



Given Name

Student Number

Centre

Signature

SPECIAL EXAMINATION

All copies of the examination paper are to be returned to the examination supervisor

8 April 2009

WITH
ANSWERS

6077AC Electrical Systems Safety – Capstone Assessment

Time allowed – Three hours plus Ten minutes reading time

25 Pages in this Question Booklet

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 3008:1.1:1998.
- 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 | Marks Possible | Marks Achieved |
|--------------|----------------|----------------|
| A | 15 | |
| B | 20 | |
| C | 28 | |
| D | 37 | |
| TOTAL | 100 | |

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 are to be attempted.
- All questions are to be answered in the space provided in this Question Booklet. Answers to Section A (multiple choice questions) are to be recorded on the Answer Sheet attached to this Question Booklet (Page 23).
- 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.
- Equation Sheets are on Pages 24 and 25.

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 – (Cont'd)

QUESTION 5. (1 Mark)

What is the minimum clearance for insulated aerial conductors above a porch awning?

- (a) 2 m
- (b) 0.5 m
- (c) 1 m
- (d) not permitted

QUESTION 6. (1Mark)

What are the requirements for installing insulated unsheathed cables in trunking systems?

- (a) Cables shall be effectively retained in position and, where installed in a readily accessible position, shall not be removed without the use of tools
- (b) Covers shall be effectively retained in position and, where installed in a readily accessible position, shall not be removed without the use of tools
- (c) Trunking may only be used to enclose unsheathed cables in areas not readily accessible
- (d) Unsheathed cables are not permitted to be installed in cable trunking

QUESTION 7. (1Mark)

What would be an acceptable level of insulation resistance for a 230 V lighting circuit?

- (a) 50 ohms
- (b) 500 ohms
- (c) 50 M ohms
- (d) 500 k ohms

QUESTION 8. (1Mark)

Where a common neutral is used to supply a multiphase circuit for an oven hotplate combination, the size of the neutral must:

- (a) have a current carrying capacity equal to the sum of the protective devices supplying each circuit
- (b) have a current carrying capacity equal to the current carrying capacity of the smallest associated active conductor
- (c) have a current carrying capacity equal to the current carrying capacity of the largest associated active conductor
- (d) be at least 4 mm²

SECTION A – (Cont'd)

QUESTION 13. (1Mark)

A certificate of Compliance must be finalised when an electrical installation is tested and should be certified by:

- (a) the customer
- (b) the installing tradesperson
- (c) the electrician who completed the test
- (d) the electrical contractor

QUESTION 14. (1Mark)

The minimum disconnection time for protection against indirect contact for a fixed cooktop is:

- (a) unspecified
- (b) 0.4 sec
- (c) 400 ms
- (d) 5 sec

QUESTION 15. (1Mark)

A circuit breaker installed to protect a circuit from overcurrent must operate when:

- (a) before the circuit current exceeds 1.45 the circuit breaker rating
- (b) before the circuit current exceeds the circuit breaker rating
- (c) before the circuit conductors exceed 40 °C
- (d) before the circuit conductors exceed 100 °C

SECTION B – (Cont'd)

QUESTION 4. (2 Marks)

What are the requirements for switching devices operating in a circuit fed from an isolated inverter?

.....
.....
.....

AS/NZS 3000/2007 Reference (Clause number.....)

QUESTION 5. (2 Marks)

What are the requirements for soldered earth connections?

.....
.....
.....

AS/NZS 3000/2007 Reference (Clause number.....)

QUESTION 6. (2 Marks)

Identify an acceptable method for determining the maximum demand of a domestic circuit supplying an oven/grill and cook top.

.....
.....
.....

AS/NZS 3000/2007 Reference (Clause number.....)

QUESTION 7. (2 Marks)

Is it permissible to replace a single socket-outlet with a multiple socket-outlet when the existing circuit is not RCD protected, without upgrading the circuit to be RCD protected?

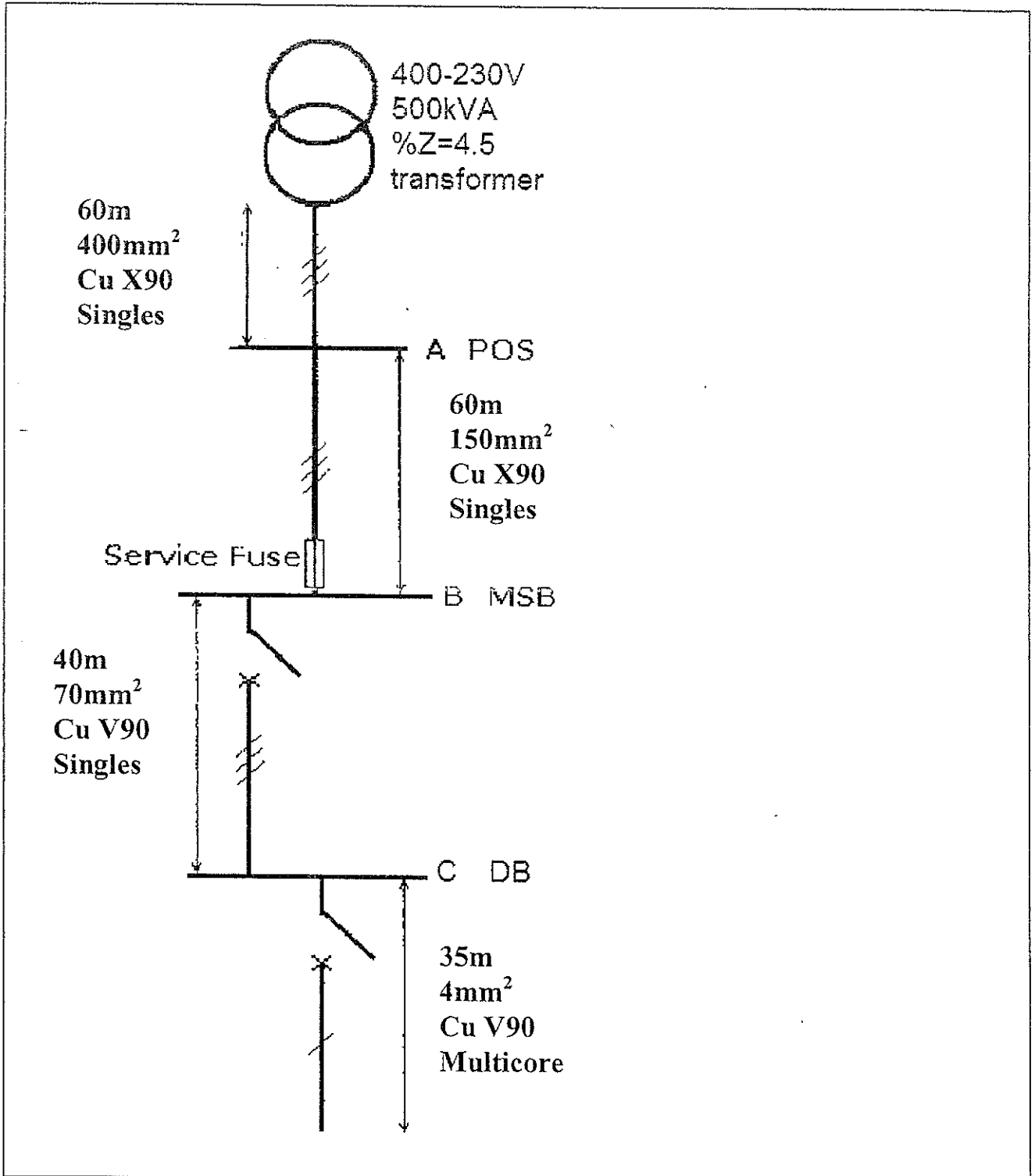
.....
.....
.....

AS/NZS 3000/2007 Reference (Clause number.....)

SECTION C – (28 Marks)

INSTRUCTIONS: This section involves calculations. Show all workings in the space provided. Marks will be awarded accordingly. Answers are to be highlighted or underlined.

QUESTION 1. (4 Marks)



1 1

SECTION C – (Cont'd)

QUESTION 2. (3 Marks)

An irrigation pump is supplied by 3 phase supply installed 500 mm underground over a distance of 45 m. The circuit comprises of 3 x 4 mm² V90 TPI cables run with a 2.5 mm² earth cable and the circuit is protected by a 25 A type D circuit breaker. Determine whether this installation satisfies the requirements for fault loop impedance ensuring the protective device will operate properly.

.....

.....

.....

.....

.....

.....

QUESTION 3. (3 Marks)

A single phase circuit supplying a domestic single socket outlet for a pool pump is supplied by a 20 A type combination RCD using a V75 TPS cable installed in HDPVC conduit 40 m from the main switchboard. The supply voltage is 230 V and the voltage drop in the consumers mains is negligible. Calculate the minimum size cable that may be used for the circuit based on voltage drop.

.....

.....

.....

.....

.....

.....

QUESTION 4. (3 Marks)

In a school workshop, determine the maximum distance a single phase 15 A socket outlet for the supply to a single phase welder can be installed from the distribution board given that the circuit will be using 4 mm² TPS cable installed partially surrounded by thermal insulation. The maximum volt drop allowed for the circuit is 4.9 V and the circuit is protected by a 20 A type D circuit breaker.

.....

.....

.....

.....

.....

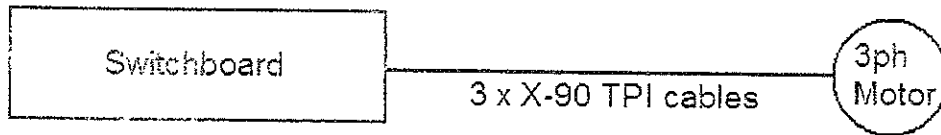
.....

SECTION C – (Cont'd)

QUESTION 7. (6 Marks)

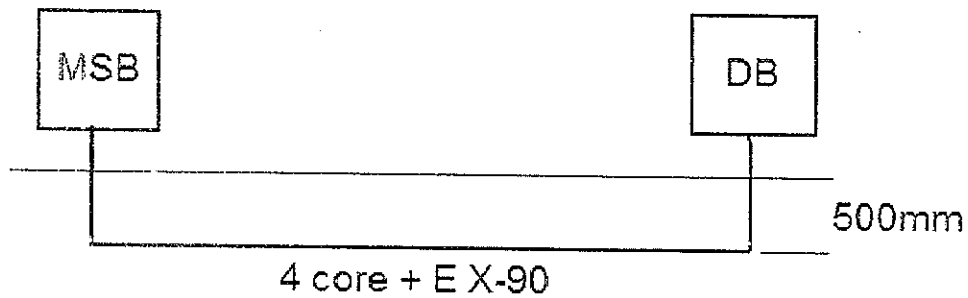
For the following installations, select the minimum permissible cable sizes for correct current carrying capacity, giving the appropriate references;

- 2 (a) A 3 phase final sub circuit to a lathe drawing 33 A per phase is installed in metallic conduit clipped to a wall. The cable type used is X90 TPI copper cable.



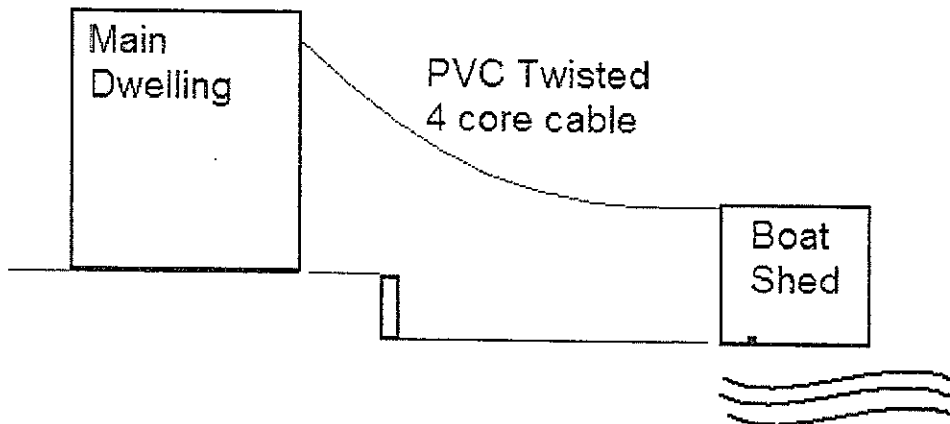
Cable size:.....Reference:.....

- 2 (b) A 4 core and earth, X-90, multicore copper, 3 phase submain is installed buried direct in the ground complying with category B requirements. The demand on the cable is 68 A per phase.



Cable size:.....Reference:.....

- 2 (c) A twisted 4 core PVC insulated aerial cable drawing 73 A, is installed in an area where the wind speed is 2 m/s.



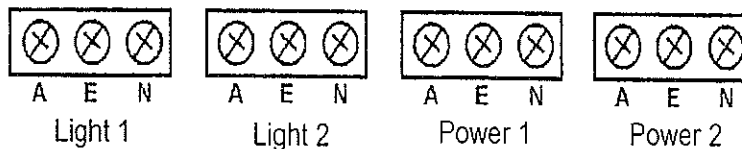
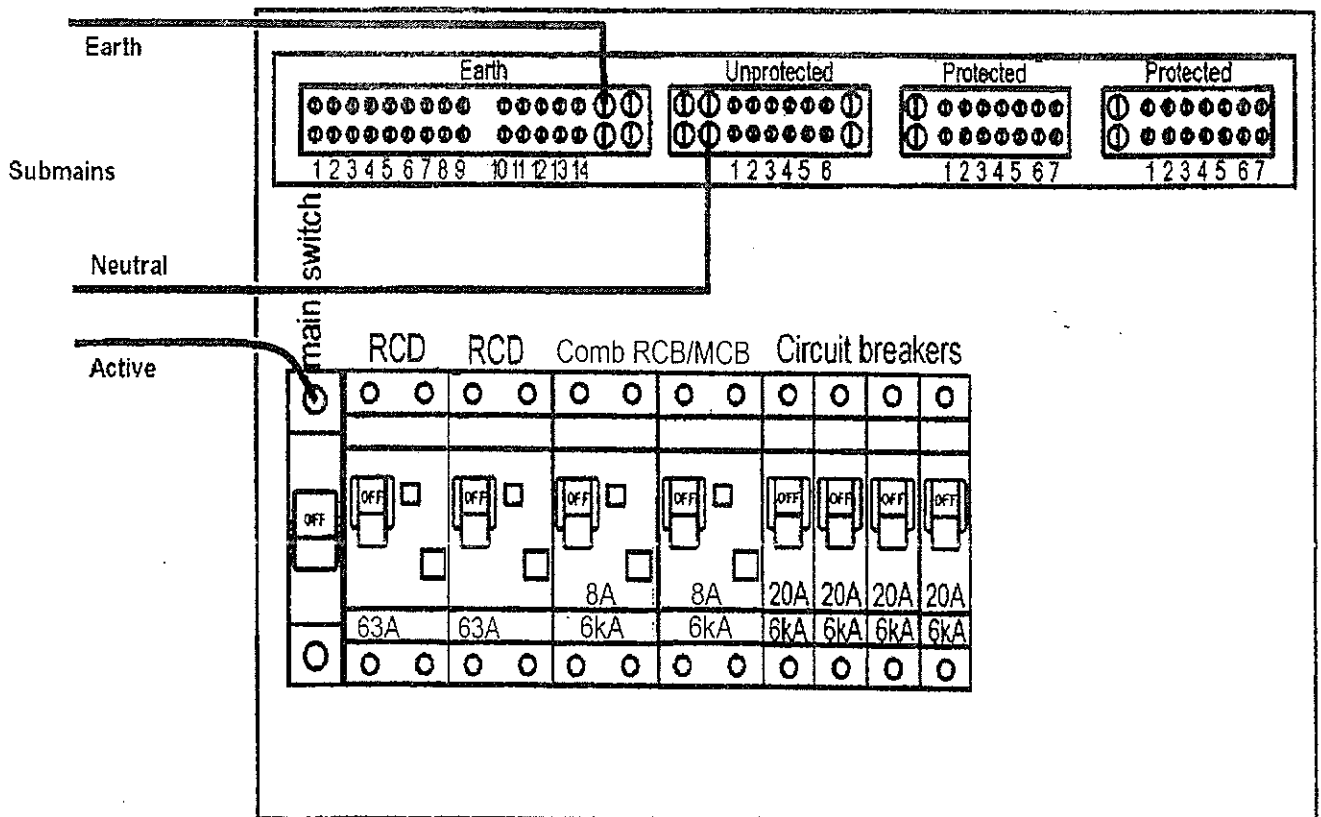
Cable size:.....Reference:.....

SECTION D – (37 Marks)

INSTRUCTIONS: Answer all the following questions in the spaces provided. Some questions require drawing which must be neat and legible. Try to avoid lines crossing almost parallel when completing wiring diagrams to avoid any confusion as to which line exits the intersection.

QUESTION 1. (4 Marks)

The equipment shown below is for a distribution board for a living unit. The four final sub-circuits are to be connected using the breakers shown below. Show on the diagram the necessary Active, Neutral and Earth connections to supply these circuits.



SECTION D – (Cont'd)

QUESTION 3. (4 Marks)

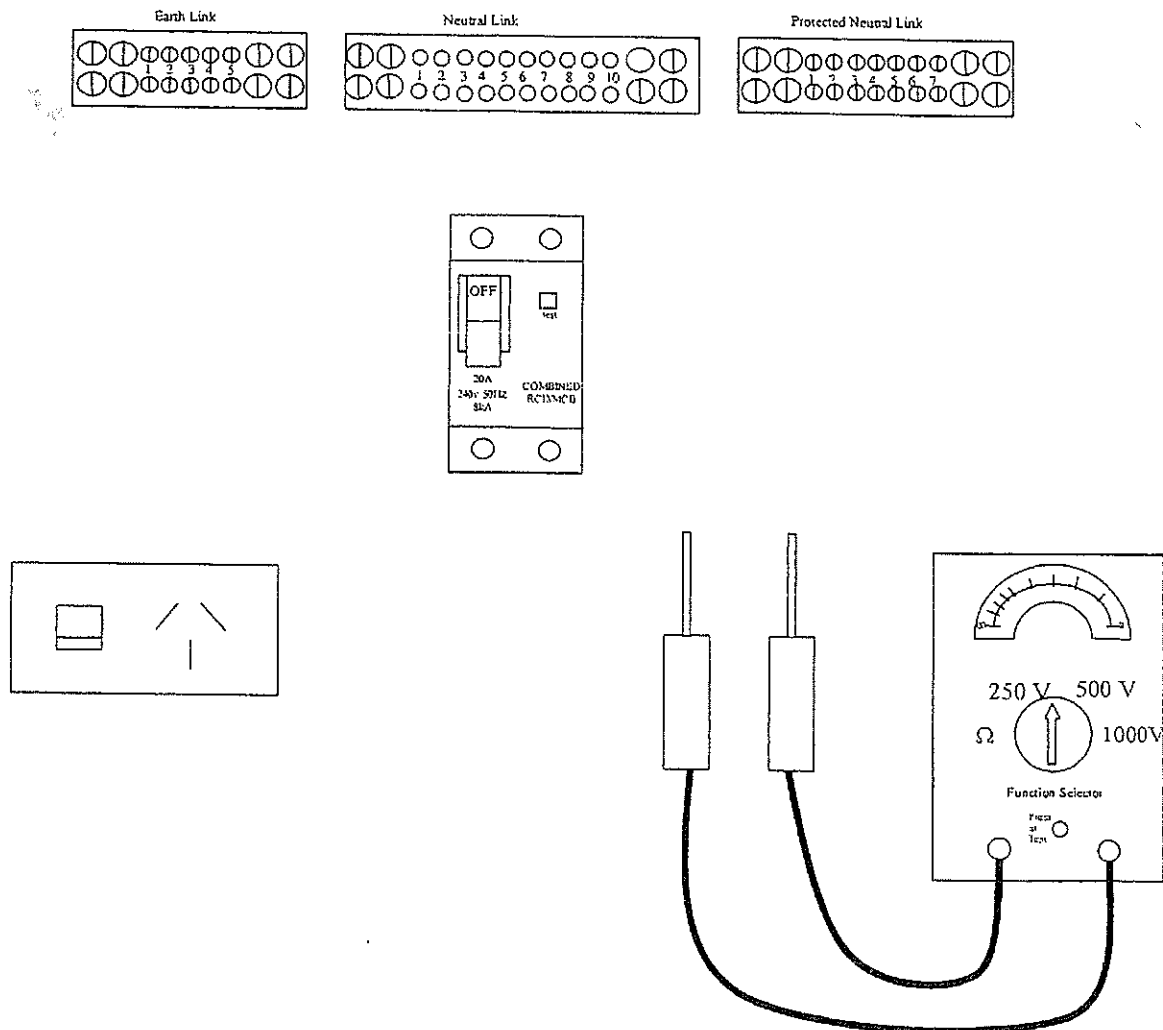
An insulation resistance test for a single phase low voltage power circuit is to be conducted.

- 2 (a) Draw and correctly label the appropriate circuit for this test to be carried out.
- 2 (b) State the position of the selector switch and the expected reading it would indicate.

Circle the correct answers.

Position: Ω , 250 V, 500 V, 1000 V

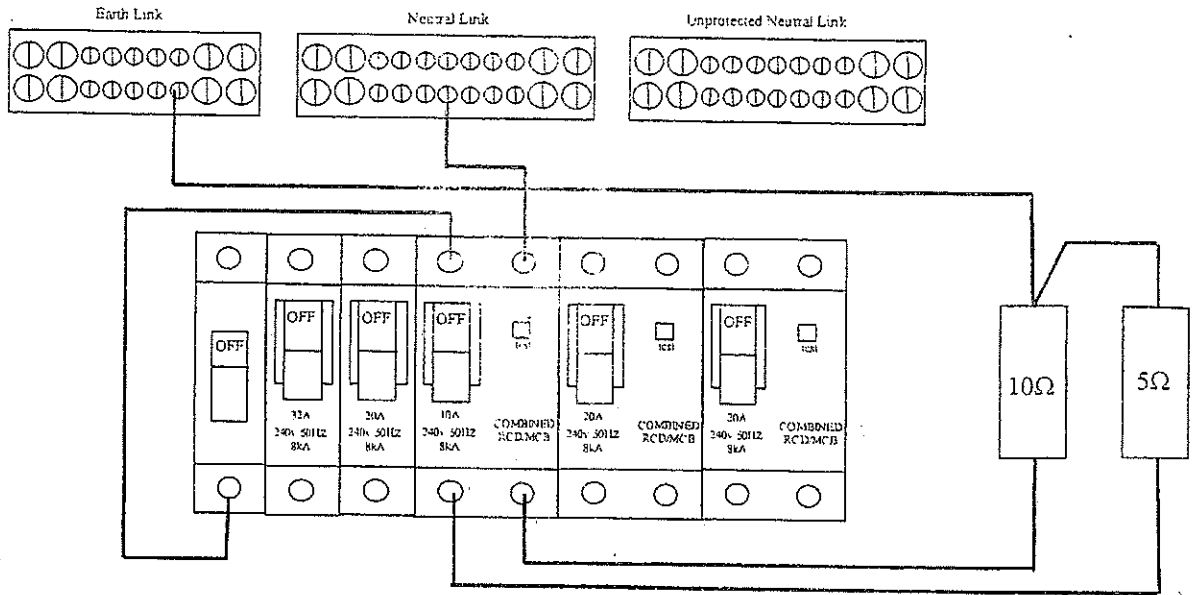
Results: 50 k Ω , 100 k Ω , 500 k Ω , 5 M Ω



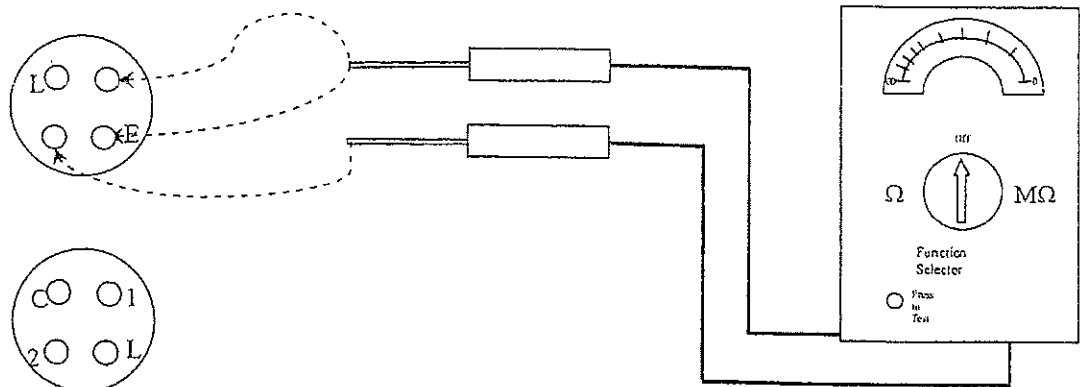
SECTION D – (Cont'd)

QUESTION 5. (4 Marks)

A polarity test is to be performed on a final sub-circuit containing light points. Record your results for the polarity test in the table below.



Switchboard connections



The results for correct polarity check would be:

| Combination | Result |
|-------------------------|--------|
| Active-neutral | Ω |
| Active-earth | Ω |
| Neutral-earth | Ω |
| Active-neutral Switched | Ω |
| Active-earth Switched | Ω |
| Neutral-earth switched | Ω |

SECTION D – (Cont'd)

QUESTION 7. (5 Marks)

Calculate the maximum demand of a sub-main supplying a town house with the following load:

- 53 lighting points
- 5 ceiling fans
- 2 exhaust fans
- 6 single socket outlets
- 16 double socket outlets
- 6.5 kW cook top
- 4.0 kW oven
- 5.0 kW ducted air conditioner (23 A)
- 3.6 kW quick recovery HWS
- 3.6 kW instantaneous HWS

| Load Group | Load | No | Calculation | Demand Amperes |
|------------|------|----|-------------|----------------|
| | | | | |
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Maximum demand:.....



Family Name

Given Name

Student Number

Centre

Signature

Answer Sheet – Section A (Multiple Choice Questions)

8 April 2009

SPECIAL EXAMINATION

6077AC Electrical Systems Safety – Capstone Assessment

Instructions:

- Enter your personal details in the top right hand corner of this sheet.
- Place an 'X' in the 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

SECTION B – (20 Mark)

INSTRUCTIONS: In this part of the assessment, you are required to answer a range of questions by using AS/NZS3000/2007. For each question, you are required to supply an answer to the question and the clause from AS/NZS3000/2007 that relates to your answer. One mark will be awarded for the correct answer and one mark for the correct clause number.

QUESTION 1. (2 Mark)

What is the maximum disconnection time for a final sub-circuit supplying a socket outlet in a lounge room?

.....0.4seconds.....
.....
.....

AS/NZS 3000/2007 Reference (Clause number...1.5.5.3.diA....) 5.7.2(a)

QUESTION 2. (2 Mark)

At what distance from the edge of a pool would a colour bond perimeter fence need to be bonded?

..... within arms reach 1.25m from waters edge.....
.....
.....

AS/NZS 3000/2007 Reference (Clause number.....5.6,2.6...1.4.12.....) (iii)

QUESTION 3. (2 Mark)

Where double insulation is maintained from the point of supply to the load terminals of the protective devices for the sub-mains and final sub-circuits, what will determine the minimum size of the main earth conductor?

.....
In relation to the CSA of largest active conductor of the largest outgoing submain or final subcircuit.....
.....
.....

AS/NZS 3000/2007 Reference (Clause number...5.3.3.2.a..)

QUESTION 4. (2 Mark)

What are the requirements for switching devices operating in a circuit fed from an isolated inverter?

.....Switching devices shall operate in all live conductors of a separated circuit.....
.....
.....

AS/NZS 3000/2007 Reference (Clause number...7.4.4.....)

7.3.8.2.2
7.4.2(i)

Why are electrical installations divided into circuits?

.....Avoid danger and minimise inconvenience in the event of a fault and facilitate safe operation, inspection, testing and maintenance

.....
AS/NZS 3000/2007 Reference (Clause number.....1.6.5.....)

QUESTION 1 (Cont'd)

1 (a) Determine the phase impedance of the transformer.

$$S_{\text{Fault}} = S / Z\% = 500\text{k} / 0.045 = 11111.11 \text{ VA}$$

$$I = S_{\text{Fault}} / \sqrt{3}V = 11111.11 / \sqrt{3} \times 400 = 16.67 \text{ A}$$

$$Z = V / I = 230 / 16.67 = \underline{0.0138} \text{ } \Omega \text{ or } 13.8 \text{ m}\Omega$$

1 (b) Assuming the transformer has a phase impedance of $6 \text{ m}\Omega$, determine the maximum 3 \emptyset prospective fault current at the POS (point A), AS3008.1 has approximate tables to determine conductor resistance.

$$\text{Table 34 X90 } 400\text{mm}^2 \text{ } 60\text{m} = 0.0039 \Omega$$

$$Z_{\text{total}} = 0.006 + 0.0039 = 0.0099 \Omega$$

$$I = V / Z = 230 / 0.0099 = \underline{23.2 \text{ kA}} \quad \text{at } 10^\circ \text{C}$$

1 (c) Determine the system impedance, for a 3 \emptyset prospective fault current of 12kA at point 'C' the Sub Board

$$Z = V / I = 230 / 12\text{kA} = \underline{0.0192 \Omega}$$

1 (d) If the Active Earth fault current is 4.8 kA at the SB (point C), determine the maximum earth fault current at the end of the final sub circuit assuming all fault current flows through the MEN at the MSB.

$$Z_{\text{ext}} = V / I = 230 / 4.8\text{kA} = 0.0479 \Omega$$

$$Z_{\text{FSC}} = Z_a + Z_e = 0.196 + 0.315 = 0.511 \Omega$$

$$Z_{\text{total}} = 0.511 + 0.0479 = 0.5589 \Omega$$

$$I_f = V / Z_t = 230 / 0.5589 = \underline{411.5 \text{ A}} \quad \text{at } 15^\circ \text{C}$$

SECTION C – (Cont'd)

QUESTION 5. (3 Marks)

Three 3 phase circuits supplying similar loads are installed spaced on a single perforated cable tray. If the current drawn by each circuit is 35A per phase, determine



Ref: T2(1) Table 1

(a) The de-rating factor applied to each cable and reference.

De-rating factor: *0.96*.....Reference :.....T23 item 15

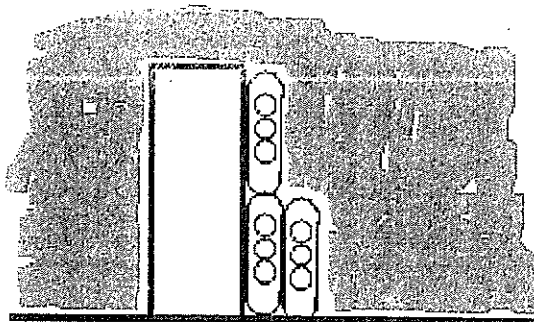
(b) The minimum current rating of the cables to supply the load.

Current rating:.....*35A*.....*30.7A* *35A x 0.96 = 33.6A*
33.6A < 35A
Ref: T23 Table 1

QUESTION 6. (3 Marks)

A 20A hot water circuit, a 20A cook top circuit and a 20A oven circuit are grouped together and clipped to the ceiling joist partially surrounded by bulk thermal insulation. Determine:

Joist
grouped on
insulation on
a surface



Ref: T2(2) Table 1

(a) The de-rating factor applied to each cable and reference.

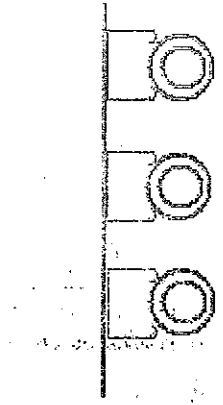
De-rating factor:.....*0.7*.....Reference:.....T22 item 2 col 6

(b) The minimum current rating of the cables to supply the load.

Current rating.....*28.6A*..... $\left(\frac{20}{0.7} = 28.6A \right)$

QUESTION 8. (3 Marks)

A three-phase, 400V sub-main has a route length of 42 meters and a maximum demand of 138A. The cables used are single core MIMS that are clipped to supports spaced from the wall be 20mm. The cable's temperature will not exceed 90°C.

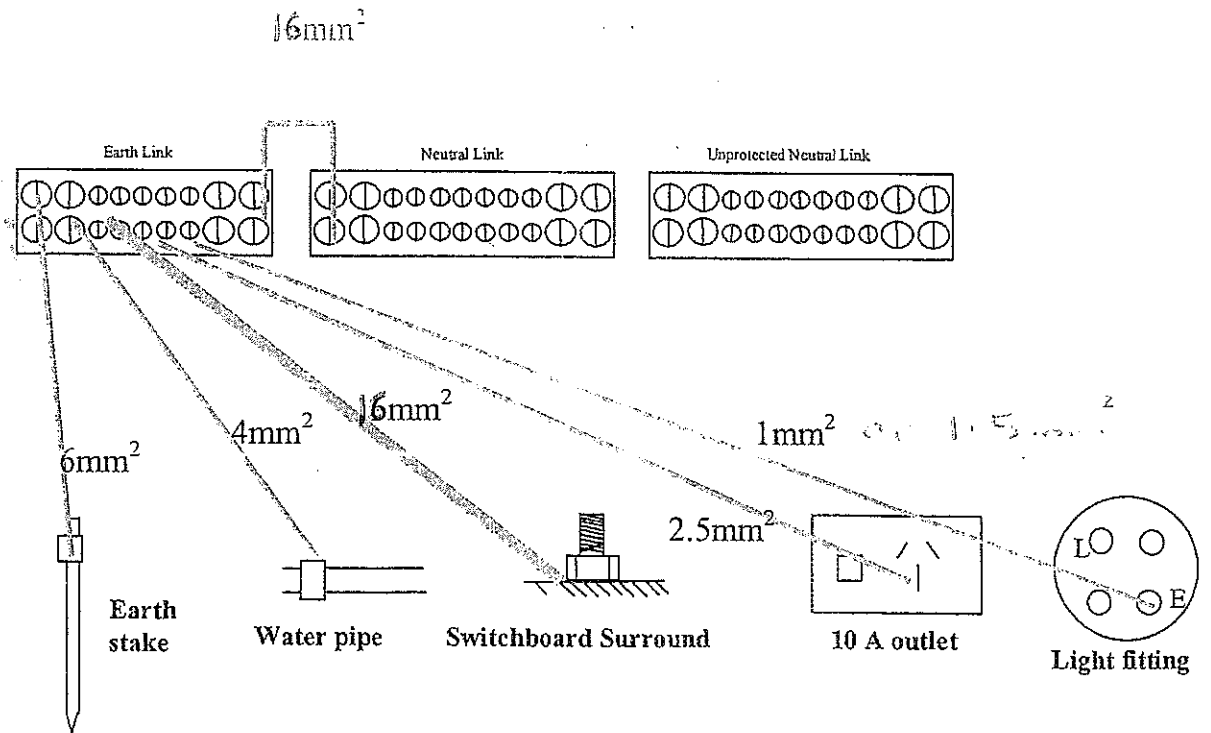


Cable size: ...25mm².....Reference:.....T18 Col5.....(3marks)

QUESTION 2 (4 marks)

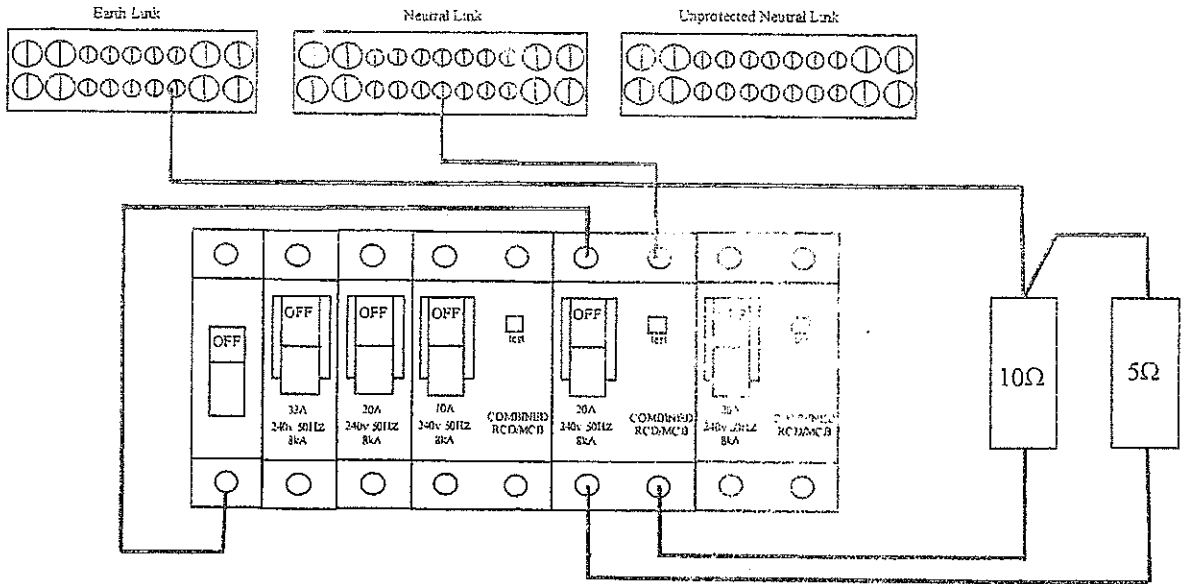
A domestic installation is supplied with 16mm^2 double insulated consumers mains with 16mm^2 BW used for meter wiring.

- (a) Draw and correctly identify all cables used in the basic earthing system for the installation. (2marks)
- (b) Nominate the minimum size cables to be used. (2marks)

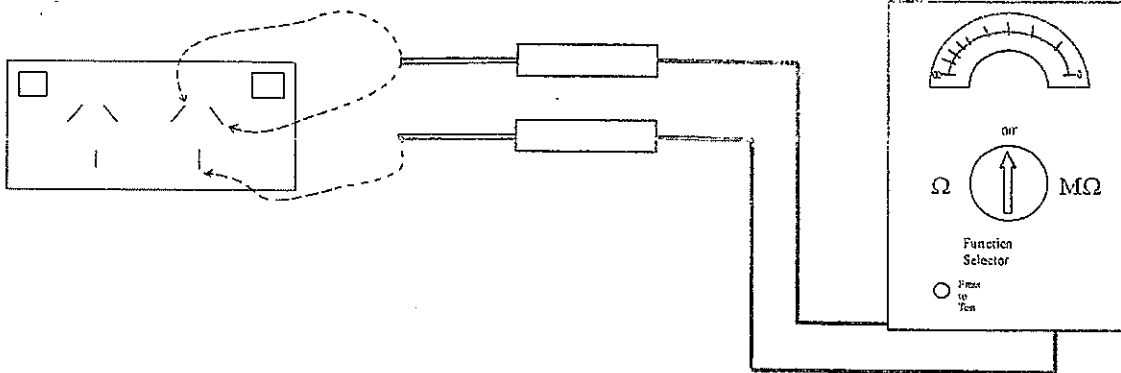


QUESTION 4 (4marks)

A polarity test is to be performed on a final sub-circuit containing socket outlets. Record your results for the polarity test in the table below. (3marks)



Switchboard connections



Select correct meter position, circle correct selection, 3Ω, 500Ω, 250V, 500V, 100V (1mark)

The results for correct polarity check would be: (3marks)

| Combination | Result |
|-------------------------|--------|
| Active-neutral | 15Ω |
| Active-earth | 5Ω |
| Neutral-earth | 10Ω |
| Active-neutral Switched | ∞Ω |
| Active-earth Switched | ∞Ω |
| Neutral-earth switched | 10Ω |

(3 marks)

* could be reversed number

$\left. \begin{array}{l} \infty \Omega \\ \infty \Omega \\ 10 \Omega \\ 15 \Omega \\ 5 \Omega \\ 10 \Omega \end{array} \right\}$

QUESTION 6 (7 marks)

Calculate the maximum demand of a 400V three phase sub-main to a factory having the following load:

- 15 x Mercury vapour high-bay lights rated at 4.5A each (3circuits)
- 90 x twin fluorescent light fittings 0.52A each (6circuits)
- 24 x double 10A single phase socket outlets (3circuits) = 48 x 10A S/O's
- 6 x three phase socket outlets 20A
- 3 x three phase socket outlets 15A
- 1 x 30kW three phase industrial air heater for factory heating
- 1 x three phase guillotine motor 20A
- 1 x three phase drill machine 15A
- 2 x three phase hydraulic presses 25A
- 1 x three phase air compressor 40A

see footnote e
Table C2
NOTE: For heating
 $P = \sqrt{3} V I \cos \phi$
heating $\cos \phi = 1$
 $I = \frac{P}{\sqrt{3} V}$

| Load group | Load type | Calculation | A phase | B phase | C phase |
|------------|-----------|---|----------------|----------------|----------------|
| A | Light | $5 \times 4.5 + 30 \times 0.52 = 38.1 \text{ A}$ <i>five mercury vapour + thirty fluro per phase</i> | 38.1 | 38.1 | 38.1 |
| Bii | 10A SO | $(1000 \text{ W} + 100 \times 15) / 230 = 10.87 \text{ A}$ <i>16 S/O per phase with personal heating</i> | 10.87 | 10.87 | 10.87 |
| Biii | 20A SO | $20 + 0.75(20 \times 5 + 15 \times 3) = 128.75 \text{ A}$ | 128.8 | 128.8 | 128.8 |
| C | Heater | $30,000 / 1.73 \times 400 = 43.3 \text{ A}$ $I = \frac{P}{\sqrt{3} V}$ | 43.3 | 43.3 | 43.3 |
| D | Motors | $40 + 0.75 \times 25 + 0.5 \times (25 + 20 + 15) = 88.8 \text{ A}$ | 88.8 | 88.8 | 88.8 |
| | | | | | |
| | | * Connected to permanent heating * | | | |
| | | | | | |
| | | | | | |
| | | Maximum Demand | 309.8 A | 309.8 A | 309.8 A |

Note:

Slight Variations in Answers!

Note

Header may be assumed 100%

QUESTION 9 (5marks)

Fill in the certificate of compliance for question 8 as a new installation Installed and inspected by you.

CERTIFICATE OF COMPLIANCE – ELECTRICAL WORK

Customer COPY

CERTIFICATE NO: 6077AB

CUSTOMER DETAILS

Name: KEY
 Address: 1/111 ...
 Cross Street: ... Postcode: 2000

Telephone Contact: _____

Deduct one mark for each incorrect entry.

INSTALLATION WORK DETAILS Indicate the type of installation and type 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 Network connection or metering
 Additions or alterations to a switchboard or associated equipment Defect Electrical or 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 |
|--|--------|-----|---|
| <input type="checkbox"/> Switchboards | | | |
| <input checked="" type="checkbox"/> Circuits | | | |
| <input checked="" type="checkbox"/> Lighting | 7A | 60 | New ... |
| <input type="checkbox"/> Socket-outlets | 15A | | |
| <input type="checkbox"/> Appliances | | | |
| Estimated increase in load A/mph | | 33A | <input checked="" type="checkbox"/> Increased load is within capacity of installation/service mains |
| <input type="checkbox"/> Work is connected to supply | | | <input type="checkbox"/> 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.

| | |
|---|---|
| <input checked="" type="checkbox"/> Earthing system integrity Ω | <input checked="" type="checkbox"/> Residual current device operation |
| <input checked="" type="checkbox"/> Insulation resistance MΩ | <input checked="" type="checkbox"/> Visual check that installation is suitable for connection to supply |
| <input checked="" type="checkbox"/> Polarity | <input type="checkbox"/> Stand-alone power system complies with AS 4806 |
| <input checked="" type="checkbox"/> Correct circuit connections | <input checked="" type="checkbox"/> 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: KEY Licence No: _____
 Signature: [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 2005

Name: KEY Licence No: _____
 Signature: [Signature] Date of Notice: _____
 Address: _____ Telephone No or Other Contact: _____

ELECTRICITY DISTRIBUTOR (DNSP) REMARKS

Inspected: _____ Date: _____
 Sir: _____
 Comments: _____

