

Australian/New Zealand Standard™

**Electrical installations—Verification
guidelines**



AS/NZS 3017:2007

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Australian Electrical and Electronic Manufacturers Association
Canterbury Manufacturers Association New Zealand
Communications, Electrical and Plumbing Union
Consumers' Federation of Australia
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Australian/New Zealand Standard™

Electrical installations—Verification guidelines

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-001 Wiring Rules to supersede AS/NZS 3017:2001 from the date of publication.

This Standard aims to provide people who carry out inspections and tests of an electrical installation with some methods of checking that the electrical installation complies with the safety requirements for the prevention of fire and the protection of persons and livestock from electric shock.

AS/NZS 3017 may be applied through legislative requirements made in each State and Territory of Australia and in New Zealand.

AS/NZS 3000, *Electrical installations* (known as the Australian/New Zealand Wiring Rules), requires electrical installations to be inspected and tested before being placed in service. The inspection and test methods described in this Standard are provided for guidance. Alternative methods are acceptable.

This Standard has been revised to align with AS/NZS 3000:2007, to include optional tests to those previously listed, and additional tests for measurement of the resistance of the earth electrode; measurement of touch voltage; tests for phase sequence; and tests of the continuity and resistance of the incoming neutral.

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Australian/New Zealand Standard
Electrical installations — Verification guidelines

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard sets out some of the common inspection and test methods required to verify that a low voltage, multiple earthed neutral (MEN) (TN-C-S) electrical installation complies with safety requirements for the prevention of fire, or a person or livestock from sustaining an electric shock.

The tests detailed in this Standard are as follows:

- (a) Earthing system continuity and resistance;
- (b) Insulation resistance;
- (c) Polarity;
- (d) Correct circuit connections;
- (e) Phase sequence;
- (f) Fault-loop impedance;
- (g) Verification of operation of residual current devices;
- (h) Earth electrode resistance;
- (i) Touch voltage; and
- (j) Continuity and resistance of the incoming neutral.

The Standard illustrates testing procedures for an electrical installation connected to an MEN system of earthing. The equipment and methods:

- (k) Are not exclusive and other equipment and methods may be used;
- (l) May be applied to types of low voltage installations other than MEN; and
- (m) May be applied to work affecting only part of an installation, e.g. alterations, additions or repairs.

1.2 SAFETY

To comply with the requirements of AS/NZS 3000, all electrical installations and any alterations, additions and repairs to electrical installations shall, prior to being placed in service or use, be:

- (a) Inspected as far as is practicable; and
- (b) Tested.

Electrical testing inherently involves some degree of hazard. It is the responsibility of the person performing the tests to ensure that safe practices are used in the performance of test procedures.

In this Standard tests are described both for situations where the supply is connected and where it is not connected. Preference has been given to tests where the supply is not connected as this would minimize the shock risk. However, testing with the supply connected may also be conducted and some alternative test methods have been included. In these situations greater care must be exercised to avoid direct or indirect contact with live parts or the energizing of exposed conductive parts.

Whether testing with supply disconnected or connected, the following precautions should be followed:

- (c) Treat equipment, such as cables and terminations, as being energized until proven otherwise;

- (d) Follow safe working practices as outlined in AS/NZS 4836;
- (e) Understand the correct use of the equipment to be used and its rating; and
- (f) Check that the equipment being used, including any test leads, probes or clips:
 - (i) Is suitable for the voltage being tested
 - (ii) Is in good working order; and
 - (iii) Has no damaged parts with which contact could be dangerous.

NOTE — For the testing of individual circuits when the circuit protective device has been removed or switched off, a no-voltage test should be conducted at the end of the circuit to ensure the correct circuit protective device has been removed or switched off.

1.3 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

61010	Safety requirements for electrical equipment for measurement, control, and laboratory use
Part 1:2003	General requirements
60269	Low-voltage fuses
Part 1:2005	General requirements
HB 187:2006	Guide to selecting a safe multimeter

AS/NZS

1125:2001	Conductors in insulated electric cables and flexible cords
3000:2007	Electrical installations (known as the Australian/New Zealand Wiring Rules)
4836:2001	Safe working on low-voltage electrical installations
60479	Effects of current on human beings and livestock
Part 1:2002	General aspects
60898	Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations
Part 1:2004	Circuit breakers for a.c. operation
60990:2002	Methods of measurement of touch current and protective conductor current

BS

88	Low voltage fuses (all Parts)
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IEC

61557	Electrical safety in low voltage distribution systems up to 1000 V a.c. and 1500 V d.c. – Equipment for testing, measuring or monitoring of protective measures
Part 3:2007	Loop impedance
Part 5:2007	Resistance to earth

1.4 DEFINITIONS

For the purposes of this Standard the definitions given in AS/NZS 3000 and those below apply.

Inspection — Examination of an electrical installation using all the senses in order to ascertain correct selection and proper erection of electrical equipment.

Known earth — An earth point previously tested to confirm that it is connected to the installation earthing system.

Reporting — Recording of the results of inspection and testing.

Supply connected — The electrical installation is connected to the network operator's distribution system.

Supply not connected — No conductor of the electrical installation, including the neutral, is connected to the network operator's distribution system.

Testing — Implementation of measures in an electrical installation by means of which its effectiveness is proved.

NOTE — It includes ascertaining values by means of appropriate measuring instruments, those values not being detectable by inspection.

Verification — All measures by means of which compliance of the electrical installation with the relevant requirements of AS/NZS 3000 is checked.

NOTE — This comprises inspection, testing and reporting.

1.5 SEQUENCE OF TESTS

Figure 1.1 shows a typical sequence for testing electrical installation work.

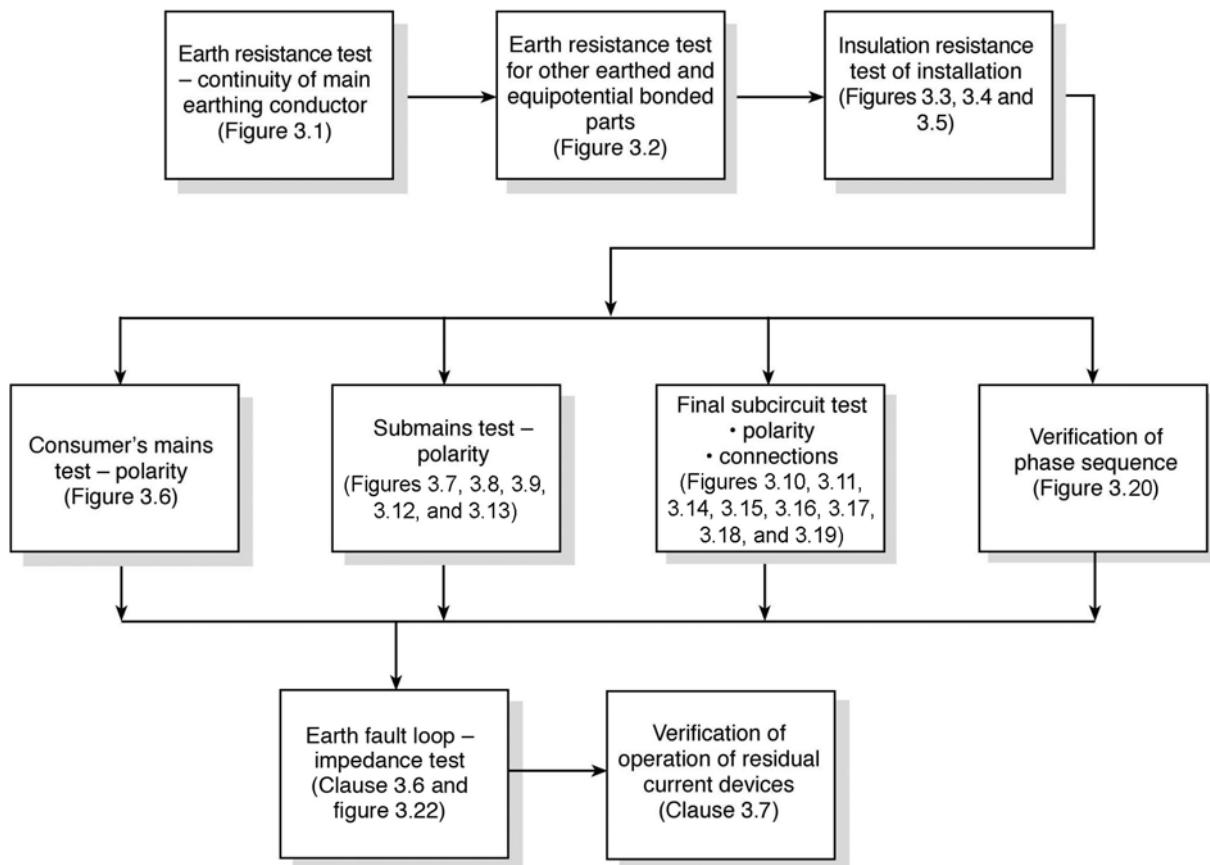


Figure 1.1 — Typical test sequence

1.6 FAILURE OF A TEST

If the electrical installation fails a test, that test and any preceding tests that may have been influenced by the fault indicated shall be repeated after the fault has been rectified.

1.7 TEST EQUIPMENT

1.7.1 Equipment checks

All test equipment should be suitable for its intended purpose and be checked from time to time, particularly after extended periods of storage, to ensure that it remains operational and safe and internal batteries are adequately charged.

NOTE —

- (1) Test instruments should comply with the requirements of AS 61010.1 and IEC 61557 or equivalent Standard and be calibrated at regular intervals.
- (2) See SA HB 187 for information on the selection of safe multimeters.

Before carrying out any tests the equipment should be checked to ensure that it is correctly set, functional and in good condition.

Instrument accuracy should be confirmed by checking against a range of resistors of known values or by regular calibration checks.

Contact probes and leads should be checked for damage to insulated parts, continuity and sound connections.

1.7.2 Equipment

To carry out all the tests detailed in this Standard the following equipment is required:

- (a) Insulation resistance tester;
- (b) Ohmmeter;
- (c) Voltage indicator (e.g. lamp, neon, LED device or meter);
- (d) Suitable probes;
- (e) Trailing leads;
- (f) A range of resistors of known values;
- (g) A suitable instrument for measuring fault-loop impedance; and
- (h) A suitable instrument or device for checking the operation of a RCD.

NOTE —

- (1) The insulation resistance tester used shall be able to maintain its terminal voltage within +20% and -10% of the nominal open-circuit terminal voltage, when measuring a resistance of 1 MΩ on the 500 V range or 10 MΩ on the 1000 V range. When applying the insulation resistance test to electronic equipment or surge protection devices, care should be taken to prevent damage to the devices.
- (2) Voltage indicators such as high impedance volt meters, neon and LED devices, should only be used to verify the presence of a voltage. They should not be used to verify the conductivity of a cable, as they will operate satisfactorily with high resistances within the circuit under test.

SECTION 2 VISUAL INSPECTION

2.1 GENERAL

A visual inspection shall be made when work on an electrical installation has been completed in order to verify that the work complies with the requirements of AS/NZS 3000.

The visual inspection shall be carried out before, or in association with testing, and should where practicable be made before the relevant part of the electrical installation is placed in service.

Where the visual inspection of a part of the electrical installation is not practicable at the completion of the work, e.g. not accessible due to enclosure in the building structure, consideration should be given to inspecting that part during the course of the installation.

2.2 CHECK LIST

The following items provide a guide to the matters to be checked during the visual inspection to assess that the relevant requirements of AS/NZS 3000 are satisfied.

NOTE — The lists below are representative of items in a standard installation but are not intended to be exhaustive.

(a) *General*

- (i) Basic protection (protection against direct contact with live parts), e.g. insulation and enclosure
- (ii) Fault protection (protection against indirect contact with exposed conductive parts), e.g. by the use of automatic disconnection of supply, double insulation or isolating transformers
- (iii) Protection against hazardous parts, e.g. enclosure, guarding or screening of flammable materials, hot surfaces and parts that may cause physical injury
- (iv) Protection against spread of fire, e.g. penetration of fire barriers, and
- (v) General condition of the electrical equipment, e.g. signs of damage that could impair safe operation, disconnection of unused electrical equipment.

(b) *Consumers mains*

- (i) Identification of cable cores
- (ii) Current carrying capacity
- (iii) Voltage drop, e.g. size and length of conductors and load
- (iv) Underground installation conditions, e.g. enclosure, depth of burial, mechanical protection
- (v) Aerial installation conditions
- (vi) Connection of wiring, and
- (vii) Protection against external influences.

(c) *Switchboards*

- (i) Location, e.g. access and egress, not in restricted location
- (ii) Protective devices, e.g. selection and setting of adjustable protective devices for compliance with overcurrent protection, arc fault protection and discrimination requirements.
- (iii) Isolating devices, e.g. main switches
- (iv) Connecting devices, e.g. neutral bars, earth bars and active links
- (v) Connection and fixing of wiring and switchgear
- (vi) Identification and labelling of electrical equipment, and

(vii) Protection against external influences, e.g. mechanical damage, effects of ultraviolet light.

(d) *Wiring systems*

- (i) Conductor size, e.g. current-carrying capacity and voltage drop
- (ii) Identification of cable cores
- (iii) Adequate support and fixing
- (iv) Connections and enclosures
- (v) Particular installation conditions, e.g. underground, aerial, safety services
- (vi) Segregation from other services and electrical installations, and
- (vii) Protection against external influences, e.g. enclosure.

(e) *Electrical equipment*

- (i) Isolation and switching devices for protection against injury from mechanical movement devices and motors
- (ii) Isolation and switching devices for protection against thermal effects, e.g. motors, room heaters, water heaters
- (iii) Switching devices for particular electrical equipment, e.g. socket-outlets, cooking appliances etc
- (iv) Particular installation conditions, e.g. locations affected by water, explosive atmospheres, extra-low voltage, high voltage
- (v) Compliance with required Standard
- (vi) Connection, support and fixing
- (vii) Protection against external influences, and
- (viii) Availability of instruction manuals, technical dossiers etc, especially for hazardous areas.

(f) *Earthing*

- (i) MEN connection
- (ii) Earth electrode
- (iii) Earthing conductors, e.g. size, identification
- (iv) Equipotential bonding conductors, e.g. size, identification
- (v) Connections, joints and terminations
- (vi) Protection against external influences
- (vii) Connection to earthing arrangements for other systems
- (viii) Creation of earthed situation that may require earthing of additional electrical equipment, and
- (ix) Supplementary bonding of extraneous conductive parts in showers, bathrooms, swimming pools, paddling pools, spa pools and spa tubs.

SECTION 3 TESTS

3.1 EARTH CONTINUITY AND RESISTANCE

3.1.1 Objective

Earth continuity and resistance tests are necessary to ensure that the earthing system has been installed in an appropriate manner and the resistance of the protective earthing conductor is low enough to permit the passage of sufficient current to cause circuit protective devices to operate if there is a fault between live parts and exposed conductive parts.

3.1.2 Requirements

The resistance of the main earthing conductor and any equipotential bonding conductor shall be not more than 0.5Ω .

The resistance of protective earthing conductors shall be low enough to permit the passage of current necessary to operate the circuit protective device. This condition is satisfied when the fault-loop impedance is low enough to allow sufficient current to flow in the earth fault-loop to cause the protective device to operate within a specified disconnection time.

NOTE —

- (1) As described in 3.6, the maximum allowable resistance of the protective earthing conductor associated with any particular circuit depends on the type and rating of the protective device and the impedance of the live conductors that comprise the circuit in which the fault occurs.
- (2) Maximum resistance values (R_e) for earthing conductors related to size of conductor and rating of associated protective device are given in table 3.2. These values may be used when testing for earth continuity.

3.1.3 Test procedures

The test procedures below show methods of testing the continuity and resistance of earthing and bonding conductors. They are shown in:

- (a) Figure 3.1 for the main earthing conductor; and
- (b) Figure 3.2 for protective earthing and equipotential bonding conductors.

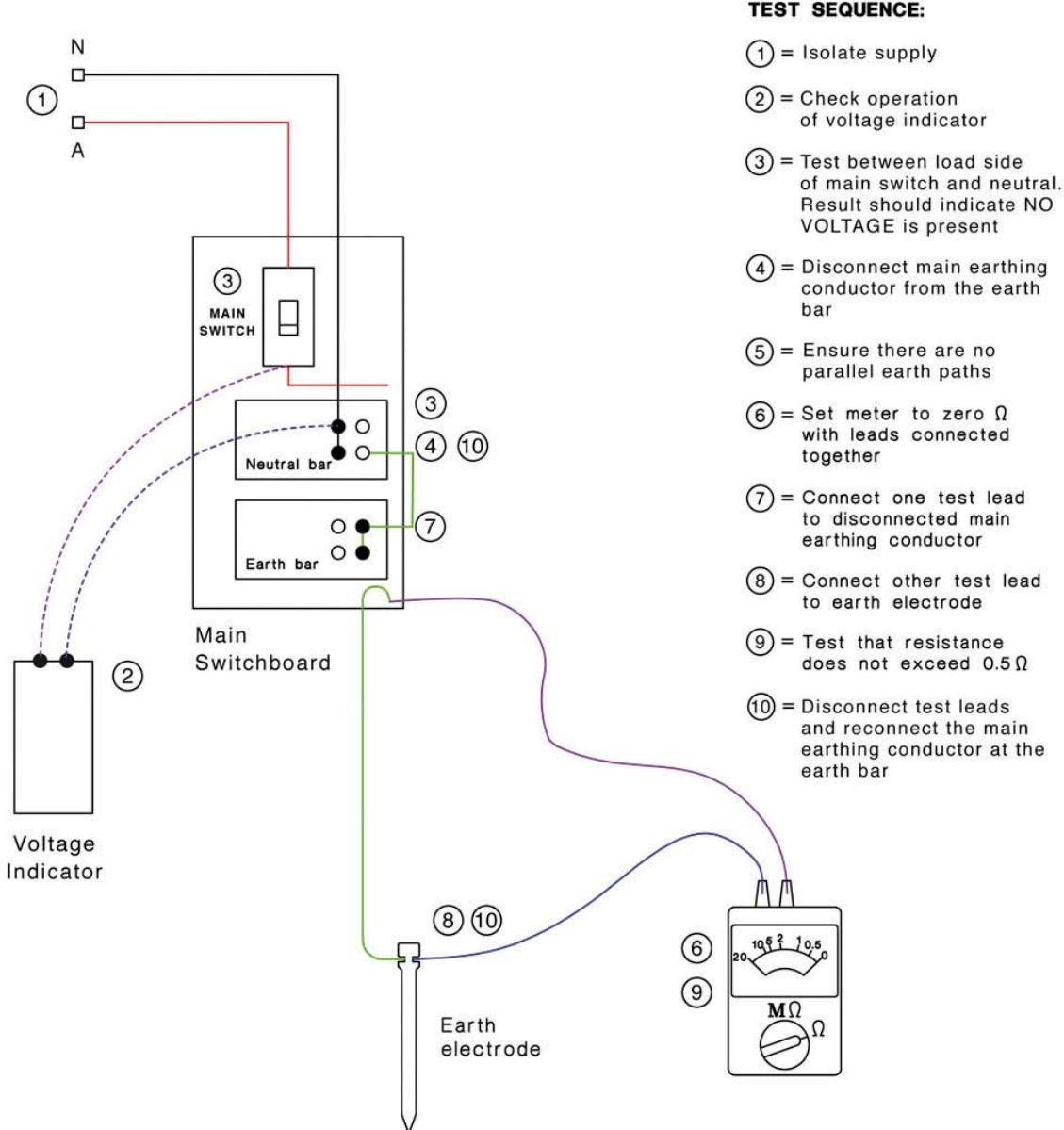
NOTE — The continuity of protective earthing conductors may also be verified by measuring the earth fault-loop impedance of the circuit. See 3.6.

3.1.4 Testing considerations

Consideration should be given to the following:

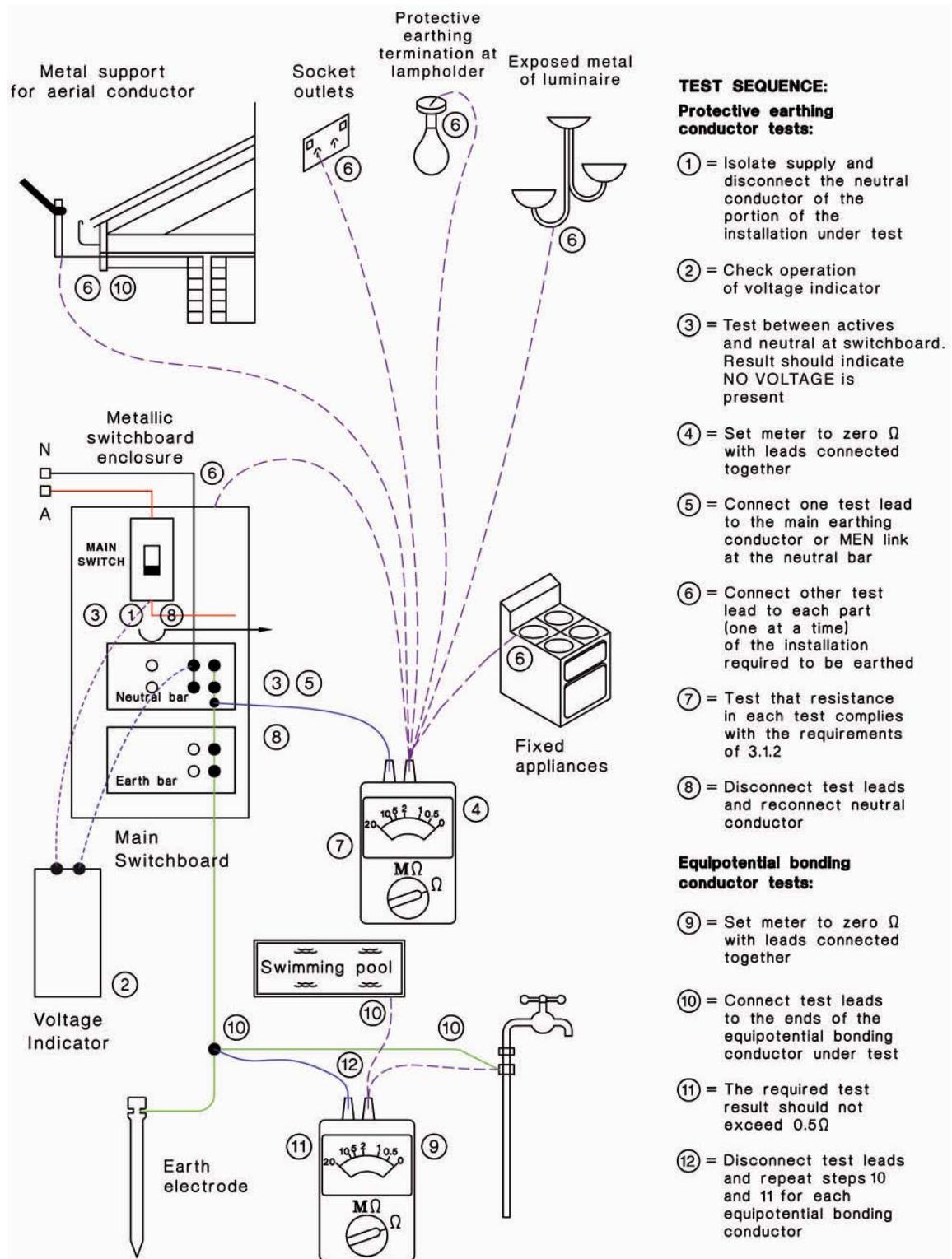
- (a) In some situations, such as the connection of equipotential bonding conductors to water piping or swimming pools, the terminations of conductors may not be accessible due to further building activities or enclosure. If this is expected to occur, testing at the termination should be carried out at the time of initial connection or other convenient time when the termination is still accessible. Where this is not practicable, the inaccessible connection may be proven by testing at a more convenient point on the parts which are to be earthed or bonded by the conductor; and
- (b) If the insulation resistance test, in accordance with 3.2, is not satisfactory (e.g. a value of less than $1 M\Omega$ is obtained) earth continuity and resistance tests may need to be repeated after any fault is rectified.

NOTE — Where there is a possibility of a parallel connection between a protective earthing conductor and other conductive parts, e.g. a water heater, the protective earthing conductor should be disconnected from the electrical device and tested independently.



NOTE — Numbers indicate test sequence.

Figure 3.1 — Resistance test of main earthing conductor



NOTE – Numbers indicate test sequence.

Figure 3.2 — Resistance test for protective earthing and equipotential bonding conductors

3.2 INSULATION RESISTANCE

3.2.1 Objective

Insulation resistance tests are necessary to ensure that the insulation resistance between all live conductors and earth or, as the case may be, all live parts and earth is adequate to ensure the integrity of the insulation. This is to prevent:

- (a) Electric shock hazards from inadvertent contact;
- (b) Fire hazards from short-circuits; and
- (c) Equipment damage.

In addition, insulation resistance tests between all conductors are necessary for consumers mains and submains to minimise potential for insulation breakdown, injury or property damage due to failure of such conductors.

The integrity of the insulation is stressed by applying a direct current at 500 V, or 250 V for equipment described in 3.2.4(e) which cannot be isolated.

3.2.2 Requirements

The insulation resistance between:

- (a) the conductors of consumers mains and submains; and
- (b) live and earthed parts of an electrical installation, or parts thereof, including consumers mains and submains

shall be not less than 1 MΩ.

Sheathed heating elements of appliances, RCDs with a functional earth connection and some other electrical equipment may cause test results lower than 1 MΩ. These should be disconnected from the circuit prior to testing.

These items may be tested individually. Acceptable insulation resistance values for such items are:

- (c) 0.01 MΩ for sheathed heating elements of appliances;
- (d) For RCDs with a functional earth connection, as specified by the manufacturer; or
- (e) A value permitted in the relevant safety Standard applicable to the electrical equipment.

NOTE — Where consumers mains or submains are not of significant length, the insulation resistance of the circuit should be significantly greater than 1 MΩ. For example, with short lengths (for example 50 m) of polymeric cables, a value in excess of 50 MΩ would be expected.

3.2.3 Test procedures

Tests for insulation resistance are shown in the following:

- (a) Figure 3.3 for testing a complete installation;
- (b) Figure 3.4 for testing consumers mains or submains; and
- (c) Figure 3.5 for testing a single circuit.

3.2.4 Testing considerations

Testing considerations include the following:

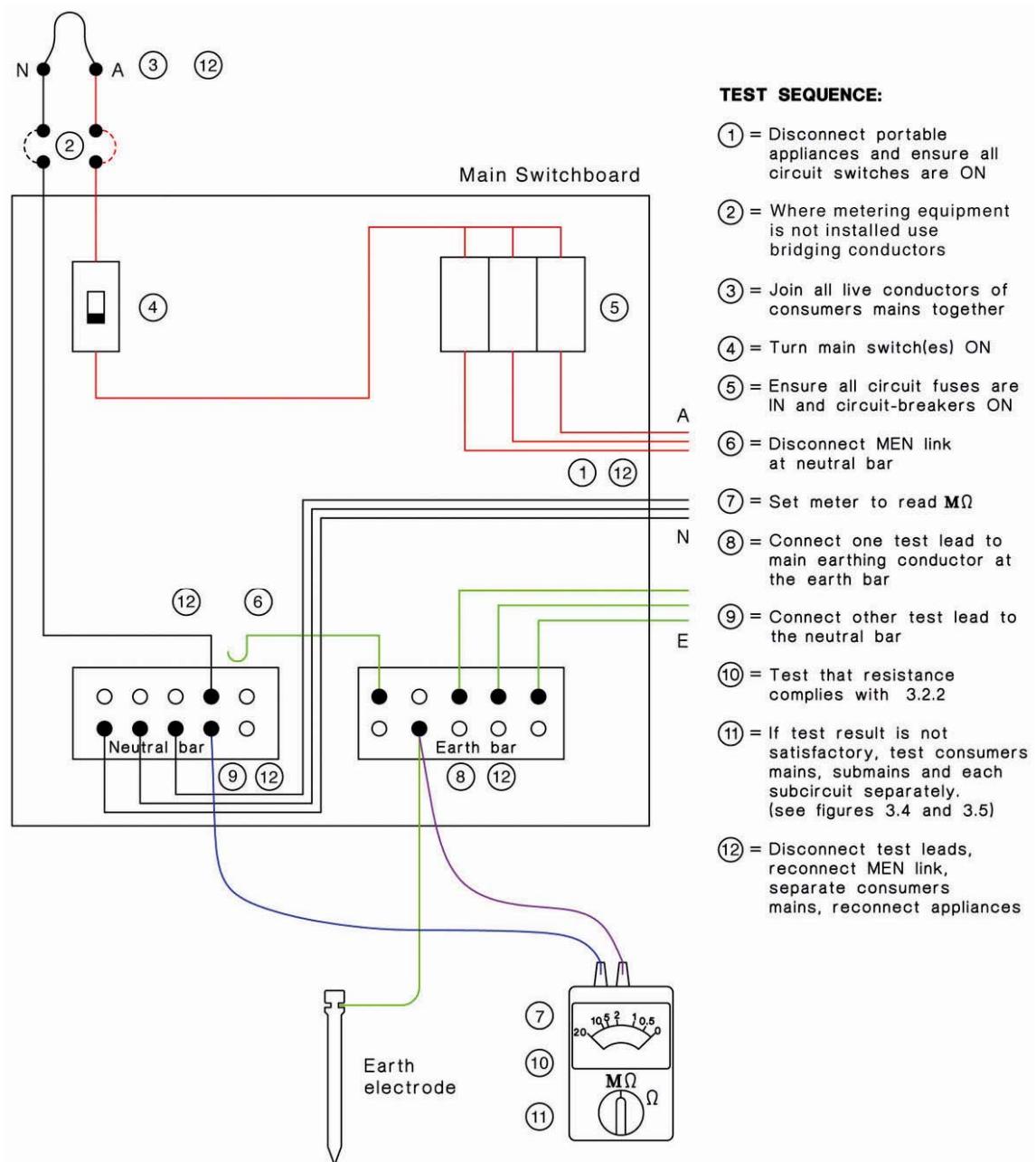
- (a) If supply is available, care must be exercised to ensure that the test equipment is not connected to energized parts. Main switches, circuit-breakers, residual current devices and fuses can be opened to disconnect most circuits. Consumers mains must be de-energized and isolated before testing;
- (b) Where outbuildings having additional MEN connections exist, they shall be disconnected before conducting the test;
- (c) If earthing arrangements for functional purposes are provided as part of the electrical installation, any connections to the protective earthing arrangements should be disconnected for the duration of this test;
- (d) If the insulation resistance test is not satisfactory (e.g. a value of less than 1 MΩ is obtained) earth continuity and resistance tests of 3.1 may need to be repeated after the fault is rectified;

- (e) Where electronic devices are installed as part of the fixed installation, care should be taken to avoid damaging such devices by overvoltage. Damage may be avoided by:
- (i) Connecting the active and neutral conductors together and testing between the conductors and earth, and
 - (ii) If the results obtained in (i) are unsatisfactory, testing between neutral conductors and earth and then between active conductors and earth.

These tests are to be carried out with the neutral conductor disconnected from the MEN system.

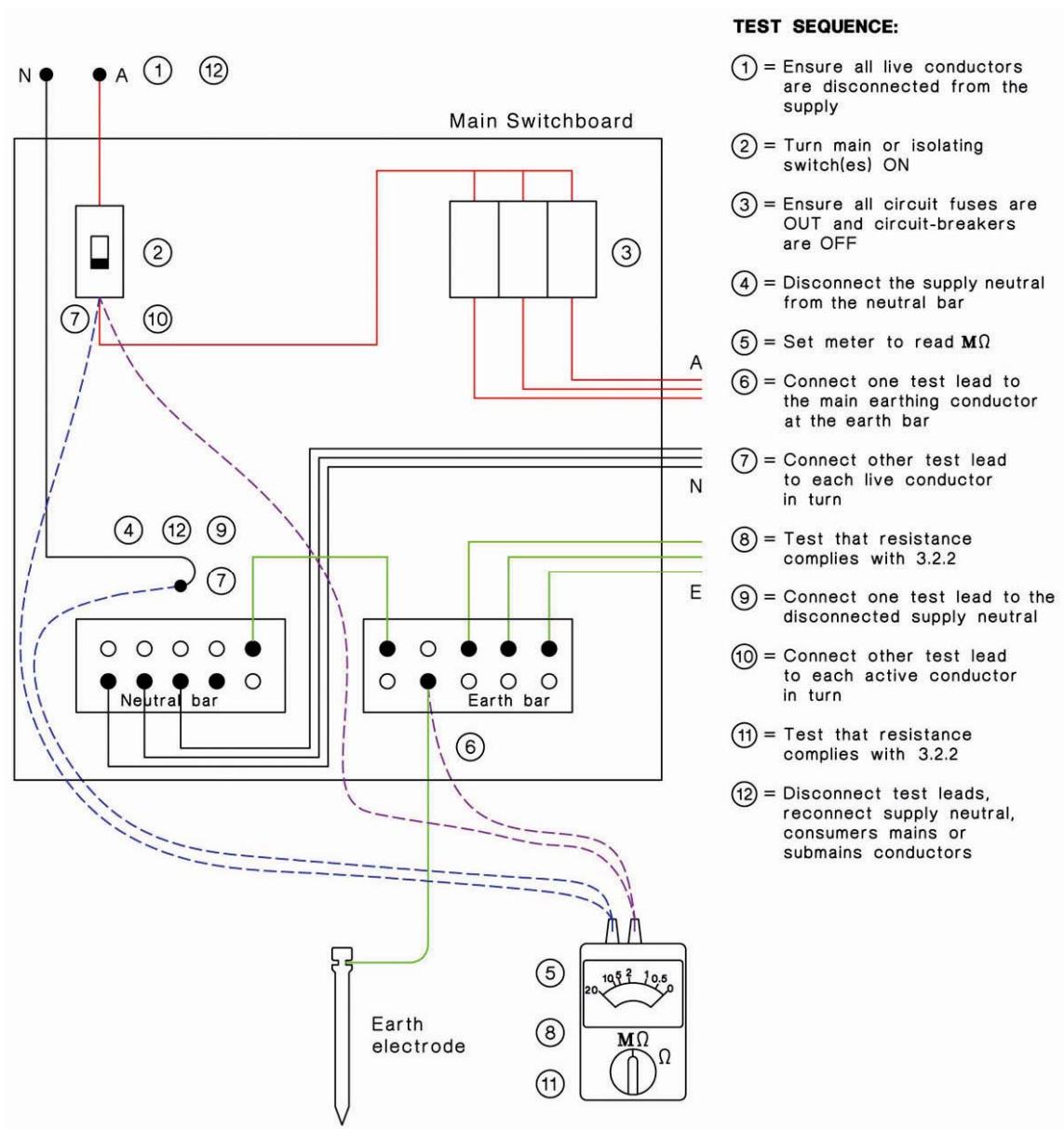
Where surge protective devices (SPDs) or other equipment are likely to influence the test or be damaged, such equipment shall be disconnected before carrying out the insulation resistance test. Where it is not reasonably practical to disconnect such equipment (e.g. in the case of fixed socket-outlets incorporating an SPD) the test voltage of the particular circuit may be reduced to 250 V d.c., but the insulation resistance should have a value of at least $1\text{ M}\Omega$;

- (f) Where an earth sheath return (ESR) system is used, the neutral conductor is not to be connected to any active conductor for the purpose of the insulation resistance test; and
- (g) All switch positions/combinations need to be tested in two-way and intermediate applications and on the load side of devices such as contactors.



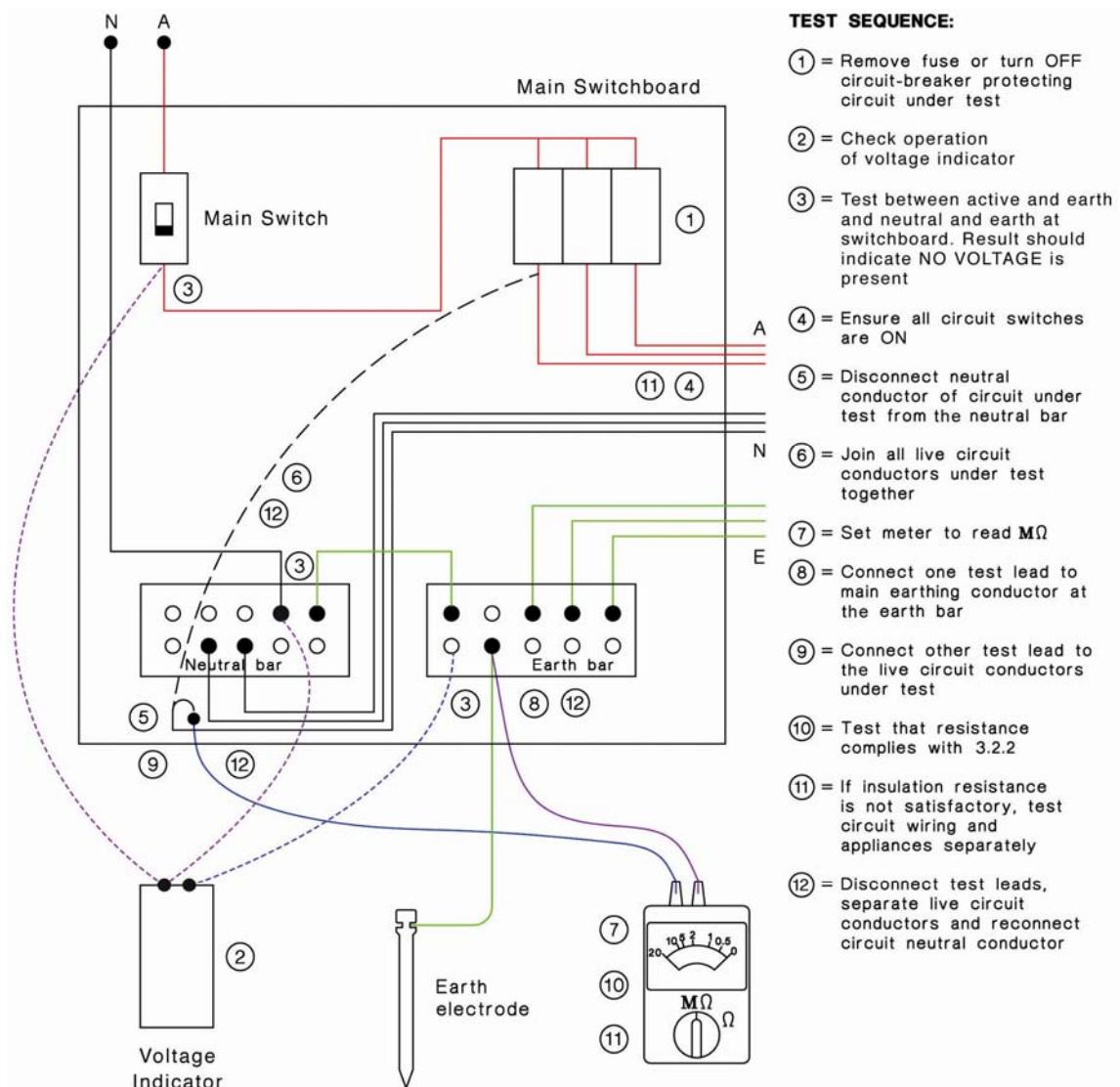
NOTE — Numbers indicate test sequence.

Figure 3.3 — Insulation resistance test of complete installation (supply not connected)

**NOTE —**

- (1) Test can be carried out on each conductor separately.
- (2) For multiphase consumers mains also test between phase conductors
- (3) Numbers indicate test sequence.

**Figure 3.4 — Insulation resistance test of consumers mains
(supply not connected)**

**NOTE —**

- (1) Test can be carried out separately on each active and neutral conductor.
- (2) Numbers indicate test sequence.

Figure 3.5 — Insulation resistance test of single circuit (supply not connected)

3.3 POLARITY

3.3.1 Objective

Polarity testing is necessary to ensure that no shock hazard results from the incorrect connection of active, neutral and earthing conductors. This testing is to ensure:

- (a) Active and neutral conductors of the consumers mains or submains are not transposed resulting in the electrical installation earthing system becoming energized;
- (b) There are no combinations of incorrect active, neutral and earthing conductor connections resulting in the exposed conductive parts of the electrical installation becoming energized; and
- (c) Switches do not operate in neutral conductors, resulting in parts of appliances, such as heating elements and lampholders, remaining energized when the switches are in the 'OFF' position.

Exception: Multi-pole RCDs, multi-pole switches in which the neutral is switched and switches in the control circuit of fire pumps.

Phase sequence testing is necessary to ensure that multi-phase equipment operates in a predictable manner, e.g. multi-phase motors, semiconductor controlled equipment etc (see 3.5).

3.3.2 Requirements

In general:

- (a) Every single-pole switch or protective device shall operate in the active conductor of the circuit in which it is connected;
- (b) A switch or protective device of a multi-phase circuit, other than some types of motor overload protective devices, shall operate in all active conductors of the circuit in which it is connected;
- (c) RCDs required to switch all live conductors shall switch the active and neutral conductors of the circuit;
- (d) Where multi-phase socket-outlets of the same type form part of an electrical installation the phase sequence of the socket-outlets shall be the same (see 3.5);
- (e) Socket-outlets which accommodate flat-pin plugs shall be connected so that, when viewed from the front of the socket-outlet, the order of connection commencing from the slot on the radial line shall be earth, active and neutral in a clockwise direction;
- (f) All neutral conductors shall be connected to the neutral bar of the switchboard; and
- (g) The consumers mains neutral shall be connected to the neutral bar of the main switchboard.

3.3.3 Test procedures

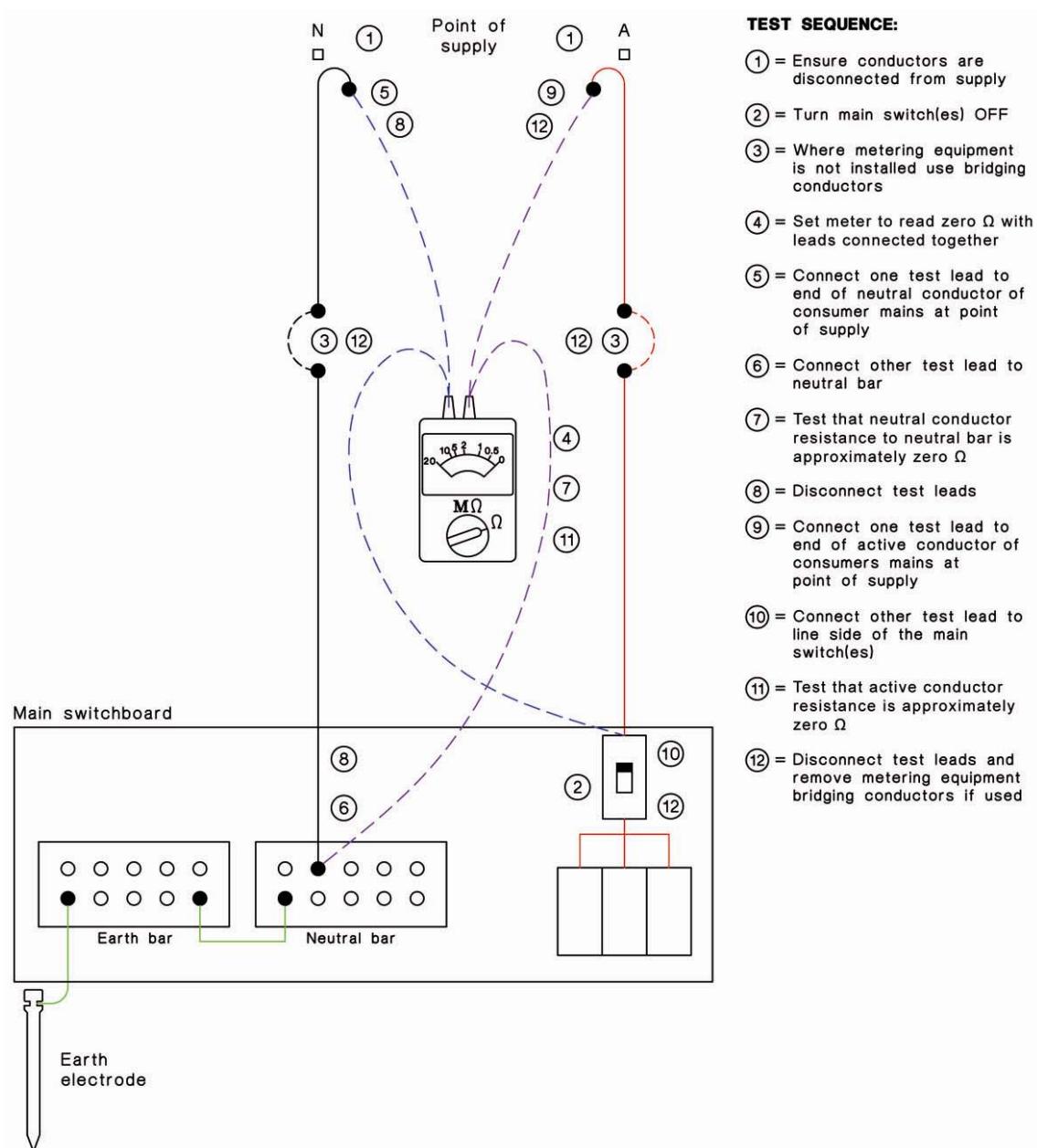
The following test procedures show methods of testing polarity. These are shown in:

- (a) Figures 3.6 to 3.11, where the supply is not connected; and

NOTE — Figures 3.8 and 3.9 show alternative tests to those in figure 3.7 for submains incorporating an earthing conductor and submains to a MEN distribution board respectively.

- (b) Figures 3.12 to 3.14, where the supply is available.

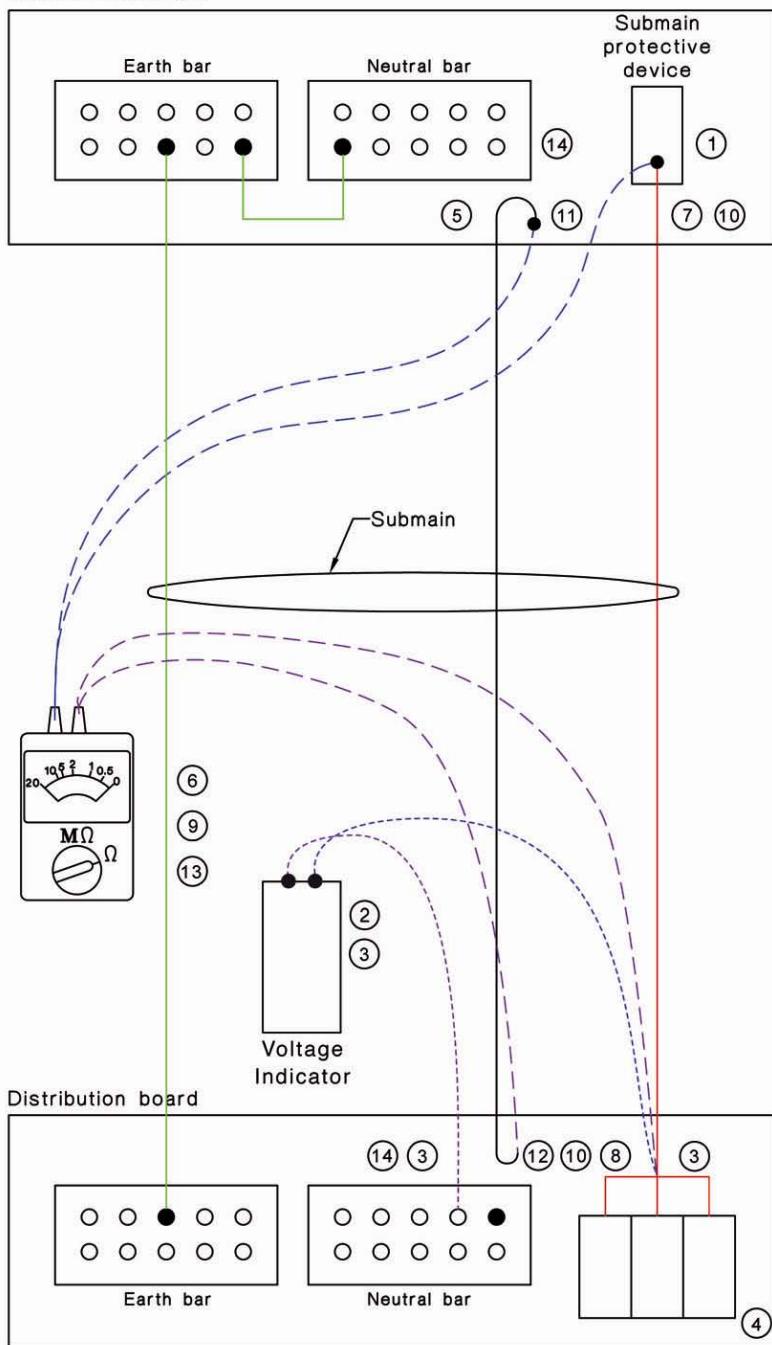
In all situations earthing and insulation resistance should have been established by earlier tests and the MEN connection should be intact.



NOTE — Numbers indicate test sequence.

Figure 3.6 — Polarity test of consumers mains (supply not connected)

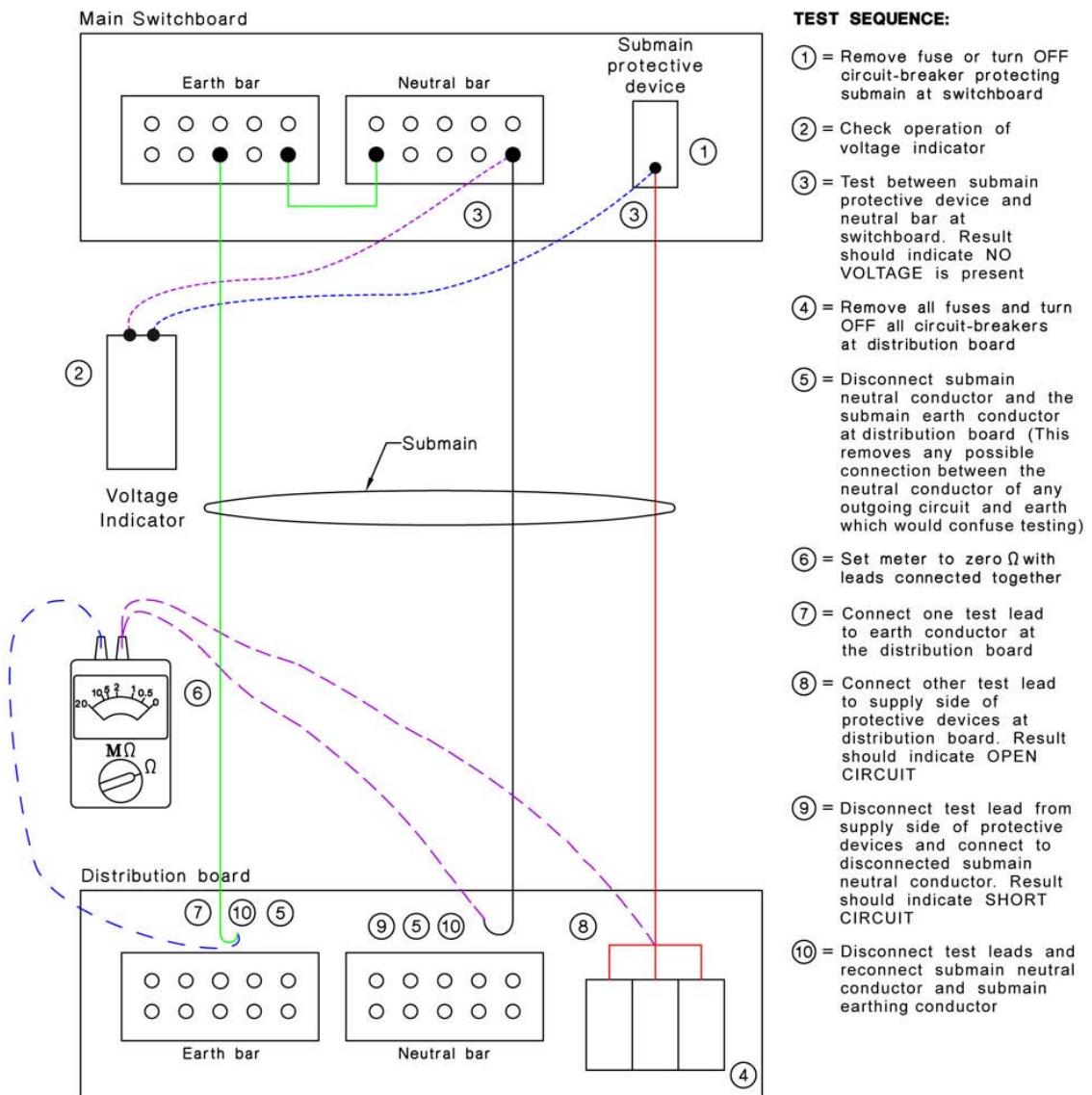
Main Switchboard

**TEST SEQUENCE:**

- ① = Remove fuse or turn OFF circuit-breaker protecting submain at switchboard
- ② = Check operation of voltage indicator
- ③ = Test between active and neutral at distribution board. Result should indicate NO VOLTAGE is present
- ④ = Remove all fuses and turn OFF all circuit-breakers at distribution board
- ⑤ = Disconnect submain neutral conductor at main switchboard and at distribution board
- ⑥ = Set meter to zero Ω with leads connected together
- ⑦ = Connect one test lead to active conductor at load side of submain protective device
- ⑧ = Connect other test lead to line side of protective devices on distribution board
- ⑨ = Test that active conductor resistance is approximately zero Ω
- ⑩ = Disconnect test leads
- ⑪ = Connect one test lead to disconnected submain neutral conductor at main switchboard
- ⑫ = Connect other test lead to disconnected submain neutral conductor at distribution board
- ⑬ = Test that neutral conductor resistance is approximately zero Ω
- ⑭ = Disconnect test leads and reconnect submain neutral conductor

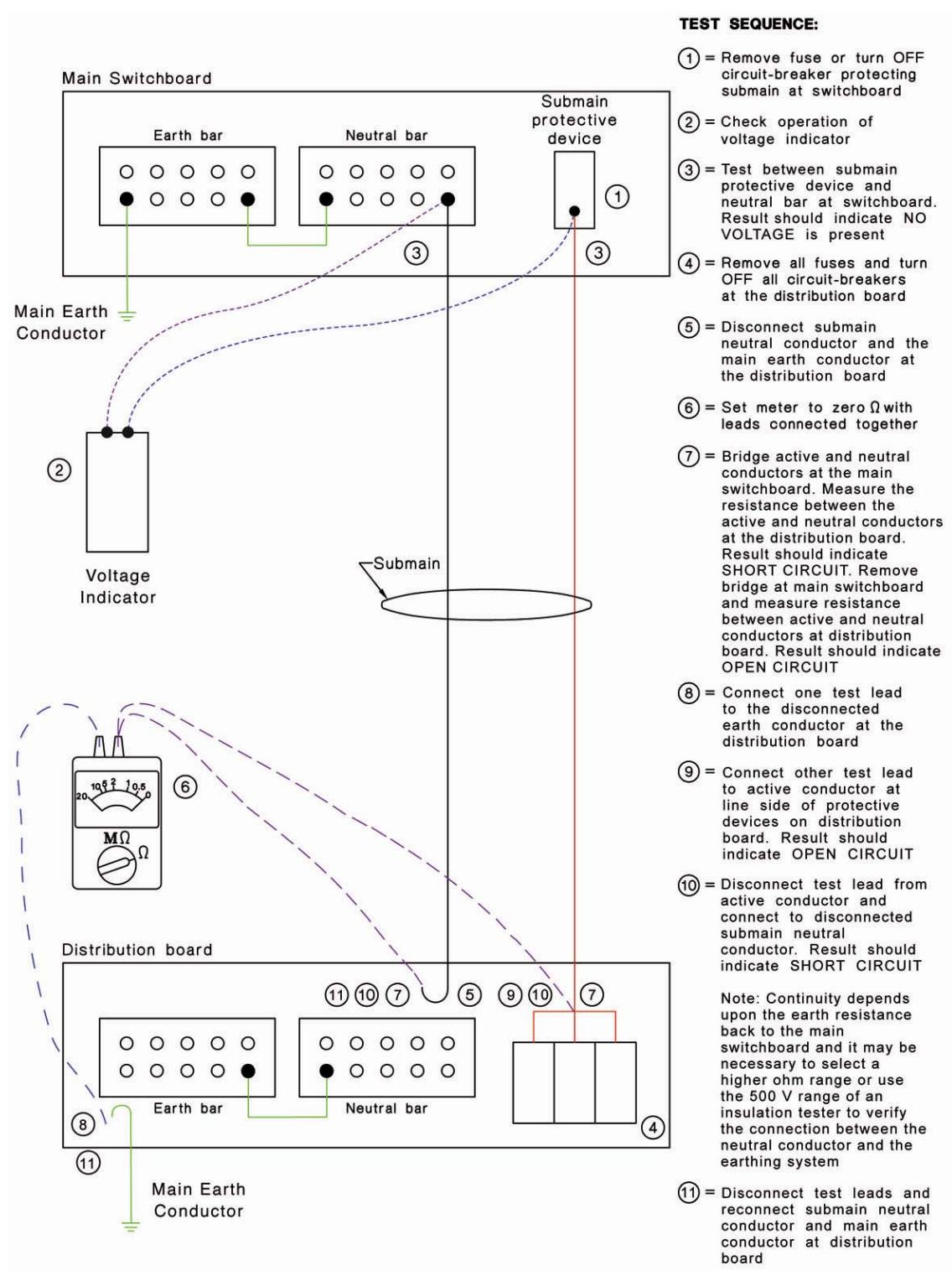
NOTE — Numbers indicate test sequence.

Figure 3.7 — Polarity test of submains incorporating an earthing conductor (supply not connected)—Method 1



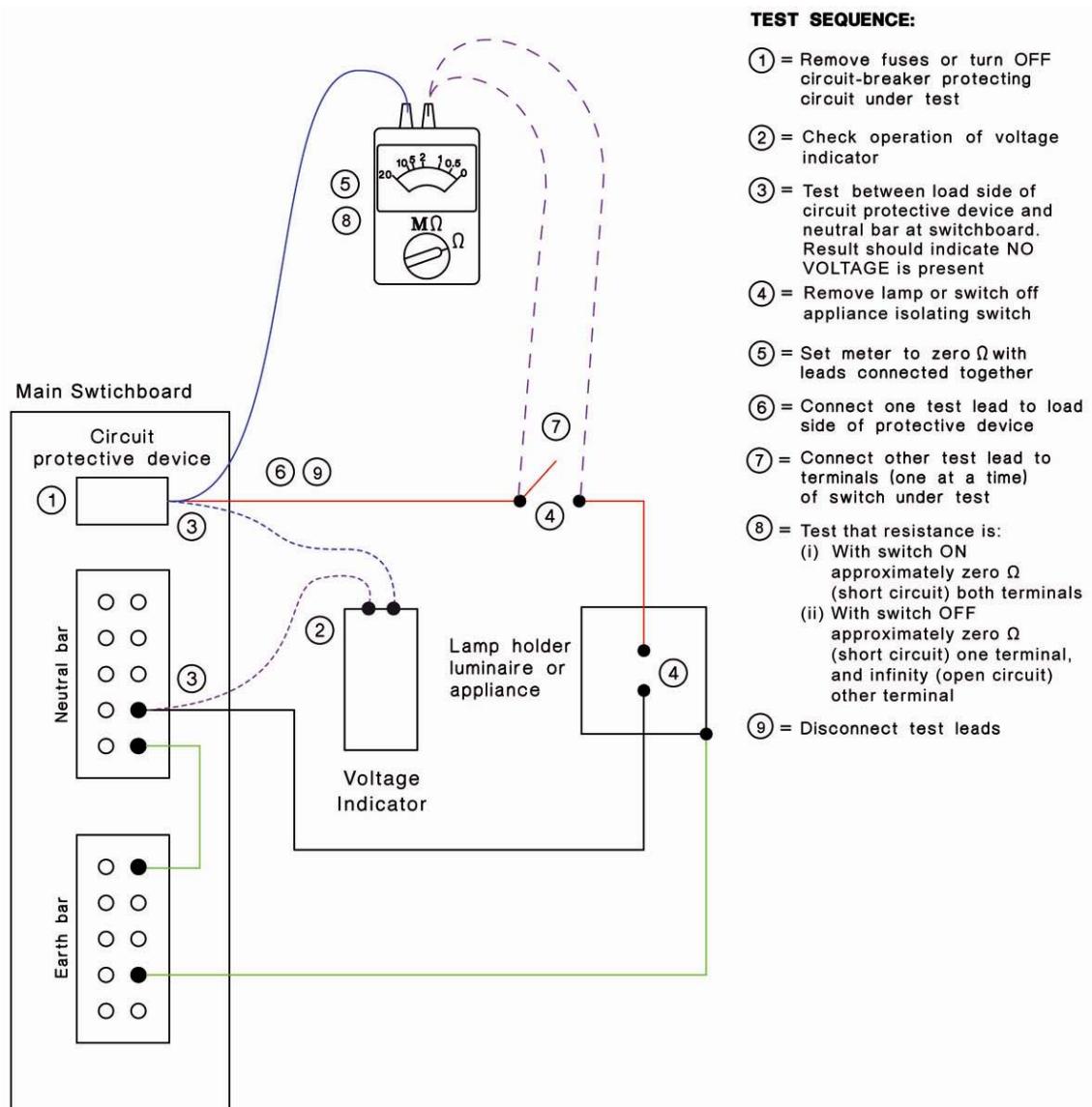
NOTE — Numbers indicate test sequence.

Figure 3.8 — Polarity test of submains incorporating an earthing conductor (supply not connected)—Method 2



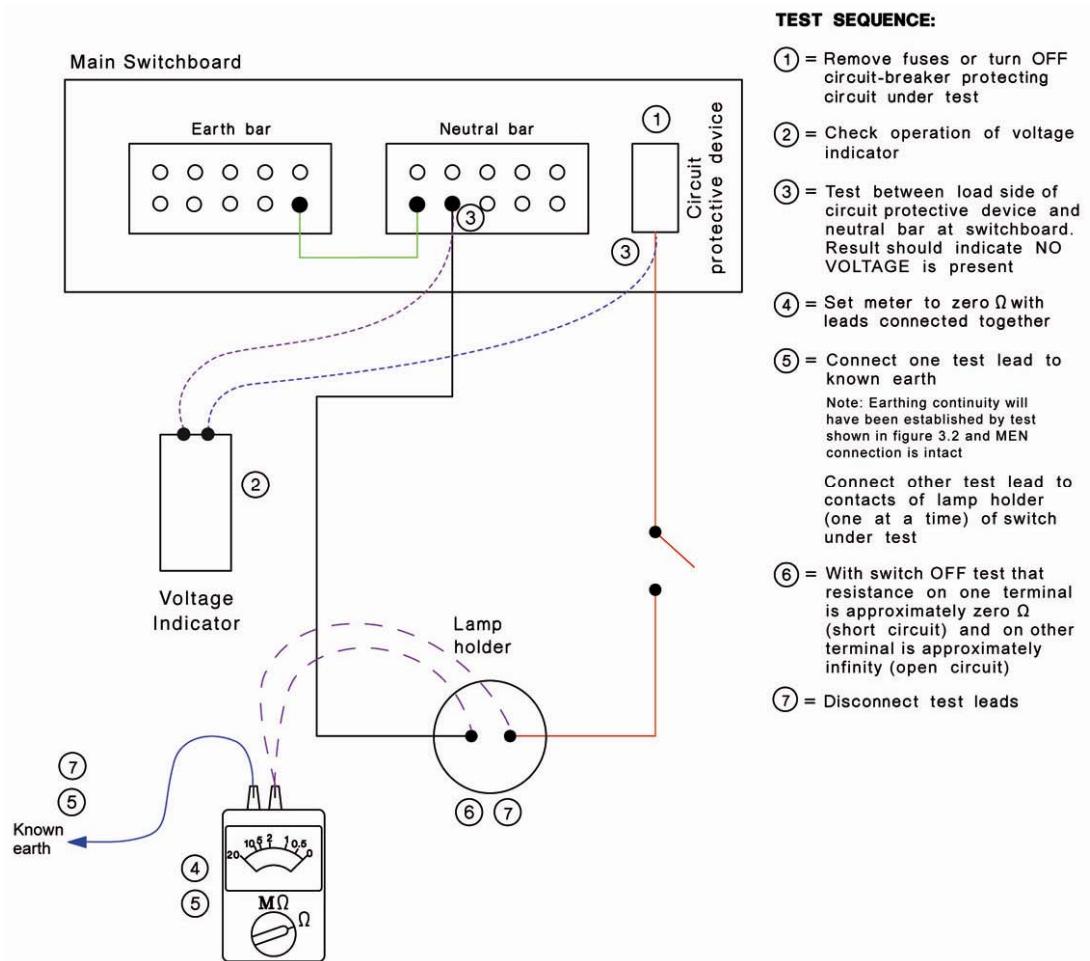
NOTE — Numbers indicate test sequence.

Figure 3.9 — Polarity test of submains not incorporating an earthing conductor (separate MEN installation) (supply not connected)



NOTE — Numbers indicate test sequence.

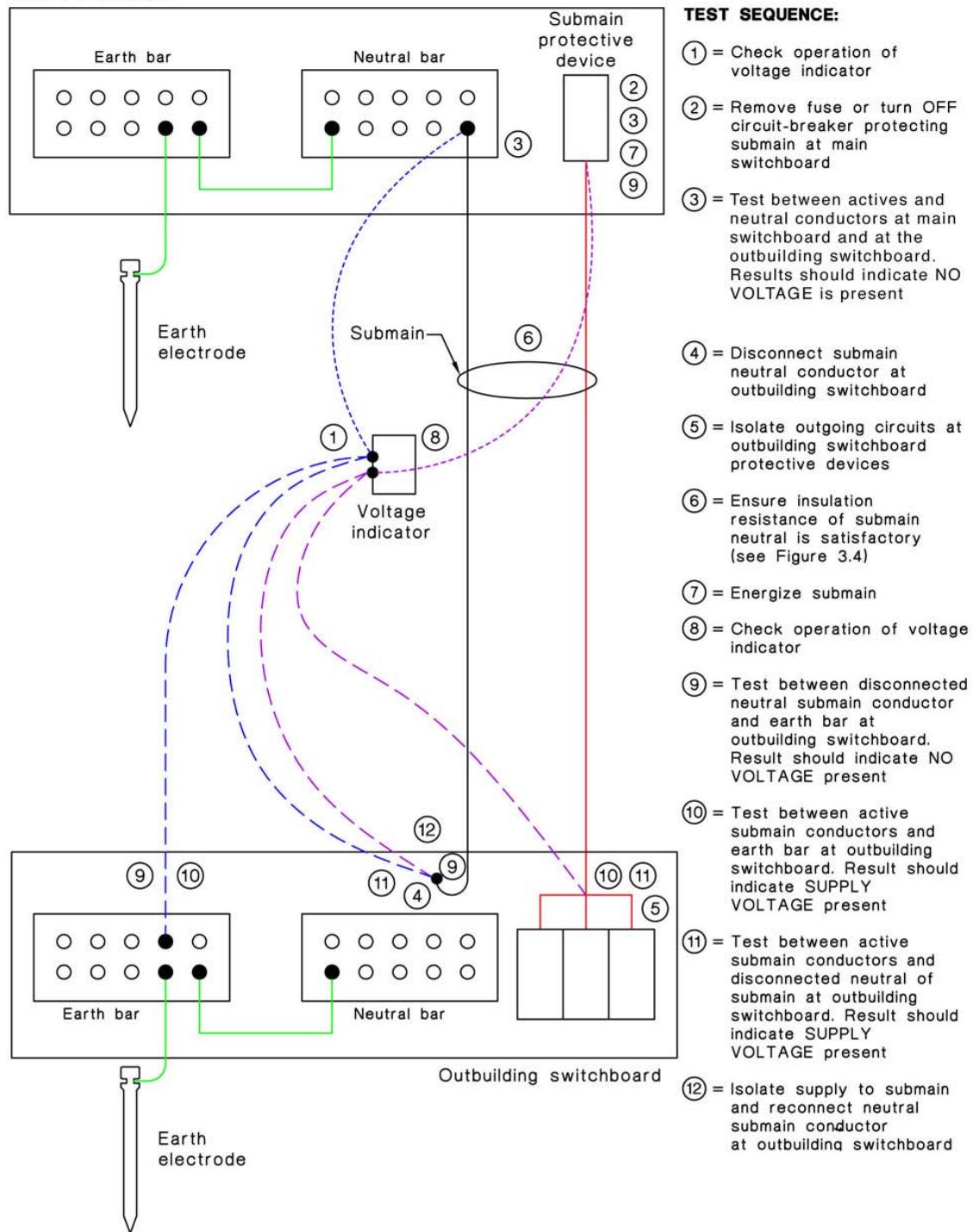
Figure 3.10 — Polarity test of single pole switch using ohmmeter (supply not connected)



NOTE — Numbers indicate test sequence.

Figure 3.11 — Alternative polarity test of single pole switch using ohmmeter (supply not connected)

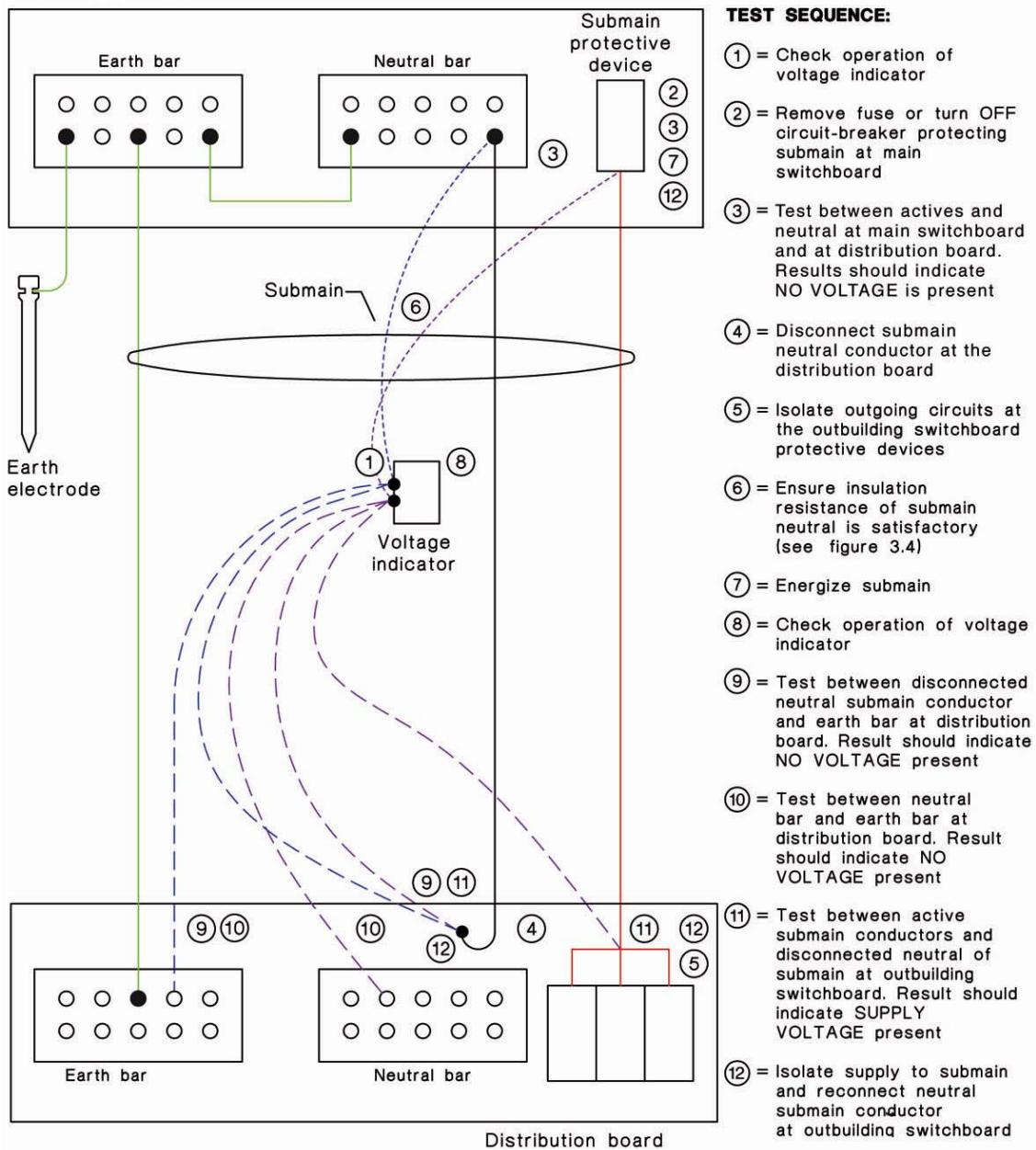
Main switchboard

**NOTE —**

- (1) Numbers indicate test sequence.
- (2) This wiring configuration uses the neutral as a PEN conductor and therefore it forms part of the earth fault-loop.
- (3) Because voltage indicators such as high impedance volt meters, neon or LED devices will operate satisfactorily with high resistances within the circuit under test, they should not be used to verify the integrity of the connections of the circuit.

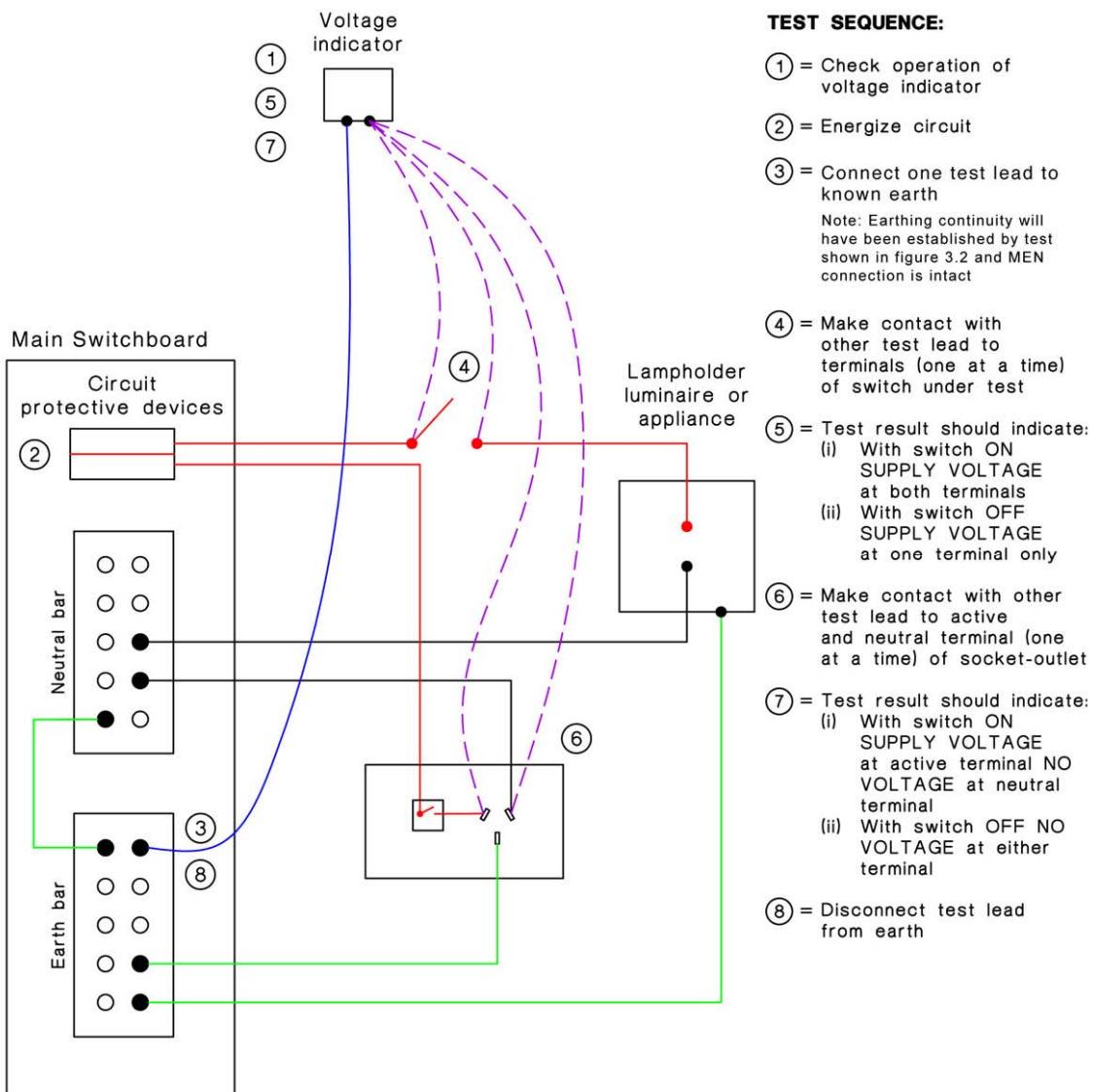
Figure 3.12 — Polarity test of submains with MEN connection at outbuilding (supply available)

Main Switchboard



NOTE — Numbers indicate test sequence.

Figure 3.13 — Polarity test of submains incorporating protective earthing conductor (supply available)



NOTE — Numbers indicate test sequence.

Figure 3.14 — Polarity test of single pole switch using voltage indicator (supply available)

3.4 CORRECT CIRCUIT CONNECTIONS

3.4.1 Objective

Tests for correct circuit connections are necessary to ensure the following:

- (a) Protective earthing conductors do not carry current in non-fault conditions; and
- (b) No short-circuit exists, because a short-circuit current flowing between live conductors and through part of the earthing system can cause considerable fire damage or personal injury, particularly in high current locations.

3.4.2 Requirements

The active, neutral and protective earthing conductors of each circuit shall be correctly connected so that:

- (a) There is no short-circuit between the conductors;
NOTE: Any MEN or earth sheath return connection is not considered as a short-circuit.
- (b) There is no transposition of conductors that could result in the earthing system and any exposed conductive parts of the electrical installation becoming energised; and
- (c) There is no interconnection of conductors between different circuits.

3.4.3 Test procedures

Testing should confirm that any resistance measured between the active and neutral conductors of a circuit is consistent with the load. For example, on a socket-outlet circuit with no connected equipment a high resistance (approximately infinity) should be expected; whereas on a 230 V, 4.8 kW water heater circuit, a resistance of about $11\ \Omega$ should be expected.

The tests illustrated in figures 3.15, 3.16, 3.17, 3.18 and 3.19 show recommended methods of testing for correct circuit connections which require the use of an ohmmeter. Some tests require the use of resistors of known values.

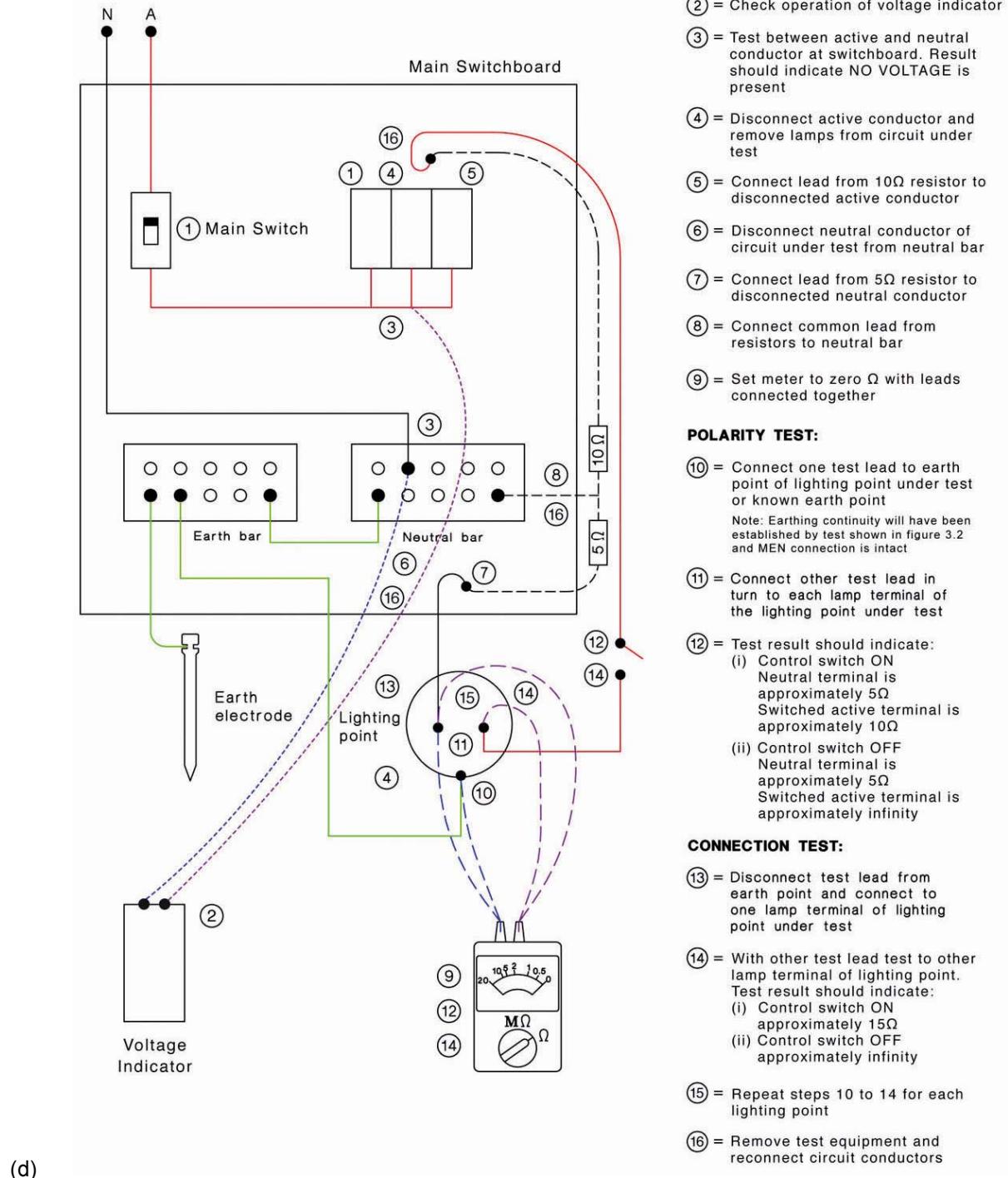
Other methods may be applied, for example:

- (a) An interconnected neutral can be detected by removing the circuit neutral at the switchboard and proving that no connection to neutral exists at the equipment;
- (b) Using a clip-on ammeter over the energized circuit conductors to verify that with all circuit equipment operating, the equivalent active load current is also passing through the correct circuit neutral; or
- (c) With only one circuit energized and equipment operational, an incorrect or interconnected active can be detected by using a voltage indicator to confirm that the load side of protective devices on other circuits are not energized from the circuit under test.

3.4.4 Testing considerations

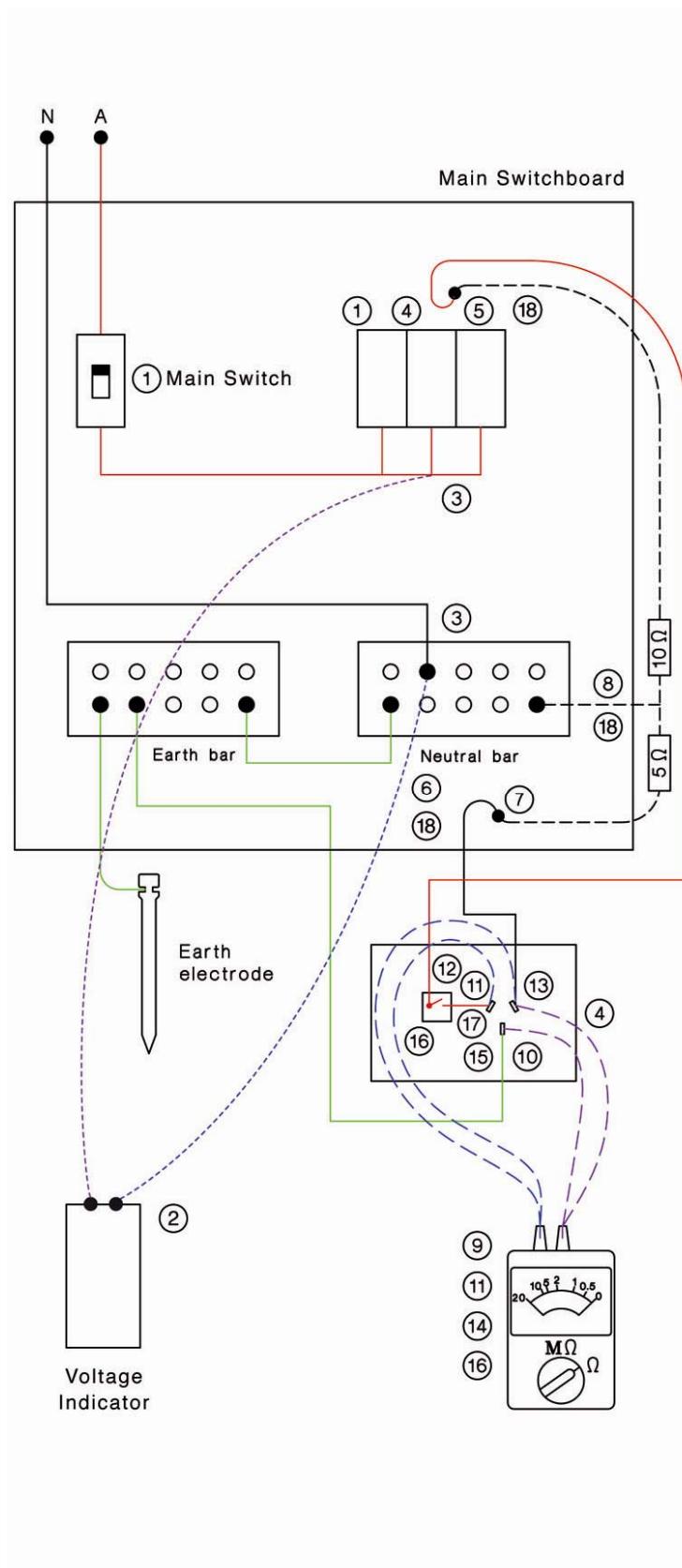
Testing considerations include the following:

- (a) Transposition of conductors is not always obvious under certain operating conditions, but is unsafe if:
 - (i) The protective earthing conductor becomes ‘open circuited’ causing one portion of the conductor and any exposed conductive parts connected to it, to become ‘live’ when there is a fault between live conductors and the portion of the protective earthing conductor isolated from the earthing system
 - (ii) The protective earthing conductor becomes overheated by carrying the load of larger neutral conductors; or
 - (iii) Work is carried out on a protective earthing conductor that has become live;
- (b) For lighting circuits, unless all two-way and intermediate switching completes the circuit, the test may not be complete because the luminaire is not in circuit; and
- (c) Where RCDs are installed, tests need to be carried out on the load side of the RCDs.



NOTE — Numbers indicate test sequence.

Figure 3.15 — Polarity and circuit connection test of lighting points using resistors (supply not connected)

**TEST SEQUENCE:**

- ① = Turn OFF main switch or remove fuse or turn OFF circuit-breaker for circuit under test
- ② = Check operation of voltage indicator
- ③ = Test between actives and neutral at switchboard. Result should indicate NO VOLTAGE is present
- ④ = Disconnect active conductor and disconnect appliances from circuit under test
- ⑤ = Connect lead from $10\ \Omega$ resistor to disconnected active conductor
- ⑥ = Disconnect neutral conductor of circuit under test from neutral bar
- ⑦ = Connect lead from $5\ \Omega$ resistor to disconnected neutral conductor
- ⑧ = Connect common lead from resistors to neutral bar
- ⑨ = Set meter to zero Ω with leads connected together

POLARITY TEST

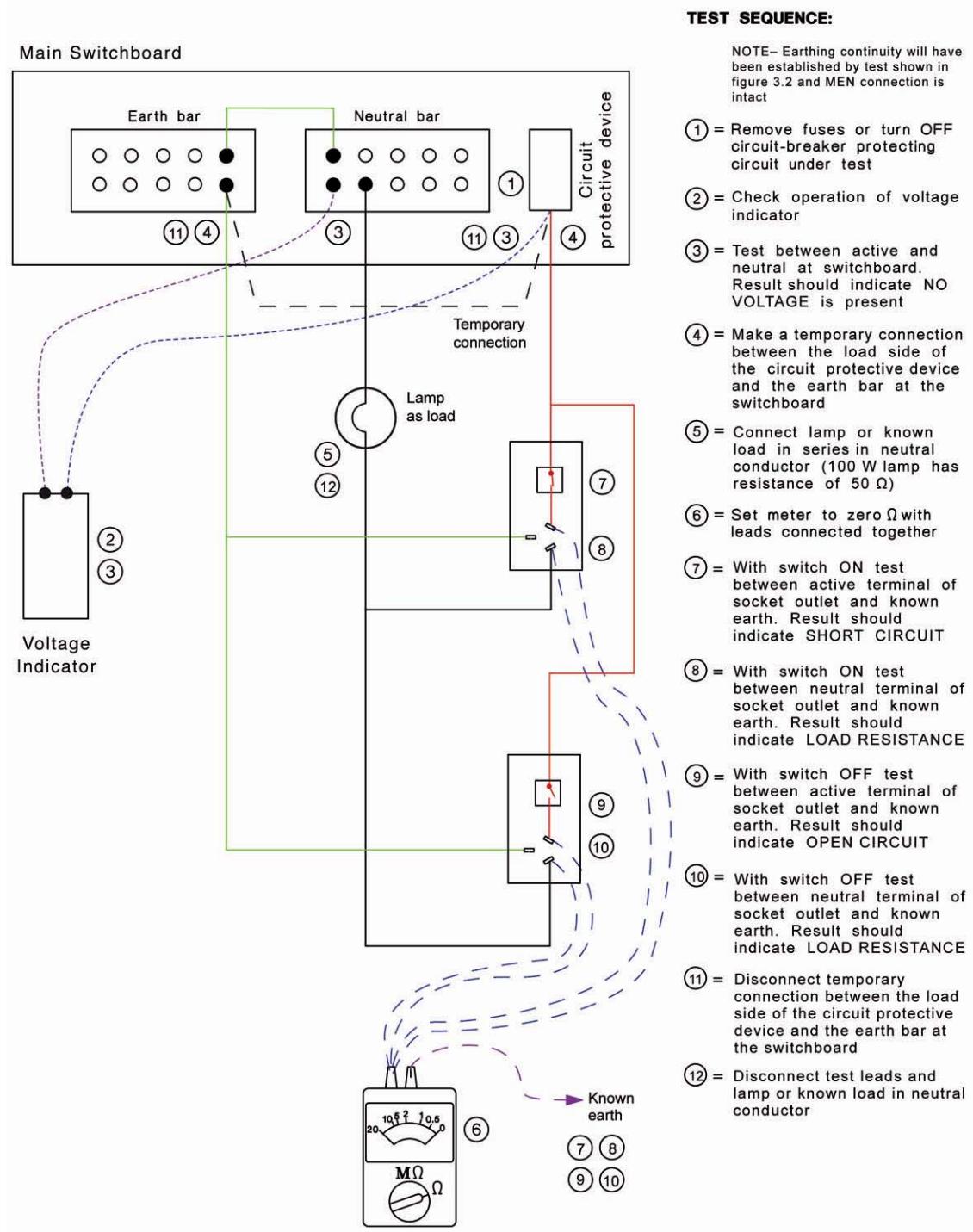
- ⑩ = Connect one test lead to earth contact of socket-outlet under test
- ⑪ = Connect other test lead to active contact of socket-outlet under test
- ⑫ = Test result should indicate:
 - (i) Control switch ON approximately $10\ \Omega$
 - (ii) Control switch OFF approximately infinity
- ⑬ = Remove test lead from active contact and connect to neutral contact of socket-outlet under test
- ⑭ = Test result should indicate: approximately $5\ \Omega$

CONNECTION TEST

- ⑮ = Remove test lead from earth contact and connect to active contact of socket-outlet under test
- ⑯ = Test result should indicate:
 - (i) Control switch ON approximately $15\ \Omega$
 - (ii) Control switch OFF approximately infinity
- ⑰ = Repeat steps 10 to 16 for each socket-outlet
- ⑱ = Remove test equipment and reconnect circuit conductors

NOTE — Numbers indicate test sequence.

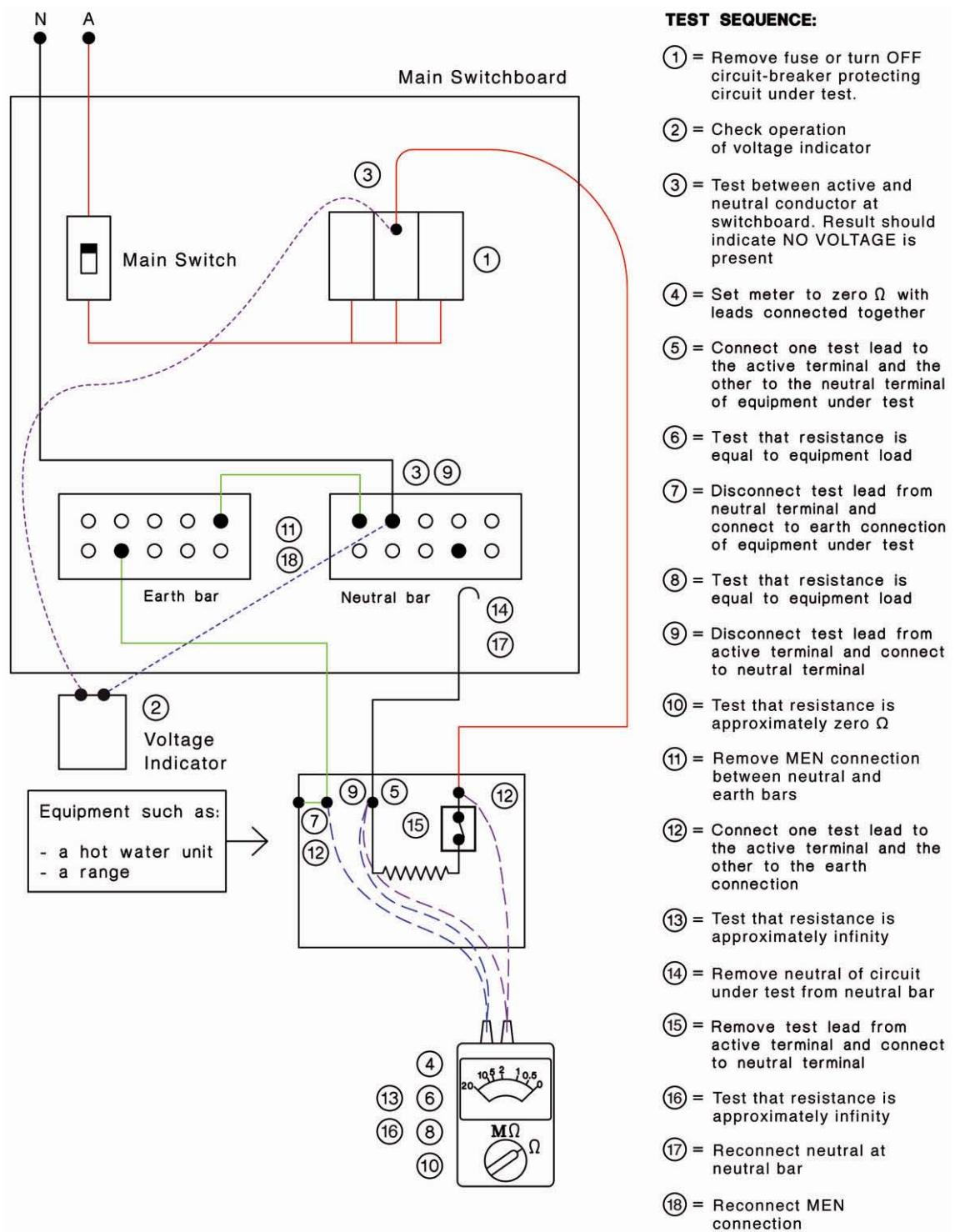
Figure 3.16 — Polarity and circuit connection test of socket-outlet subcircuits using resistors (supply not connected)

**NOTE —**

(1) Numbers indicate test sequence.

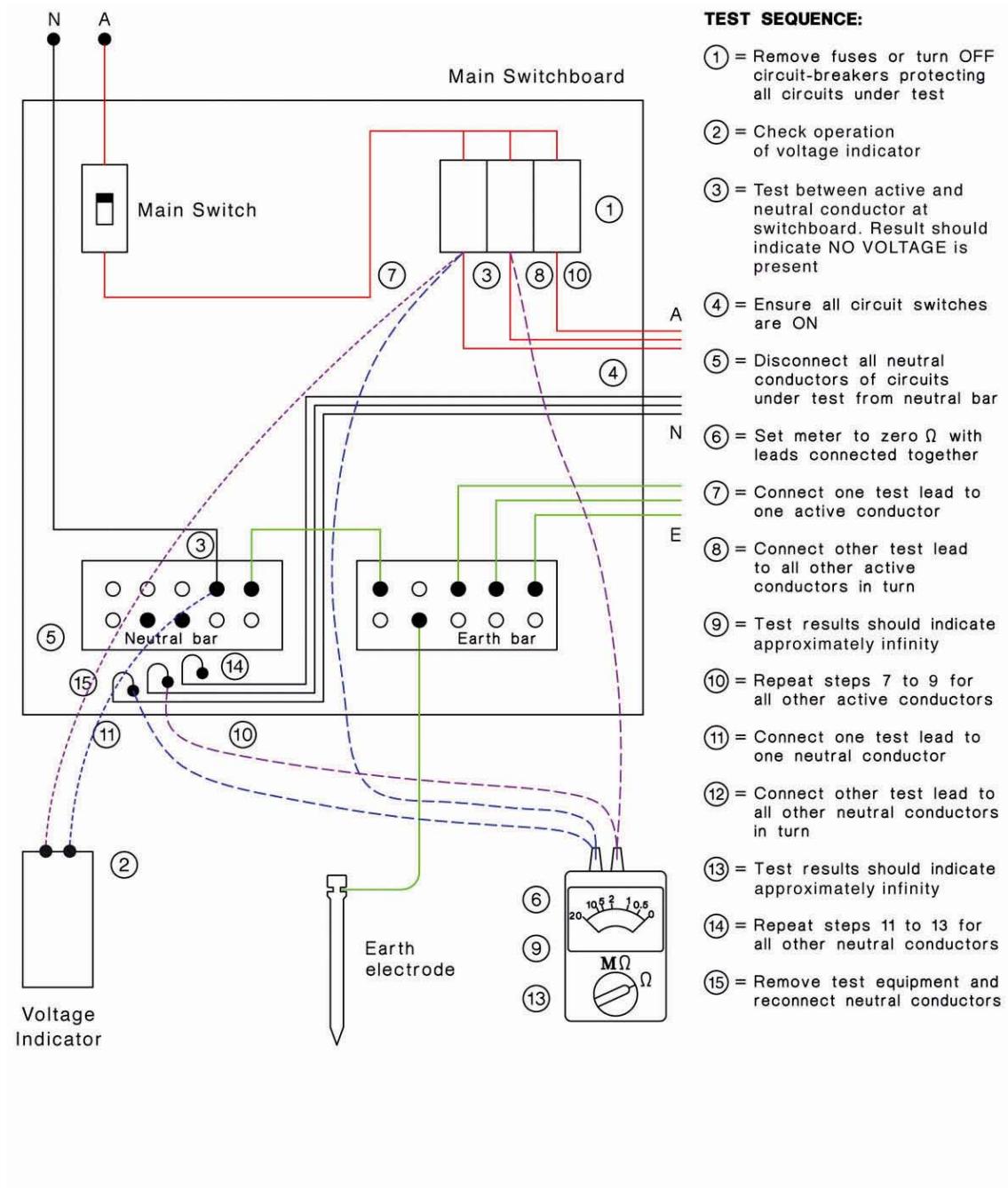
(2) This test alone would not detect an active and earth reversal.

Figure 3.17 — Polarity and circuit connection test of socket-outlet subcircuits (supply not connected)



NOTE — Numbers indicate test sequence.

Figure 3.18 — Polarity and circuit connection test of equipment (supply not connected)



NOTE — Numbers indicate test sequence.

Figure 3.19 — Interconnection test between conductors of different circuits (supply not connected)

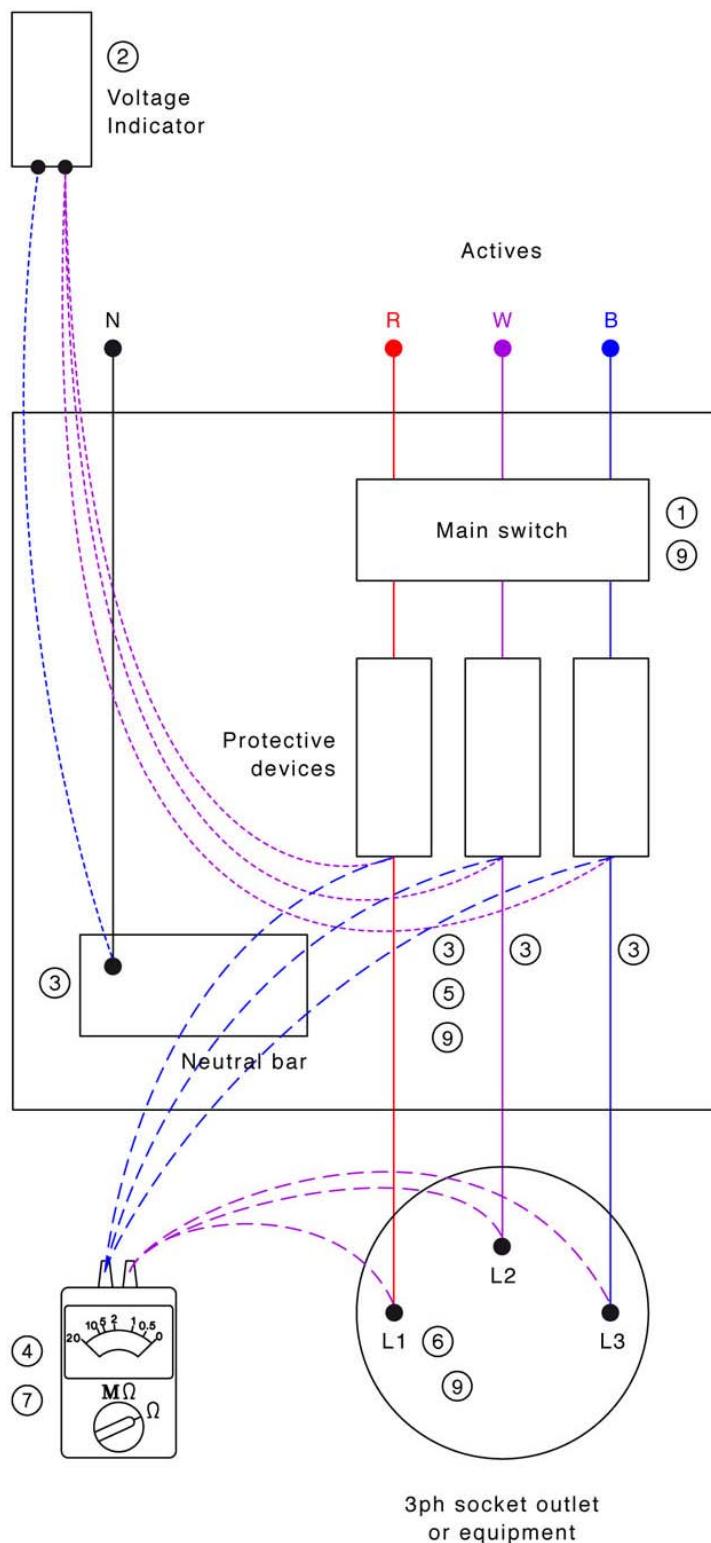
3.5 CHECK OF PHASE SEQUENCE

3.5.1 Objective

Phase sequence testing is necessary to ensure that multi-phase equipment such as multi-phase motors and semiconductor controlled equipment operates in a predictable manner.

3.5.2 Test procedure

If supply is available use a phase sequence tester in accordance with the manufacturer's instructions.
If supply is not available test as shown in figure 3.20.

**TEST SEQUENCE:**

- ① = Turn main switch OFF
- ② = Check operation of voltage indicator
- ③ = Test between actives and neutral. Result should indicate NO VOLTAGE is present
- ④ = Set meter to zero Ω with leads connected together
- ⑤ = Connect test lead to load side of red phase protective device
- ⑥ = Connect other test lead to L1 contact on 3ph socket outlet on equipment
- ⑦ = Result should indicate short circuit
- ⑧ = Repeat 5 - 7 for white and blue phases to L2 and L3 respectively
- ⑨ = Disconnect test leads and turn main switch ON

NOTE —

- (1) Repeat test for each multiphase outlet to confirm the sequence is the same for each.
- (2) Numbers indicate test sequence.

Figure 3.20 — Check of phase sequence (supply not connected)

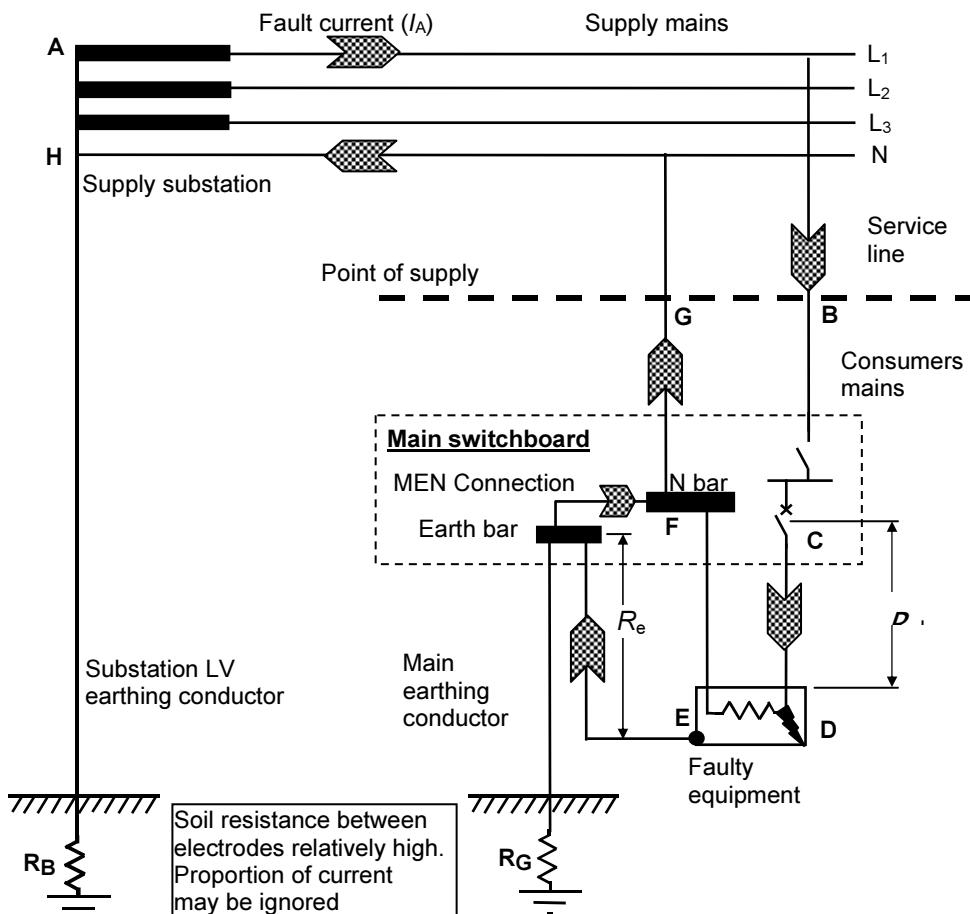
3.6 EARTH FAULT-LOOP IMPEDANCE

3.6.1 Objective

The earth fault-loop impedance of a circuit is measured to ensure that, if a fault of negligible impedance occurs between an active conductor and a protective earthing conductor or an exposed conductive part, sufficient current will flow in the earth fault-loop to cause a protective device to operate within a specified disconnection time.

NOTE —

- (1) See figure 3.21 for a simplified earth fault-loop.
- (2) The earth fault-loop impedance test can be made as follows:
 - (a) With supply connected (see 3.6.4.1); or
 - (b) With supply not connected (see 3.6.4.2).
- (3) An earth fault-loop impedance tester functions by measuring voltage drop during a short duration fault, applied by a function of the tester, and can only be used with the supply connected.
- (4) Additional information on earth fault-loop impedance can be found in AS/NZS 3000.



NOTE —

- (1) Resistance values for R_e and R_{ph} are given in table 3.2.
- (2) Although supply from a distribution system is shown, the same principle applies where the substation forms part of the electrical installation.

Figure 3.21 — MEN system (simplified) showing fault current (I_a) path

3.6.2 Earth fault-loop

The earth fault-loop in a MEN system comprises the following parts, starting and ending at the point of fault (see figure 3.21):

- (a) The protective earthing conductor including the main earthing terminal/connection or bar and MEN connection;
- (b) The neutral-return path, consisting of the neutral conductor, (N), between the main neutral terminal or bar and the neutral point at the transformer (the earth return path R_G to R_B has a relatively high resistance and may be ignored in an MEN system);
- (c) The path through the neutral point of the transformer and the transformer winding; and
- (d) The active conductor as far as the point of the fault.

The earth fault-loop is normally regarded as consisting of the following two parts:

- (e) Conductors upstream or "external" to the reference point; and
- (f) Conductors downstream or "internal" to the circuit, from the reference point.

Figure 3.21 shows an active to earth fault, which for the purposes of calculations is deemed to be of negligible impedance.

At the instant of the fault, current will flow through the earth fault-loop and its magnitude is only limited by the total system impedance Z_s that is obtained from all the individual impedances in the earth fault-loop as follows:

$$Z_s = Z_{AB} + Z_{BC} + Z_{CD} + Z_{DE} + Z_{EF} + Z_{FG} + Z_{GH} + Z_{HA}$$

In figure 3.21 impedances Z_{AB} , Z_{BC} , Z_{FG} , Z_{GH} and Z_{HA} are all upstream of the protective device within the electrical installation under consideration and are regarded as being external to the reference point. Hence they may be collectively referred to as Z_{ext} . The remainder that are downstream from the reference point (or "internal") may be referred to as Z_{int} . Therefore $Z_s = Z_{ext} + Z_{int}$.

3.6.3 Requirements

3.6.3.1 Supply connected

Maximum values of earth fault-loop impedance shall not exceed the values shown in table 3.1 or the value of I_a for the protective device being used in accordance with the manufacturer's data.

The values of Z_s in table 3.1 were calculated using the following equation:

$$Z_s = \frac{U_o}{I_a}$$

Where:

- Z_s = earth fault-loop impedance
- U_o = nominal phase voltage (230 V)
- I_a = current causing automatic operation of the protective device, as follows:
 - I_a for circuit-breakers is the mean tripping current as follows:
 - Type B = 4 times rated current
 - Type C = 7.5 times rated current
 - Type D = 12.5 times rated current
 - I_a for fuses are approximate mean values from AS 60269.1.

Table 3.1 Maximum values of earth fault-loop impedance (Z_s) at 230 V a.c.

Protective device rating A	Circuit-breakers			Fuses	
	Type B	Type C	Type D		
	Disconnection times				
0.4 s			0.4 s	5 s	
Maximum earth fault-loop impedance Z_s Ω					
6	9.58	5.11	3.07	11.50	15.33
10	5.75	3.07	1.84	6.39	9.20
16	3.59	1.92	1.15	3.07	5.00
20	2.88	1.53	0.92	2.09	3.59
25	2.30	1.23	0.74	1.64	2.71
32	1.80	0.96	0.58	1.28	2.19
40	1.44	0.77	0.46	0.96	1.64
50	1.15	0.61	0.37	0.72	1.28
63	0.91	0.49	0.29	0.55	0.94
80	0.72	0.38	0.23	0.38	0.68
100	0.58	0.31	0.18	0.27	0.48
125	0.46	0.25	0.15	0.21	0.43
160	0.36	0.19	0.12	0.16	0.30
200	0.29	0.15	0.09	0.13	0.23

NOTE —

- (1) The impedance values are based on a normal operating temperature of 75 °C for the conductors when they are carrying maximum current. If there is no load on the electrical installation being tested, the values are reduced to 80% (based on a conductor temperature of 20 °C).
- (2) The types of circuit breakers (Type B, C and D) are based on the types described in AS/NZS 60898.1.
- (3) Fuses based on AS 60269.1 were previously known as BS 88 type fuses.
- (4) When the nominal phase voltage of the electrical installation is not 230 V, Z_s may be determined by multiplying by a factor of $U_o/230$. For a nominal phase voltage of 240 V, the factor would be ≈ 1.04.
- (5) Five second disconnection times are not shown for circuit breakers as they are intended to operate in the instantaneous trip zone.

3.6.3.2 Supply not connected

When tested in accordance with 3.6.4.2, the total resistance (R_{phe}) of the active and protective earthing conductors of an individual circuit which forms part of the earth fault-loop shall not exceed the values shown in table 3.2.

The values in table 3.2 were calculated using the d.c. resistance values for conductors at 20 °C as specified in AS/NZS 1125 and the maximum lengths of circuits given in table B1 of AS/NZS 3000.

Table 3.2 Maximum values of resistances

Conductor size		Protective device rating	Circuit breaker								Fuses			
Active	Earth		Type B			Type C			Type D					
mm^2	mm^2	A	Maximum resistances											
			R_{phe}	R_{ph}	R_e	R_{phe}	R_{ph}	R_e	R_{phe}	R_{ph}	R_e	R_{phe}	R_{ph}	R_e
1	1	6	6.16	3.08	3.08	3.30	1.65	1.65	2.00	1.00	1.00	7.38	3.69	3.69
1	1	10	3.70	1.85	1.85	2.00	1.00	1.00	1.20	0.60	0.60	4.12	2.06	2.06
1.5	1.5	10	3.70	1.85	1.85	2.00	1.00	1.00	1.20	0.60	0.60	4.12	2.06	2.06
1.5	1.5	16	2.32	1.16	1.16	1.24	0.62	0.62	0.76	0.38	0.38	2.00	1.00	1.00
2.5	2.5	16	2.32	1.16	1.16	1.24	0.62	0.62	0.74	0.37	0.37	2.00	1.00	1.00
2.5	2.5	20	1.86	0.93	0.93	1.00	0.50	0.50	0.60	0.30	0.30	1.36	0.68	0.68
4	2.5	25	1.50	0.43	1.07	0.80	0.23	0.57	0.48	0.14	0.34	1.00	0.24	0.76
4	2.5	32	1.17	0.45	0.72	0.62	0.24	0.38	0.37	0.14	0.23	0.83	0.32	0.51
6	2.5	40	0.93	0.27	0.66	0.50	0.15	0.35	0.30	0.09	0.21	0.62	0.18	0.44
10	4	50	0.76	0.22	0.54	0.40	0.11	0.29	0.24	0.07	0.17	0.47	0.13	0.34
16	6	63	0.60	0.16	0.44	0.32	0.09	0.23	0.19	0.05	0.14	0.36	0.10	0.26

NOTE —

- (1) The values, which have been rounded to two decimal places, are approximately 64% of the values given in table 3.1. This is due to the following:
 - (a) A reduction to 80% (0.8) due to a conductor temperature of 20 °C; and
 - (b) A further reduction as the length of circuits given in table B1 of AS/NZS 3000 was calculated using 80% (0.8) of supply voltage.
 Therefore $0.8 \times 0.8 = 0.64$ (64%).
- (2) Resistances for active conductors (R_{ph}) and protective earthing conductors (R_e) are also provided.
- (3) The types of circuit breakers (Type B, C and D) are based on the types described in AS/NZS 60898
- (4) Fuses based on AS 60269.1 were previously known as BS 88 type fuses.
- (5) When the nominal phase voltage of the electrical installation is not 230 V, Z_s may be determined by multiplying by a factor of $U_o/230$. For a nominal phase voltage of 240 V, the factor would be ≈ 1.04 .

3.6.4 Testing considerations

3.6.4.1 Supply connected

The earth fault-loop impedance should be measured using an instrument that has a facility for measuring and indicating low values of impedance.

NOTE —

- (1) Special training and advice should be obtained for measurement of earth fault-loop impedance on circuits from a supply source rated over 100 A. For example, readings of less than 0.2 Ω require system voltage to be constant (i.e. no cyclic load on the installation) and may require test lead length and fusing compensation and higher test currents.
- Guidance is given in IEC 61557-3.
- (2) Earth continuity and resistance tests should be carried out on protective earthing conductors in accordance with 3.1 before measuring the earth fault-loop impedance.
- (3) It is preferable to measure the earth fault-loop impedance using the permanent network supply rather than a temporary supply.
- (4) The measuring circuit includes the impedance of the flexible test lead, which must be as supplied with the meter. If the meter leads are fused, the fuse resistance must be taken into account.

The MEN connection is to be left intact.

Measurements for a final subcircuit should be made with the instrument connected between the furthest point on the active conductor and the corresponding point on the associated protective earthing conductor, for example, at a socket-outlet.

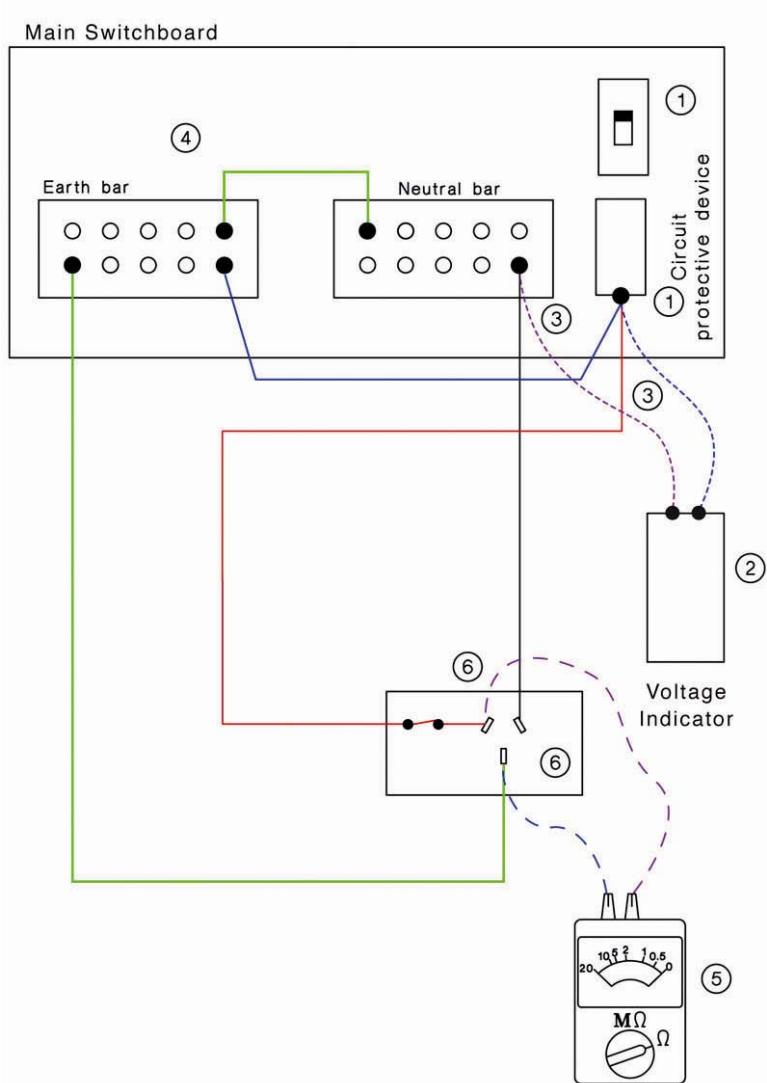
NOTE —

- (5) This test provides the maximum value of Z_s for the complete circuit. Typical maximum values of Z_s are given in table 3.1.
- (6) If an RCD operates during the earth fault-loop impedance test, the test result is considered satisfactory.

3.6.4.2 Supply not connected

When the supply is not connected the resistance of the conductors of an individual circuit which forms part of the earth fault-loop may be measured by an ohmmeter as follows:

- (a) Connect the active conductor and protective earthing conductor together at the origin of the particular circuit (normally where the protective device is fitted). See figure 3.22;
- (b) At the furthermost point on the circuit, connect one lead of the ohmmeter to the active conductor and the other lead to the associated protective earthing conductor; and
- (c) The measured value of resistance (R_{phe}) shall not exceed the values in table 3.2 for the appropriate conductors and protective device.

**TEST SEQUENCE:**

- ① = Turn OFF main switch or remove fuse or turn OFF circuit breaker
- ② = Check operation of voltage indicator
- ③ = Test between active and neutral at switchboard. Result should indicate NO VOLTAGE is present
- ④ = Make a temporary connection between the load side of the circuit protective device and the earth bar at the switchboard
- ⑤ = Set meter to zero Ω with leads connected together
- ⑥ = At furthest point on circuit test between active and earth contacts. Result should indicate that the resistance does not exceed the R_{phe} value in table 3.2

NOTE — Numbers indicate test sequence.

Figure 3.22 — Measurement of an individual circuit earth fault-loop impedance (supply not connected)

3.7 OPERATION OF RESIDUAL CURRENT DEVICES (RCDs)

3.7.1 Objective

Testing of an RCD is carried out to ensure that the RCD operates and disconnects the designated circuit.

The function of the RCD is verified by the operation of the integral test device, or by the use of special test equipment.

For New Zealand, RCDs shall be of a type where tripping is ensured for residual alternating current and residual pulsating direct current (Type A).

3.7.2 Requirements

3.7.2.1 Testing by use of the integral test device

Operation of the integral test device shall cause the RCD to trip and disconnect the designated circuit.

NOTE —

- (1) Tripping the RCD by means of the integral test device establishes:
 - (a) That the RCD is functioning correctly; and
 - (b) The integrity of the electrical and mechanical elements of the tripping device.
- (2) Operation of the integral test device does not provide a means of checking:
 - (a) The continuity of the main earthing conductor or the associated circuit protective earthing conductors;
 - (b) Any earth electrode or other means of earthing; or
 - (c) Any other part of the associated electrical installation earthing.
- (3) Tripping the RCD by means of the integral test device, or by special test equipment such as a test plug with a resistor between the active and earth pins, may be used to verify that the circuits required to be protected by the RCD are protected.

3.7.2.2 Testing by special test equipment

The RCD tester shall apply the rated tripping current $\pm 5\%$ and measure the tripping time with an accuracy dependent on the nominal tripping time as follows:

Type of RCD	Residual tripping current $I_{\Delta n}$	Maximum Tripping Time	Accuracy
1	$\leq 10\text{mA}$	40 ms	$\pm 2\text{ ms}$
General	Any value	300 ms	$\pm 8\text{ ms}$

A current, equal to the rated tripping current, shall be "suddenly" applied between the active and protective earth and the operating time measured.

WARNING. Extreme care is needed to ensure that this test can be and is carried out safely. Be aware that this test may cause a rise in voltage to earth on other exposed metal. Testing for earth continuity in accordance with 3.1 shall be carried out prior to this test.

NOTE —

- (1) Some RCDs may have a different result (approximately 10 milliseconds) depending on which point on the wave the test is initiated. In case of doubt, the operating time at both 0° and 180° should be tested.
- (2) Load leakage and stored energy can affect the result and increase the meter trip time indication. In case of doubt, all loads on the circuit should be disconnected.
- (3) Tests on three- or four-pole RCDs, used on a three phase supply, shall be tested with a three phase supply connected. The tests shall be carried out individually on each phase in turn with all load and neutral connections disconnected, as any standing leakage current on the load side may add or subtract vectorially from the test current.
- (4) The possible wave form of a fault current to earth can affect the operation of an RCD and RCD test equipment.

Where the source of supply is other than smooth sinusoidal, such as an inverter, the advice of the manufacturer of the RCD tester should be sought. Further information is contained in AS/NZS 3000.

- (5) When testing a circuit, RCD testers do not provide a means of checking:
- (i) The continuity of the main earthing conductor
 - (ii) Any earth electrode or other means of earthing, or
 - (iii) Any other part of the associated electrical installation earthing other than the circuit under test.

3.7.2.3 Confirmation of RCD type

For New Zealand the RCD shall be verified as being Type A by the presence of the symbol  or by the manufacturer's compliance documentation.

3.8 METHOD FOR MEASUREMENT OF THE RESISTANCE OF THE EARTH ELECTRODE

3.8.1 Objective

To specify methods for measuring resistances to ground which are related to various parts of the installation. Typical values are included in the test clauses.

NOTE —

- (1) The MEN system has a multiplicity of neutral earthing electrodes and an earth electrode at each installation. The distribution neutral earth electrodes give the system ground resistance.
- (2) The installation earth electrode is connected to the installation exposed conductive parts. Exposed conductive parts are in contact, via bonding or fortuitously, with other grounded parts such as water pipes. Bonding minimises the touch voltage between exposed conductive parts of the installation and grounded conductive parts.
- (3) The installation MEN connection connects the earth electrode to the supply neutral. As the supply neutral also acts as a return path for earth fault currents it is a Protective Earth and Neutral (PEN).
- (4) This system of bonding and earthing should minimise the touch voltage from the exposed conductive parts to ground during normal operation. However, if the supply neutral (PEN) is disconnected the path through the ground is the only path. The touch voltage to ground is then dependent on the resistance of the paths to ground in series with the load resistance and the current flowing.
- (5) Similarly, if the supply neutral (PEN) is high resistance, the touch voltage depends on the ground paths in parallel with the neutral (PEN). On single phase installations this current is the same as the active current; on three phase installations the neutral current is the vector sum of the active currents.
- (6) During a fault the fault current should return to the transformer via the neutral (PEN) and operate the overcurrent or RCD protection. If the neutral is open circuit or high resistance, the voltages to neutral will be unbalanced and a voltage will exist from neutral (PEN) to the exposed conductive parts and ground, and current may flow in water pipes and voltages may exist across disconnected pipes. In the event of an open or high resistance neutral, a single earth electrode cannot be relied upon to provide a low resistance path sufficient to operate the protective devices

3.8.2 Requirements

AS/NZS 3000 does not specify a maximum value for the resistance of the earth electrode. However, when the earth resistance is required to be measured any of the procedures in 3.8.3 may be used.

3.8.3 Test procedures

3.8.3.1 Test using an earth fault-loop impedance meter

The approximate earth electrode resistance may be obtained by the use of a proprietary earth fault-loop impedance meter.

With the MEN connection removed, measure the 'ground loop without PEN' impedance by connecting an earth fault-loop impedance meter between the incoming active supply (for example, at the main switch) and the main earth.

The 'ground loop without PEN' impedance includes the installation ground resistance (the earth electrode in parallel with any bonding to grounded exposed conductive parts) in series with the distribution system ground resistance to the PEN, the transformer impedance and the active conductor impedance.

The approximate value obtained by the use of a proprietary earth fault-loop impedance meter is typically in the order of $10\ \Omega$ to $50\ \Omega$ in good soil conditions with non-metallic water pipes.

NOTE — This test could be carried out in conjunction with the test in 3.10.2.1

WARNING. As this test procedure removes the parallel connection between the earthing system and the supply neutral, ensure there is no current flowing in the MEN connection before removing it.

3.8.3.2 Test of the resistance to ground of the installation earth electrode using the 'fall of potential method'

When using this method, a proprietary meter, or the method in figure 3.23, may be used.

NOTE — IEC 61557-5 specifies that the meter shall have a maximum output voltage of 50 V and a maximum current of 3.5 mA.

When using the test in figure 3.23, if the three readings obtained in sequences 8 and 10 are

substantially the same, the electrode resistance is the mean of the three values. If the readings are not substantially the same, the test should be repeated with the distance between T and T₁ increased.

The approximate value obtained by the use of a proprietary meter is typically in the order of 50 Ω to 200 Ω in good soil conditions.

WARNING. Extreme care is needed to ensure that this test can be and is carried out safely. Be aware that this test may cause the touch voltage of extraneous, exposed, conductive parts of the installation to rise.

3.8.3.3 Test using an earth ground clamp meter

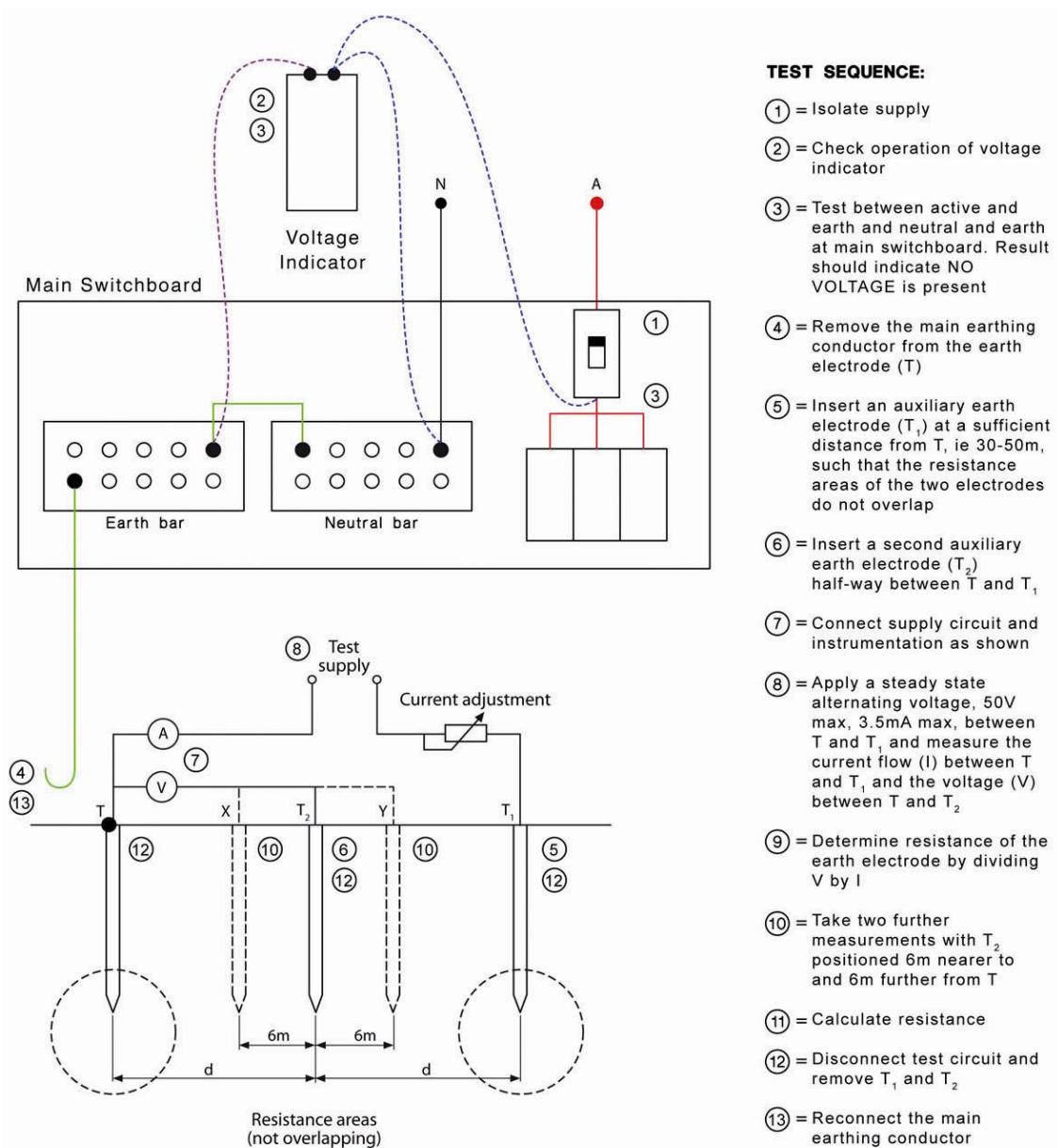
A proprietary earth ground clamp meter may be used to measure the loop impedance of the earth electrode.

NOTE — The meter measures the loop impedance by inducing a voltage into the circuit and measuring the corresponding current within the loop.

Measure the 'ground loop to PEN' impedance by placing the jaws of the ground clamp meter around the electrode or the main earth conductor connected to it.

The 'ground loop to PEN' impedance includes the installation ground resistance (the earth electrode in parallel with any bonding to grounded exposed conductive parts), to the PEN (via the system neutral earth resistances) but excludes the transformer impedance and the active conductor impedance.

The approximate value obtained by the use of a proprietary meter is typically in the order of 10 Ω to 50 Ω in good soil conditions.



NOTE — Numbers indicate test sequence.

Figure 3.23 — Measurement of the resistance of the earth electrode

3.9 MEASUREMENT OF TOUCH VOLTAGE

3.9.1 Objective

When an item of electrical equipment is suspected of causing an electric shock, touch voltage tests are performed to ensure that shock currents resulting from contact between exposed metal of the electrical equipment and extraneous conductive parts do not exceed the IEC shock current limits specified in AS/NZS 60479-1. In the case of earthed equipment, the touch voltage between the earthed metal of the electrical equipment and an item of equipment earthed through another earthing conductor is usually the voltage drop along the protective earthing conductor (See figure 3.24).

In the case of Class II (double insulated) equipment containing switch mode power supplies, the touch voltage between the extraneous metal of the electrical equipment and either earthed metallic equipment or extraneous conductive parts may be due to capacitive coupling.

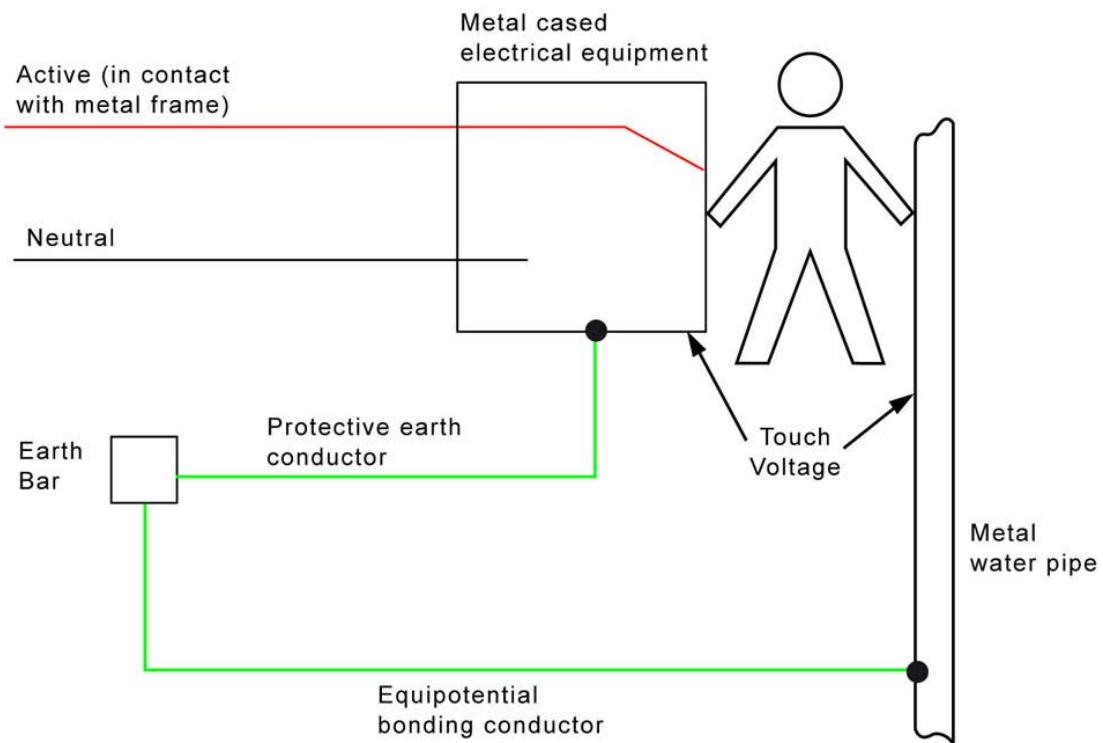


Figure 3.24 — Example of touch voltage

3.9.2 Requirement

The severity of an electric shock is dependent, among other factors, on the magnitude of the voltage across the human body, or part thereof, and the time it is present.

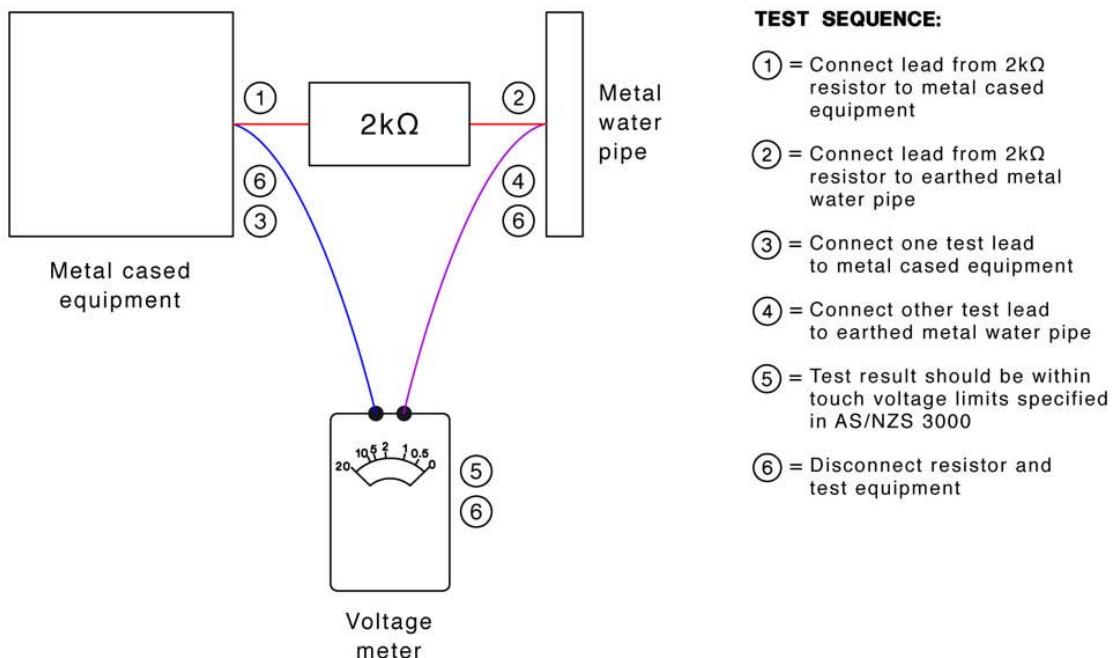
The touch voltage shall not exceed the values specified in AS/NZS 3000.

NOTE — The touch voltages specified in AS/NZS 3000, dependent on environmental conditions, are:

- (a) 50 V a.c. or 120 V ripple free d.c.;
- (b) 25 V a.c. or 60 V ripple free d.c.;
- (c) 12 V a.c. or 30 V ripple free d.c.; and
- (d) 6 V a.c. or 15 V ripple free d.c.

3.9.3 Test procedures

The test procedure for measurement of touch voltage is shown in figure 3.25. A high impedance voltmeter, i.e. an input impedance greater than $5\text{ M}\Omega$, must be used.



NOTE —

- (1) A $2\text{k}\Omega$ resistor is used to simulate the body resistance of a typical person.
- (2) Numbers indicate test sequence.
- (3) The $2\text{k}\Omega$ resistor is a simplified version of the circuits shown in AS/NZS 60990.

Figure 3.25 — Measurement of touch voltage

3.10 TEST FOR CONTINUITY AND RESISTANCE OF THE INCOMING NEUTRAL

3.10.1 Objective

To ensure the incoming neutral [PEN] connections are of low resistance so that fault protective devices operate correctly and touch voltages are minimised.

3.10.2 Test procedures

3.10.2.1 Test using an earth fault-loop impedance meter

The incoming neutral can be tested by using a proprietary earth fault-loop impedance tester as follows:

- (a) Turn all main switches OFF;
- (b) To remove all alternate current paths, for example, water pipe bond, remove MEN connection and incoming neutral from the neutral bar at the main switchboard; and
- (c) Measure between the incoming active(s) on line side of main switch and incoming neutral.

NOTE —

- (1) In multi-phase installations, the readings should be substantially the same.
- (2) Expert advice is required to reconnect earth fault-loop testers for active to neutral tests instead of active to earth tests.
- (3) If the earth fault-loop impedance is greater than 0.5Ω consult the electricity network provider.

3.10.2.2 Test using a clamp type ammeter

The condition of the supply neutral may be assessed by measuring the current in the consumers mains active(s) and neutral conductors, the main earthing conductor and the MEN connection. With a substantial load such as an electric range or water heater applied, use a clamp ammeter to measure the current flow in the active and neutral conductors separately, upstream of the MEN connection, and in the MEN connection. For multiphase installations, place the clamp meter around all active conductors simultaneously, ensuring the line and load of each phase conductor is orientated the same way.

NOTE —

- (1) The current flowing in the active conductor(s) and the neutral conductor should be substantially the same.
- (2) If a large proportion of the active current is flowing in the main earthing conductor and MEN connection, there is the possibility of a continuity problem with the consumer mains/service neutral connections for that installation.
- (3) If the sum of the currents in the main neutral conductor and MEN connection exceeds that in the active conductor(s), there is a possibility of a continuity problem with another installation further from the distribution transformer than the installation under test. This can be confirmed by checking for current in the main neutral conductor and the MEN connection with the main switch(es) off.
- (4) This test requires a competent person trained in this testing technique.

3.10.2.3 Test using a volt meter

The procedure for testing the continuity and high resistance is shown in figure 3.26.

NOTE — A substantial difference, ie $> 5V$, indicates a loose or high resistance neutral connection either at the switchboard, overhead line connector box or to the consumers mains or service line.

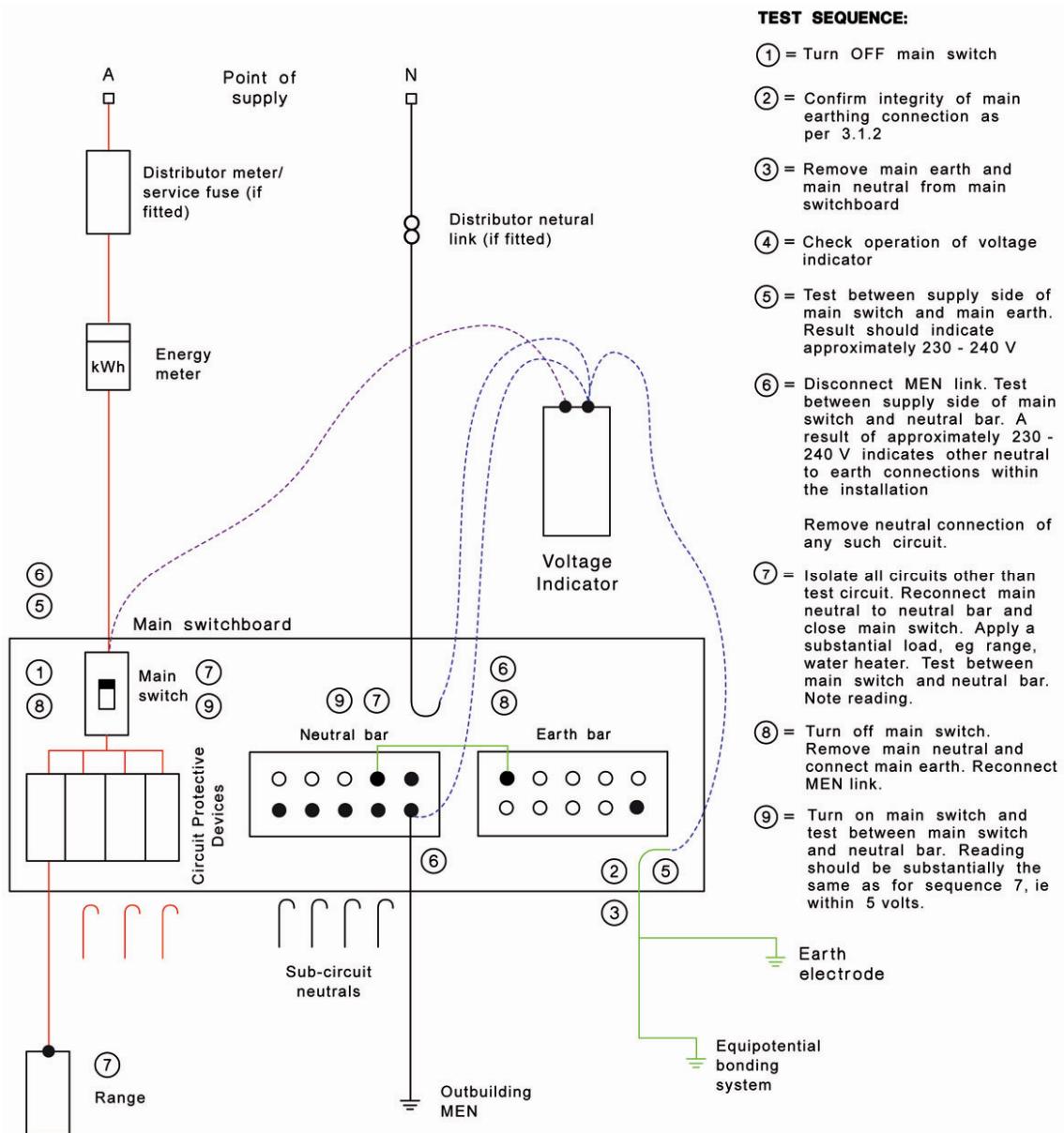
3.10.2.4 Test using a proprietary meter

Some proprietary test equipment measure voltages under load and no load and give values for consideration.

Special training in the use of the test equipment and interpretation of test results may be required.

3.10.3 Testing considerations

A large number of shocks are found to be the result of loose or poor neutral connections and a load test shall always be followed up by a physical and visual examination of connections in the main neutral back to the distributor's mains, taking particular note of line taps, aluminium to copper connections, etc.



WARNING: Due to the significant rise in voltage on earthed equipment, including the earth electrode, during the course of this test, the premises should be vacated by all persons and the test conducted by an experienced person trained in this technique.

NOTE — Numbers indicate test sequence.

Figure 3.26 — Test for continuity and high resistance of the incoming neutral (supply available)

NOTES

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Under a Memorandum of Understanding between Standards Australia and Standards New Zealand, Australian/New Zealand Standards are prepared by committees of experts from industry, governments, consumers and other sectors. The requirements or recommendations contained in published Standards are a consensus of the views of representative interests and also take account of comments received from other sources. They reflect the latest scientific and industry experience. Australian/New Zealand Standards are kept under continuous review after publication and are updated regularly to take account of changing technology.

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Standards Australia and Standards New Zealand are responsible for ensuring that the Australian and New Zealand viewpoints are considered in the formulation of international Standards and that the latest international experience is incorporated in national and Joint Standards. This role is vital in assisting local industry to compete in international markets. Both organizations are the national members of ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission).

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