Electrical Installation Testing & Verification

MA NUE 408

6077AH

Electrical Trades

Contents

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Introduction

This resource manual contains learning exercises, review questions and sample assessment instruments. It is designed to assist students achieve the outcomes and purpose described in the national module descriptor *NUE408 Electrical Installation Testing and Verification* and is an example of the depth and breadth of learning expected.

The topics listed in the content are arranged in the preferred learning sequence. It is recognised that this is not the only sequence in which the material could be learnt.

General references for this module

The following textbooks are recommended for this module:

Principal reference

- *AS/NZS 3000:2000 Wiring rules,* Standards Australia.
- *AS/NZS 3017:2001 Electrical Installations -Testing and Inspection Guidelines,* Standards Australia.

Other useful references

- *AS/NZS 4836:2001, Safe working on low voltage electrical installation,* Standards Australia.
- *AS/NZS 3760:2001, In service safety inspection and testing of electrical equipment,* Standards Australia.
- *AS/NZS 3012:2003, Construction and demolition sites,* Standards Australia.
- *HB 301-2001, Electrical Installations - Designing to the Wiring rules,* Standards Australia.
- *HB 300-2001, Electrical installations - Guide to using the Wiring rules,* Standards Australia.
- Pethebridge K. and Neeson I., *Electrical Wiring Practice*, 6th Ed., Vol 1, McGraw Hill, Sydney, 2001.
- Local electricity distributor and authority regulations.
- State and Territory Electricity Safety Acts and Regulations.

Additional resources for this module

You will also need the following items to complete this module:

- pens, pencils
- calculator
- writing paper
- graph paper.

Notes

1. Regulation Requirements

Purpose

In this topic you will learn about the obligations of electrical contractors and supply authorities in accordance with relevant electrical safety legislation.

Objectives

At the end of this topic you should be able to:

- state the need of electricians to ensure that their installation complies with the regulations
- state the responsibilities and obligations of contractors and their staff in complying with the regulations
- state the responsibilities and obligations of supply authorities in complying with the regulations
- state the AS/NZS 3000 Wiring rules requirements that directly relate to the tests prescribed under the regulations.

Technical information

You will find the information to undertake this topic in the following references. At least one reference text should be used.

- *AS/NZS 3000:2000, Wiring rules,* Standards Australia.
- *AS/NZS 3012:2003, Construction and Demolition Sites,* Standards Australia.
- *AS/NZS 3017:2001, Electrical Installation - Testing and Inspection Guidelines,* Standards Australia.

References for this topic

- *Electricity Safety (Electrical Installations) Regulation,* 1998 (NSW).
- *Electricity Safety Act.* 1971 - Ammended (ACT).
- *National Electricity (South Australia) Act*, 1996.
- *Electricity Safety (Installations) Regulations,* 1999 (Vic).
- *Electricity Industry Safety and Administration Regulation*, 1999 (Tas).
- *Electricity (Licensing) Regulations*, 1991 (W.A.).
- *Electricity Safety Act.* 2002 (Qld).
- *Electricity Reform (Safety and Technical) Regulations*, 2000 (N.T.).
- Pethebridge K. and Neeson I., *Electrical Wiring Practice*, 6th Vol. 1, McGraw Hill, Sydney, 2001, Chapter 11.

Introduction

The relevant issues relating to testing and inspections of electrical work carried out in installations are covered in the various state and territory acts and regulations.

The regulations may cover all or some of the following:

- definitions
- testing requirements
- commissioning of installation work
- notification of installation work
- notification of test results
- qualifications of persons to carry out testing
- different grades of electrical licensing
- penalties for non compliance to safety regulations
- inspection requirements
- responsibilities of installers and supply authorities.

The aim of all state and territory Electrical regulations is to ensure the safety of persons, livestock and property from electrical shock, fire and physical injury from hazards that may arise.

Definitions

A clear understanding of the terms used in the regulations should be gained before looking at the responsibilities of installers and supply authorities.

Student exercise 1

In your own words describe what is meant by the following terms.

Consumers mains ____

____

Hazardous areas ____

____

Dead ____

____

Live ____

____

Supply authority ____

____

Authorised person ____

Installation work ____

Installing contractor ____

Consumers installation ____

Safe ____

Student exercise 2

(a) Name the body in your state/territory that is responsible for the issuing of electrical licenses?

(b) What grades of electrical license are issued in your state/territory?

Installation work requirements

Installation work must:

- comply with the requirements of AS/NZS 3000 Wiring rules
- not be connected to the supply unless it complies with AS/NZS 3000 and any local regulations or relevant codes.

The testing must be carried out by either:

- the installing contractor
- another installing contractor
- an authorised person.

Student exercise 3

(a) What qualifications are required by your state/territory for the issue of a license to install and test electrical work?

(b) An unqualified person carrying out testing is liable for a penalty of:

____

____

The test on the installation work must include the procedures necessary to check that:

- there is earth continuity and that the earth resistance is safe
- the insulation resistance is safe
- polarity is correct
- there is no transposition of earth and neutral conductors
- there is no short circuit between conductors
- there is no intermix between conductors of different circuits
- switchboard equipment is correctly marked
- the installation will operate as intended.

Notification to the electricity distributor

Student exercise 4

(a) What are the notification requirements in your state/territory for:

- notification of complete work (not yet tested)?

____

____

- notification of the tests?

____

____

(b) Under what conditions is it not required to lodge notification certificates to the electricity distributor?

____

____

(c) Copies of notification must be kept for __________ years and must be produced on demand by a relevant authority.

Inspectors authority responsibilities

Testing and checking electrical work is the responsibility of the installing electrician who must notify the electricity distributors or inspection body when all tests are complete and comply with regulations.

The inspection authority within your area has the responsibility to test the installation if the work carried out involved:

- the consumers mains

- high voltage installations
- hazardous areas
- the main switchboard

Before connection to the supply

For installation work not associated with the above, inspection authorities will employ discretionary inspections.

If an inspection relevant defects associated with the work the inspection authority must notify in writing the installing contractor and the customer about non-compliance and give a time period for the defect to be fixed.

Student exercise 5

Complete the relavent paper work as provided by your teacher for the installation in a new dwelling consisting of:

- 26 light points
- 28 double 10 A socket outlets
- 2 single 10 A socket outlets
- 1 13 kW electric range
- 1 4.8 kW controlled load water heater
- 1 - 4 A pump.

Test results will be supplied by your teacher.

Review questions

These question will help you revise what you have learnt in this topic.

1. You have installed an additional 10 A socket outlet to an existing circuit. What actions will you need to carry out to fulfil your obligations under the regulations?

2. What are the obligations, under the regulations, of an electrical contractor carrying out repairs to a faulty socket outlet?

3. If you replace the main neutral link in an existing installation is the inspecting authority obligated to test your work?

4. Installation work that has been completed but not tested:
   (A) must be notified to the inspecting authority within 14 days of completion
   (B) can be connected to the supply before being tested
   (C) will be tested by the supply authority
   (D) is the responsibility of the consumer to arrange testing.

5. An installation:
   (A) can be connected to the supply if minor defects exist
   (B) need only be tested for earth continuity and insulation resistance before being connected to the supply
   (C) must comply with the AS/NZS 3000 Wiring rules
   (D) must be fully tested by the inspecting authority before being connected to the supply.

6. Notification of electrical work:
   (A) need only be submitted to the inspecting authority
   (B) need only be submitted for new work
   (C) must be filled out and submitted by the consumer
   (D) copies must be kept by the installing contractor for auditing

7. Inspecting authorities have the responsibility under the various state/territory Electrical (Installation Safety) Regulations to inspect:
   (A) all work
   (B) all work associated with consumers' mains and main switchboards
   (C) only work for which they receive notification
   (D) only work in hazardous areas.

Review questions

8. Testing of electrical installations as required under safety regulations can be carried out by:
   (A) an electrical apprentice under supervision of the consumer
   (B) a person nominated by the installing contractor
   (C) a person qualified to test
   (D) an electrician's assistant.

Notes

2. Test Equipment and Procedures

Purpose

In this topic you will learn about the test equipment needed to conduct the tests that check compliance of an installation with AS/NZS 3000. Test and tagging requirements will also be covered.

Objectives

At the end of this topic you should be able to:

- identify suitable test equipment which can be used to confirm that an installation meets prescribed requirements
- check essential test equipment to determine instrument accuracy on known loads
- maintain test equipment in a safe and operational working condition
- confirm that the readings taken using essential test equipment are within a range of expected values for typical load conditions
- list the required periodic inspection and tests that show workplace equipment is safe to use.

Technical information

You will find the information to undertake this topic in the following references. At least one reference text should be used.

- *AS/NZS 3017:2003, Electrical Installations - Testing and Inspection Guidelines,* Standards Australia.
- *AS/NZS 3000:2000, Wiring rules,* Standards Australia.
- *AS/NZS 3012:2003, Construction and Demolition Sites,* Standards Australia.
- *AS/NZS 3012:2003, Electrical Installations - Construction and Demolition Sites,* Standards Australia.
- *AS/NZS 3760:2001, In-Service Safety Inspection and Testing of Electrical Equipment,* Standards Australia.
- *AS/NZS 3002:2002, Electrical Installations - Shows and Carnivals,* Standards Australia.

References for this topic

- *HB 300:2001, Electrical Installations* - Guide to using the Wiring rules, Standards Australia.
- Pethebridge K. and Neeson I., *Electrical Wiring Practice*, 6th Ed., Vol. 1, McGraw Hill, Sydney 2001, Chapter 11.

Test equipment types

The essential instruments needed for testing that an installation complies with the requirements of the safety regulations are as follows:

- insulation/continuity resistance tester
- ohmmeter - ohms range of a multimeter - capable of displaying accurate readings in the range between 0.5 and 5 ohms.
- series (400 V/230 V) test lamps

Additional instruments useful in testing are:

- voltmeter - voltage range of a multimeter or clip-on ammeter
- neon tester
- phase sequence indicator
- clamp-on ammeter (tong tester)
- RCD tester
- fault loop impedance tester

Accessories used in testing procedures include:

- fluorescent lamp starter, base wired and with insulated alligator clip.
- 15 W lamp and 40 W lamp wired with insulated alligator clips. These are used as known loads.
- trailing lead of known resistance - 100 m flexible cable fitted at one end with an insulated alligator clip and the other with a plug suitable for connecting to test instruments.
- resistance calibration panel for checking instrument accuracy.

  Suggest resistance values:

  - for earth resistance testing - 0.5 Ω, 1 Ω and 2 W at 1% tolerance 1 W

  - for typical loads - 10 Ω, 15 Ω, 20 Ω and 50 Ω at 1% tolerance 1 W

  - for insulation resistance - 10 kΩ, 1 MΩ and 10 MΩ at 1% tolerance 1 W
- temporary test bridges - short lengths, say 300 mm, of flexible cable fitted with insulated alligator clips.

Insulation resistance tester

Description

The Wiring rules require insulation resistance is to be measured by applying a d.c. voltage of 500 V where the working voltage between the conductors under test and earth does not exceed 250 V a.c. In cases where the working voltage is above 250 V a.c. to earth a 1000 V d.c. test voltage is to be used. As an electrician you will be familiar with the 500 V and 1000 V insulation resistance tester, sometimes referred to as "megger" and you will have used hand driven generator types or a pushbutton electronic type. Theses a instruments may also include an ohmmeter or continuity tester.

The Wiring rules requirements for low voltage wiring systems is to have a minimum insulation resistance of 1 megohm between all live conductors and earth, and 10,000 ohms for low voltage equipment with a heating element such as found on stoves and water heaters.

Use

Some important points to remember when using insulation resistance testers:

- although the instrument may not be able to deliver enough energy to cause a fatality it can give a nasty shock capable of causing a secondary accident such as falling from a ladder
- a 500 V testing voltage applied to a solid state component in devices such as light dimmers would destroy them
- an insulation resistance tester must only be used on wiring disconnected from the supply, ie. DEAD testing.

As these instruments age there may be a deterioration of components such as the strength of permanent magnet fields in a hand driven type or a change in circuit component valves in the electronic type. This can result in a decrease in the test voltage to well below 500 V d.c. which normally occurs under operating conditions.

It is important that your insulation resistance tester measures resistance accurately if you are to ensure the installation you test complies with the requirements.

The insulation resistance tester must maintain its terminal voltage within +20% - 10% of the nominal open circuit terminal voltage, when measuring a resistance of 1 MΩ on the 500 V range.

Ohmmeter

AS/NZS 3000 requires the main earth system resistance not to exceed 0.5 Ω. This involves the use of an ohmmeter to accurately measure the main earthing system during testing procedures. Ohmmeters are also used in other tests where continuity testing methods are employed.

Ohmmeters are usually one of the functions of analog and digital multimeters. Some types of insulation resistance testers also have an ohmmeter function by selection switch or alterative test terminals. These instruments are usually referred to as an insulation/continuity resistance tester.

The following points are worthwhile keeping in mind when using an ohmmeter:

- select a meter scale where the 2 ohms point is within ¼ to midscale
- when using an analog type instrument the pointer will take a short time to settle to a stationary position before a reading can be taken
- the lead resistance and terminal resistance will need to be accounted for every time the instrument is used. This is called zero adjusting and can be achieved by shorting the lead terminals together and adjusting the zero knob on the instrument to zero.

Note: Some digital types don't have a zero function, in this case the leads are still shorted together and the resistance recorded and subtracted from the reading of the circuit under test.

Series (400 V/230 V) test lamps

Series test lamps with a HRC fused probe are one of the most useful items of test equipment as they place a load on a circuit and provide glowing lamps as indication that the circuit is live. Since a current is required to drive the lamps a false indication due to induction does not occur as in some other instruments such as digital voltmeters and neon lamp testers.

As with any test instrument used for detecting supply it must be tested on a known LIVE supply to verify the correct operation of the lamps before it can be used as a testing tool. Remember to carry a spare replacement lamp.

Voltmeter

Voltmeters are incorporated in multimeters. You should always ensure that you select the correct range. Voltmeters have a limited use for installation testing for two main reasons:

- digital types may indicate induced voltage and give a false reading
- to sight the reading you need to take your eyes off your work which can be dangerous.

If a voltmeter is to be used, correct voltmeter operation needs to be verified on a known LIVE supply before normal testing begins. For unknown low voltage levels select the highest range before testing.

Neon tester

Neon testers have limited use for installation testing as the operator forms part of the circuit and this may give a false indication. The main application is to initially test if exposed metal is LIVE.

Phase sequence indicator

Phase sequence indicators give an indication of the phase sequence at a test point and this result can be compared to other test points. A typical application would be to ensure all multiphase outlets in an installation are connected with the same phase sequence.

Clamp-on ammeter

Clamp-on ammeters or tong testers are useful for checking load currents when testing to ensure an installation operates as intended.

Clamp-on ammeters are available with very low ranges suitable for measuring earth leakage current associated with residual current devices.

Residual current device tester

These instruments are used to check that an RCD operates at rated current within the required trip time. They are connected to RCD protected socket outlets simply by plugging into a protected socket.

Fault loop impedance testers

This instrument can be used to measure the impedance of the active to earth path to verify that the protective device will disconnect an earth fault current within time and touch voltage requirements.

Testing equipment must be maintained in a serviceable condition and also tested at intervals not exceeding 6 months. Test records, including serial numbers, are to be kept for at least 2 years.

Always ensure the test instrument is functioning properly before and after each test.

Visual examination

A visual inspection of the complete circuit should include:

- main earth conductor size is correct
- location and suitability of equipment and accessories in restricted zones such as laundries, bath-rooms, swimming pools, etc.
- voltage drop in all circuits is not excessive
- maximum demand of circuits does not exceed the current carrying capacity of the cables
- circuit protective devices are correctly rated for current carrying capacity and fault current
- mechanical protection is adequate where required
- switchboard markings are correct including neutral conductor identification
- fixing and supports are adequate

- final subcircuits are used for appliances
- the number of points per final subcircuit is not excessive
- RCD's are installed on the required circuits
- equipotential bonds are installed and of correct size
- environmental considerations such as heat, chemicals, etc are taken into consideration.

Testing and tagging

The OH&S Acts of all stages and territories place a duty of care to provide a safe work place. To meet this duty of care, testing and tagging of electrical equipment is required.

Inspection and testing needs to be in accordance with the performance specifications of:

- *AS/NZS 3760:2001, In-Service Safety Inspection and Testing of Electrical Equipment*
- *AS/NZS 3012:2003, Electrical Installations - Construction and Demolition Sites*
- *AS/NZS 3002:2002, Electrical Installations - Shows and Carnivals*

Construction site testing

Construction site wiring must meet the same standard as wiring in a completed building. In addition the following tests are required on electrical equipment:

- all construction wiring, switchboards and wiring within relocatable structures must be tested prior to connection to the supply and re-tested every 6 months
- portable safety switches must have a daily pushbutton test before use and then every three months
- fixed safety switches must have a monthly pushbutton test and then every 12 months
- all plant, electrical equipment and flexible electrical cords should be inspected for wear and mechanical damage and tested for earth continuity and insulation resistance prior to first use, and every 3 months thereafter.

All inspections must be carried out by a competent person, all equipment must be tagged, and a record of inspection and tests kept.

The details recorded shall include:

- the date of inspection
- plant number of the item inspected
- licence number and signature of the inspecting electrician
- any repairs required as a result of the inspection.

The following tables indicate the testing and inspection intervals for various work environments.

Table 1 Classification of class of work

Work environments	*Examples of equipment environments*
1. Manufacturing, repair work	Factories, workshops, repair centres, assembly, maintenance, fabrication.
2. Construction and demolition sites	Construction and demolition sites, office refurbishment, supplying equipment services to construction sites, for example electrical or plumbing.
3. Office environment	Office environment where equipment is not subject to constant flexing of the supply cords. For example computers which are used in a fixed position.
4. Commercial environments	Laboratories, tea rooms office kitchenettes, kitchens, schools, cleaning, and where equipment is subject to constant flexing of the supply cord.
5. Hire equipment industry	Hire of equipment or similar contract (leased equipment).

Table 2 Frequency of inspection and tests of all electrical equipment other than fixed equipment

Class of work (refer to the table below)	Class of equipment		Additional testing for RCDs		Cord extension sets & electrical portable outlet devices (EPODs)
	Class 1 (protectively earthed)	Class 2 (double insulated)	Push-button test (by user)	Test for operation	
1. Manufacturing	6 months	12 months	Daily, or before every use, whichever is the longer	12 months	6 months
2. Construction etc (see AS 3012)	3 months	3 months	Immediately after connection to a socket outlet and every day in use	Each day	3 months
3. Office	5 years	5 years	3 months	2 years	5 years
4. Commercial	12 months	12 months	3 months or before every use, whichever is the longer	2 years	12 months
5. Hire	Before each hire	Before each hire	Before each hire	Before each hire	Before each hire
6. Shows/carnivals	6 months	12 months	Daily, or before every use, whichever is the longer	12 months	6 months

Practical exercise - Test instrument calibration

Task

- To perform an open circuit test and load test on an insulation resistance tester.
- To test an ohmmeter for accuracy.

Objectives

At the completion of this exercise you should be able to:

- test an insulation resistance tester for compliance with AS/NZS 3017 requirements
- test an analog and digital ohmmeter for accuracy.

Equipment

Your teacher will supply you with the specifications of the equipment to be used.

	Specifications
▪ 1 Insulation resistance tester	Type ____________________
▪ 1 Digital voltmeter	Type ____________________
▪ 1 Analogue multimeter	Type ____________________
▪ 1 Digital mulitmeter	Type ____________________
▪ 1 Resistor panel (suggest range of 0.5 to 1 megohm)	Size ________ Rating ________ W
▪ Connection leads	Type ____________________

Procedure A: Open circuit and load test of an insulation resistance tester

1. Measure the open circuit voltage of your 500 V insulation resistance tester with a d.c. digital voltmeter. Record this value in Table 2.1.

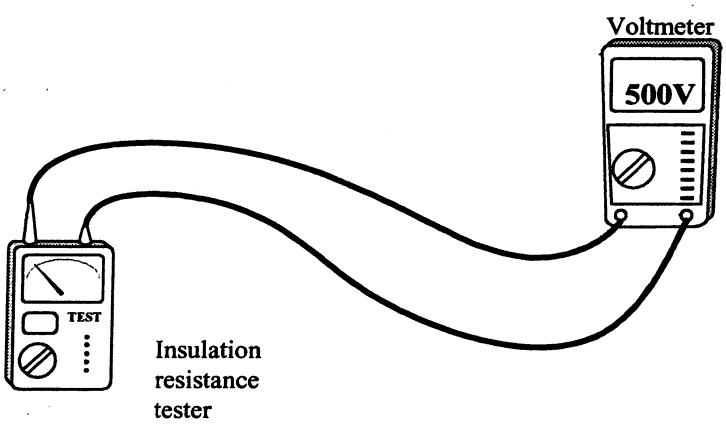

Figure 2.1 Open circuit test

2. Connect the insulation resistance tester to each resistor (resistance values will be indicated by your teacher) and use a voltmeter to measure the voltage output of the insulation resistance tester under load. Record your results in Table 2.1.

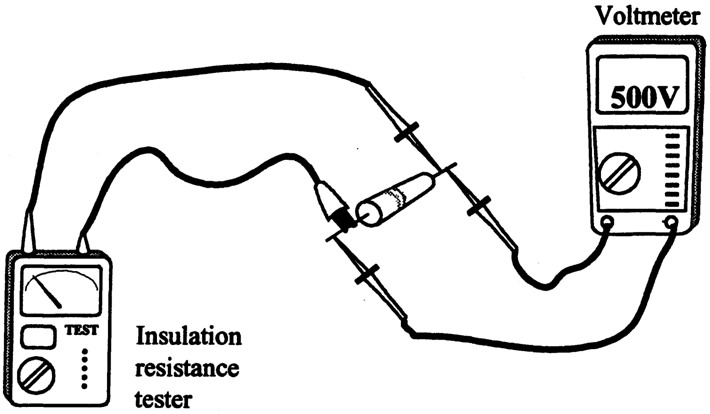

Figure 2.2 Load test

Table 2.1

Resistance	*Measured voltage*
Open circuit	
R_1 =	
R_2 =	
R_3 =	
R_4 =	
R_5 =	

Procedure B: Resistance measurement

1. Select the analogue multimeter, set to ohms range and short the test leads together to zero adjust.
2. Measure the resistors as directed by your teacher and record your results in Table 2.2.

Note: Remember to zero adjust the meter each time you change range.

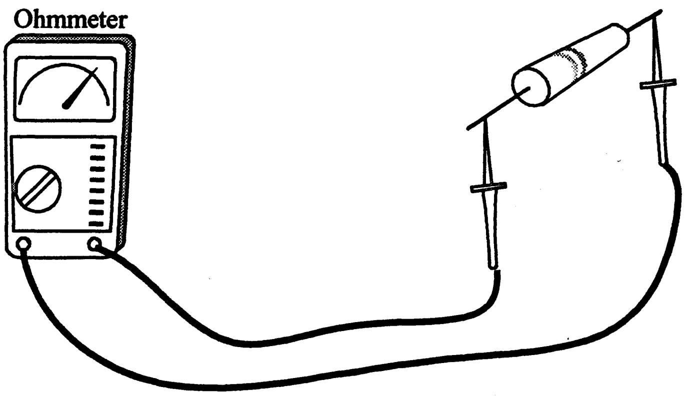

Figure 2.3 Resistance test

3. Select the digital multimeter and measure the resistors as directed by you teacher and record your results in Table 2.2.

Table 2.2

Resistance	*Measured value analog multimeter*	*Measured value digital multimeter*
R_1 =		
R_2 =		
R_3 =		
R_4 =		
R_5 =		

Observations

1. From the results of Table 2.1, does the meter under test meet the requirements recommended in AS/NZS 3017 to obtain reliable and readable results? Explain your answer.

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2. From the results of Table 2.2, would the meters under test be suitable to accurately measure the main earth resistance of an installation? Explain your answer.

____

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____

Notes

Review questions

These questions will help you revise what you have learnt in this topic.

1. Two globes connected in series being used as test lamps, can be used:
   (A) on single and polyphase loads
   (B) to check continuity on any electronic circuit
   (C) on 400 V 50 Hz supplies
   (D) to test circuit continuity with power off.

2. When carrying out insulation resistance testing on circuits with electronic components connected, the test leads must never be connected between:
   (A) neutral and earth
   (B) common and active
   (C) active and neutral
   (D) active and earth.

3. When testing earthing system resistance:
   (A) associated circuits should be connected to the supply
   (B) an insulation resistance tester is used
   (C) an ohmmeter is used
   (D) all earthing conductors must be disconnected.

4. The insulation resistance tester must be calibrated regularly for accurate readings of range values of:
   (A) 50 ohms and 10 megohms
   (B) 1 ohm and 1 megohm
   (C) 200 ohms and 1 megohm
   (D) 10 kilohms and 1 megohm.

5. Series test lamps are chosen for use as test instruments because they:
   (A) can be used on all voltage levels
   (B) can be assured of operating without the need for testing on a known supply
   (C) will not indicate induced voltages
   (D) operate only on single phase.

6. The expected resistance measured between the active and neutral conductors at the switch-board of a circuit supplying a 2.4 kW range element would be approximately:
   (A) 12 ohms
   (B) 10 ohms
   (C) 24 ohms
   (D) 14 ohms.

Review questions

7. The element of a 4.8 kW, 230 V storage water heater would be expected to have a resistance of:
   (A) 1 megohm
   (B) 12 ohms
   (C) 20 ohms
   (D) 10 000 ohms.

8. The insulation resistance of a single phase 230 V system is required to be tested by applying:
   (A) 1000 V d.c.
   (B) 250 V d.c.
   (C) 415 V d.c.
   (D) 500 V d.c.

9. An insulation resistance tester used to test a 400 V three-phase circuit must be able to maintain an open circuit output voltage of:
   (A) 1000 V d.c.
   (B) 2500 V d.c.
   (C) 250 V d.c.
   (D) 500 V d.c.

10. The type of test equipment used to test an existing circuit for standing earth leakage is:
    (A) an insulation resistance tester
    (B) 0-100 m A clamp-on ammeter
    (C) 0-1 A clamp-on ammeter
    (D) RCD tester.

11. Before using an analogue multimeter to measure resistance, it is important to:
    (A) select a high resistance range
    (B) ensure the supply is connected to the circuit to be tested
    (C) select an appropriate range and zero adjust the instrument
    (D) ensure the load on the circuit to be tested is disconnected.

12. List the tests to be carried out every 3 months on equipment used on construction sites, to ensure they are safe to use.

13. Does testing and tagging of leads and portable equipment have to be carried out by a licensed electrician?

14. Why do RCD's have to be tested?

Review questions

15. What information must be recorded on the tags after an extension lead has been tested safe?

16. List three test instruments which are necessary to carry out the installation tests required by AS/NZS 3000.

Notes

3. Earth Continuity and Resistance

Purpose

In this topic you will learn about the equipment and methods that will test earth continuity and that earth resistance is safe in an installation.

Objectives

At the end of this topic you should be able to:

- state the reasons for ensuring earth continuity and correct earth resistance
- identify actions which could be taken during the installation of circuits which would minimise the possibility of high earth resistance
- select and prepare the appropriate test equipment for testing earth continuity and earth resistance
- demonstrate dead testing procedures to confirm the earth continuity and earth resistance
- determine that earthing resistance complies with AS/NZS 3000 requirements.

Technical information

You will find the information to undertake this topic in the following references. At least one reference text should be used.

- *AS/NZS 3017:2003, Electrical Installations - Testing and Inspection Guidelines*, Standards Australia.
- *AS/NZS 3000:2000, Wiring rules* Standards Australia.

References for this topic

- *HB 300:2001, Electrical Installations* - Guide to using the Wiring rules, Standards Australia.
- Pethebridge K. and Neeson I., *Electrical Wiring Practice*, 6th Ed., Vol. 1, McGraw Hill, Sydney 2001, Chapter 11.

Why this test is needed

When a fault between live parts and an earth occurs the circuit protection device operates rapidly to cut off the supply and then isolates the fault. To ensure the circuit protection device operates as intended under earth fault conditions the earthing system must have a very low resistance. An earthing system that is not installed correctly could expose the installation to damage and persons in risk of electric shock if an earth fault occurs.

AS/NZS 3000 requirements

A summary of AS/NZS 3000 requirements:

- the resistance of the protective earth must be low enough to permit the passage of current necessary to operate the protective device
- the maximum resistance of the protective earth depends on the type and rating of the protective device and the impedance of the active conductor. (See Table 3.2 AS/NZS 3017)
- the resistance between the MEN connection and earth electrode is not to exceed 0.5 ohms
- the resistance of any equipotential bonding conductor is not to exceed 0.5 ohms.

Student exercise 1

Complete the diagram of the earthing installation shown below. The appliance is protected by a 25 A type C circuit breaker and is wired using 4 mm², V 90, TPS and earth. Indicate on the diagram the maximum allowable resistance of each earthing/bonding conductor.

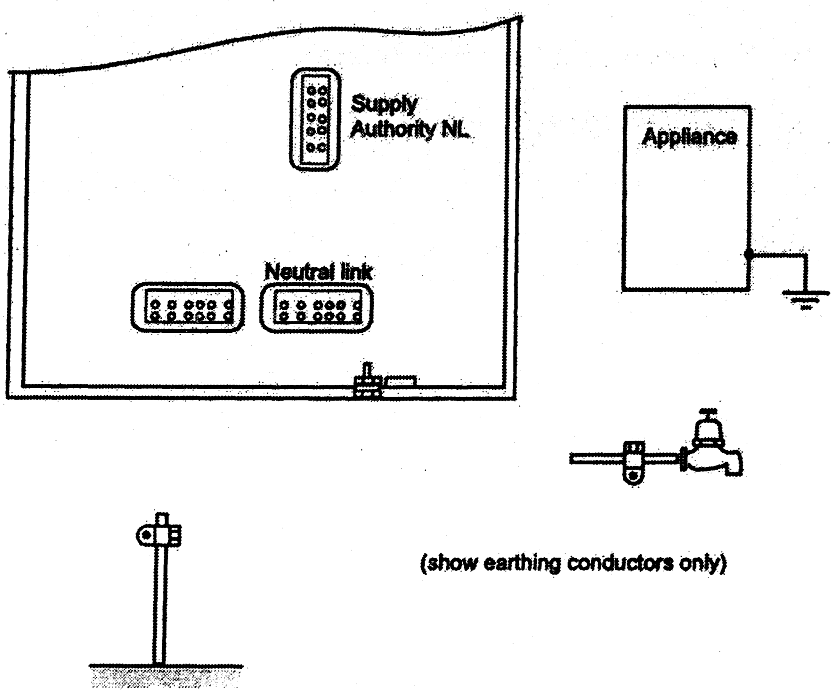


Figure 3.1

Quality actions - no defects

The following suggestion will help eliminate earthing system defects and the need for costly rework.

- Identify all exposed metal required to be earthed before the installation is commenced.
- Complete all earthing connections during fit out.
- Check that all earthing connections are made correctly.

Other tests

Transposition of neutral and earthing conductor can also be detected with this test.

Equipment

Equipment needed for this test is:

- a multimeter set on the low ohms range, or
- an insulation/continuity tester set on the continuity range

Testing methods

Guidelines for testing the main earth can be found in Figure 3.1 AS/NZS 3017. For other earthing and equipotential bonding conductor testing refer to Figure 3.2 AS/NZS 3017.

Preparation

1. Isolate the supply at the main switchboard (if necessary).
2. Disconnect the main earth from the MEN connection at the neutral link. This should only be done when the whole installation is isolated.
3. Disconnect the earthing conductor from any water heaters.

Procedures

Measurements are made of the earthing resistance between the disconnected main earth at the neutral link and equipment earth terminal and all metal required to be earth. (See Figures 3.1 and 3.2 AS/NZS 3017).

Below is a list of the most common items that require earthing.

- earth electrode
- bonded metal water pipe systems
- metallic conduit systems
- metal lamp poles
- metal switchboard surrounds
- metal supports for aerial conductors
- earth socket of outlets
- earth pin/terminal or metal surround at lighting points
- earth conductor at water heaters
- metal surrounds of electrical equipment and appliances
  - washing machines

- air-conditioners
- dishwashers
- ceiling fans
- ovens
- cook tops
- fixed space heating

• all bonded items:

- above ground pool structure
- swimming pool fences
- ladders
- steel reinforcing for in-ground pools
- metal decks, metal garden sheds etc.
- steel frames of house
- other piping systems such as gas, phone, flammable liquids, water sprinkler etc.

At the completion of testing reconnect all earthing conductors to their correct terminals.

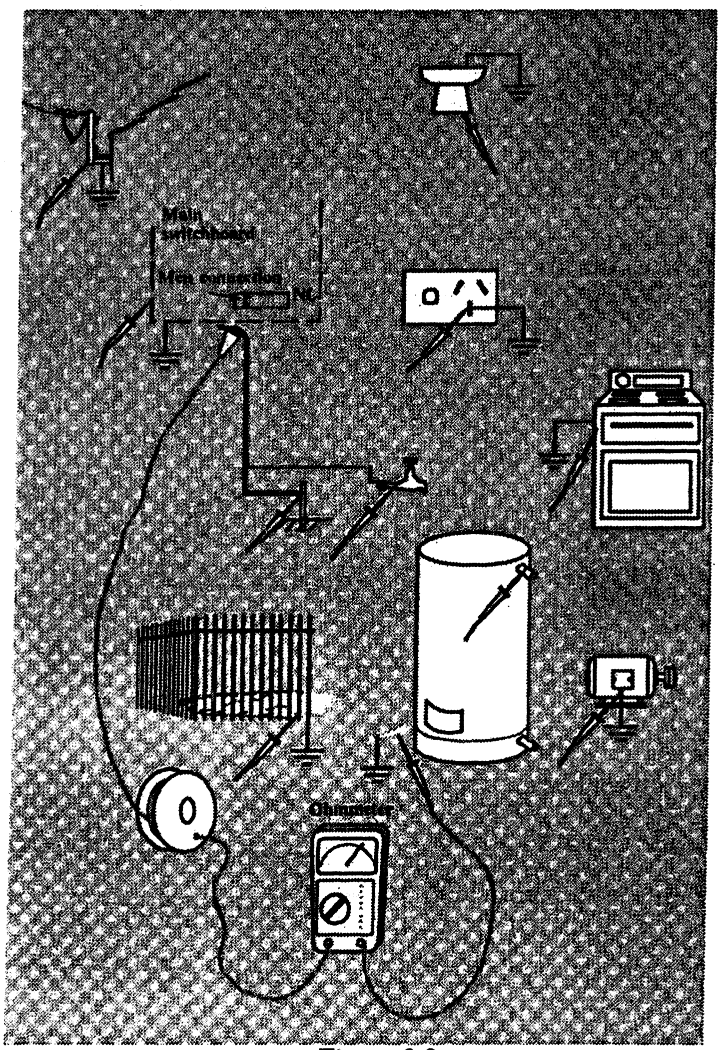


Figure 3.2

Practical exercise - Earth continuity and resistance testing

Task

- To conduct tests on a simulated installation
- To determine that there is earth continuity and the earthing resistance is safe.

Objectives

At the completion of this exercise you should be able to:

- test the main earth for continuity and its resistance value
- test final sub circuit earth conductors for continuity and resistance value

Equipment

Your teacher will provide you with the specifications of the equipment to be used and the type of circuit to be tested.

- 1 ohmmeter Type ______________________
- 1 trailing lead Type ______________________
- Contact probes

Procedure

1. Isolate all circuits at the switchboard.
2. Select the ohmmeter range and zero adjust with the trailing lead connected to the meter.
3. Follow the test sequence as set down in AS/NZS 3017.
4. Record the values of each test in Table 3.1.

Note: Your teacher will indicate the parameters of each circuit to test.

Table 3.1

Circuit	*Cable size*	*Protective device*	*Test results (ohms)*
Lights			
Socket outlets			
Water heater			
Range			
Main earth			
Water pipe			

Observations

1. What is the maximum allowable earth resistance for each circuit under test?

2. Which of the circuits tested met the requirements of AS/NZS 3000 for earth continuity and resistance? Indicate reasons why, if any, a circuit failed the test.

Review questions

These questions will help you revise what you have learnt in this topic.

1. When undertaking initial earth continuity checks it is recommended that the main earth conductor be disconnected from:
   (A) the water system
   (B) all outgoing earthing conductors
   (C) the main neutral
   (D) the earth electrode.

2. The earthing system must have a low resistance to ensure:
   (A) the correct operation of appliances if an earth fault occurs
   (B) the effective operation of circuit protection devices if an earth fault occurs
   (C) the neutral is at a safe potential at all times
   (D) protection against induced voltages.

3. When testing earth resistance:
   (A) a multimeter set on megohms range is suitable
   (B) an insulation resistance tester must be used
   (C) all earthing conductors must be disconnected
   (D) associated circuits should be isolated from the supply.

4. When testing earth continuity it is recommended that:
   (A) circuit earthing conductors be disconnected from all appliances
   (B) circuit earthing conductor be disconnected from water heaters
   (C) an insulation resistance tester be used
   (D) the supply is connected to the installation.

5. Earth resistance can be determined using:
   (A) an ohmmeter set on voltage range
   (B) a series test lamp
   (C) an insulation resistance tester set on the 500 V range
   (D) an insulation resistance tester set on continuity range.

6. Why must the main earth conductor be disconnected from the neutral bar when testing its resistance?

7. When testing protective earths for continuity and resistance the neutral of the circuit under test must be disconnected. How would the test be affected if the neutral was not disconnected.

Review questions

8. Briefly outline the procedure to test the earth resistance for a final sub-circuit supplying a hot water storage heater. Specify what, if any, connections need to be disconnected and what type of special equipment is needed to allow measurements to be made between distant points.

9. State three instances where equipotential bonding to the main earthing system is necessary to comply with AS/NZS 3000.

4. Insulation Resistance Testing

Purpose

In this topic you will learn about the equipment and methods to ensure insulation resistance is safe in an installation.

Objectives

At the end of this topic you should be able to:

- state the reasons for ensuring that insulation resistance is safe
- identify actions which could be taken during the installation of circuits to minimise the possibility of unsafe insulation resistance
- select and prepare the appropriate test equipment for testing the insulation resistance
- demonstrate dead testing procedures to verify that insulation resistance is safe
- determine the safety of an installation from the insulation resistance test results.

Technical information

You will find the information to undertake this topic in the following references. At least one reference text should be used.

- *AS/NZS 3017:2003, Electrical Installations - Testing and Inspection Guidelines,* Standards Australia.
- *AS/NZS 3000:2000, Wiring rules,* Standards Australia.

References for this topic

- *HB 300:2001, Electrical Installations* - Guide to using the Wiring rules, Standards Australia.
- Pethebridge K. and Neeson I., *Electrical Wiring Practice*, 6th Ed., Vol. 1, McGraw Hill, Sydney 2001, Chapter 11.

Why this test is needed

The resistance of the insulation between live conductors and earth and live parts and earth must be adequate to ensure the insulation does not break down under normal operating conditions.

Safety

Insulation breakdown could expose persons to risk of electric shock or cause damage from a resulting fault current.

Requirements

The AS/NZS 3000 Wiring rules require that:

- insulation between live conductors/parts and earth be stress tested by the application of a d.c. voltage.
- the test voltage is to be 500 V d.c. on circuits where the working voltage between conductors and earth does not exceed 250 V. The test voltage is 1000 V d.c. in all other cases.
- the insulation resistance must not be less than 1.0 MΩ for general wiring. In the case of appliances incorporating calrod type heating element the resistance must not be less than 0.01 MΩ. Also the value of 1 MΩ may be reduced to a value permitted in the relevant safety standard applicable to the electrical equipment.

Quality actions - no defects

The following suggestions will help eliminate insulation resistance defects and the need for costly rework.

- Verify insulation resistance of each cable before terminations are made.
- Ensure insulation resistance between conductors and conductors and earth is maintained at equipment terminals and cable points
- Adopt procedures to prevent cable insulation damage during the installation

Other Tests

Insulation resistance testing will also reveal short circuit and transposition of neutral and earthing conductor defects. Further tests would be needed to identify the specific location of such defects. (See short circuit and transposition testing).

Equipment

Equipment needed for this test:

- 500 V insulation resistance tester for a circuit with a working voltage between conductors and earth not exceeding 250 V.
- 1000 V insulation resistance tester for all other cases.

Testing methods

Guidelines for testing insulation resistance can be found in AS/NZS 3017. Refer to Clause 3.2 and Figure 3.3, 3.4 and 3.5 for:

- insulation resistance test of the complete installation
- insulation resistance test of consumers mains or submains

- insulation resistance test of a single circuit

Preparation

For the circuits under test:

1. isolate the supply at the switchboard.
2. when testing a whole installation disconnect the main earthing conductor from the neutral link
3. step through the points outlined in AS/NZS 3017.

Important note

Take care not to damage electronic components such as those incorporated in switching and control devices. If there is any doubt, carry out insulation resistance testing with electronic devices bridged out or disconnected from the circuit. If bridging out these components make sure the bridge is placed between the correct terminals.

DO NOT TEST ACROSS ACTIVE AND NEUTRAL

4. test the insulation resistance between the main earth and all active conductors connected to each phase as a group or each active conductor individually.
5. test the insulation resistance between the main earth and all neutral conductors as a group connected to the neutral link or each neutral conductor individually.
6. test fixed wired appliances incorporating heating appliance between active terminal and earth, and neutral terminal and earth.

Notes

Practical exercise: Insulation Resistance Testing

Task

To conduct tests to determine that the insulation resistance of a simulated installation is safe.

Objectives

At the completion of this practical exercise you should be able to:

- test the insulation resistance of various circuits within an installation
- from the results obtained determine if the circuits are safe to connect to the supply

Equipment

Your teacher will provide you with the specifications of the equipment to be used and the type of circuits to be tested.

Specifications

- insulation resistance tester — Type ______________________________
- connecting leads

Procedure

1. Isolate all circuits at the switchboard.
2. Carry out test preparations and procedures.
3. Follow the test procedures as set down in AS/NZS 3017 for testing the complete installation. Record your results in Table 4.1.
4. Follow the test procedures as set down in AS/NZS 3017 for testing the consumers mains. Record your results in Table 4.1.
5. Follow the test procedures as set down in AS/NZS 3017 for testing single circuits. (Your teacher will indicate which subcircuits to test). Record your results in Table 4.1.

Table 4.1

Circuit	*Test results*	*Condition*	
		Correct	*Faulty*
Complete installation			
Consumers mains			
Subcircuits 1. 2. 3. 4.			

6. At the completion of all testing, reconnect all conductors to their correct terminals.

Observations

1. Which test, if any, indicated unsafe insulation resistance?

___

___

2. What are possible causes of low insulation resistance in light or socket outlet circuits?

___

___

3. Why is the insulation resistance of water heaters allowed to be reduced to 10 kΩ instead of 1 MΩ?

___

___

___

Review questions

These questions will help you revised what you learnt in this topic.

1. The circuit switches must be in the ON position when testing for insulation resistance to test the:
   (A) switch-wire insulation
   (B) earth insulation
   (C) neutral insulation
   (D) active insulation.

2. Normally, the insulation resistance of general wiring shall not be less than:
   (A) 1 megohm
   (B) 10 000 ohms
   (C) 2.0 ohms
   (D) infinity.

3. When testing insulation resistance of circuits with electronic components connected, the test leads must never be connected between:
   (A) neutral and earth
   (B) common and active
   (C) active and neutral
   (D) active and earth.

4. Adequate insulation resistance helps to ensure:
   (A) active and neutral continuity
   (B) protection against direct contact with live parts
   (C) earthing continuity
   (D) protection against mechanical damage of conductors.

5. To test the insulation resistance of a single phase 230 V system the required d.c. test voltage would be:
   (A) 1000 V
   (B) 250 V
   (C) 415 V
   (D) 500 V.

6. An electric storage water heater element may have a minimum insulation resistance of:
   (A) 2.0 ohms
   (B) 1.0 megohm
   (C) 10,000 ohms
   (D) no specific value in the MEN system.

Review questions

7. When testing for insulation resistance, portable appliances must be:
   (A) disconnected from sockets
   (B) left connected to sockets
   (C) left connected to sockets with the socket switched on
   (D) connected and running.

8. When testing the insulation resistance of an installation, what is the requirement of AS/NZS 3000 with regard to the test equipment?

9. Briefly outline the procedure for checking the insulation resistance of a socket outlet circuit. Assume it is an existing circuit where the RCD is tripping for no apparent reason.

5. Polarity Testing

Purpose

In this topic you will learn about the equipment and methods to ensure the active and neutral conductors are connected to the correct terminals.

Objectives

At the end of this topic you should be able to:

- state the reasons for ensuring correct polarity of circuits
- identify actions which could be taken during installation of circuits which would minimise the possibility of incorrect polarity
- select and prepare the appropriate test equipment for testing the polarity of submains and final subcircuits
- demonstrate DEAD testing procedures to confirm the polarity of submains and final subcircuits
- demonstrate LIVE testing procedures on a final subcircuit using series test lamps to confirm correct polarity
- determine the polarity condition of a circuit from test results
- accurately record the number of points contained on each final subcircuit.

Technical information

You will find the information to undertake this topic in the following references. At least one reference text should be used.

- *AS/NZS 3017:2003, Electrical Installations - Testing and Inspection Guidelines,* Standards Australia.
- *AS/NZS 3000:2000, Wiring rules,* Standards Australia.

References for this topic

- *HB 300:2001, Electrical Installations* - Guide to using the Wiring rules, Standards Australia.
- Pethebridge K. and Neeson I., *Electrical Wiring Practice*, 6th Ed., Vol. 1, McGraw Hill, Sydney 2001, Chapter 11.

Why this test is needed

Polarity testing is necessary to ensure that no shock hazard arises from the incorrect connection of active and neutral conductors within socket outlets, luminaries or permanently connected equipment. This testing is to prevent the transposition of active, neutral and earth conductors. This test is to prevent:

- the connection of switches in neutral conductors resulting in parts of appliances remaining energised when the switches are in the off position
- combinations of incorrect active, neutral and earthing conductor connections resulting in the exposed metal parts of equipment becoming energized
- final subcircuit earthing conductors from carrying current
- short circuits existing
- the number of points that may be connected to a circuit being excessive. This is intended to minimise overloading and the subsequent operation of circuit protective devices.

Other tests

Other tests which have similar preparation and can be conducted at the same time are:

- intermix of conductors of different circuits
- transposition of neutral and earthing conductors.

Note: The following section contains information relating to the polarity testing of final subcircuits containing socket outlets. The procedure for testing luminaries is in many ways similar to socket outlets and sometimes both tests may be undertaken in conjunction with each other. Mixed circuits could require the testing of socket outlets, luminaries and equipment. The testing procedure used will of course be determined by the type and size of installation but in any case should be systematic to ensure that testing objectives are achieved.

Polarity requirements

AS/NZS 3000 stipulates that:

- single pole switches and circuit breakers must operate in the active conductor of the circuit in which it is connected
- multi-phase switches and circuit breakers must operate in all active conductors of the circuit in which it is connected
- socket outlets, when viewed from the front must have the polarity of earth, active and neutral in a clockwise direction
- all neutral conductors must be connected to the consumer mains neutral
- the consumers mains neutral must be connected to the neutral bar of the main switchboard.

Equipment need for this test

DEAD testing:

- a multimeter set on the low ohms range, or
- an insulation/continuity set on the continuity range
- trailing lead

- known loads - 15 W lamp or 10 Ω resistor
- short circuit bridges.

Live testing

Equipment needed for this test is:

- series test lamps
- lamps to be placed in the circuit

Testing methods

Guideline for polarity testing can be found in AS/NZS 3017. Refer to Clause 3.3 and Figure 3.6 to 3.12 which show the testing techniques for:

- DEAD test of consumers mains polarity
- DEAD test of submains polarity
- DEAD test of single pole switch polarity
- DEAD test of socket outlet polarity
- live test of submains polarity with an MEN connection at an outbuilding
- live test of submains polarity incorporating protective earthing conductor
- live testing of single pole switch polarity using a voltage indicator.

Quality action - no defects

The following suggestions will help eliminate incorrect polarity defects and the need for costly rework:

- colour code active and neutral conductors and switch wires
- check that conductors are connected to the correct terminals after each connection is made.

Other tests

Tests which have similar preparation and can be conducted at the same time are:

- intermix of conductors of different circuits
- transposition of neutral and earthing conductors

DEAD testing

Incorrect polarity connections can be detected by identifying the active and neutral conductors at the load or accessory terminals. This can be done in a variety of ways:

- using a trailing lead

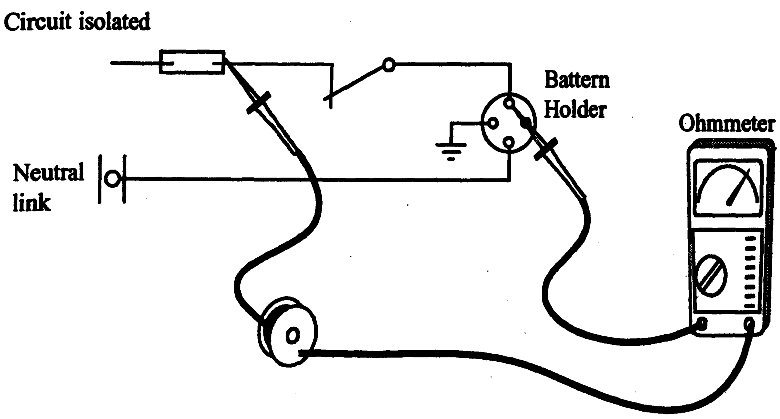


Figure 5.1 Testing active polarity

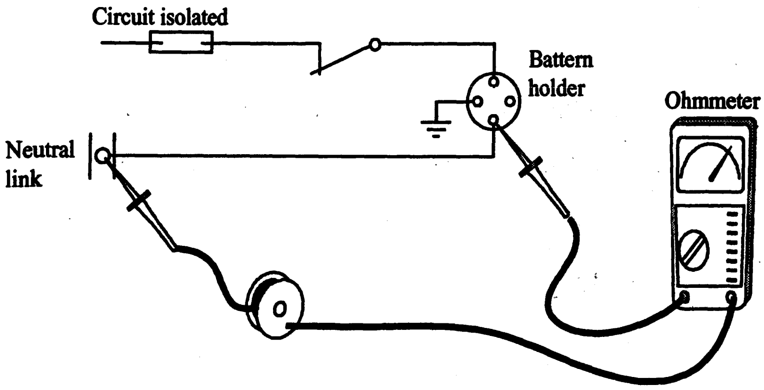


Figure 5.2 Testing neutral polarity

- using a known load and earth as a reference point

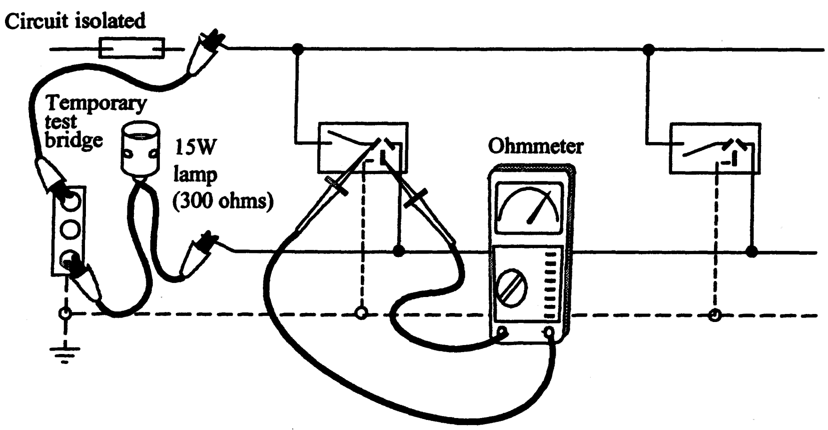


Figure 5.3 Testing with known load

Student exercise 1

Using Figure 5.3, the results of a correctly connected circuit would be:

A to E ________________ ohms

E to N ________________ ohms

Live testing

Live testing to determine that polarity is correct should not be necessary on a new installation if correct ongoing polarity testing and marking was carried out during installation. If it is required the circuit switches should be left open until the polarity is verified.

Series test lamps are preferred to a voltmeter as series test lamps provide a load, eliminating false readings due to induced voltage. Also, series test lamps give an easily identified visual indication of circuit conditions.

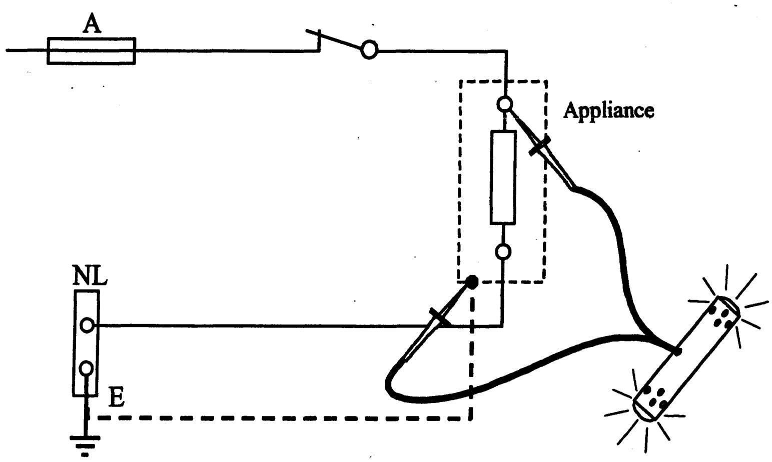


Figure 5.4 Live testing with series test lamps

Student exercise 2

Using Figure 5.5, the results for a correctly connected circuit would be:

A to E Bright/dull glow of test lamps

N to E Bright/dull glow of test lamps

What steps would need to be taken if the circuit of Figure 5.5 is protected by a RCD?

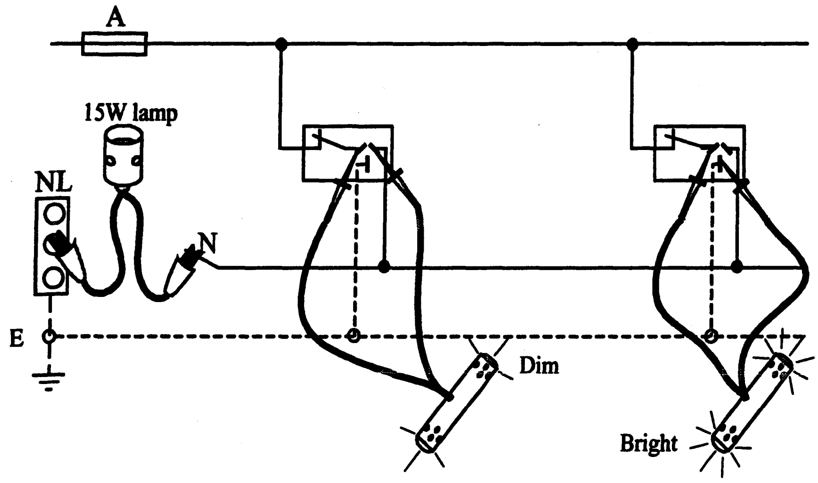


Figure 5.5 Polarity testing socket outlet circuit

Practical exercise - Polarity testing

Task

- To conduct dead and live tests to determine whether the polarity is correct in a simulated installation.
- To conduct tests to determine whether the polarity of submains is correct in a simulated installation.

Objectives

At the completion of the practical exercise you should be able to:

- apply dead testing procedures on a final subcircuit to determine if circuit polarity is correct
- apply live testing procedures on a final subcircuit to determine if circuit polarity is correct
- dead test a submain to determine if circuit polarity is correct.

Equipment

Your teacher will provide you with the specifications of the equipment to be used and the types of circuits to be tested.

	Specifications
▪ Extra low voltage a.c. supply	Type ____________________
▪ Test lamps (with correct rated globes)	Type ____________________
▪ Multimeter	Type ____________________
▪ Ohmmeter	Type ____________________
▪ Connection leads	
▪ Resistors	____________ Ω ________ W
▪ 15 W lamps	Type ____________________

Procedure A: Polarity testing of dead circuits

1. Isolate all circuits at the switchboard.
2. List the type of circuits to be tested and the required test equipment in Table 5.1.

Table 5.1 Dead testing

Test equipment	*Type of circuit*	*Test result*	*Condition*	
			Correct	*Faulty*
	1.			
	2.			
	3.			

3. Carry out test preparation and procedures on circuits designated by your teacher. Record your results in Table 5.1.
4. At the completion of the testing remove all shorting test bridges and reconnect all conductors to their correct terminals.

Procedures B: Polarity testing of live circuits

1. Ensure all circuits are connected and the installation is safe for connection to the supply.
2. List the type of circuits to be tested and the required test equipment in Table 5.2.

Table 5.2 Live testing

Test equipment	*Type of circuit*	*Test result*	*Condition*	
			Correct	*Faulty*
	1.			
	2.			
	3.			

3. Carry out test preparation and procedures on circuits designated by your teacher. Record your results in Table 5.2.
4. At the completion of the test isolate the supply and leave the installation safe. Reconnect any conductors to their correct terminals.

Procedure C: Polarity testing of submains

The correct polarity of submains (and consumers mains) should be verified by dead testing only.

1. Isolate the submain at its originating switchboard.
2. Test that exposed metal to the distribution board supplied by the submains is not alive.
3. Test that the submain is isolated.
4. Isolate all outgoing circuits from the distribution board.
5. Disconnect the submain neutral conductor from the distribution board neutral link.
6. If the distribution board has a separate MEN connection disconnect the main earthing conductor from the neutral link.
7. The following two diagrams indicate the testing procedures for polarity testing submains. Using the diagram that suits your circuit, test the circuit polarity. Record your results in Table 5.3.

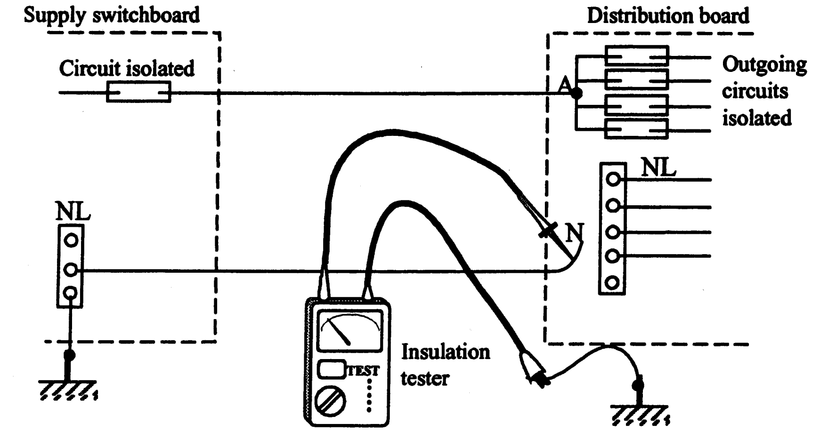


Figure 5.6 Separate MEN connection

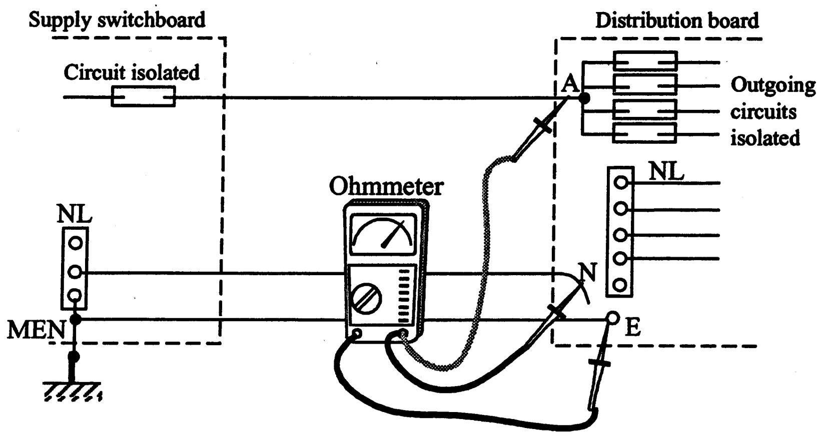


Figure 5.7 Submain incorporating protective earth conductor

Table 5.3 Submain polarity results

Test points	*Test result*
N to E	
A to E	

Observations

1. From your results recorded in Tables 5.1 to 5.3, was the polarity incorrect for any circuit?

____

____

____

2. What are the dangers if a socket outlet circuit is wired with the active and neutral reversed?

____

____

____

3. What are the dangers of incorrect polarity of submains with a separate MEN connection? Will the circuit protective device operate?

____

____

____

4. What are the dangers of incorrect polarity of consumers mains? Will the circuit protective device operate?

____

____

____

Review questions

These questions will help you revise what you have learnt in this topic.

1. The dangerous condition of an incorrect polarity of a submain to a distribution board having a separate MEN connection:
   (A) will not appear to affect the operation of the final subcircuits supplied from the distribution board
   (B) will cause the submain protection device to operate
   (C) will not pose an immediate danger
   (D) will not affect the polarity of the final subcircuit supplied from the distribution board.

2. If the polarity of the active and neutral conductors is reversed at a socket outlet the switch will operate in the:
   (A) earthing conductor
   (B) switch wire
   (C) active conductor
   (D) neutral conductor.

3. If the supply is not available, incorrect polarity at a range element may be determined using:
   (A) a series test lamps
   (B) a neon test pencil
   (C) an insulation tester set on 500 V range
   (D) an ohmmeter.

4. The AS/NZS Wiring rules require that a single pole switch must operate in:
   (A) the active conductor
   (B) the active neutral and earth conductors
   (C) the active and neutral conductor
   (D) both active and neutral conductors simultaneously.

5. Live testing of final subcircuits to ensure polarity is correct can be carried out using:
   (A) an ohmmeter
   (B) insulation tester set on the 500 V range
   (C) series test lamps
   (D) continuity tester.

6. Correct polarity of sub-mains can be safely determined by:
   (A) testing the polarity of final sub-circuits supplied from the distribution board
   (B) switching on the supply and seeing if the circuit protection device operates
   (C) testing continuity between neutral conductor and earthing conductor and between active conductor and earthing conductor
   (D) measuring the current in sub-main active and neutral conductors.

Review questions

7. Series test lamps used to live test polarity of socket outlets will indicate:
   (A) the active terminal only
   (B) the active terminal and the neutral terminal
   (C) the active terminal and the earth terminal
   (D) the neutral terminal and the earth terminal.

8. If incorrect polarity of the active and neutral conductors occurs at a socket outlet the switch will operate in:
   (A) the earth
   (B) the switch-wire
   (C) the active
   (D) the neutral.

9. If when testing an electric range element for polarity a resistance of 5,000 ohms was recorded. This would probably indicate the presence of:
   (A) an electric clock
   (B) a short circuit
   (C) incorrect polarity
   (D) a high resistance earth.

10. How do you determine, using suitable test equipment which is the neutral conductor on single phase low voltage mains?

11. Briefly outline the procedure used to test the polarity of sub-mains. Assume it is run from an existing main switchboard to a new distribution board in a factory.

6. Correct Circuit Connections - Transposition Testing

Purpose

In this topic you will learn about the equipment and methods for testing that there is no transposition of earthing and neutral conductors in an installation.

Objectives

At the end of this topic you should be able to:

- state the reasons for ensuring that there is no transposition of earthing and neutral conductors
- identify action which could be taken during the installation of circuits to minimise the possibility of transposition of earthing and neutral
- select and prepare the appropriate test equipment for testing that there is no transposition of earthing and neutral conductors in submains and final subcircuits
- demonstrate DEAD testing procedures to confirm that there is no transposition of earthing and neutral conductors in submains and final subcircuits
- demonstrate LIVE testing procedures on a final subcircuit using series test lamps to confirm that there is no transposition of earthing and neutral conductors in submains and final subcircuits
- determine the terminals to which earthing and neutral conductors are connected from the test results.

Technical information

You will find the information to undertake this topic in the following references. At least one reference text should be used.

- *AS/NZS 3017:2003, Electrical Installations - Testing and Inspection Guidelines,* Standards Australia.
- *AS/NZS 3000:2000, Wiring rules,* Standards Australia.

References for this topic

- *HB 300:2001, Electrical Installations* - Guide to using the Wiring rules, Standards Australia.
- Pethebridge K. and Neeson I., *Electrical Wiring Practice*, 6th Ed., Vol. 1, McGraw Hill, Sydney 2001, Chapter 11.

Why this test is needed

The transposition of the neutral and earthing conductors is a condition where the neutral conductor is connected to the earth terminal and the earthing conductor is connected to the neutral terminal at the equipment or accessory.

This is an unsafe condition not necessarily apparent under the normal operation of an installation.

Under normal circuit operations with the MEN earthing system no real problem may seem to exist, but:

- if the earthing conductor is of a smaller cross sectional area (CSA) than the neutral conductor and the circuit was to carry full rated current then the earthing conductor would become overheated and could initiate a fire.
- if the earthing conductor became open circuited, any exposed metal downstream of the open circuit would become LIVE.

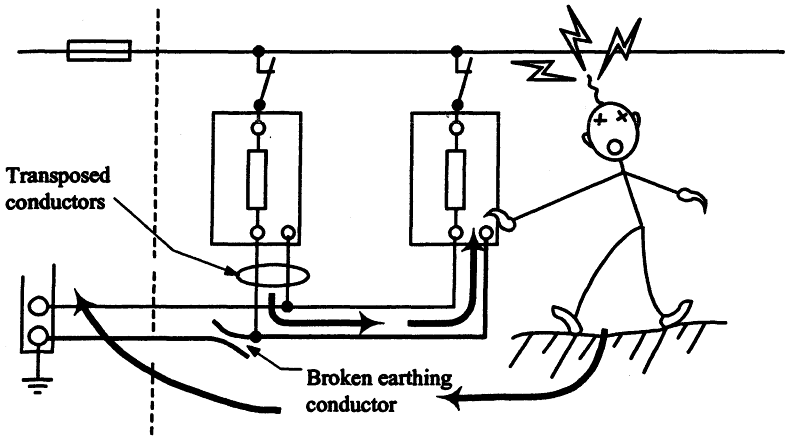


Figure 6.1 Unsafe condition due to transposition of neutral/earth conductors

AS/NZS Requirements

AS/NZS 3000 requires that the earthing conductor can only be connected at a single MEN point.

Quality actions - No defects

The following suggestions will help eliminate transposition of neutral and earth conductor defects and the need for costly rework.

Connection to the wrong terminals can easily occur particularly at batten holders and socket outlets. Check that conductors are connected to the correct terminals after each connection is made.

Other tests

Tests which have similar preparation and can be conducted at the same time are:

- polarity
- interconnection of conductors of different circuits
- short circuit

Equipment

Dead testing

Equipment needed for this test is:

- a multimeter set on the low ohms range, or
- an insulation/continuity tester set on the ohms range
- 15 W lamp or 10 Ω resistor.

Live testing

Equipment needed for this test is:

- series test lamps; or
- a multimeter set on higher voltage range than the circuit voltage
- 15 W lamp.

Testing Methods

Dead testing - circuits with loads connected

Transposition of neutral and earthing conductors can be detected in circuits supplying permanently connected loads and 'lamped' lighting points by measuring the resistance between the circuit conductors at the switchboard.

Preparation

For each circuit under test.

1. Isolate the supply at the switchboard.
2. Disconnect the neutral conductor from the neutral link.
3. Turn on all circuit control switches.
4. Set the test instrument to ohms range and zero adjust.

Procedure

Measure the resistance between active and neutral conductors, active and earth conductors and neutral and earth conductors.

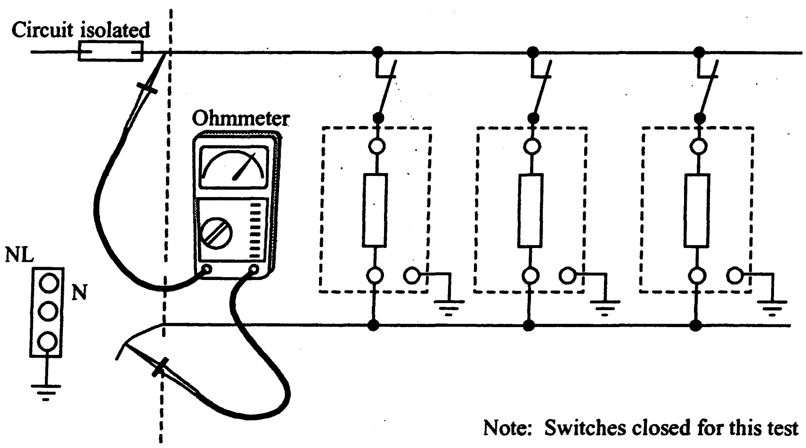


Figure 6.2 Transposition dead testing - loads connected

The results for a correctly connected circuit are as follows.

Table 6.1 Dead testing results - load connected

Test points	*Test result*
A to N	Load resistance
A to E	Open circuit
N to E	Open circuit

2. At the completion of the test reconnect all conductors to their correct terminals.

Dead testing - circuits with loads not connected

Transposition of neutral and earthing conductors can be detected in circuits supplying socket outlets and unlamped light points by using a known resistance to identify the neutral and earthing conductors.

Preparation

For the circuit/s under test.

1. Isolate the supply at the switchboard
2. Connect a 15 W lamp or 10 W resistor between the circuit neutral and the neutral link.
3. Connect a shorting test bridge between the active conductor and earth.
4. Set the test instrument to ohms range and zero adjust.

Procedures

1. At each socket outlet turn on the switch and measure the resistance between active and neutral terminals, active and earth terminals and neutral and earth terminals.

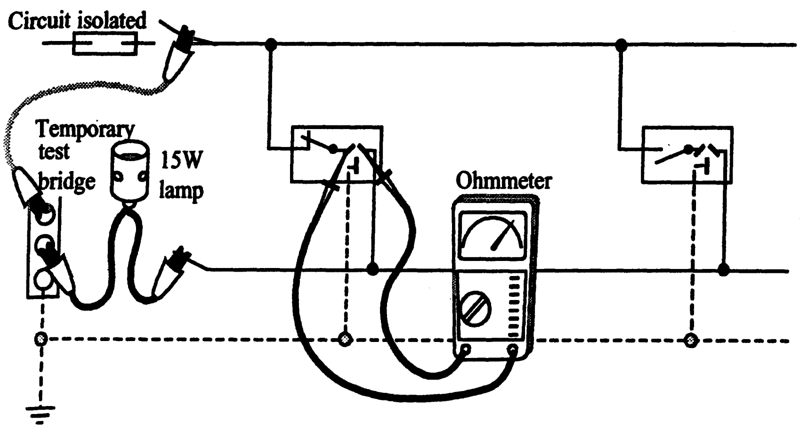


Figure 6.3 Transposition dead testing - no loads connected

The results for a correctly connected load are as follows.

Table 6.2 Dead testing results - no loads connected

Test points	*Test result*
A to N	Resistance of 15 W lamp
A to E	Short circuit
N to E	Resistance of 15 W lamp

2. At the completion of the test remove all temporary test bridges and test resistances (15 W lamp) and reconnect all conductors to their correct terminals.

Live testing

It is recommended that live testing for transposition of neutral and earthing conductor faults be used as a check only, where deemed necessary, after dead testing has confirmed connections are correct.

Live testing used as the initial test could create a dangerous situation during the test. A transposition fault on the circuit under test could cause exposed metal to become live.

Preparation

For the circuit/s under test.

1. Isolate the supply from the circuit under test.
2. Connect a 15 W lamp in series with the circuit neutral at the neutral link.
3. Switch the supply on to the circuit.

Procedures

1. Switch the power on at each load in turn.
2. Test with series test lamps between active and neutral terminals and active and earth terminals at each load point or socket outlet.

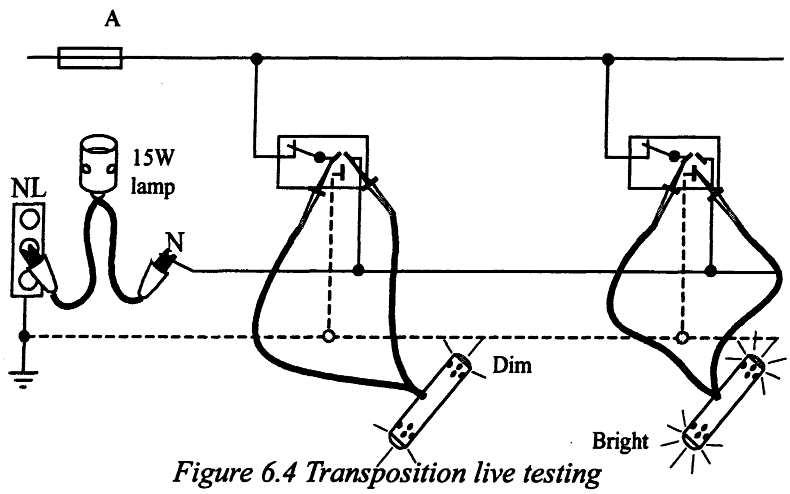


Figure 6.4 Transposition live testing

The test results for a correctly connected load or accessory are as follows.

Table 6.3 Live testing results

Test points	*Test result*
A to N	Dim test lamp
A to E	Bright test lamp

3. At the … the 15 W lamp. Reconnect the neutral at the neutral link.

Note 1 The same procedure can be used to conduct tests on circuits with loads that are permanently connected, such as stoves.

Note 2 A more convenient way of testing incandescent light points is to use a fluorescent starter in series with the circuit neutral instead of the 15 W lamp. When each light point is switched on it will blink if there is no transposition of neutral and earthing conductors. An incorrect connection will cause the lamp to stay on. This can also be used to check the interconnection of neutrals of different light circuits.

Note: Also see AS/NZS 3017 - Clause 3.4

Practical exercise - Transposition testing

Task

To conduct tests to determine whether there is transposition between neutral and earth conductors of the final subcircuits in a simulated installation.

Objectives

At the completion of this practical exercise you should be able to:

- test a circuit for transposition of neutral and earth using dead testing procedures.
- test a circuit for transposition of neutral and earth using the live testing procedures.

Equipment

Your teacher will provide you with the specifications of the equipment to be used and the types of circuits to be tested.

	Specifications
▪ Extra low voltage a.c. supply	Type ________________
▪ Multimeter	Type ________________
▪ 15 W lamps	Type ________________
▪ Test lamps (with correct rated globe)	Type ________________
▪ Connection leads	

Procedure A: Transposition testing of dead circuits

1. Isolate all circuits at the switchboard
2. Carry out test preparation and procedures on the circuits designated by your teacher. Record your results in the following table.

Table 6.4 Dead testing results

Circuit	*Test results*	*Condition*	
		Correct	*Faulty*
Light 1			
Light 2			
Power 1			
Power 2			
Range			
Water heater			
Submain			

3. At the completion of testing remove all test items including temporary test bridges and reconnect all conductors to their correct terminals.

Procedure B: Transposition testing of live circuits

1. Carry out test preparation and procedures on the circuits designated by your teacher. Record your results in the following table.

Table 6.5 Live testing results

Circuit	*Test results*	*Condition*	
		Correct	*Faulty*
Light 1			
Light 2			
Power 1			
Power 2			
Range			
Water heater			
Submain			

3. At the completion of testing remove all test items including temporary test bridges and reconnect all conductors to their correct terminals.

Review questions

These questions will help you revised what you learnt in this topic.

1. When the load is connected to circuits supplying water heaters, ranges or luminaries a method of verifying that the neutral and earthing conductors are not transposed is to:
   (A) measure the load resistance between active and neutral
   (B) test the earth continuity with the main earth connected to the neutral link
   (C) test the insulation resistance at the switch
   (D) carry out a visual check.

2. If the earthing conductor for a circuit supplying a single phase 11 kW range was transposed with the neutral conductor:
   (A) the final sub-circuit protection device will operate
   (B) no dangerous condition would exist
   (C) the range will not operate
   (D) the earthing conductor would likely overheat.

3. If equipment is connected with the earthing conductor and neutral conductor transposed:
   (A) the circuit protection will operate, isolating the supply
   (B) the earthing resistance will be much greater than 2 ohms
   (C) exposed metal can become live if the earthing conductor becomes open circuited
   (D) the neutral conductor will carry excessive load current.

4. If a fluorescent lamp starter is used to identify the neutral conductor in a lighting circuit and a light point stays on when the supply is connected:
   (A) the neutral and earthing conductors are transposed
   (B) the active and earthing conductors are transposed
   (C) the switch is in the off position
   (D) the earthing conductor is open circuited.

5. The transposition of earth and neutral conductors in a circuit may cause overheating of the:
   (A) active conductors
   (B) neutral and active conductors
   (C) neutral conductors
   (D) earth conductors.

6. Connecting a lamp or fluorescent lamp starter in series with a particular neutral conductor is to:
   (A) limit test current
   (B) limit the voltage and minimise shocks
   (C) identify the neutral conductor from the earthing conductor at the points under test
   (D) check the operation of that sub-circuit.

Review questions

7. A lamp or fluorescent lamp starter in series with a neutral conductor for the purposes of transposition testing must be connected between the circuit:
   (A) neutral and the neutral link
   (B) active and the neutral link
   (C) earth and the earth link
   (D) active and the earth link.

8. One of the major problems of earth/neutral transposition is that:
   (A) circuit protection devices will operate
   (B) circuit will appear to operate normally but is potentially dangerous
   (C) earth resistance exceeds the required value
   (D) the insulation resistance between active and neutral is below 1 megohm.

9. Test equipment suitable to live test for neutral and earth transposition is:
   (A) an ohmmeter
   (B) 15 W lamp and series test lamp
   (C) continuity tester
   (D) insulation resistance tester.

10. Using the testing arrangements shown in Figure 6.4 a 'dim' test lamp between active and earth terminals indicates:
    (A) incorrect active and neutral polarity
    (B) open circuited neutral
    (C) incorrect active and earth conductors
    (D) transposition of neutral and earthing conductors.

7. Correct Circuit Connections - Short Circuit Testing

Purpose

In this topic you will learn about the equipment and methods that will test that there is no short circuit between conductors in an installation.

Objectives

At the end of this topic you should be able to:

- state the reasons for ensuring that there are no short circuits between conductors
- identify procedures that could minimise the possibility of short circuits between conductors
- select and prepare the appropriate test equipment prior to testing for short circuits between conductors
- demonstrate DEAD testing procedures to confirm there are no short circuits between conductors

Technical information

You will find the information to undertake this topic in the following references. At least one reference text should be used.

- *AS/NZS 3017:2003, Electrical Installations - Testing and Inspection Guidelines,* Standards Australia.
- *AS/NZS 3000:2000, Wiring rules,* Standards Australia.

References for this topic

- *HB 300:2001, Electrical Installations* - Guide to using the Wiring rules, Standards Australia.
- Pethebridge K. and Neeson I., *Electrical Wiring Practice*, 6th Ed., Vol. 1, McGraw Hill, Sydney 2001, Chapter 11.

Why this test is needed

The current due to short circuits between live conductors of different potential and live conductors and earth can initiate a fire, cause damage to property or injury to persons. This is particularly the case where the prospective fault current is high.

The resistance of a short circuit may be high enough that the resulting fault current is not sufficient to operate the circuit protection device. In this case heat generated at the short circuit could be the source of ignition for a fire.

A very dangerous situation exists if an active conductor has a short circuit to another active conductor of the same phase. The circuits concerned may operate but when one circuit is isolated at the switchboard it may in fact be still alive through the short circuit.

AS/NZS 3000 requirements

AS/NZS 3000 Wiring rules requires electrical installations to be arranged so their is no risk of short circuits. Creepage distances between live conductors and live conductors and earth must be maintained.

Quality actions - no defects

The following suggestions should eliminate short circuit defects and the need for costly rework:

- mark each cable during installation.
- check that conductors are connected to the correct terminals when fitting out an installation.
- anticipated where short circuits are likely to occur, such as an incorrectly connected batten holder.
- verify the installation is free of short circuits before it is connected to the supply.

Other tests

Tests which have similar preparation and can be conducted at the same time are:

- polarity testing
- insulation testing
- interconnection testing

Equipment

Equipment needed for this test is:

- a multimeter on low ohms range, or
- an insulation/continuity resistance tester on the ohms range.

Test methods

Short circuits are detected by measuring the resistance of each circuit at the switchboard. Verification that there are no short circuits should be done before a circuit is connected to the supply.

Preparation

For each circuit under test.

1. Isolate the supply at the switchboard.
2. Set the test instrument to ohms and zero adjust.

3. Disconnect the neutral conductor from the neutral link.
4. Switch all load switches on.

Procedure

1. At the switchboard, test the resistance of each circuit between active and neutral conductor as shown in Figure 7.1.
2. Similarly, test resistance between neutral and earth or active and earth.

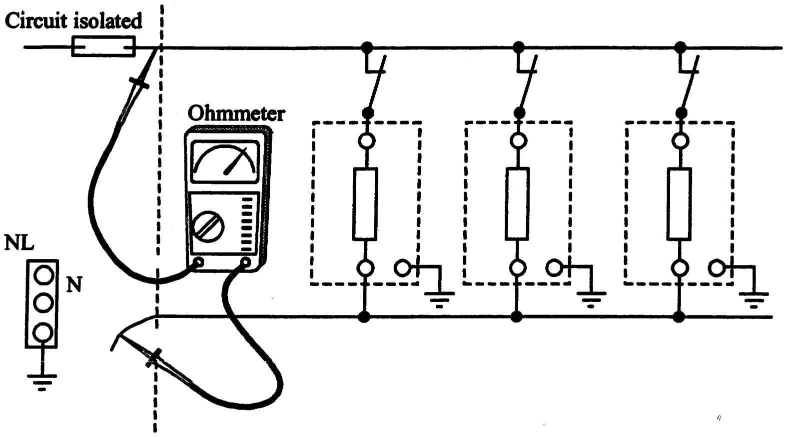


Figure 7.1 Short circuit testing

The results for a correctly connected circuit are as follows:

Table 7.1 Short circuit test results

Circuit/test points	*Test results*
Light circuit A to N	Depending on a number of points and lamp rating Typical 3 to 50 Ω
Water heater A to N	Depending on rating Typical 4.8 kW - 12 Ω 3.6 kW - 16 Ω
Range A to N	Depending on rating Typical 8.4 kW - 7 Ω
Socket outlets A to N	Infinity
A to E or N to E	Infinity

3. At the completion of testing reconnect all conductors to their correct terminals.

Note: Also see AS/NZS 3017 - Clause 3.4.

Notes

Practical exercise - Short circuit testing

Task

To determine that there are no short circuits between conductors of each final subcircuit in a simulated installation.

Objectives

At the completion of this practical exercise you should be able to:

- test for short circuits between active and neutral.
- test for short circuits between active and earth.
- test for short circuits between neutral and earth.

Equipment

Your teacher will provide you with the specifications of the equipment to be used and the types of circuits to be tested.

Specifications

- Extra low voltage a.c. supply — Type ______________________
- Ohmmeter — Type ______________________
- Connection leads

Procedure

1. Isolate the circuits at the switchboard.
2. Carry out test preparation and procedure on circuits designated by your teacher.
3. At the completion of testing reconnect all conductors to their correct terminal.

Record your results in the table below.

Table 7.2 Short circuit test results

Circuit	*Test results*	*Condition*	
		Correct	*Faulty*
Light 1			
Light 2			
Power 1			
Power 2			
Range			
Water heater			
Submain			

Observations

1. What circuits, if any, were found to have failed the short circuit tests. Indicate the type of fault?

____

____

____

2. A lighting circuits consists of 10 - 60 W incandescent lights. What is the expected resistance between active and neutral with all control switches on?

____

____

____

Review questions

These questions will help you revise what you have learnt in this topic.

1. An installation should be tested to ensure there are no short circuits:
   (A) by switching on the supply
   (B) before the supply is connected
   (C) using series test lamps
   (D) in the circuit wiring only.

2. To test the switch wire of a lighting circuit for possible short circuits the control switch must be:
   (A) disconnected
   (B) switched off
   (C) switched on
   (D) tested in both positions.

3. A short circuit between active conductors and a switchwire of the same circuit:
   (A) can be detected by measuring the resistance between circuit active and neutral at the switchboard
   (B) will prevent the controlling switch from turning off the load
   (C) will cause the circuit protection device to operate
   (D) cannot be detected by dead testing methods.

4. Name other tests required by AS/NZS 3000 that will at the same time detect short circuit faults.

Notes

8. Correct Circuit Connections - Interconnection Testing

Purpose

In this topic you will learn about the equipment and methods that test that there is no intermix between conductors of different circuits in an installation.

Objectives

At the end of this topic you should be able to:

- state the reasons for ensuring circuit wiring is independent of other circuits.
- identify action which could be taken during the installation of circuits which would minimise the possibility of interconnection of different circuits.
- select and prepare the appropriate test equipment for testing the origin of actives and neutrals.
- demonstrate DEAD testing procedures to confirm no interconnection has occurred within the installation or to an adjacent installation.
- demonstrate LIVE testing procedures to confirm no interconnection has occurred within the installation or to an adjacent installation.
- determine the circuit conditions of an installation from test results.

Technical information

You will find the information to undertake this topic in the following references. At least one reference text should be used.

- *AS/NZS 3017:2003, Electrical Installations - Testing and Inspection Guidelines,* Standards Australia.
- *AS/NZS 3000:2000, Wiring rules,* Standards Australia.

References for this topic

- *HB 300:2001, Electrical Installations* - Guide to using the Wiring rules, Standards Australia.
- Pethebridge K. and Neeson I., *Electrical Wiring Practice*, 6th Ed., Vol. 1, McGraw Hill, Sydney 2001, Chapter 11.

Why this test is needed

Interconnection refers to the connection of an active conductor from one circuit to another circuit or the connection of a neutral conductor from one circuit to another circuit.

Although interconnected circuits may operate satisfactorily a dangerous condition exists which could cause:

- overload due to cables carrying load currents from both circuits
- the isolation of one circuit not being achieved when the protection device of the other circuit operates.

AS/NZS 3000 requirements

AS/NZS 3000 Wiring rules require that:

- in general a common neutral shall not be used for two or more final sub-circuits
- fuses and circuit breakers shall operate in all active conductors simultaneously for each circuit.

Quality actions - no defects

The following suggestions should help eliminate interconnection defects and the need for costly rework. Anticipate where the interconnection of circuits is possible in a given installation. These could be:

- locations where cables of different circuits share a common accessory or item of equipment. For example, multi-gang switches, junction boxes in deck work and switchboards
- extension or alteration to an existing installation.

During the fitting out stage of an installation, clearly identify all conductors and their circuits before connecting to accessories and equipment.

Other tests

Other tests that require similar preparation and can be conducted at the same time include:

- transposition of neutral and earth
- short - circuit between conductors

Test equipment

Dead testing

Equipment needed for this test is:

- a multimeter set on low ohms range, or
- an insulation tester/continuity tester set on the ohms range
- 15 W lamp

Live testing

Equipment needed for this test is:

- series test lamps, or
- voltmeter
- 15 W lamp

Student exercise 1

What loads would you expect to isolate by removing the fuse for circuit 1, Figure 8.1?

Which loads will actually be isolated by removing the fuse of circuit 1, Figure 8.1?

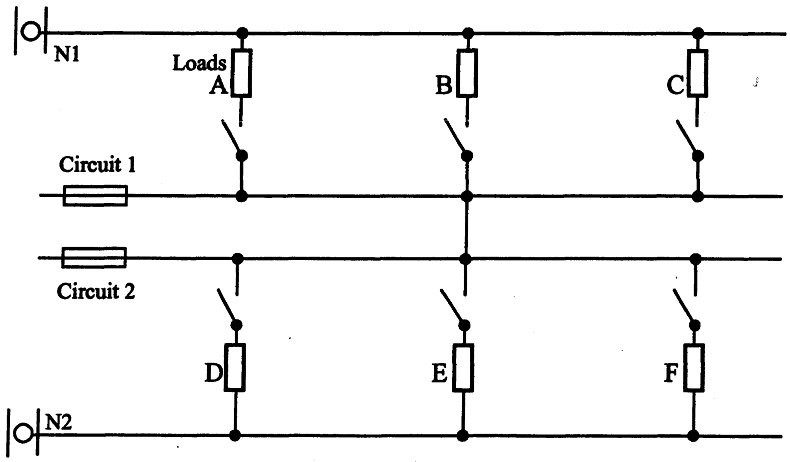


Figure 8.1

What is the potential (voltage) between the disconnected neutral and the load terminal shown in Figure 8.2?

What could be the consequence of an electrician working on circuit 4, Figure 8.2?

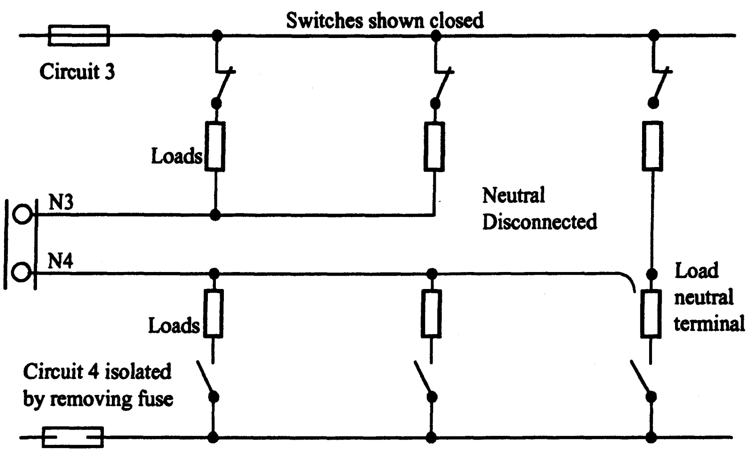


Figure 8.2

Testing methods

Dead testing - circuits with loads connected

Interconnection of conductors of different circuits can be detected in circuits supplying permanently connected loads and 'lamped' lighting points by testing for continuity between neutrals and actives of all circuits at the switchboard.

Preparation

For each circuit under test:

1. Isolate the supply at the switchboard.
2. Disconnect all the neutral conductors.
3. Ensure loads are connected and controlling switches are on.
4. Set the test instrument to ohms and zero.

Procedures

1. Test for no continuity between neutral conductors as shown in Figure 8.3.
2. Similarly, test for no continuity between active conductors.

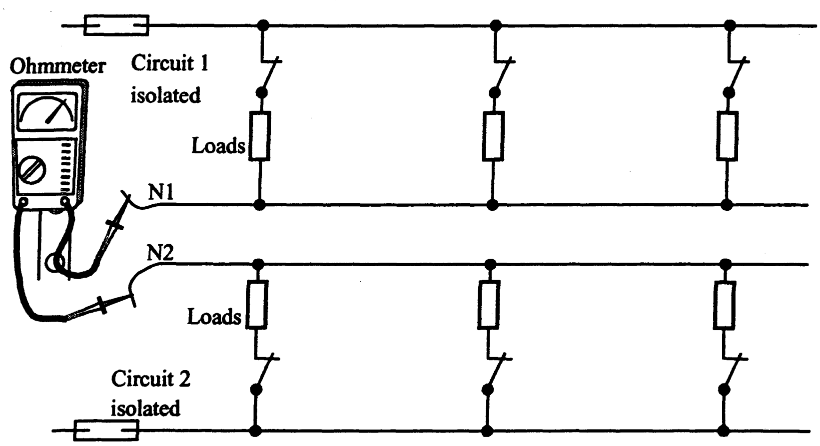


Figure 8.3 Interconnection DEAD testing - loads connected

The results for a correctly connected installation are as follows.

Circuit/test points	*Test results*
N_1 to $N_{2,3}$ etc	Infinity
A_1 to $A_{2,3}$ etc	Infinity

3. At the completion of the test reconnect all conductors to their correct terminals.

Note Testing between active and neutral conductors of different circuits will also reveal an inter-connection defect.

Faults can be located by switching off each load in turn during the test.

Student exercise 2

A test with an ohmmeter between two active conductors during an interconnection check indicates a closed circuit. What action would you take to locate the fault and how would you know that you have found the fault?

____

____

____

____

Dead testing - circuits with loads not connected

Interconnection of conductors of different circuits can be detected in circuits supplying socket outlets by using a known resistance between the active and neutral conductors of each circuit provided that no transposition between earthing and neutral conductors has been proven.

Preparation

1. Isolate the supply at the switchboard.
2. Disconnect active conductors from the load side of the protection device.
3. Disconnect the neutral conductor from the neutral link.
4. Connect a 15 W lamp or 10 Ω resistor between the active and the neutral conductors for a given circuit.
5. Set the test instrument to ohms scale and zero adjust.

Procedure

1. At each socket outlet turn on the switch and measure the resistance between active and neutral terminals.

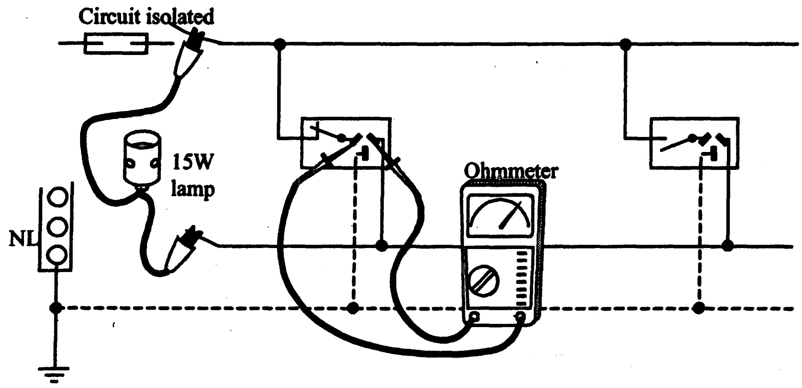


Figure 8.4 Interconnection DEAD testing - loads not connected

The results of a correctly connected circuit are as follows.

Table 8.1 Test results

Circuit/test points	*Test results*
A to N	300 Ω, switch on (Resistance of 15 W lamp)
A to N	Infinity, switch off

2. At the completion of the test remove the 15 W lamp and reconnect all conductors to their correct terminals.

Live testing

Live testing to determine there is no interconnection between circuits should only be required as a final check if appropriate dead testing and procedures were carried out during installation.

Preparation

For the circuits under test:

1. Isolate the supply.
2. Connect a 15 W lamp in series with the circuit neutral
3. Connect supply to the circuit under test only.

Procedure

1. Test with series test lamps between active and neutral terminals at each load.

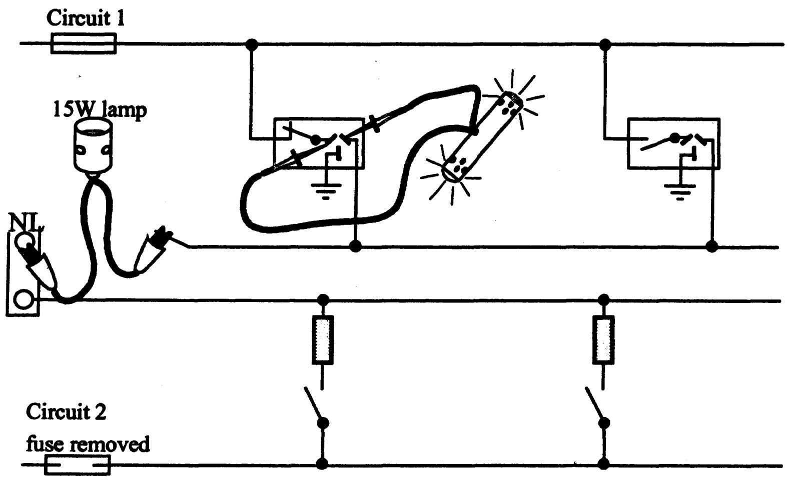


Figure 8.5

The result of a correctly connected load are as follows.

Table 8.2 Test results

Circuit/test points	*Test results*
A to N	Dim test lamp

2. At the completion of the test isolate the circuit, remove the 15 W lamp and reconnect all conductors to their correct terminals.

   Note: Also see AS/NZS 3017 - Clause 3.4.

Notes

Practical exercise - Interconnection testing

Task

To conduct tests to determine whether there is interconnection between circuits in a simulated installation.

Objectives

At the completion of this practical exercise you should be able to:

- apply interconnection dead testing techniques to determine if circuits are safe.
- apply interconnection live testing techniques to determine if circuits are safe.

Equipment

Your teacher will provide you with the specifications of the equipment to be used and the types of circuits to be tested.

	Specifications
▪ Extra low voltage a.c. supply	Type ______________________
▪ Ohmmeter	Type ______________________
▪ 15 W lamp	Type ______________________
▪ Series test lamp	Type ______________________
▪ Voltmeter	Type ______________________

Procedure A: Interconnection testing of dead circuits

1. Isolate all circuits at the switchboard.
2. Carry out test preparation and procedures on circuits as designated by your teacher. Record your results in the Table 8.3.
3. At the completion of testing remove all test items including temporary test bridges and reconnect all conductors to their correct terminals.

Table 8.3 Test results - dead testing

Circuit	*Test results*	*Condition*	
		Correct	*Faulty*
Light 1			
Light 2			
Power 1			
Power 2			
Range			
Water heater			
Submain			

Procedure B: Interconnection testing of live circuits

1. Isolate all circuits at the switchboard.
2. Carry out test preparation and procedures on circuits as designated by your teacher. Record your results in the Table 8.4.
3. At the completion of testing remove all test items including temporary test bridges and reconnect all conductors to their correct terminals.

Table 8.4 Test results - live testing

Circuit	*Test results*	*Condition*	
		Correct	*Faulty*
Light 1			
Light 2			
Power 1			
Power 2			
Range			
Water heater			
Submain			

Observations

1. Which circuits, if any, were found to have interconnected conductors? Indicate the type of fault.

____

____

____

2. What electrical hazards are caused by the interconnection of actives between circuits?

____

____

____

3. What electrical hazards are caused by the interconnection of neutrals between circuits?

____

____

____

Review questions

These questions will help you revised what you have learnt in this topic.

1. A low resistance measured between neutrals of different circuits indicates the probability of:
   (A) an interconnection between the two circuits
   (B) low insulation resistance
   (C) a short circuit between neutral and earth
   (D) neutral conductor continuity.

2. A common neutral:
   (A) cannot be used for individual cooking units
   (B) cannot be used for two or more final subcircuits
   (C) can be used for two or more lighting circuits
   (D) can be used for two or more socket outlet circuits.

3. Using the testing arrangements of Figure 8.5, a 'bright' test lamp would indicate:
   (A) interconnection between the earthing conductors of circuits 1 and 2
   (B) interconnection of the neutral conductors of circuit 1 and the earthing conductor of circuit 2
   (C) interconnection of the neutral conductors between circuits 1 and 2
   (D) interconnection of the neutral conductor of circuit 1 and the active conductor of circuit 2.

4. What are the possible effects on the safety of an installation of an interconnection between conductors of different circuits?

____

____

____

____

5. What action could you take to eliminate interconnection defects?

____

____

____

____

Notes

9. Switchboard Marking

Purpose

In this topic you will learn about the equipment and methods that test that switchboard equipment is correctly set out and marked.

Objectives

At the end of this topic you should be able to:

- state the reasons for ensuring that switchboard marking and equipment arrangement is correct
- identify actions which could be taken to ensure that switchboards are marked and arranged correctly and that circuits are not overloaded
- select and prepare the appropriate test equipment for checking switchboard marking and arrangement and the loading of circuits
- demonstrate DEAD testing procedures to confirm switchboard marking, arrangement and circuit loads
- demonstrate LIVE testing procedures to confirm switchboard marking, arrangement and circuit loads
- determine the condition of switchboard marking and arrangement, and circuit loads from the test results.

Technical information

You will find the information to undertake this topic in the following references. At least one reference text should be used.

- *AS/NZS 3017:2003, Electrical Installations - Testing and Inspection Guidelines,* Standards Australia.
- *AS/NZS 3000:2000, Wiring rules,* Standards Australia.

References for this topic

- *HB 300:2001, Electrical Installations* - Guide to using the Wiring rules, Standards Australia.
- Pethebridge K. and Neeson I., *Electrical Wiring Practice*, 6th Ed., Vol. 1, McGraw Hill, Sydney 2001, Chapter 11.

Why this test is needed

A correctly marked switchboard is needed to help ensure that installation maintenance and repairs are carried out safely. Marking is necessary to ensure that the correct circuit is disconnected from the supply.

AS/NZS 3000 requirements

AS/NZS 3000 Wiring rules require switchboards to be marked to identify the:

- relationship of the switchboard, protection devices and switchgear to the various section of the installation.
- active and neutral links
- terminals of corresponding active and neutral connections.
- common neutrals.
- switches which initiate emergency supplies.
- the main earthing conductor and neutral conductor MEN connection

Quality action - No defects

The following suggestions will help eliminate incorrect switchboard marking and the need for costly rework.

- The planning stage of an installation should involve determining the circuits required to accommodate the number of points and types of loads
- Following this, the allocation of appropriate switchboard equipment for the various circuits need to be decided.
- Clearly mark all cable ends during the installation stage. Record the circuit schedule at the same time as wiring the switchboard
- Mark the switchboard immediately after each circuit or group of circuits have been connected.

Other tests

Tests which have similar preparation and can be conducted at the same time are:

- transposition testing
- polarity testing
- short circuit testing

Equipment

Dead testing

Equipment needed for this test is:

- a multimeter set on the low ohms range, or
- an insulation/continuity resistance tester set on the ohms range
- 15 W lamp.

Live testing

Equipment needed for this test is:

- series test lamp
- 15 W lamp

Testing methods

Dead testing - circuits with loads connected

Incorrect switchboard marking can be detected in circuits supplying permanently connected loads and 'lamped' lighting points by measuring the resistance between circuit conductors at the switchboard.

Preparation

For each circuit under test:

1. Isolate the supply at the switchboard.
2. Disconnect the neutral from the neutral link.
3. Turn on all circuit control switches.
4. Set the test instrument to ohms range and zero adjust

Procedure

1. Measure the resistance between active and neutral of each circuit.

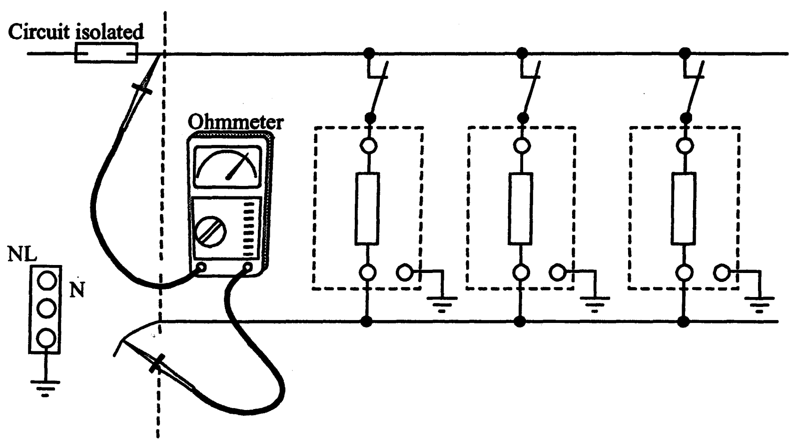


Figure 9.1 Dead testing - loads connected

The results that identify various types of loads are as follows.

Table 9.1 Expected results

Circuit	*Condition*
Light circuit	5 to 50 Ω depending on the number of lamps in the circuit
4.8 kW water heater	12 Ω
3.6 kW water heater	16 Ω
10.4 kW range	5.6 Ω

Note The reading on the ohmmeter should be a value consistent with the resistance value estimated for that circuit with all loads connected.

2. At the completion of the test reconnect all neutral conductors to their correct terminal.

Dead testing – circuits with loads not connected

Incorrect switchboard marking can be detected in circuits supplying points such as socket outlets by using a known resistance to identify the neutral conductor. The test can also be used for any circuit to check the number of points connected to the circuit.

Preparation

1. Isolate the supply at the switchboard.
2. Connect a 15 W lamp between the circuit neutral and the neutral link.
3. Connect a temporary test bridge between the active conductor and the neutral link.
4. Set the test instrument to ohms range and zero adjust.

Procedures

1. At each load point turn on the control switch and measure the resistance between active and neutral terminals.

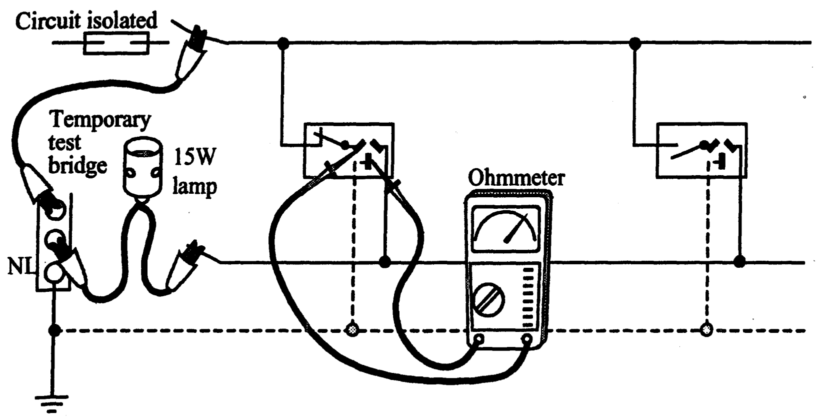


Figure 9.2 Dead testing - no connected loads

The point for a given circuit is identified by a test reading of approximately 300 Ω (cold resistance of 15 W lamp).

Note To check the number of points connected, count the number of outlets that provide the same reading.

2. At the completion of the test remove all temporary test bridges and the 15 W lamp and reconnect all conductors to their correct terminals.

Live testing

Live testing to determine switchboard marking should only be required as a final check if appropriate dead testing and procedures were carried out during installation.

Preparation

For the circuits under test:

1. Isolate the supply.
2. Connect a 15 W lamp in series with the neutral.

3. Connect supply to the circuit under test only.

Procedure.

1. Test with series test lamp between active and neutral terminals at each load.

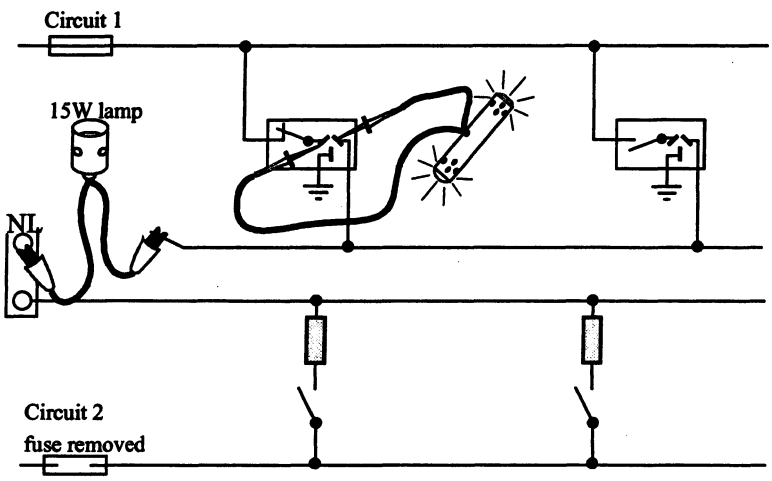


Figure 9.3

The results of a correctly marked circuit are as follows.

Table 9.2 Test results

Circuit/test points	*Test results*
A to N	Dim test lamp

2. At the completion of the test isolate the circuit, remove the 15 W lamp and reconnect all conductors to their correct terminals.

Notes

Practical exercise - Switchboard marking

Task

To test a switchboard to determine that marking is correct.

Objectives

At the completion of this practical exercise you should be able to:

- test to determine that switchboard marking is correct and adequate.

Equipment

Your teacher will provide you with the specifications of the equipment to be used and the types of circuits to be tested.

	Specifications
▪ Extra low voltage a.c. supply	Type ______________________
▪ Ohmmeter	Type ______________________
▪ 15 W lamp	Type ______________________
▪ Series test lamp	Type ______________________

Procedure A: Dead testing switchboard marking

1. Isolate all circuits at the switchboard.
2. Carry out test preparation and procedures on circuits as designated by your teacher. Record your results in the Table 9.1.
3. At the completion of testing remove all test items including temporary test bridges and reconnect all conductors to their correct terminals.

Table 9.3 Test results

Circuit	*Test results*	*Condition*	
		Correct	*Faulty*
Light 1			
Light 2			
Power 1			
Power 2			
Range			
Water heater			
Submain			

Procedure B: Live testing switchboard marking

1. Isolate all circuits at the switchboard.
2. Carry out test preparations and procedures on circuits as designated by your teacher. Record your results in Table 9.4.
3. At the completion of testing remove all test items including temporary test bridges and reconnect all conductors to their correct terminals.

Table 9.4 Test results

Circuit	*Test results*	*Condition*	
		Correct	*Faulty*
Light 1			
Light 2			
Power 1			
Power 2			
Range			
Water heater			
Submain			

Observations

1. Which circuits, if any, were incorrectly marked?

___

___

___

2. What electrical hazards are caused by incorrect marking on a switchboard?

___

___

___

Review questions

These question will help you revised what you have learnt in this topic.

1. One of the main reasons for clearly marking isolating switches on switchboards is that:
   (A) consumers are happier
   (B) switches need a mark to work correctly
   (C) ease of identification for maintenance and emergency
   (D) appearance of the switchboard is improved.

2. The expected resistance measured between the active and neutral conductors at the switchboard of a circuit supplying a 3.6 kW heating appliance would be:
   (A) 12 ohms
   (B) 1 megohm
   (C) 16 ohms
   (D) 24 ohms.

3. The maximum number of main switches on any main switchboard shall be:
   (A) 4
   (B) 2
   (C) 6
   (D) no limit.

4. The number of points that may be connected to one circuit is:
   (A) unlimited provided the circuit operates as intended
   (B) the current carrying capacity of the cable divided by the rating of one point
   (C) not more than 20 points
   (D) determined by the type and current rating of the protective device.

5. List the items required to be marked and clearly identified on a switchboard.

6. What are the requirements for the identification of the following components on a typical switchboard?
   - main switches
   - bars and links
   - wiring

7. List **three** methods commonly used to identify circuits and main switches on switchboards that are legible and indelible.

Notes

10. Optional Tests

Purpose

In this topic you will learn about the optional tests that verify an electrical installation meets the requirements of the Wiring rules.

Objectives

At the end of this topic you should be able to:

- state the reasons why the fault loop impedance of a circuit should be tested
- state the reasons why RCD operation should be tested on final subcircuits
- demonstrate both live and dead testing procedures used to determine the fault loop impedance of a final subcircuit.
- demonstrate the procedures required to test the operation of a RCD.

Technical information

You will find the information to undertake this topic in the following references. At least one reference text should be used.

- *AS/NZS 3017:2003, Electrical Installations - Testing and Inspection Guidelines,* Standards Australia.
- *AS/NZS 3000:2000, Wiring rules,* Standards Australia.

References for this topic

- *HB 300:2001, Electrical Installations* - Guide to using the Wiring rules, Standards Australia.
- Pethebridge K. and Neeson I., *Electrical Wiring Practice*, 6th Ed., Vol. 1, McGraw Hill, Sydney 2001, Chapter 11.

Fault-loop impedance test

This test is carried out to confirm the fault-loop impedance value of each circuit will be low enough to ensure the operation of the protective device during a fault within the time and touch voltage requirements.

Live testing

To perform the fault-loop impedance test, a fault-loop impedance meter is required. Test procedure is as follow:

- energise all circuits
- connect the fault-loop impedance meter to the extremity of each installed circuit and measure the earth-loop impedance of each circuit
- the measured value must be less than the maximum values tabulated in Table B4.1 of AS/NZS 3000 or Table 3.1 of AS/NZS 3017
- if an RCD operates during the test, the test result can be considered satisfactory.

Dead testing

Where the supply is not connected, an ohmmeter can be used to measure the fault-loop impedance as follows:

- connect together the active and earth conductors of the circuit under test at the switchboard
- at the extremely of the circuit, connect the ohmmeter between the active and earth terminals
- the value indicated will be the sum of the active and protective earth resistance (Rphe). This value must not exceed the values in Table 3.2 of AS/NZS 3017.

RCD testing

This test is to confirm that the RCD trip mechanism is functioning correctly and also to ensure that the RCD will trip within the specified trip time or residual current tolerance.

Testing the integrity of the RCD trip mechanism is normally achieved by pressing the test button on the RCD. This test only confirms that the RCD is functioning correctly and the tripping device mechanism is operating.

To test the complete circuit:

- connect a purpose built RCD tester which will indicate the tripping current and tripping time, or
- connect approved test lamps that draw a current greater than the rated residual current of the device between the circuit active and protective earth conductor.

Practical exercise - Optional tests

Task

- To determine the fault-loop impedance of a final subcircuit.
- To conduct tests to determine the integrity of a RCD protected circuit.

Objectives

At the completion of this practical exercise you should be able to:

- measure the fault loop impedance of a final subcircuit
- connect a fault-loop impedance tester to determine the fault-loop impedance of a final subcircuit
- from the results determine if the circuits meet the requirements of AS/NZS 3000.
- conduct tests to verify the integrity of a RCD protected circuit.

Equipment

Your teacher will provide you with the specifications of the equipment to be used and the types of circuits to be tested.

	Specifications
▪ Extra low voltage a.c. supply	Type ____________________
▪ Fault-loop impedance tester	Type ____________________
▪ Ohmmeter	Type ____________________
▪ RCD tester	Type ____________________
▪ Test lamps	Type ____________________
▪ Connection leads	

Procedure A: Fault-loop impedance

1. Isolate all circuits at the switchboard.
2. At the switchboard, connect together the active and protective earth of the circuit under tests.
3. Connect a low reading ohmmeter to the other end of the circuit. Record the value of the circuit resistance (R_{phe}) in Table 10.1.

Table 10.1 Fault-loop impedance results

Circuit breaker setting	*Circuit breaker type*	*Active mm^2*	*Earth mm^2*	*R_{phe}*	*Fault-loop impedance reading*

4. Reconnect all conductors to their correct terminals.
5. Connect the fault-loop impedance tester to the circuit as per manufacturer's instructions.
6. Turn on the supply and measure the fault-loop impedance of the circuit, as per manufacturer's instructions. Record the value in Table 10.1.

Procedure B: RCD verification

1. Connect the supply to the circuit under test.
2. Operate the test button of the RCD and observe if the RCD trips. Record your observations in Table 10.2.

Table 10.2 RCD test results

Test button operation		*RCD tester results*	
RCD tripped		Trip current	Trip time
Yes	No		

3. Reset the RCD if required and connect the RCD tester to the circuit as per manufacturer's instructions.
4. Operate the RCD tester as per manufacturer's instructions and record the tripping current and tripping time in Table 10.2.

Observations

1. Using Table 10.1 and Table 3.2 of AS/NZS 3017, determine the maximum permissible value of fault-loop impedance of the test circuit.

   R_{phe} = _______________ ohms.

2. From the test results recorded in Table 10.1, does the circuit satisfy the requirements for fault-loop impedance?

   ____

   ____

3. Compare and explain any difference between the ohmmeter and fault-loop meter readings.

   ____

   ____

   ____

4. From your results recorded in Table 10.2, does the RCD meet the requirements of AS/NZS 3000 in relation to tripping current and tripping time.

   ____

   ____

Review questions

These question will help you revised what you have learnt in this topic.

1. The mean tripping current for a type D circuit breaker is:
   (A) 4 times rated current
   (B) 7.5 times rated current
   (C) 12.5 times rated current
   (D) similar to HRC fuses.

2. To verify the correct operation of a RCD the following would be required:
   (A) trip the RCD using the test button on the device
   (B) obtain special test equipment or use the RCD test button
   (C) verification is unnecessary with a new device in a new installation
   (D) test to ensure that the maximum tripping time is not exceeded.

3. AS/NZS 3000:2000 requires that RCD's shall be installed for the protection of final sub circuits suppling socket outlets in residential type areas such as boarding houses must have a residual current of:
   (A) 10 mA
   (B) 30 mA
   (C) 50 mA
   (D) 30 mS.

4. A live test would be the appropriate and safe way for checking an existing installation for which of the following tests:
   (A) insulation resistance for a power circuit
   (B) polarity testing of lighting circuits
   (C) short circuit checks on lighting circuits
   (D) fault loop impedance.

5. Testing of RCD operation should be carried out by the use of:
   (A) an insulation tester
   (B) a multimeter
   (C) a tong tester
   (D) special test equipment.

6. Testing of an RCD using its test button does not check:
   (A) the continuity of the earth system
   (B) the integrity of its mechanical mechanism
   (C) the integrity of its electrical elements
   (D) the RCD is operating correctly.

Review questions

7. As required by AS/NZS 3000, the resistance of protective earthing conductors shall be:
   (A) not more than 2 ohms
   (B) not more than 0.5 ohms
   (C) low enough for correct operation of overcurrent devices
   (D) high enough to limit induced voltages.

8. A RCD that continually trips after resetting could indicate:
   (A) low leakage current
   (B) transposition of neutral and earthing conductors
   (C) low earthing system resistance
   (D) the polarity of A and N reversed at a socket outlet.

9. The earthing system must have a low resistance to ensure:
   (A) the correct operation of the appliance if an earth fault occurs
   (B) the effective operation of circuit protection devices if an earth fault occurs
   (C) the neutral is at a safe potential at all times
   (D) protection against induced voltage.

10. When testing earthing resistance:
   (A) a multimeter set on megohms range is suitable
   (B) a insulation resistance tester must be used
   (C) all earthing conductors must be disconnected
   (D) associated circuits should be isolated from the supply.

11. The tripping operation of a RCD protecting socket outlets can be tested by a/an:
   (A) continuity tester across the active and neutral terminals at the protected outlets
   (B) insulation resistance tester between the neutral and earth terminals at the protected outlets
   (C) series test lamps between the active and earth terminals at the protected outlets
   (D) digital voltmeter between the active and neutral terminals of the protected outlets.

12. When considering circuits which operate on 240 V a.c. the values given for maximum circuit lengths in AS/NZS 3000:2000 can be:
   (A) increased by a factor of 230/240
   (B) decreased by a factor of 230/240
   (C) decreased by a factor of 1.04
   (D) increased by a factor of 1.04.

13. A roll of 6 mm^2 copper conductor has a resistance of 3.08 Ω/km. Determine the length of the conductor from the roll if its resistance is 0.05 Ω.

Review questions

14. What is the maximum value of fault-loop impedance permitted on a circuit operating on 230 volt and protected by a 20 ampere type C circuit breaker?

15. A domestic installation has the socket outlet final sub-circuits protected by miniature combination MCB-RCD's. Describe how, on a live circuit, test lamps can be used to determine if the RCD component of the MCB-RCD is operating as it should for that circuit.

16. The maximum permissible fault-loop impedance of a sub-circuit is 1.5 Ω, and the impedance of the active is 0.5 Ω. What is the maximum permissible impedance of the earthing conductor?

17. When considering fault-loop impedance, what is the maximum length permitted for a 230 volt circuit with a 25 mm^2 active and 6 mm^2 earth conductor? The circuit protection is an 80 ampere type D circuit breaker.

18. If the circuit described above was operating on 240 V a.c., what is the maximum circuit breaker?

Notes

11. Documentation of Electrical Work

Purpose

In this topic you will learn about the documentation requirements to comply with government safety acts and regulations.

Objectives

At the end of this topic you should be able to:

- name the government acts and regulations that regulate electrical safety in your area
- list the notification and reporting requirements required by your local inspecting authority
- name the local inspecting authority in your area
- document the results of testing an installation as required by the local authority.

Technical information

You will find the information to undertake this topic in the following references. At least one reference text should be used.

- *AS/NZS 3000:2000, Wiring rules,* Standards Australia.
- *AS/NZS 3012:2003, Construction and Demolition Sites,* Standards Australia.
- *AS/NZS 3017:2001, Electrical Installation - Testing and Inspection Guidelines,* Standards Australia.

References for this topic

- *Electricity Safety (Electrical Installations) Regulation,* 1998 (NSW).
- *Electricity Safety Act.* 1971 - Ammended (ACT).
- *National Electricity (South Australia) Act*, 1996.
- *Electricity Safety (Installations) Regulations,* 1999 (Vic).
- *Electricity Industry Safety and Administration Regulation*, 1999 (Tas).
- *Electricity (Licensing) Regulations*, 1991 (W.A.).
- *Electricity Safety Act.* 2002 (Qld).
- *Electricity Reform (Safety and Technical) Regulations*, 2000 (N.T.).
- Pethebridge K. and Neeson I., *Electrical Wiring Practice*, 6th Ed., Vol. 1, McGraw Hill, Sydney 2001, Chapter 11.

State and Territory Safety Acts and Regulations

Electrical installation work must be carried out in accordance with relevant electrical safety legislation:

- *Electricity Safety (Electrical Installations) Regulation,* 1998 (NSW).
- *Electricity Safety Act.* 1971 - Ammended (ACT).
- *Electricity Safety (Installations) Regulations,* 1999 (Vic).
- *National Electricity (South Australia) Act.* 1996.
- *Electricity Safety Act.* 2002 (Qld).
- *Electricity Industry Safety and Administration Regulation,* 1999 (Tas).
- *Electricity Reform (Safety and Technical) Regulations,* 2000 (N.T.).
- *Electricity (Licensing) Regulations,* 1991 (W.A.).

The purpose of the Act's is to "Eliminate the cost to individuals, families and the community of death, injury and destruction that can be caused by electricity".

As an example the Electricity Safety Regulation of NSW sets out the requirements for:

- electrical testing safety and compliance tests
- notification of installation work
- notification of results of safety and compliance tests
- penalties for non-compliance.

Information about licensing, inspection bodies, required certificates etc. can be downloaded from the following websites.

- www.erac.gov.au
- www.ipe.nt.gov.au
- www.eso.qld.gov.au
- www.ocei.vic gov.au
- www.energy.wa.gov.au
- www.energysafety.sa.gov.au
- www.doe.nsw.gov.au
- www.fairtrading.nsw.gov.au
- www.actpla.act.gov.au
- www.wsa.tas.gov.au

Student exercise 1

1. Name the inspection authority in your area.

2. List the types of certificates required to be sent to your inspection authority. Also include the time frame for each certificate.

3. List in point form the information required on each certificate.

4. What penalties are imposed for the following:

   (a) Failure to submit certificates

   (b) Installation does not comply with AS/NZS 3000.

5. What type of electrical work does not require the electrician to notify the inspection authority?

6. List the type of electrical work that cannot be commissioned unless the inspection authority has permitted its connection to the electricity supply main.

7. For what period of time must the electrician keep a copy of all test results for auditing purposes?

____

____

Student exercise 2

From the description below complete the relevant form/s which will be supplied by your teacher

Customer's name - Mr & Mrs B. Smith
Installation address - 1 Jones St, Jonesville
Phone No. - 02 817 8171
Maximum demand - 68 A
Circuits & loading - L_1 - 10 lighting points
- L_2 - 15 lighting points
- P_1 - 12, 10 A socket outlets
- P_2 - 12, 10 A socket outlets
HWS - 4.8 kW
Range - 9.6 kW range
A/C - 15 A air conditioning unit

Contractor's details
Name - Harry Holt
Address - Harry Electric's
1 Holt St, Holtville
Phone - 0414 2161
Licence No - EC 142536

Circuit		*No of points*	*Circuit breaker*	*Cable*	*Insulation resistance*	*Earth continuity*
Consumers mains				16 mm² SDI	100 MΩ	
Lights	L_1	10	10 A	1.5 mm² TPS	10 MΩ	0.3 Ω
	L_2	15	10 A	1.5 mm² TPS	8 MΩ	0.4 Ω
Socket outlets	P_1	12	16 A	2.5 mm² TPS	100 MΩ	0.25 Ω
	P_2	12	16 A	2.5 mm² TPS	150 MΩ	0.35 Ω
HWS 4.8 kW		1	25 A	4 mm² TPS	2 MΩ	0.2 Ω
Range 10.2 kW		1	32 A	6 mm² TPS	4 MΩ	0.3 Ω
Main earth				6 mm²	*	0.4 Ω
Equipotential bond				4 mm²	*	0.3 Ω

The main earth electrode and water pipe is located to the left of the main switchboard.

All other tests meet the requirements of AS/NZS 3000.

The following table is an example of a job record sheet that can be used to record all test results for a particular job.

Test Inspection results

Job details: Lot:	Street:		Suburb:
Tenant:	Phone:	Owner:	Phone:
Electrical worker installing:		Licence No:	
Work performed:			

Visual Inspection		*Y*	*N*
Clause	*General*		
1.7.3	Ensure that all electrical insulation and electrical enclosures provide effective protection against direct contact with live parts.		
1.7.4	Ensure that all electrical insulating and electrical enclosures, double insulation and/or isolation transformers provide effective protection against indirect contact with live parts.		
1.7.6	Protection provided against thermal effects, eg. enclosure, guarding or screening of flammable materials, hot surfaces and parts that may cause physical injury.		
1.7.13	Ensure that where electrical cables and/or equipment penetrate fire barriers, that effective protection is provided to prevent the spread of fire.		
1.10	Ensure that electrical equipment and accessories are safe to use. There is no damage that could impair safe operation. Unused electrical equipment is safely disconnected.		

Clause	*Consumer's mains*	*Y*	*N*
1.8.3	Ensure that the current carrying capacity of consumer's mains and submains is correct		
3.12	Ensure that aerial installation conditions are correct.		
3.7.2	Ensure that consumer's mains wiring is terminated correctly.		
1.8.6	Ensure that cables are protected against external influences.		

Clause	*Switchboards*	*Y*	*N*
2.9.8	Ensure the switchboard is installed correctly, including restricted locations.		
2.9.10	Ensure that emergency exists are provided.		
2.4.3	Ensure that correct protective overload devices are fitted, especially for max. circuit lengths as per Appendix B5.3.		
2.5.1	Ensure that correct residual current devices are fitted.		
2.4.4.3	Ensure that the fault current ratings for circuit breakers and RCD's are appropriate.		
2.8.3.3	Ensure that main switch(es) are fitted and clearly labelled.		
2.9.3	Ensure that neutral bars, earth bars, and active links are fitted and correctly terminated.		
2.9.5	Ensure that switchboard wiring is correctly terminated.		
2.1	Ensure that switchgear is correctly fitted and terminated.		
2.9.4	Ensure that switchboards and their electrical equipment are clearly labelled.		
1.8.6	Ensure that switchboards are protected against external influences.		

Clause	*Wiring systems*	*Y*	*N*
3.4	Ensure that the current carrying capacity of circuit wiring is correct.		
1.8.4	Ensure that the total voltage drop for the installation is under 5%		
3.8.2	Ensure that cable cores are identified.		
3.9.3	Ensure there is adequate support and fixing for cables.		
3.7	Ensure that wiring connections are correct.		
3.7.3	Ensure that enclosures are fitted correctly.		
3.11	Ensure that underground wiring is installed correctly.		
3.12	Ensure the aerial wiring is installed correctly.		
7.10.7	Ensure that emergency systems are installed correctly.		
1.10.4	Ensure that cables are segregated from other services and electrical installations.		
3.3.1	Ensure that cables are protected against external influence.		
1.7.7	Ensure that unused cables are protected against unwanted voltages by suitable termination.		

Clause	*Electrical equipment*	*Y*	*N*
2.8.4	Ensure that isolation and switching devices are fitted to protect against injury from mechanical movement in electrical devices and motors.		
4.3	Ensure that isolation and switching devices are fitted to protect against thermal effects produced by motors, room heaters, water heaters, etc.		
4.3.11	Ensure that functional switching devices are fitted to cooking appliances.		
7.1.4.2	Particular installation conditions for socket outlets around *baths, showers and other fixed eater containers.*		
7.1.4.3	Particular installation conditions for switches and other accessories around *baths, showers and other fixed eater containers.*		
7.1.4.4	Particular installation conditions for other electrical equipment around *baths, showers and other fixed eater containers.* The correct degree of protection required for each Zone, will be provided for all other electrical equipment.		
7.2.4.3	Particular installation conditions for socket outlets around *swimming, paddling and spa pools.* There will not be any socket outlets fitted within Zone 0. The correct degree of protection required for Zones 1, 2 and 3, will be provided for all socket outlets installed within those Zones.		
7.3.4	Particular installation conditions for the selection and installation of electrical equipment for *sauna heaters.* The correct degree of protection shall be provided for all equipment. Specific reference must be made for mounting of equipment in the restricted zones.		
7.4.4	Particular installation conditions for the selection and installation of electrical equipment for *refrigeration rooms.* The correct degree of protection shall be provided for all equipment.		
7.5.4	Particular installation conditions for the selection and installation of electrical equipment for *hose down areas.* The correct degree of protection shall be provided for all equipment.		
7.6.4	Particular installation conditions for the selection and installation of electrical equipment for *fountains and water features.* The correct degree of protection shall be provided for all equipment. Specific reference must be made for mounting of equipment in the restricted zones.		
7.7	Particular installation condition for the selection and installation of electrical equipment for *extra low voltage installations.*		
7.8	Ensure that electrical installation complies with requirements of high voltage.		
1.9.5	Ensure that all electrical equipment intended to be installed within an installation complies with required standards.		
1.10.1	Ensure that electrical equipment is connected, supported and fixed, in an acceptable manner.		
1.9.3	Ensure that electrical equipment is protected against external influences.		
4.9.4	Ensure that switching devices for socket outlets are installed as required.		

Clause	Earthing	Y	N
5.6.5	Ensure that the MEN connection is installed correctly.		
5.6.2	Ensure that the Earth electrode is installed correctly.		
5.5	Ensure that all the Earthing conductors are the appropriate size and colour.		
5.8	Ensure that all the Equipotential bonding conductors are the appropriate size and colour.		
3.7	Ensure that all connections, joints and terminations in earthing conductors are correct.		
1.8.6	Ensure that earthing conductors and equipment are protected against external influences.		
5.6.6	Ensure that earthing in outbuildings and detached portions of an electrical installation comply with standards, especially neutral connection.		
5.7	Ensure that the creation of an earthed situation that may require earthing of additional electrical equipment is addressed.		

Clause	Testing (Ref: AS/NZS 3000:2000 Section 6, Page 163)	Y	N
	Mandatory Tests		
6.3.3.2.2	Earthing resistance test of main earthing conductor Max 0.5 ohms		
6.3.3.3	Insulation resistance test of installation. Min 1 Megohm		
6.3.3.2	Earth resistance test for other earthed and equipotential bonded parts.		
6.3.3.4	Consumer's mains test - Ensure polarity is correct.		
6.3.3.4	Submain's tests - Ensure polarity is correct.		
6.3.3.4	Final subcircuit tests - Ensure polarity is correct.		
6.3.3.5	Final subcircuit tests - Ensure connections are correct.		

Clause	Optional tests	Y	N
6.3.4.2	Fault loop impedance test.		
6.3.4.3	Verify operation of residual current devices.		

Electrical worker testing: **Licence No:**

Signature:	**Date:**

Review questions

These questions will help you revised what you have learnt in this topic.

1. A notification of electrical work is required to be submitted to the inspection authority. List who is to receive a copy?

2. How long must the contractor retain his copy?

3. Who receives the original copy of the inspection certificate in your area?

4. The supply or inspection authorities have the responsibility to inspect:
   (A) all work carried out by the electrical contractor.
   (B) only work for which they receive notification.
   (C) work associated with consumers mains and switchboards
   (D) hazardous area work only.

5. An installation:
   (A) can be connected to the supply if minor defects exist.
   (B) need only be tested for earth continuity and insulation resistance before being connected to the supply
   (C) must comply with AS/NZS 3000 Wiring rules
   (D) must be fully tested by the supply authority before being connected to the supply.

6. Inspection authorities have the responsibility to inspect:
   (A) all work
   (B) work associated with consumer's mains and main switchboard
   (C) only for work which they receive notification
   (D) some work in hazardous areas.

7. All installation work once completed by the electrical contractor must be tested:
   (A) as the circuits are installed
   (B) by the inspecting authority
   (C) after the supply is connected
   (D) before being permanently connected to the supply.

Review questions

8. Temporary connection of an installation to the supply is permitted if:
   - (A) the contractor needs to move to another job urgently
   - (B) the consumer needs supply urgently
   - (C) it is safe to do so and for testing purposes only
   - (D) the inspection authority is delayed in providing the service.

9. Testing of an electrical installation can be carried out by:
   - (A) an electrician's assistant
   - (B) any person nominated by the electrical contractor
   - (C) any person nominated by the building contractor
   - (D) a person qualified to test.

10. From the regulations of your State/Territory, explain what the installing contractor's responsibilities are in relation to the installation work.

INSTALLATION TESTING

STUDENT WORKBOOK

SYDNEY INSTITUTE OF TECHNOLOGY
ELECTRICAL TRADES SECTION
BUILDING K

STUDENT NAME ....

CLASS .... YEAR ....

INSTALLATION TESTING

AS/NZS 3000 and a wide range of other regulations require the safe installation of all electrical services. To ensure this safety, it is necessary to correctly test all installations before supply is connected.
AS/NZS 3000 (Section 6) details the minimum level of testing required to achieve the required assurances of safety.

The minimum tests are -

(i) a **visual inspection** of the whole or part of the installation that is to be connected to the supply

(ii) a test of the **continuity of the main earthing conductor**, measured between the earth electrode and the main earthing position at the main switchboard

(iii) a test to ensure the **continuity of all protective and bonding earthing conductors**

(iv) an **insulation test**, to ensure a minimum insulation resistance of 1 Megohm is maintained between current carrying parts and earth.

(v) a **polarity test**, to ensure the correct connection of active, neutral and earthing conductors

(vii) a test of **circuit connections**, to ensure that there are no connections between active, neutral or earth cables, and that there are no interconnections between the cables of different circuits.

Other desirable, but not mandatory tests are -

(viii) a **fault loop impedance** test, to ensure correct operation of the circuit breaker in the event of a short circuit fault between active and earth

(ix) a test of the **function of any residual current devices.**

TESTING AN INSTALLATION PRIOR TO THE CONNECTION OF SUPPLY

SUGGESTED SEQUENCE OF STEPS

The sequence of steps is arranged in four parts -

A. General tests, to ensure that it is safe to proceed to the performance of detailed testing

B. Tests performed at the switchboard

C. Tests performed at the various load points.

D. Recording and verification of test results.

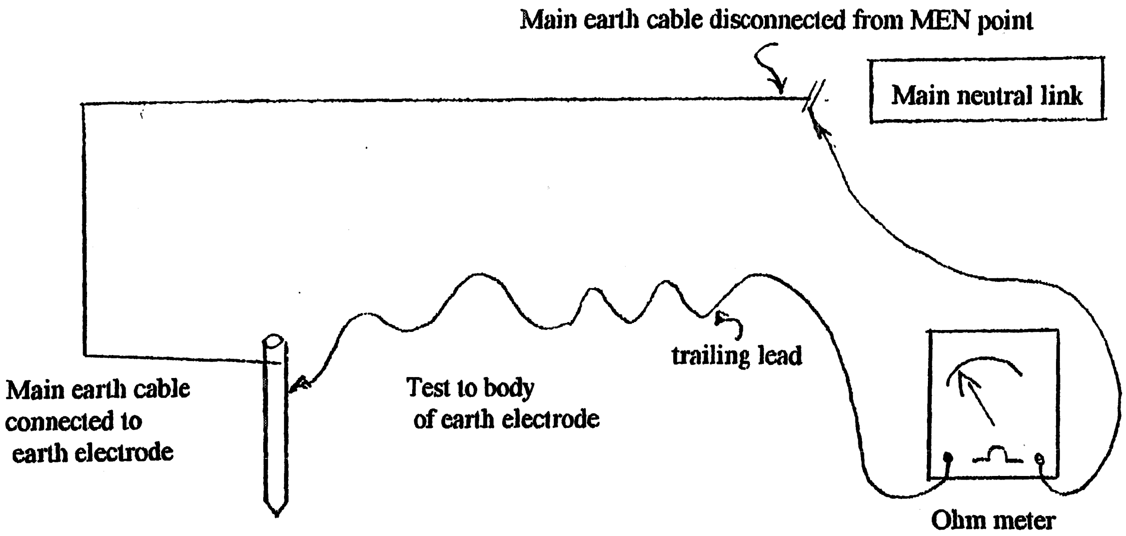
A. General tests

1. Ensure that **no supply** is present.
For a new, complete installation, test to ensure that supply is not present at the switchboard, consumers mains or point of attachment.
Where supply is already connected to the consumers mains, it will be necessary to isolate the circuits to be tested from both the active and neutral of the consumers mains.

2. Ensure that the **installation is complete**.
Ensure that all active, neutral and earth conductors are correctly terminated at the switchboard, and throughout the installation.
Visually check that all loads and associated equipment are correctly fitted, to provide protection from contact with live parts, and from the effects of moisture, dust and mechanical damage.
Switch all loads 'on', as a preparation for later tests.

B. Tests performed at the switchboard

1. Test the **continuity of the main earthing conductor**
Using a trailing lead method, test the resistance between the main earth electrode and the end of the main earthing conductor at the switchboard. No reading should be greater than 0.5 ohms - generally it should be much less.



2. Test **polarity of mains and sub mains.**
Test the polarity of all mains and sub mains connected to the switchboard.
This may be carried out in conjunction with the earthing (trailing lead) test. Temporarily disconnect the MEN point. Connect a known value resistor (10 to 100 ohms) between the main neutral link and the disconnected MEN cable tail.
Readings between the trailing lead and neutral points must equal the resistor. Readings between the trailing lead and active points (with the controlling switch 'off') must be open circuit.
AS/NZS 3017 provides simple, useful methods, with diagrams for the testing of mains and sub mains polarity.
Note that AS/NZS 3000. 2000 requires that phase sequencing must be uniform throughout all parts of a multi phase installation. This means that phase sequence testing of sub mains and mains must be carried out to ensure uniformity throughout any multi phase installation.
Refer to AS/NZS 3017 for information on this testing requirement

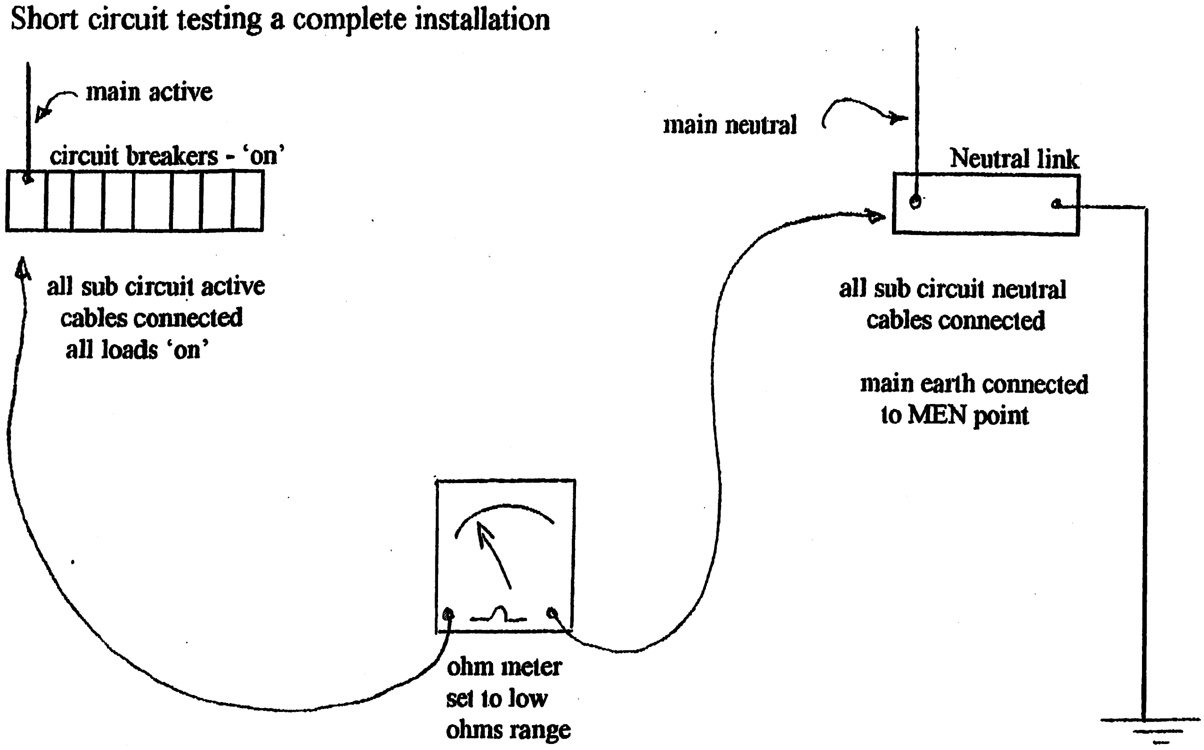
3. Perform a **short circuit test.**

All supplies must be isolated from the installation to be tested. All loads must be connected, and circuit control gear must be switched 'on'.

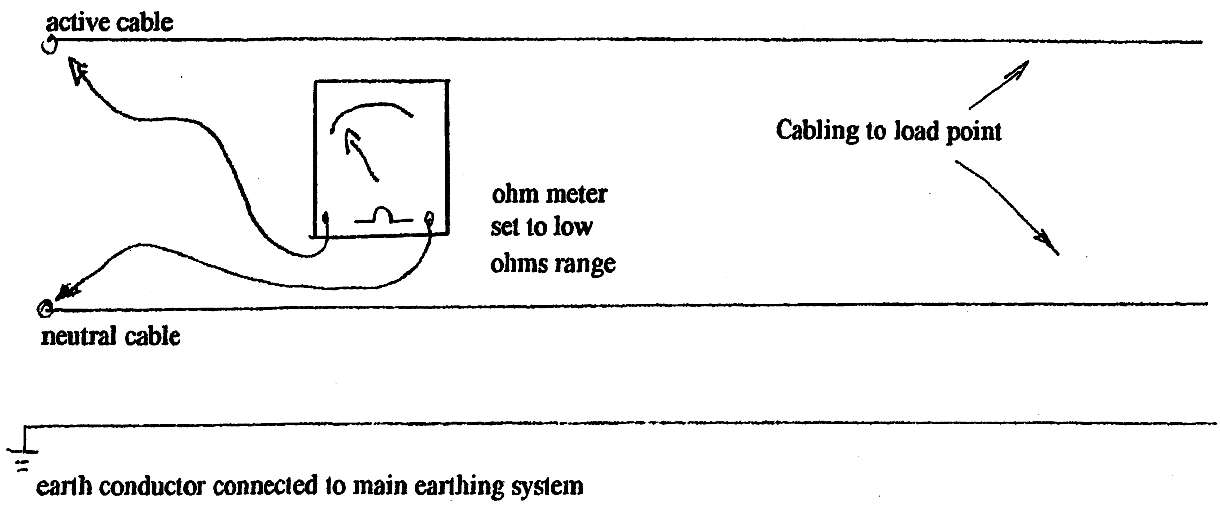
Using a low voltage continuity tester, measure the resistance of the whole installation. For a new, complete installation, this is done by connecting the ohmmeter between the main neutral and the line side of the main switch. The result will show a low resistance reading, depending on the circuit loads, but should not be zero or close to zero.

For an additional circuit, in an existing installation, the active and neutral conductors must be isolated from the supply. The earthing conductor should be connected to the main earth.

Short circuit testing a complete installation



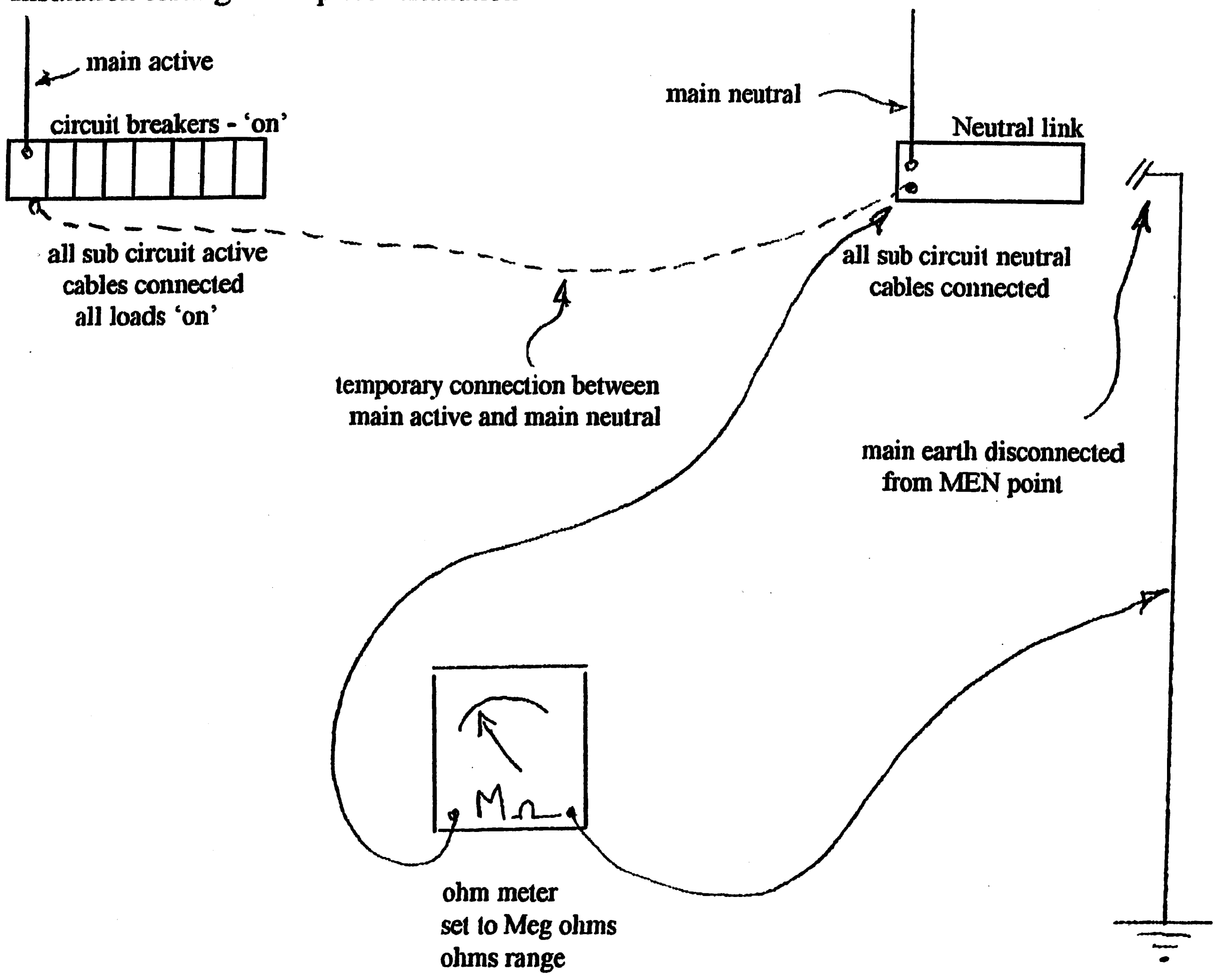
Short circuit testing a single final sub circuit



4. Perform an **insulation test**
For an additional circuit in an existing installation, temporarily join the (isolated) active and neutral conductors together, Ensure that the earthing conductor is connected to the main earthing system.
For a new installation, connect a temporary bridge between the main neutral link and a point common to all actives. This should be the load side of the main switch. With the switch 'on' the metering and consumers mains can be tested simultaneously with the remainder of the installation, or separated by turning the switch 'off'.

Connect an insulation tester between the main earthing conductor and the main neutral link. Set the tester to a suitable voltage (500 volts, DC.), and test the insulation of all components with a single test. Ideally, the result will be 'infinity'. Where the result is less than infinity, disconnect and reconnect circuits one at a time until the reading corrects, thereby identifying the circuit that is the cause of the non ideal test reading.
This disconnection will involve disconnecting the active by switching the circuit breaker 'off', and removing the sub circuit neutral conductor from the neutral link.

Insulation testing a complete installation



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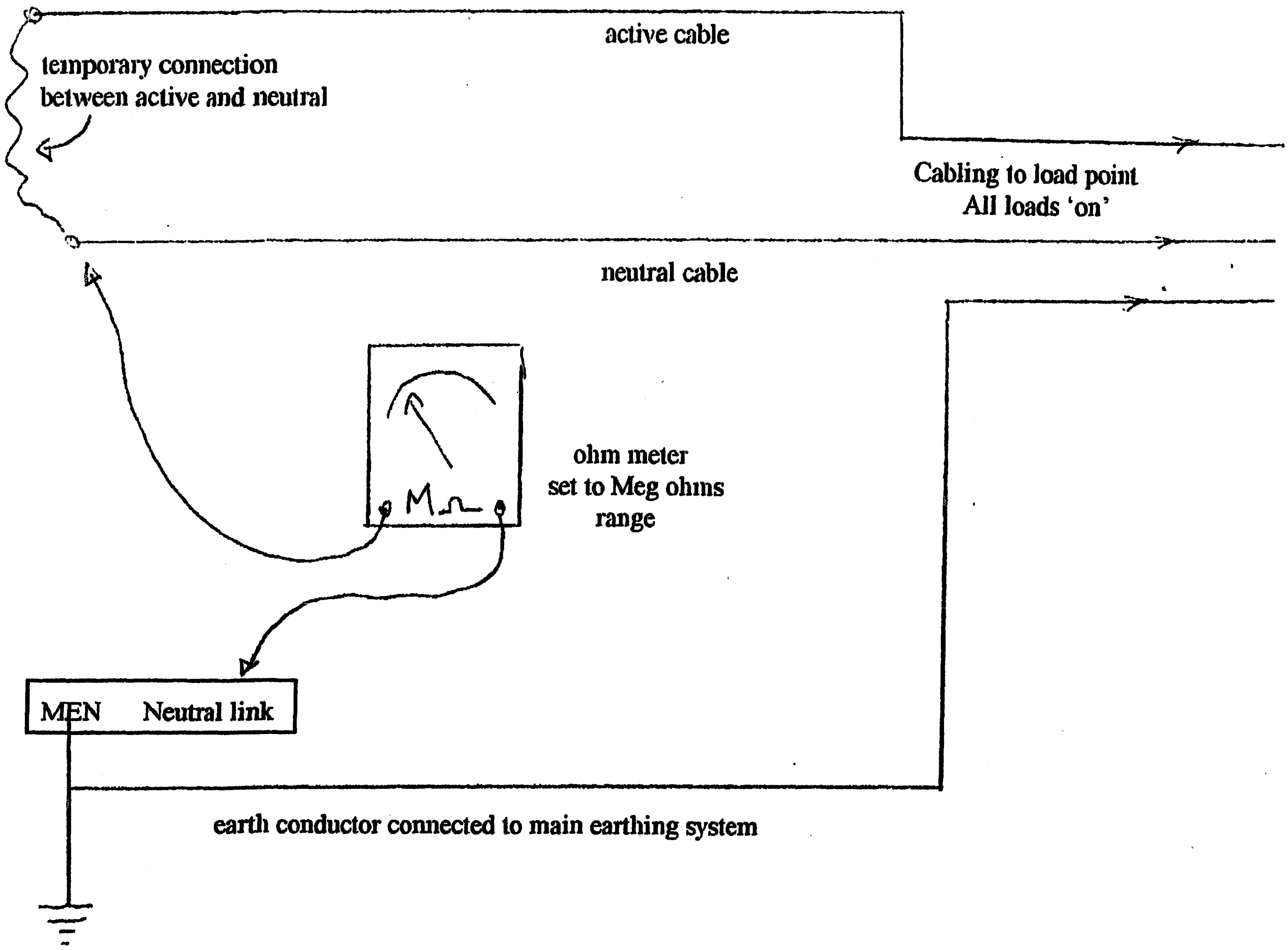
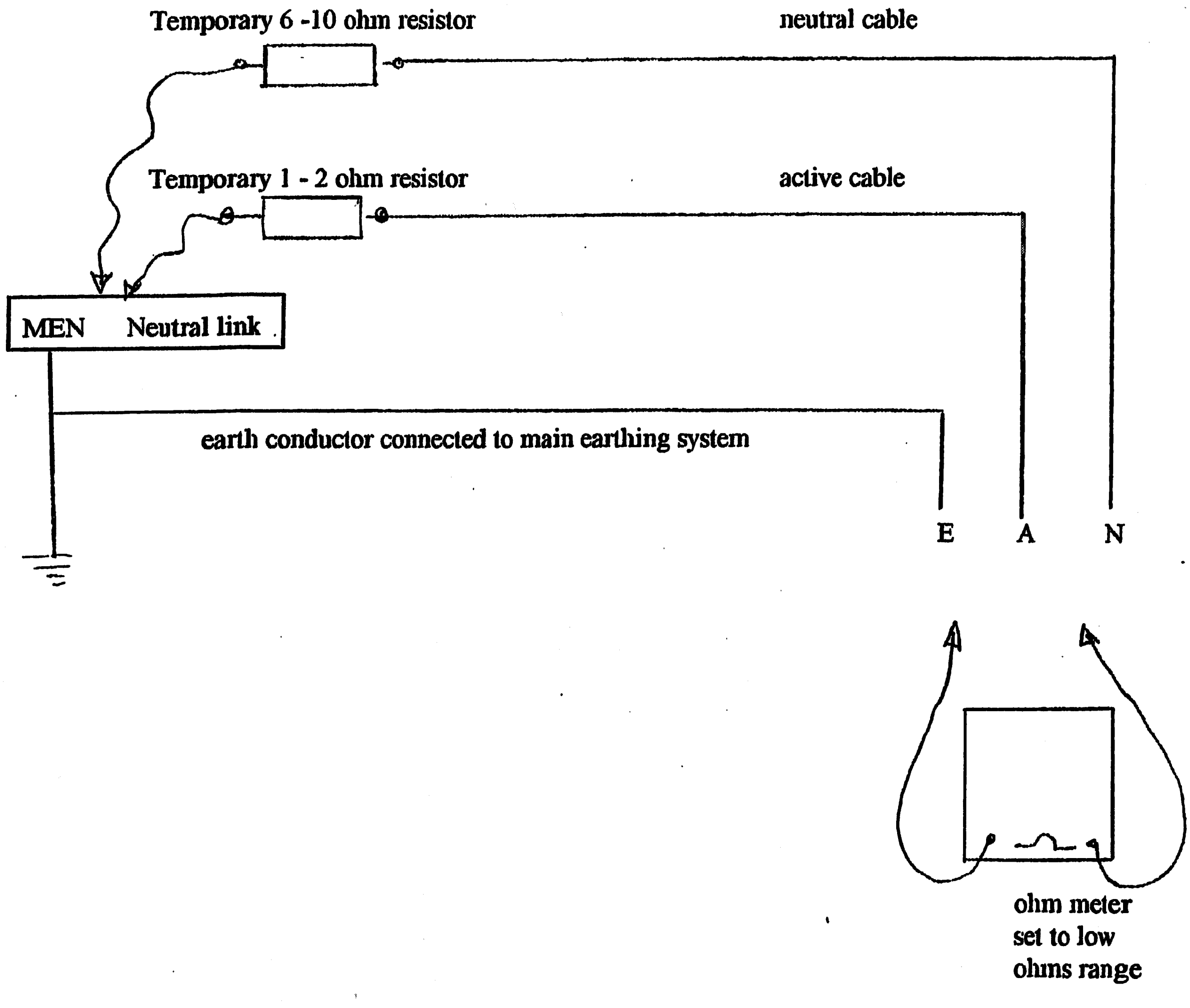
Insulation testing a single final sub circuit



C. Tests performed at the various load points.

A single test can be carried out at the load point to test for a combination of factors. This includes mandatory testing for - **polarity, continuity of earthing conductors**, and **intermix** of circuit conductors with other circuits, and also includes a dead test of **fault loop impedance**.
This test is performed on each individual circuit, one at a time, with all other circuits connected to the switchboard.

The measurement of fault loop resistance can be coupled with testing for polarity, transposition and circuit intermix, by the inclusion of temporary, known, resistors between the circuit neutral conductor and the circuit active conductor, and the (MEN) neutral link, as shown in the diagram below.



The resistor in the neutral should be 6 to 10 ohms. The resistor in the active conductor must be an accurate value, preferably 1 ohm, up to a maximum value of two ohms.

Measurement at the load, using an ohm meter should show -
Active to earth - a resistance below the maximum allowable, being the sum of the testing resistor, and the resistance of the fault loop path in the sub circuit.
Active to neutral - the sum of both resistors.
Neutral to earth - the value of the (larger) test resistor in the neutral, plus the small amount of resistance in the earth conductor.

Test Connection at load point	Expected (correct) Result	Non Expected (incorrect) Result	Likely cause of a non expected result
active to earth	less than maximum resistance, as shown in the table for type B,C, or D circuit breaker	higher than expected resistance	high resistance cable connection
			incorrect polarity
		lower than expected resistance	intermix with another circuit
neutral to earth	value of neutral series test resistor, plus some (minor) cable resistance	higher than expected resistance	high resistance cable connection
		lower than expected resistance	intermix with another circuit
			incorrect polarity
active to neutral	value of both series test resistors, plus some (minor) cable resistance	higher than expected resistance	high resistance cable connection
		lower than expected resistance	intermix with another circuit

EXPECTED RESISTANCE READINGS WHEN MEASURING FAULT LOOP RESISTANCE DURING DEAD TESTING

On the basis that at least 80% of mains voltage will be available at the circuit breaker during earth fault situations (up to 20% will be used in the supply system impedance), it is possible to determine a guide to a maximum acceptable measured resistance for a fault loop, in a circuit, through the active and earth conductors.

The minimum acceptable fault loop impedance relates directly to the rating of the circuit breaker or fuse.
AS/NZS 3000 (Clause B5.2.1 (b)) allows the calculation of expected results by assuming fault condition voltage in the sub circuit is at least 80% of the supply voltage. Up to a maximum of 20% is used in the supply system.
The following table is based on using a voltage of 80% of 230 volts, and is intended for use as a guide to maximum values of resistance, when testing between the earthed part of a load, and the active conductor connection, at the load. The use of 230 volts provides a 'worst case senario', with the test values being even safer when used with a 240 volt supply.

circuit breaker rating	Resistance between active and earth connections at load. Resistance values of fault loop impedance (less values of installed test resistors)		
	Type B	Type C	Type D
8 amps	5.7 ohms,	3 ohms	1.8
10 amps	4.6 ohms	2.45	1.2
16 amps	2.8 ohms	1.5	0.9
20 amps	2.3 ohms	1.2	0.7
32 amps	1.4 ohms	0.76	0.46
40 amps	1.1 ohms	0.6	0.36
63 amps	0.7 ohms	0.39	0.23
80 amps	0.5 ohms	0.3	0.18
100 amps	0.4 ohms	0.24	0.14

D. Recording and verification of test results.

The recording of test results, while not specified in AS/NZS 3000, is required under the regulations associated with the various supply authorities, and is an essential component in the good management of an electrical contracting business.
A simple 'tick the box' recording of test results on forms submitted to the supply authority may not provide adequate evidence of testing, in the event of problems occurring at a later date.
The actual test readings (in 'ohms') should be recorded, with a copy of the results kept by the contractor for at least seven years. This will allow the contractor to provide evidence that the installation was in correct, safe, condition at the time of connection to the supply, and that all reasonable steps were taken to provide a safe installation.

TESTING WHEN SUPPLY IS AVAILABLE

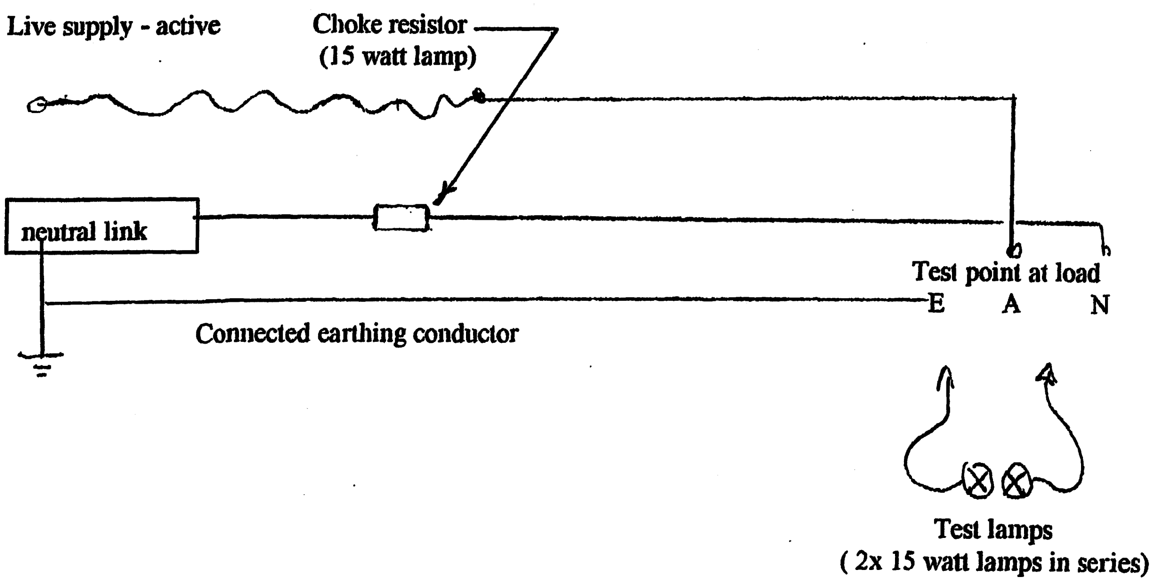
There are a range of (non mandatory) tests that may be performed where supply is available. These tests must not be used as a substitute for correct 'dead' testing methods, but may be used in addition to those test previously detailed.

'Live' testing includes -

A. **Fault loop testing** - this utilises a purpose made testing meter to measure the fault loop impedance of the supply system at any point. The meter leads are connected between active and earth at the point, and the meter reads the fault loop impedance in 'ohms'. This reading must then be correlated to the type of circuit breaker fitted to the circuit. (See AS/NZS 3000 Table B4.1)

B. **Testing of residual current devices** - an r.c.d. tester is connected between active and earth at the point, and used to read the current (in milli amps) at which the device trips. Where a purpose made tester is not available, the use of test lamps will suffice to provide a tripping action. While not as desireable as a graduated testing device, the use of test lamps is preferable to not performing the test at a load point.
It should be noted that using the 'test' button on a r.c.d. tests only at the unit - it does not test the wiring system supplying the load point.

C. **'Live' polarity testing with test lamps** - a choke resistor is fitted between the sub circuit neutral and the neutral link, at the switchboard, and test lamps are used at each load point to test for correct polarity. Note that where r.c.d. units are fitted to the circuit, this testing method will require temporary by passing of the r.c.d. unit.



Test connection	Correct result
active to earth	high lamp glow at test lamp
active to neutral	reduced lamp glow at test lamp
neutral to earth	no glow at test lamp

'LIVE TESTING' GPO CIRCUITS FOR POLARITY AND FUNCTION

Connect the sub circuit earthing conductor to the main earthing system.

Before making any active or neutral connections, carry out insulation and short circuit tests on the sub circuit.

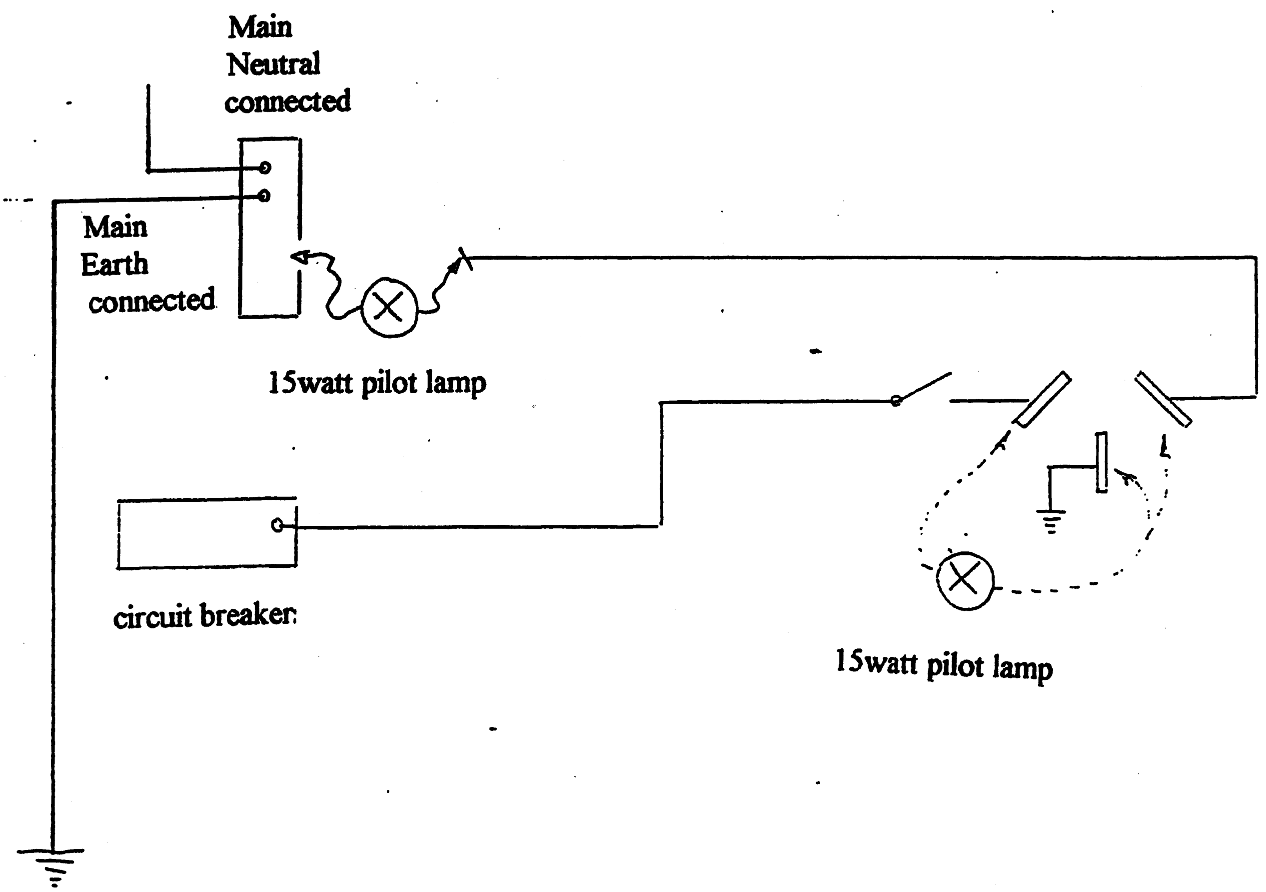
Where the sub circuit is controlled by RCD, the unit must be bypassed by fitting temporary jumper leads.

Connect a resistor (a 15watt pilot lamp is ideal) between the sub circuit neutral and the neutral link.

Connect the sub circuit active to the circuit breaker.

Switch supply on, and test at each point, using a 15watt pilot lamp. The results should be -

Test connection	Required result
Between active pin and earth pin	Full lamp brilliance
Between active pin and neutral pin	Dimmed lamp
Between earth pin and neutral pin	No lamp function



SIMULTANEOUS 'LIVE TESTING' TWO GPO CIRCUITS FOR POLARITY, FUNCTION AND INTERMIX OF CONDUCTORS

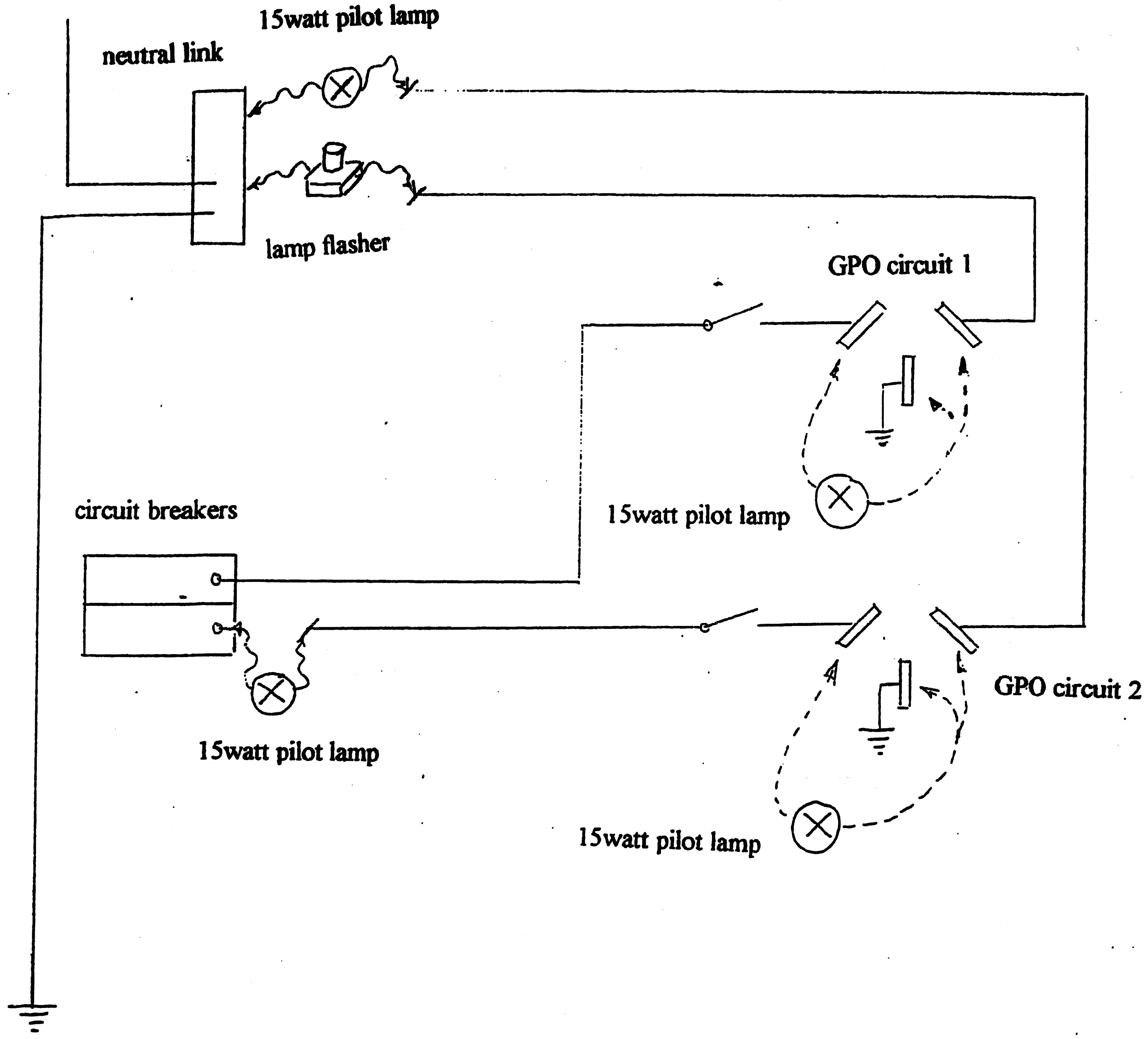
Connect the sub circuit earthing conductor to the main earthing system.
Before making any active or neutral connections, carry out insulation and short circuit tests on the sub circuits.
Where any sub circuit is controlled by RCD, the unit must be bypassed by fitting temporary jumper leads.

Connect testing devices as shown in the table below -

Circuit 1	Connect a lamp flasher between the sub circuit neutral and the neutral link Connect the sub circuit active to the circuit breaker
Circuit 2	Connect a 15watt lamp between the sub circuit neutral and the neutral link Connect ~~a 15watt lamp between the sub~~ circuit active and the circuit breaker

Switch supply on, and test at each point, using a 15watt pilot lamp. The results should be -

Test connection	Required result
Circuit 1 Between active pin and earth pin Between active pin and neutral pin Between neutral pin and earth pin	 Full lamp brilliance Flashing lamp No lamp function
Circuit 2 Between active pin and earth pin Between active pin and neutral pin Between neutral pin and earth pin	 Low lamp brilliance Very low lamp brilliance No lamp function



SIMULTANEOUS 'LIVE TESTING' TWO GPO CIRCUITS FOR POLARITY, FUNCTION AND INTERMIX OF CONDUCTORS

INSTALLATION TESTING - WORKBOARD TEST RESULTS TABLE No. 1

<table>
<tr><th rowspan="2">Switch No.</th><th colspan="2">Switch position</th><th rowspan="2">Test Results</th></tr>
<tr><th>Up (off)</th><th>Down (on)</th></tr>
<tr><td>1</td><td></td><td>X</td><td rowspan="2">Insulation Test - Whole installation
Result ....Meg ohms.</td></tr>
<tr><td>2</td><td></td><td>X</td></tr>
<tr><td>3</td><td></td><td>X</td><td rowspan="2">Short Circuit Test - Whole installation
Result .... ohms</td></tr>
<tr><td>4</td><td></td><td>X</td></tr>
<tr><td>5</td><td></td><td>X</td><td rowspan="10">Where the results for insulation testing and short circuit testing are not ideal, the sub circuits that are causing this result are

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms</td></tr>
<tr><td>6</td><td></td><td>X</td></tr>
<tr><td>7</td><td></td><td>X</td></tr>
<tr><td>8</td><td></td><td>X</td></tr>
<tr><td>9</td><td></td><td>X</td></tr>
<tr><td>10</td><td></td><td>X</td></tr>
<tr><td>11</td><td></td><td>X</td></tr>
<tr><td>12</td><td></td><td>X</td></tr>
<tr><td>13</td><td></td><td>X</td></tr>
<tr><td>14</td><td></td><td>X</td></tr>
<tr><td>15</td><td></td><td>X</td><td rowspan="13">Combined polarity and earth continuity tests for each circuit (result - correct or incorrect)

socket outlet circuit No.1 Result polarity ....
earth cont. ....

socket outlet circuit No.2 Result polarity ....
earth cont. ....

range circuit Result polarity ....
earth cont. ....

water heater circuit Result polarity ....
earth cont. ....

light circuit Result polarity ....
earth cont. ....</td></tr>
<tr><td>16</td><td></td><td>X</td></tr>
<tr><td>17</td><td></td><td>X</td></tr>
<tr><td>18</td><td></td><td>X</td></tr>
<tr><td>19</td><td></td><td>X</td></tr>
<tr><td>20</td><td></td><td>X</td></tr>
<tr><td>21</td><td></td><td>X</td></tr>
<tr><td>22</td><td></td><td>X</td></tr>
<tr><td>23</td><td></td><td>X</td></tr>
<tr><td>24</td><td></td><td>X</td></tr>
<tr><td>25</td><td></td><td>X</td></tr>
<tr><td>26</td><td></td><td>X</td></tr>
<tr><td>27</td><td></td><td>X</td></tr>
</table>

INSTALLATION TESTING - WORKBOARD TEST RESULTS TABLE No. 2

<table>
<tr><th>Switch No.</th><th colspan="2">Switch position Up (off) Down (on)</th><th>Test Results</th></tr>
<tr><td>1</td><td>X</td><td></td><td rowspan="2">Insulation Test - Whole installation
Result ....Meg ohms.</td></tr>
<tr><td>2</td><td>X</td><td></td></tr>
<tr><td>3</td><td>X</td><td></td><td rowspan="2">Short Circuit Test - Whole installation
Result .... ohms</td></tr>
<tr><td>4</td><td></td><td>X</td></tr>
<tr><td>5</td><td></td><td>X</td><td rowspan="10">Where the results for insulation testing and short circuit testing are not ideal, the sub circuits that are causing this result are

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms</td></tr>
<tr><td>6</td><td></td><td>X</td></tr>
<tr><td>7</td><td></td><td>X</td></tr>
<tr><td>8</td><td></td><td>X</td></tr>
<tr><td>9</td><td></td><td>X</td></tr>
<tr><td>10</td><td></td><td>X</td></tr>
<tr><td>11</td><td>X</td><td></td></tr>
<tr><td>12</td><td>X</td><td></td></tr>
<tr><td>13</td><td>X</td><td></td></tr>
<tr><td>14</td><td></td><td>X</td></tr>
<tr><td>15</td><td></td><td>X</td><td rowspan="13">Combined polarity and earth continuity tests for each circuit (result - correct or incorrect)

socket outlet circuit No.1 Result polarity ....
earth cont. ....

socket outlet circuit No.2 Result polarity ....
earth cont. ....

range circuit Result polarity ....
earth cont. ....

water heater circuit Result polarity ....
earth cont. ....

light circuit Result polarity ....
earth cont. ....</td></tr>
<tr><td>16</td><td></td><td>X</td></tr>
<tr><td>17</td><td></td><td>X</td></tr>
<tr><td>18</td><td></td><td>X</td></tr>
<tr><td>19</td><td></td><td>X</td></tr>
<tr><td>20</td><td></td><td>X</td></tr>
<tr><td>21</td><td>X</td><td></td></tr>
<tr><td>22</td><td></td><td>X</td></tr>
<tr><td>23</td><td></td><td>X</td></tr>
<tr><td>24</td><td></td><td>X</td></tr>
<tr><td>25</td><td>X</td><td></td></tr>
<tr><td>26</td><td></td><td>X</td></tr>
<tr><td>27</td><td>X</td><td></td></tr>
</table>

INSTALLATION TESTING - WORKBOARD TEST RESULTS TABLE No. 3

Switch No.	Switch position Up (off)	Down (on)	Test Results
1		X	Insulation Test - Whole installation Result ....Meg ohms.
2		X	
3		X	Short Circuit Test - Whole installation Result .... ohms
4		X	
5		X	Where the results for insulation testing and short circuit testing are not ideal, the sub circuits that are causing this result are
6		X	
7		X	circuit name .... Test results insulation ....Megohms short circuit .... ohms
8		X	
9		X	circuit name .... Test results insulation ....Megohms short circuit .... ohms
10		X	
11		X	
12	X		circuit name .... Test results insulation ....Megohms short circuit .... ohms
13		X	
14		X	
15		X	Combined polarity and earth continuity tests for each circuit (result - correct or incorrect)
16		X	
17		X	socket outlet circuit No.1 Result polarity .... earth cont. ....
18		X	
19		X	socket outlet circuit No.2 Result polarity .... earth cont. ....
20		X	
21		X	range circuit Result polarity .... earth cont. ....
22	X		
23	X		water heater circuit Result polarity .... earth cont. ....
24	X		light circuit Result polarity .... earth cont. ....
25	X		
26	X		
27	X		

INSTALLATION TESTING - WORKBOARD TEST RESULTS TABLE No. 4

Switch No.	Switch position Up (off)	Down (on)	Test Results
1	X		Insulation Test - Whole installation Result ....Meg ohms.
2	X		
3	X		Short Circuit Test - Whole installation Result .... ohms
4		X	
5		X	Where the results for insulation testing and short circuit testing are not ideal, the sub circuits that are causing this result are circuit name .... Test results insulation ....Megohms short circuit .... ohms circuit name .... Test results insulation ....Megohms short circuit .... ohms circuit name .... Test results insulation ....Megohms short circuit .... ohms
6		X	
7		X	
8		X	
9	X		
10		X	
11		X	
12		X	
13		X	
14		X	
15		X	Combined polarity and earth continuity tests for each circuit (result - correct or incorrect) socket outlet circuit No.1 Result polarity .... earth cont. .... socket outlet circuit No.2 Result polarity .... earth cont. .... range circuit Result polarity .... earth cont. .... water heater circuit Result polarity .... earth cont. .... light circuit Result polarity .... earth cont. ....
16		X	
17		X	
18	X		
19	X		
20	X		
21		X	
22		X	
23		X	
24		X	
25		X	
26		X	
27		X	

INSTALLATION TESTING - WORKBOARD TEST RESULTS TABLE No. 5

<table>
<tr><th>Switch No.</th><th colspan="2">Switch position
Up (off) Down (on)</th><th>Test Results</th></tr>
<tr><td>1</td><td>X</td><td></td><td rowspan="2">Insulation Test - Whole installation
Result ....Meg ohms.</td></tr>
<tr><td>2</td><td>X</td><td></td></tr>
<tr><td>3</td><td>X</td><td></td><td rowspan="2">Short Circuit Test - Whole installation
Result .... ohms</td></tr>
<tr><td>4</td><td></td><td>X</td></tr>
<tr><td>5</td><td></td><td>X</td><td rowspan="10">Where the results for insulation testing and short circuit testing are not ideal, the sub circuits that are causing this result are

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms</td></tr>
<tr><td>6</td><td></td><td>X</td></tr>
<tr><td>7</td><td></td><td>X</td></tr>
<tr><td>8</td><td></td><td>X</td></tr>
<tr><td>9</td><td></td><td>X</td></tr>
<tr><td>10</td><td></td><td>X</td></tr>
<tr><td>11</td><td></td><td>X</td></tr>
<tr><td>12</td><td></td><td>X</td></tr>
<tr><td>13</td><td></td><td>X</td></tr>
<tr><td>14</td><td></td><td>X</td></tr>
<tr><td>15</td><td></td><td>X</td><td rowspan="13">Combined polarity and earth continuity tests for each circuit (result - correct or incorrect)

socket outlet circuit No.1 Result polarity ....
earth cont. ....

socket outlet circuit No.2 Result polarity ....
earth cont. ....

range circuit Result polarity ....
earth cont. ....

water heater circuit Result polarity ....
earth cont. ....

light circuit Result polarity ....
earth cont. ....</td></tr>
<tr><td>16</td><td></td><td>X</td></tr>
<tr><td>17</td><td></td><td>X</td></tr>
<tr><td>18</td><td></td><td>X</td></tr>
<tr><td>19</td><td>X</td><td></td></tr>
<tr><td>20</td><td></td><td>X</td></tr>
<tr><td>21</td><td></td><td>X</td></tr>
<tr><td>22</td><td>X</td><td></td></tr>
<tr><td>23</td><td></td><td>X</td></tr>
<tr><td>24</td><td></td><td>X</td></tr>
<tr><td>25</td><td>X</td><td></td></tr>
<tr><td>26</td><td>X</td><td></td></tr>
<tr><td>27</td><td></td><td>X</td></tr>
</table>

INSTALLATION TESTING - WORKBOARD TEST RESULTS TABLE No. 6

<table>
<tr><th>Switch No.</th><th colspan="2">Switch position
Up (off) Down (on)</th><th>Test Results</th></tr>
<tr><td>1</td><td>X</td><td></td><td rowspan="2">Insulation Test - Whole installation
Result ....Meg ohms.</td></tr>
<tr><td>2</td><td>X</td><td></td></tr>
<tr><td>3</td><td>X</td><td></td><td rowspan="2">Short Circuit Test - Whole installation
Result .... ohms</td></tr>
<tr><td>4</td><td>X</td><td></td></tr>
<tr><td>5</td><td></td><td>X</td><td rowspan="10">Where the results for insulation testing and short circuit testing are not ideal, the sub circuits that are causing this result are

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms</td></tr>
<tr><td>6</td><td></td><td>X</td></tr>
<tr><td>7</td><td></td><td>X</td></tr>
<tr><td>8</td><td></td><td>X</td></tr>
<tr><td>9</td><td></td><td>X</td></tr>
<tr><td>10</td><td></td><td>X</td></tr>
<tr><td>11</td><td>X</td><td></td></tr>
<tr><td>12</td><td>X</td><td></td></tr>
<tr><td>13</td><td>X</td><td></td></tr>
<tr><td>14</td><td></td><td>X</td></tr>
<tr><td>15</td><td></td><td>X</td><td rowspan="13">Combined polarity and earth continuity tests for each circuit (result - correct or incorrect)

socket outlet circuit No.1 Result polarity ....
earth cont. ....

socket outlet circuit No.2 Result polarity ....
earth cont. ....

range circuit Result polarity ....
earth cont. ....

water heater circuit Result polarity ....
earth cont. ....

light circuit Result polarity ....
earth cont. ....</td></tr>
<tr><td>16</td><td></td><td>X</td></tr>
<tr><td>17</td><td></td><td>X</td></tr>
<tr><td>18</td><td></td><td>X</td></tr>
<tr><td>19</td><td></td><td>X</td></tr>
<tr><td>20</td><td></td><td>X</td></tr>
<tr><td>21</td><td></td><td>X</td></tr>
<tr><td>22</td><td></td><td>X</td></tr>
<tr><td>23</td><td></td><td>X</td></tr>
<tr><td>24</td><td></td><td>X</td></tr>
<tr><td>25</td><td></td><td>X</td></tr>
<tr><td>26</td><td></td><td>X</td></tr>
<tr><td>27</td><td></td><td>X</td></tr>
</table>

INSTALLATION TESTING - WORKBOARD TEST RESULTS   TABLE No. 7

<table>
<tr><th>Switch No.</th><th colspan="2">Switch position
Up (off) Down (on)</th><th>Test Results</th></tr>
<tr><td>1</td><td>X</td><td></td><td rowspan="2">Insulation Test - Whole installation
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<tr><td>3</td><td>X</td><td></td><td rowspan="2">Short Circuit Test - Whole installation
Result .... ohms</td></tr>
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<tr><td>5</td><td></td><td>X</td><td rowspan="10">Where the results for insulation testing and short circuit testing are not ideal, the sub circuits that are causing this result are

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms</td></tr>
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<tr><td>8</td><td></td><td>X</td></tr>
<tr><td>9</td><td></td><td>X</td></tr>
<tr><td>10</td><td></td><td>X</td></tr>
<tr><td>11</td><td></td><td>X</td></tr>
<tr><td>12</td><td></td><td>X</td></tr>
<tr><td>13</td><td></td><td>X</td></tr>
<tr><td>14</td><td></td><td>X</td></tr>
<tr><td>15</td><td></td><td>X</td><td rowspan="13">Combined polarity and earth continuity tests for each circuit (result - correct or incorrect)

socket outlet circuit No.1 Result polarity ....
earth cont. ....

socket outlet circuit No.2 Result polarity ....
earth cont. ....

range circuit Result polarity ....
earth cont. ....

water heater circuit Result polarity ....
earth cont. ....

light circuit Result polarity ....
earth cont. ....</td></tr>
<tr><td>16</td><td></td><td>X</td></tr>
<tr><td>17</td><td>X</td><td></td></tr>
<tr><td>18</td><td></td><td>X</td></tr>
<tr><td>19</td><td></td><td>X</td></tr>
<tr><td>20</td><td></td><td>X</td></tr>
<tr><td>21</td><td></td><td>X</td></tr>
<tr><td>22</td><td>X</td><td></td></tr>
<tr><td>23</td><td></td><td>X</td></tr>
<tr><td>24</td><td></td><td>X</td></tr>
<tr><td>25</td><td></td><td>X</td></tr>
<tr><td>26</td><td></td><td>X</td></tr>
<tr><td>27</td><td>X</td><td></td></tr>
</table>

INSTALLATION TESTING - WORKBOARD TEST RESULTS TABLE No. 8

<table>
<tr><th>Switch No.</th><th colspan="2">Switch position
Up (off) Down (on)</th><th>Test Results</th></tr>
<tr><td>1</td><td></td><td>X</td><td rowspan="2">Insulation Test - Whole installation
Result ....Meg ohms.</td></tr>
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<tr><td>3</td><td></td><td>X</td><td rowspan="2">Short Circuit Test - Whole installation
Result .... ohms</td></tr>
<tr><td>4</td><td></td><td>X</td></tr>
<tr><td>5</td><td></td><td>X</td><td rowspan="10">Where the results for insulation testing and short circuit testing are not ideal, the sub circuits that are causing this result are

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms</td></tr>
<tr><td>6</td><td></td><td>X</td></tr>
<tr><td>7</td><td></td><td>X</td></tr>
<tr><td>8</td><td></td><td>X</td></tr>
<tr><td>9</td><td></td><td>X</td></tr>
<tr><td>10</td><td></td><td>X</td></tr>
<tr><td>11</td><td>X</td><td></td></tr>
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<tr><td>13</td><td>X</td><td></td></tr>
<tr><td>14</td><td>X</td><td></td></tr>
<tr><td>15</td><td></td><td>X</td><td rowspan="13">Combined polarity and earth continuity tests for each circuit (result - correct or incorrect)

socket outlet circuit No.1 Result polarity ....
earth cont. ....

socket outlet circuit No.2 Result polarity ....
earth cont. ....

range circuit Result polarity ....
earth cont. ....

water heater circuit Result polarity ....
earth cont. ....

light circuit Result polarity ....
earth cont. ....</td></tr>
<tr><td>16</td><td></td><td>X</td></tr>
<tr><td>17</td><td></td><td>X</td></tr>
<tr><td>18</td><td></td><td>X</td></tr>
<tr><td>19</td><td></td><td>X</td></tr>
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<tr><td>22</td><td>X</td><td></td></tr>
<tr><td>23</td><td></td><td>X</td></tr>
<tr><td>24</td><td></td><td>X</td></tr>
<tr><td>25</td><td>X</td><td></td></tr>
<tr><td>26</td><td>X</td><td></td></tr>
<tr><td>27</td><td>X</td><td></td></tr>
</table>

INSTALLATION TESTING - WORKBOARD TEST RESULTS TABLE No. 9

<table>
<tr><th>Switch No.</th><th colspan="2">Switch position
Up (off) Down (on)</th><th>Test Results</th></tr>
<tr><td>1</td><td></td><td>X</td><td rowspan="2">Insulation Test - Whole installation
Result ....Meg ohms.</td></tr>
<tr><td>2</td><td></td><td>X</td></tr>
<tr><td>3</td><td></td><td>X</td><td rowspan="2">Short Circuit Test - Whole installation
Result .... ohms</td></tr>
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<tr><td>5</td><td></td><td>X</td><td rowspan="10">Where the results for insulation testing and short circuit testing are not ideal, the sub circuits that are causing this result are

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms

circuit name ....
Test results insulation ....Megohms
short circuit .... ohms</td></tr>
<tr><td>6</td><td></td><td>X</td></tr>
<tr><td>7</td><td></td><td>X</td></tr>
<tr><td>8</td><td></td><td>X</td></tr>
<tr><td>9</td><td></td><td>X</td></tr>
<tr><td>10</td><td></td><td>X</td></tr>
<tr><td>11</td><td></td><td>X</td></tr>
<tr><td>12</td><td></td><td>X</td></tr>
<tr><td>13</td><td></td><td>X</td></tr>
<tr><td>14</td><td></td><td>X</td></tr>
<tr><td>15</td><td></td><td>X</td><td rowspan="13">Combined polarity and earth continuity tests for each circuit (result - correct or incorrect)

socket outlet circuit No.1 Result polarity ....
earth cont. ....

socket outlet circuit No.2 Result polarity ....
earth cont. ....

range circuit Result polarity ....
earth cont. ....

water heater circuit Result polarity ....
earth cont. ....

light circuit Result polarity ....
earth cont. ....</td></tr>
<tr><td>16</td><td></td><td>X</td></tr>
<tr><td>17</td><td></td><td>X</td></tr>
<tr><td>18</td><td></td><td>X</td></tr>
<tr><td>19</td><td>X</td><td></td></tr>
<tr><td>20</td><td>X</td><td></td></tr>
<tr><td>21</td><td>X</td><td></td></tr>
<tr><td>22</td><td>X</td><td></td></tr>
<tr><td>23</td><td></td><td>X</td></tr>
<tr><td>24</td><td></td><td>X</td></tr>
<tr><td>25</td><td></td><td>X</td></tr>
<tr><td>26</td><td></td><td>X</td></tr>
<tr><td>27</td><td>X</td><td></td></tr>
</table>

INSTALLATION TESTING - WORKBOARD TEST RESULTS TABLE No. 10

Switch No.	Switch position Up (off)	Down (on)	Test Results
1		X	Insulation Test - Whole installation Result ....Meg ohms.
2		X	
3		X	Short Circuit Test - Whole installation Result .... ohms
4		X	
5		X	Where the results for insulation testing and short circuit testing are not ideal, the sub circuits that are causing this result are circuit name .... Test results insulation ....Megohms short circuit .... ohms circuit name .... Test results insulation ....Megohms short circuit .... ohms circuit name .... Test results insulation ....Megohms short circuit .... ohms
6		X	
7		X	
8		X	
9		X	
10		X	
11	X		
12	X		
13	X		
14		X	
15		X	Combined polarity and earth continuity tests for each circuit (result - correct or incorrect) socket outlet circuit No.1 Result polarity .... earth cont. .... socket outlet circuit No.2 Result polarity .... earth cont. .... range circuit Result polarity .... earth cont. .... water heater circuit Result polarity .... earth cont. .... light circuit Result polarity .... earth cont. ....
16		X	
17		X	
18	X		
19		X	
20		X	
21		X	
22	X		
23		X	
24		X	
25		X	
26		X	
27	X		

INSTALLATION TESTING - WORKBOARD TEST RESULTS TABLE No. 11

Switch No.	Switch position Up (off)	Down (on)	Test Results
1		X	Insulation Test - Whole installation Result ....Meg ohms.
2		X	
3		X	Short Circuit Test - Whole installation Result .... ohms
4		X	
5		X	Where the results for insulation testing and short circuit testing are not ideal, the sub circuits that are causing this result are
6		X	
7		X	circuit name .... Test results insulation ....Megohms short circuit .... ohms
8		X	
9		X	
10		X	circuit name .... Test results insulation ....Megohms short circuit .... ohms
11		X	
12		X	circuit name .... Test results insulation ....Megohms short circuit .... ohms
13		X	
14	X		
15		X	Combined polarity and earth continuity tests for each circuit (result - correct or incorrect)
16	X		
17		X	socket outlet circuit No.1 Result polarity .... earth cont. ....
18		X	
19		X	socket outlet circuit No.2 Result polarity .... earth cont. ....
20		X	
21		X	range circuit Result polarity .... earth cont. ....
22	X		
23		X	water heater circuit Result polarity .... earth cont. ....
24		X	light circuit Result polarity .... earth cont. ....
25		X	
26		X	
27	X		

INSTALLATION TESTING - WORKBOARD TEST RESULTS TABLE No. 12

Switch No.	Switch position Up (off)	Down (on)	Test Results
1	X		Insulation Test - Whole installation Result ....Meg ohms.
2	X		
3	X		Short Circuit Test - Whole installation Result .... ohms
4		X	
5		X	Where the results for insulation testing and short circuit testing are not ideal, the sub circuits that are causing this result are circuit name .... Test results insulation ....Megohms short circuit .... ohms circuit name .... Test results insulation ....Megohms short circuit .... ohms circuit name .... Test results insulation ....Megohms short circuit .... ohms
6		X	
7		X	
8		X	
9		X	
10		X	
11	X		
12	X		
13	X		
14		X	
15		X	Combined polarity and earth continuity tests for each circuit (result - correct or incorrect) socket outlet circuit No.1 Result polarity .... earth cont. .... socket outlet circuit No.2 Result polarity .... earth cont. .... range circuit Result polarity .... earth cont. .... water heater circuit Result polarity .... earth cont. .... light circuit Result polarity .... earth cont. ....
16		X	
17		X	
18		X	
19		X	
20	X		
21		X	
22		X	
23		X	
24		X	
25	X		
26		X	
27		X	

Review Questions - Answers

1. Regulation requirements

1. Test the installation and complete relevant inspecting authority forms.

2. Test the outlet, no forms required.

3. See inspecting authority regulations.

4. (A) Must be notified to the inspecting authority within 14 days of completion.

5. (C) Must comply with the AS/NZS 3000 Wiring rules.

6. (D) Copies must be kept by the installing contractor for auditing.

7. (B) All work associated with consumers' mains and main switchboards.

8. (C) A person qualified to test.

2. Test equipment

1. (A) On single and polyphase loads.

2. (C) Active and neutral.

3. (A) Associated circuits should be connected to the supply.

4. (D) 10 kilohms and 1 megohm.

5. (C) Will not indicate induced voltages.

6. (C) 24 ohms.

7. (B) 12 ohms.

8. (D) 500 V d.c.

9. (A) 1000 V d.c.

10. (B) 0-100 mA clamp-on ammeter.

11. (C) Select an appropriate range and zero adjust the instrument.

12. Visual inspection for wear and mechanical damage earth continuity.

13. See State/Territory regulations.

14. To test tripping mechanism/circuit.

15.
- Date of inspection
- Plant number
- Licence number of tester
- Owner
- Equipment type

16. Insulation resistance tester, ohmmeter, voltage indicator.

3. Earth continuity and resistance

1. (B) All outgoing earthing conductors.

2. (B) The effective operation of circuit protection devices if an earth fault occurs.

3. (D) Associated circuits should be isolated from the supply.

4. (B) Circuit earthing conductor be disconnected from water heaters.

5. (D) An insulation tester set on continuity range.

6. To exclude the possibility that earth continuity is detected via the neutral.

7. Test may indicate resistance of a transposed neutral and earth.

8. Using a trailing lead of known resistance:
   - disconnect the earth at the water heater
   - measure resistance using ohmmeter and trailing lead
   - calculate actual resistance = Rmeasured - Rtrailing

9. Water pipes, swimming pool fitting concrete mesh.

4. Insulation resistance testing

1. (A) Switch-wire insulation.

2. (A) 1 megohm.

3. (C) Active and neutral.

4. (B) Protection against direct contact with live parts.

5. (D) 500 V.

6. (C) 10,000 ohms

7. (A) Disconnected from sockets.

8. Maintain its voltage between +20% and -10% of its terminal voltage across a 1 MΩ resistor.

9.
- Isolate circuit and unplug all appliances
- Disconnect the neutral from neutral link
- Using insulation tester test A-N, A-E, N-E.

5. Polarity testing

1. (A) Will not appear to affect the operation of the final subcircuits supplied from the distribution board.

2. (D) Neutral conductor.

3. (D) An ohmmeter.

4. (A) The active conductor.

5. (C) Series test lamps.

6. (C) Testing continuity between neutral conductor and earthing conductor and between active conductor and earthing conductor.

7. (A) The active terminal only.

8. (D) The neutral.

9. (A) An electric clock.

10. Using test lamps test between a known earth and the active, then neutral conductor.

11.
- test must be carried out before the installation is connected to the supply.
- test for continuity of both active and neutral
- identify needs with tape or similar
- connect submains using tape as the identification.

6. Correct circuit connection - Transposition testing

1. (A) Measure the load resistance between active and neutral.

2. (D) The earthing conductor would likely overheat.

3. (C) Exposed metal can become live if the earthing conductor becomes open circuited.

4. (A) The neutral and earthing conductor are transposed.

5. (D) Earth conductors.

6. (C) Identify the neutral conductor from the earthing conductor at the points under test.

7. (A) Neutral and the neutral link.
8. (B) Circuit will appear to operate normally but is potentially dangerous.

9. (B) 15 W series lamp and series test lamp.

10. (D) Transposition of neutral and earthing conductors.

7. Correct circuit connections - short circuit testing

1. (B) Before the supply is connected.

2. (C) Switched on.

3. (B) Will prevent the controlling switch from turning off the load.

4.
   - Polarity testing
   - Insulation testing
   - Interconnection testing

8. Correct circuit connections - interconnection testing

1. (C) A short circuit between neutral and earth.

2. (B) Cannot be used for two or more final subcircuits.

3. (C) Interconnection of the neutral conductors between circuits 1 and 2.

4. Live conductors may carry more current than intended. Interconnection will prevent circuits from being isolated by the protective device.

5. Identify all conductors before connecting, especially at points where the conductors of different circuits are connected in the same accessory, load device or switchboard.

9. Switchboard marking

1. (C) Ease of identification for maintenance and emergency.

2. (C) 16 ohms

3. (D) no limit.

4. (A) Unlimited provided the circuit operates as intended.

5.
   - Active and neutral links
   - Terminals of corresponding active and neutral connections
   - Common neutrals
   - Relationship of switches, circuit-breaker, fuses, RCD's
   - Switches which initiate emergency supplies.

6.
   - Main switches - clearly marked as a main switch for a particular load.
   - Base & links - marked as active or neutral
   - Must be able to identify an active and neutral of a particular circuit; MEN connection marked; common neutrals marked to identify associated active conductors.

7.
   - Daylo permanent board marker or alike
   - Engraving
   - Paint
   - Trefolite labels or alike

10. Optional tests

1. (C) 12.5 times rated current.

2. (D) Test to ensure that the maximum tripping time is not exceeded.

3. (B) 30 mA

4. (D) Fault loop impedance.

5. (D) Special test equipment.

6. (A) The continuity of the earth system.

7. (C) Low enough for correct operation of overcurrent devices.

8. (B) Transposition of neutral and earthing conductors.

9. (B) The effective operation of circuit protection devices if an earth fault occurs.

10. (D) Associated circuits should be isolated from the supply.

11. (C) Series test lamps between the active and earth terminal at the protected outlets.

12. (D) Increased by a factor of 1.04.

13. 16.2 m.

14. 1.53 ohms

15. Connect test lamps between active and earth terminals.

16. 1 ohm

17. 40 m

18. 41.6 m

11. Documentation

1.
   - Contractor
   - Customer
   - Inspecting authority

2. See inspection authority regulations.

3. See inspection authority regulations.

4. (C) Work associated with consumer's mains and switchboards.

5. (C) Must be fully tested by the supply authority before being connected to the supply.

6. (B) Work associated with consumer's mains and main switchboard.

7. (D) Before being permanently connected to the supply.

8. (C) It is safe to do so and for testing purposes only

9. (D) A person qualified to test.

10. See inspection authority regulations.

Notes

NEW SOUTH WALES DEPARTMENT OF EDUCATION AND TRAINING

TAFE NSW

Family Name ....

Given Name ....

Student Number ....

Centre ....

Signature ....

7 December 2004

6077HA Electrical Installation Testing & Verification

Time allowed – One hour plus Ten minutes reading time

18 Pages in this Question Booklet

ALL **Questions to be attempted**

TOTAL MARKS AVAILABLE = 100

Section	Possible Mark	Actual Mark
A	25	
B	35	
C	30	
D	10	
Total	100	

Aids to be supplied by college:

- None.

Aids to be supplied by student:

- Australian/New Zealand Wiring Rules AS/NZS 3000:2000 (AMDT No 3 – July 2003).
- Students own marginal notes, indexing and formal amendments may be included in the above regulation books.
- Pen, pencil, eraser, rule, calculator.

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 **Examination Paper.** Answers to Section A – multi-choice questions, are to be answered on Page 18.
- You are not to use any other reference book in this exam.
- 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	Yes	No	No	Yes

SECTION A – (25 Marks)

INSTRUCTIONS: Select the best answer for the following statements and place an 'X' in the appropriate box on the Answer Sheet on Page 18 of the examination paper. Each correct answer is worth ONE (1) mark.

QUESTION 1. (1 Mark)

Copies of the results of all compliance tests, for a completed electrical installation (NOEW form), are distributed to the:

(a) owner, Office of Fair Trading and the electrical supply authority
(b) supply authority, owner, contractor, and Office of Fair Trading
(c) local council, owner and contractor
(d) owner, contractor and the electrical supply authority

QUESTION 2. (1 Mark)

Polarity testing is performed on a socket outlet:

(a) only on the earth conductor
(b) only on the active conductor
(c) to ensure conductors are not transposed
(d) to ensure there is no intermix from other circuits

QUESTION 3. (1 Mark)

A lighting circuit has its neutral intermixed with a neutral from another lighting circuit. The most likely long term effect is:

(a) the RCD would trip
(b) neither circuit would work
(c) excess current would be drawn
(d) the circuit would operate normally

QUESTION 4. (1 Mark)

Switchboards must have equipment grouped and be marked correctly to:

(a) identify the connected load
(b) improve the appearance of the switchboard
(c) ensure rapid operation of the service protection
(d) assist in quickly isolating circuits or the whole installation

SECTION A – (Cont'd)

QUESTION 5. (1 Mark)

When carrying out a short circuit test on a lighting circuit, it is necessary to:

(a) ensure all switches are off
(b) remove all lamps and leave switches on
(c) ensure switches are on and all lamps are installed
(d) disconnect the sub-circuit neutral conductor from the consumers neutral link

QUESTION 6. (1 Mark)

The polarity of consumers mains can be determined:

(a) by insulation testing the circuit
(b) by continuity testing the individual conductors
(c) only after supply has been made available
(d) by inspecting the insulation colour at each end of the run

QUESTION 7. (1 Mark)

A person testing an installation removes the neutral conductor of a circuit from the neutral link and removes the active conductor from the load side of the circuit breaker. The two ends are joined and an instrument that measures Mega-ohms at twice the normal operating voltage d.c. is used to test between the conductors and the earth link. Which of the following tests is being performed?

(a) polarity test
(b) transposition test
(c) insulation resistance test
(d) interconnection test

QUESTION 8. (1 Mark)

After making all other tests, an ohmmeter is connected across the active and neutral conductors of a 4.8 kW hot water system circuit. The expected reading would be:

(a) $\infty\,\Omega$
(b) $2\,\Omega$
(c) $12\,\Omega$
(d) $>1\,M\Omega$

SECTION A – (Cont'd)

QUESTION 9. (1 Mark)

The first test that should be made on a completely new installation is:

(a) visual inspection test
(b) insulation resistance test
(c) earth resistance on the main earthing conductor
(d) earth resistance of sub-circuit earthing conductors

QUESTION 10. (1 Mark)

Replacement of existing socket outlets with outlets of the same rating requires:

(a) testing but no lodgement of a NOEW form
(b) testing and lodgement of a NOEW form
(c) no testing or lodgement of a NOEW form
(d) lodgement of a NOEW form but not testing

QUESTION 11. (1 Mark)

Using the test button of a residual current device (RCD) does NOT test the:

(a) correct operation of the RCD
(b) continuity of the earthing system
(c) integrity of the RCD's electrical elements
(d) integrity of the RCD's mechanical mechanism

QUESTION 12. (1 Mark)

The correct piece of test equipment to use when carrying out a short circuit test between conductors on a single-phase installation is:

(a) a multimeter set on volts
(b) a continuity tester set on ohms
(c) an insulation resistance tester set on 500 V d.c.
(d) an insulation resistance tester set on 1000 V d.c.

SECTION A – (Cont'd)

QUESTION 13. (1 Mark)

The operation of an RCD installed on a switchboard in a construction site, must be tested using the built-in test button:

(a) daily
(b) weekly
(c) monthly
(d) quarterly

QUESTION 14. (1 Mark)

The results of tests carried out on wiring and equipment in a construction site:

(a) is not required to be documented
(b) should be kept within the main switchboard on the site
(c) must be kept in an on-site register and available for audit
(d) must be noted on the tag applied to the equipment and wiring

QUESTION 15. (1 Mark)

Which of the following documents details the requirements for testing of electrical installations prior to connection to supply?

(a) AS/NZS 3000
(b) AS/NZS 3017
(c) NSW Safety (Electrical Installations) Regulation 1998
(d) NSW Occupational Health and Safety Act 2000

QUESTION 16. (1 Mark)

When live testing, a lamp load in the neutral of a single-phase socket outlet circuit assists in conclusive identification of:

(a) a faulty socket outlet switch
(b) the neutral conductor
(c) the earth conductor
(d) the active conductor

SECTION A – (Cont'd)

QUESTION 17. (1 Mark)

Any metallic water pipe associated with a building must be connected by an equipotential bonding conductor having a maximum resistance of:

(a) 0.5 Ω
(b) 1 Ω
(c) 2 Ω
(d) low enough to allow sufficient current flow to operate circuit protective device

QUESTION 18. (1 Mark)

Tools and equipment used on a job site must be inspected for safe operation:

(a) weekly
(b) monthly
(c) quarterly
(d) yearly

QUESTION 19. (1 Mark)

A completed NOEW form should be recorded and notified to the electricity provider and owner of the installation within:

(a) 2 days
(b) 7 days
(c) 14 days
(d) 30 days

QUESTION 20. (1 Mark)

FOUR (4) items of information that the person performing the tests on a portable appliance must note on the appliance test tag are:

(a) owner of equipment, who performed the test, date of test, next test due date
(b) equipment manufacturer, test results, name of supply authority, next test due date
(c) name of supply authority, serial number of test instrument, equipment manufacturer, test results
(d) name of person performing test, name of supply authority, test results, next test due date

SECTION A – (Cont'd)

QUESTION 21. (1 Mark)

What is the minimum specified interval for visual inspection of wiring on a construction site:

(a) daily
(b) weekly
(c) monthly
(d) half yearly

QUESTION 22. (1 Mark)

Which of the following documents details of the tests required for portable power tools and equipment?

(a) AS/NZS 3000
(b) AS/NZS 3760
(c) NSW Safety (Electrical Installations) Regulation 1998
(d) NSW Occupational Health and Safety Act 2000

QUESTION 23. (1 Mark)

The 'NSW Workcover Code of Practice for Electrical Work on Construction and Demolition Sites' requires the insulation resistance of a double-insulated power tool to be:

(a) not less than 10 MΩ
(b) greater than 1 MΩ
(c) greater than 10 kΩ
(d) less than 0.5 Ω

QUESTION 24. (1 Mark)

All installation work must be tested

(a) as each circuit is installed
(b) after the supply has been connected
(c) by the supply authority
(d) before being permanently connected to the supply

SECTION A – (Cont'd)

QUESTION 25. **(1 Mark)**

The Australian Standard used for providing guidelines for the testing and inspection of electrical installations is:

(a) AS/NZS 3012
(b) AS/NZS 3016
(c) AS/NZS 3017
(d) AS/NZS 3018

SECTION B – (35 Marks)

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

QUESTION 1. (11 Marks)

Insulation resistance test of a complete 3-phase installation when supply is not connected:

Test sequence:

1. Disconnect any portable appliances and ensure that all circuit switches are in the ________________ position.

2. Join all ________________ ________________ of the consumers mains together.

3. Turn main switch (es) to the ________________ position.

4. Ensure that all circuit fuses are ________________ and that all circuit breakers are in the ________________ position.

5. Disconnect the ________________ ________________ at the neutral bar.

6. Set the meter to read ________________ at ________________ volts.

7. Connect one test lead to the ________________ ________________ conductor at the earth bar.

8. Connect the other test lead to the ________________ ________________.

9. Test that the resistance complies with the minimum specified.

10. If the test result is not satisfactory, test consumers mains, sub-mains and each ________________ separately.

11. Disconnect the test leads, reconnect the ________________ ________________, separate the ________________ ________________ of the consumers mains and reconnect portable appliances.

SECTION B – (Cont'd)

QUESTION 2. (10 Marks)

Resistance test of main earthing conductor in a complete 3-phase installation when supply is not connected:

Test sequence:

1. Ensure that the consumers mains are NOT ________________.

2. Disconnect the ________________ ________________ conductor or ________________ ________________ from the neutral bar.

3. If using an analogue meter, set the meter to read ________________ with the meter leads connected together.

4. Connect one test lead to the disconnected ________________ ________________ conductor or ________________ ________________.

5. Connect the other test lead to the ________________ ________________ conductor at the ________________ ________________.

6. Test that the resistance complies with the specified resistance.

7. Disconnect the test leads, reconnect the ________________ ________________ conductor or ________________ ________________ at the neutral bar.

SECTION B – (Cont'd)

QUESTION 3. (14 Marks)

Polarity test of a single-phase sub-main in a complete 3-phase installation when supply is not connected:

Test sequence:

1. Remove the fuse or turn off circuit breaker protecting the sub-main at the ________________.

2. Remove all fuses and turn off all circuit breakers at the ________________ ________________.

3. Disconnect the sub-main ________________ conductor at the ________________

4. If using an analogue meter, set the meter to read ________________ with the meter leads connected together.

5. Connect one test lead to the ________________ conductor at the ________________ side of the sub-main protective device.

6. Connect the other test lead to the ________________ side of the circuit protective device at the ________________ board.

7. Test that the resistance of the active conductor is ________________.

8. Disconnect the test leads.

9. Connect one test lead to the disconnected ________________ neutral conductor at the switchboard.

10. Connect the other test lead to the ________________ ________________ at the distribution board.

11. Test that the resistance of the neutral conductor is ________________.

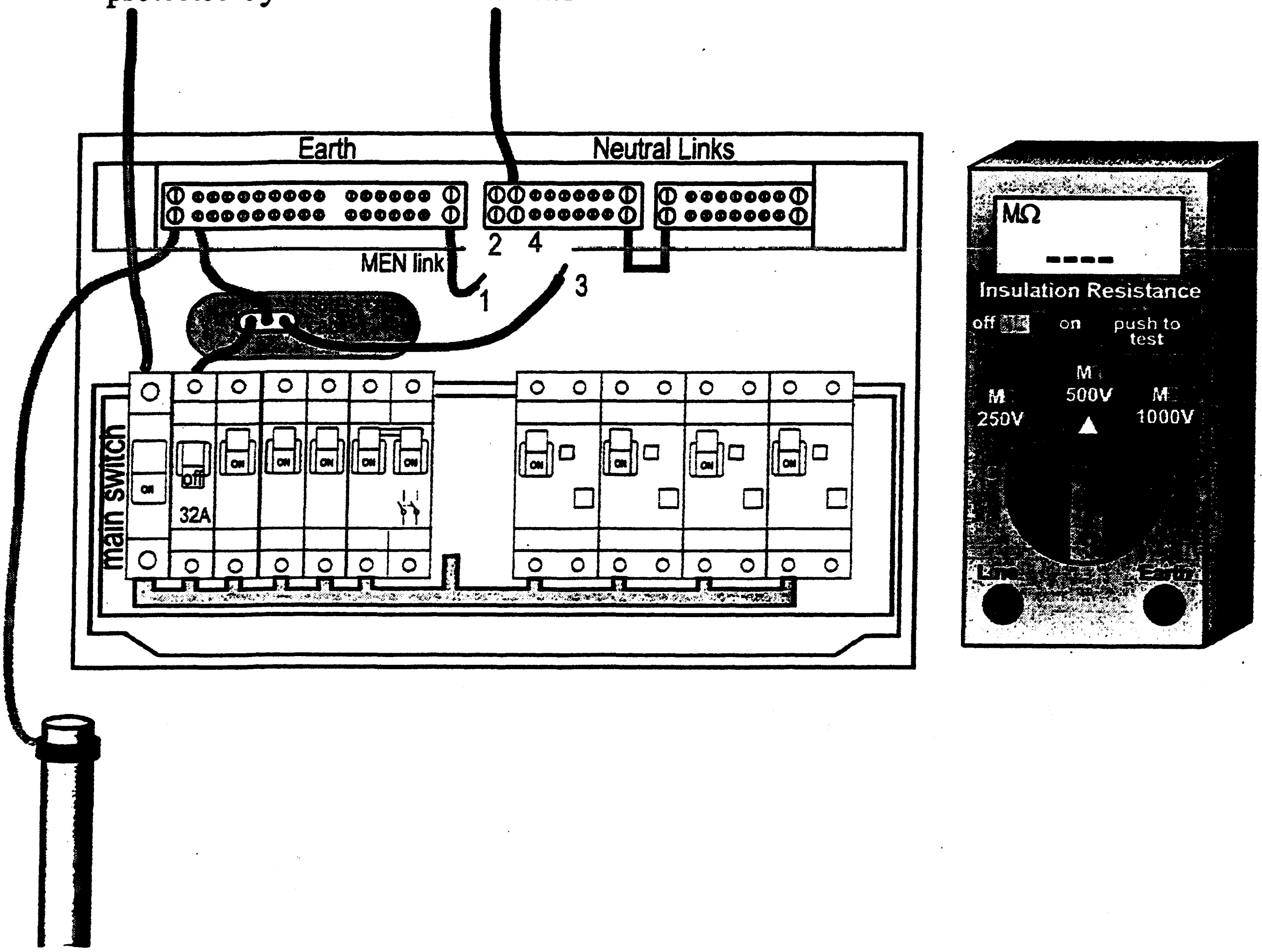
13. Disconnect the test leads, reconnect the ________________ ________________ conductor.

SECTION C – (30 Marks)

INSTRUCTIONS: The following questions in this section require some simple drawing and answering questions relating to the drawings. Ensure that the drawing is neat and legible. Write your answers to each question in the space provided. The use of pencil on the drawing is acceptable in this section only.

QUESTION 1. (3 Marks)

Complete the following diagram to show how the Insulation Resistance Tester would be connected when testing a single-phase circuit supplying an air conditioner and protected by a 32 A circuit breaker.



QUESTION 2. (1 Mark)

The Men link would connect to Position 1 / Position 2 (circle correct response) for the test.

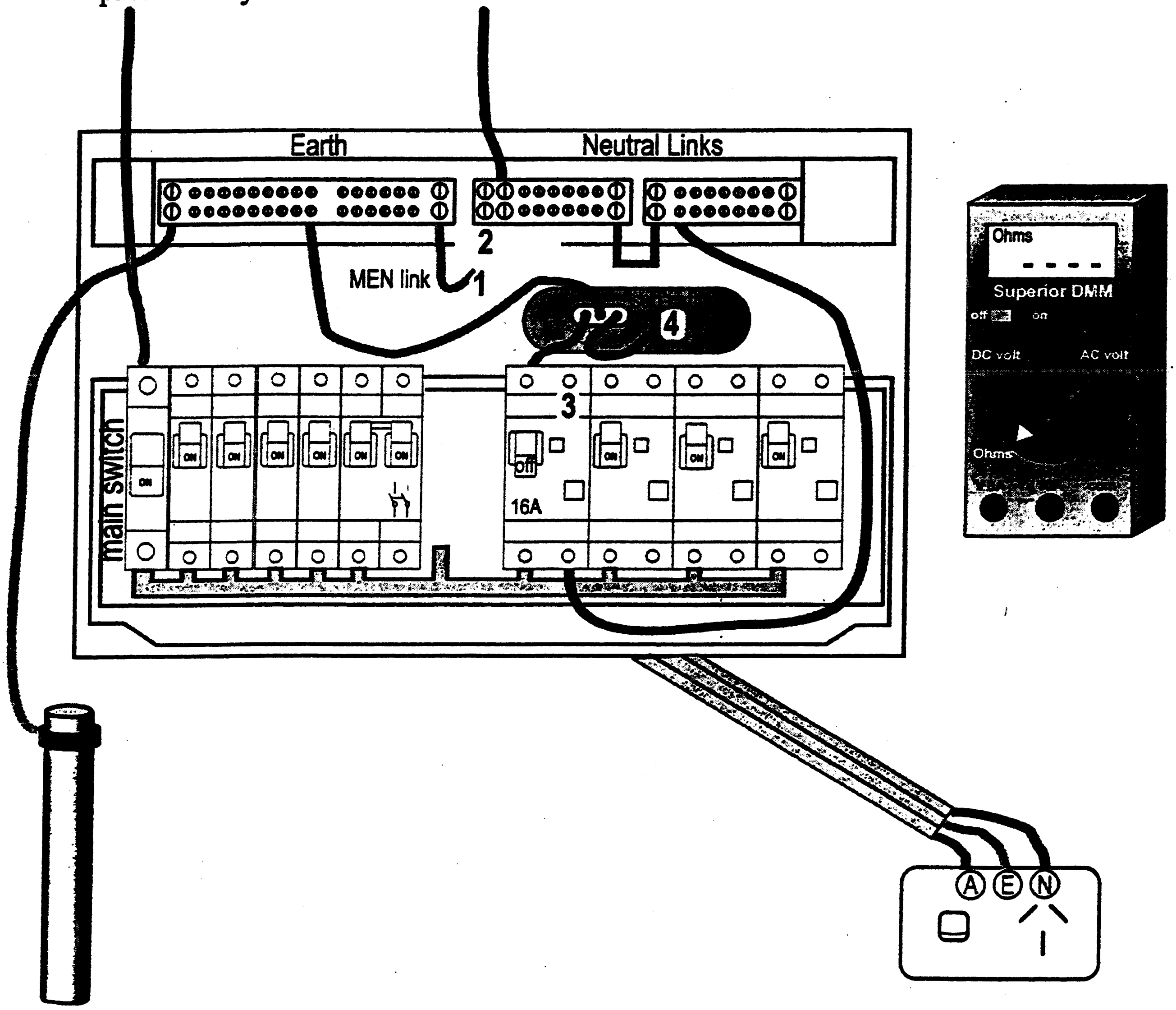
QUESTION 3. (1 Mark)

The sub-circuit neutral conductor would connect to Position 3 / Position 4 (circle correct response) for the test.

SECTION C – (Cont'd)

QUESTION 4. (3 Marks)

Complete the following diagram to show how the Ohmmeter would be connected when testing the earth continuity of a single-phase circuit supplying a socket outlet and protected by a 16 A combination RCD/MCB.



QUESTION 5. (1 Mark)

The Men link would connect to Position 1 / Position 2 (circle correct response) for the test.

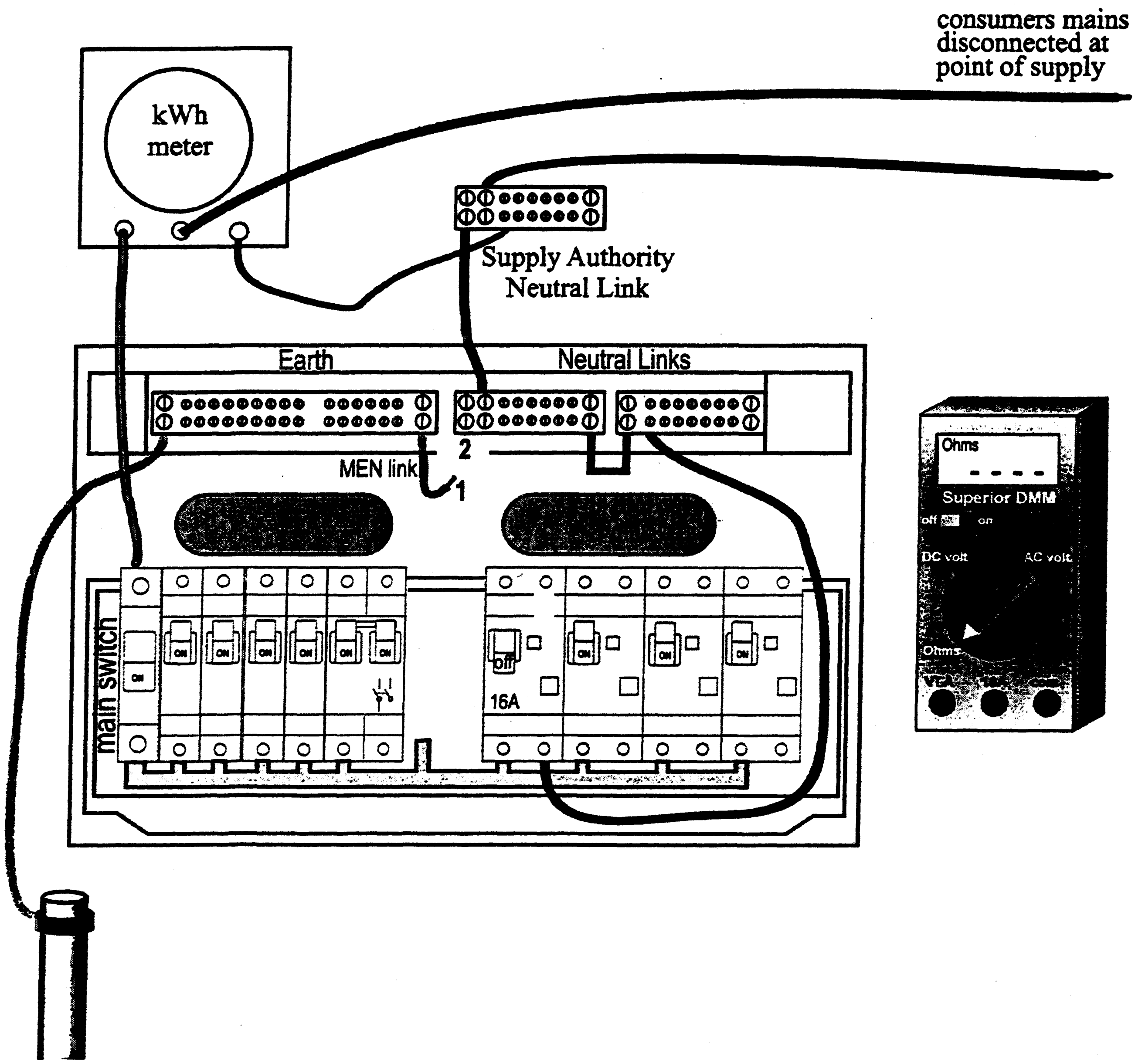
QUESTION 6. (1 Mark)

The sub-circuit neutral conductor should connect to Position 3 / Position 4 (circle correct response) for the test.

SECTION C – (Cont'd)

QUESTION 7. **(4 Marks)**

Complete the following diagram to show how the Ohmmeter would be connected when testing the polarity of both the active and neutral conductors in a single-phase consumers main.



QUESTION 8. **(1 Marks)**

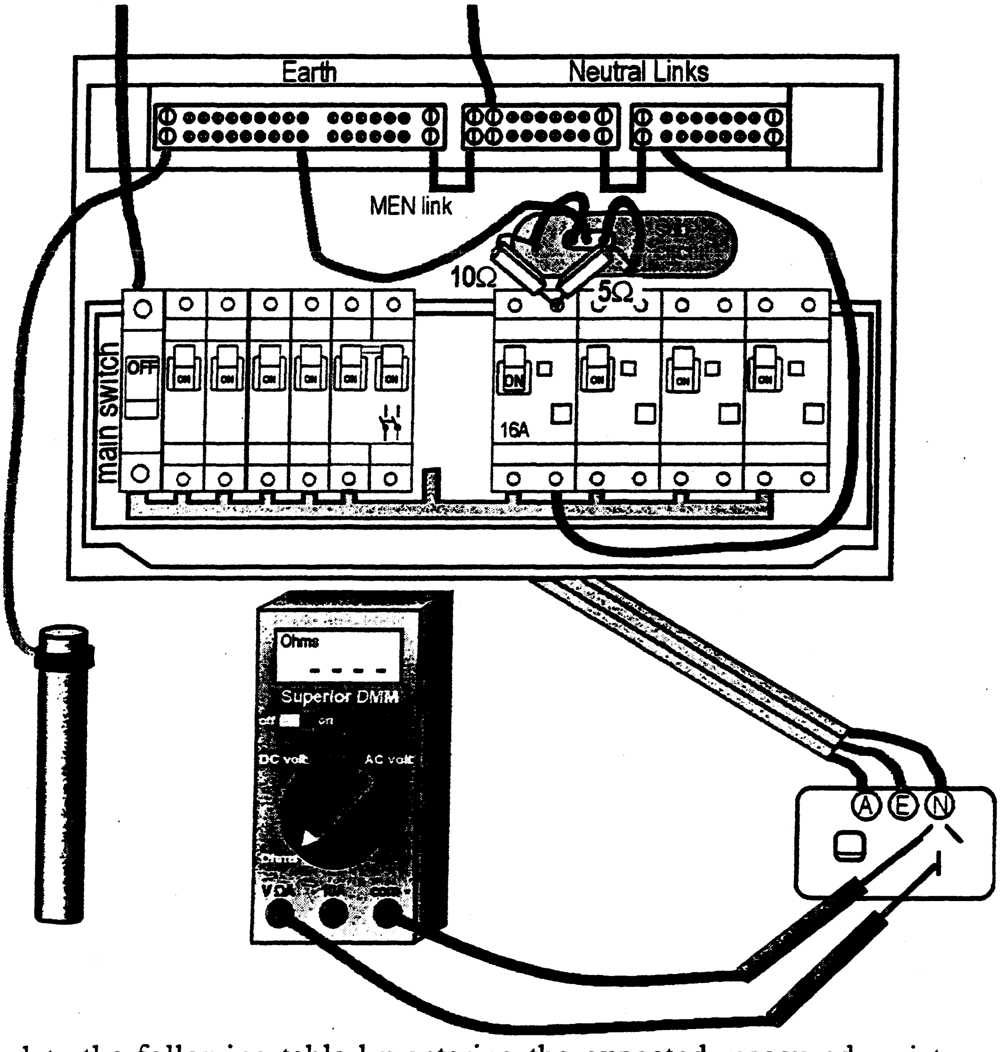
The Men link would connect to Position 1 / Position 2 (circle correct response) for the test.

SECTION C – (Cont'd)

QUESTION 9. (5 Marks)

The following test circuit is connected to check the polarity and circuit connection of a circuit supplying single-phase socket outlets:

Supply is isolated and Main switch is OFF
Active disconnected from RCD/MCB and connected to one side of 10 Ω resistor
Neutral disconnected from RCD/MCB and connected to one side of 5 Ω resistor
Other end of resistors is joined and connected to the neutral of the RCD/MCB



Complete the following table by entering the expected measured resistance values at the socket outlet between the nominated points.

Earth to Active with switch off	
Earth to Active with switch on	
Earth to Neutral	
Neutral to Active with switch off	
Neutral to Active with switch on	

SECTION C – (Cont'd)

QUESTION 10. (10 Marks)

Complete the required switchboard marking, on the following diagram, for the circuit information provided in TABLE 1.

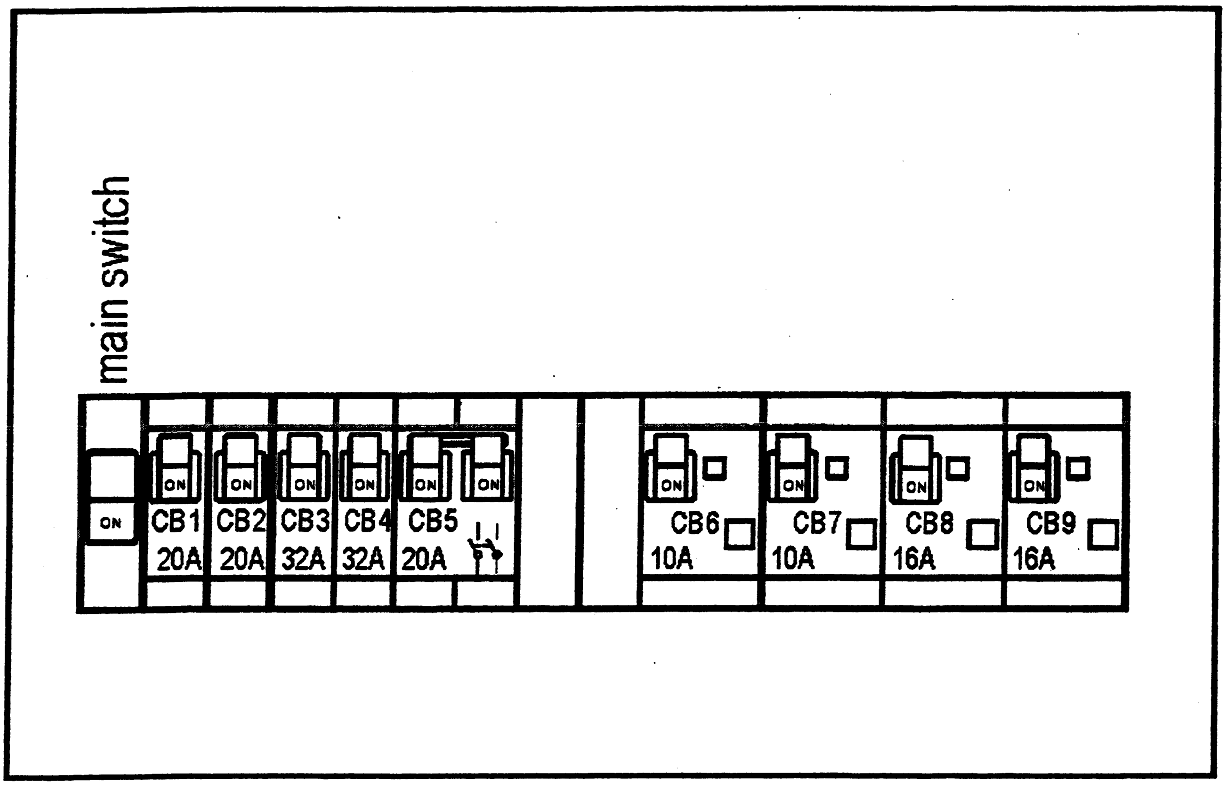


TABLE 1

Circuit	Description	CB	Neutral
1	Lights	6	1
2	Power	8	10
3	Air conditioner	3	5
4	Cook top	2	4
5	Dual element HWS	5	7

SECTION D – (10 Marks)

INSTRUCTIONS: This section involves calculations. Show all necessary working in the space provided, marks will be awarded accordingly. Write answers in the spaces provided.

QUESTION 1. (5 Marks)

A final sub-circuit supplies a load consisting of 10 A socket outlets. A 16 A Type C circuit breaker protects the circuit. Determine the maximum *measured* internal fault-loop impedance of the final sub-circuit, based on 230 V, when supply is unavailable and the ambient temperature is 20°C.

QUESTION 2. (5 Marks)

A digital ohmmeter and trailing lead are used to perform an earth continuity test on a 2.5 mm^2 earthing conductor that is part of a circuit supplying socket outlets in a single-phase installation. When the meter lead and trailing lead are joined, the meter indicates 0.65 Ω. Use the information provided in TABLE 2 to determine the expected reading on the ohmmeter if the length of the measured circuit is 45 metres.

TABLE 2

Nominal conductor csa (mm^2)	Nominal conductor resistance at 20°C (Ω/m)	Length of cable (m)							
		5	10	15	20	25	30	40	50
1	0.0177	0.0885	0.1770	0.2655	0.3540	0.4425	0.5310	0.7080	0.8850
1.5	0.0119	0.0595	0.1190	0.1785	0.2380	0.2975	0.3570	0.4760	0.5950
2.5	0.0072	0.0360	0.0720	0.1080	0.1440	0.1800	0.2160	0.2880	0.3600
4	4.52×10^{-3}	0.0226	0.0452	0.0678	0.0904	0.1130	0.1356	0.1808	0.2260
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

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)

7 December 2004

6077HA Electrical Installation Testing & Verification

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				

Question	(a)	(b)	(c)	(d)
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
Totals				

Total Marks Section A: .... /25

END OF EXAMINATION

MARKING GUIDE

MODULE NO: 6077HA

MODULE NAME: Electrical Installation Testing & Verification

EXAM DATE: 7 December 2004

NUMBER OF PAGES: 12

NEW SOUTH WALES DEPARTMENT OF EDUCATION AND TRAINING

TAFE NSW

Family Name ...MARKING KEY.........

Other name.......................................

Centre ....

Signature ....

7 December 2004

6077HA (Electrical Installation Testing & Verification)

Time allowed – 1 hour plus Ten minutes reading time

11 Pages in this Question Booklet

***All* Questions to be attempted**

TOTAL MARKS AVAILABLE = 100

Section	Possible mark	Actual mark
A	25	
B	35	
C	30	
D	10	
Total	100	

Aids to be supplied by college

- None

Aids to be supplied by student

- Australian/New Zealand Wiring rules AS/NZS 3000:2000 (AMDT No 3 – July 2003)
- Students own marginal notes, indexing and formal amendments may be included in the above regulation books.
- Pen, pencil, eraser, rule, calculator

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 **examination paper.** Answers to Section A – multi-choice questions, are to be answered on the sheet attached to this examination paper.
- 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.

Aids permitted where indicated:

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

NEW SOUTH WALES DEPARTMENT OF EDUCATION AND TRAINING

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Family Name ....

Given Name ....

Student Number..

Centre ....

Signature ....

ANSWER SHEET – Section A (Multi-choice Questions)

7 December 2004

6077HA Electrical Installation Testing & Verification

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				X
2			X	
3	X			
4				X
5		X	X	
6		X		
7			X	
8			X	
9	X			
10	X			
11		X		
12		X		
13	X			

Question	(a)	(b)	(c)	(d)
14				X
15	X	X		
16		X		
17	X			
18		X		
19			X	
20	X			
21				X
22		X		
23	X			
24				X
25			X	
Totals				

Total Marks Section A: .... /25

END OF EXAMINATION

Name:........................

College:......................

ANSWER SHEET – Section A (Multi-choice Questions)

Module - 6077HA Examination Date: 7 December 2004

Instructions:

- Enter your name and college on this sheet.
- Place an **X** in box of your choice. If you make a mistake- circle your answer (X) and choose again.
- For your convenience you can remove this page while you answer Section A. **Remember to re-attach it** to the paper when you hand it in.

Question	a	b	c	d
1				■
2			■	
3	■			
4				■
5		■		
6		■		
7			■	
8			■	
9	■			
10	■			
11		■		
12		■		
13	■			
14				■
15				■
16		■		
17	■			
18		■		
19			■	
20	■			
21				■
22		■		
23	■			
24				■
25			■	
Totals	7	7	5	6

Total Marks Section A: .... /25

SECTION B – (35 Marks)

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

QUESTION 1. (11 Marks)

Insulation resistance test of a complete 3-phase installation when supply is not connected:

Test is outlined on page 14 of AS/NZS 3017
NO part marks (ie 1 or 0)

Test sequence:

1. Disconnect any portable appliances and ensure that all circuit switches are in the ____ON____ 1 mark .position.

2. Join all ____LIVE____ ____CONDUCTORS____ of the consumers mains together. 1 mark

3. Turn main switch(es) to the ____ON____ position. 1 mark

4. Ensure that all circuit fuses are ____IN____ 1 mark and that all circuit breakers are in the ____ON____ 1 mark position.

5. Disconnect the ____MEN____ ____LINK____ at the neutral bar. 1 mark

6. Set the meter to read ____MΩ____ 1 mark at ____500 d.c.____ 1 mark volts.

7. Connect one test lead to the ____MAIN____ ____EARTHING____ conductor at the earth bar. 1 mark

8. Connect the other test lead to the ____NEUTRAL____ ____BAR____. 1 mark

9. Test that the resistance complies with the minimum specified.

10. If the test result is not satisfactory, test consumers mains, sub-mains and each ____SUB-CIRCUIT____ separately. 1 mark

11. Disconnect the test leads, reconnect the ____MEN____ ____LINK____ 1 mark, separate the ____LIVE____ ____CONDUCTORS____ 1 mark of the consumers mains and reconnect portable appliances.

SECTION B – (Cont'd)

QUESTION 2. (10 Marks)

Resistance test of main earthing conductor in a complete 3-phase installation when supply is not connected:

Test sequence: Test is outlined on page 11 of AS/NZS 3017
NO part marks (ie 1 or 0)

1. Ensure that the consumers mains are NOT __CONNECTED__ (1 mark).
2. Disconnect the __MAIN__ (1 mark) __EARTHING__ conductor or __MEN__ __LINK__ from the neutral bar. (1 mark)
3. If using an analogue meter, set the meter to read __0 Ω__ (1 mark) with the meter leads connected together.
4. Connect one test lead to the disconnected __MAIN__ (1 mark) __EARTHING__ conductor or __MEN__ (1 mark) __LINK__.
5. Connect the other test lead to the __MAIN__ (1 mark) __EARTHING__ conductor at the __EARTH__ __ELECTRODE__. (1 mark)
6. Test that the resistance complies with the specified resistance.
7. Disconnect the test leads, reconnect the __MAIN__ (1 mark) __EARTHING__ conductor or __MEN__ __LINK__ at the neutral bar. (1 mark)

QUESTION 3. **(14 Marks)**

Polarity test of a single-phase sub-main in a complete 3-phase installation when supply is not connected:

Test sequence: Test is outlined on page 19 of AS/NZS 3017
NO part marks (ie 1 or 0)

1. Remove the fuse or turn off circuit breaker protecting the sub-main at the SWITCHBOARD (1 mark).

2. Remove all fuses and turn off all circuit breakers at the DISTRIBUTION BOARD (1 mark)

3. Disconnect the sub-main NEUTRAL (1 mark) conductor at the SWITCHBOARD (1 mark)

4. If using an analogue meter, set the meter to read 0 Ω (1 mark) with the meter leads connected together.

5. Connect one test lead to the ACTIVE (1 mark) conductor at the LOAD (1 mark) side of the sub-main protective device.

6. Connect the other test lead to the LINE (1 mark) side of the circuit protective device at the DISTRIBUTION board.

7. Test that the resistance of the active conductor is ≈ 0 Ω (1 mark) .

   1 mark

8. Disconnect the test leads.

9. Connect one test lead to the disconnected SUB-MAIN (1 mark) neutral conductor at the switchboard.

10. Connect the other test lead to the NEUTRAL (1 mark) BAR at the distribution board.

11. Test that the resistance of the neutral conductor is ≈ 0 Ω (1 mark) .

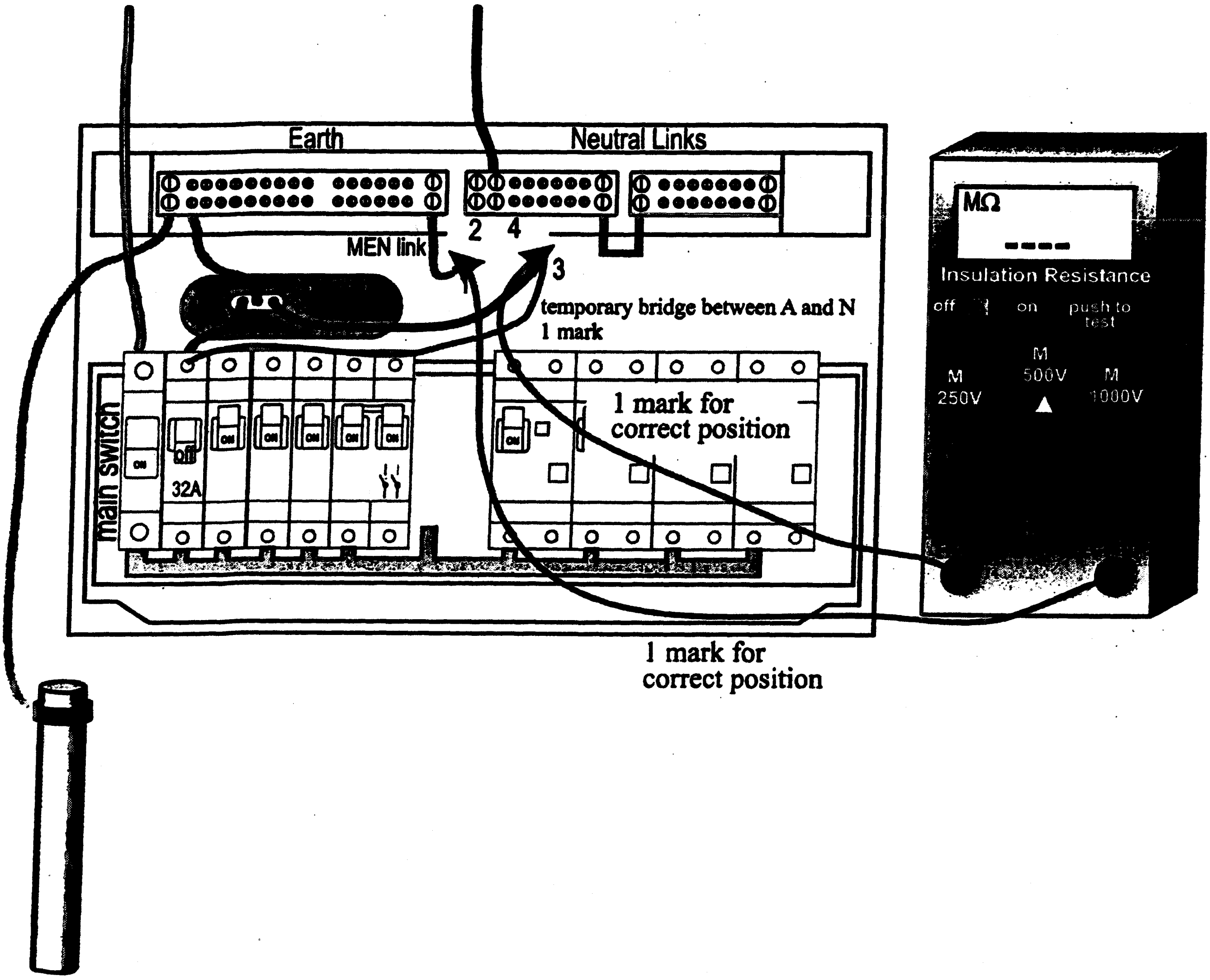
12. Disconnect the test leads, reconnect the SUB-MAIN NEUTRAL conductor. (1 mark)

SECTION C – (30 Marks)

INSTRUCTIONS: The Following questions in this section require some simple drawing and answering questions relating to the drawings. Ensure that the drawing is neat and legible. Write your answers to each question in the space provided. The use of pencil on the drawing is acceptable in this section only.

QUESTION 1. (3 Marks)

Complete the following diagram to show how the Insulation Resistance Tester would be connected when testing a single-phase circuit supplying an air conditioner and protected by a 32 A circuit breaker.



QUESTION 2. (1 Mark)

The Men link would connect to Position1 / Position 2 (circle correct response) for the test.

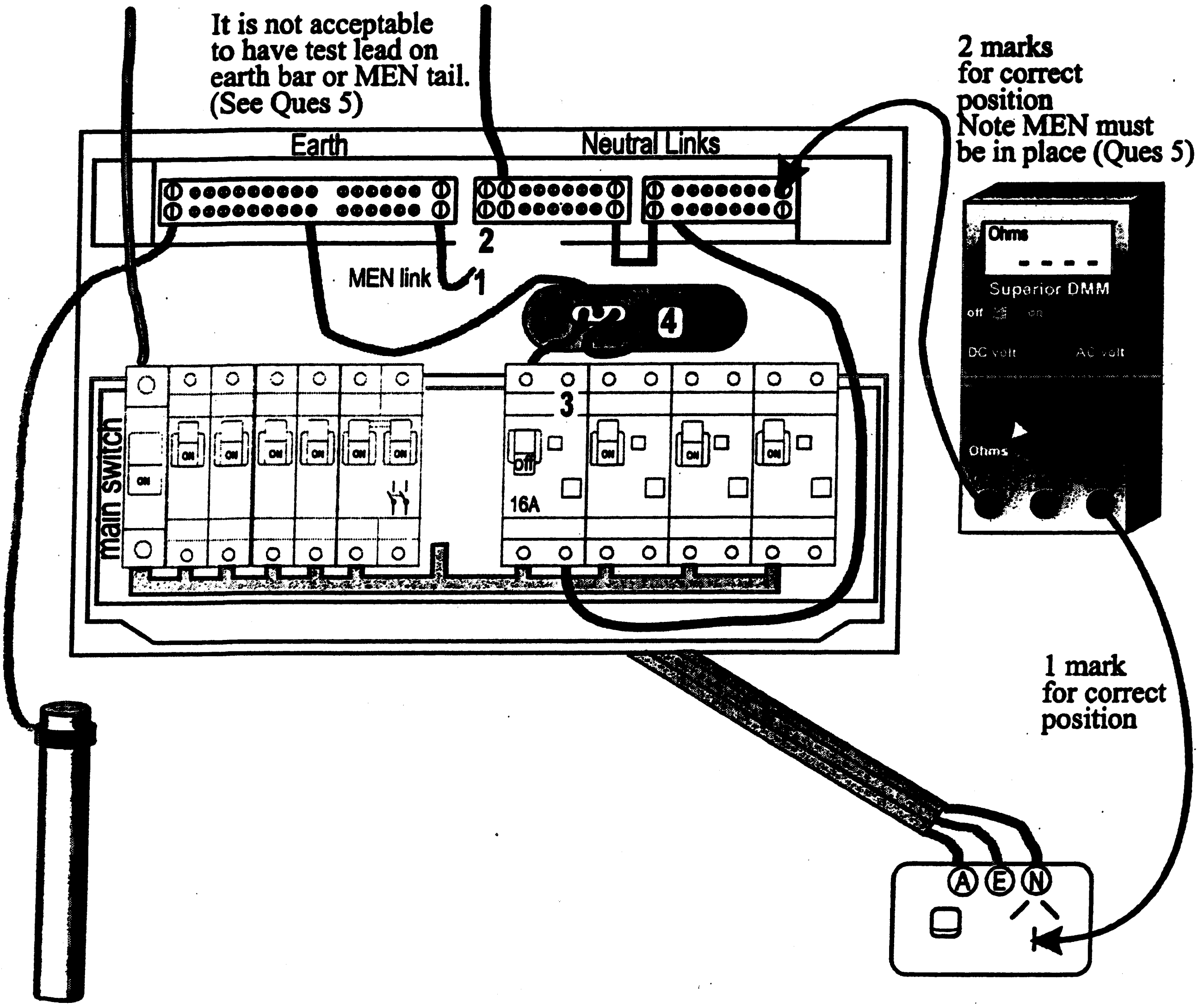
QUESTION 3. (1 Mark)

The sub-circuit neutral conductor would connect to Position 3 / Position 4 (circle correct response) for the test.

SECTION C – (Cont'd)

QUESTION 4. (3 Marks)

Complete the following diagram to show how the Ohmmeter would be connected when testing the earth continuity of a single-phase circuit supplying a socket outlet and protected by a 16 A combination RCD/MCB.



QUESTION 5. (1 Mark)

The Men link would connect to Position1 / Position 2 (circle correct response) for the test.

QUESTION 6. (1 Mark)

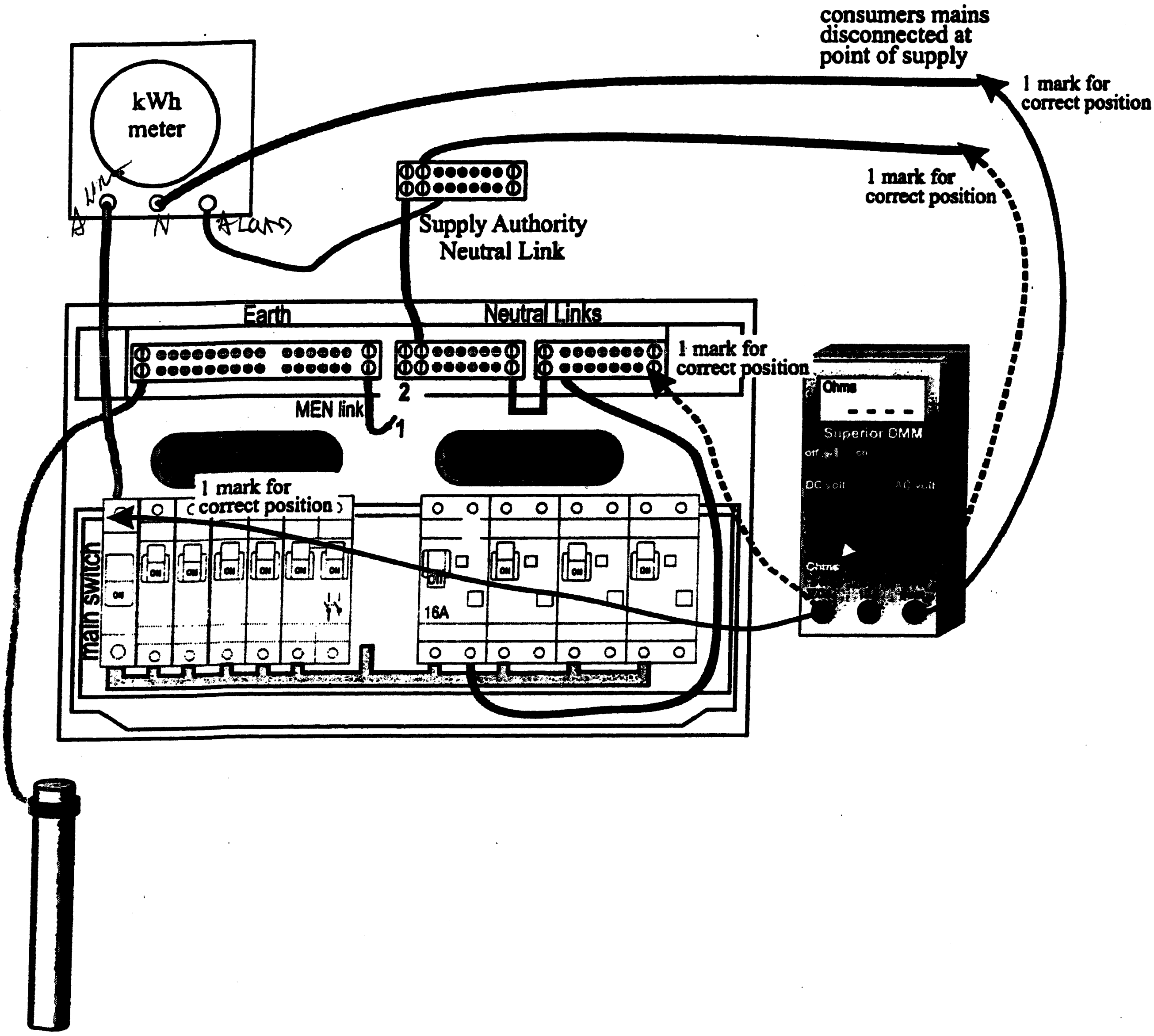
The sub-circuit neutral conductor should connect to Position 3 / Position 4 (circle correct response) for the test.

This ensures isolation of final sub-circuit neutral

SECTION C – (Cont'd)

QUESTION 7. (4 Marks)

Complete the following diagram to show how the Ohmmeter would be connected when testing the polarity of both the active and neutral conductors in a single-phase consumers main.



QUESTION 8. (1 Marks)

The Men link would connect to Position1 / Position 2 (circle correct response) for the test.

SECTION C – (Cont'd)

QUESTION 9. (5 Marks)

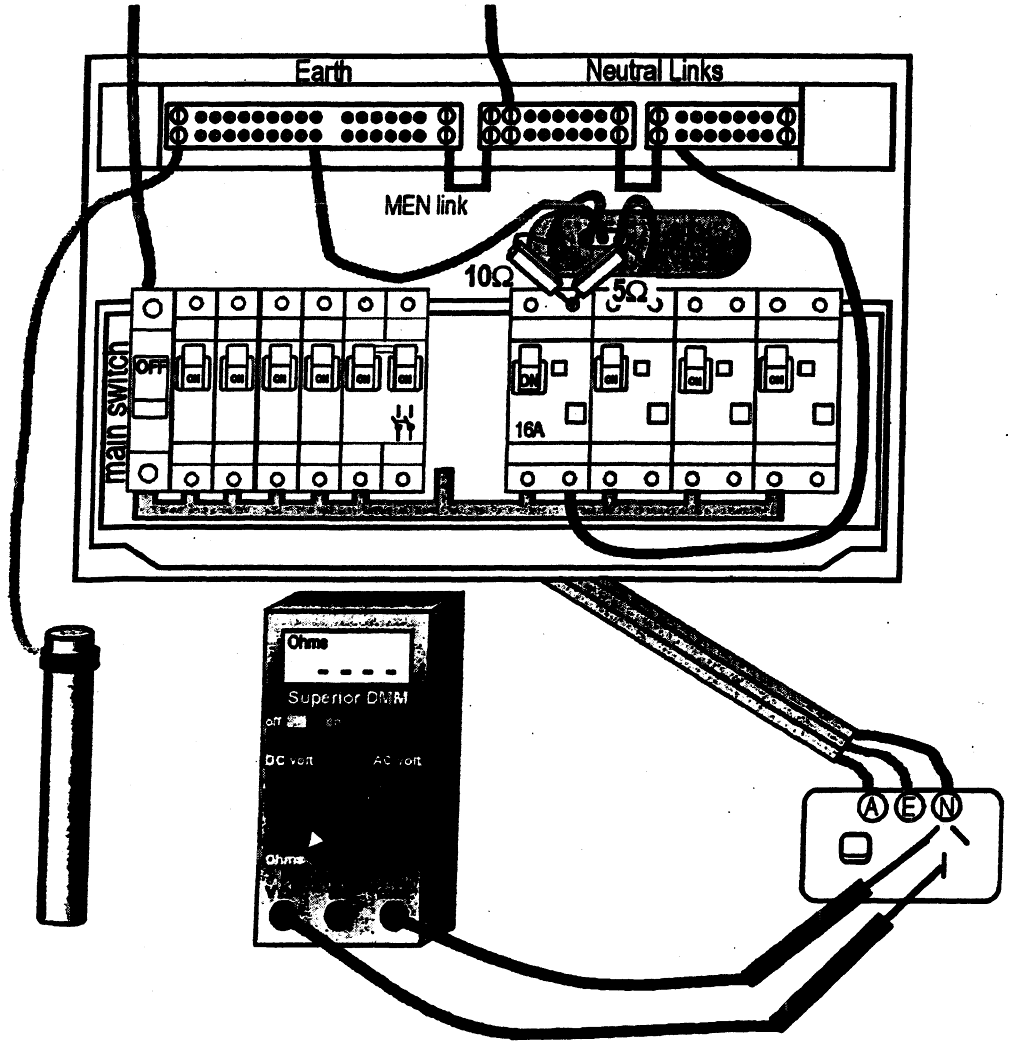
The following test circuit is connected to check the polarity and circuit connection of a circuit supplying single-phase socket outlets:

Supply is isolated

Active disconnected from RCD/MCB and connected to one side of 10 Ω resistor

Neutral disconnected from RCD/MCB and connected to one side of 5 Ω resistor

Other end of resistors is joined and connected to the neutral of the RCD/MCB



Complete the following table by entering the expected measured resistance values at the socket outlet between the nominated points.

Earth to Active with switch off	∞ (infinity)
Earth to Active with switch on	**10 Ω (ten Ohms)**
Earth to Neutral	**5 Ω (5 Ohms)**
Neutral to Active with switch off	∞ (infinity)
Neutral to Active with switch on	**15 Ω (15 Ohms)**

SECTION C – (Cont'd)

QUESTION 10. (10 Marks)

Complete the required switchboard marking, on the following diagram, for the circuit information provided in Table 1.

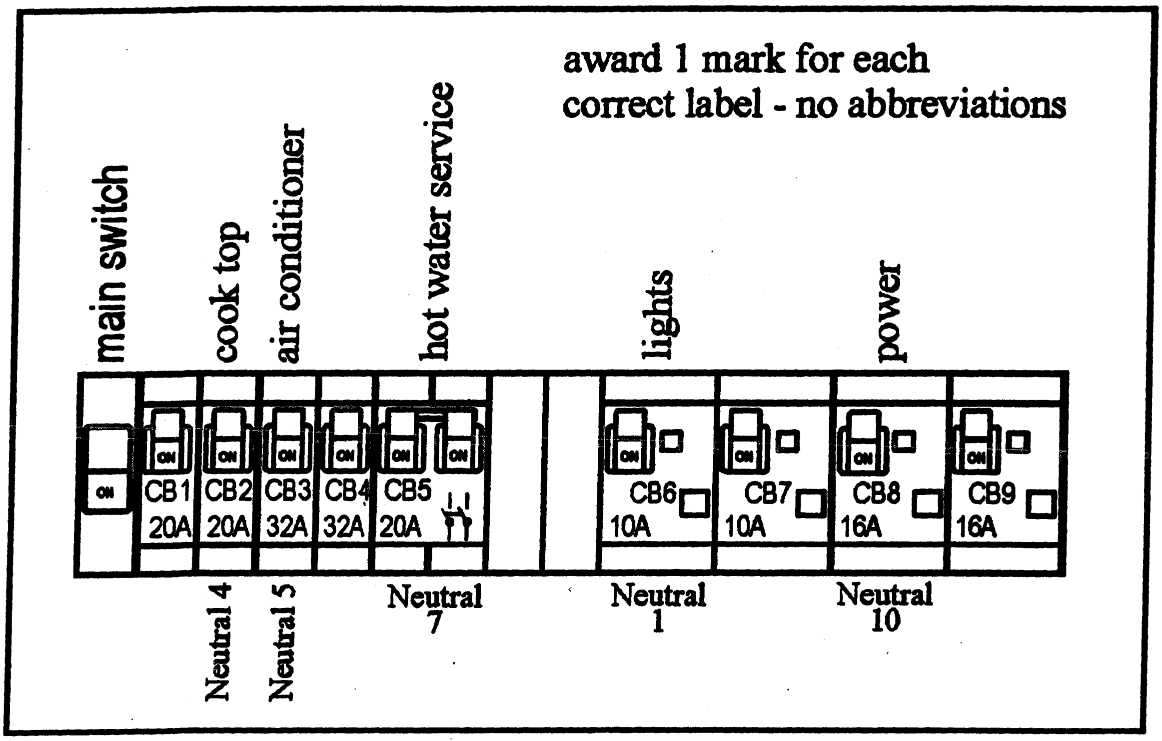


Table 1

Circuit	Description	CB	Neutral
1	Lights	6	1
2	Power	8	10
3	Air conditioner	3	5
4	Cook top	2	4
5	Dual element HWS	5	7

SECTION D – (10 Marks)

INSTRUCTIONS: This section involves calculations. Show all necessary working in the space provided, marks will be awarded accordingly. Write answers in the spaces provided.

QUESTION 1. (5 Marks)

A final sub-circuit supplies a load consisting of 10 A socket outlets. A 16 A Type C circuit breaker protects the circuit. Determine the maximum *measured* internal fault-loop impedance of the final sub-circuit, based on 230 V, when supply is unavailable and the ambient temperature is 20°C.

$$Z_{int}\text{ measured} = 0.8 \times 0.8 \times Z_S$$
$$= 0.8 \times 0.8 \times 1.92 \text{ (from Table B4.1)}$$
$$= \underline{1.23\Omega}$$

No part marks

QUESTION 2. (5 Marks)

A digital ohmmeter and trailing lead are used to perform an earth continuity test on a 2.5 mm^2 earthing conductor that is part of a circuit supplying socket outlets in a single-phase installation. When the meter lead and trailing lead are joined, the meter indicates 0.65 Ω. Use the information provided in Table 2 to determine the expected reading on the ohmmeter if the length of the measured circuit is 45 metres.

$$R_{cable} = R_{40\,metre} + R_{5\,metre}$$
$$= 0.2880 + 0.0360$$
$$= 0.3240\,\Omega$$

2 marks

$$R_{measured} = R_{cable} + R_{lead}$$
$$= 0.3240 + 0..65$$
$$= \underline{0.9740\,\Omega}$$

3 marks

Table 2

Nominal conductor csa (mm^2)	Nominal conductor resistance at 20°C (Ω/m)	Length of cable (m)							
		5	10	15	20	25	30	40	50
1	0.0177	0.0885	0.1770	0.2655	0.3540	0.4425	0.5310	0.7080	0.8850
1.5	0.0119	0.0595	0.1190	0.1785	0.2380	0.2975	0.3570	0.4760	0.5950
2.5	0.0072	0.0360	0.0720	0.1080	0.1440	0.1800	0.2160	0.2880	0.3600
4	4.52×10^{-3}	0.0226	0.0452	0.0678	0.0904	0.1130	0.1356	0.1808	0.2260
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

END OF EXAMINATION