NEW SOUTH WALES
DEPARTMENT
OF EDUCATION
AND TRAINING

TAFE NSW

Family Name .....

Given Name .....

Student Number .....

Centre .....

Signature .....

25 June 2009

6077AC Electrical Systems Safety - Capstone Assessment

Time allowed – Three hours plus Ten minutes reading time

32 Pages in this Question Booklet

With Answers

TOTAL MARKS AVAILABLE = 100

Aids to be supplied by college:

- None.

Aids to be supplied by student:

- Australian/New Zealand Wiring Rules, AS/NZS 3000:2007
- Australian/New Zealand Standard Electrical Installations – Selection of Cables, AS/NZS 3008:1:1998.
- NSW Service and Installation Rules
- Students own marginal notes, indexing and formal amendments may be included in the above regulation books.
- Pen, pencil, eraser, rule, calculator.

Section	Possible Mark	Actual Mark
A	15	
B	20	
C	45	
D	20	
TOTAL	100	

Instructions to student:

- **Mobile phones are to be turned off and removed from your person.** You cannot access a mobile phone during this test.
- All questions to be answered in the space provided on this **Question Booklet.** Answers to Section A – multi-choice questions, are to be answered on the sheet attached to this Question Booklet.
- You are not to use any other reference book in this examination.
- The whole of this paper is to be handed to the Supervisor upon completion.
- *ALL* Questions to be attempted.

Aids permitted where indicated:

Standard Dictionaries	Bilingual Dictionaries	Technical Dictionaries	Programmable Calculators	Non-programmable Calculators	Electronic Devices
No	No	No	No	Yes	No

SECTION A – (15 Marks)

INSTRUCTIONS: Select the best answer for the following statements and place an 'X' in the appropriate box on the Answer Sheet attached to the back of this examination paper. Each correct answer is worth one (1) mark.

QUESTION 1. (1 Mark)

Which of the following steps must be followed before undertaking an insulation resistance test on a power circuit having socket outlets, which incorporate surge protection devices?

(a) turn off switches for socket outlets containing the surge protection devices

(b) only use an ohmmeter on these circuits

(c) join neutral to earth for socket outlets containing the surge protection devices

(d) do not exceed 250 V with the insulation resistance tester

QUESTION 2. (1 Mark)

The sign shown in ***Figure 1*** is an example of:

(a) prohibition sign

(b) mandatory sign

(c) restriction sign

(d) warning sign

Figure 1

QUESTION 3. (1 Mark)

Polarity testing is performed on a socket outlet:

(a) to ensure conductors are not transposed

(b) only on the earth conductor

(c) only on the active conductor

(d) to ensure there is no intermix from other circuits

QUESTION 4. (1 Mark)

The colour coding used to identify a dry chemical powder fire extinguisher is:

(a) red without colour stripe

(b) red with white stripe

(c) red with black stripe

(d) blue without colour stripe

SECTION A – (Cont'd)

QUESTION 5. (1 Mark)

Equipment used in an electrical installation must:

(a) carry the EMI compliant mark

(b) be rated for 230V, 50Hz operation

(c) be safe to use and not cause danger

(d) carry the regulatory compliant mark

QUESTION 6. (1 Mark)

A major hazard with confined spaces is:

(a) difficulty in using tools

(b) unable to stand upright when working

(c) only one person can work at a time

(d) flammable contaminants and oxygen depletion

QUESTION 7. (1 Mark)

A Certificate of Compliance – Electrical Work should be completed when the installation is tested and the 'Contractors Copy' retained by the electrical contractor for a period of:

(a) 14 days

(b) 1 year

(c) 5 years

(d) 7 years

QUESTION 8. (1 Mark)

The minimum number of residual current devices required to protect two (2) lighting and two (2) power circuits in a domestic electrical installation is:

(a) one for power circuit only

(b) one for lighting circuit only

(c) one for both lighting and power circuits

(d) two residual current devices are required

SECTION A – (Cont'd)

QUESTION 9. (1 Mark)

The MEN system of earthing is where:

(a) all parts of an installation required to be earthed are not connected to the general mass of earth but are connected to the main neutral link

(b) all parts of an installation required to be earthed are connected to the general mass of earth but not to the main neutral link

(c) all parts of an installation required to be earthed are connected to the general mass of earth and in addition are connected to the main neutral link

(d) all parts of an installation required to be earthed are connected only to the general mass of earth and the main earth link

QUESTION 10. (1 Mark)

Automatic disconnection of the supply is required to limit the harmful effects of switchboard internal arcing. Protection should initiate at a current less than:

(a) 20% of phase to earth prospective fault current

(b) 20% of three-phase prospective fault current

(c) 30% of three-phase prospective fault current

(d) 60% of phase to earth prospective fault current

QUESTION 11. (1 Mark)

It is necessary to verify earth fault-loop impedance for final sub-circuits supplying:

(a) lighting points

(b) socket outlets not protected by RCDs

(c) socket outlets protected by RCDs

(d) cooking appliances

SECTION A – (Cont'd)

QUESTION 12. (1 Mark)

When selecting a cable for a final sub-circuit, its continuous current carrying capacity should be:

(a) at least equal to demand of final sub-circuit and at least equal to circuit breaker rating

(b) at least equal to demand of final sub-circuit and less than circuit breaker rating

(c) less than demand of final sub-circuit and at least equal to circuit breaker rating

(d) less than demand of the final sub-circuit and less than circuit breaker rating

QUESTION 13. (1 Mark)

A socket outlet installed for the supply of pool equipment and located a distance of 1.5 metres from the pool rim shall:

(a) have an IP rating of at least IPX4

(b) have an IP rating of at least IPX5

(c) have an IP rating of at least IPX6

(d) not be permitted

QUESTION 14. (1 Mark)

A circuit in a non-air conditioned, non-domestic installation supplies 10 A socket outlets. If the circuit comprises 4 mm^2 copper conductor the maximum number of single socket outlets it can supply when protected by a 25 A Type C circuit breaker is:

(a) 10

(b) 12

(c) 15

(d) 20

QUESTION 15. (1 Mark)

One method for determining the size of consumer mains and sub-mains of an electrical installation is:

(a) safe design and construction

(b) measuring the average current over any 15 minute period

(c) summing current rating of isolation devices for associated circuits

(d) summing current settings of circuit breakers protecting associated circuits

SECTION B – (20 Marks)

INSTRUCTIONS: Use AS/NZS 3000:2007 to best answer each question in the space provided showing the AS/NZS 3000:2007 references used to obtain the answer. You will be awarded 2 marks for providing the correct answer and reference. Part marks are not available.

QUESTION 1. (2 Marks)

The requirements detailed in AS/NZS 3000:2007 are to ensure the safety of persons, livestock, and property against dangers and damage that may arise in the reasonable use of an electrical installation. What are the three major risks identified?

_____

_____

Reference (_____)

QUESTION 2. (2 Marks)

When determining the maximum demand of an electrical installation it is necessary to consider a number of requirements. What are three considerations?

_____

_____

Reference (_____)

QUESTION 3. (2 Marks)

The design of an electrical installation must take into account a number of considerations. What are these considerations?

_____

_____

_____

_____

_____

Reference (_____)

SECTION B – (Cont'd)

QUESTION 4. (2 Marks)

What are the requirements for aluminium earthing conductors?

Reference (_____)

QUESTION 5. (2 Marks)

What is the maximum circuit length of a 2.5mm^2 TPS twin and earth cable supplying 10A socket outlets and protected by a 20A Type C circuit breaker so as not to exceed the maximum earth-fault impedance for a 230 volt installation?

Reference (_____)

QUESTION 6. (2 Marks)

What is the function of the MEN link?

Reference (_____)

SECTION B – (Cont'd)

QUESTION 7. (2 Marks)

What is the minimum distance required between a 50 watt, 12 volt recessed dichroic lamp and its supply transformer?

_____

Reference (_____)

QUESTION 8. (2 Marks)

What is the minimum number of residual current devices in domestic installation having multiple final sub-circuits?

_____

Reference (_____)

QUESTION 9. (2 Marks)

What are three examples of circuits that do not require over-current protection due to the opening of the circuit causing greater danger than the over-current?

_____

_____

_____

Reference (_____)

QUESTION 10. (2 Marks)

Generally every motor shall be controlled through an isolating switch. What situations do not require motor isolating switches?

_____

_____

Reference (_____)

SECTION C – (45 Marks)

INSTRUCTIONS: This section involves calculations. Show all necessary working in the space provided, marks will be awarded accordingly. Answers are to be highlighted or underlined.

The questions in this section relate to a factory unit complex. A main switchboard supplies a number of switchboards in the complex. *Figure 2* shows the site plan and *Figure 3* details the single-line diagram for the sub-main to factory unit 4.

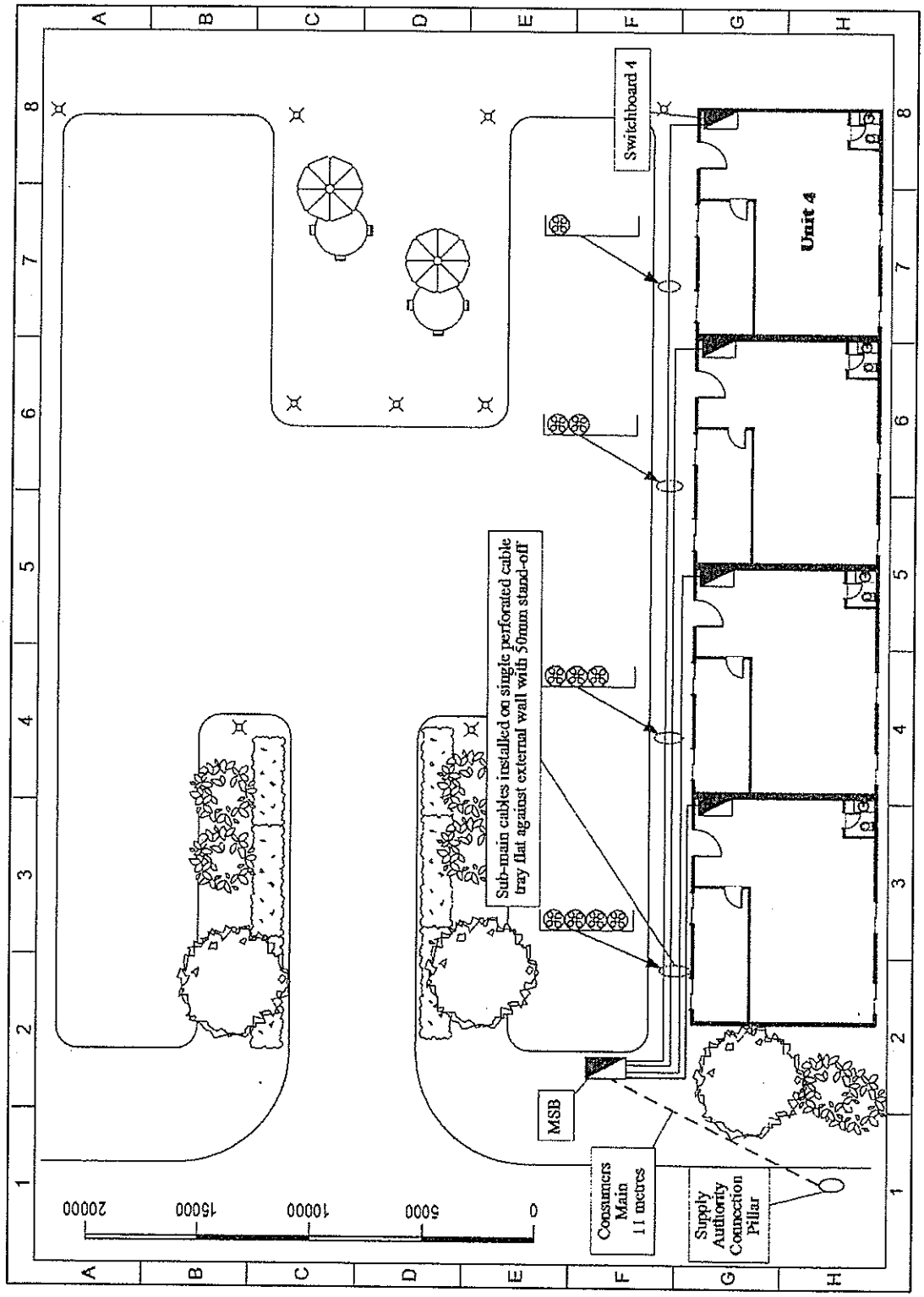
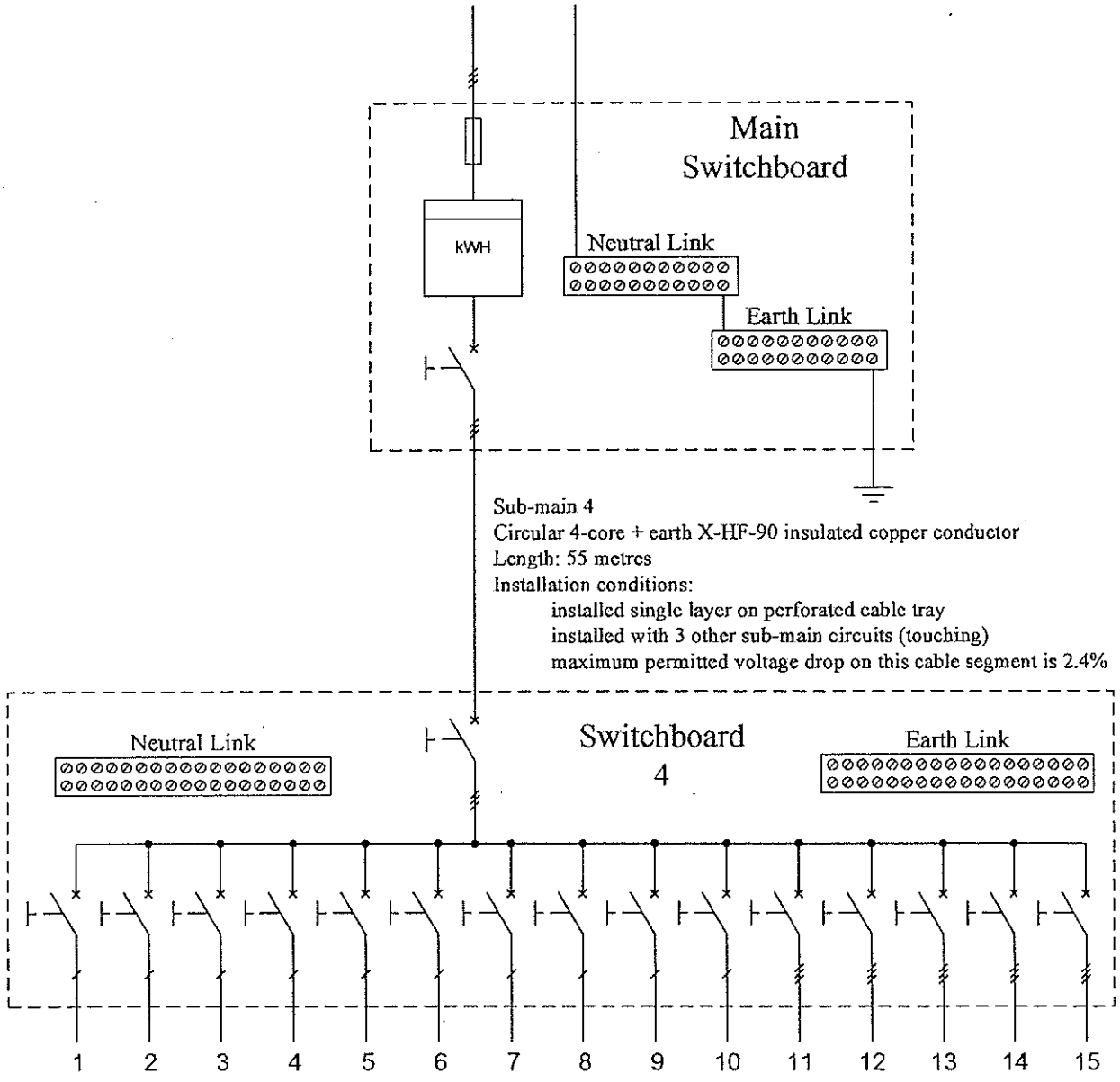


Figure 2

SECTION C – (Cont'd)



Circuit	Description	Qty	Rating
1	Hi Bay Lighting	6	3.8 A each
2	Hi Bay Lighting	6	3.8 A each
3	Fluorescent Lighting	15	0.85 A each
4	Fluorescent Lighting	12	0.85 A each
5	1-ph single socket outlet	10	10 A each
6	1-ph single socket outlet	9	10 A each
7	1-ph double socket outlet	5	10 A each
8	1-ph socket outlet	1	15 A
9	1-ph instantaneous water heater	1	9.5 A
10	1-ph motor	3	3.5 A each
11	3-phase socket outlet	1	32 A
12	3-phase socket outlet	1	32 A
13	3-phase socket outlet	1	25 A
14	3-phase socket outlet	1	25 A
15	3-phase socket outlet	1	15 A

Figure 3

SECTION C – (Cont'd)

Use the information in Table 1 to assist in answering Question 1.

Table 1

Conductor size (mm^2)	a.c. resistance at 50 Hz in Ω/km		
	at 75°C	at 90°C	at 110°C
2.5	9.01	9.45	10.0
4	5.61	5.88	6.24
6	3.75	3.93	4.17
10	2.23	2.33	2.48
16	1.40	1.47	1.56
25	0.884	0.927	0.984
35	0.638	0.668	0.710
50	0.471	0.494	0.524
70	0.327	0.342	0.363
95	0.236	0.247	0.262
120	0.188	0.197	0.208
150	0.153	0.160	0.169
185	0.123	0.129	0.136

QUESTION 1. (4 Marks)

The 3-phase **230/400**-volt consumer main to the factory comprise X-HF-110 SDI cables having circular copper conductors. The active conductors are 185 mm^2. The Supply Authority nominates the fault level at the point of supply as 30 kA. The soil resistivity for the installation is very low. The cables have a route length of 11 metres. Calculate the fault current rating of distribution equipment located on the main switchboard given that that the supply authority does not provide short circuit protection on the supply side of the consumers main.
(Assume the return path has negligible resistance due to the low soil resistivity)

SECTION C – (Cont'd)

QUESTION 2. (4 Marks)

Calculate the maximum demand of the **230/400** volt, three-phase sub-main to Switchboard 4. The occupant intends to use rotating electrical machines in this area. This factory unit does not contain heating or cooling.

Enter required information for each circuit as listed in the following Table.

Complete the Table fully – marks are deducted for each incomplete or incorrect line.

Load group	Load description	Qty	Calculation	Demand (Red)	Demand (White)	Demand (Blue)
	Circuit 1 — Hi Bay Lighting					
	Circuit 2 — Hi Bay Lighting					
	Circuit 3 — Fluorescent Lighting					
	Circuit 4 — Fluorescent Lighting					
	Circuit 5 — 1 ph Power 10A					
	Circuit 6 — 1 ph Power 10A					
	Circuit 7 — 1 ph Power 10A					
	Circuit 8 — 1 ph Power 15A					
	Circuit 9 — 1 ph Water Heater					
	Circuit 10 — 1 ph Motors					
	Circuit 11 — 3 ph Power 32 A					
	Circuit 12 — 3 ph Power 32 A					
	Circuit 13 — 3 ph Power 25 A					
	Circuit 14 — 3 ph Power 25 A					
	Circuit 15 — 3 ph Power 15 A					
			Maximum Demand			

Maximum demand of the three-phase sub-main 4 is _____

SECTION C – (Cont'd)

Table 2
Circuit Breakers for Power Distribution – Electrical Characteristics

Electrical Characteristic	Circuit Breaker Designation							
	CB1	CB2	CB3	CB4	CB5	CB6	CB7	CB8
								
Poles	3 or 4	3 or 4	3 or 4	3 or 4	3 or 4	3 or 4	3 or 4	3 or 4
Rated Current (A)	100	160	200	250	320	400	500	630
Rated Operational Voltage (V)	500	500	500	500	500	500	500	500
Rated Short-Circuit capacity @ 440V (kA)	20	20	20	25	30	30	40	40
Trip Unit	TMF	TMF	TMF	TMF	TMF	TMF	TMF	TMF
Category Rating (Type)	D	D	D	D	D	F	F	F
TMF= Thermo-magnetic trip unit with fixed thermal and magnetic threshold								

QUESTION 3. (2 Marks)

If the maximum demand of sub-main 4 was determined to be 185 A, use Table 2 (above) and the fault levels indicated below to select a suitable protective device for sub-main 4.

Fault level at point of supply: 30 kA

Fault level at main switchboard: 22 kA

Fault level at switchboard 4: 16 kA

Designation of selected device (eg CB1): _____

SECTION C – (Cont'd)

QUESTION 4. (5 Marks)

The maximum demand of the sub-main 4 was determined to be 185 Ampere. A 200 Ampere type D circuit breaker protects the sub-main at its origin. The major portion of the load connects between active and neutral conductors. What would be the minimum size of the active, neutral and earth conductors for a X-HF-90 four-core and earth cable having circular copper conductors when installed vertically on single perforated cable tray with three other sub-main circuits (that is touching)?

Derating (if applicable)

Standard used:	Table No used:	Column:	Derating factor:

Required current carrying capacity: _____

Active conductor

Standard used:	Table No used:	Column:	Cross-sectional area:	Current carrying capacity

Neutral conductor

Standard used:	Table No used:	Column:	Cross-sectional area:	Current carrying capacity

Earth conductor

Standard used:	Table No used:	Column:	Cross-sectional area:

SECTION C – (Cont'd)

QUESTION 5. (6 Marks)

The maximum demand of the **230/400** volt, sub-main 4 was determined to be 185 A, and the sub-main comprised a X-HF-90 four-core and earth cable having 70 mm^2 circular copper active and neutral conductors, that are protected by a 200A Type D circuit breaker. Calculate the voltage drop for this segment and state if it is within the specified limit of 2.4% when the route length of the circuit is 55 metres.

Standard used: _____

Table No: _____

mV/A.m rating: _____

_____

_____

_____

_____

(a) Does this comply with the 2.4% specified limit?

_____

(b) What is the optimal copper conductor size for this cabling segment?

_____

_____

_____

_____

SECTION C – (Cont'd)

QUESTION 6. (2 Marks)

The maximum demand of the **230/400** volt, sub-main 4 was determined to be 185 A, and the sub-main comprised a X-HF-90 four-core and earth cable having 70 mm^2 circular copper active and neutral conductors with a 25 mm^2 earth conductor. Verify that a 200 Ampere type D circuit breaker would adequately protect the circuit with the fault-loop impedance limitations.

SECTION C – (Cont'd)

The remaining questions in this section relate to a multiple domestic installation comprising sixteen (16) separate occupancies.

A main switchboard for the complex supplies a switchboard in each of the occupancies. *Figure 4* shows the site plan and *Figure 5* details the single-line diagram for the sub-main to unit 9.

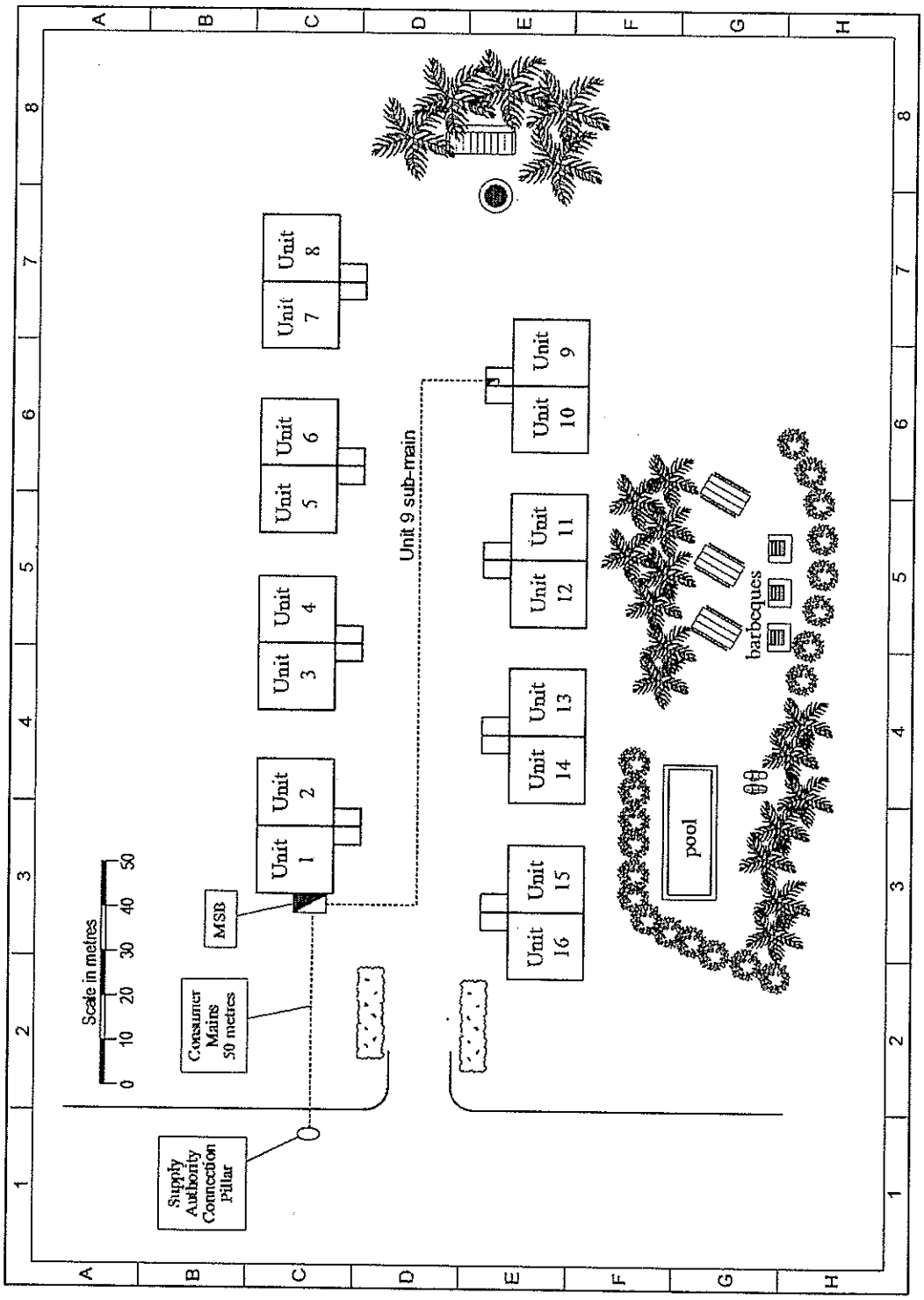
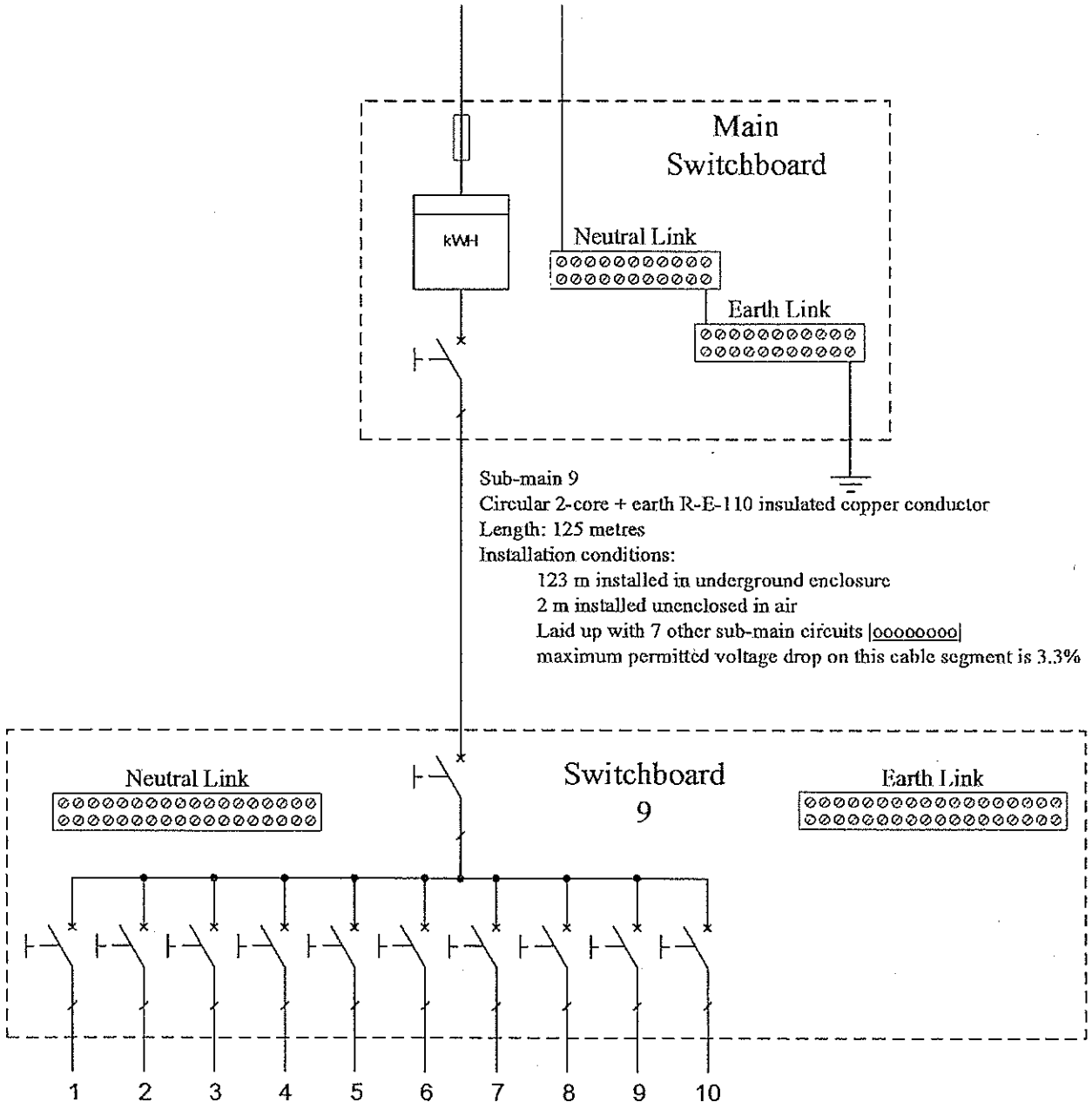


Figure 4

SECTION C – (Cont'd)



Circuit	Description	Qty	Rating
1	Lighting	16	60W each
2	Lighting	18	60W each
3	1-ph single socket outlet	8 double	10 A each
4	1-ph single socket outlet	5 double + 6 single	10 A each
5	1-ph single socket outlet	6 double + 4 single	10 A each
6	1-ph single socket outlet	1	15 A
7	1-ph air conditioner	1	9.5 A
8	1-ph 180 litre, 3.45kW QRHWS	1	15 A @ 230V
9	1-ph cook top	1	8.6 kW @ 230V
10	1-ph wall oven	1	4.2 kW @ 230V

Figure 5

SECTION C – (Cont'd)

QUESTION 7. (3 Marks)

Calculate the maximum demand of the single-phase sub-main to Unit 9.
Enter required information for each load description as listed in the following Table.
Complete the Table fully – marks are deducted for each incomplete or incorrect line.

Load group	Load description	Qty	Calculation	Demand
	Lighting			
	1 ph Power (10 A)			
	1 ph Power (15 A)			
	Air Conditioning			
	Quick Recovery HWS			
	Cook-top			
	Wall oven			
			Maximum Demand	

Maximum demand of the single-phase sub-main to Unit 9 is _____

SECTION C – (Cont'd)

QUESTION 8. (5 Marks)

The maximum demand of the 230 volt, sub-main to unit 9 was determined to be 75 Ampere. An 80 Ampere type D circuit breaker provides over-current protection at the point of origin for this cable. What would be the minimum size of the active, neutral and earth conductors for a 2-core and earth R-E-110 cable having circular copper conductors when installed in an underground trench together with seven (7) other similar sub-main cables when all eight (8) conduits are touching each other?

Derating (if applicable)

Standard used:	Table No used:	Column:	Derating factor:

Required current carrying capacity: _____

Active conductor

Standard used:	Table No used:	Column:	Cross-sectional area:	Current carrying capacity

Neutral conductor

Standard used:	Table No used:	Column:	Cross-sectional area:	Current carrying capacity

Earth conductor

Standard used:	Table No used:	Column:	Cross-sectional area:

SECTION C – (Cont'd)

QUESTION 9. (4 Marks)

The maximum demand of the 230 volt, sub-main to unit 9 was determined to be 75 Ampere, and the 2-core and earth R-E-110 cable had 10 mm^2 circular copper conductors, determine the voltage drop and state if it is within the specified limit of 3.3% when the route length is 125 metres.

Standard used: _____

Table No: _____

mV/A.m rating: _____

_____

_____

_____

_____

Does this comply with the 3.3% specified limit?

_____

QUESTION 10. (3 Marks)

Final sub-circuit 3 supplies a load consisting of 10 A socket outlets. A 16 A Type C circuit breaker protects the circuit of 2.5 mm^2 V-90, TPS, 2-core and earth cable. Determine the maximum *measured* internal fault-loop impedance of the final sub-circuit, based on **240 V**, when supply is unavailable and the ambient temperature is 20°C.

_____

_____

_____

_____

_____

SECTION C – (Cont'd)

Table 3 — Communal Schedule

This load connects to two single-phase meters.

Location	Appliance	A
Outside Unit 1 Garage	18 W Bollard	0.15
Outside Unit 2 Garage	18 W Bollard	0.15
Outside Unit 3 Garage	18 W Bollard	0.15
Outside Unit 4 Garage	18 W Bollard	0.15
Outside Unit 5 Garage	18 W Bollard	0.15
Outside Unit 6 Garage	18 W Bollard	0.15
Outside Unit 7 Garage	18 W Bollard	0.15
Outside Unit 8 Garage	18 W Bollard	0.15
Outside Unit 9 Garage	18 W Bollard	0.15
Outside Unit 10 Garage	18 W Bollard	0.15
Outside Unit 11 Garage	18 W Bollard	0.15
Outside Unit 12 Garage	18 W Bollard	0.15
Outside Unit 13 Garage	18 W Bollard	0.15
Outside Unit 14 Garage	18 W Bollard	0.15
Outside Unit 15 Garage	18 W Bollard	0.15
Outside Unit 16 Garage	18 W Bollard	0.15
RH side driveway entry	18 W Bollard	0.15
LH side driveway entry	18 W Bollard	0.15
Barbecue area	500 W halogen flood	2.7
	500 W halogen flood	2.7
	500 W halogen flood	2.7
	500 W halogen flood	2.7
Swimming pool area	500 W halogen flood	2.7
	500 W halogen flood	2.7
	500 W halogen flood	2.7
	500 W halogen flood	2.7
	Pool pump (hard-wired)	4.5

SECTION C – (Cont'd)

QUESTION 11. (4 Marks)

Calculate the maximum demand of the *whole* installation detailed in ***Figure 4*** and ***Figure 5*** if each of the units has identical electrical loading and the Communal loading detailed in Table 3 is included.
Enter required information for each load description as listed in the following Table.
Complete the Table fully – marks are deducted for each incomplete or incorrect line.

Load group	Load description	Qty	Calculation	Demand (Red)	Demand (White)	Demand (Blue)
	Lighting					
	1 ph Power (10 A)					
	1 ph Power (15 A)					
	Air Conditioning					
	Quick Recovery HWS					
	Cook-top					
	Wall oven					
	Communal Circuit 1 – 18 Bollards					
	Communal Circuit 2 – 4 Halogen floods					
	Communal Circuit 3 – 4 Halogen floods					
	Communal Circuit 4 – swimming pool pump					
			Maximum Demand			

Maximum demand of the installation is _____

SECTION C – (Cont'd)

QUESTION 12. (3 Marks)

Calculate the maximum demand, based on the energy demand method, of the three-phase, **230/400** volt sub-main to a portion of a shopping complex using the floor area details in Table 4 below. Complete the maximum demand Table (Table 4)

Table 4 — Shopping centre floor area

Occupancy	Floor area (m^2)	Equipment	Average energy demand (VA/m^2)	Total energy demand (VA/m^2)
Shop 1	150	Light / power		
		Air conditioning		
Shop 2	180	Light / power		
		Air conditioning		
Shop 3	180	Light / power		
		Air conditioning		
Shop 4	150	Light / power		
		Air conditioning		
Theatre	1200	Light / power		
Tavern	800	Light / power / ac		
Basement car park	1200	Lighting		
			Total:	

Demand per phase: _____

Maximum demand current per phase: _____

SECTION D – 20 Marks

INSTRUCTION: The questions in this section require some simple drawing. Ensure that the drawing is neat and legible. The use of pencil on the drawing is acceptable in this section only.

QUESTION 1. (4 Marks)

The diagram of *Figure 6* following represents the main switchboard in a domestic installation. The diagram also shows five (5) final sub-circuits (earthing conductors only) that the switchboard supplies. Note that the diagram does not show all equipment the switchboard supplies. Details of the installation are as follows:

The consumer mains are 3-phase 400 V comprising four (4) 25 mm^2 V-90 SDI cables enclosed in HDUPVC conduit. Double insulation is maintained up to the supply terminals of the service protective devices, which provide short circuit protection.

The consumer mains do not have short circuit protection on the supply side.

Single-insulated cables are used to connect the equipment on the load side of the service protective devices.

The main switchboard supplies, in part, the following circuits:

• Circuit 1	Lighting	1.5 mm^2 TPS twin and earth.
• Circuit 2	Power	2.5 mm^2 TPS twin and earth.
• Circuit 3	Power	2.5 mm^2 TPS twin and earth.
• Circuit 4	Range	6 mm^2 TPS twin and earth.
• Circuit 5	Water heater	4 mm^2 TPS twin and earth.

(a) Draw on the diagram all necessary **earthing** and **equipotential bonding** conductors necessary to effect the MEN system of earthing. DO NOT show active and neutral conductors.

(b) Identify on each cable the **minimum** conductor size.

Only correct connections, labelling and conductor sizes gain marks.

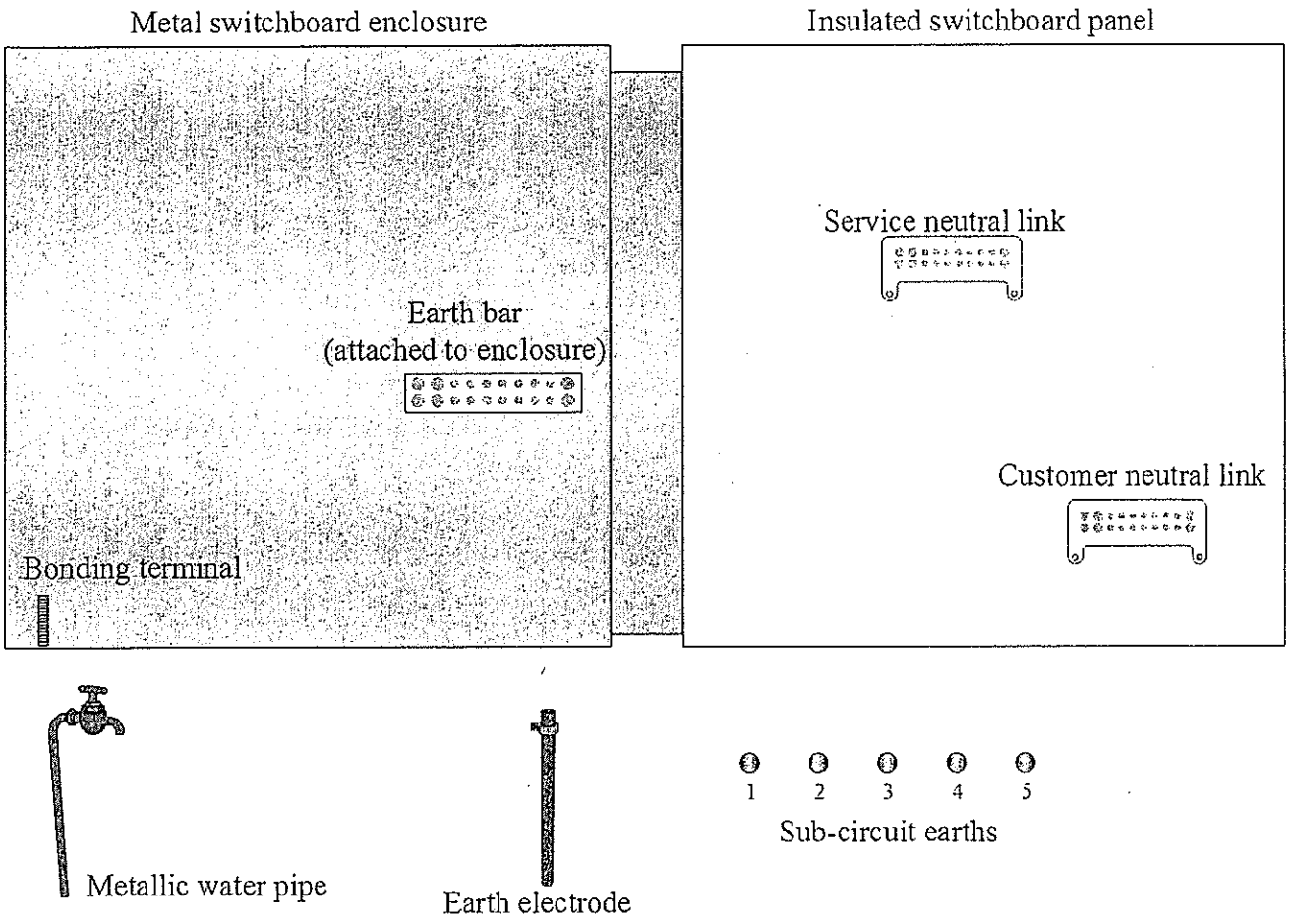


Figure 6

SECTION D – (Cont'd)

QUESTION 2. (3 Marks)

Determine the suitability of a 63 A type D circuit breaker having a tripping characteristic in the range shown in *Figure 7*. The circuit breaker is to protect a sub-main circuit having a maximum demand current of 55 A. The prospective fault current at the origin of the sub-main is 700 A. Show all working and show on the diagram how you arrived at the answer.

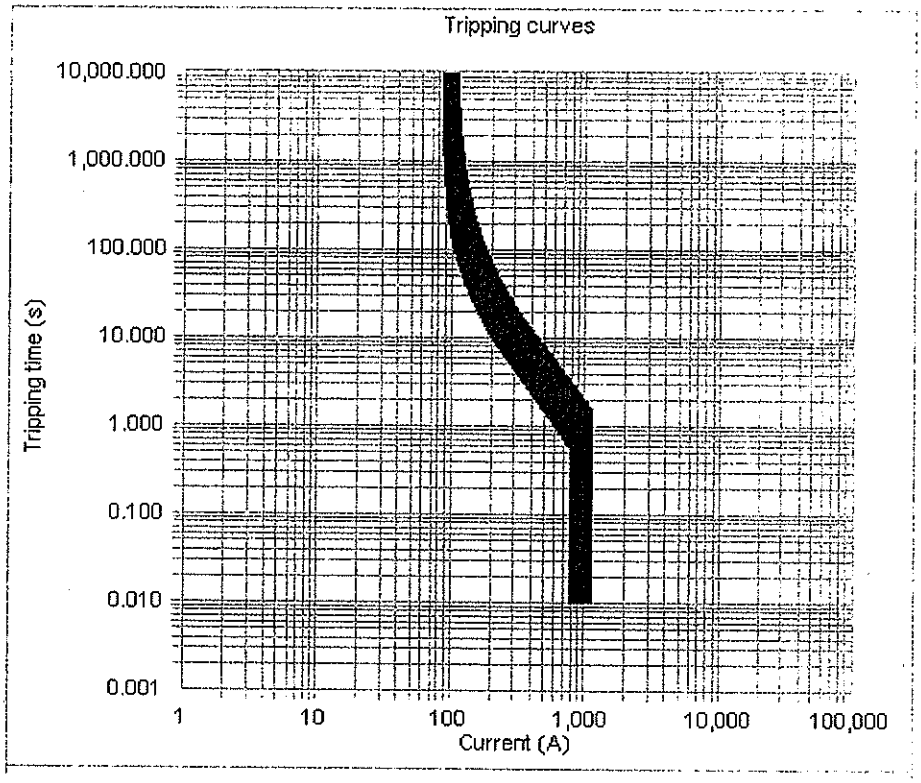


Figure 7

SECTION D – (Cont'd)

QUESTION 3. (7 Marks)

INSTRUCTIONS: Blank spaces in the following statements represent omissions. Write the appropriate word, words or information in the spaces provided.

Test:

Polarity test of single pole switch using voltage indicator with supply available.

Test sequence:

1. Check operation of _____ _____.
2. Energise the circuit
3. Connect one test lead to a known _____.
4. Connect the other test lead to one _____ of the switch under test.
5. Operate the switch.
6. Move the test lead to the other _____.
7. Operate the switch.
8. Test results should indicate:

   With switch on _____ _____ at _____ terminals

   With switch off _____ _____ at _____ terminals

9. Disconnect the test leads.

SECTION D – (Cont'd)

QUESTION 4. (3 Marks)

Complete the following diagram to show how the Insulation Resistance Tester would connect when testing a single-phase circuit supplying an electric range and protected by a 32 A circuit breaker. Note that the MEN link and sub-circuit neutral are disconnected and the circuit breaker is turned off.

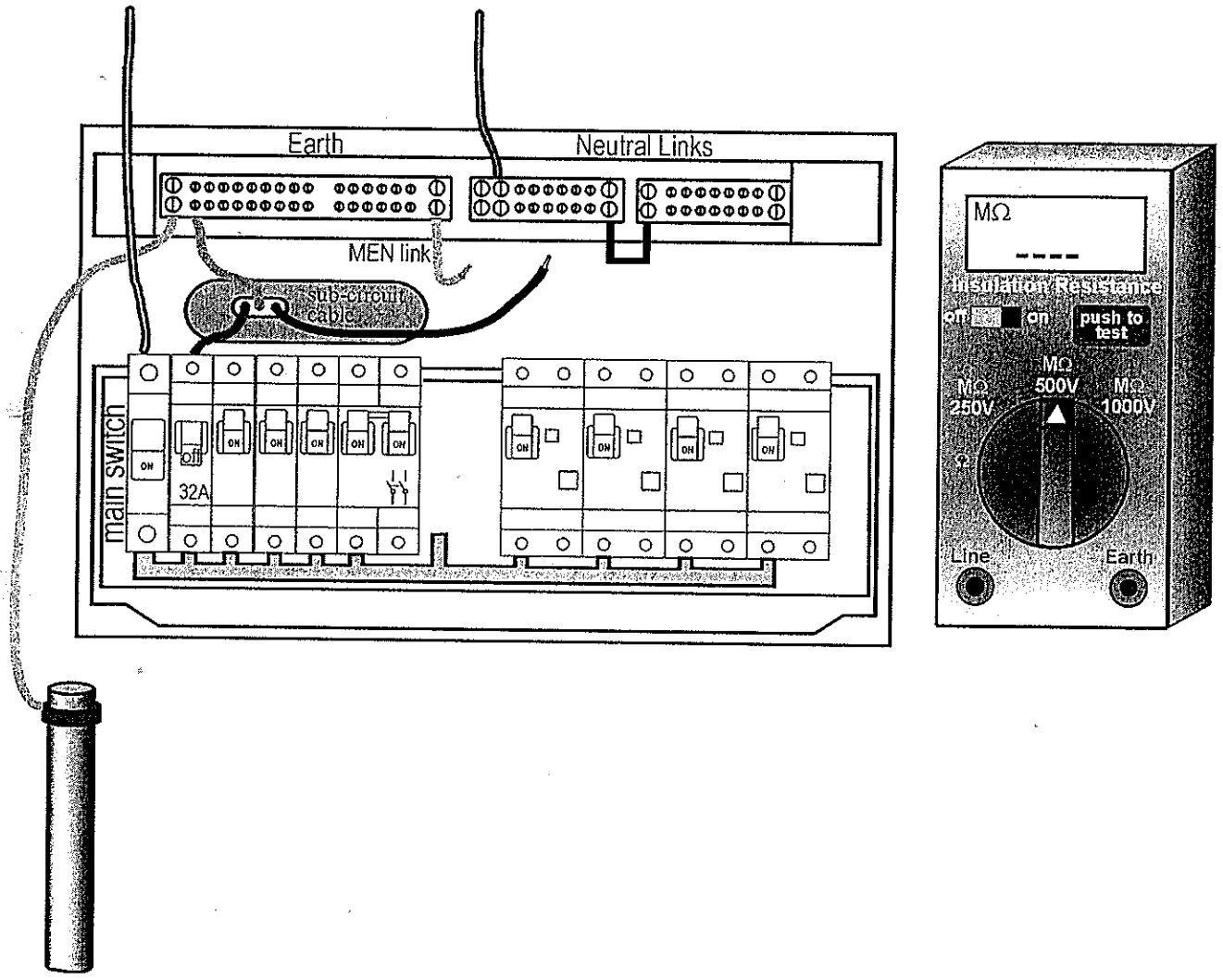


Figure 8

SECTION D – (Cont'd)

QUESTION 5. (3 Marks)

Complete the required sections on the Certificate of Compliance – Electrical Work of *Figure 9* on the following page to satisfy the following. Note: Do NOT include any details for the electrician or tester.

Customer:	Ted E Bear, 22 Honeysuckle Drive, Bearsville. 2299.
Cross street:	Coronation Drive
Meter number:	12345
Electrician:	Ignore any reference
Installation details	Additional (new) power circuit comprising 8 single 10 A socket outlets in domestic residence and connected to supply.
Consumer mains:	Four by 16mm^2 SDI
Main earth electrode:	Directly below switchboard
Water service equipotential bond:	At water pipe entry at front of building on switchboard side of building

Test results:

Insulation resistance:	Water heater	5 MΩ
	Range	0.4 MΩ
	Other circuits	Infinity
Earth continuity:	Main earth	0.12 Ω
	Equipotential bond	0.18 Ω
	All other	<0.8 Ω
All other tests:	Correct	

CERTIFICATE OF COMPLIANCE – ELECTRICAL WORK

Customer COPY

CERTIFICATE NO: 000403

CUSTOMER DETAILS

Name

Address

Cross Street | Postcode

Telephone Contact

Meter No:

NMI (if applicable)

INSTALLATION WORK DETAILS Indicate the type of installation and types of work performed under this Notice

Type of Installation	☐ Residential	☐ Commercial	☐ Industrial	☐ Rural	☐ Other
Special Conditions	☐ over 100 amps	☐ High Voltage	☐ Hazardous Area	☐ Generator	☐ Unmetered Supply

CERTIFICATE MUST BE ISSUED TO THE CUSTOMER FOR ALL ELECTRICAL WORK

Work of the following type must ALSO be notified to the **ELECTRICITY DISTRIBUTOR (DNSP)**

☐ New Installation

☐ Additions or alterations to a switchboard or associated equipment

☐ Network connection or metering

☐ Defect Rectification No:

DETAILS OF EQUIPMENT *Describe the equipment and estimate load increase of the work affected by this Notice. If insufficient space attach separate sheets.*

EQUIPMENT	RATING	No.	PARTICULARS OF WORK
☐ Switchboards			
☐ Circuits			
☐ Lighting			
☐ Socket-outlets			
☐ Appliances			
Estimated increase in load A/ph			☐ Increased load is within capacity of installation/service mains
☐ Work is connected to supply			☐ Work is not connected to supply pending inspection by DNSP

The work has been carried out or supervised by:

Licence No:

TEST REPORT *Indicate the relevant tests and checks that have been performed on the work. If test records are provided attach as separate sheets.*

☐ Earthing system integrity Ω	☐ Residual current device operation
☐ Insulation resistance MΩ	☐ Visual check that installation is suitable for connection to supply
☐ Polarity	☐ Stand-alone power system complies with AS 4509
☐ Correct circuit connections	☐ Fault loop impedance (if necessary)

I confirm that I have carried out the above tests and visually checked that the installation work described in this Certificate complies with AS/NZS 3000 and is suitable for its intended use.

Name:

Signature:

Licence No:

Date of Testing:

CERTIFICATION

I, the Electrical Contractor give notice to the Customer and _____ (Name of DNSP or OFT), that the work described in this Certificate has been completed in accordance with the Electricity (Consumer Safety) Regulation 2006

Name:

Signature:

Address:

Licence No:

Date of Notice:

Telephone No. or Other Contact

ELECTRICITY DISTRIBUTOR (DNSP) REMARKS

Inspected by:

Date

Comments:

neca

Figure 9

NEW SOUTH WALES DEPARTMENT OF EDUCATION AND TRAINING

TAFE NSW

Family Name .....

Given Name .....

Student Number.....

Centre .....

Signature .....

ANSWER SHEET – Section A (Multi-choice Questions)

25 June 2009

6077AC Electrical Systems Safety - Capstone Assessment

INSTRUCTIONS:

- Enter your personal details in the top right hand corner of this sheet.
- Place an **X** in box of your choice. If you make a mistake circle your answer (X) and choose again.

Question	A	B	C	D
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
Totals				
Total Correct Section A				

Total Marks Section A: ..... /15

END OF EXAMINATION

MARKING GUIDE

Module/Unit No:	**6077 AC**
Module/Unit Name:	**Electrical Systems Safety - Capstone Assessment**
Exam Date:	**25/06/09**
Number of Pages:	**34** (including this page)

DEPARTMENT OF EDUCATION AND TRAINING

TAFE NSW

Family Name ..... Marking Key

Given Name .....

Student Number .....

Centre .....

Signature .....

25 June 2009

6077AC Electrical Systems Safety

Time allowed - Three hours plus Ten minutes reading time

33 ~~37~~ Pages in this Question Booklet

ALL Questions to be attempted

TOTAL MARKS AVAILABLE =100

Section	Possible Mark	Actual Mark
A	15	
B	20	
C	45	
D	20	
TOTAL	100	

Aids to be supplied by college:

- None.

Aids to be supplied by student:

- Australian/New Zealand Wiring rules AS/NZS 3000:2007
- Australian/New Zealand Standard Electrical Installations – Selection of Cables Part 1.1 AS/NZS 3008.1.1:1998
- NSW Service and Installation Rules
- Students own marginal notes, indexing and formal amendments may be included in the above regulation books.
- Pen, pencil, eraser, rule, calculator.

Instructions to Students:

- **Mobile phones are to be turned off and removed from your person.** You cannot access a mobile phone during this examination.
- All questions to be answered in the space provided on this **examination paper**. Answers to Section A – multi-choice questions, are to be recorded on the Answer Sheet attached to this examination paper.
- You are not to use any other reference books in this examination.
- The whole of this paper is to be handed to the Supervisor upon completion.

Aids permitted where indicated:

Standard Dictionaries	Bilingual Dictionaries	Technical Dictionaries	Programmable Calculators	Non-programmable Calculators
No	No	No	No	Yes

SECTION A – (15 Marks)

INSTRUCTIONS: Select the best answer for the following statements and place an 'X' in the appropriate box on the Answer Sheet attached to the back of this examination paper. Each correct answer is worth one (1) mark.

QUESTION 1. (1 Mark)

Which of the following steps must be followed before undertaking an insulation resistance on a power circuit having socket outlets, which incorporate surge protection devices?

(a) turn off switches for socket outlets containing the surge protection devices

(b) only use an ohmmeter on these circuits

(c) join neutral to earth for socket outlets containing the surge protection devices

(d) do not exceed 250 V with the insulation resistance tester

QUESTION 2. (1 Mark)

The sign shown in ***Figure 1*** is an example of:

(a) prohibition sign

(b) mandatory sign

(c) restriction sign

(d) warning sign

Figure 1

QUESTION 3. (1 Mark)

Polarity testing is performed on a socket outlet:

(a) to ensure conductors are not transposed

(b) only on the earth conductor

(c) only on the active conductor

(d) to ensure there is no intermix from other circuits

QUESTION 4. (1 Mark)

The colour coding used to identify a dry chemical powder fire extinguisher is:

(a) red without colour stripe

(b) red with white stripe

(c) red with black stripe

(d) blue without colour stripe

SECTION A – (Cont'd)

QUESTION 5. (1 Mark)

Equipment used in an electrical installation must:

(a) carry the EMI compliant mark

(b) be rated for 230V, 50Hz operation

(c) be safe to use and not cause danger

(d) carry the regulatory compliant mark

QUESTION 6. (1 Mark)

A major hazard with confined spaces is:

(a) difficulty in using tools

(b) unable to stand upright when working

(c) only one person can work at a time

(d) flammable contaminants and oxygen depletion

QUESTION 7. (1 Mark)

A Certificate of Compliance – Electrical Work should be completed when the installation is tested and the 'Contractors Copy' retained by the electrical contractor for a period of:

(a) 14 days

(b) 1 year

(c) 5 years

(d) 7 years

QUESTION 8. (1 Mark)

The minimum number of residual current devices required to protect two (2) lighting and two (2) power circuits in a domestic electrical installation is:

(a) one for power circuit only

(b) one for lighting circuit only

(c) one for both lighting and power circuits

(d) two residual current devices are required

SECTION A – (Cont'd)

QUESTION 9. (1 Mark)

The MEN system of earthing is where:

(a) all parts of an installation required to be earthed are not connected to the general mass of earth but are connected to the main neutral link

(b) all parts of an installation required to be earthed are connected to the general mass of earth but not to the main neutral link

(c) all parts of an installation required to be earthed are connected to the general mass of earth and in addition are connected to the main neutral link

(d) all parts of an installation required to be earthed are connected only to the general mass of earth and the main earth link

QUESTION 10. (1 Mark)

Automatic disconnection of the supply is required to limit the harmful effects of switchboard internal arcing. Protection should initiate at a current less than:

(a) 20% of phase to earth prospective fault current

(b) 20% of three-phase prospective fault current

(c) 30% of three-phase prospective fault current

(d) 60% of phase to earth prospective fault current

QUESTION 11. (1 Mark)

It is necessary to verify earth fault-loop impedance for final sub-circuits supplying:

(a) lighting points

(b) socket outlets not protected by RCDs

(c) socket outlets protected by RCDs

(d) cooking appliances

SECTION A – (Cont'd)

QUESTION 12. (1 Mark)

When selecting a cable for a final sub-circuit, its continuous current carrying capacity should be:

(a) at least equal to demand of final sub-circuit and at least equal to circuit breaker rating

(b) at least equal to demand of final sub-circuit and less than circuit breaker rating

(c) less than demand of final sub-circuit and at least equal to circuit breaker rating

(d) less than demand of the final sub-circuit and less than circuit breaker rating

QUESTION 13. (1 Mark)

A socket outlet installed for the supply of pool equipment and located a distance of 1.5 metres from the pool rim shall:

(a) have an IP rating of at least IPX4

(b) have an IP rating of at least IPX5

(c) have an IP rating of at least IPX6

(d) not be permitted

QUESTION 14. (1 Mark)

A circuit in a non-air conditioned, non-domestic installation supplies 10 A socket outlets. If the circuit comprises 4 mm^2 copper conductor the maximum number of single socket outlets it can supply when protected by a 25 A Type C circuit breaker is:

(a) 10

(b) 12

(c) 15

(d) 20

QUESTION 15. (1 Mark)

One method for determining the size of consumer mains and sub-mains of an electrical installation is:

(a) safe design and construction

(b) measuring the average current over any 15 minute period

(c) summing current rating of isolation devices for associated circuits

(d) summing current settings of circuit breakers protecting associated circuits

SECTION B – (20 Marks)

INSTRUCTIONS: Use AS/NZS 3000:2007 to best answer each question in the space provided showing the AS/NZS 3000:2007 reference used to obtain the answer. You will be ☑ Award 2 marks for correct answer and reference
☒ No marks for all other cases
Other references may be accepted if correct
reference. Part mar

QUESTION 1. (2 Marks)

The requirements detailed in AS/NZS 3000:2007 are to ensure the safety of persons, livestock, and property against dangers and damage that may arise in the reasonable use of an electrical installation. What are the three major risks identified?

Shock current, Excessive temperatures, and Explosive atmospheres OR

Electric shock, fire and physical injury hazards

Reference (1.5.1)

OR 1.1 Scope

QUESTION 2. (2 Marks)

When determining the maximum demand of an electrical installation it is necessary to consider a number of requirements. What are three considerations?

Capacity, physical distribution and intended use of electrical equipment in the installation

and the manner in which the presentation requirements might vary

Reference (1.6.3)

Note: Clause 2.2.2 is not acceptable

QUESTION 3. (2 Marks)

The design of an electrical installation must take into account a number of considerations. What are these considerations?

Protect persons, livestock and property from harmful effects

Function correctly as intended

Connect, operate safely and be compatible with the supply source to which it connects

Minimise inconvenience in event of a fault

Facilitate safe operation, inspection, testing, and maintenance

Reference (1.6.1)

SECTION B – (Cont'd)

QUESTION 4. (2 Marks)

What are the requirements for aluminium earthing conductors?

Conductors ≤ 10 mm^2 must be solid

Minimum Conductor size of 16 mm^2 for main earth

Take care to provide satisfactory termination and prevent corrosion of conductor

Not installed underground or damp situations

Reference (5.3.2.1.2)

QUESTION 5. (2 Marks)

What is the maximum circuit length of a 2.5mm^2 TPS twin and earth cable supplying 10A socket outlets and protected by a 20A Type C circuit breaker so as not to exceed the maximum earth-fault impedance for a 230 volt installation?

68 metres

Reference (Table B1)

QUESTION 6. (2 Marks)

What is the function of the MEN link?

To connect the earthing system within the electrical installation to the supply neutral conductor by means of a connection from the main earth connection to the earthing terminal on the main neutral link

Reference (5.3.5.1)

also 1-4-16

SECTION B – (Cont'd)

QUESTION 7. (2 Marks)

What is the minimum distance required between a 50 watt, 12 volt recessed dichroic lamp and its supply transformer?

50 mm

Reference (4.5.2.3 / Figure 4.7)

QUESTION 8. (2 Marks)

What is the minimum number of residual current devices in domestic installation having multiple final sub-circuits?

Two

Reference (2.6.3.2 (c))
also 2.6.2.4 c)

QUESTION 9. (2 Marks)

What are three examples of circuits that do not require over-current protection due to the opening of the circuit causing greater danger than the over-current?

Certain safety system supplies

Lifting magnets

Exciter circuits of machines and secondary circuits of current transformers

Reference (2.5.1.3 Note 1)
also 7.5.9.2 c)

QUESTION 10. (2 Marks)

Generally every motor shall be controlled through an isolating switch. What situations do not require motor isolating switches?

Motor connected by plug and socket or incorporated in an appliance having no exposed moving parts or rated not more than 150 VA

Reference (4.13.1.1 Exception 2)

SECTION C – (45 Marks)

INSTRUCTIONS: This section involves calculations. Show all necessary working in the space provided, marks will be awarded accordingly. Answers are to be highlighted or underlined.

The questions in this section relate to a factory unit complex. A main switchboard supplies a number of switchboards in the complex. *Figure 2* shows the site plan and *Figure 3* details the single-line diagram for the sub-main to factory unit 4.

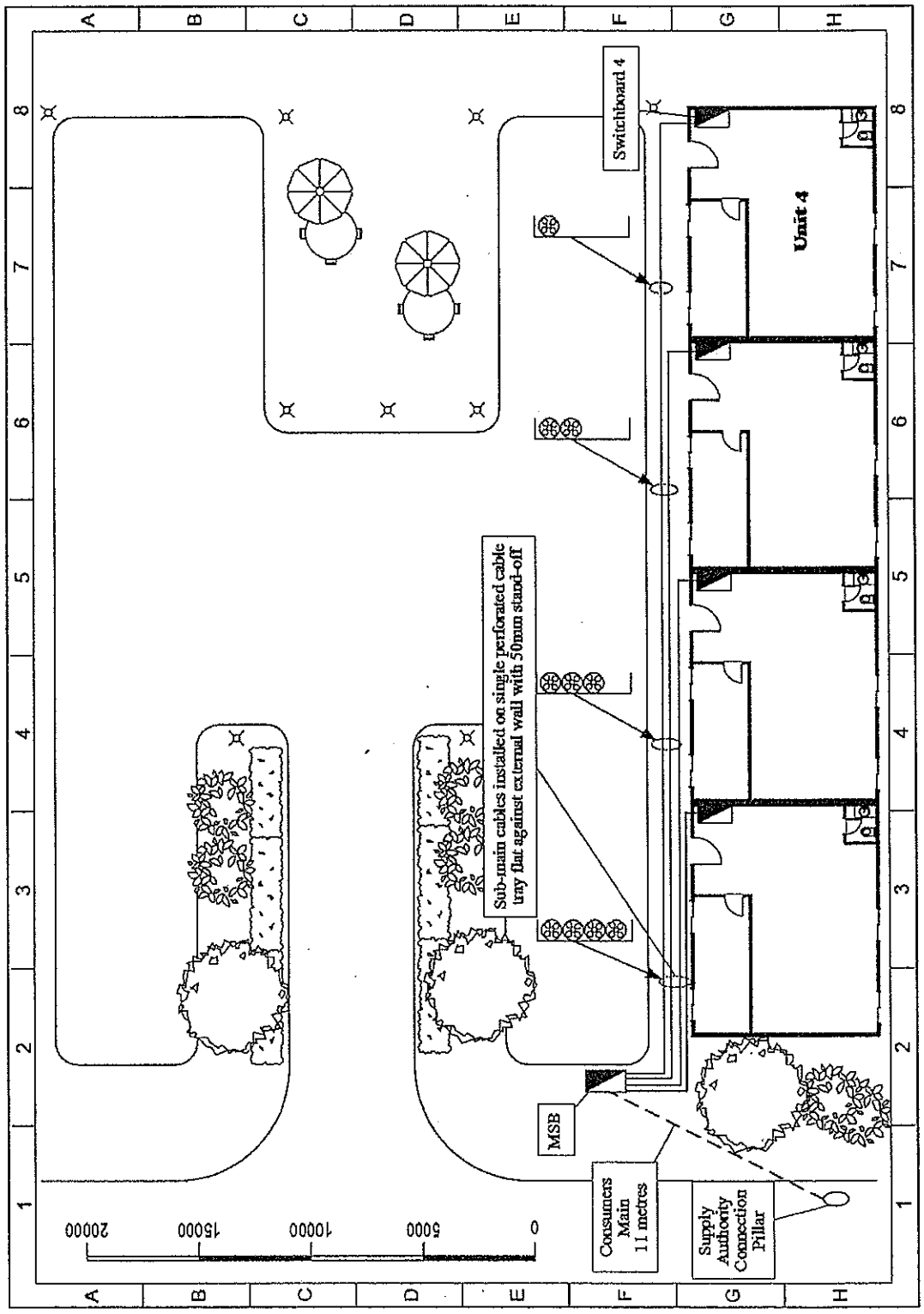
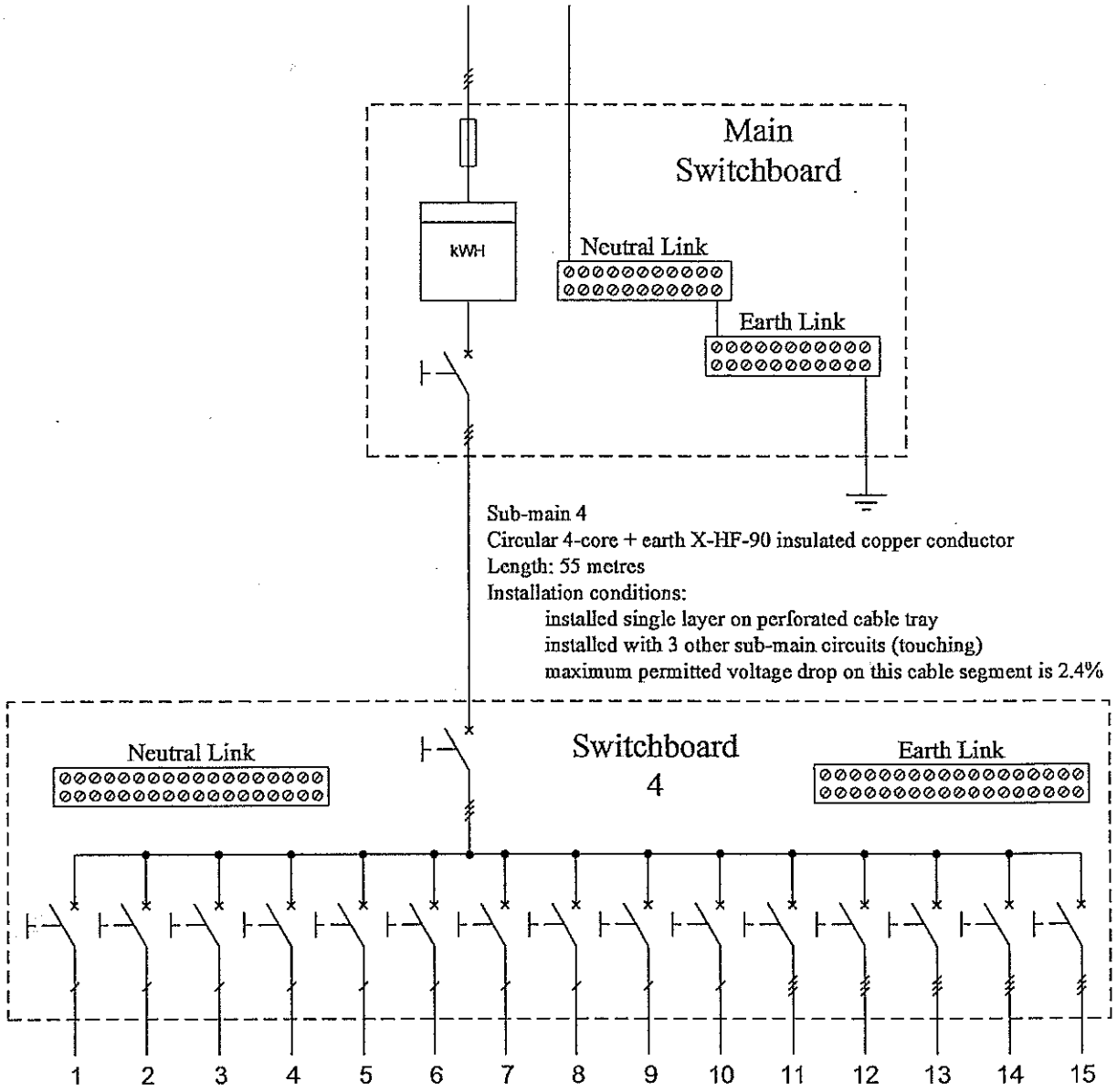


Figure 2

SECTION C – (Cont'd)



Circuit	Description	Qty	Rating
1	Hi Bay Lighting	6	3.8 A each
2	Hi Bay Lighting	6	3.8 A each
3	Fluorescent Lighting	15	0.85 A each
4	Fluorescent Lighting	12	0.85 A each
5	1-ph single socket outlet	10	10 A each
6	1-ph single socket outlet	9	10 A each
7	1-ph double socket outlet	5	10 A each
8	1-ph socket outlet	1	15 A
9	1-ph instantaneous water heater	1	9.5 A
10	1-ph motor	3	3.5 A each
11	3-phase socket outlet	1	32 A
12	3-phase socket outlet	1	32 A
13	3-phase socket outlet	1	25 A
14	3-phase socket outlet	1	25 A
15	3-phase socket outlet	1	15 A

Figure 3

SECTION C – (Cont'd)

Use the information in Table 1 to assist in answering Question 1.

Table 1

Conductor size (mm^2)	a.c. resistance at 50 Hz in Ω/km		
	at 75°C	at 90°C	at 110°C
2.5	9.01	9.45	10.0
4	5.61	5.88	6.24
6	3.75	3.93	4.17
10	2.23	2.33	2.48
16	1.40	1.47	1.56
25	0.884	0.927	0.984
35	0.638	0.668	0.710
50	0.471	0.494	0.524
70	0.327	0.342	0.363
95	0.236	0.247	0.262
120	0.188	0.197	0.208
150	0.153	0.160	0.169
185	0.123	0.129	0.136

QUESTION 1. (4 Marks)

The 3-phase **230/400**-volt consumer main to the factory comprise X-HF-110 SDI cables having circular copper conductors. The active conductors are 185 mm^2. The Supply Authority nominates the fault level at the point of supply as 30 kA. The soil resistivity for the installation is very low. The cables have a route length of 11 metres. Calculate the fault current rating of distribution equipment located on the main switchboard given that that the supply authority does not provide short circuit protection on the supply side of the consumers main.
(Assume the return path has negligible resistance due to the low soil resistivity)

$$Z_{Source} = \frac{V_{phase}}{I_{fault}}$$

$$= \frac{230}{30 \times 10^3}$$

$$= 0.007\,67\,\Omega$$

$$Z_{active} = \frac{\text{length} \times \Omega/\text{km}}{1000}$$

$$= \frac{11 \times 0.136}{1000}$$

$$= 0.0015\,\Omega$$

$$I_{Fault} = \frac{V_{phase}}{Z_{Source} + Z_{Active}}$$

$$= \frac{230}{0.007\,67 + 0.0015}$$

$$= \underline{\underline{25.1\,kA}}$$

☑ 1 mark. Student must show correct working and answer	☑ 1 mark. Student must show correct working and answer	☑ 2 marks. Student must show correct working and answer

SECTION C – (Cont'd)

QUES

☒ Deduct 1 mark for each incorrect line or part thereof
Allocation of load to different phase than that shown is acceptable.

Calcu

Switchboard 4. The occupant intends to use rotating electrical machines in this area. This factory unit does not contain heating or cooling.

Enter required information for each circuit as listed in the following Table.

Complete the Table fully – marks are deducted for each incomplete or incorrect line.

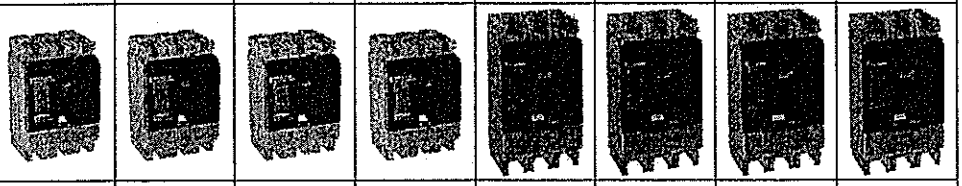
Load group	Load description	Qty	Calculation	Demand (Red)	Demand (White)	Demand (Blue)
A	Circuit 1 — Hi Bay Lighting	*6*	*6 x 3.8*	*22.8*		
A	Circuit 2 — Hi Bay Lighting	*6*	*6 x 3.8*		*22.8*	
A	Circuit 3 — Fluorescent Lighting	*15*	*15 x 0.85*			*12.8*
A	Circuit 4 — Fluorescent Lighting	*12*	*12 x 0.85*			*10.2*
B(i)	Circuit 5 — 1 ph Power 10A	*10*	*(1000+(9 x 750)) / 230*	*33.7*		
B(i)	Circuit 6 — 1 ph Power 10A	*9*	*(1000+(8 x 750)) / 230*			*30.4*
B(i)	Circuit 7 — 1 ph Power 10A	*5*	*(1000+(9 x 750)) / 230*		*33.7*	
B(iii)	Circuit 8 — 1 ph Power 15A	*1*	*0.75 x 15*			*11.3*
C	Circuit 9 — 1 ph Water Heater	*1*	*—*		*9.5*	
D	Circuit 10 — 1 ph Motors	*3*	*(1 + 0.75 + 0.5) x 3.5*	*7.9*		
B(iii)	Circuit 11 — 3 ph Power 32 A	*1*	*—*	*32.0*	*32.0*	*32.0*
B(iii)	Circuit 12 — 3 ph Power 32 A	*1*	*0.75 x 32*	*24.0*	*24.0*	*24.0*
B(iii)	Circuit 13 — 3 ph Power 25 A	*1*	*0.75 x 25*	*18.8*	*18.8*	*18.8*
B(iii)	Circuit 14 — 3 ph Power 25 A	*1*	*0.75 x 25*	*18.8*	*18.8*	*18.8*
B(iii)	Circuit 15 — 3 ph Power 15 A	*1*	*0.75 x 15*	*11.3*	*11.3*	*11.3*
			Maximum Demand	169.3	170.9	169.6

☒ Deduct 1 mark for each incorrect Maximum demand

Maximum demand of the three-phase sub-main 4 is 170.9 A

SECTION C – (Cont'd)

Table 2
Circuit Breakers for Power Distribution – Electrical Characteristics

Electrical Characteristic	Circuit Breaker Designation							
	CB1	CB2	CB3	CB4	CB5	CB6	CB7	CB8
								
Poles	3 or 4	3 or 4	3 or 4	3 or 4	3 or 4	3 or 4	3 or 4	3 or 4
Rated Current (A)	100	160	200	250	320	400	500	630
Rated Operational Voltage (V)	500	500	500	500	500	500	500	500
Rated Short-Circuit capacity @ 440V (kA)	20	20	20	25	30	30	40	40
Trip Unit	TMF	TMF	TMF	TMF	TMF	TMF	TMF	TMF
Category Rating (Type)	D	D	D	D	D	F	F	F
TMF= Thermo-magnetic trip unit with fixed thermal and magnetic threshold								

QUESTION 3. (2 Marks)

If the maximum demand of sub-main 4 was determined to be 185 A, use Table 2 (above) and the fault levels indicated below to select a suitable protective device for sub-main 4.

Fault level at point of supply: 30 kA

Fault level at main switchboard: 22 kA

Fault level at switchboard 4: 16 kA

* sub-main 4 originates at MSB → ∴ Fault level required for C/B.

Designation of selected device: CB4 [note CB3 does not have required fault level]

☒ No part marks

SECTION C – (Cont'd)

QUESTION 4. (5 Marks)

The maximum demand of the sub-main 4 was determined to be 185 Ampere. A 200 Ampere type D circuit breaker protects the sub-main at its origin. The major portion of the load connects between active and neutral conductors. What would be the minimum size of the active, neutral and earth conductors for a X-HF-90 four-core and earth cable having circular copper conductors when installed vertically on single perforated cable tray with three other sub-main circuits (th

☒ No part marks.
Every step and reference must be correct
Units must be correct eg mm^2 and Ampere

Refer T2(1) Item 10

Derating (if applicable)

Standard used:	Table No used:	Column:	Derating factor:
AS/NZS 3008.1.1	24	8	0.77 [item No 19]

Required current carrying capacity: 200 / 0.77 = 260 A

Active conductor

Standard used:	Table No used:	Column:	Cross-sectional area:	Current carrying capacity
AS/NZS 3008.1.1	13	2	95 mm^2	285 Ampere

Neutral conductor

Standard used:	Table No used:	Column:	Cross-sectional area:	Current carrying capacity
AS/NZS 3008.1.1	13	2	95 mm^2	285 Ampere

Refer AS/NZS 3000:2007 Clause 3.5.2

Earth conductor

Standard used:	Table No used:	Column:	Cross-sectional area:
AS/NZS 3000	5.1	2	25 mm^2

* No part marks

SECTION C – (Cont'd)

QUESTION 5. (6 Marks)

The maximum demand of the **230/400** volt, sub-main 4 was determined to be 185 A, and the sub-main comprised a X-HF-90 four-core and earth cable having 70 mm^2 circular copper active and neutral conductors, that are protected by a 200A Type D circuit breaker. Calculate the voltage drop for this segment and state if it is within the specified limit of 2.4% when the route length of the circuit is 55 metres.

☒ No part marks. Every step and reference must be correct

lard used: AS/NZS 3008.1.1:1998

Table No: 42

mV/A.m rating: 0.609

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

$$= \frac{55 \times 185 \times 0.609}{1000}$$

$$= 6.2\ V$$

(a) Does this comply with the 2.4% specified limit?

2.4% of 400 V = 9.6 V So this arrangement IS acceptable

(b) What is the optimal copper conductor size for this cabling segment?

$$V_C = \frac{1000 \times V_d}{L \times I}$$

$$= \frac{1000 \times 9.6}{55 \times 185}$$

$$= 0.943\ mV/A.m$$ so from Table 42 optimum size is 50 mm^2

* No part marks

SECTION C – (Cont'd)

QUESTION 6. (2 Marks)

Length of submain = 55m (see page 10)

The maximum demand of the **230/400** volt, sub-main 4 was determined to be 185 A, and the sub-main comprised a X-HF-90 four-core and earth cable having 70 mm^2 circular copper active and neutral conductors with a 25 mm^2 earth conductor. Verify that a 200 Ampere type D circuit breaker would adequately protect the circuit with the fault-loop impedance limitations.

$$L_{max} = \frac{0.8 \times U_O \times S_{PH} \times S_{PE}}{I_a \times \rho \times (S_{PH} + S_{PE})}$$

$$= \frac{0.8 \times 230 \times 70 \times 25}{(12.5 \times 200) \times (22.5 \times 10^{-3}) \times (70 + 25)}$$

$$= 60.2 \text{ metres}$$

TBI

OR 70mm^2 Act 25mm^2 Earth 200A Type D C/B

Length = 60m

As the actual circuit length is 55 metres this arrangement IS suitable

☒ No part marks. Student must show calculation and plausible explanation

SECTION C – (Cont'd)

The remaining questions in this section relate to a multiple domestic installation comprising sixteen (16) separate occupancies.

A main switchboard for the complex supplies a switchboard in each of the occupancies. *Figure 4* shows the site plan and *Figure 5* details the single-line diagram for the sub-main to unit 9.

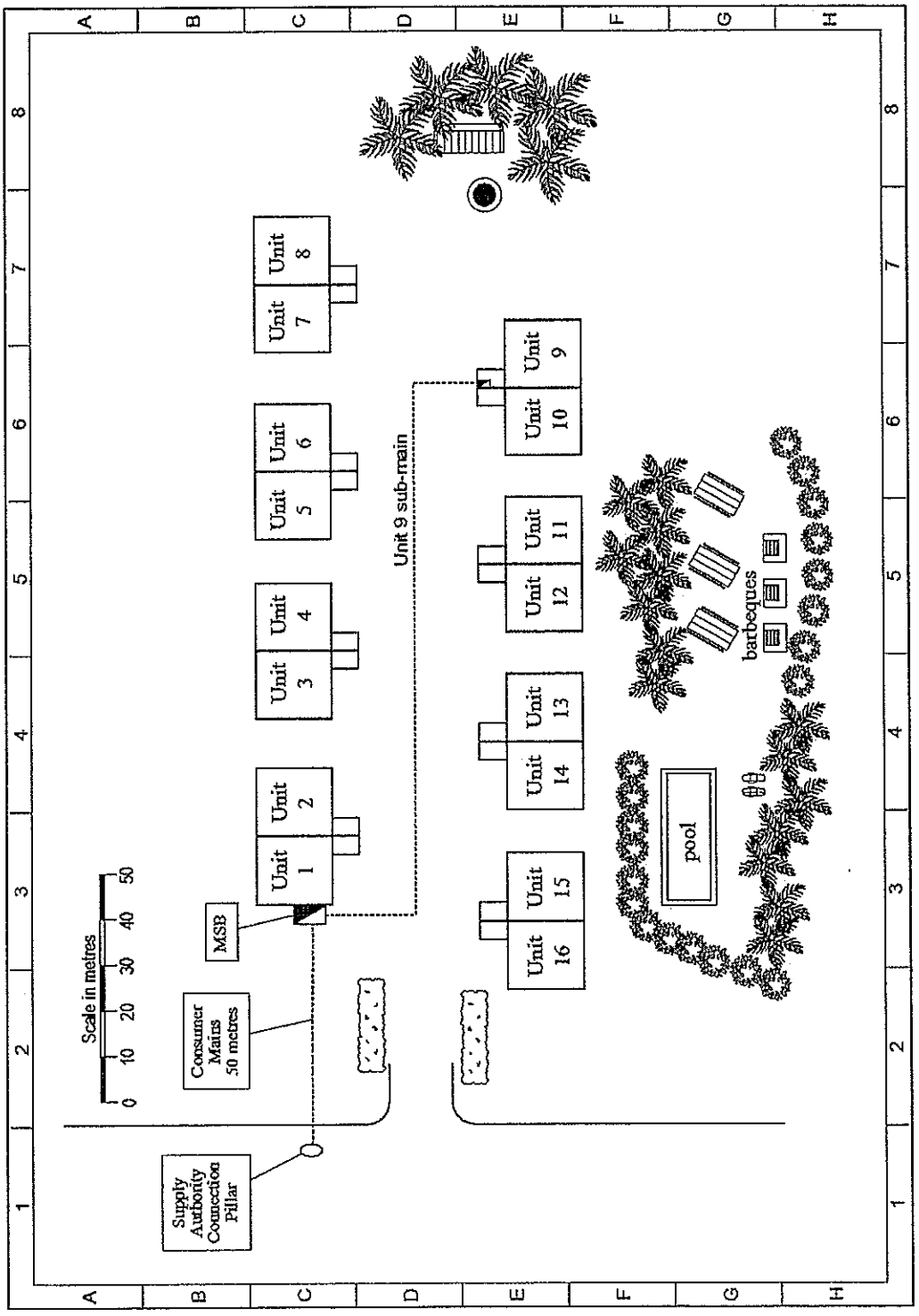
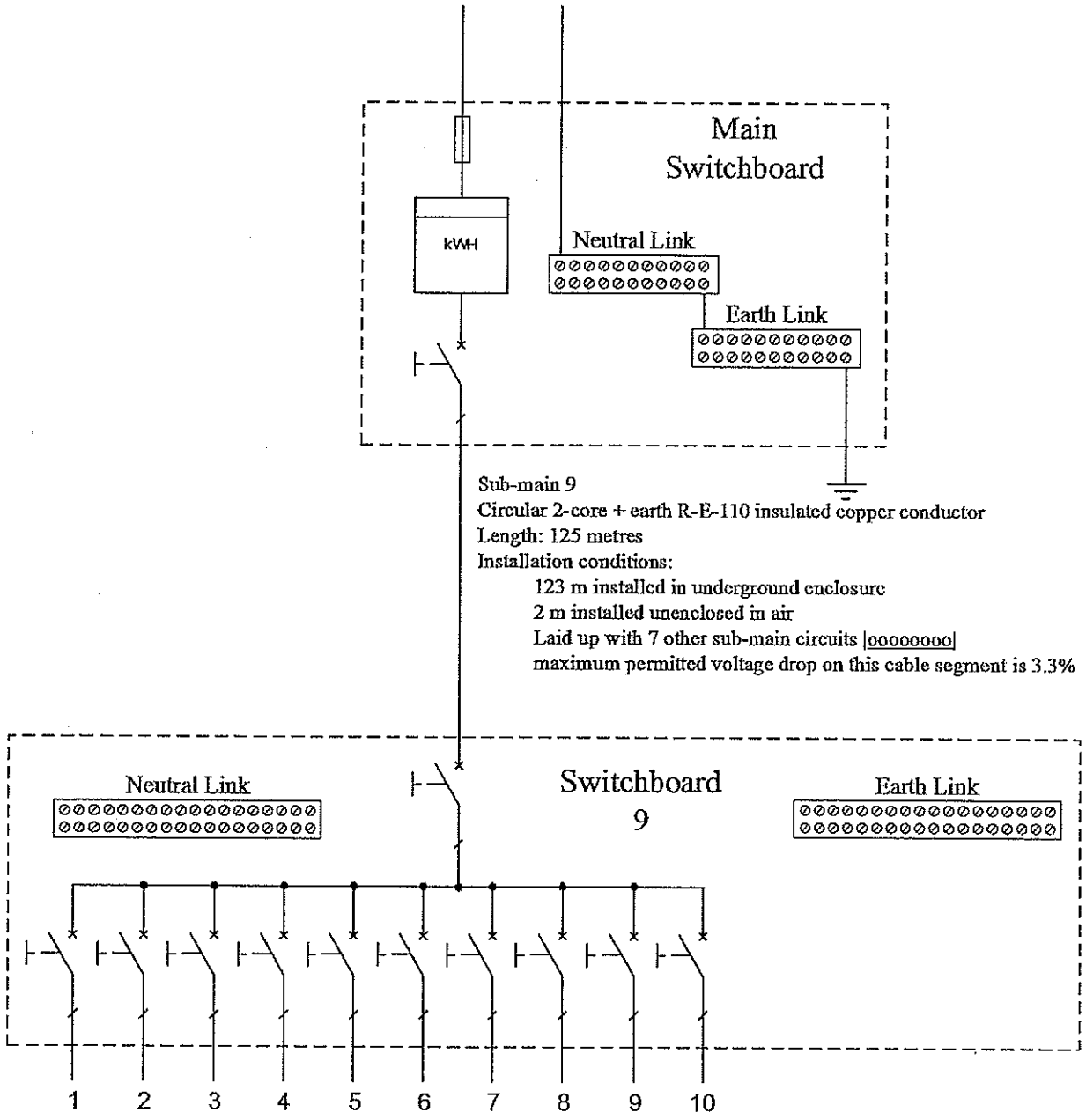


Figure 4

SECTION C – (Cont'd)



Circuit	Description	Qty	Rating
1	Lighting	16	60W each
2	Lighting	18	60W each
3	1-ph single socket outlet	8 double	10 A each
4	1-ph single socket outlet	5 double + 6 single	10 A each
5	1-ph single socket outlet	6 double + 4 single	10 A each
6	1-ph single socket outlet	1	15 A
7	1-ph air conditioner	1	9.5 A
8	1-ph 180 litre, 3.45kW QRHWS	1	15 A @ 230V
9	1-ph cook top	1	8.6 kW @ 230V
10	1-ph wall oven	1	4.2 kW @ 230V

Figure 5

SECTION C – (Cont'd)

QUESTION 7. (3 Marks)

Calculate the maximum demand of the single-phase sub-main to Unit 9.
Enter required information for each load description as listed in the following Table.
Complete the Table fully – marks are deducted for each incomplete or incorrect line.

Load group	Load description	Qty	Calculation	Demand
Ai	Lighting	*16+18 = 34*	*3 + 2*	*5.0*
Bi	1 ph Power (10 A)	*16+16+16 = 48*	*10 + 5 + 5*	*20.0*
Bii	1 ph Power (15 A)	*1*	—	*10.0*
Bi	Air Conditioning	*1*	~~*Included in Bi above*~~ 9.5 x 0.75	*0.0* 7.1
F	Quick Recovery HWS under 100w/site	*1*	—	*15.0*
C	Cook-top	*1*	$\frac{0.5 \times 8600}{230}$	*18.7*
C	Wall oven	*1*	$\frac{0.5 \times 4200}{230}$	*9.1*
			Maximum Demand	**77.8**

Designated circuit to A/C

Maximum demand of the single-phase sub-main to Unit 9 is **77.8 A** + 7.1 A = 84.9 A

☒ Deduct 1 mark for each incorrect line or part thereof up to total available marks for this question.

SECTION C – (Cont'd)

QUESTION 8. (5 Marks)

The maximum demand of the 230 volt, sub-main to unit 9 was determined to be 75 Ampere. An 80 Ampere type D circuit breaker provides over-current protection at the point of origin for this cable. What would be the minimum size of the active, neutral and earth conductors for a 2-core and earth R-E-110 cable having circular copper conductors when installed in an underground trench together with seven (7) other similar sub-main cables when all eight (8) conduits are touching each other?

☒ No part marks. Every step and reference must be correct

Ref: Tz(4) Item 3

Derating (if applicable)

Standard used:	Table No used:	Column:	Derating factor:
AS/NZS 3008.1.1	26(2)	2	0.70

Required current carrying capacity: 80 / 0.7 = 114.3 A

Active conductor

Standard used:	Table No used:	Column:	Cross-sectional area:	Current carrying capacity
AS/NZS 3008.1.1	11	8	16 mm^2	115 Ampere

Neutral conductor

Standard used:	Table No used:	Column:	Cross-sectional area:	Current carrying capacity
AS/NZS 3008.1.1	11	8	16 mm^2	115 Ampere

Refer AS/NZS 3000:2007 Clause 3.5.2

Earth conductor

Standard used:	Table No used:	Column:	Cross-sectional area:
AS/NZS 3000	5.1	2	6 mm^2

* No part marks

SECTION C – (Cont'd)

QUESTION 9. (4 Marks)

The maximum demand of the 230 volt, sub-main to unit 9 was determined to be 75 Ampere, and the 2-core and earth R-E-110 cable had 10 mm^2 circular copper conductors, determine the voltage drop and state if it is within the specified limit of 3.3% when the route length is 125 metres.

☒ No part marks.
Every step and reference must be correct

rd used: AS/NZS 3008.1.1:1998

Table No: 42

4·29×1·155

mV/A.m rating: 4.29 3-phase = 4.95 1-phase

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

$$= \frac{125 \times 75 \times 4.95}{1000}$$

$$= 46.4\ V$$

Does this comply with the 3.3% specified limit?

3.3% of 230 V = 7.59 V So this arrangement is NOT acceptable

QUESTION 10. (3 Marks)

Final sub-circuit 3 supplies a load consisting of 10 A socket outlets. A 16 A Type C circuit breaker protects the circuit of 2.5 mm^2 V-90, TPS, 2-core and earth cable. Determine the maximum *measured* internal fault-loop impedance of the final sub-circuit, based on **240 V**, when supply is unavailable and the ambient temperature is 20°C.

$$Z_{int}\ \text{measured} = R_{PHE} \times \frac{U}{U_0}$$

$$= 1.24 \times \frac{240}{230}$$ (2.00 is from Table 8.2 of AS/NZS 3000)

$$= 1.29\ \Omega$$

☒ No part marks.

OR

T8·1 for a 16A Type C C/B

$Z_s = 1.92\ \Omega$

Z_{int} (with no supply) = 0·8X0·8X1·92 = 1·23 @ 23

$1.23 \times \frac{240}{230} = 1.28\ \Omega$

SECTION C – (Cont'd)

Table 3 — Communal Schedule

This load connects to two single-phase meters.

Location	Appliance	A
Outside Unit 1 Garage	18 W Bollard	0.15
Outside Unit 2 Garage	18 W Bollard	0.15
Outside Unit 3 Garage	18 W Bollard	0.15
Outside Unit 4 Garage	18 W Bollard	0.15
Outside Unit 5 Garage	18 W Bollard	0.15
Outside Unit 6 Garage	18 W Bollard	0.15
Outside Unit 7 Garage	18 W Bollard	0.15
Outside Unit 8 Garage	18 W Bollard	0.15
Outside Unit 9 Garage	18 W Bollard	0.15
Outside Unit 10 Garage	18 W Bollard	0.15
Outside Unit 11 Garage	18 W Bollard	0.15
Outside Unit 12 Garage	18 W Bollard	0.15
Outside Unit 13 Garage	18 W Bollard	0.15
Outside Unit 14 Garage	18 W Bollard	0.15
Outside Unit 15 Garage	18 W Bollard	0.15
Outside Unit 16 Garage	18 W Bollard	0.15
RH side driveway entry	18 W Bollard	0.15
LH side driveway entry	18 W Bollard	0.15
Barbecue area	500 W halogen flood	2.7
	500 W halogen flood	2.7
	500 W halogen flood	2.7
	500 W halogen flood	2.7
Swimming pool area	500 W halogen flood	2.7
	500 W halogen flood	2.7
	500 W halogen flood	2.7
	500 W halogen flood	2.7
	Pool pump (hard-wired)	4.5

SECTION C – (Cont'd)

QUESTION 11. (4 Marks)

Calculate the maximum demand of the ***whole*** installation detailed in ***Figure 4*** and ***Figure 5*** if each of the units has identical electrical loading and the Communal loading detailed in Table 3 is included.

Enter required information for each load description as listed in the following Table.

Complete the Table fully – marks are deducted for each incomplete or incorrect line.

5units 5units 6units

Load group	Load description	Qty	Calculation	Demand (Red)	Demand (White)	Demand (Blue)
Ai	Lighting	*5,5,6*	— *5 + (6 x 0.25)*	*6.0*	*6.0*	*6.5*
Bi	1 ph Power (10 A)	*5,5,6*	*10+(5 x 5)* *15+(6 x 3.755)*	*35.0*	*35.0*	*37.5*
Bii	1 ph Power (15 A)	*5,5,6*	—	*10.0*	*10.0*	*10.0*
D	Air Conditioning	*5,5,6*	9.5x5x0.75 ~~*Included in load group Bi*~~ 9.5x6x0.75	35.6 ~~0.0~~	35.6 ~~0.0~~	42.8 ~~0.0~~
F	Quick Recovery HWS	*5,5,6*	*5 x 6* *6 x 6*	*30.0*	*30.0*	*36.0*
C	Cook-top	*5,5,6*	— *6 x 2.8*	*15.0*	*15.0*	*16.8*
C	Wall oven	*5,5,6*	*Included above*	*0.0*	*0.0*	*0.0*
H	Communal Circuit 1 – 18 Bollards	*18*	*18 x 0.15*	*2.7*		
H	Communal Circuit 2 – 4 Halogen floods	*4*	*4 x 2.7*	*10.8*		
H	Communal Circuit 3 – 4 Halogen floods	*4*	*4 x 2.7*		*10.8*	
i	Communal Circuit 4 – swimming pool pump	*1*	*1 x 2*		*4.5*	
				109.5 + 35.6	*111.3* + 35.6	*106.8* + 42.8

Designated circuit to A/C

☒ Deduct 1 mark for each incorrect line or part thereof up to total available marks for this

Maximum demand of the installation is **111.3 A** + 35.6 = 146.9A

☒ Deduct 1 mark for incorrect Maximum demand.

SECTION C – (Cont'd)

QUESTION 12. (3 Marks)

Calculate the maximum demand, based on the energy demand method, of the three-phase, **230/400** volt sub-main to a portion of a shopping complex using the floor area details in Table 4 below. Complete the maximum demand Table (Table 4)

Table 4 — Shopping centre floor area

Occupancy	Floor area (m^2)	Equipment	Average energy demand (VA/m^2)	Total energy demand (kVA/m^2)
Shop 1	150	Light / power	*150 x 70 = 10 500*	*15*
		Air conditioning	*150 x 30 = 4 500*	
Shop 2	180	Light / power	*180 x 70 = 12 600*	*18*
		Air conditioning	*180 x 30 = 5 400*	
Shop 3	180	Light / power	*180 x 70 = 12 600*	*18*
		Air conditioning	*180 x 30 = 5 400*	
Shop 4	150	Light / power	*150 x 70 = 10 500*	*15*
		Air conditioning	*150 x 30 = 4 500*	
Theatre	1200	Light / power	*1200 x 100*	*120*
Tavern	800	Light / power / ac	*800 x 80*	*64*
Basement car park	1200	Lighting	*1200 x 15*	*18*
			Total:	*268*

☒ Deduct 1 mark for each incorrect line or part thereof up to total available marks for this question.

Demand per phase: **89.3 kVA** [268 ÷ 3]

Maximum demand current per phase: **388 A** [89.3 x 10^3 ÷ 230]

☒ Deduct 1 mark for incorrect Maximum demand.

SECTION D – 20 Marks

INSTRUCTION: The questions in this section require some simple drawing. Ensure that the drawing is neat and legible. The use of pencil on the drawing is acceptable in this section only.

QUESTION 1. (4 Marks)

The diagram of *Figure 6* following represents the main switchboard in a domestic installation. The diagram also shows five (5) final sub-circuits (earthing conductors only) that the switchboard supplies. Note that the diagram does not show all equipment the switchboard supplies. Details of the installation are as follows:

The consumer mains are 3-phase 400 V comprising four (4) 25 mm^2 V-90 SDI cables enclosed in HDUPVC conduit. Double insulation is maintained up to the supply terminals of the service protective devices, which provide short circuit protection.

The consumer mains do not have short circuit protection on the supply side.

Single-insulated cables are used to connect the equipment on the load side of the service protective devices.

size of earth
T5.1

The main switchboard supplies, in part, the following circuits:

• Circuit 1	Lighting	1.5 mm^2 TPS twin and earth.	1.5 mm^2
• Circuit 2	Power	2.5 mm^2 TPS twin and earth.	2.5 mm^2
• Circuit 3	Power	2.5 mm^2 TPS twin and earth.	2.5 mm^2
• Circuit 4	Range	6 mm^2 TPS twin and earth.	2.5 mm^2
• Circuit 5	Water heater	4 mm^2 TPS twin and earth.	2.5 mm^2

(a) Draw on the diagram all necessary **earthing** and **equipotential bonding** conductors necessary to effect the MEN system of earthing. DO NOT show active and neutral conductors.

(b) Identify on each cable the **minimum** conductor size.

Only correct connections, labelling and conductor sizes gain marks.

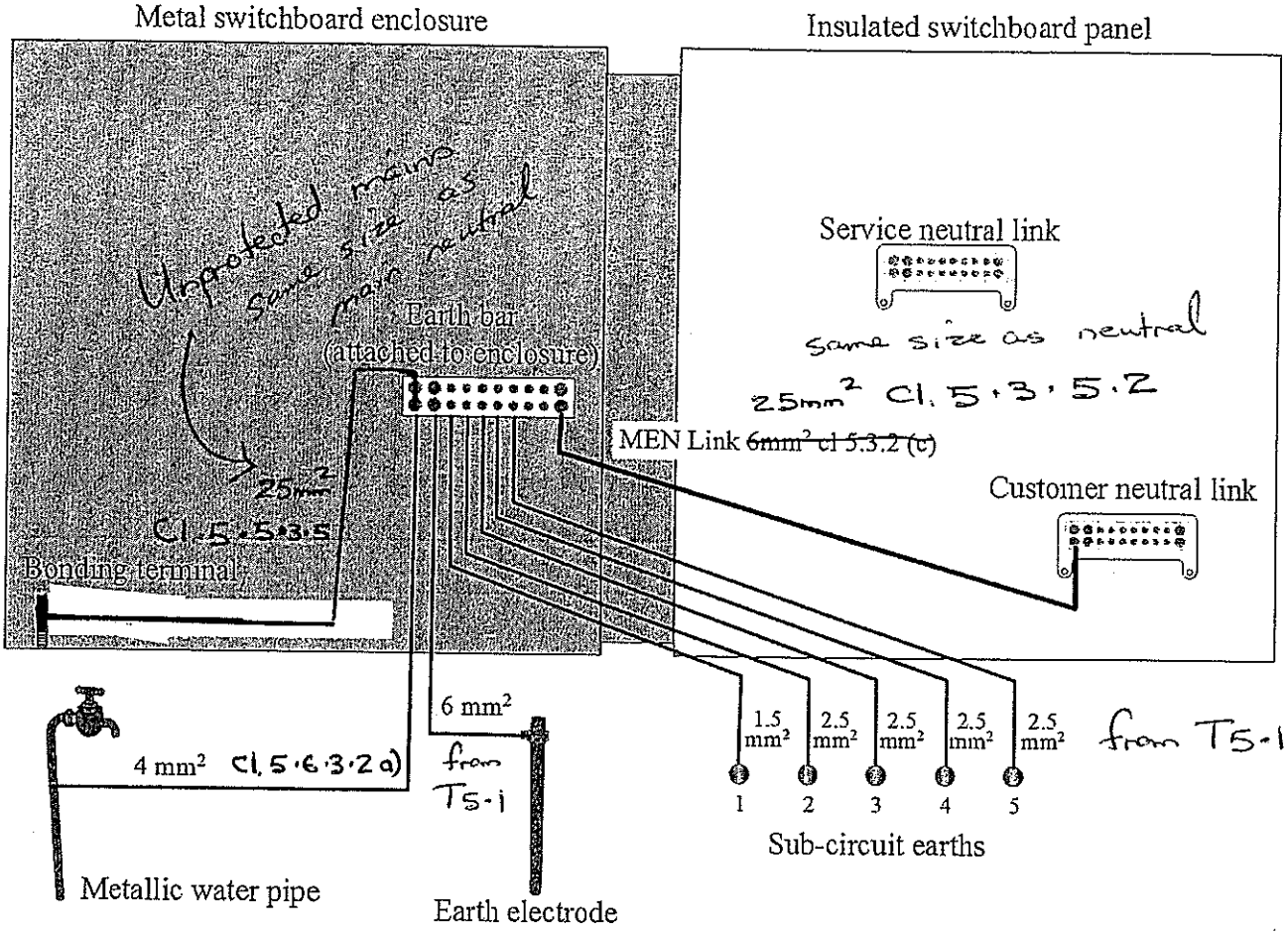


Figure 6

* C.M's are not protected

* Deduct 1 mark for each error *

SECTION D – (Cont'd)

QUESTION 2. (3 Marks)

Determine the suitability of a 63 A type D circuit breaker having a tripping characteristic in the range shown in *Figure 7*. The circuit breaker is to protect a sub-main circuit having a maximum demand current of 55 A. The prospective fault current at the origin of the sub-main is 700 A. Show all working and show on the diagram how you arrived at the answer.

☑ 1 mark for plotting on graph

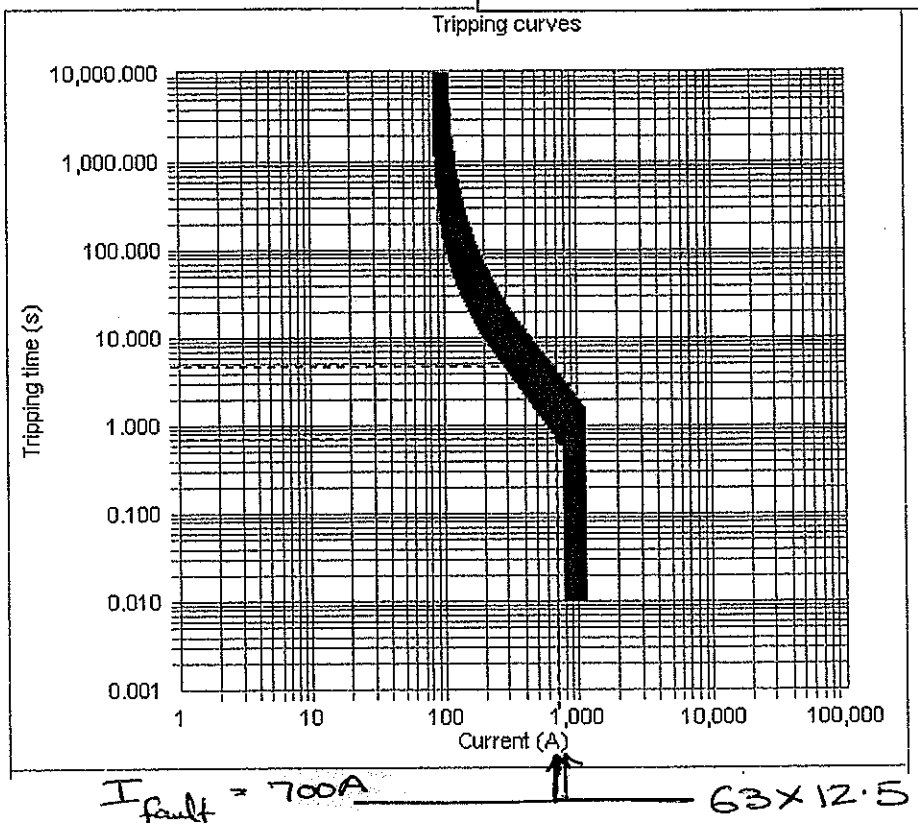


Figure 7

Circuit breaker would trip between 0.7 second to 5 second making it suitable

☑ 2 mark for answer

Disconnection time for submains is - maximum-5 seconds — Clause 1·5·5·3(d)(ii).

Therefore, the C/B is suitable.

SECTION D – (Cont'd)

☑ Test is outlined on page 28 of AS/NZS 3017:2007
☒ There are 11 responses required
Deduct 1 mark for each incorrect response
☒ NO part marks (ie 1 or 0)

QUESTION 3. (7 Marks)

INSTRUCTIONS: Bla

Write the appropriate word, words or information in the spaces provided.

Test:

Polarity test of single pole switch using voltage indicator with supply available.

Test sequence:

1. Check operation of *Voltage* . *Indicator* .
2. Energise the circuit
3. Connect one test lead to a known *Earth* .
4. Connect the other test lead to one *Terminal* of the switch under test.
5. Operate the switch.
6. Move the test lead to the other *Terminal* .
7. Operate the switch.
8. Test results should indicate:

   With switch on *Supply* . *Voltage* .at *Both* . terminals

   With switch off *Supply* . *Voltage* .at *One of the* .terminals
   OR zero volts at the other terminal
9. Disconnect the test leads.

SECTION D – (Cont'd)

QUESTION 4. (3 Marks)

Complete the following diagram to show how the Insulation Resistance Tester would connect when testing a single-phase circuit supplying an electric range and protected by a 32 A circuit breaker. Note that the MEN link and sub-circuit neutral are disconnected and the circuit breaker is turned off.

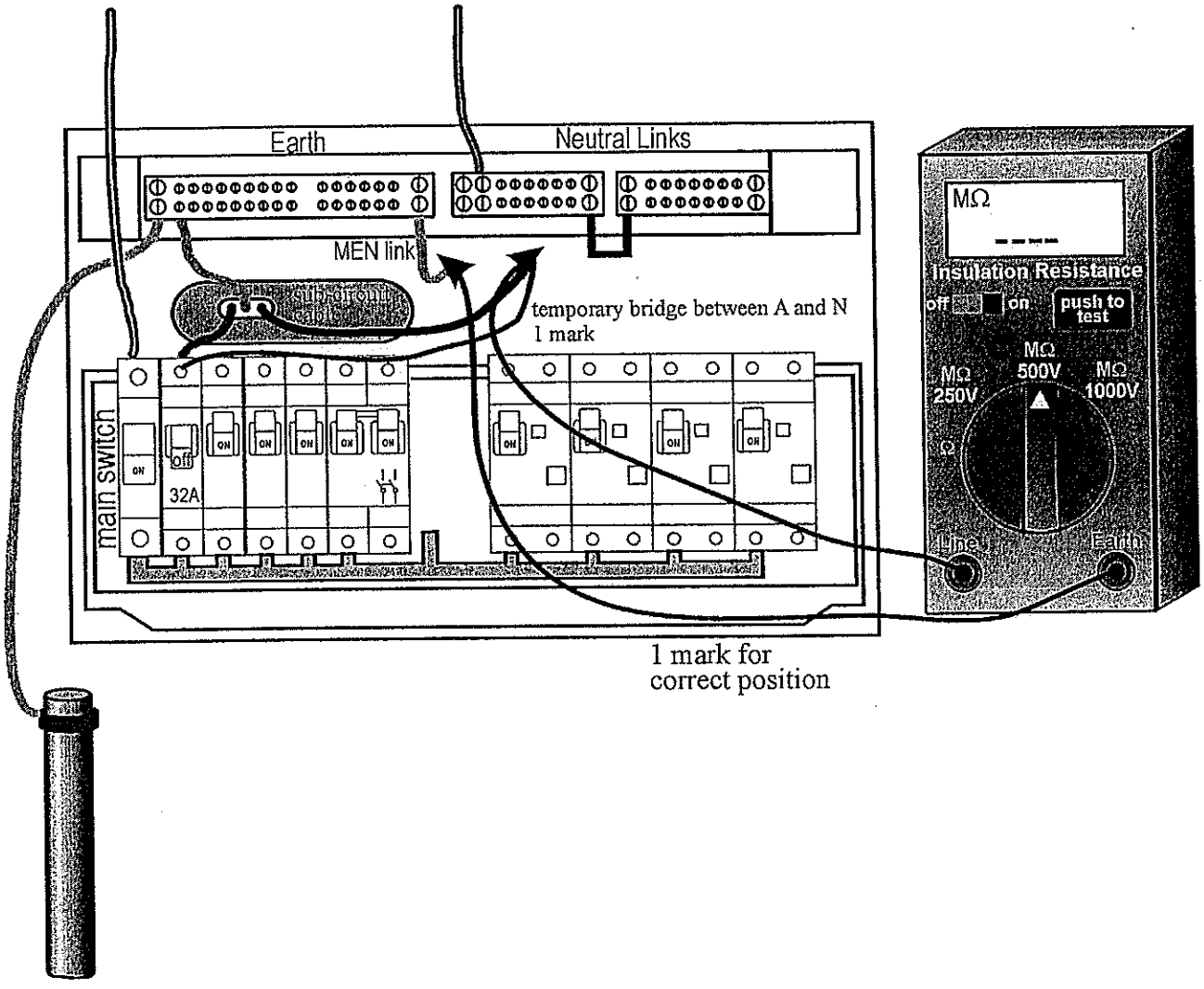


Figure 8

Figure 9 on the following page to satisfy the following. Note: Do NOT include any details for the electrician or tester.

Customer:	Ted E Bear, 22 Honeysuckle Drive, Bearsville. 2299.
Cross street:	Coronation Drive
Meter number:	12345
Electrician:	Ignore any reference
Installation details	Additional (new) power circuit comprising 8 single 10 A socket outlets in domestic residence and connected to supply.
Consumer mains:	Four by 16mm^2 SDI
Main earth electrode:	Directly below switchboard
Water service equipotential bond:	At water pipe entry at front of building on switchboard side of building

Test results:

Insulation resistance:	Water heater	5 MΩ
	Range	0.4 MΩ
	Other circuits	Infinity
Earth continuity:	Main earth	0.12 Ω
	Equipotential bond	0.18 Ω
	All other	<0.8 Ω
All other tests:	Correct	

QUESTION 5 (3marks)

CERTIFICATE OF COMPLIANCE – ELECTRICAL WORK

Customer COPY

CERTIFICATE NO: 000403

CUSTOMER DETAILS

Name	Ted E Bear,			Telephone Contact	
Address	22 Honeysuckle Drive, Bearsville.			Meter No:	12345
Cross Street	Coronation Drive	Postcode	2299.	NMI (if applicable)	

INSTALLATION WORK DETAILS Indicate the type of installation and types of work performed under this Notice

Type of Installation	☑ Residential	☐ Commercial	☐ Industrial	☐ Rural	☐ Other
Special Conditions	☐ over 100 amps	☐ High Voltage	☐ Hazardous Area	☐ Generator	☐ Unmetered Supply

1 mark

CERTIFICATE MUST BE ISSUED TO THE CUSTOMER FOR ALL ELECTRICAL WORK

Work of the following type must ALSO be notified to the **ELECTRICITY DISTRIBUTOR (DNSP)**

☐ New Installation ☐ Network connection or metering

☑ Additions or alterations to a switchboard or associated equipment ☐ Defect Rectification No:

DETAILS OF EQUIPMENT *Describe the equipment and estimate load increase of the work affected by this Notice. If insufficient space attach separate sheets.*

EQUIPMENT	RATING	No.	PARTICULARS OF WORK
☐ Switchboards			
☐ Circuits			
☐ Lighting			
☑ Socket-outlets	10A	12	
☐ Appliances			
Estimated increase in load A/ph	5A		☑ Increased load is within capacity of installation/service mains
☑ Work is connected to supply			☐ Work is not connected to supply pending inspection by DNSP

1 mark

The work has been carried out or supervised by: *Licence No:*

TEST REPORT *Indicate the relevant tests and checks that have been performed on the work. If test records are provided attach as separate sheets.*

☑ Earthing system integrity Ω	☑ Residual current device operation
☑ Insulation resistance MΩ	☑ Visual check that installation is suitable for connection to supply
☑ Polarity	☐ Stand-alone power system complies with AS 4509
☑ Correct circuit connections	☑ Fault loop impedance (if necessary) OPTIONAL

1 mark

I confirm that I have carried out the above tests and visually checked that the installation work described in this Certificate complies with AS/NZS 3000 and is suitable for its intended use.

Name: *Licence No:*

Signature: *Date of Testing:*

CERTIFICATION

I, the Electrical Contractor give notice to the Customer and _____ (Name of DNSP or OFT), that the work described in this Certificate has been completed in accordance with the Electricity (Consumer Safety) Regulation 2006

Name: *Licence No:*

Signature: *Date of Notice:*

Address: *Telephone No. or Other Contact*

ELECTRICITY DISTRIBUTOR (DNSP) REMARKS

Inspected by: *Date*

Comments:

neca

Figure 9