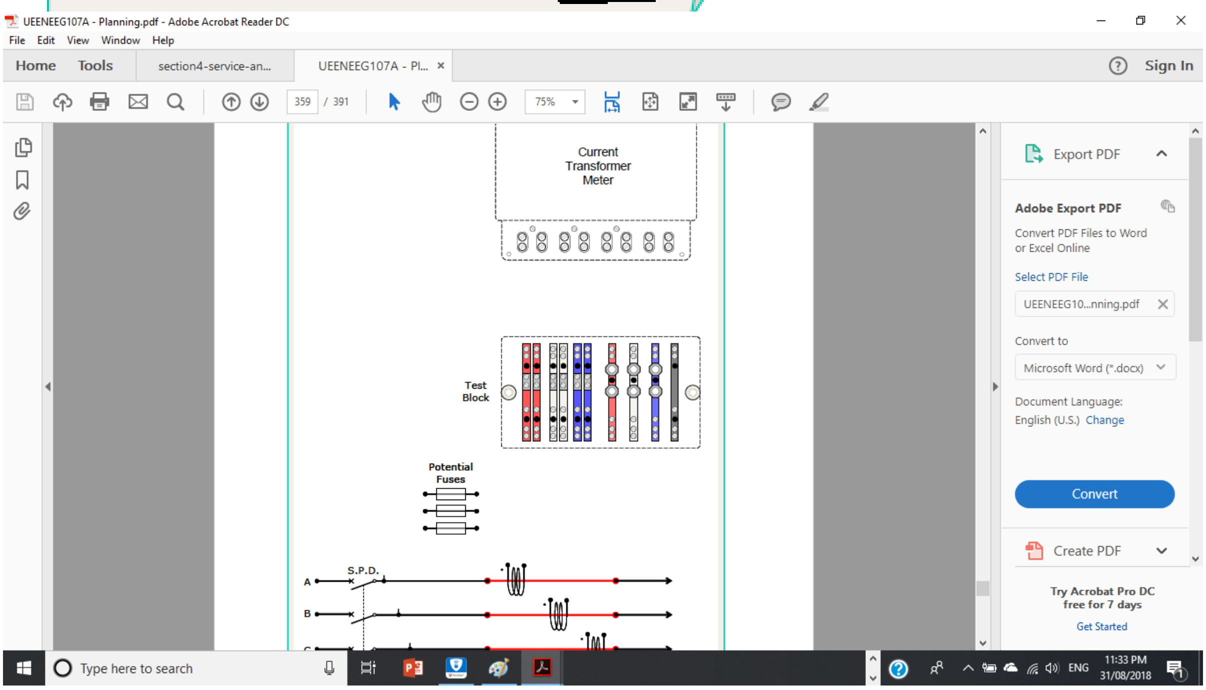
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4.17.6 CT Enclosure - Construction

The CT enclosure when forming part of a cubicle switchboard must be constructed so that a tool or article accidentally dropped by a person working on the connections cannot fall from the CT compartment into other areas of the switchboard.

CTs should be segregated from other equipment. No part of the electrical installation, including any measuring instruments and control devices, is permitted within the CT enclosure, except the customer's measurement current transformers.

Do not mount the customer measurement transformers on the removable section of the busbar provided for the metering transformers or impede access thereto.

For other situations apply to the electricity distributor.

These requirements also apply to the unmetered sections of a cubicle type switchboard.

All live conductors within 300mm of the secondary terminals, voltage circuit fuses and metering neutral link must be insulated or screened to prevent inadvertent contact. Convenient access is required for removal of CTs. These requirements may be met by the provision of a removable screen of light insulating material with openings shaped to fit over the CT secondary terminals and associated wiring. The secondary terminals, voltage-circuit fuses and metering neutral link must be accessible without removal of the screen. Where a screen is used it must be fitted with two insulated handles and be secured to the switchboard.

4.17.7 Vermin Proofing

All entries to the CT compartments/enclosures should be fitted with suitable gland plates, barriers etc, to prevent pests from entering.

4.17.8 Doors and Access Cover

Provide doors and access covers that are easy and safe to open or remove. If they are hinged, they must be capable of opening to 90° minimum.

Access covers must not be greater than 1 square metre in area. The length must not exceed 1500 mm. Fit a handle to each side of the cover, slightly higher than its horizontal centre line.

Provide fixings so that the cover remains in position when the fasteners are released or removed.

4.17.9 Identification of Enclosures

The customer must provide identification for the CT metering enclosure.

The cover, whether hinged or removable, must:

(a) Be marked "Electricity Distributor Metering CTs Enclosed". (b) Clearly identify the customer. (c) Identify the relevant tariffs, if more than one tariff is involved.
Fix a similar label adjacent to the CTs.

4.17.10 CT Security Locking or Sealing

The CT compartment and unmetered sections of a switchboard/installation must be sealed or locked as follows:

(a) The CT access cover/s and unmetered sections must be locked where located outdoors or remote from the meter position. All locks must be the electricity distributor's security type and provided at the customer's cost. Locking facilities must accept a 10mm shank.
(b) The CT access covers and unmetered sections may be sealed where located within a building.

The sealing facilities must be designed so that they can be sealed with short lengths of sealing line.

Provide sealing for:

(a) **A door** - at the side of the door opposite to its hinged edge.

(b) **A removable cover** -at two approximately diagonally opposite points on the cover.

4.17.11 CT Location and Access

Locate CTs, removable busbars, voltage-circuit fuses, and neutral links so that they are:

(a) More than 500mm.

(b) Less than 2500mm

from the ground floor or platform of access.

4.17.12 Voltage Circuit Protection

The customer must provide and install all the links and the voltage circuit protection fuses.

All fuses must be:

(a) a 10A current limiting (HRC) fuse type NS to AS 60269.3.0 and AS 60269.3.1, in an enclosure with class IP2X to AS 1939 'Degrees of protection provided by enclosures for electrical equipment (IP Code)', or

(b) Class G current limiting (HRC) fuse links in a modular fuse holder complying with IEC 269 - Part 2