AS/NZS 3017:2022

Australian/New Zealand Standard™

Electrical installations — Verification by inspection and testing

AS/NZS 3017:2022

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- Consumers Federation of Australia
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- Electrical Workers Registration Board
- ElectroComms and Energy Utilities Industry Skills Council
- Energy Networks Australia
- Engineering New Zealand
- Engineers Australia
- Institute of Electrical Inspectors
- Master Electricians Australia
- Master Electricians NZ
- National Electrical and Communications Association
- National Electrical Switchboard Manufacturers Association
- The Manufacturers Network
- WorkSafe New Zealand

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AS/NZS 3017:2022

Australian/New Zealand Standard™

Electrical installations — Verification by inspection and testing

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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 3017:2007 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 verifying 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 in this Standard are provided as a means for satisfying these requirements.

This Standard has been revised to align with AS/NZS 3000:2018, and to include the following:

(a) Additional tests for measurement of the resistance of the earth electrode and measurement of touch voltage.

(b) Tests of the integrity of incoming neutral.

The major changes in this edition are as follows:

(i) Increased guidance on selection and checking of test equipment.

(ii) Most figures illustrating test procedures amended for increased clarity.

(iii) Figures amended to reflect increasing use of residual current devices (RCDs).

(iv) Test for de-energized added, to be carried out before all other testing.

(v) Tests for polarity, phase rotation and correct circuit connections combined, because they are interrelated.

(vi) Testing for correct installation and functioning of RCDs amended.

This Standard is accompanied by additional data in the PDF attachments. The attachment contains an editable PDF form.

The terms “normative” and “informative” are used in Standards to define the application of the appendices to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is only for information and guidance.

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Introduction

Application of typefaces

Four different typefaces are used in this Standard. Each of these has a specific purpose as follows:

Normal print indicates requirements that form the main part of a clause. It also indicates deemed to comply methods that satisfy the requirements. Normal print is used in the Appendices to present informative material for guidance only.

Italic print indicates exceptions or variations to requirements. Exceptions generally give specific examples where the requirements do not apply or where they are varied for certain applications. They may contain requirements. Examples are also presented in italic text.

Reduced normal print indicates Notes which give explanations and advice. They are preceded by “NOTE” in the manner used in previous editions.

Bold print indicates SAFETY WARNINGS.

It is important not to read text in any single typeface without consulting the preceding or following paragraphs, which may contain additional or modifying requirements.

Deemed to comply

The term “deemed to comply” means that a requirement can be met by following a specified Standard or method.

So, where an installation is carried out in accordance with the specified Standard or method, within the text of this Standard, the installation is “deemed to comply” with the requirements of this Standard.

Conformance to a deemed to comply Standard may exceed the minimum requirements of this Standard.

Notes

Statements expressed in mandatory terms in notes to tables and figures are deemed to be requirements of this Standard. Notes to text are informative and give explanations or advice. They do not form a mandatory part of this Standard.

Cross-references

Where reference to another clause has been made, such reference, unless otherwise stated, includes all appropriate subclauses and paragraphs of the clause or portion thereof referred to.

Provision for revision

This Standard is not intended to discourage invention or to exclude materials, equipment and methods that may be developed. Revisions will be made from time to time in view of such developments and Amendments to this edition will be made where essential.

NOTES

Australian/New Zealand Standard

Electrical installations — Verification by inspection and testing

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 electrical installation, or part installation, complies with safety requirements.

This Standard illustrates testing procedures for an electrical installation connected to a Multiple Earth Neutral (MEN) (TN-C-S) system of earthing. The equipment and methods —

(a) are not exclusive and other equipment and methods may be used; provided they give equally valid results; and

(b) may be applied to types of low voltage installations other than MEN (TN-C-S); and

(c) may be applied to work that affects only part of an installation, e.g. alterations or repairs.

Although verification of compliance refers to the completed work undertaken, it is reasonable to expect that the inspection and test methods set out in this Standard may be applied during the design, selection and installation phases of the work as a matter of sound practice. Records of the on-going inspection and testing would contribute to verification of the completed work.

This Standard describes alternate test methods for electrical installations that are either energized or de-energized. The user of this Standard is to determine the appropriate test methods.

1.2 Application

The principal application of this Standard is for verification of electrical installations used by electricity consumers.

This Standard may be applied through legislative requirements, made in each state and territory of Australia and in New Zealand, concerned with the verification of electrical installations. The Standard may also be applied in conjunction with any additional requirements, exemptions or restrictions in such legislation.

1.3 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this Standard:

NOTE Documents for informative purposes are listed in the Bibliography.

AS 61010.1, *Safety requirements for electrical equipment for measurement, control and laboratory use — Part 1: General requirements (IEC 61010-1:2001 MOD)*

AS/NZS 3000:2018, *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

AS ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

IEC 61557 (series), *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*

1.4 Terms and definitions

For the purposes of this Standard the terms and definitions in AS/NZS 3000 and those below apply. Where an additional term is defined in a particular Section or Clause, the term takes the meaning defined in that Section or Clause.

1.4.1
competent person
person who has acquired, through education, training, qualification or experience or a combination of these, the knowledge and skill enabling that person to perform the task required

1.4.2
de-energized
separated from all sources of supply, but not necessarily isolated, earthed or out of commission

1.4.3
earth fault-loop impedance
impedance of the earth fault-current loop (active-to-earth loop) starting and ending at the point-of-earth fault

1.4.4
energized
connected to a source of electrical supply

1.4.5
equipotential bonding
electrical connections intended to bring exposed conductive parts or extraneous conductive parts to the same or approximately the same potential, but not intended to carry current in normal service

1.4.6
exposed conductive part
conductive part of electrical equipment that —

(a) can be touched with the standard test finger; and

(b) is not a live part but can become live if basic insulation fails

Note 1 to entry: The specification of the standard test finger is given in AS/NZS 3100.

Exception: The term "exposed conductive part" does not apply to any of the following:

(a) *Conductive parts within an enclosure where the parts cannot be touched unless a key or a tool is required to remove the covers of the enclosure.*

(b) *Conductive parts within electrical equipment where the parts cannot be touched in normal use and during the movement of the electrical equipment, because of its configuration and size.*

(c) *Conductive parts that are effectively and permanently separated from live parts by—*

  (i) *double insulation; or*

  (ii) *other conductive parts that are earthed.*

(d) *Conductive parts that are in the form of nameplates, screw heads, covers and similar attachments that cannot become live in the event of failure of insulation of live parts because of the manner in which they are supported and fixed.*

(e) *A removable or hinged conductive panel fitted to a switchboard or other enclosure containing conductors that are so located and/or restrained that, in the event of any conductor becoming detached from a terminal or mounting, the conductor is incapable of making contact with the panel.*

1.4.7
ingress protection (IP) classification
classification of degrees of protection provided by enclosures for electrical equipment

Note 1 to entry: Refer to AS 60529 for information and requirements on IP classification.

1.4.8
insulated
separated from adjacent conducting material by a non-conducting substance or airspace permanently providing resistance to the passage of current, or to disruptive discharges through or over the surface of the substance or space, to obviate danger of shock or injurious leakage of current

1.4.9
isolated
separated from all possible sources of electrical energy (supply) and rendered incapable of being energized unintentionally

1.4.10
isolation (isolating function)
function intended to cut off the supply from the whole installation, or a discrete section of it, by separating it from every source of electrical energy for reasons of safety

1.4.11
known earth
earth point previously tested to confirm that it is connected to the installation earthing system

1.4.12
reporting
providing a record of the results of inspection and testing to other parties

1.4.13
shall
indicates a statement is mandatory

1.4.14
should
indicates a recommendation

1.4.15
testing
use of test instruments or test equipment by a *competent person* (1.4.1)

1.4.16
verification
provision of objective evidence that a given item fulfils specified requirements

[SOURCE: ISO/IEC 17025:2017, 3.8]

Note 1 to entry: This comprises inspection, testing and reporting.

1.4.17
visual inspection
inspection of an electrical installation and/or electrical equipment using vision

1.5 Safety

1.5.1 General

Electrical inspection and testing inherently involves a degree of hazard and shall be undertaken by a competent person. It is the responsibility of the person performing the inspection and tests to ensure that safe practices are used in the performance of all inspection and testing procedures.

This Standard describes tests methods both for situations where the circuit under test is energized, and where it is not. Working safely on de-energized circuits requires that the circuit under test be isolated.

Tests where the circuit under test is isolated minimize the risk of electric shock; however, some types of test can only be performed with supply connected and energized.

1.5.2 Work health and safety

Before commencing inspection and testing, a site-specific risk assessment is required to identify risks and establish control methods.

NOTE The risk assessment and resulting control measures should consider the following:

(a) The age and condition of the equipment being tested that may expose persons to additional hazards.

(b) Requirements of the Regulatory Authorities for the jurisdiction before the commencement of testing.

(c) The safe work practices in health and safety legislation and as outlined in AS/NZS 4836.

(d) Safety procedures for each test are described in Section 4, Testing installations.

(e) Use of personal protective equipment (PPE) appropriate and suitable for the inspection and testing task.

(f) Risk of wearing conductive body adornments and devices.

Section 2 Test equipment

2.1 Equipment required

The following test instruments are required to carry out all the tests detailed in this Standard:

(a) Voltage indicator.

(b) Volt meter.

(c) Low range ohmmeter.

(d) Insulation resistance test instrument.

(e) Instrument for measuring fault-loop impedance.

(f) Instrument or device for initiating the operation of a RCD.

NOTE 1 Measuring the operation time of the RCD is not required by this Standard.

These instruments may be individual instruments designed for conducting just one type of test; or multi-function instruments capable of conducting a range of tests.

Where a test instrument assesses results as “pass” or “fail”; it is crucial that the parameters are correctly set up.

NOTE 2 Instruments with multiple functionality are often referred to as “installation testers”. Such instruments often have additional functions not required for testing electrical work; but useful for other testing purposes, such as diagnosing faults.

NOTE 3 If there is no setting that exactly matches the pass/fail criterion stipulated for the particular test procedure; the nearest setting on the “fail” side should be used. This is to ensure that the instrument does not provide false “pass” results.

Regardless of which type(s) of instruments are chosen, the user shall —

(i) understand the use and capabilities of the instrument for each type of test;

(ii) ensure that the instrument meets the requirements specified in Clause 2.2.1; and

(iii) ensure that the instrument is correctly set up.

For some tests, additional equipment will be required. For example, the following:

(A) Test leads and probes.

(B) Trailing leads.

(C) Means of making temporary connection to mass of earth.

(D) A range of resistors of known value.

(E) Portable independent sources providing a 50 Hz supply.

2.2 Selection of test equipment

2.2.1 Equipment requirements

2.2.1.1 General

All test equipment shall be suitable for its intended purpose; in accordance with Clause 2.2.2; with regard to the environment in which it is intended to be used, e.g. damp or hazardous areas.

Measuring equipment (meters) shall comply with the relevant requirements of AS 61010.1 or the IEC 61557 series or an equivalent Standard.

See Appendix A for additional information for selecting and using test equipment.

2.2.1.2 Meter error

Meters shall have a maximum inherent error of —

(a) *for mechanical analogue meters* — 5 % full scale deflection; or

(b) *for digital meters (including digital-analogue)* — 5 % of the value being measured.

NOTE See Appendix A for additional information.

2.2.1.3 Voltage ratings

Meters and leads shall have an appropriate voltage rating for the circuit under test.

Meters shall have an ability to withstand impulse voltages in accordance with Table 2.1.

Table 2.1 — Impulse voltage and typical use

Impulse-voltage Category	Circuit voltage	Suitable for	Examples
I	ELV	Measurements on circuits not directly connected to an LV source of supply	Battery powered circuits, ELV lighting
II	LV	Measurements on equipment directly connected to an LV installation	Appliances
III	LV	Measurements performed on an LV installation	Final subcircuits; distribution boards; submains
IV	LV	Measurements performed at the source of an LV installation	Consumer mains and main switchboards

NOTE 1 Category I meters are not suitable for testing LV installations.

NOTE 2 See Appendix A for additional information.

2.2.1.4 Safe selection and use

Meters and leads shall be selected and adjusted for the electrical quantity and parameters to be measured.

On energized circuits, incorrect selection, adjustment and/or placement of test probes can result in damage and injury from excessive –

(a) voltage being applied to the equipment; or

(b) currents, up to the prospective fault current, flowing through the meter and test leads.

2.2.2 Requirements for specific types of test equipment

2.2.2.1 Voltage indicator

Voltage indicators are required to perform the following functions to —

(a) confirm that no hazardous voltage is present; and

(b) confirm the presence of voltage.

Non-contact and single-contact voltage indicators shall not be relied on for proving that no hazardous voltage is present, and that the wiring or fittings have been de-energized and/or isolated to a safe state. A dual-contact voltage indicator is required for this function.

NOTE When using a voltage meter, low-impedance meters are preferred as they draw current from the circuit under test, reducing the effects from circuit anomalies, for example, those due to capacitive effects or external mutual inducted current. Analogue voltmeters are a low-impedance device, and some digital meters have a selectable low input impedance function.

2.2.2.2 Low range ohmmeter

The tests specified in this Standard require the ability to accurately measure low values of resistance. Test instruments have inherent errors. It is essential that these errors are only a small fraction of the maximum permitted value.

The meter shall be either —

(a) an analogue type meter with a range having full scale deflection of the needle of no more than 2 Ω; or

(b) a digital type or electronic-analogue meter giving readings, in ohms, to at least 2 decimal places.

Most insulation resistance meters have a suitable range.

NOTE See Appendix A for additional information.

2.2.2.3 Instrument for measuring insulation resistance

The meter shall have a nominal open-circuit terminal voltage in accordance with the following:

(a) *For measurements on ELV circuits* — 250 V d.c.

(b) *For LV circuits up to and including 500 V* — 500 V d.c.

(c) *For circuits above 500 V and not exceeding 1 000 V* — 1 000 V d.c.

The insulation resistance meter 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 250 V and 500 V ranges, and 10 MΩ on the 1 000 V range.

2.2.2.4 Instrument for measuring fault-loop impedance

The following instruments are required:

(a) For measuring the active conductor and protective earth conductor (R_{ph} and R_e) loop values of a de-energized circuit, a low range ohmmeter, as specified in Clause 2.2.2.2, is required.

(b) For measuring earth fault-loop impedance on an energized circuit, an earth fault-loop impedance meter is required.

NOTE This type of meter can also be used for a number of other functions, including locating high-impedance faults in circuits, and verifying the prospective short-circuit current and prospective earth fault current.

2.2.2.5 Equipment for confirming correct operation of RCDs

The test equipment shall be capable of performing the following three functions:

(a) Confirming the RCD has been correctly connected. This requires use of voltage and/or continuity test equipment.

(b) Initiating operation of the RCD, by applying an appropriate residual current through the RCD sensing coil. This requires that the RCD be energized and a suitable residual current be applied. The value of the residual current shall be at least the RCD's rated residual current, and should not exceed 120 % of that value.

NOTE 1 A portable independent source providing 50 Hz supply will be needed for testing RCDs where normal supply is not available. See Clause 2.2.2.6.

(c) Confirming that operation of the RCD results in disconnection of the circuit(s) intended to be protected by the RCD. This requires the use of a dual-contact voltage indicator and/or ohmeter.

NOTE 2 Testing advice of the RCD manufacturer should be followed.

NOTE 3 See Appendix A for additional information.

2.2.2.6 Portable independent source providing 50 Hz supply

The purpose of this equipment is to enable testing of RCDs in cases where normal supply is not available.

Suitable sources include —

(a) a motor-generator set; or

(b) a battery-powered inverter with a nominally "pure sine wave" output.

The output of the source shall be sufficient to supply the required test current without causing voltage to drop.

NOTE Refer to Appendix A for additional information.

2.2.2.7 Test leads and probes

Test leads and probes shall be rated for the maximum voltage they are to be connected to.

Probes for making contact with live parts shall be suitable for the intended purpose and shrouding of the probes may be required.

Testing of multi-phase RCDs may be facilitated by use of a special test lead with a phase selection switch.

2.2.2.8 Trailing lead

Any suitable length of insulated conductor may be used. A dedicated lead, kept on a suitable reel, is recommended. The lead's conductor should be a flexible type, e.g. appliance wire.

For earth continuity testing, the resistance of the lead shall be known. The value should be recorded.

For confirming no hazardous voltage is present on earth-referenced systems; the lead should have a suitable terminal or clip to permit easy connection to the independent earth spike (see Clause 2.2.2.9).

NOTE Refer to Appendix A for additional information.

2.2.2.9 Means of making temporary connection to mass of earth

A suitable means is a metal spike capable of penetrating 150 mm into the ground and provided with a suitable means of connection for a test lead.

2.2.2.10 Resistors

Resistors, for checking polarity and phase rotation, should be selected such that —

(a) each resistor is a different value; and

(b) no combination of resistor values adds up to the value of any other resistor or combination.

Resistors for conducting routine checks of instrument accuracy should be selected to approximate typical values.

Resistors marked as having 5 % tolerance are preferred over those having 10 % tolerance.

NOTE Refer to Appendix A for additional information.

2.3 Test equipment checks

2.3.1 Basic functional checks before each use

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

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

After each test, or group of tests, the pre-test checks should be undertaken again. This will confirm that the equipment has not developed a fault during the testing.

In summary, the process is:

PROVE operation of equipment → TEST circuit → PROVE operation of equipment

NOTE Appendix A provides guidance on pre-use checks for particular types of test equipment.

2.3.2 Periodic checks of accuracy

All test equipment shall be checked regularly, and particularly after extended periods of storage, to ensure that it remains operational and safe, and that internal batteries are adequately charged.

The interval between checks should be determined by the frequency of use. The interval shall not exceed 12 months.

Instrument accuracy may be confirmed by checking —

(a) against a range of resistors of known values; or

(b) against a circuit of known characteristics.

NOTE Appendix A includes guidance on periodic checks for particular types of test equipment.

2.3.3 Calibration

Full calibration by a test laboratory should be undertaken if routine checks indicate significant error in accuracy.

Laboratories that perform calibration tests outlined in this Standard shall meet the requirements of AS ISO/IEC 17025.

Section 3 Visual inspection

3.1 General

A visual inspection shall be performed when work on an electrical installation has been completed in order to verify that the work complies with the applicable requirements.

The visual inspection shall be carried out before, or in association with testing. Visual inspection should, where practicable, be completed 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.

3.2 Safety requirements — Before visual inspection

Before the inspection, a risk assessment shall be undertaken to identify hazards and risks and establish the need for —

(a) appropriate PPE;

(b) appropriate equipment; and

(c) safe access, where required.

NOTE Refer to AS/NZS 4836 for further guidance.

3.3 Check list

This clause provides a guide to the matters to be checked during the visual inspection.

The lists below are representative of items in an electrical installation that are the subject of visual inspection. They include but are not limited to the following:

(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.

  (v) General condition of the electrical equipment, e.g. signs of damage that could impair safe operation, disconnection of unused electrical equipment.

(b) *Consumer mains*:

  (i) Consumer mains wiring conductors shall be clearly identified to indicate their intended function.

  (ii) Installation wiring systems conditions, e.g. underground systems — enclosure, depth of burial, mechanical protection. Aerial systems — mechanical protection, cables likely to be disturbed, support systems.

(iii) Connection of wiring.

(iv) Protection against external influences.

(v) Arrangement.

(c) *Switchboards*:

(i) Location, e.g. access and egress.

(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.

(vii) Protection against external influences.

(viii) Construction (refer to applicable Standards).

(ix) Correct RCDs installed or alternate protection method.

(d) *Wiring systems*:

(i) Conductor size — coordination with protective devices.

(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.

(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, water heaters, etc.

(iv) Particular installation conditions, e.g. locations affected by water, explosive atmospheres, extra-low voltage, high voltage.

(v) Conformance with applicable Standards and the additional requirements as specified in the manufacturers' instructions.

(vi) Connection, support and fixing.

(vii) Protection against external influences including ingress of moisture (IP rating) where required by any clause.

(viii) Suitability for intended voltage, current and frequency.

(f) *Earthing*:

(i) MEN (TN-C-S) connection (link).

(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.

Section 4 Testing installations

4.1 General requirements

This Section provides the considerations, requirements, results and processes for the tests being conducted.

After completion of, or in association with, the visual inspection, tests shall be carried out in accordance with this Standard on the electrical installation to verify that it complies with the requirements of applicable Standards and that it is suitable for the use intended.

Testing shall be carried out in such a manner that the safety of the operator, other people in the vicinity, the installation being tested and test equipment are not placed at risk.

The test methods set out in this Standard are common test methods. Other methods are not precluded, provided that they give equally valid results.

Electrical installations can be configured in a variety of ways. The figures in this section show test methods as applied to typical installations. Minor variations may be needed to apply the same test procedure to an installation with a different configuration.

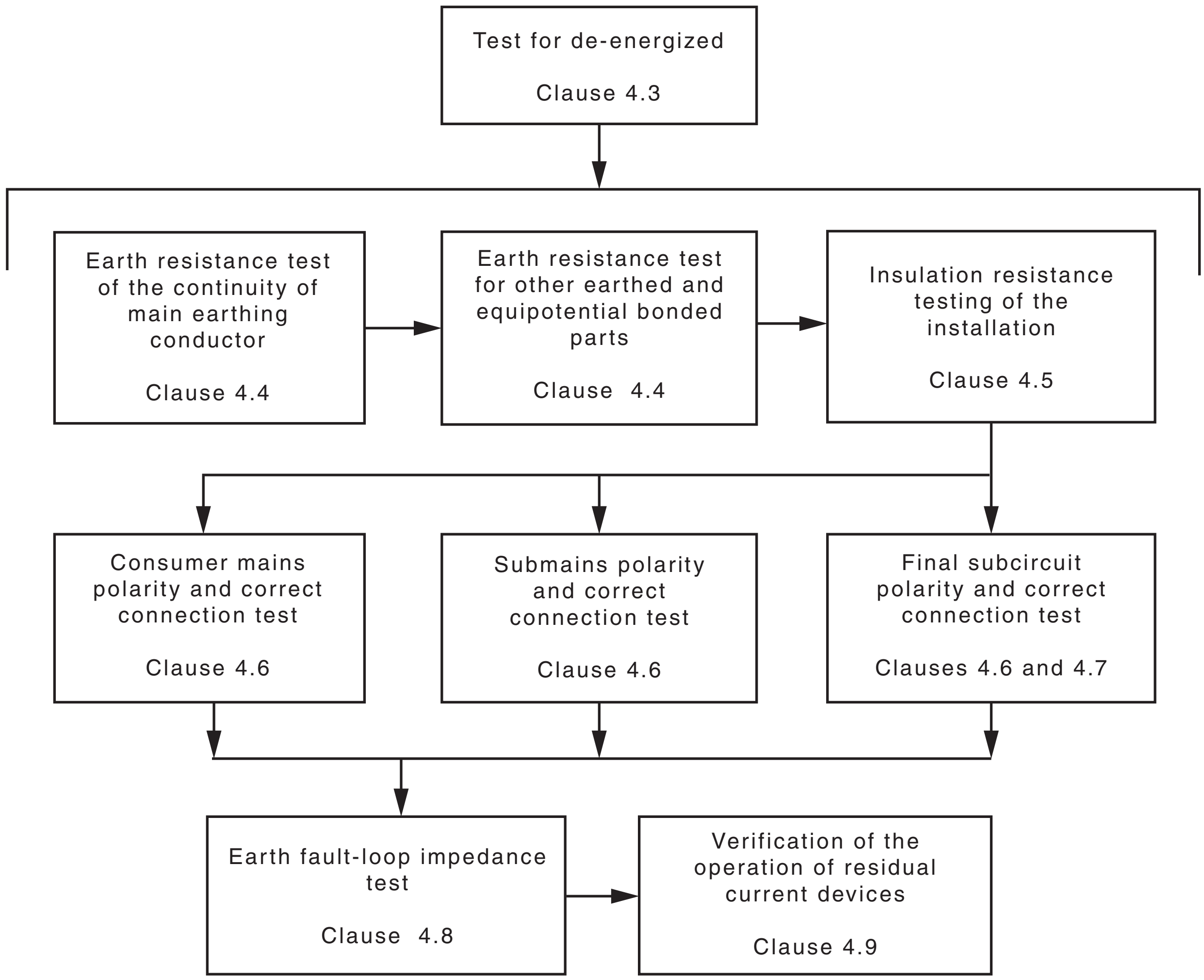
NOTE Placement of test probes may vary depending on the specific configuration of the circuit, particularly circuit protection devices.

4.2 Verification tests

4.2.1 Sequence of tests

Figure 4.1 shows a preferred sequence for testing electrical installation work.

NOTE The order in which the various tests are carried out matters, because a fault found by a later test may have caused a misleading result in a different type of test carried out previously. For example, insulation resistance tests between live parts and earth cannot be relied on unless the integrity of the earthing system has first been proven.



NOTE The sequence of tests shown in this figure is recommended. Tests performed out of sequence may result in invalid results for subsequent tests.

Figure 4.1 — Sequence of verification tests

4.2.2 Test failures

If any part of 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.

4.3 Test for de-energized

4.3.1 General

Before any electrical testing can be undertaken, the presence of any voltage shall be identified.

Irrespective of the type of tests (continuity, insulation resistance) being performed, a test to confirm whether any voltage is present on the circuit(s) under test shall be performed before any further actions.

Particular care is required where there may be multiple sources, for example:

(a) Alternative or supplementary supplies.

(b) Circuits with multiple switching paths.

Confirming the absence of supply voltage on active conductors is not sufficient.

WARNING: ALL ELECTRICAL CONDUCTORS, INCLUDING EARTHING CONDUCTORS, SHALL BE TREATED AS ENERGIZED UNTIL PROVEN DE-ENERGIZED.

NOTE 1 Even when all normal, alternative, and supplementary supplies to an installation have been isolated; faults in the supply network, or within another installation, can result in hazardous voltages being present. Common examples include the following:

(i) Incorrect polarity of the incoming supply, resulting in the installation's earthing system being energized and isolation devices being ineffective.

(ii) Faulty connections in PEN conductors of other installations supplied from same source, resulting in load current of the other installation being carried by the installation's earthing system and supply neutral.

NOTE 2 Caution is needed when disconnecting an MEN link or connections of the main earthing conductor, in case either is carrying current.

NOTE 3 Capacitive or induced voltage could influence test results.

4.3.2 Considerations

The correct selection of the type of voltage indicator and its operating condition to indicate the presence of voltage shall be verified before any testing is performed.

The test instrument shall be confirmed to be in a serviceable condition, safe to use and its operational settings understood by the person performing the test.

NOTE HB 187 provides an industry reference to assist in meter selection and use.

4.3.3 Requirements

Testing shall be carried out to ensure that all sources of supply have been isolated.

4.3.4 Results

The electrical installation shall be proven to be de-energized so work can progress safely.

4.3.5 Test procedure — Confirming isolation

4.3.5.1 Preparation

The immediate area and environment shall be assessed for the safety of personel performing the tests.

Adequate lighting and free movement are essential when performing LV testing. Risk control methods established through the site risk assessment shall be followed.

4.3.5.2 Testing for de-energized

Testing for de-energized shall be undertaken as follows:

(a) The test instrument shall be checked immediately before testing on a known voltage source to ensure operational condition.

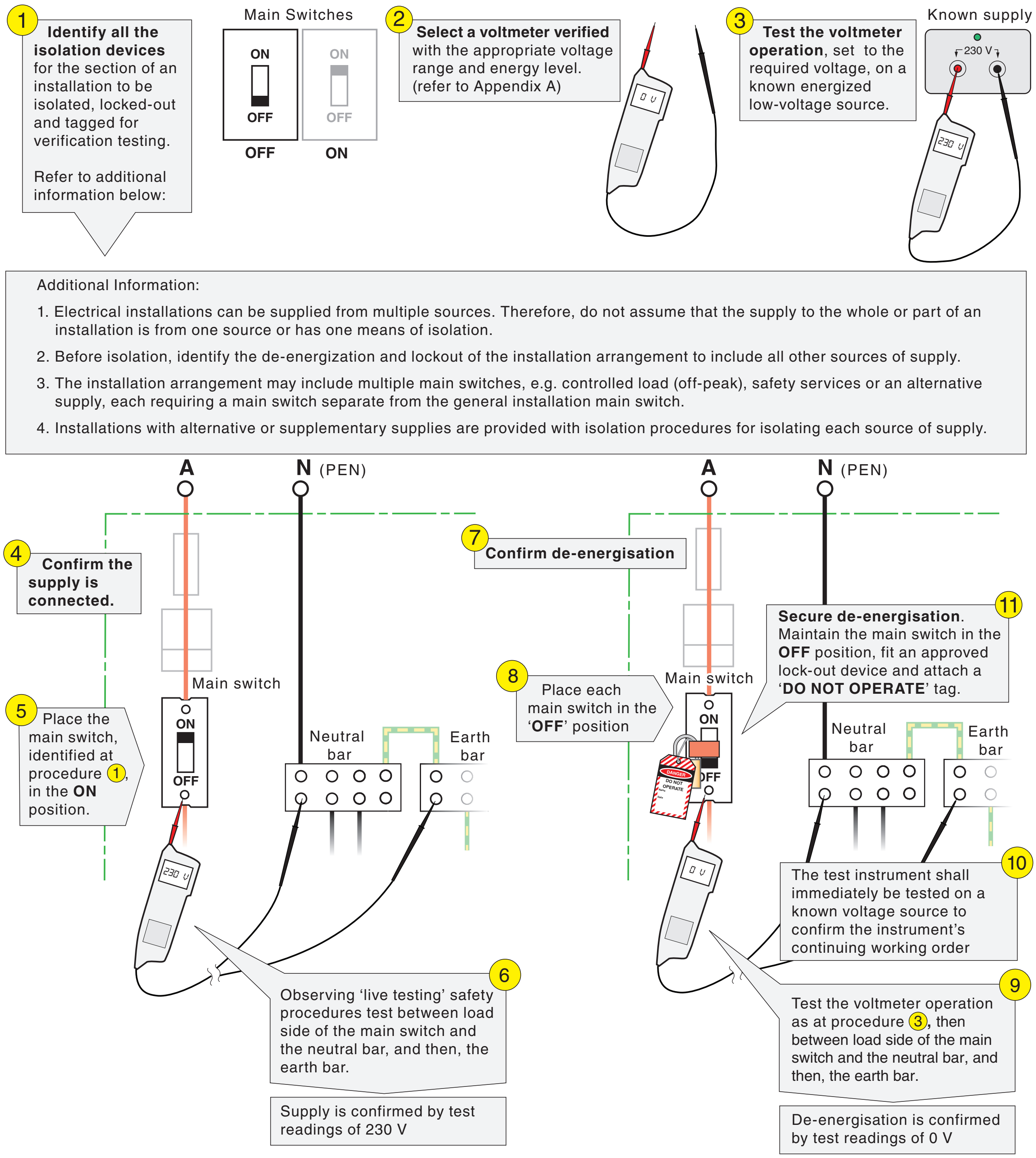
(b) Testing shall be performed (see Figure 4.2).

(c) The test instrument shall immediately be tested on a known voltage source to confirm the instrument's continuing working order.

NOTE The confirmation of the instrument's ability to indicate voltage after the de-energized state is confirmed may require an alternative power supply.

4.3.5.3 Isolation

Where there is a requirement for continued de-energization, ensure the isolation device for each possible source is locked out and tagged or physically separated from the supply equipment so that the circuits under test cannot be energized unintentionally. See Figure 4.2.



NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.2 — Confirm and secure isolation of energized installation

4.4 Earth continuity and resistance

4.4.1 General

Testing to prove the continuity of the earthing system (earth resistance of the main earthing conductor, protective earthing conductors, combined protective earthing and neutral (PEN) conductors and bonding conductors) shall be carried out to ensure that the earthing system has been installed in a manner that will cause circuit protective devices to operate if there is a fault between live parts, other than the neutral, and the mass of earth.

An effective earthing system will ensure that exposed conductive parts of electrical equipment do not reach dangerous voltages when such faults occur.

Where the touch potential exceeds 50 V a.c or 120 V ripple-free d.c., the circuit-protective device shall cause disconnection of supply within the required time.

4.4.2 Considerations

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.

NOTE 1 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 may be disconnected from the electrical device and tested independently.

NOTE 2 Tables 4.5 and 4.6 of this document are for miniature circuit breakers only. Where other than miniature circuit breakers are used as the protection device, the manufacturer's data shall be consulted to obtain the value of current (*I*a) for calculating the resistance of the protective earthing conductor.

4.4.3 Requirements

Testing to prove the continuity of the earthing system includes the following:

(a) Earth resistance of the main earthing conductor.

(b) Protective earthing conductors.

(c) Bonding conductors.

Where a PEN submain is installed to supply a separate MEN installation in an individual outbuilding, testing shall confirm that the earth terminal, point or bar of the sub-board is connected via the PEN conductor to the earth terminal, point or bar of the main switchboard.

The earthing system in a separate MEN installation shall be connected to the submain neutral conductor supplying the outbuilding. In this case, the submain neutral conductor supplying the outbuilding is a combined protective earthing and neutral (PEN) conductor.

4.4.4 Results

The resistance of protective earthing conductors shall be —

(a) low enough to permit the passage of current necessary to operate the overcurrent protective device; and

(b) consistent with the length, cross-sectional area and type of conductor material.

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

The resistance of the combined protective earthing and neutral (PEN) shall be low enough to permit the passage of current necessary to operate the circuit protective device.

NOTE 1 As described in Clause 4.8 (EFLI), 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.

NOTE 2 Maximum resistance values (R_e) for earthing conductors related to size of conductor and rating of R_e for earthing conductors are given in AS/NZS 3000 as a function of the rating of the associated overcurrent protective device. These values may be used when testing for earth continuity.

4.4.5 Procedures

4.4.5.1 Figures

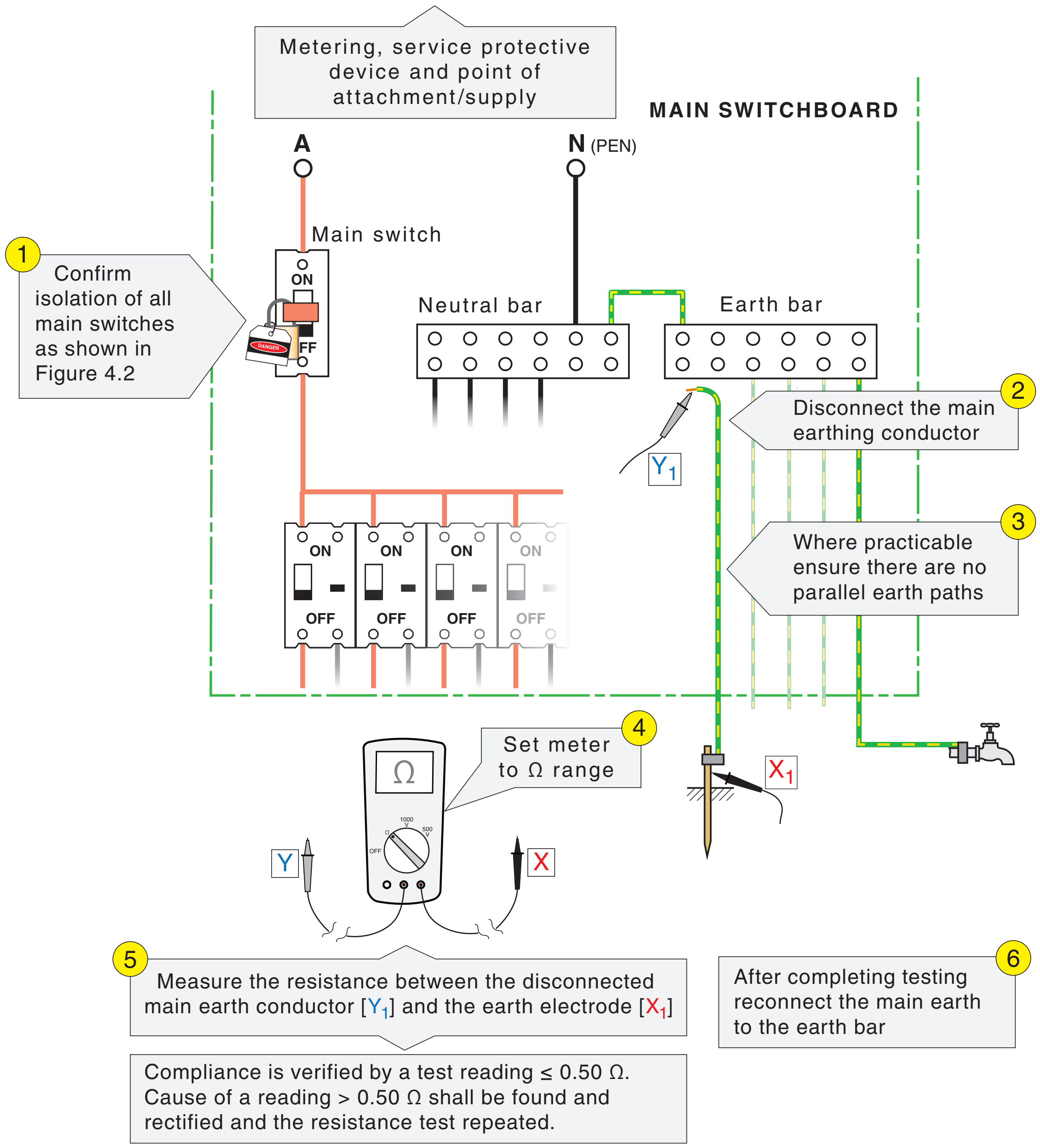
Tests for earth continuity and resistance are shown in Table 4.1.

Table 4.1 — Earth continuity and resistance tests

Figure no.	Figure title
Figure 4.3	Resistance test of main earthing conductor – Installation isolated
Figure 4.4	Resistance test for protective earthing and equipotential bonding conductors — Circuit(s) isolated

4.4.5.2 Main earthing conductor

Figure 4.3 shows a method of testing the continuity and resistance of the main earthing conductor.



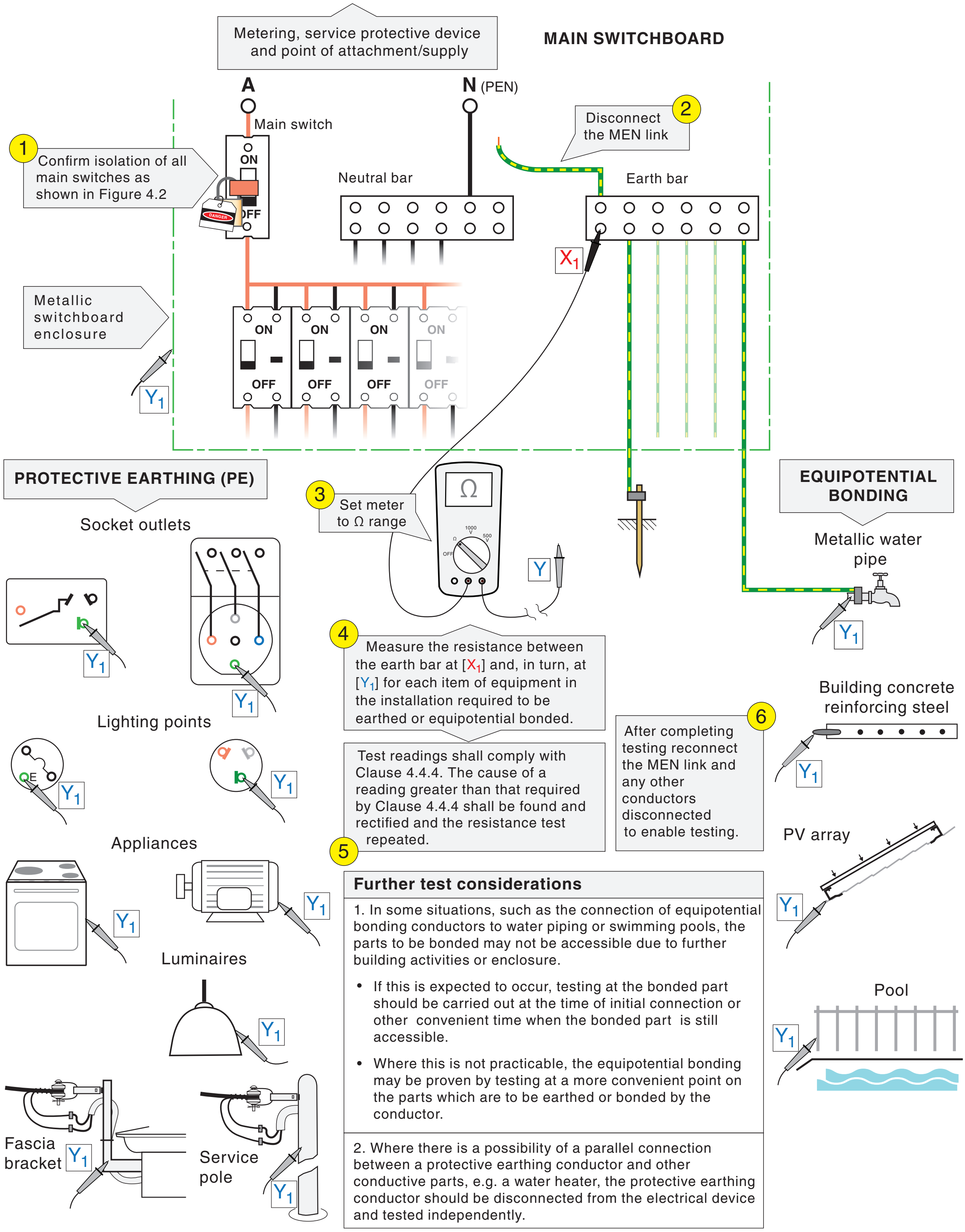
NOTE 1 Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

NOTE 2 When a trailing lead is used, the resistance of the trailing lead shall be considered.

Figure 4.3 — Resistance test of main earthing conductor — Installation isolated

4.4.5.3 Protective earthing and equipotential bonding conductors

Figure 4.4 shows a method of testing the continuity and resistance of earthing and bonding conductors.



NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.4 — Resistance test for protective earthing and equipotential bonding conductors — Circuit(s) isolated

4.5 Insulation resistance

4.5.1 General

Insulation resistance testing shall be carried out 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 testing is to prevent —

(a) electric shock hazards from inadvertent contact;

(b) fire hazards from short-circuits; and

(c) equipment damage.

In addition, an insulation resistance test between all conductors is necessary for consumer mains and submains to minimize risk of injury or property damage because of insulation breakdown.

4.5.2 Considerations

The following matters shall be considered:

(a) Care needs to be taken to ensure that the test equipment is not connected to energized parts. In most cases, main switches, circuit-breakers, residual current devices and fuses can be opened to isolate circuits.

(b) Some connected equipment may be damaged by overvoltage. Manufacturer's instructions should be referred to. Examples include EMC filters, surge protection devices, and electronic equipment. Damage may be avoided by —

  (i) connecting the live (active and neutral) conductors together and testing between all live conductors and earth; or

  (ii) testing the equipment with a test voltage of 250 V.

(c) Equipment connected to the circuit(s) under test may cause an unacceptably low result, so should be disconnected and tested separately. Examples include the following:

  (i) Equipment connected to consumer mains; such as revenue metering or load control equipment.

  (ii) Connections between neutral conductors and the earthing system; such as the incoming neutral of consumer mains, the installation's MEN link, outbuildings with neutral-earth (N-E) connections, and polarity sensing devices.

  (iii) Equipment with functional earthing; such as some types of RCD

  (iv) Sheathed heating elements.

  NOTE For some equipment a different minimum insulation resistance may apply.

(d) For final sub-circuits with separate neutral and protective earthing conductors, tests for insulation resistance to earth may be carried out either between earth and individual live conductors, or between earth and live conductors connected together.

(e) All switch positions/combinations shall be tested, for example 2-way, intermediate and change-over switching configurations.

(f) Parts of circuits on the load side of switching devices such as contactors and control devices shall be tested. This may require either testing those parts separately, or using bridging connections across the switching devices.

(g) If the insulation resistance test is not satisfactory, earth continuity and resistance tests may need to be repeated after the fault is rectified.

4.5.3 Requirements

4.5.3.1 Preparation

All circuits, including consumer mains, sub-mains and final sub-circuits shall be proven de-energized and isolated before they are tested.

Testing shall be carried out with the neutral conductor(s) of the circuit(s) under test disconnected from the MEN system. Where applicable —

(a) consumer mains shall not be connected to the distribution neutral conductor, and the installation MEN link shall be removed

(b) outbuildings or other distribution boards that have additional MEN or N-E connections, such connections shall be disconnected before conducting the test.

Where an earth sheath return system is used, the neutral conductor shall not be connected to any active conductor for the purpose of the insulation resistance test.

If earthing arrangements for functional purposes are provided as part of the electrical installation, any connections to the protective earthing arrangement should be disconnected for the duration of this test.

Where surge protective devices (SPD) or other equipment are likely to influence the test or be damaged, such equipment shall be disconnected before carrying out the insulation resistance test.

4.5.3.2 Testing

The integrity of the insulation is stressed by applying a direct current at 500 V for low voltage circuits.

Exception 1: Where equipment, such as electromagnetic compatibility (EMC) filters, equipment containing surge protective devices connected to earth, or electronic equipment, is likely to be damaged by the test. Such equipment may be disconnected or switched off before carrying out the insulation resistance test on the circuit; or the test voltage for the particular circuit may be reduced to 250 V d.c. The insulation resistance test is performed between —

(a) *each live conductor and each other live conductor of consumers mains and submains; and*

(b) *all live (active and neutral) conductors and earth for consumers mains, submains and final sub-circuits; and*

(c) *all live (active and neutral) conductive parts and earthed parts (earthing system) of equipment connected to the installation.*

Exception 2: Where connected equipment such as sheathed heating elements of appliances or an RCD with an FE connection is likely to influence the test, the equipment may be disconnected before carrying out the insulation resistance test on the circuit, and the equipment tested separately.

4.5.4 Results

The insulation resistance shall be not less than 1 MΩ.

Exception: Acceptable insulation resistance values for items likely to adversely affect test results are as follows:

(a) *For sheathed heating elements of appliances, not less than 0.01 MΩ.*

(b) *A value permitted in the Standard applicable to the electrical equipment.*

(c) *For functional earth connections of RCD, not less than 0.05 MΩ, or as prescribed by the manufacturer.*

NOTE 1 For shorter cable runs, the insulation resistance should be significantly greater than 1 MΩ, e.g. for polymeric insulated cables up to 50 m a value in excess of 50 MΩ would be expected.

NOTE 2 Insulation resistance varies with insulation materials, and decreases with increased length and/or higher temperature.

NOTE 3 PVC insulated cables with a route length of 50 m can be expected to have insulation resistances of at least 20 MΩ at a temperature not exceeding 20 °C but only 6 MΩ at a temperature of 30 °C.

NOTE 4 XLPE insulated cables can be expected to have insulation resistance of at least 1500 MΩ for a route length of 50 m.

NOTE 5 The relevant regulatory authority or electricity distributor should be consulted regarding acceptable minimum insulation resistance values.

4.5.5 Procedures

4.5.5.1 Figures

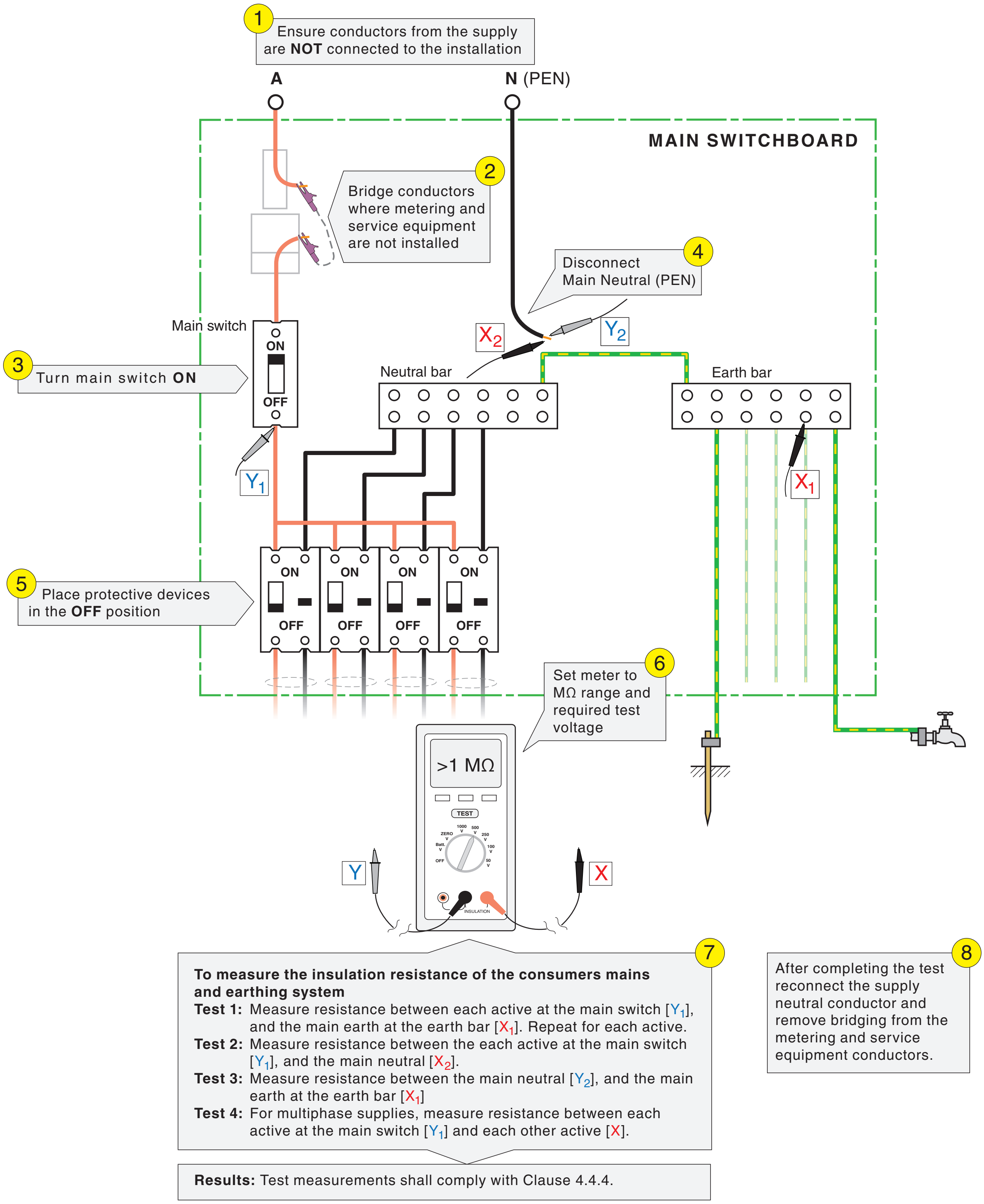
Tests for insulation resistance are shown in Table 4.2.

Table 4.2 — Insulation resistance tests

Figure no.	Figure title
Figure 4.5	Insulation resistance test of consumer mains — Installation not connected to supply
Figure 4.6	Insulation resistance test of a submain or final subcircuit — Circuit isolated

4.5.5.2 Insulation resistance test of consumer mains

Figure 4.5 shows a method of testing the insulation resistance of consumer mains when supply is not connected to the installation.

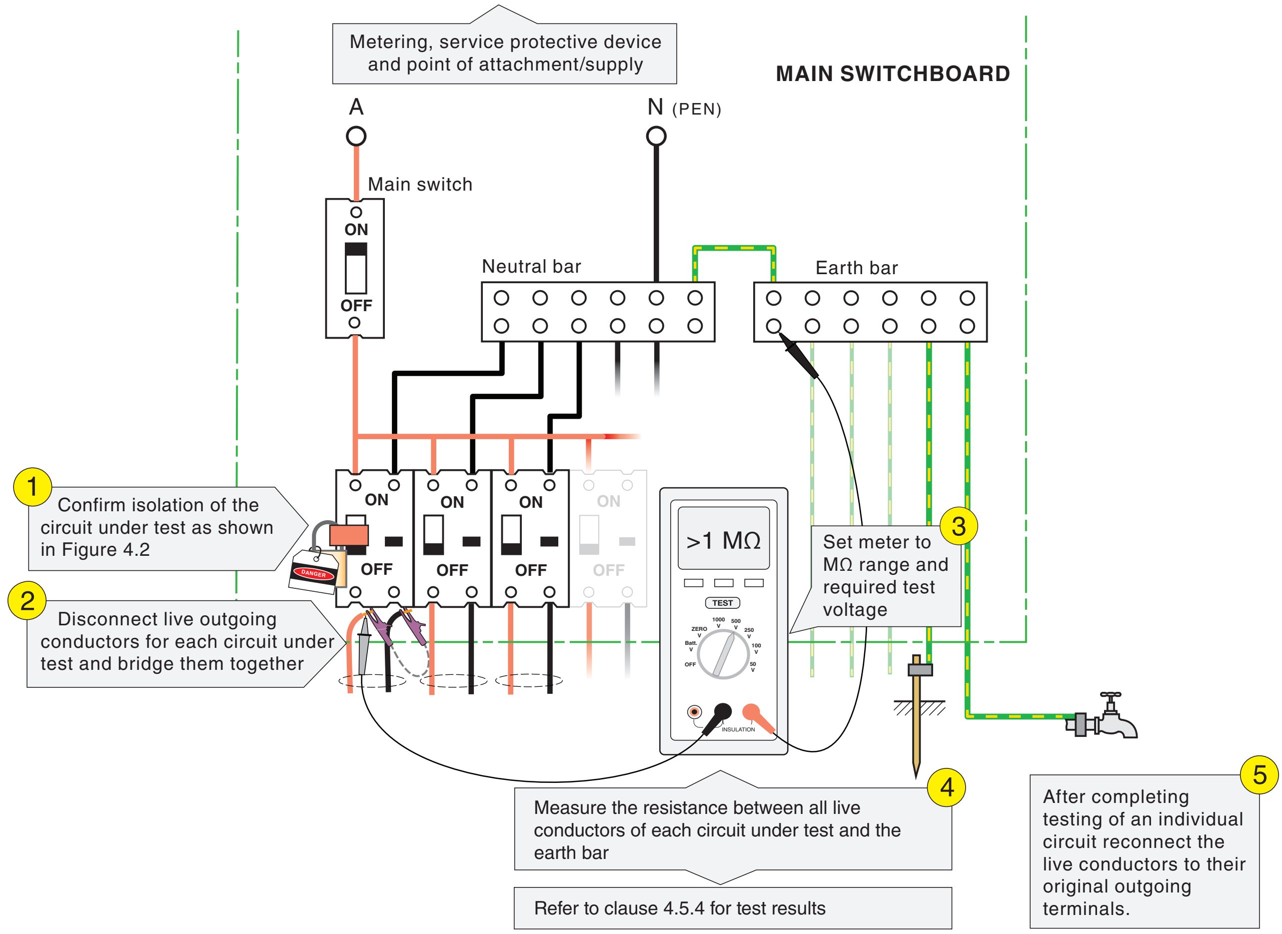


NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.5 — Insulation resistance test of consumer mains — Installation not connected to supply

4.5.5.3 Insulation resistance test of each individual final subcircuits

Figure 4.6 shows a method of testing the insulation resistance of individual final subcircuits.



INSTALLATION ITEMS	FURTHER PREPARATION AND TESTING PROCEDURES
Circuit protective devices	Ensure circuit protective devices are OFF or open. Protective devices may be a circuit breaker (CB), residual current device with overcurrent protection (RCBO, RCD/CB) or HRC fuse.
Socket connected device	Unplug all socket connected devices before undertaking insulation resistance tests.
Earth sheath return (ESR) systems	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.
Switching devices in a circuit	All circuit switches in the circuit shall to be in the **ON** position before undertaking insulation resistance tests.
	Test circuit with the two-way and intermediate switching with both two-way switches in the same position and again in the opposite position. Intermediate switches should be maintained in the same position for each test.
	The load side conductors of devices such as contactors should be temporally connected to the line side conductors or tested separately.
Functional earthing (FE)	Functional earthing (FE) should be disconnected from protective earthing arrangements for the duration of insulation resistance testing.
Electronic devices installed as part of a fixed installation	Avoid overvoltage damage by connecting the active and neutral conductors together at electronic devices. Alternatively, test between neutral conductors and earth and then between active conductors and earth.
Surge protection devices (SPD) or other equipment likely to influence the test or be damaged.	Such equipment shall be disconnected before carrying out the resistance tests. 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 shall be reduced to 250 V d.c., the insulation resistance shall have a value of at least 1MΩ.

NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.6 — Insulation resistance test of a submain or final subcircuit — Circuit isolated

4.6 Polarity and correct circuit connections

4.6.1 General

Polarity and correct circuit connection testing shall be carried out to ensure that no shock hazard arises from the incorrect connection of active, neutral and earthing conductors.

This testing is to prevent —

(a) the transposition of active and neutral conductors of the consumer mains, or submains supplying an outbuilding having an MEN connection, resulting in the electrical installation earthing system becoming energized; and

(b) combinations of incorrect active, neutral and earthing conductor connections resulting in the exposed conductive parts of the electrical installation becoming energized; and

(c) the connection of switches or protective devices in neutral conductors resulting in parts of appliances, such as heating elements and lampholders, remaining energized when the switches are in the “OFF” position; and

(d) multiphase equipment, such as multiphase motors, and semiconductor-controlled equipment operating in an unpredictable manner; and

(e) protective earthing conductors carrying current under normal conditions of operation; and

(f) short-circuits existing between conductors.

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 Clause 4.7).

4.6.2 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; or

  (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 energized.

(b) For lighting circuits, unless all two-way and intermediate switching complete the circuit, the test may not be complete because the luminaire is not in circuit.

(c) Where RCDs are installed, tests need to be carried out on the load side of the RCDs.

4.6.3 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 Clause 4.7.4);

(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.

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

(i) there is no short-circuit between the conductors;

NOTE Any MEN or earth sheath return connection is not considered as a short-circuit.

(ii) there is no transposition of conductors that could result in the earthing system and any exposed conductive parts of the electrical installation becoming energized; and

(iii) there is no interconnection between live (active or neutral) conductors of different circuits.

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 Ω should be expected.

The tests listed in Table 4.3 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.

4.6.4 Results

The polarity and correct circuit connection testing shall show that all active, neutral and protective earthing conductors in the electrical installation are correctly connected to the corresponding terminals of electrical equipment so that —

(a) there is no transposition of conductors that could result in the electrical equipment becoming unsafe when it is connected to supply, particularly where appliances are connected by socket-outlets;

(b) switches or protective devices do not operate in the earthing or a combined protective earthing and neutral (PEN) conductor;

(c) switches or protective devices do not operate independently in neutral conductors;

(d) all Edison screw lampholders that are not incorporated in an appliance or provided with a shroud or skirt that prevents contact with the outer contact shall have the neutral connected to the outer contact;

(e) all fixed socket-outlets for multiphase supplies are connected so the phase sequence is the same throughout the installation;

(f) there are no short-circuits between the live conductors; and

(g) there is no connection between live (active or neutral) conductors of different circuits.

NOTE Any MEN or ESR connection is not considered as a short-circuit.

4.6.5 Procedures

4.6.5.1 General

Tests for polarity and correct circuit connections are shown in Table 4.3.

Table 4.3 — Tests for polarity and correct circuit connections

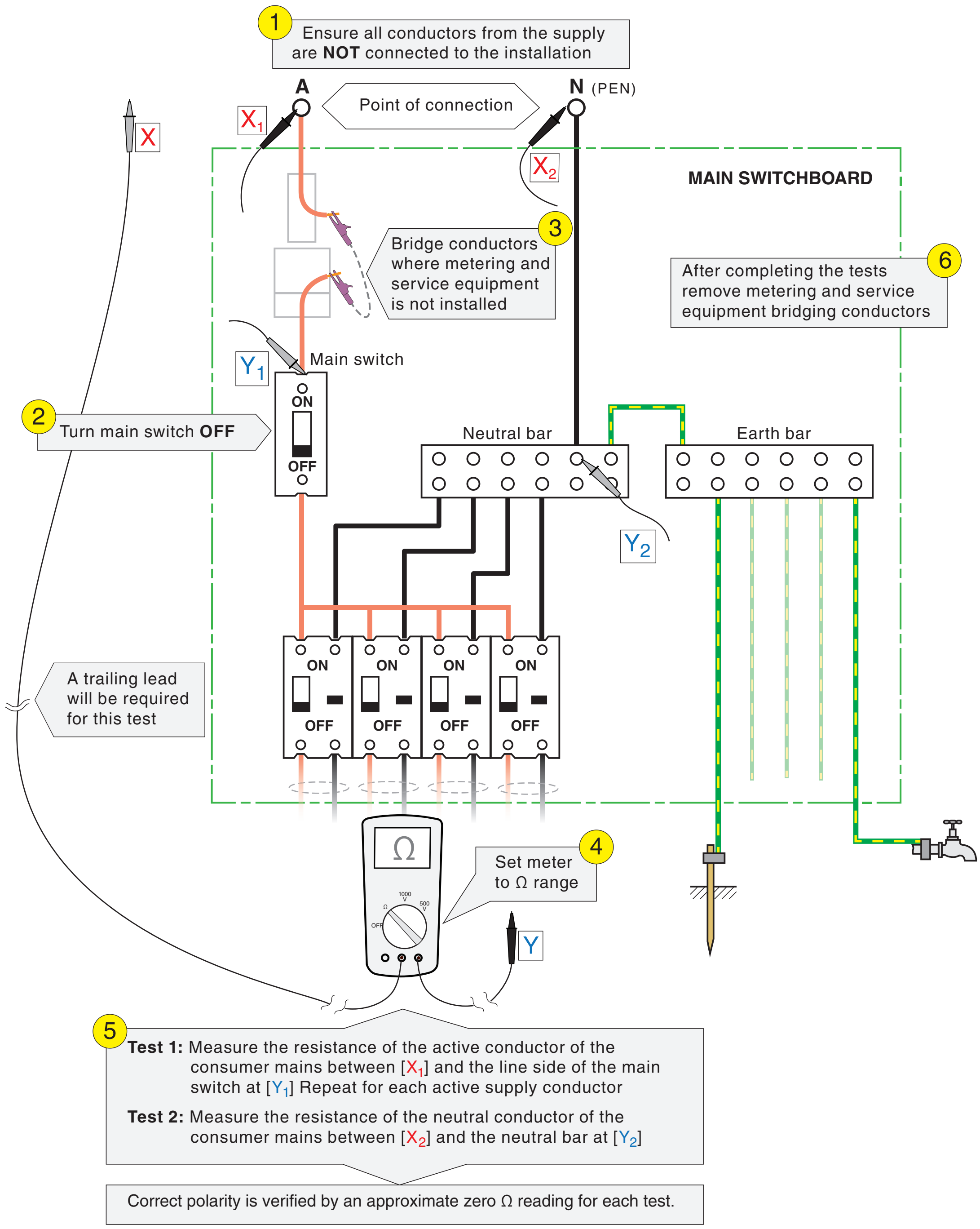
Figure no.	Figure title
Figure 4.7	Polarity test of consumer mains — Installation not connected to supply
Figure 4.8	Polarity test of submains with earthing conductor — Circuit isolated — Method 1
Figure 4.9	Polarity test of submains with earthing conductor — Circuit isolated — Method 2
Figure 4.10	Polarity test of submains for separate MEN installation in outbuilding - Circuit isolated
Figure 4.11	Polarity test of switch — Circuit isolated
Figure 4.12	Prepare for polarity test of energized submain — Confirm correct identification of protection device
Figure 4.13	Polarity test of energized submains to outbuilding with MEN connection
Figure 4.14	Polarity test of energized submains incorporating protective earth conductor
Figure 4.15	Polarity test of switches or socket outlets — Circuit energized
Figure 4.16	Polarity test and correct connection of lighting points using resistors — Circuit isolated
Figure 4.17	Polarity test and correct connection of socket outlet subcircuits using resistors — Circuit isolated
Figure 4.18	Polarity test and correct connection of appliance circuits — Circuit isolated
Figure 4.19	Interconnection test between conductors of different circuits — Circuits isolated

NOTE 1 Polarity tests of submains, final subcircuits, and switches that rely on the circuit under test being energized cannot be relied on to provide valid results unless polarity of the supply to the installation has first been confirmed as correct.

NOTE 2 Live testing with MEN connected cannot detect N-E transposition. Always confirm correct connection of protective earthing conductors before testing for polarity.

4.6.5.2 Polarity test — Consumer mains

Figure 4.7 shows a method of testing the polarity of consumer mains when the installation is not connected to supply.

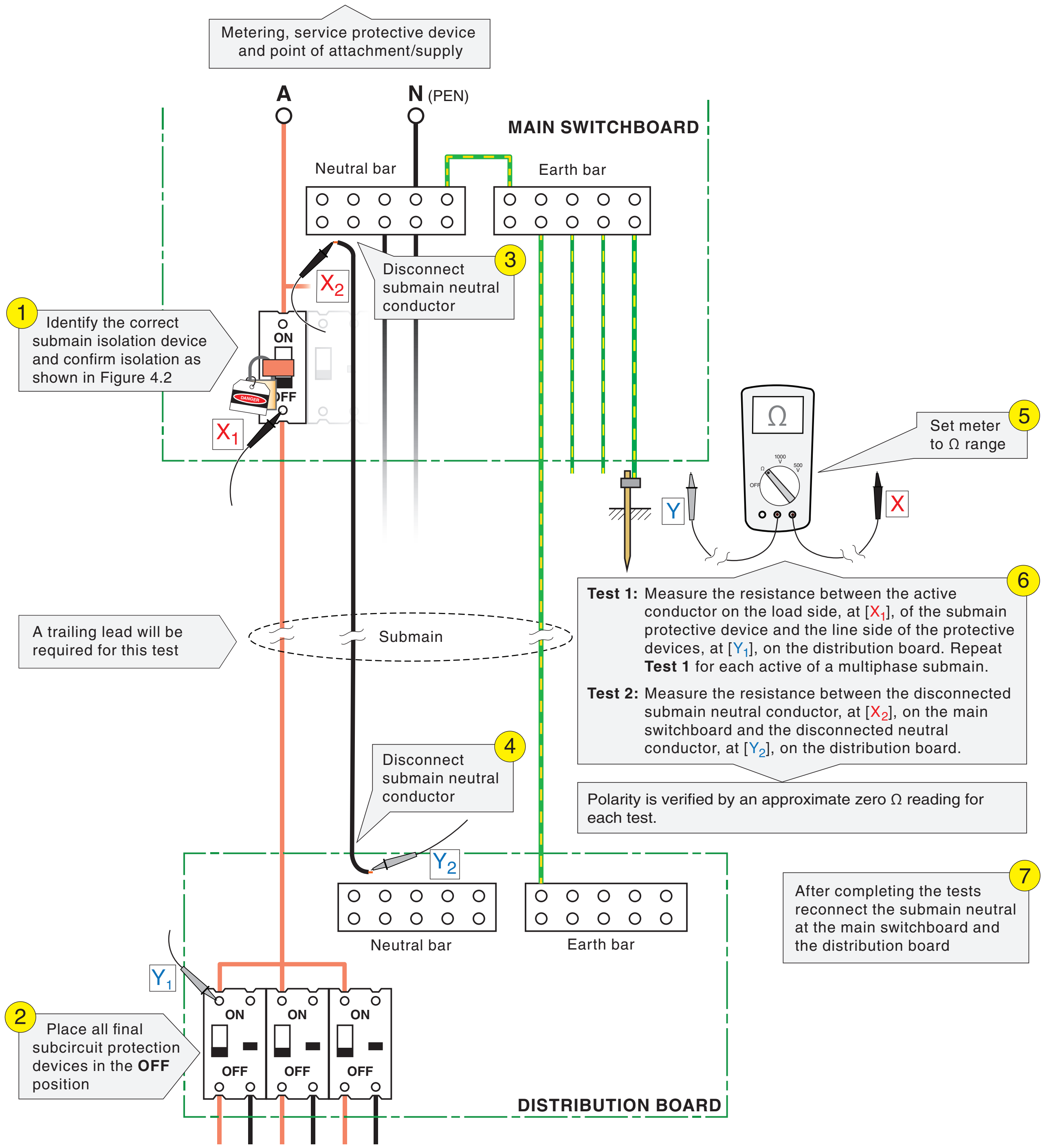


NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.7 — Polarity test of consumer mains — Installation not connected to supply

4.6.5.3 Polarity test — Submains method 1

Figure 4.8 shows a method of testing the polarity of submains incorporating and earth conductor with circuit isolated.



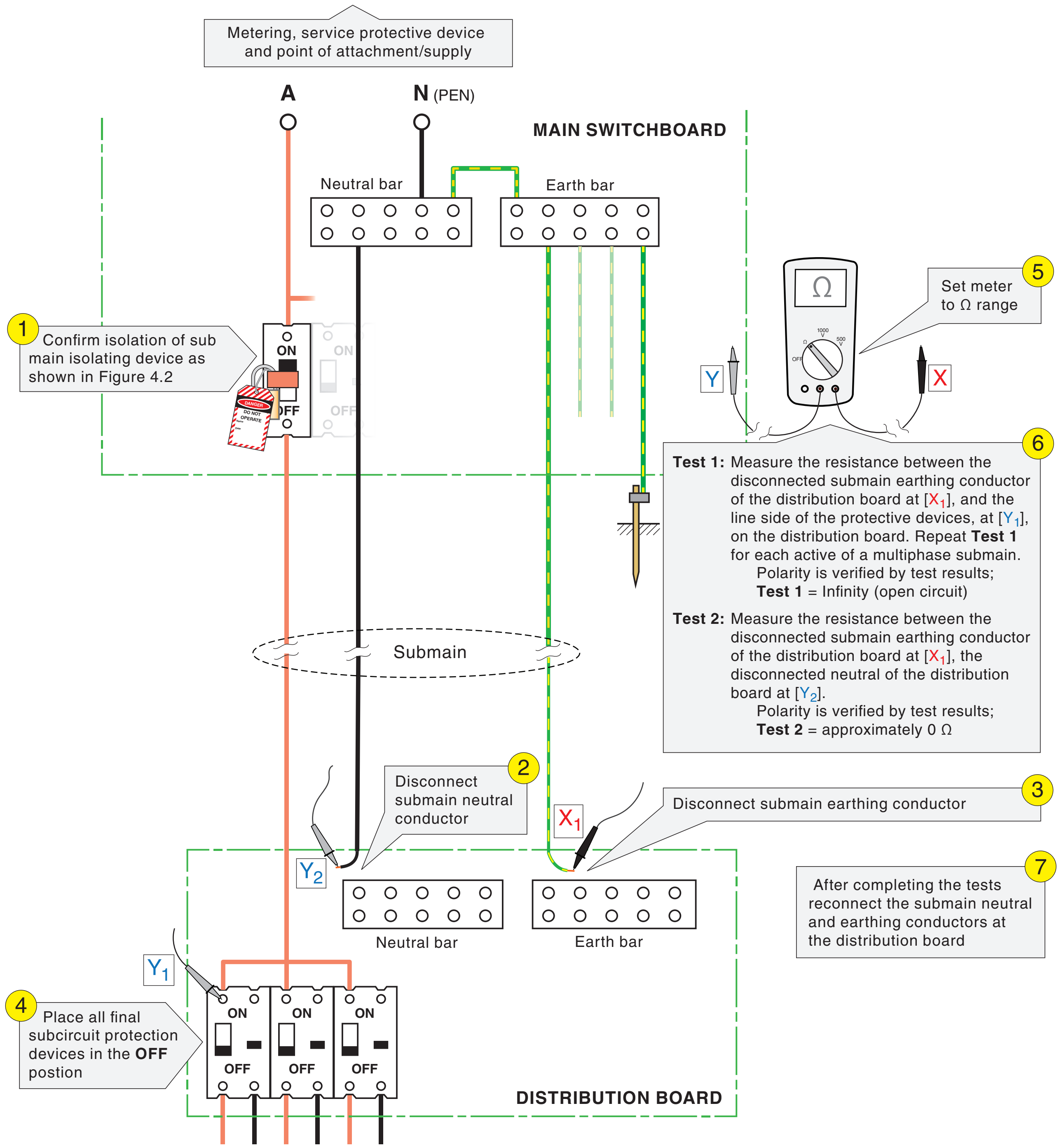
NOTE 1 Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

NOTE 2 When a trailing lead is used, the resistance of the trailing lead will be considered.

Figure 4.8 — Polarity test of submains with earthing conductor — Circuit isolated — Method 1

4.6.5.4 Polarity test — Submains method 2

Figure 4.9 shows a method of testing the polarity of submains incorporating and earth conductor when the circuit is isolated.

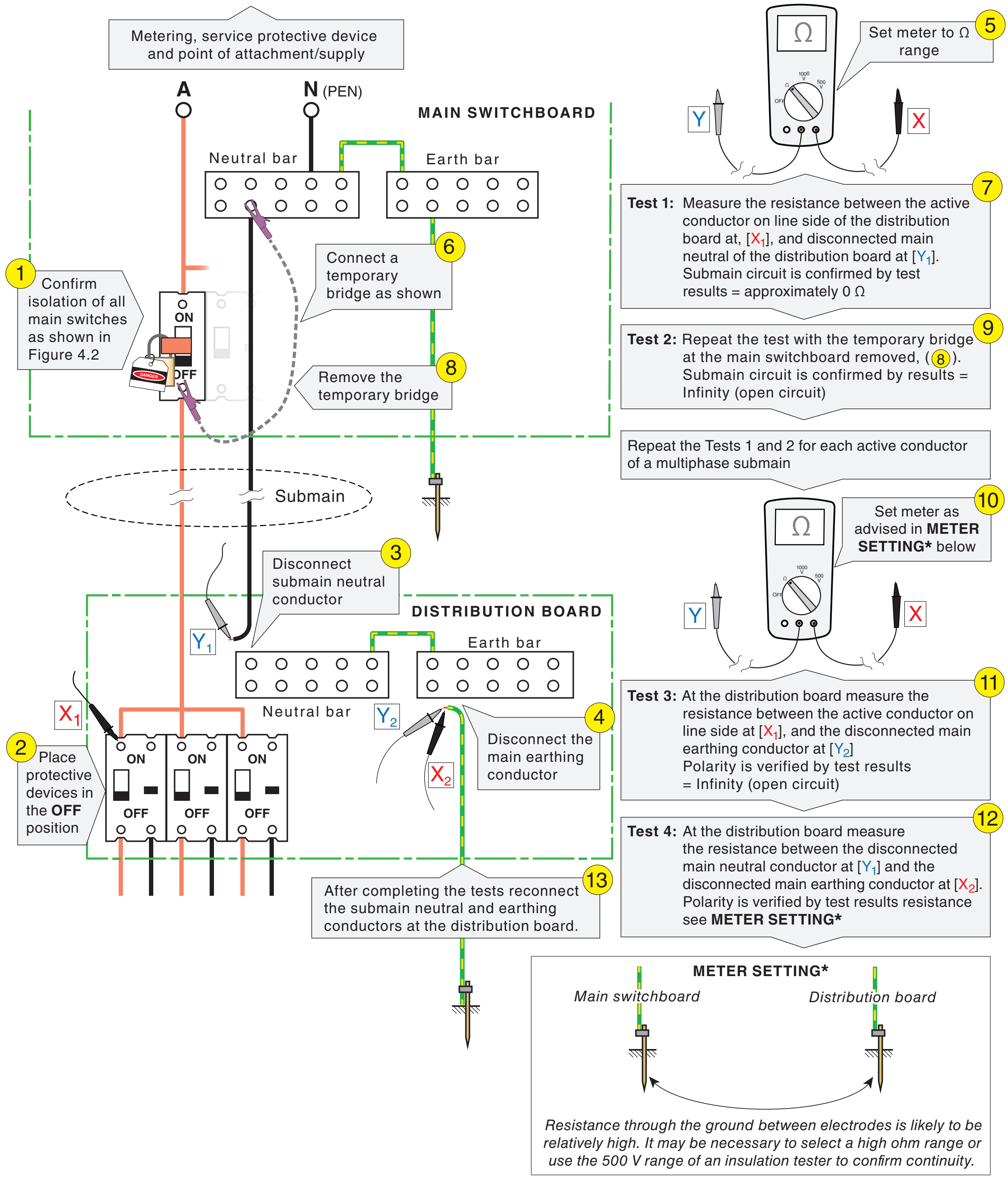


NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.9 — Polarity test of submains with earthing conductor — Circuit isolated — Method 2

4.6.5.5 Polarity test of submains for separate MEN installation in outbuilding

Figure 4.10 shows a method of testing the polarity of submains for an installation incorporating a separate MEN with the circuit isolated.

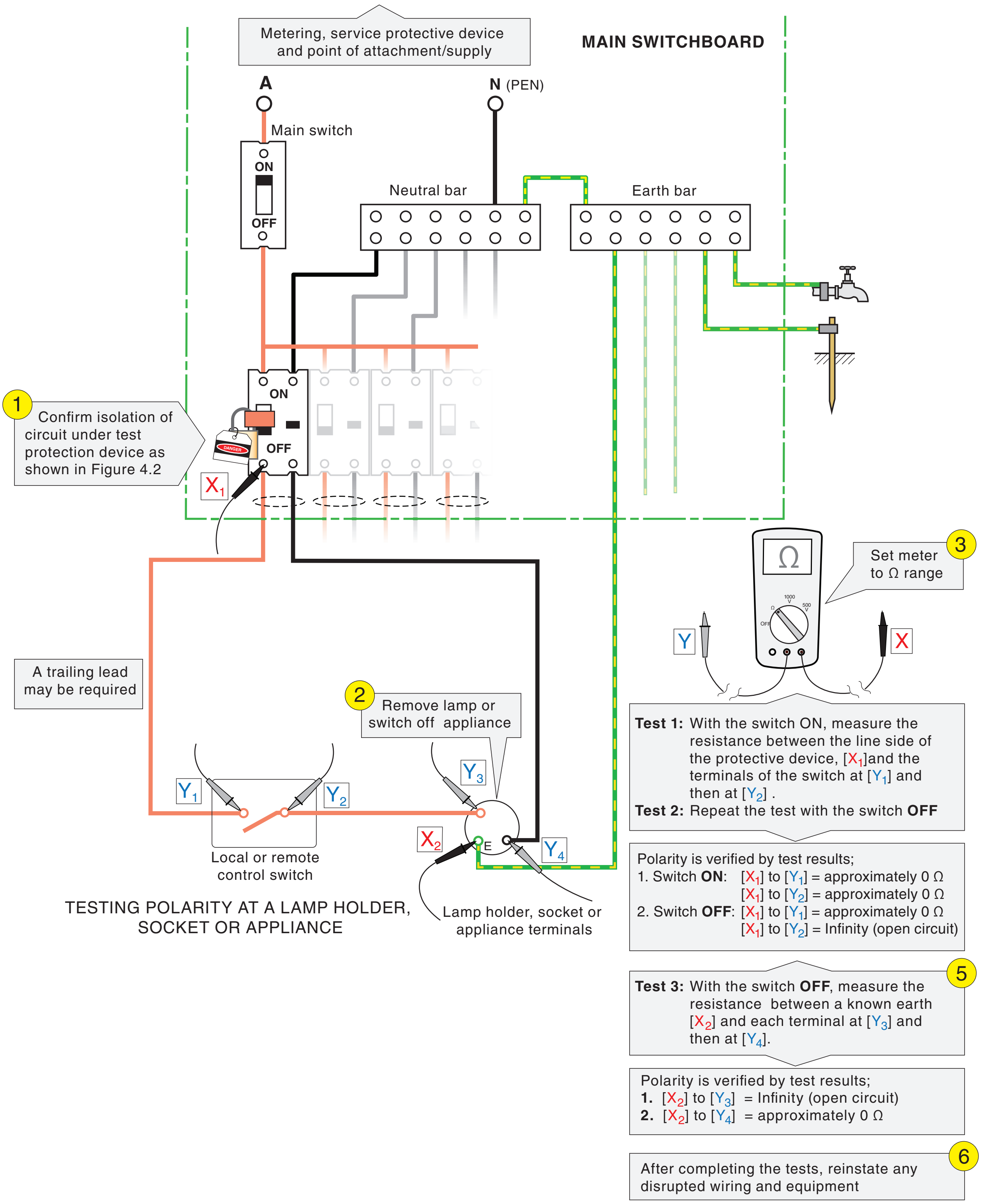


NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.10 — Polarity test of submains for a separate MEN installation — Circuit isolated

4.6.5.6 Polarity test of a switch using ohmmeter

Figure 4.11 shows a method of testing the polarity of a switch with the circuit isolated.



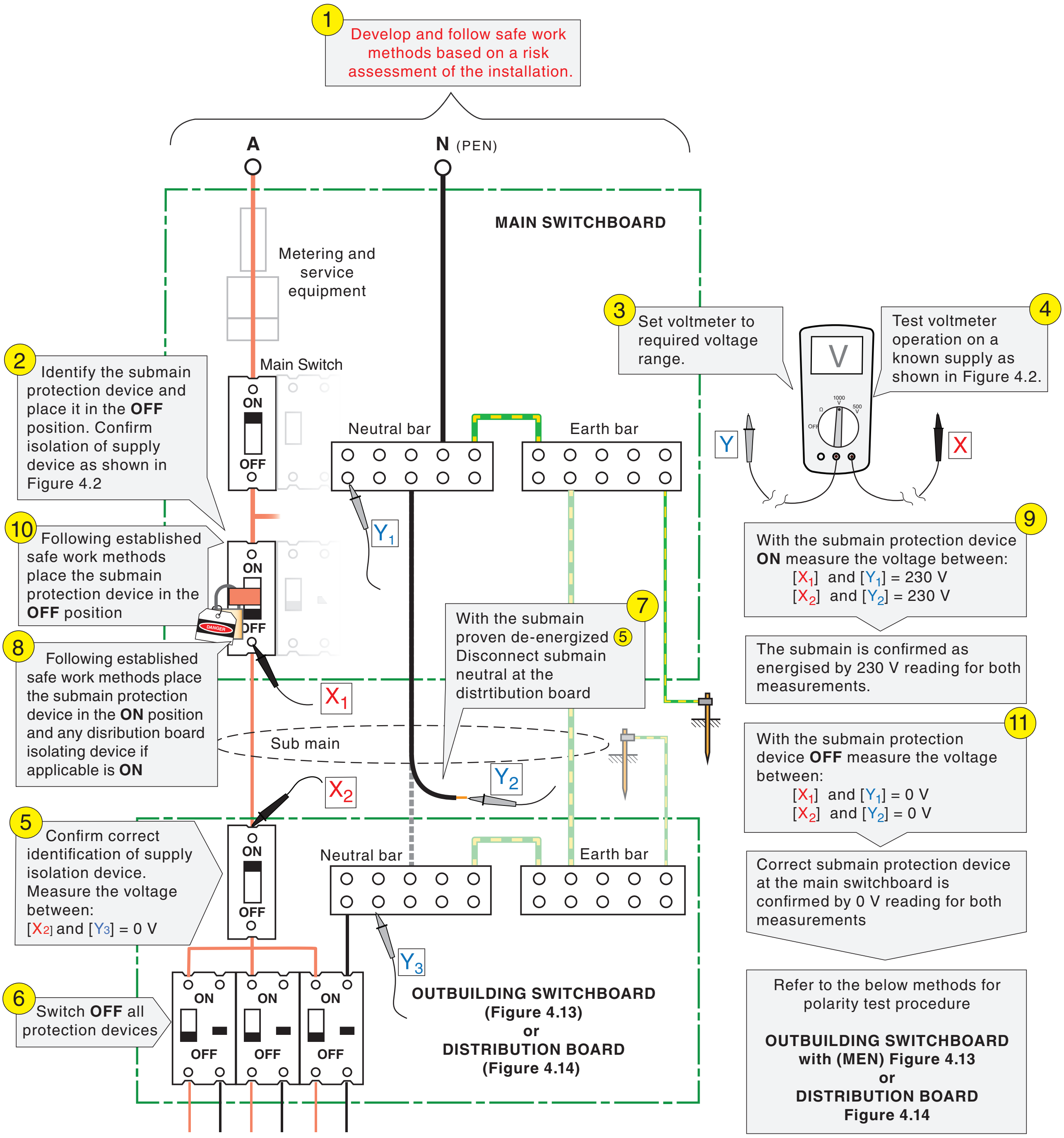
NOTE 1 Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

NOTE 2 A light point can be at a ceiling rose, lamp holder, socket, coupler or a directly connected luminaire.

Figure 4.11 — Polarity test of switch — Circuit isolated

4.6.5.7 Preparation for a polarity test of an energized submain

Figure 4.12 shows a test method for confirming the submain isolation device has been correctly identified before undertaking polarity testing of energized submains.

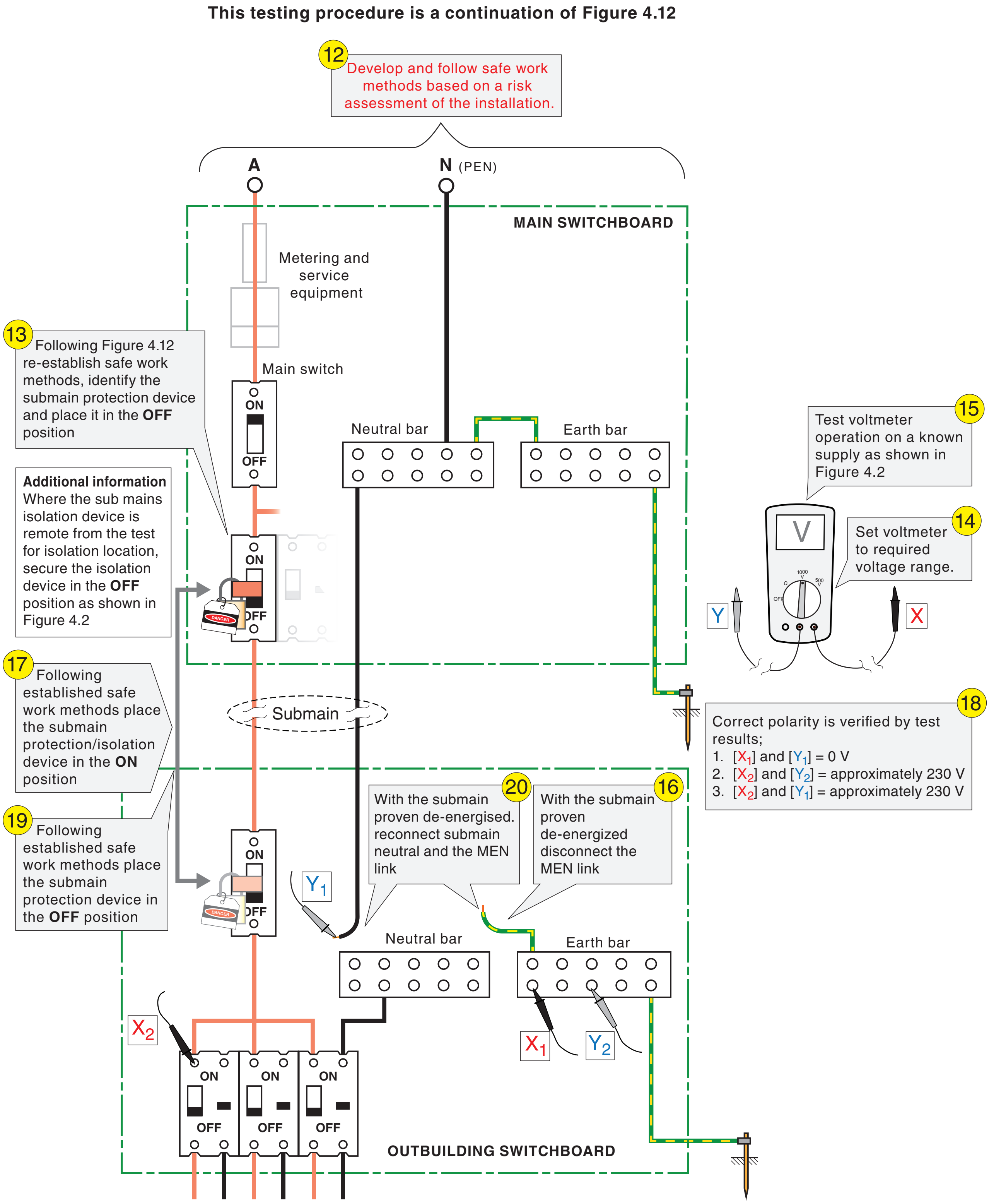


NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.12 — Prepare for polarity test of energized submains – Confirm correct identification of protection device

4.6.5.8 Testing polarity of energized submains to an outbuilding with MEN connection

Figure 4.13 shows a method of testing the polarity of submains with an MEN connection at an outbuilding and when supply is connected to the installation.

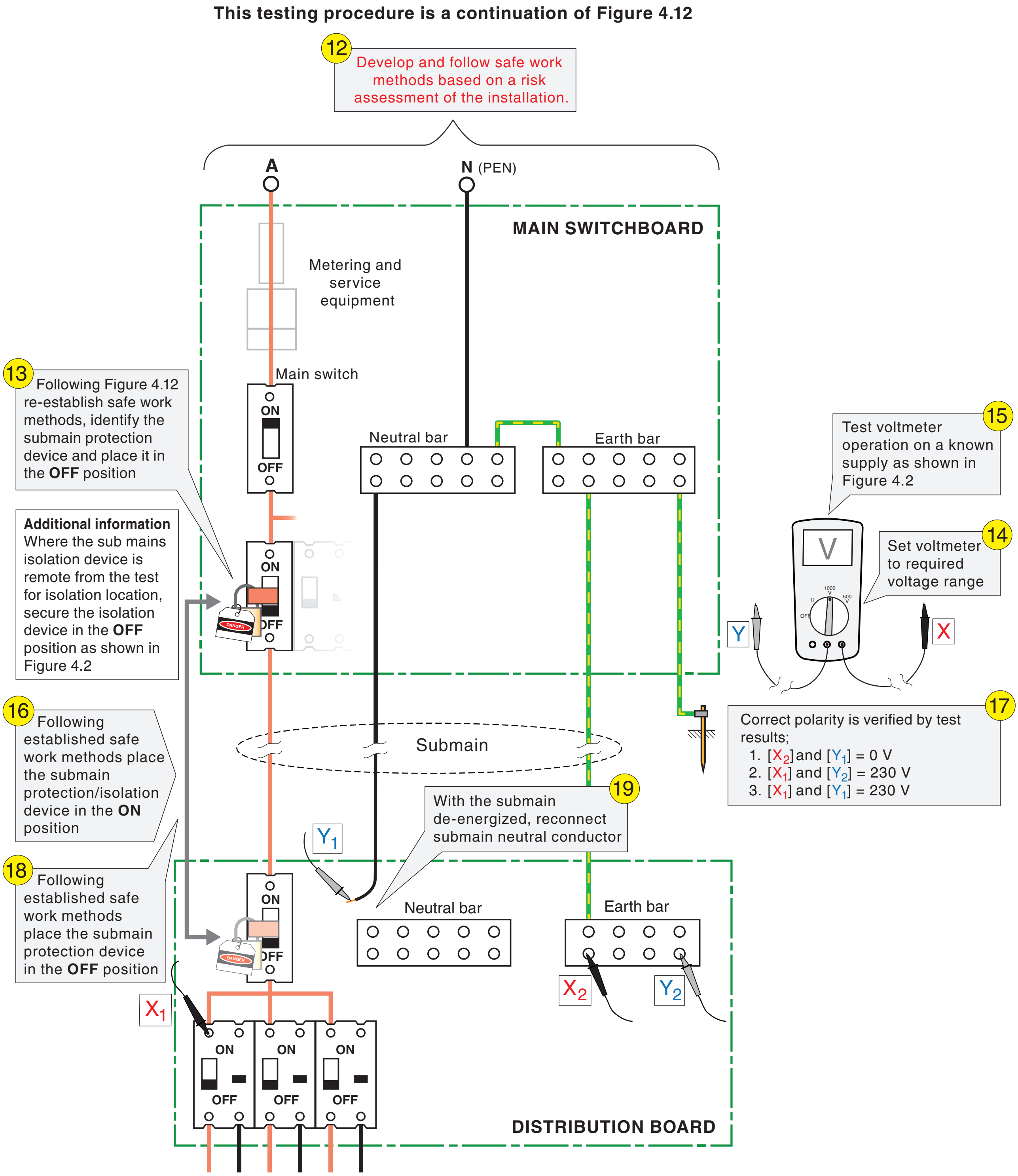


NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.13 — Polarity test of energized submains to an outbuilding with MEN connection

4.6.5.9 Polarity test of energized submains incorporating protective earthing conductor

Figure 4.14 shows a method of testing the polarity of energized submains incorporating a protective earthing conductor.

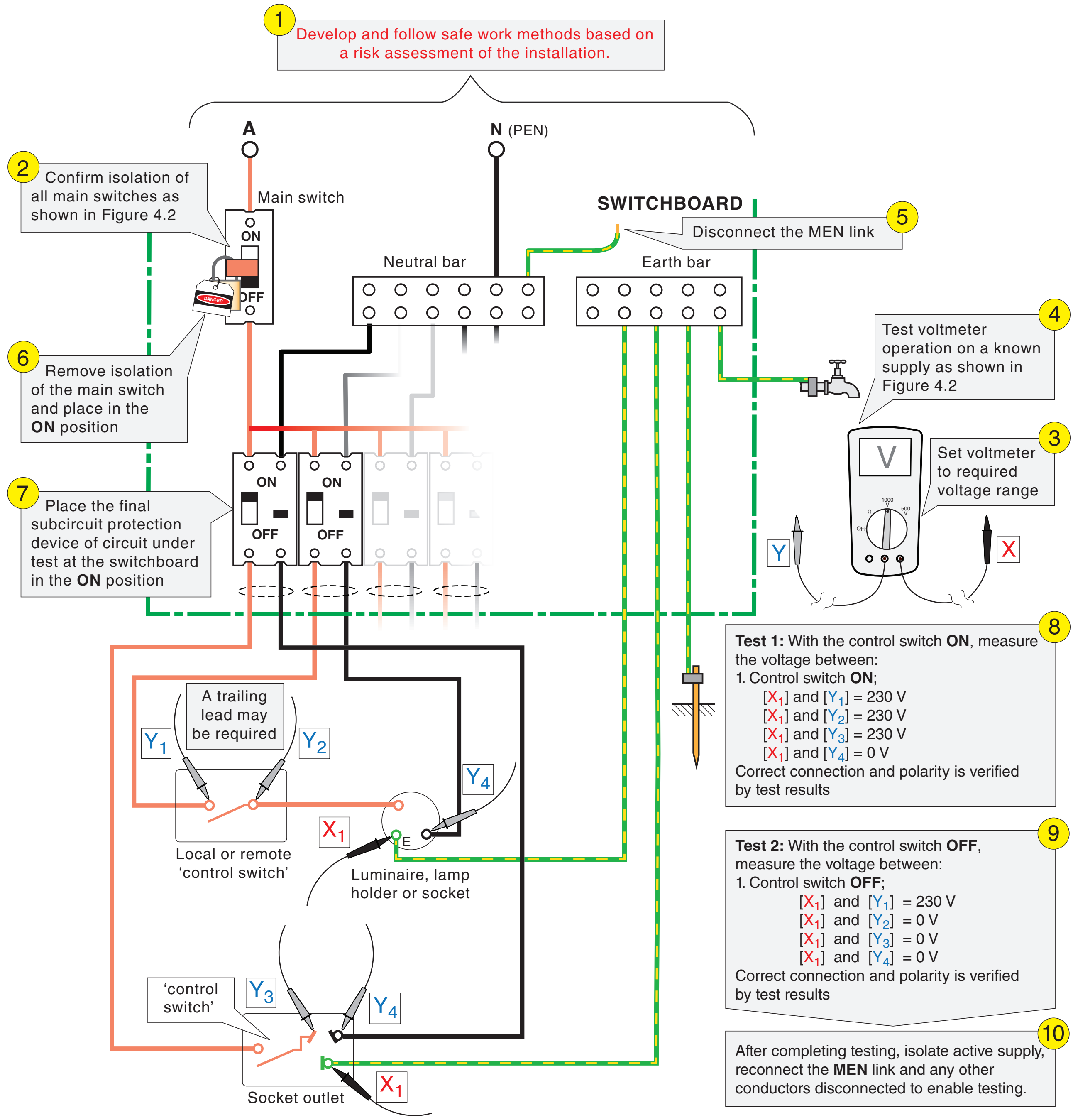


NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.14 — Polarity test of energized submains with protective earthing conductor

4.6.5.10 Polarity test of energized switch or socket outlet

Figure 4.15 shows a method of testing the polarity of a single pole switch or socket outlet when the circuit is energized.



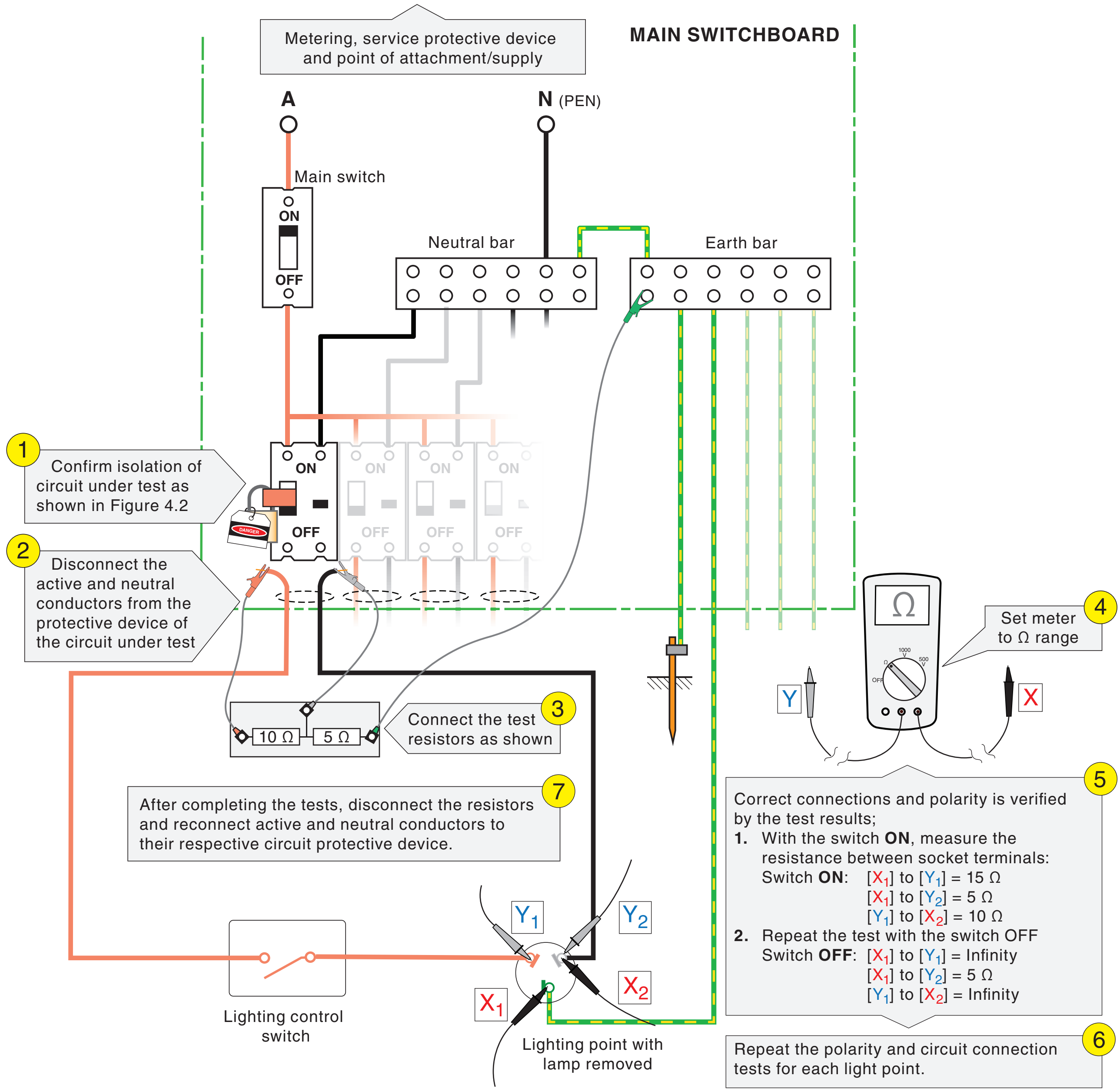
NOTE 1 Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

NOTE 2 When a trailing lead is used, consider the resistance of the trailing lead.

Figure 4.15 — Polarity test of switch or socket-outlet — Circuit energized

4.6.5.11 Polarity and circuit connections test of lighting points using resistors

Figure 4.16 shows a method of testing the polarity and circuit connections of lighting points using resistors with the circuit isolated.



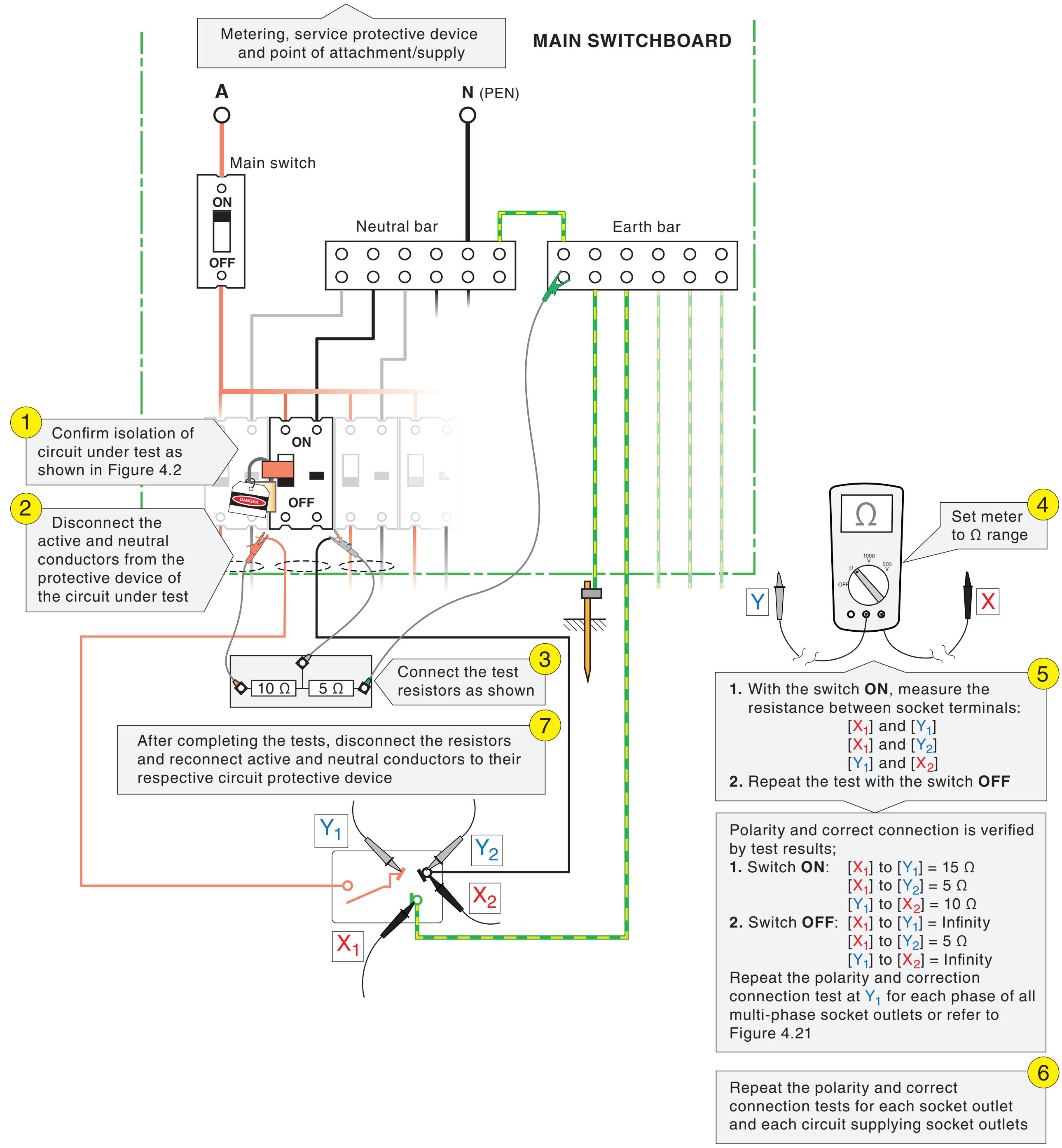
NOTE 1 Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

NOTE 2 A light point can be at a ceiling rose, lamp holder, coupler or a directly connected luminaire.

Figure 4.16 — Polarity test and correct connection of lighting points using resistors — Circuit isolated

4.6.5.12 Polarity test of socket-outlet subcircuits using resistors

Figure 4.17 shows a method of testing the polarity and circuit connections of socket-outlets, with circuit isolated, using resistors.

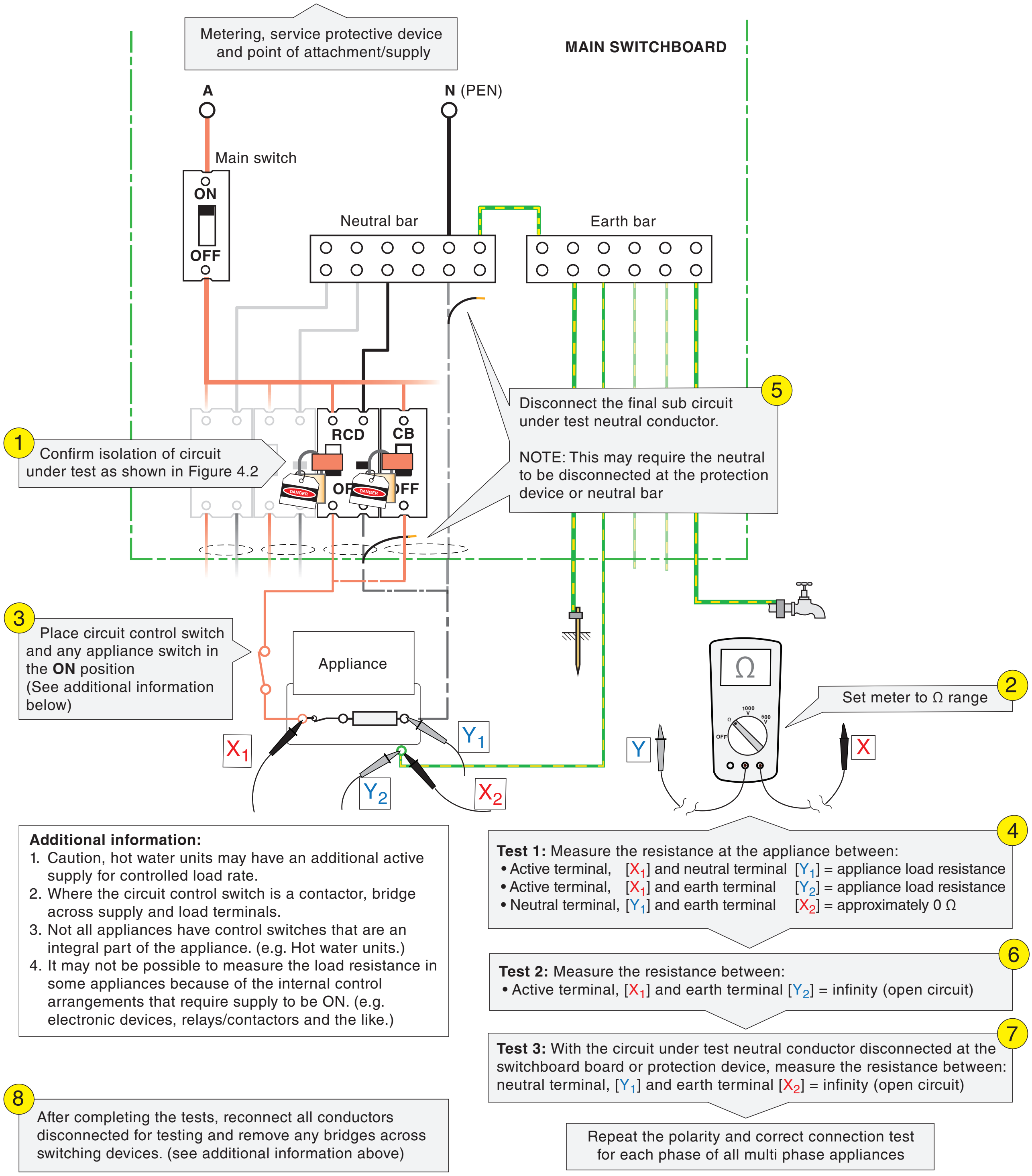


NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.17 — Polarity test and correct connection of socket-outlet subcircuits using resistors — Circuit isolated

4.6.5.13 Polarity test of points supplying appliances

Figure 4.18 shows a method of testing the polarity and circuit connections of points supplying appliances with the circuit isolated.

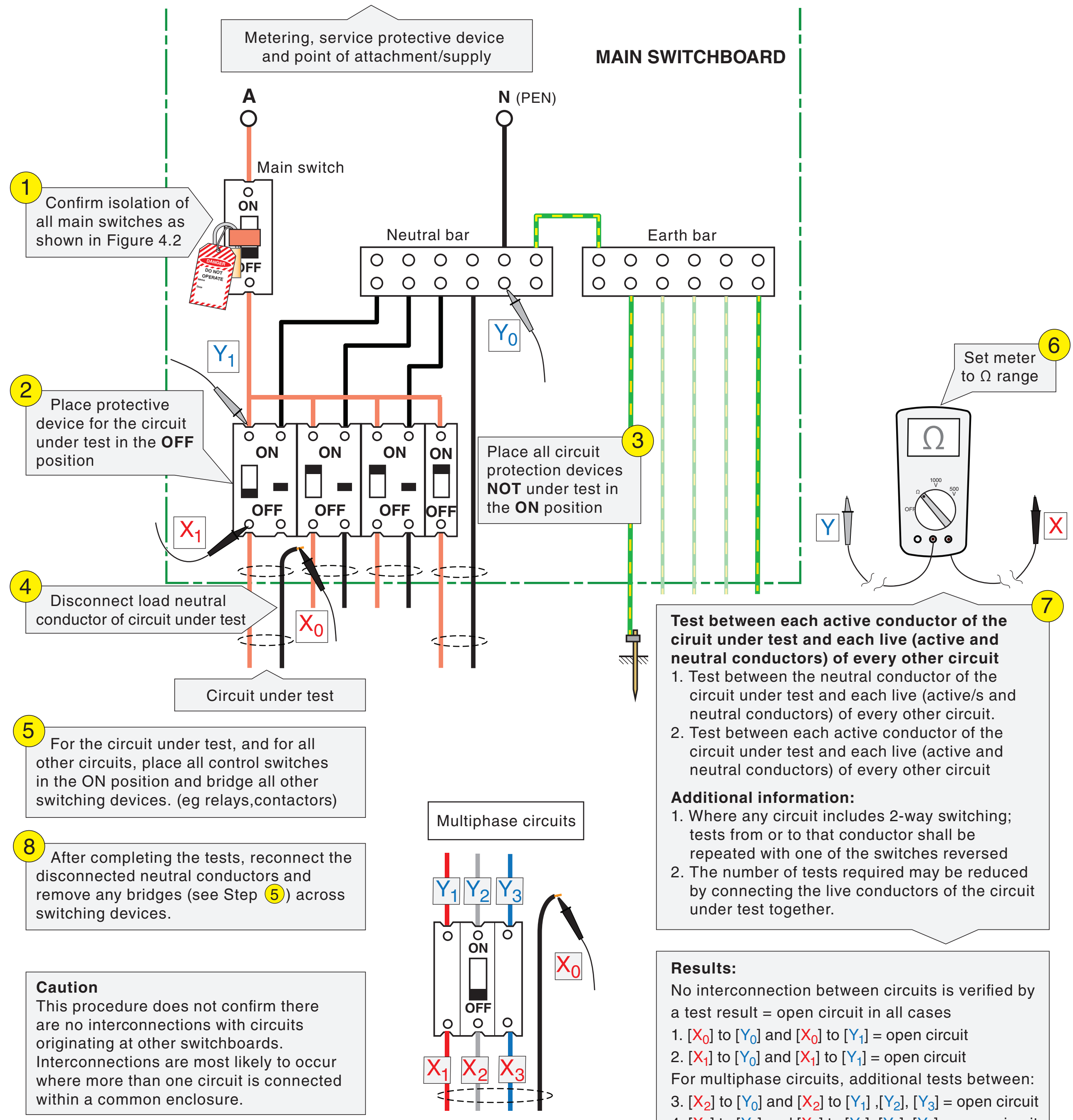


NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.18 — Polarity test and correct circuit connection of appliance subcircuits — Circuit isolated

4.6.5.14 Interconnection test between conductors of different circuits

Figure 4.19 shows a method of testing for interconnections between conductors of different circuits with all circuits isolated.



NOTE Numbers indicate the sequence of safety preparation, test preparration, tests and compliant results and reinstatement after completion.

Figure 4.19 — Interconnection test between conductors of different circuits — Circuits isolated

4.7 Test of phase sequence of multi-phase socket outlets

4.7.1 General

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

4.7.2 Considerations

Testing considerations for socket outlets include the following:

(a) Testing with circuit isolated, as follows:

(i) Perform IR test between earth and the circuit conductors and then between conductors to ensure the conductors are electrically isolated from each other.

(ii) Bridge across the line and load terminal for switching devices such as contactors and electronic control equipment that may contain contactors/relays.

(iii) Disconnect the load terminals at the permanently connected consumer equipment.

(b) Testing with circuit energized, as follows:

(i) Using a phase rotation meter, connect/clamp the test probes in accordance with the test instrument manufacturer's instructions and record the test result.

(ii) If the circuit under test has phase sensitive equipment connected (e.g. roller door, motor etc.) and provided the rotation result is correct, energize the equipment and check the operation is in the correct direction of travel.

4.7.3 Requirements

Phase sequence testing of socket outlets is carried out to ensure multi-phase equipment such as multi-phase motors and semiconductor-controlled equipment operates in a predictable manner.

4.7.4 Results

The polarity and correct circuit connection testing shall show that all active, neutral and protective earthing conductors in the electrical installation are correctly connected to the corresponding terminals of electrical equipment so that all fixed socket-outlets of the same type for multiphase supplies are connected so the phase sequence is the same throughout the installation.

Phase sequence testing of socket outlets shall show a consistent phase polarity across all multi-phase socket-outlets of the same type of the installation on the circuit and be compatible with the operational requirements of connected consumer equipment.

4.7.5 Procedures

4.7.5.1 Figures

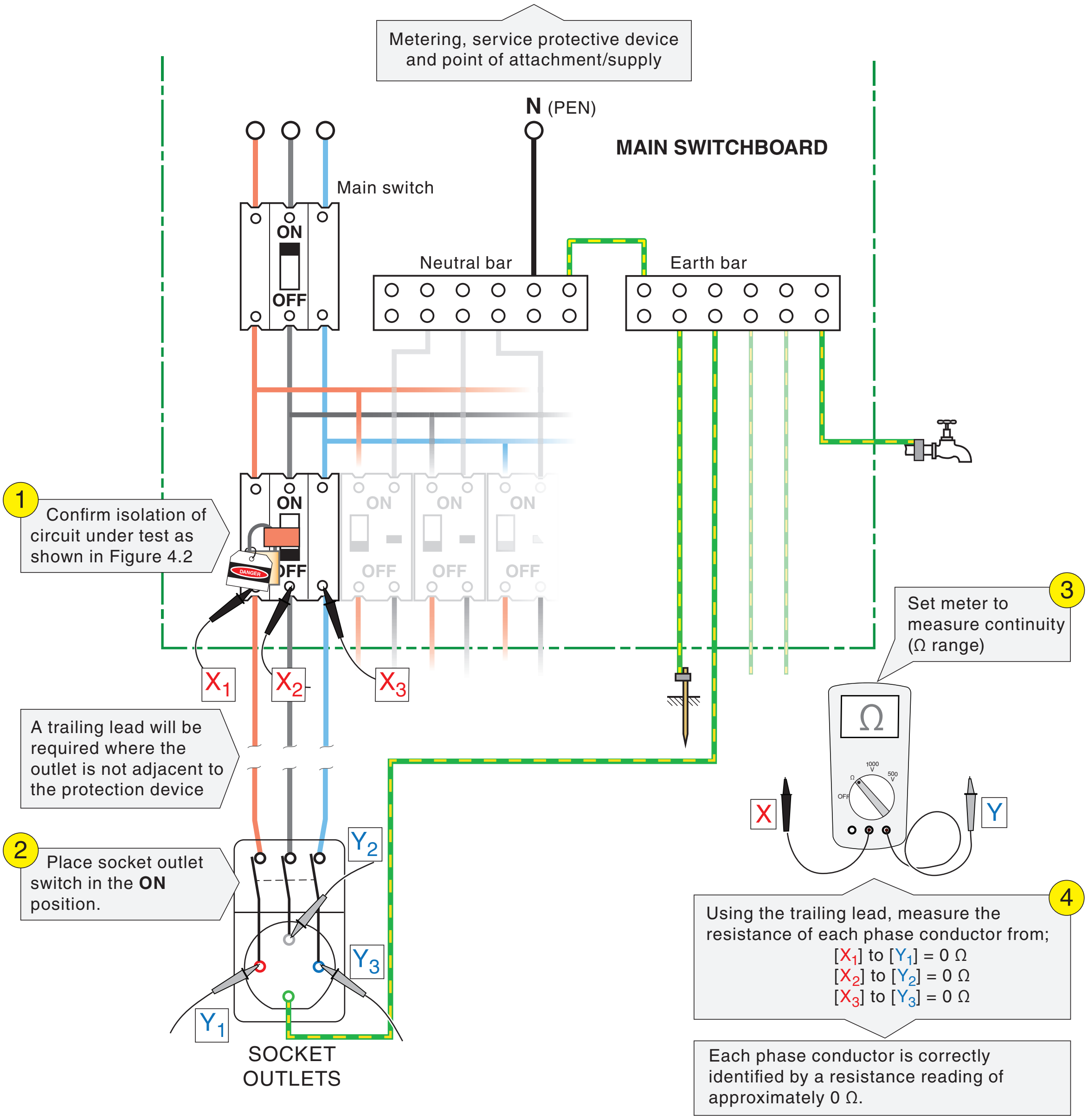
Tests for phase sequences of socket outlets are shown in Table 4.4.

Table 4.4 — Tests for polarity and correct circuit connections

Figure no.	Figure title
Figure 4.20	Phase sequence check for socket outlets (continuity method) — Circuit isolated
Figure 4.21	Check of polarity and phase sequence for socket outlets (resistor method) — Circuit isolated
Figure 4.22	Check phase sequence using a phase rotation test instrument — Circuit energized

4.7.5.2 Phase sequence check continuity method for socket outlets (circuit isolated)

Figure 4.20 shows the continuity method for testing the phase sequence of socket outlets with circuit isolated.



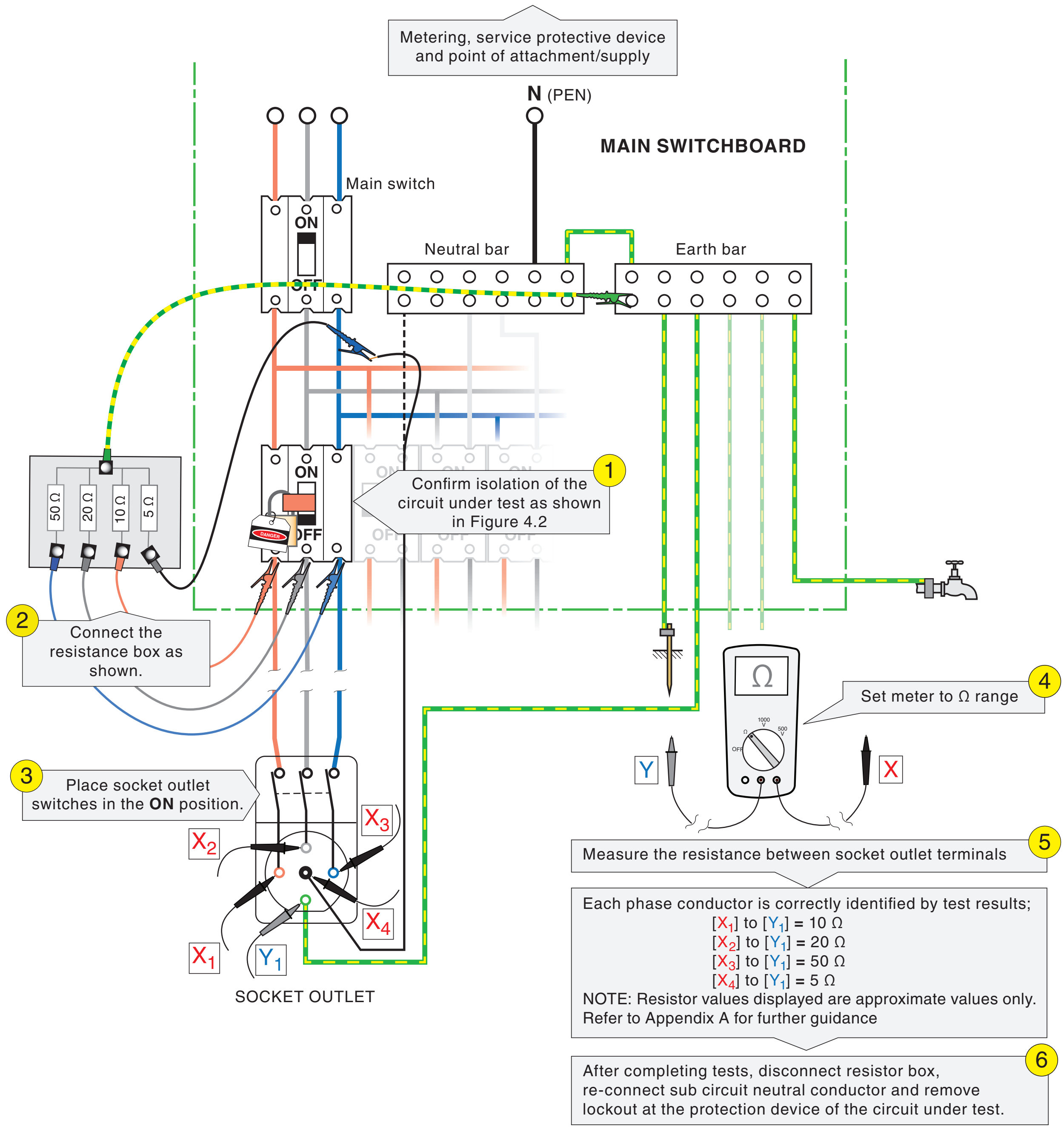
NOTE 1 Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

NOTE 2 When a trailing lead is used, the resistance of the trailing lead shall be considered.

Figure 4.20 — Phase sequence check for socket outlets (continuity method) — Circuit isolated

4.7.5.3 Phase sequence check for socket outlets — resistor method; (circuit isolated)

Figure 4.21 shows a method for testing the phase sequence of socket outlets using resistors when circuit is isolated.

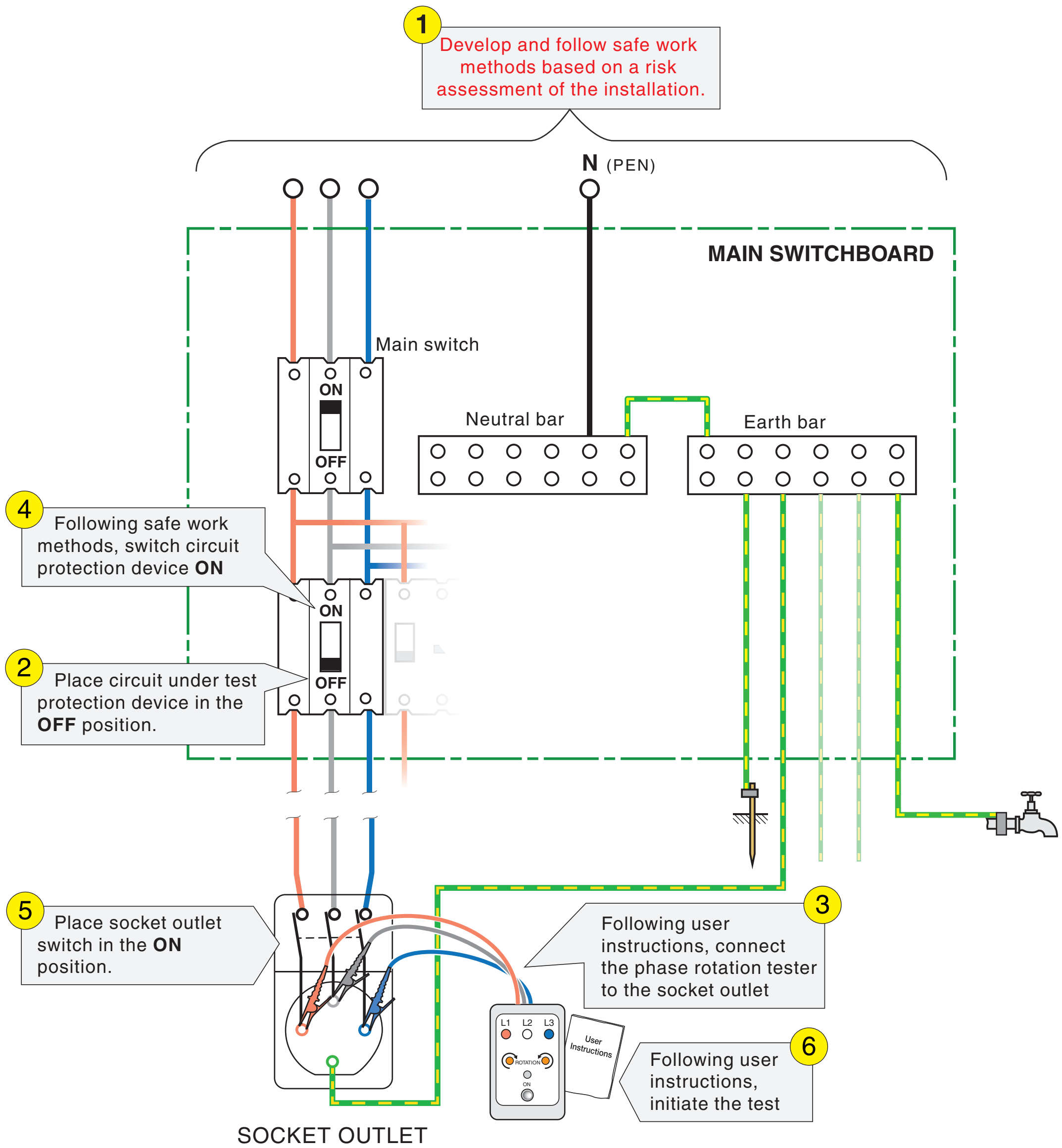


NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.21 — Check of polarity and phase sequence for socket outlets (resistor method) — Circuit isolated

4.7.5.4 Phase sequence check for socket outlets — Using a phase rotation test instrument (circuit energized)

Figure 4.22 shows a method for testing the phase sequence of socket outlets using a phase rotation test instrument with the circuit energized.



NOTE Test sequence numbers follow procedures for safety and test preparation, conducting tests as well as the results that verify compliance and finally a reminder to reinstating the installation after testing is completed.

Figure 4.22 — Check phase sequence using a phase rotation test instrument — Circuit energized

4.8 Earth fault-loop impedance

4.8.1 General

The earth fault-loop impedance (EFLI) 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.

The requirement to ensure the circuit protection device operates applies to all circuits within an electrical installation that use automatic disconnection of supply as the means of fault protection. For circuits that use a combined neutral and protective earthing (PEN) conductor; the PEN conductor will be the earthing conductor for the purpose of calculating the EFLI.

Clause 4.8.2 covers the alternate methods of testing that the earth fault-loop impedance is sufficiently low to ensure automatic operation of the protective device within a specified disconnection time.

The earth fault-loop in an MEN system comprises the following parts, starting and ending at the point of fault (see Figure 4.23):

(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) or the PEN conductor, between the main neutral terminal or bar and the neutral point at the transformer (the earth return path RG to RB via the general mass of earth 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.

(d) The active conductor as far as the point of the fault.

The test in Clause 4.8.2.3 provides the impedance of the entire fault-loop; however it can only be carried out where supply is available.

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

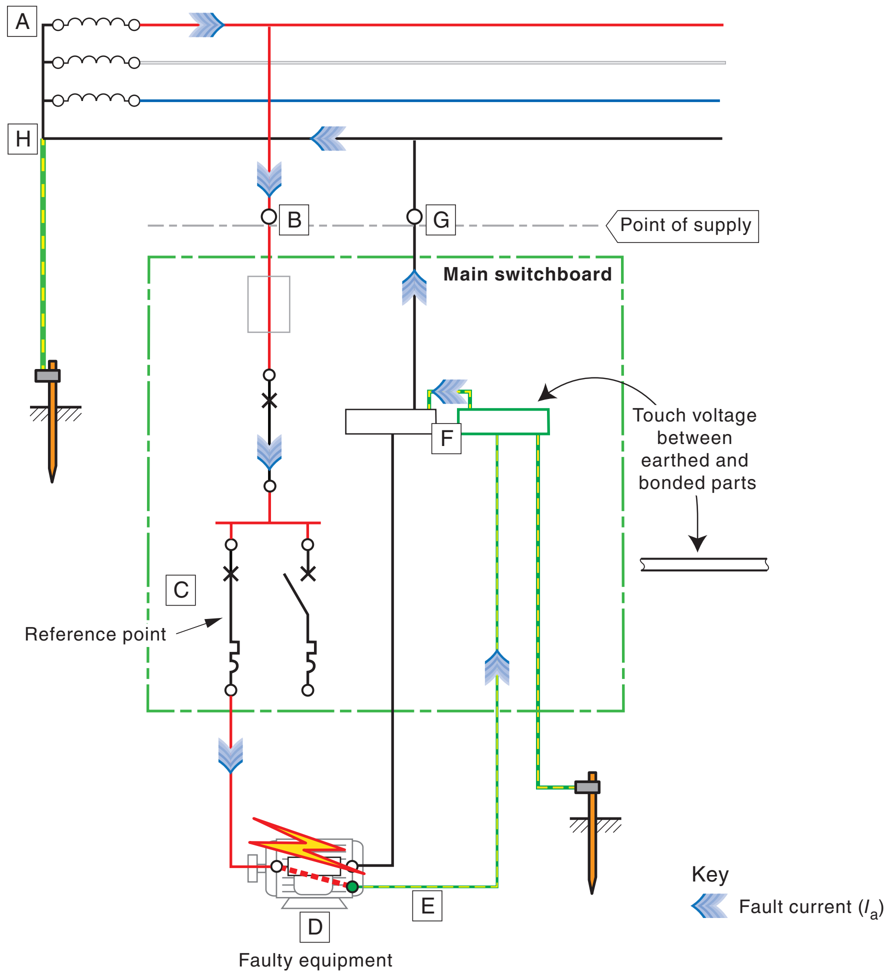
(i) Conductors upstream or “external” to the reference point; and

(ii) Conductors downstream or “internal” to the circuit, from the reference point, where the reference point is the overcurrent protective device for the circuit.

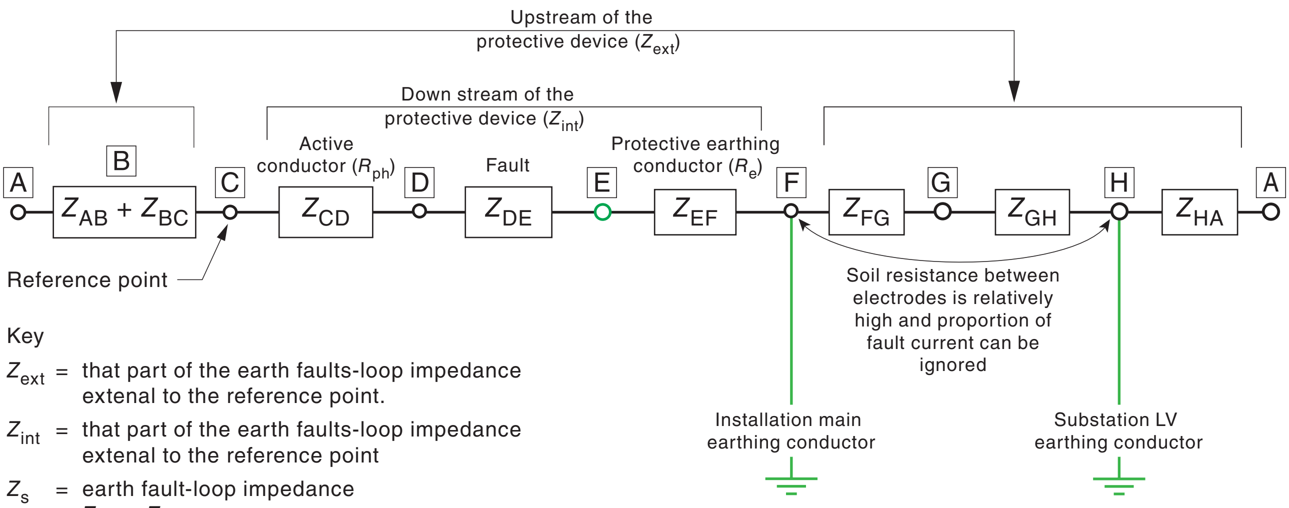
The test in Clause 4.8.2.3 provides a result for the “internal” part only. It relies on the assumption that 80 % of the EFLI is in this part, with 20 % being in the “external” part. Refer to AS/NZS 3000 for additional information.

For installations, that have substations on site there is only the “internal” downstream component to be considered.

Figure 4.23 shows the fault current path for an active to earth fault, where the electrical installation is supplied by an external supply. For the purposes of calculations the short circuit 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:



Key

Z_{ext} = that part of the earth faults-loop impedance extenal to the reference point.

Z_{int} = that part of the earth faults-loop impedance extenal to the reference point

Z_s = earth fault-loop impedance
= $Z_{ext} + Z_{int}$

Figure 4.23 — MEN system showing earth fault current path

4.8.2 Considerations

4.8.2.1 EFLI testing considerations

The EFLI can be tested by one of two methods described in Clause 4.8.5.

Clause 4.8.5.1 describes a method for testing EFLI on an energized circuit.

Clause 4.8.5.2 describes a method for testing EFLI for a circuit that has been isolated.

The following shall be taken into consideration before testing EFLI of circuits:

(a) Testing an energized circuit gives more accurate results.

(b) Testing an energized circuit at any point other than a socket outlet requires direct access to live parts, so increased risk of electric shock. A safe work method should be adopted.

NOTE 1 Refer to AS/NZS 3000 for further information on testing requirements.

NOTE 2 The use of Tables 4.5 and 4.6 of this document are for miniature circuit breakers and HRC fuses only. Where other devices are used as the protection device, the manufacturer's data shall be consulted to obtain the value of current (Ia) for calculating the resistance of the protective earthing conductor.

4.8.2.2 Supply energized

Where EFLI testing is to be carried out under energized conditions, see Clause 4.8.5.1.

The location of the protection device for the circuit being tested shall be identified. The earth fault-loop impedance for each branch of each final subcircuit shall be tested at the furthest point of each branch of the final subcircuit. This may be achieved by use of an earth loop fault impedance test instrument.

4.8.2.3 Supply isolated

EFLI testing is not specifically required for circuits supplying equipment other than socket-outlets because of the risk of electric shock when performing the test on live electrical equipment.

For a circuit that is not RCD protected and supply is not available see Clause 4.8.4.2. Where EFLI testing is to be undertaken, test to ensure the circuits are de-energized.

When testing de-energized, consider the most appropriate location to place the temporary connection (active to earth).

NOTE For guidance on appropriate locations, see Figure 4.25.

4.8.3 Requirements

4.8.3.1 General

One of the following methods (Clause 4.8.3.2 or 4.8.3.3) shall be used, depending on the availability of supply.

4.8.3.2 Supply available

Where supply is available, the earth fault-loop impedance for each branch of each final subcircuit shall be determined using an earth fault-loop impedance tester at the socket outlet furthest from the supply on each branch of the final subcircuit.

The MEN connection shall be left intact.

4.8.3.3 No supply available

Where no supply is available, the total resistance (R_{phe}) of the active and protective earthing conductors of the circuit shall be measured using an ohmmeter.

Each active conductor in turn and the protective earthing conductor shall be connected together at the origin of the circuit (normally where the protective device is fitted). The resistance of each active-PEC pair shall be determined using an ohmmeter at the furthest point of each branch of the circuit.

NOTE 1 Where supply is available and the electrical installation is connected to a distribution system, the earth fault-loop impedance test is preferred in order to verify the complete earth fault-loop including the integrity of the MEN connectin and the supply neutral (PEN) conductors.

NOTE 2 Where no supply is available, the resistance method establishes the contribution of the final subcircuit to the total impedance of the full earth fault-loop.

4.8.4 Results

4.8.4.1 Testing energized circuit

Maximum values of earth fault-loop impedance shall not exceed the values shown in Table 4.5 or the value of I_a for the protective device being used in accordance with the manufacturer's data.

Table 4.5 — Maximum values of EFLI for the total circuit relating to rating of protective devices

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

[SOURCE: AS/NZS 3000:2018, Table 8.1, Notes modified.]

NOTE 1 These maximum values apply for the test procedure in Clause 4.8.2.2.

NOTE 2 See Clause 4.8 for EFL test instrument tolerances.

NOTE 3 Refer to AS/NZS 3000 for further information.

4.8.4.2 Testing isolated circuit

Maximum values of earth fault-loop resistance shall not exceed the values shown in Table 4.6 for the size of the active and earth conductors 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 4.6 were calculated using the following equation:

$$Z_S = U_o / I_a$$

where

Z_S = earth fault-loop impedance

U_o = nominal phase voltage (230 V)

I_a = current causing automatic operation of 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

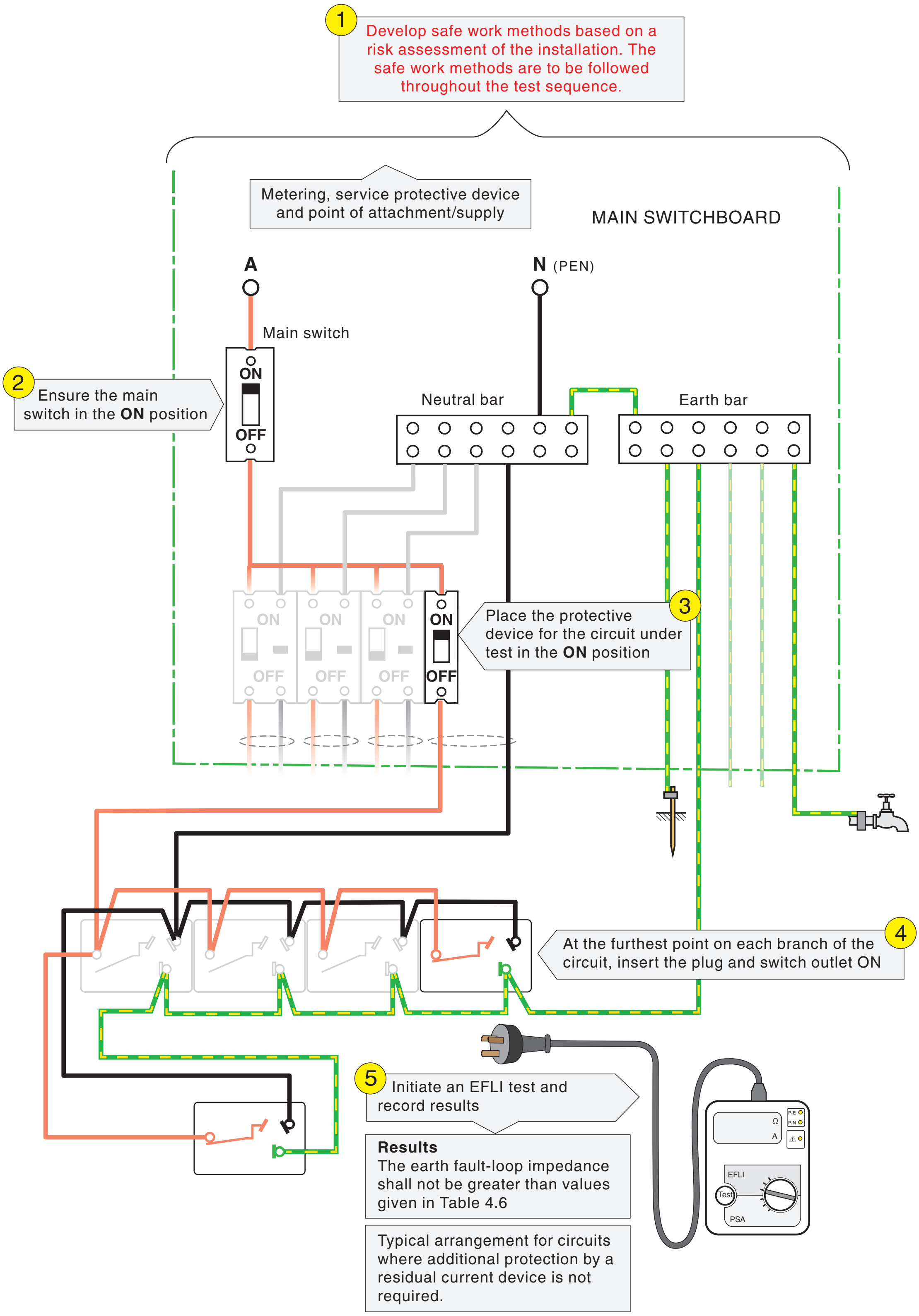
I_a for fuses are approximate mean values from AS 60269.1

The circuit protection devices Type B, C and D are only applicable to miniature circuit breakers. For moulded case and ACBs, the manufacturer's data sheet is to be consulted to obtain the I_a for 0.4 s.

4.8.5 Procedures

4.8.5.1 Circuit energized

Test for EFLI with supply connected using an earth fault-loop impedance test instrument is shown in Figure 4.24.



NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.24 — Measuring EFLI of an individual circuit — Circuit energized

4.8.5.2 Supply not available

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

(a) Connect the active conductor and protective earthing conductors of the circuit under test together at the origin of the circuit (normally where the protective device is fitted). See Figure 4.25.

(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.

Measure the combined resistance of the active and protective earthing conductors.

NOTE 1 A low ohm range meter is suitable to undertake this task; refer to Clause 2.1.

NOTE 2 The following Table is reproduced from AS/NZS 3000:2018 Table 8.1.

Table 4.6 — Maximum values of resistance of final subcircuits

Protective device rating, A	Conductor size		Circuit breakers						Fuses			
			Disconnection times									
	Active mm²	Earth mm²	0.4 s						0.4 s		5.0 s	
			Type B MCB		Type C MCB		Type D MCB		HRC fuses			
			R_{phe}	R_e	R_{phe}	R_e	R_{phe}	R_e	R_{phe}	R_e	R_{phe}	R_e
			Maximum final subcircuit resistance, Ω									
6	1.0	1.0	6.1	3.1	3.3	1.6	2.0	1.0	7.4	3.7	9.8	4.9
10	1.0	1.0	3.7	1.8	2.0	1.0	1.2	0.6	4.1	2.0	5.9	2.9
10	1.5	1.5	3.7	1.8	2.0	1.0	1.2	0.6	4.1	2.0	5.9	2.9
16	1.5	1.5	2.3	1.2	1.2	0.6	0.7	0.4	2.0	1.0	3.2	1.6
16	2.5	2.5	2.3	1.2	1.2	0.6	0.7	0.4	2.0	1.0	3.2	1.6
20	2.5	2.5	1.8	0.9	1.0	0.5	0.6	0.3	1.3	0.7	2.3	1.1
25	4.0	2.5	1.5	0.9	0.8	0.5	0.5	0.3	1.0	0.6	1.7	1.1
32	4.0	2.5	1.2	0.7	0.6	0.4	0.4	0.2	0.8	0.5	1.4	0.9
40	6.0	2.5	0.9	0.6	0.5	0.3	0.3	0.2	0.6	0.4	1.0	0.7
50	10.0	4.0	0.7	0.5	0.4	0.3	0.2	0.2	0.5	0.3	0.8	0.6
63	16.0	6.0	0.6	0.4	0.3	0.2	0.2	0.1	0.4	0.3	0.6	0.4

[SOURCE: AS/NZS 3000:2018, Table 8.2.]

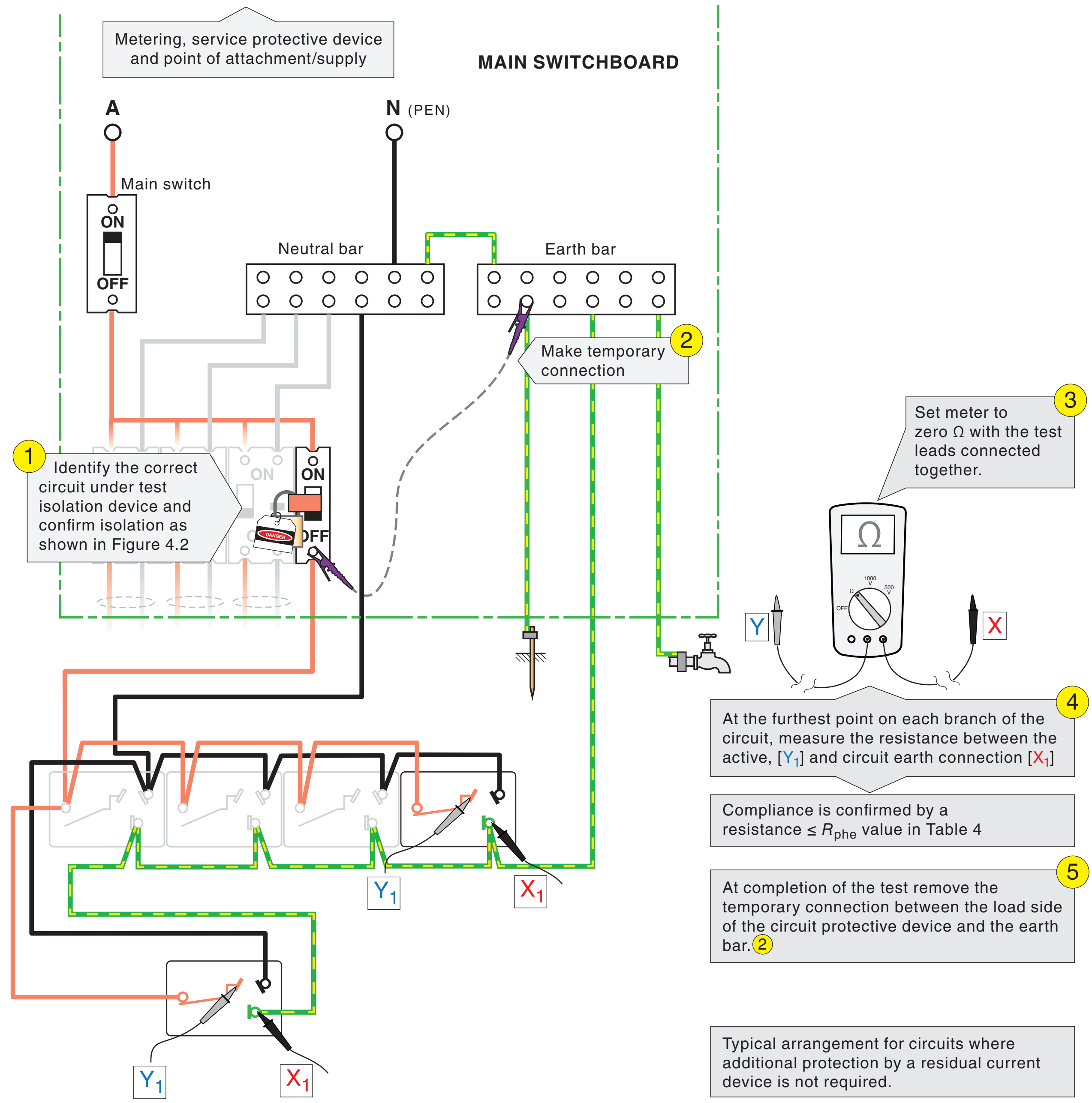
NOTE 1 The values, which have been rounded to one decimal place, are calculated using R_{phe} as 64 % × Z_s in AS/NZS 3000:2018 Table 8.1.

NOTE 2 64 % takes into account deemed reduction values of 80 % × Z_s (typical value for the final subcircuit). 80 % assumes that conductor temperature for Z_s at rated current is 70 °C and for tests at no load current is 20°C).

NOTE 3 AS/NZS 3000:2018 Table B1 gives earth fault-loop route lengths for final subcircuits will satisfy the requirements of AS/NZS 3000:2018 Clauses 1.5.5.3, 5.7 and 8.3.9 for automatic disconnection of supply for the conditions of AS/NZS 3000:2018 Clause B5.2.2. These values comply with this table and may be used as an alternative to resistance values.

NOTE 4 In addition, AS/NZS 3000:2018 Table B1 also includes final subcircuit route length for voltage drops complying with AS/NZS 3000:2018 Clause 3.6.2.

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



NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.25 — Measuring internal EFLI of an individual circuit — Supply not available

4.9 Confirming function of residual current devices

4.9.1 General

Testing the operation of residual current devices (RCDs) is carried out to confirm that —

(a) the RCD has been correctly installed; and

(b) when operated, the RCD disconnects supply from the protected circuit(s)

NOTE 1 The term RCD includes all devices having the function of detecting and reacting to the presence of residual currents, including where residual current functions are performed by an add-on device attached to and controlling another device. The test methods in this clause are designed for integrated devices, such as residual current circuit breaker with overcurrent protection (RCBOs); where the detection, reaction, and resulting disconnection are all performed within one device. Where other types of RCDs are to be tested; the same test method may be used but test equipment may need to be connected to different terminals.

NOTE 2 Confirmation that the correct type and rating of RCD has been selected is a matter of visual inspection, in accordance with Section 2.

NOTE 3 Guidance on the suitability of types of RCD is contained in AS/NZS 3000

4.9.2 Considerations

Testing the operation of RCDs requires supply to be available either from the normal supply or by a portable independent source as outlined in Clause 2.2.2.6

> **WARNING: TESTING THE OPERATION OF RCDS REQUIRES ENERGIZING THE RCD AND THE CIRCUIT(S) IT PROTECTS. ACCORDINGLY, EXTREME CARE IS NEEDED TO ENSURE THAT THIS TEST CAN BE (AND IS) CARRIED OUT SAFELY.**

Testing RCDs does not provide a means of checking —

(a) the continuity of the main earthing conductor;

(b) any earth electrode or other means of earthing; or

(c) any part of the associated electrical installation earthing other than the circuit under test.

Any standing leakage current on the protected circuit(s) may add or subtract vectorially from the test current; causing either nuisance tripping or delayed operation. To reduce such effects, the protected circuits should be carrying no load when tested.

The wave form of a fault current to earth can affect the operation of both an RCD and test equipment, in particular, circuits utilizing a variety of semiconductor devices. The suitability of an RCD shall be confirmed in accordance with Clause 3.3(c)(ix).

To avoid damage to test equipment; where the source of supply is other than smooth sinusoidal, such as an inverter, the advice of the manufacturer of the RCD test instrument should be sought.

4.9.3 Requirements

4.9.3.1 Mandatory tests

Testing for earth continuity in accordance with Clause 4.4 shall be carried out before the tests in this Clause.

The correct installation and operation of each RCD shall be tested by —

(a) confirming correct connection to supply, in accordance with Clause 4.9.5.2; and

(b) initiating operation of the RCD, in accordance with Clause 4.9.5.3; and

(c) confirming that operation of the RCD has the effect of disconnecting all conductors of the circuit that are required to be disconnected, in accordance with Clause 4.9.5.3.

Where the manufacturer's instructions specify any particular procedure for functional testing of the RCD, that procedure shall be undertaken in addition to the testing specified by this clause.

NOTE Operation under conditions other than sinusoidal current need not be tested. Provided the markings on the RCD indicate that it is of an appropriate Type for the circuit, it is sufficient to confirm operation on sinusoidal current.

4.9.4 Results

Results of testing shall demonstrate that all of the following conditions are met:

(a) The RCD has been correctly installed.

(b) The RCD operates when a residual current of approximately the rated value is present on the protected circuit.

(c) When operated, the protected circuit(s) are disconnected from supply to the required degree (all actives, or all actives plus neutral).

4.9.5 Procedures

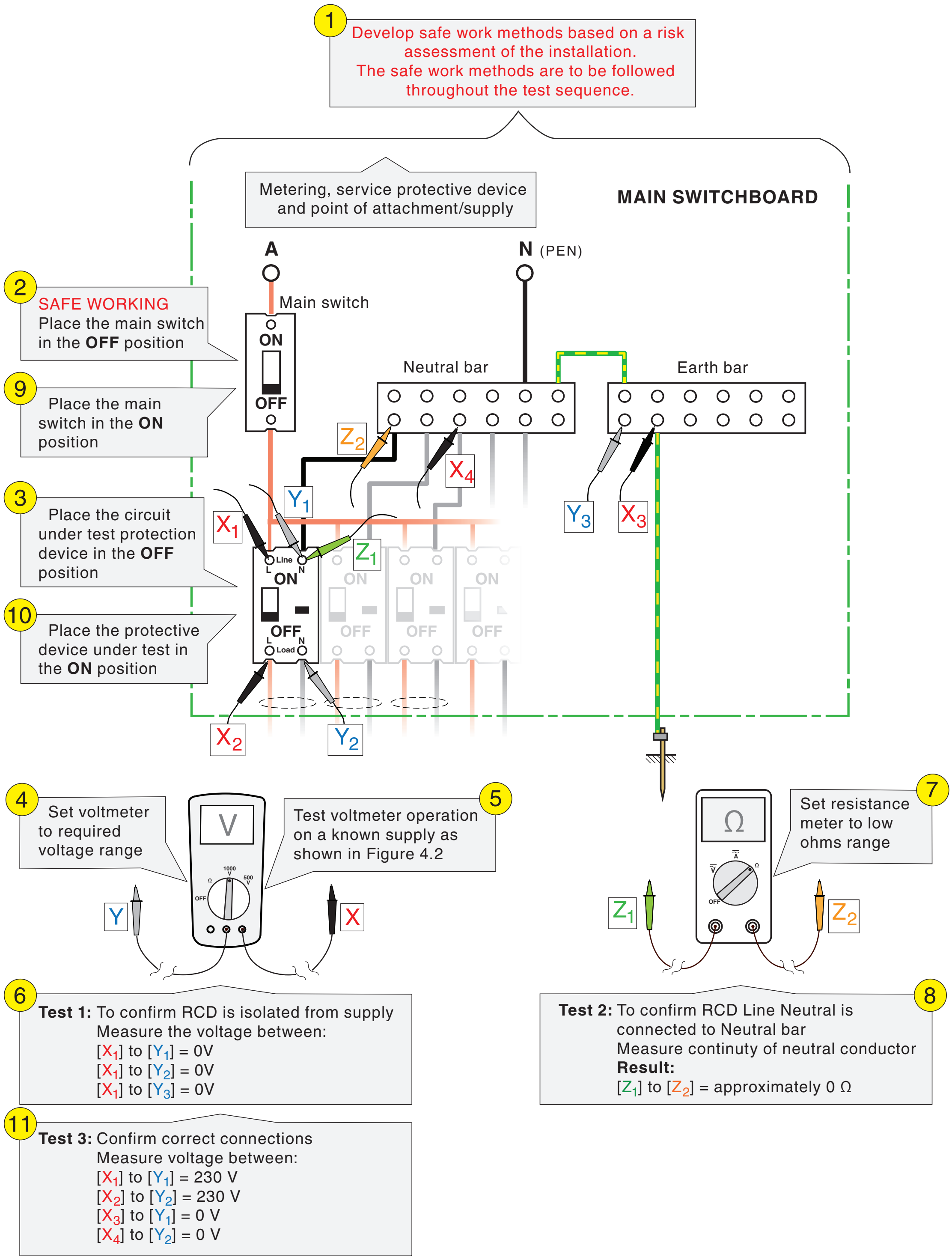
4.9.5.1 General

Where supply to an installation is not available an independent 230 V 50 Hz source of supply is needed.

4.9.5.2 Confirming correct connection to supply

The preliminary procedure for testing and checking that RCDs are correctly connected at a switchboard is shown in Figure 4.26.

NOTE This procedure confirms, by testing, the correct connections confirmed by the visual inspection in accordance with Clause 3.3(c)(v).



NOTE 1 Numbers indicate the sequence of safety preparation, tests and compliant results and reinstatement after completion

NOTE 2 RCDs may be an RCBO (as illustrated) or a separate RCD in series with one or more over-current protective devices

NOTE 3 This procedure applies to each individual RCD protected circuit and each phase of a three phase protected circuit.

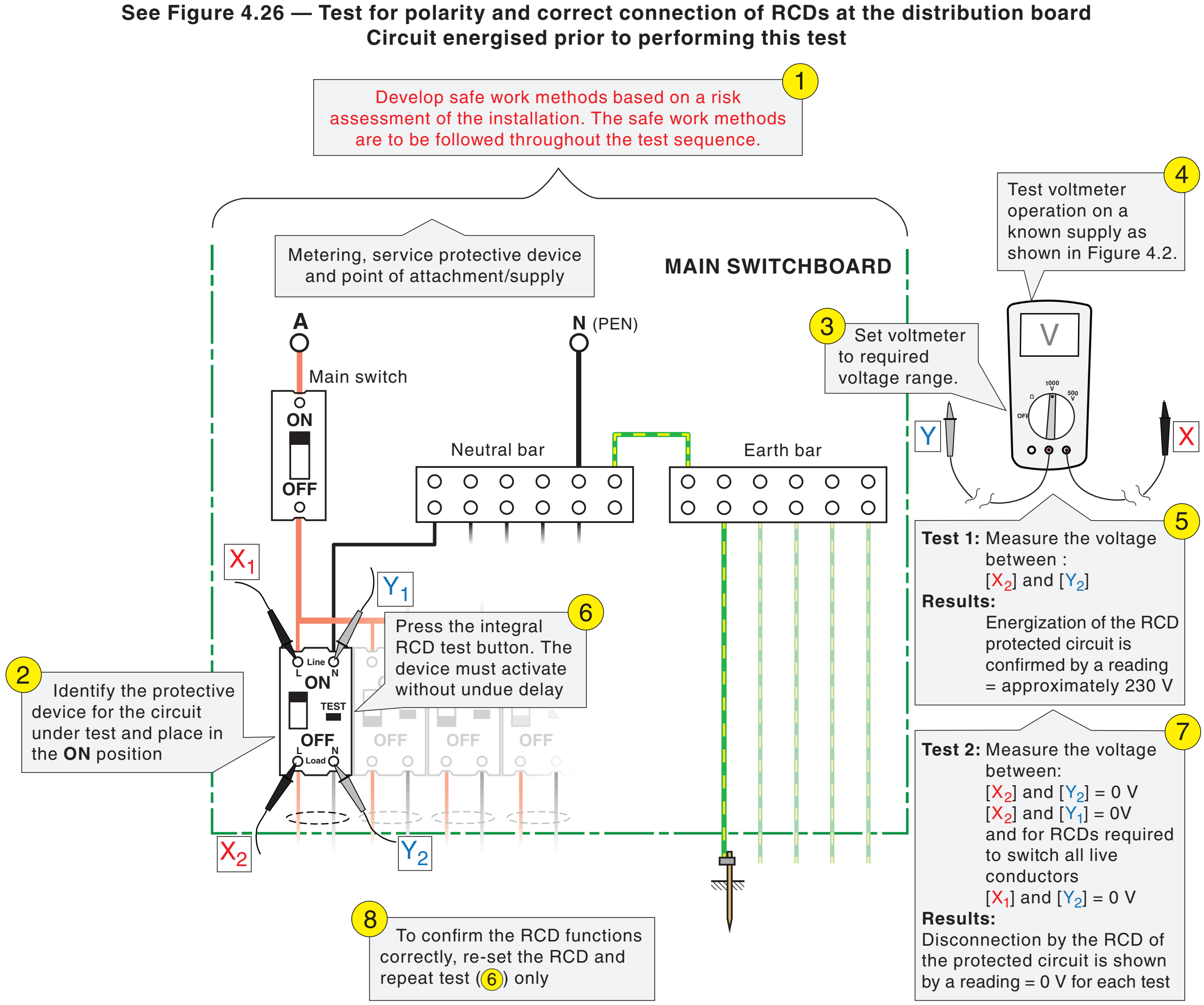
Figure 4.26 — Test for correct connection of RCDs at the distribution board — Circuit energized

4.9.5.3 Confirming operation of RCD and disconnection of protected circuit(s)

Procedure for testing the correct operation of RCDs and disconnection of protected circuits using the integral test button is shown in Figure 4.27.

Procedures for testing the correct operation of RCDs at the termination of installation wiring at a socket outlet and an appliance using *IΔn* test instrument are given in Figures 4.28 and 4.29.

NOTE Use an RCD test instrument with trip time facility where test of operating time is required by a relevant Standard.

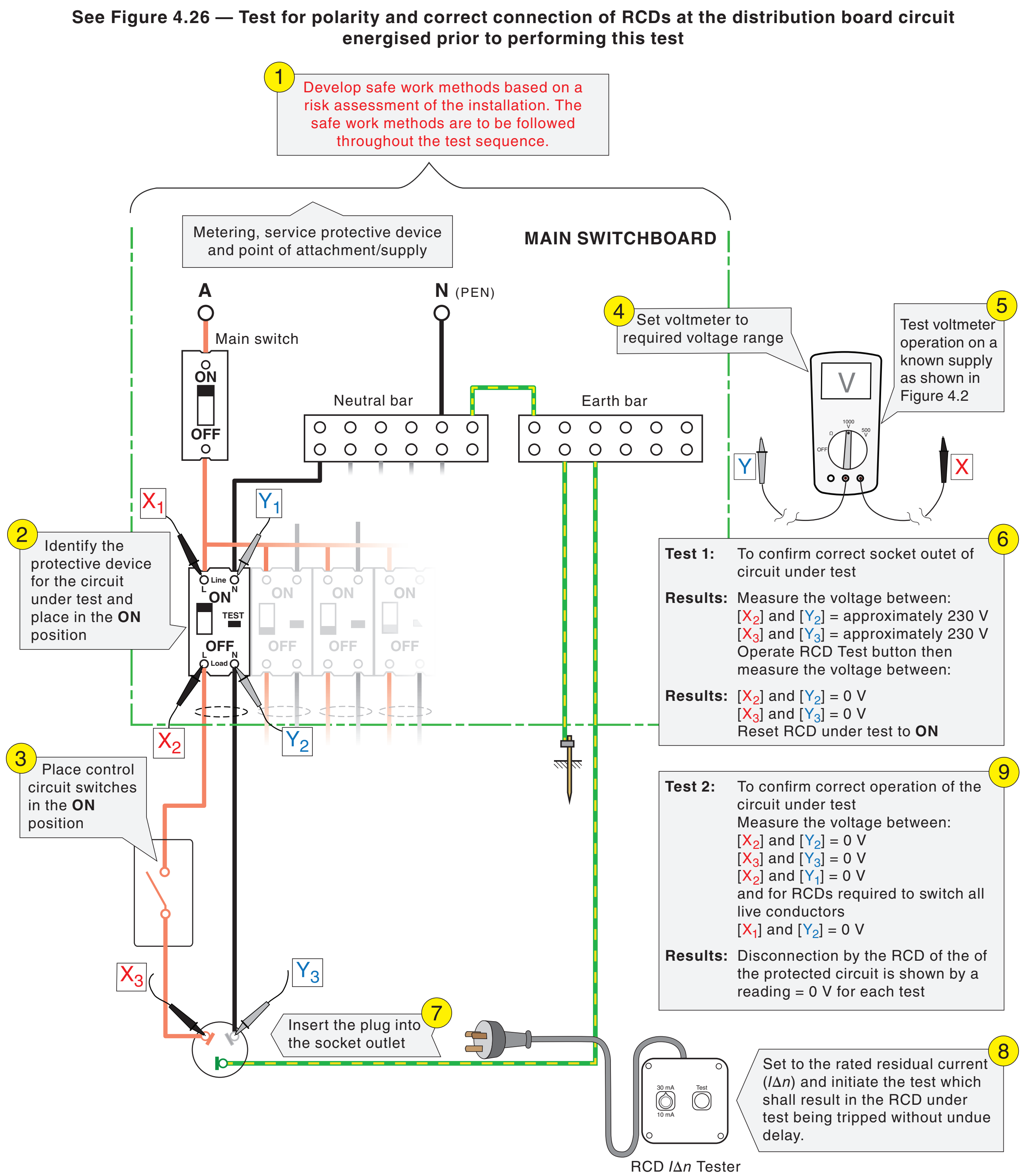


NOTE 1 Numbers indicate the sequence of safety preparation, tests and compliant results and reinstatement after completion.

NOTE 2 RCDs may be an RCBO (as illustrated) or a separate RCD in series with one or more over-current protective devices.

NOTE 3 This procedure applies to each individual RCD protected circuit and each phase of a three phase protected circuit.

Figure 4.27 — Test for correct operation of RCDs using the integral test button — Circuit energized

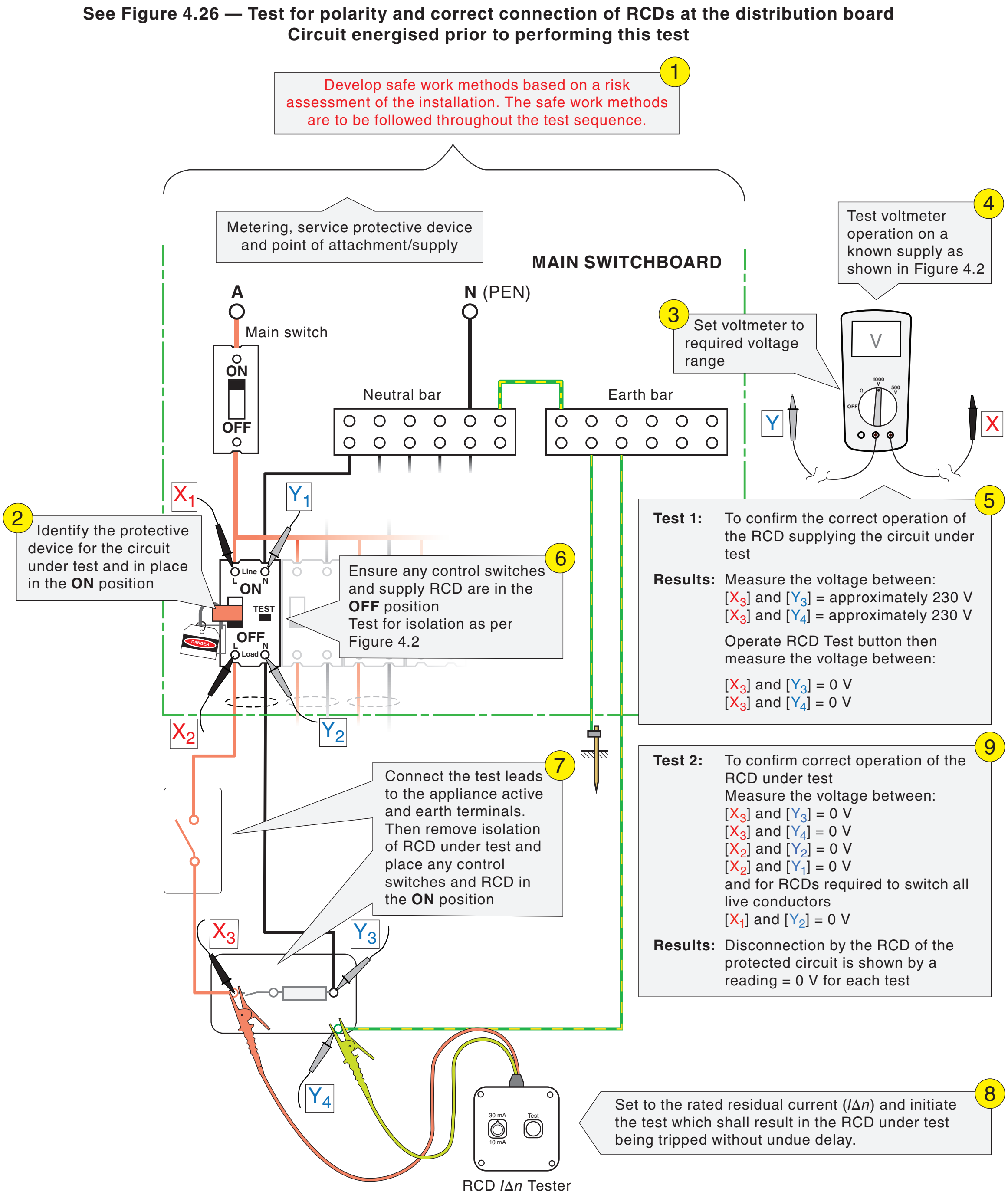


NOTE 1 Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement of completion.

NOTE 2 RCDs may be an RCBO (as illustrated) or a separate RCD in series with one or more over-current protective devices.

NOTE 3 Use RCD test instrument with trip time facility where confirmation of maximum tripping is required.

Figure 4.28 — Testing correct operation of RCDs protecting circuits terminated at a socket outlet — Circuit energized



NOTE 1 Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

NOTE 2 RCDs may be an RCBO (as illustrated) or a separate RCD in service with one or more over-current protective devices.

NOTE 3 Use RDC tester with trip time facility where confirmation of maximum tripping time is required.

Figure 4.29 — Test correct operation of RCDs using a direct connection test instrument — Circuit energized

4.10 Measuring resistance of earth electrode to general mass of earth

4.10.1 General

The following subclauses 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.

NOTE 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 minimizes the touch voltage between exposed conductive parts of the installation and grounded conductive parts).

NOTE 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).

NOTE 4 This system of bonding and earthing should minimize 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.

NOTE 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.

NOTE 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.

4.10.2 Electrode testing

4.10.2.1 Method A – EFLI meter method (installation energized)

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

With the MEN connection removed, the “ground loop without PEN” impedance shall be measured 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 Ω to 50 Ω in good soil conditions with non-metallic water pipes.

NOTE This test could be carried out in conjunction with the test in Clause 4.12.5.1.

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.

4.10.2.2 Method B — Fall of potential

The resistance to ground of the installation earth electrode shall be tested using the “fall of potential method”.

Figure 4.30 shows the fall of potential method of testing the electrode, using a proprietary meter.

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

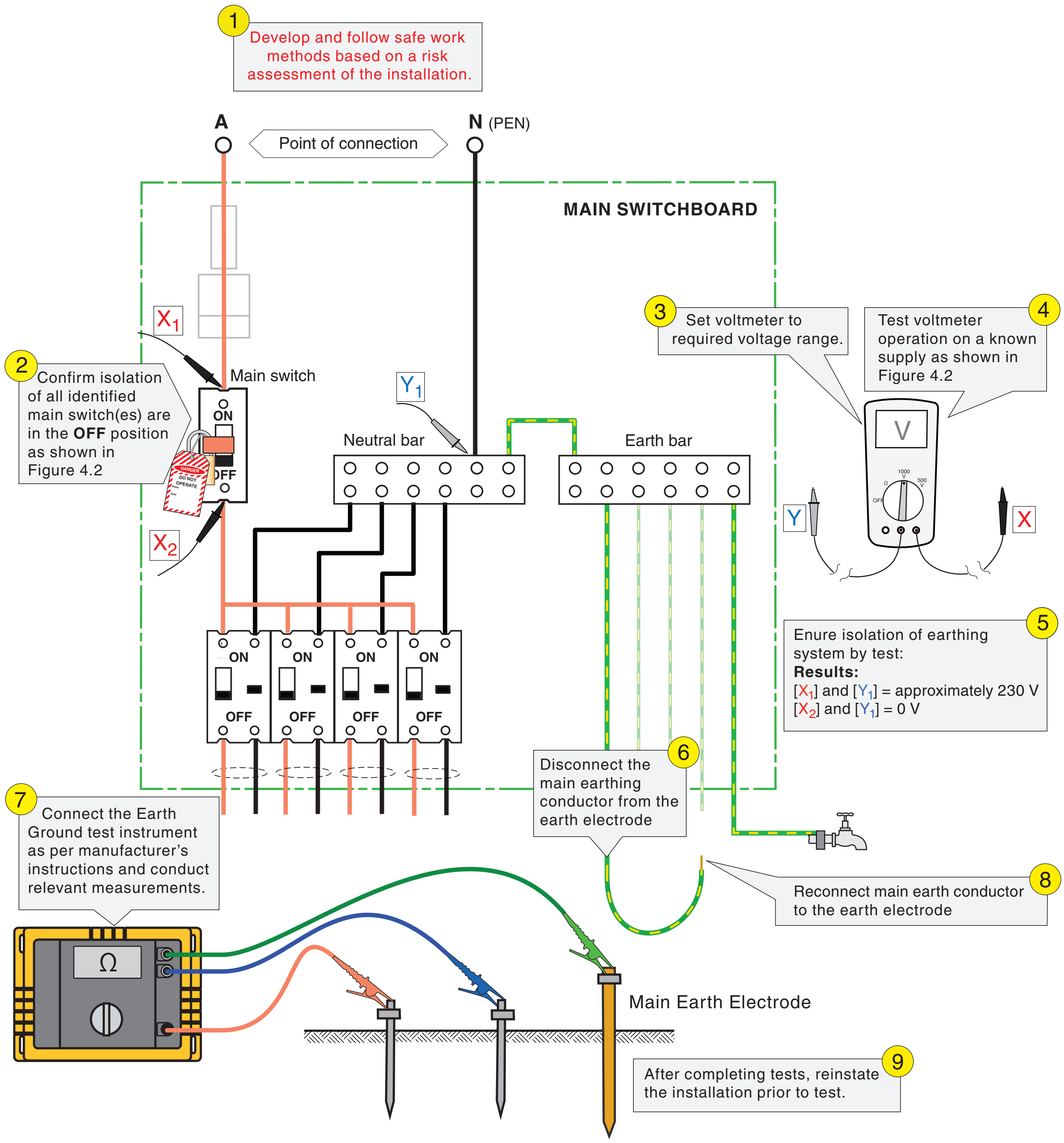


Figure 4.30 — Measurement of the resistance of the earth electrode — Fall of potential method

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.

4.10.2.3 Method C — 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.

The “ground loop to PEN” impedance shall be measured 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.

4.11 Measuring touch voltage

4.11.1 General

When an item of electrical equipment is suspected of causing an electric shock, touch voltage tests shall be performed to ensure that shock currents resulting from contact between exposed metal of the electrical equipment and extraneous conductive parts do not exceed the shock voltages limits as specified in AS/NZS 3000.

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 4.31).

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.

4.11.2 Considerations

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.

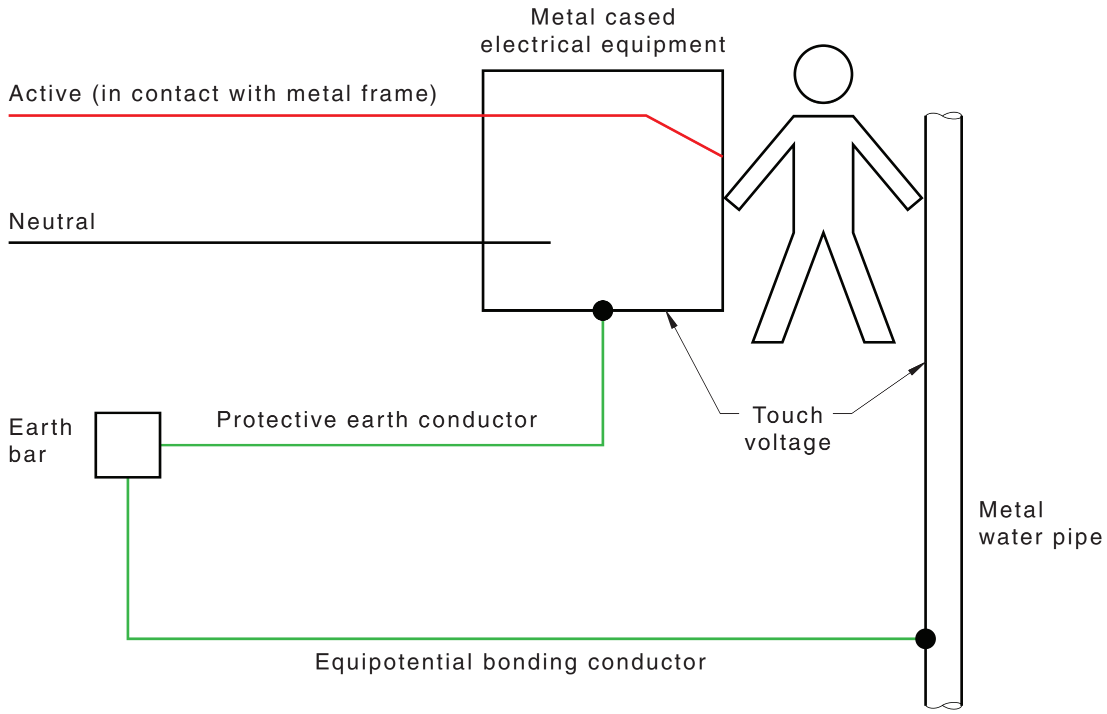


Figure 4.31 — Example of touch voltage

4.11.3 Results

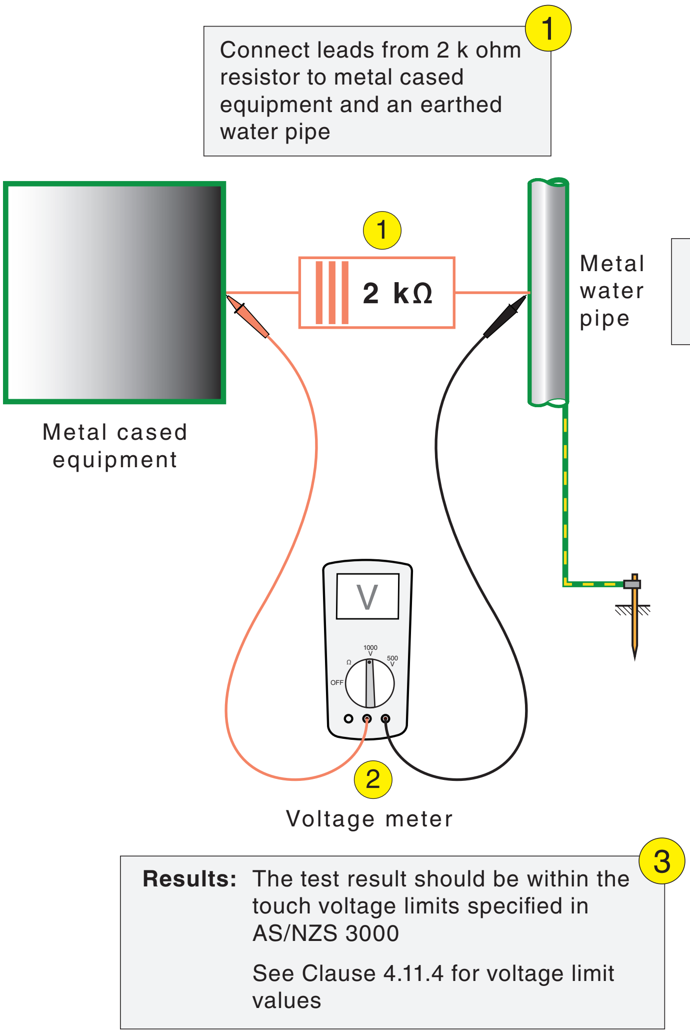
The touch voltage shall not exceed the following values as specified in AS/NZS 3000 dependant on environmental conditions:

(a) 50 V a.c. or 120 V ripple-free d.c. for normal conditions.

(b) 25 V a.c. or 60 V ripple-free d.c. for wet conditions.

4.11.4 Procedure

The test procedure for measurement of touch voltage is shown in Figure 4.32. A high impedance voltmeter, i.e. an input impedance greater than 5 MΩ, is required.



NOTE 1 A 2 kΩ resistor is used to simulate the body resistance of a typical person.

NOTE 2 Numbers indicate test sequence.

NOTE 3 The 2 kΩ resistor is a simplified version of the circuits shown in AS/NZS 60990.

Figure 4.32 — Measurement of touch voltage

4.12 Test for integrity of the incoming neutral

4.12.1 General

This test is intended to prove the integrity of neutral (PEN) connections of the supply to electrical installations, within the limits of the test.

The type of test shall be designed to identify ineffective neutral connections or whether the neutral is inadvertently connected to switched conductors, such as the actives of street lighting circuits.

When developing and interpreting results of this test, consideration shall be given to MEN systems where currents will be shared between the neutrals of the electricity network and the earthing system of an electrical installation that may affect the test.

4.12.2 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.

4.12.3 Requirements

Electrical continuity across neutral connections shall be confirmed by testing.

The commonly used methods of testing the integrity of the neutral connection are based on assessment of the following:

(a) Loop impedance.

(b) Current.

(c) Voltage.

Any combination of the above methods can be used to exploit the advantages and minimize the disadvantages that are inherent in the individual methods described.

The implications of a three phase system need to be considered.

4.12.4 Results

Voltage on the neutral is measured to an effective independent earth.

A voltage on the neutral of 6 V or less is acceptable.

A voltage on the neutral of greater than 6 V and less than 15 V shall be subject to investigation to ensure the reading is a result of normal system conditions.

Network configurations which produce neutral voltages of greater than 15 V, but less than 32 V, shall be subject to a risk assessment to adequately provide for the safety of the public.

Neutral voltages of greater than 32 V, in line with other published Australian Standards, are generally considered unacceptable.

A voltage on an active conductor exceeding the nominal limits in the relevant Australian Standard may indicate a supply system abnormality.

Refer to AS 4741 for additional guidance.

4.12.5 Procedures

4.12.5.1 Test using an earth fault-loop impedance meter – Installation energized

The incoming neutral may be tested by using a proprietary earth fault-loop impedance test instrument 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.

(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.

NOTE 2 If the earth fault-loop impedance is greater than 0.5 Ω further investigation may be required.

4.12.5.2 Test using a clamp type ammeter – Installation energized

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, a clamp ammeter shall be used 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, the clamp meter shall be placed around all active conductors simultaneously, ensuring the line and load of each phase conductor is orientated the same way.

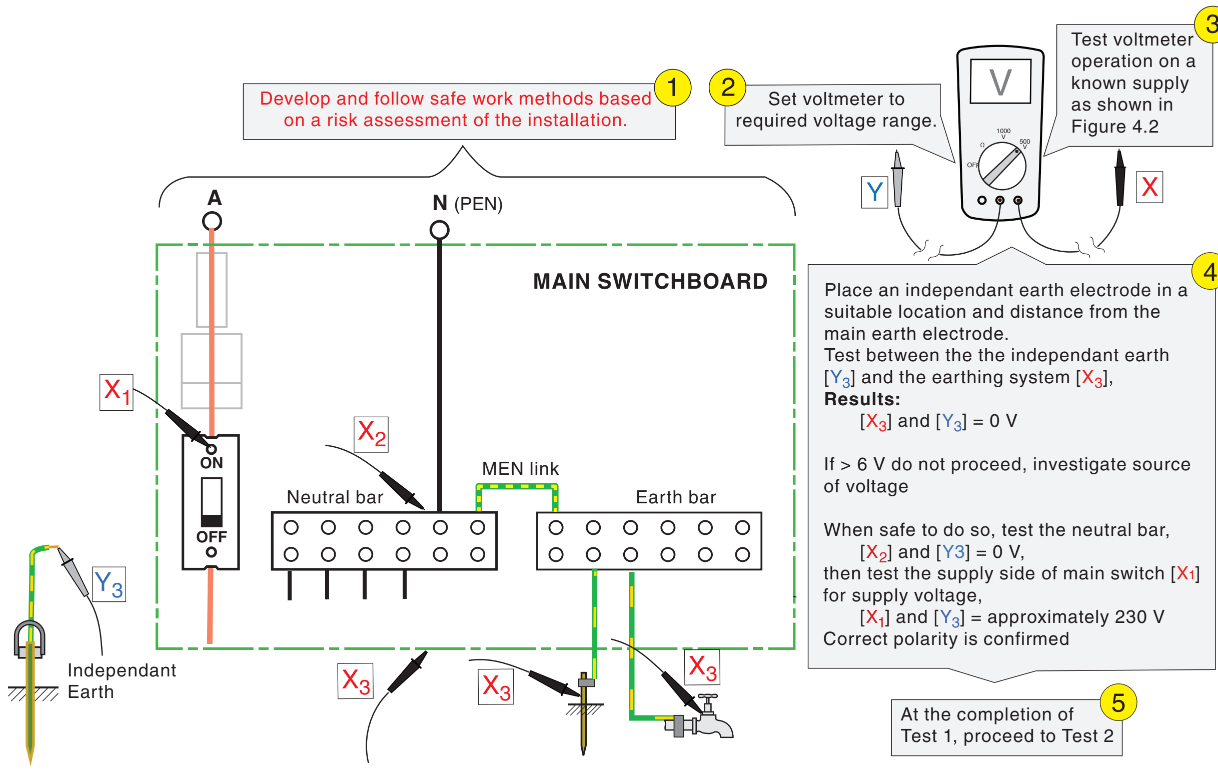
NOTE 1 The current flowing in the active conductor(s) and the neutral conductor should be substantially the same.

NOTE 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.

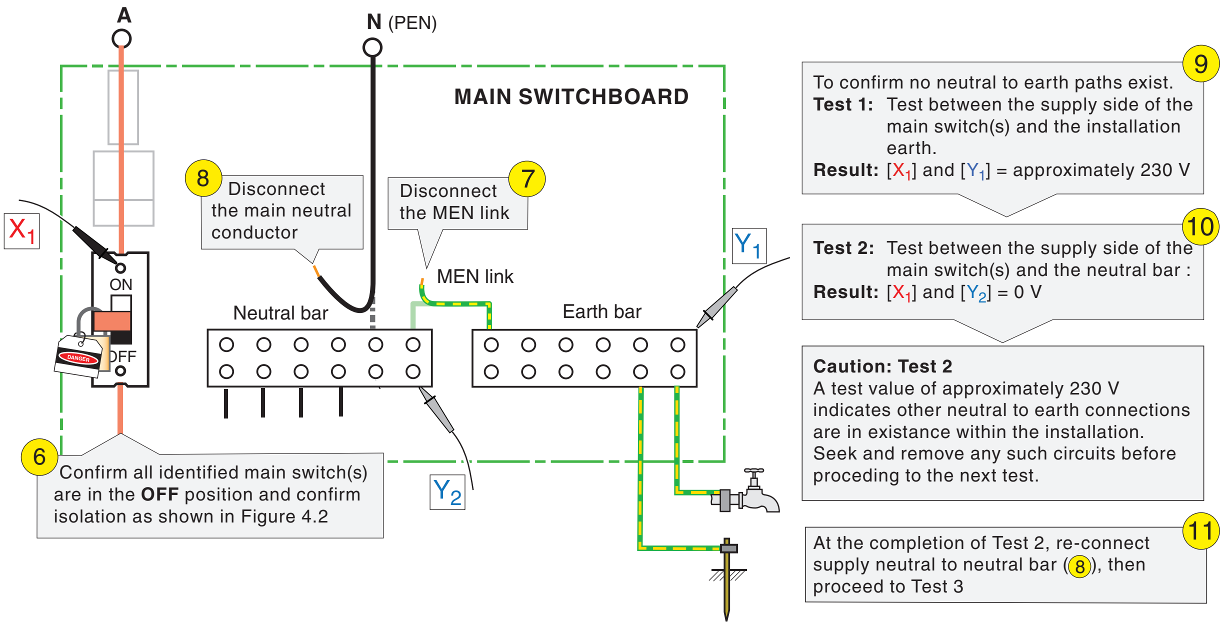
NOTE 3 If the current in the main neutral conductor and MEN connection exceeds that in the active conductor(s), there is a possibility of a continuity problem with another installation further from the distribution transformer than the installation under test. This can be confirmed by checking for current in the main neutral conductor and the MEN connection with the main switch(es) off.

4.12.5.3 Test using a volt meter

Figure 4.33 shows a method of testing the high resistance of the incoming neutral (PEN).



Test 1. Establish the supply of the installation is the correct polarity and is at the required voltage. Correct polarity can be performed using Figure 4.7 where supply is not connected or by using this test procedure



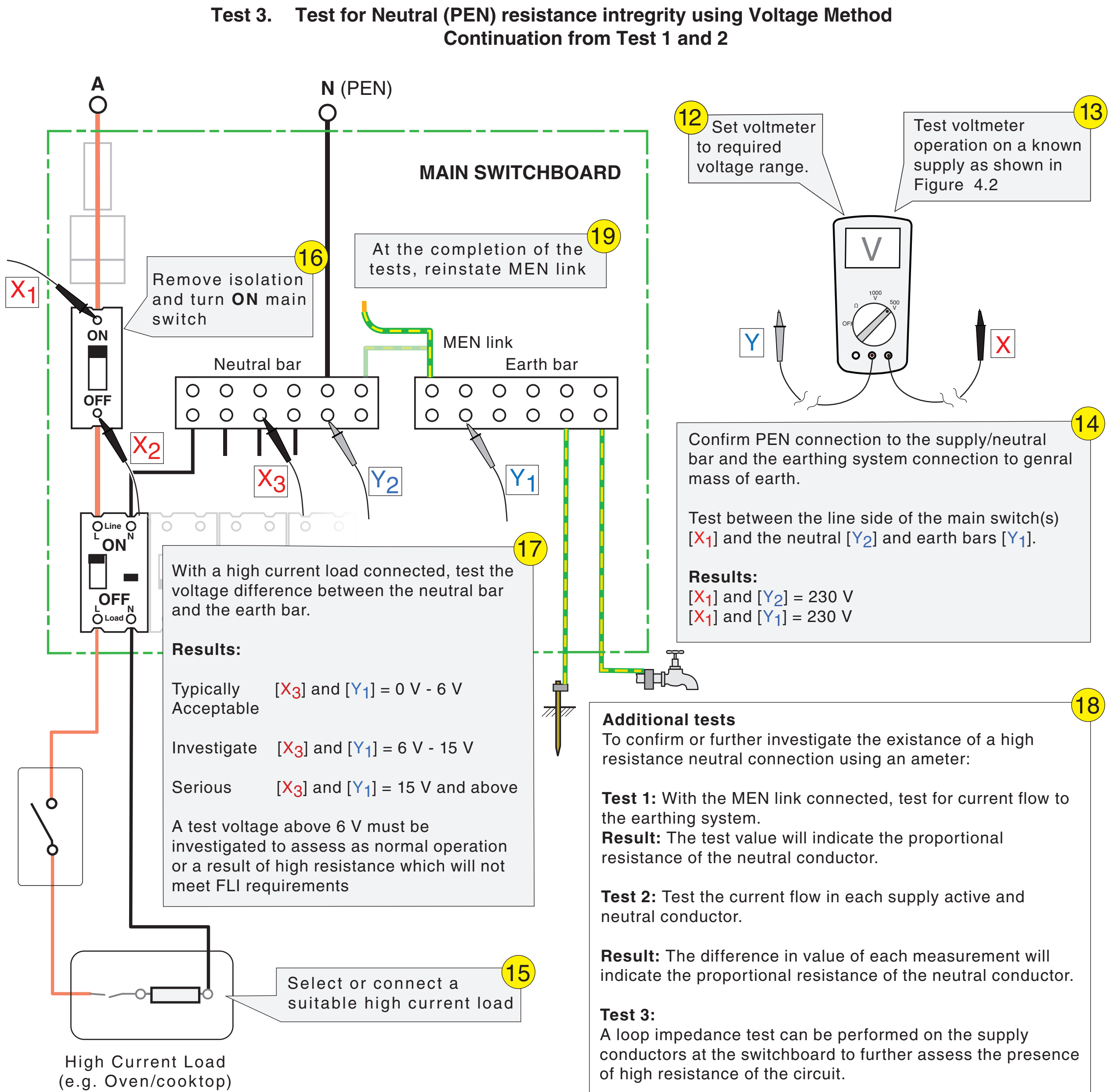
Test 2. Determine that there are no other neutral earth connections in the installation than at the MEN link.

NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.33(a) — Test for high resistance of the incoming neutral (PEN) — Installation energized — Test 1 and Test 2

NOTE A substantial difference, i.e. > 6 V, indicates a the possibility of a loose or high resistance neutral connection either at the switchboard, overhead line connector box or to the consumers mains or service line.

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 A COMPETENT PERSON TRAINED IN THIS TECHNIQUE.



NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

Figure 4.33(b) — Test for high resistance of the incoming neutral (PEN) — Installation energized — Test 3

Section 5 Installation test records

Results of all testing undertaken should be recorded. Such records may be used as evidence that mandatory testing was carried out, and may be used for comparison with later tests results.

Test records should include:

(a) identification of the circuit (s) tested;

(b) the tests undertaken;

(c) the results of those tests;

(d) the identity of the person who carried out the testing; and

(e) the date.

Test records should be kept for a minimum of 5 years.

NOTE Legislative requirements may be made in each State or Territory of Australia or New Zealand relating to the format and contents of test records.

Examples of test record forms are shown in Appendix B.

Appendix A
(informative)

Additional information for selecting and using test equipment

A.1 General

This Appendix provides additional information relevant to selecting, using and maintaining equipment used for testing and verifying compliance of low voltage electrical installations. The principal requirements for such equipment are in Section 2.

A.2 Test equipment

A.2.1 General specifications

A.2.1.1 General

AS 61010.1 and IEC 61557 series or an equivalent Standard specify requirements for measuring devices used in this Standard.

Test instruments and associated test leads may require laboratory testing to show that compliance with the relevant standards is ensured. Initial compliance is generally confirmed by a manufacturer's declaration of conformity.

A.2.1.2 Instruments for use on energized circuits

To reduce risk of damage and personal injury, test instruments and associated test leads for use on energized circuits (typically voltmeter, clamp meters, RCD test instruments and earth fault-loop impedance test equipment) need to have an impulse voltage withstand category rating as shown in Table A.1.

Table A.1 — Impulse voltage withstand

Nominal a.c. or d.c. line to neutral voltage of mains supply	Category II	Category III	Category IV
150	1 500	2 500	4 000
300	2 500	4 000	6 000
600	4 000	6 000	8 000
1 000	6 000	8 000	12 000
[SOURCE: Adapted from AS 61010.1:2003, Table 17.]			

A.2.1.3 Meter accuracy

Specified accuracy is particularly important when applied to low values such as in resistance measurement associated with earthing, bonding and earth fault- loops. See Clause A.3.1 for further guidance.

A.2.2 Voltage devices

A.2.2.1 Voltage indicators

Non-contact and single-contact voltage devices are indicators only. They cannot be not relied on for proving that no hazardous voltage is present, and that the wiring or fittings have been de-energized or isolated to a safe state.

A.2.2.2 Voltmeters

The voltage scale on an analogue multimeter typically have a lower input impedance than digital voltmeters meaning they draw a higher current from the circuit under test. This attribute makes them most useful for showing circuit anomalies, for example, resulting from capacitive or external mutual inducted current not detected with most digital meters. However, there are quality digital multimeters available that have a selectable low input impedance facility.

A.2.3 Low range ohmmeter

A.2.3.1 Accuracy

The tests specified in this Standard require the ability to accurately measure low values of resistance. All test instruments have inherent errors. It’s critical that these errors are only a small fraction of the maximum permitted value.

The tests requiring most accuracy required to verify compliance are those for which a maximum value is specified, such as maximum resistance of earthing and bonding conductors, and the internal contribution to earth fault-loop impedance. For such low measurements, analogue meters should have sufficiently low range scales and digital meter displays should show at least 3 digits and a resolution of 0.01 Ω.

A.2.3.2 Analogue meter

Accurately reading an analogue ohmmeter requires a consideration of the following:

(a) The scale to use.

(b) The specified accuracy of the meter, commonly a ± percentage at full-scale deflection (FSD), e.g. ± 5 % FSD.

For example, measuring resistance of the main earth conductor on a 2 Ω scale of a meter with an accuracy of 5 % FSD, the measurement will be ± 0.01 Ω. This applies at any point on that scale. See Figure A.1.

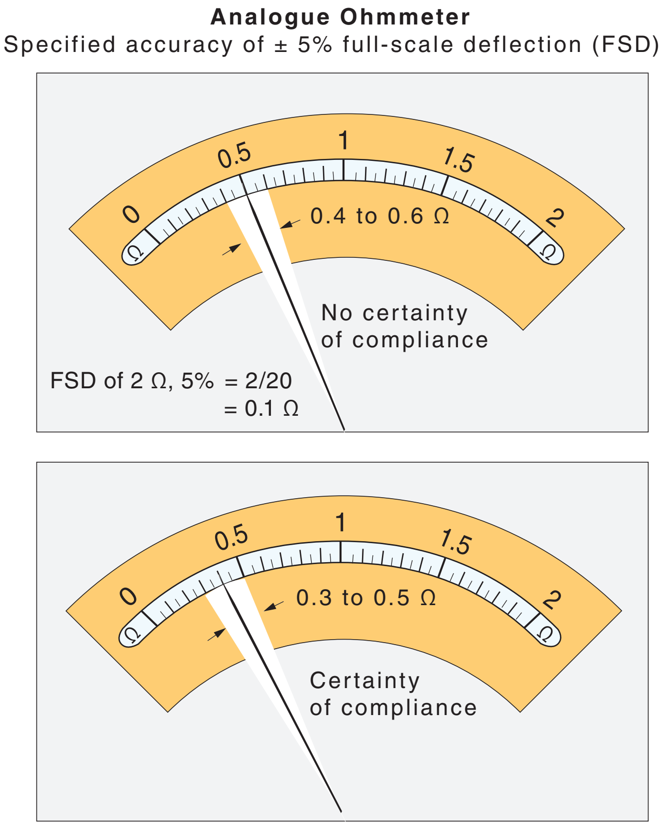


Figure A.1 — Example of applying the specified meter accuracy to an analogue meter

A.2.3.3 Digital meter

Digital meters have accuracy specified as ± percentage of the displayed value ± *n,* where *"n"* is a multiplier for the value represented by the least significant figure displayed (specified as "counts").

Accurately reading a digital meter display requires a combination the following:

(i) The parameter to be measured.

(ii) The specified accuracy of the meter for the selected range.

For example, measuring resistance of the main earth conductor with the meter set to measure ohms. See Figure A.2.

NOTE Some meters are essentially digital but present the test reading on a pseudo-analogue display. In such cases there will be no "least significant digit" on the display so this aspect cannot be applied. Refer to the manufacturer's specification of accuracy.

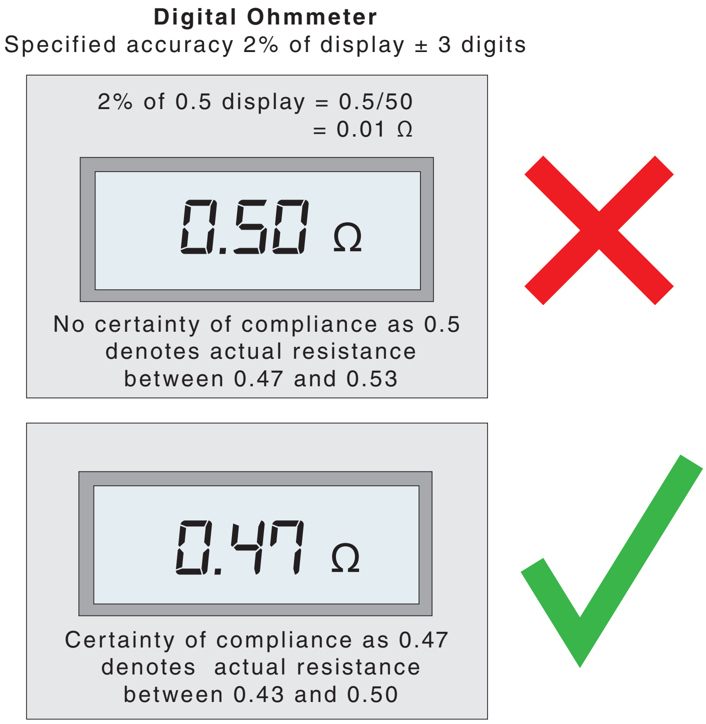


Figure A.2 — Example of applying the specified meter accuracy to a digital meter display

A.2.4 Device for initiating operation of RCDs

The RCD’s integral test button creates a residual current (net current in all live conductors) by allowing current to flow, via a suitable resistor, from an active terminal on the load side of the RCD to the neutral terminal on the line side. The current through the resistor does not flow through the RCD’s sensing coil, and is therefore detected as a residual current. The other types of initiating device apply current from an active conductor of the protected circuit to the protective earth conductor.

A suitable arrangement for a test device is shown in Figure A.4. Suitable values of resistor are given in Table A.2.

The equipment listed here is limited to that required for carrying out the testing required by AS/NZS 3000.

Table A.2 — Preferred value of resistors for initiating operation of RCDs

Rated residual current	Nominal voltages	
	230 V	110 V (e.g. centre-tap supply source)
10 mA	20 kΩ	10 kΩ
30 mA	6.8 kΩ	3.3 kΩ
100 mA	2 kΩ	1 kΩ
300 mA	680 Ω	330 Ω

NOTE 1 Resistors should be 5 % tolerance and minimum 5 W rating.

NOTE 2 The calculated values are to provide 110 % rated residual current at the nominal voltage. The nearest commonly available value to the stated value in Table A.2 may be used.

Resistors marked as having 5 % tolerance are preferred over those having 10 % tolerance.

Some optional tests require additional or special equipment. Examples include equipment that is able to —

(a) apply a residual current either randomly, or at a particular moment of the 50 Hz cycle;

(b) apply a varying residual current;

(c) apply a non-sinusoidal residual current; and

(d) accurately measure the time between application of the test residual current, and disconnection of the circuit under test.

Such instruments should comply with IEC 61557-6.

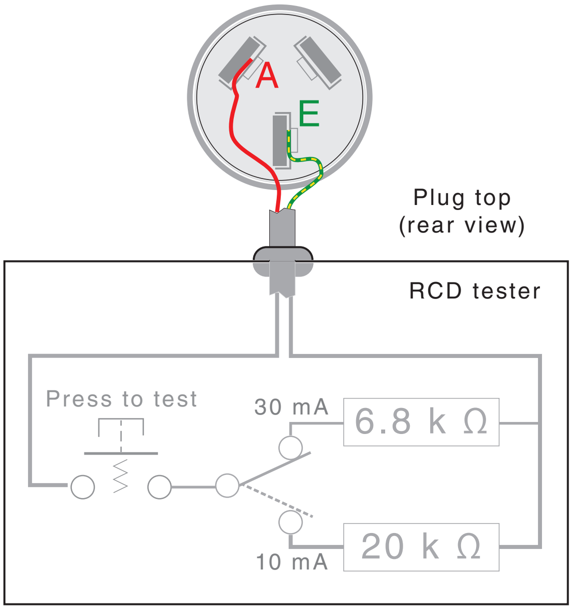


Figure A.3 — Example of RCD test instrument device for initiating RCD operation for circuits terminated at socket-outlets

A.2.5 Independent source providing 50 Hz supply

A.2.5.1 Features

An independent supply for use when testing correct installation of RCDs should be selected with due regard to the following considerations.

(a) Voltage: The RCD manufacturer's instructions should be consulted. Most RCDs require a 230 V supply for the operation of their integral test function. A multi-phase supply may be used but is not required.

NOTE 1 The test procedures specified by Clause 4.9.5 do not require all phases of multi-phase RCDs to be energized.

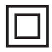
(b) Power: The source must be capable of providing a constant current at least equal to the rated residual current of the RCD. The source should be capable of delivering a peak current of 4 A. For testing RCDs with rated residual current of 30 mA, a 300 VA (constant) source is generally adequate; but 500 VA (constant) is preferable.

NOTE 2 Some RCDs require additional current in order to operate the tripping mechanism.

(c) Wave-form: For simple initiation of operation by either the integral test button or an external device, a high-quality waveform is not required. However a high-quality wave-form, closely approximating a sine wave, is required for more advanced testing such as measuring operating time or determining the value of current required to cause operation (ramp test).

NOTE 3 RCD test instruments can not operate unless the waveform of the source is stable and of suitable quality. Some test instruments may be damaged by use on sources having unsuitable waveform.

(d) Output configuration: The independent source should have an output isolated from earth; however a source with neutral connected to earth may be used. Other output configurations should not be used. Portable inverters complying with AS/NZS 4763 and marked with a double insulation symbol are suitable.



When using the integral test button to initiate operation, the residual current is developed by applying a suitable resistance between the circuit’s live conductors. No connection between neutral and earth is required.

When using an external device to initiate operation, a connection between neutral and earth is required upstream of the RCD being tested.

NOTE 4 When testing RCDs within an MEN installation, the installation's MEN link provides the N-E connection.

NOTE 5 When testing RCDs in situations where no MEN link is present (for example, a connectable electrical installation); either use a supply with neutral connected to earth, or create a temporary N-E link to simulate an MEN supply.

NOTE 6 If an independent supply with output N connected to earth is connected to an MEN installation, there will be two N-E connections in parallel; but this will not adversely affect the testing process or the validity of the results

A.2.5.2 Connections and use

The independent source is intended primarily for confirming correct functioning of RCDs, in accordance with Clause 4.9, in installations that are not yet connected to their normal supply.

WARNING: USE OF AN INDEPENDENT SUPPLY ENERGIZES PART(S) OF THE INSTALLATION. EXTREME CARE IS NEEDED TO ENSURE THAT THIS CAN BE DONE SAFELY.

A safe work method should be prepared and implemented for use of the independent supply as follows:

(a) Before connection of the independent supply the following actions should be taken—

  (i) isolate all normal, alternative and supplementary supplies, and secure the isolation, in accordance with Clause 4.3.5.3;

  (ii) confirm the circuit(s) supplied by the RCD that are to be tested are either confirmed safe to liven; or disconnected from the RCD; in accordance with Clause 4.9.5.1; and

  (iii) isolate all other circuits that could be energized from the supply.

(b) After securing isolation of all other supplies, the independent supply should be connected as follows:

  (i) Connect active to line side of RCD (point X_1 in Figure 4.26).

  (ii) Connect neutral of independent supply to neutral busbar (point Z_2 in Figure 4.26).

  (iii) Connect earth of independent supply to earth busbar (point Y_3 in Figure 4.26).

  (iv) If required; make a temporary connection between neutral and earth busbars.

NOTE For multi-phase RCDs, and if/where intending to use the integral test button; ensure active is connected to the phase used by the integral test circuit.

(c) Energize the independent supply.

(d) Conduct tests of RCD function, in accordance with Clause 4.9, for all RCDs connected to that phase.

(e) Isolate the independent supply.

(f) Disconnect the independent supply, and any temporary N-E connection.

(g) Reconnect any circuit(s) disconnected for safety.

A.2.6 Test leads and probes

Test leads and probes shall be rated for the maximum voltage to which they are to be connected.

Probes for making contact with live parts should be shrouded type.

Testing of multi-phase RCDs may be facilitated by use of a special test lead with a phase selection switch.

A.2.7 Resistors used in tests where supply isolated

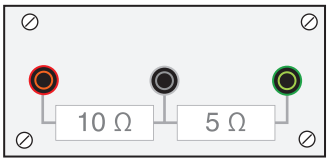
Resistors, for checking polarity correct circuit connections and phase rotation, should be selected such that —

(a) each resistor is a different value; and

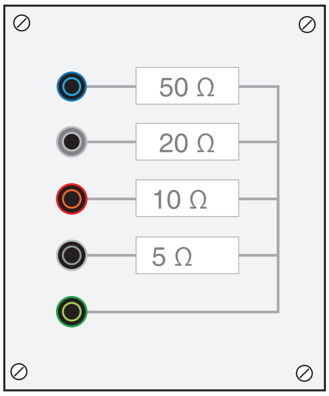
(b) no combination of resistor values adds up to the value of any other resistor or combination.

Resistors for conducting routine checks of instrument accuracy should be selected to approximate typical values.

Suggested arrangements are shown in Figure A.4.



Used for polarity testing single phase circuits



Used for polarity testing three-phase circuits

Figure A.4 — Suggested arrangements of resistors used in verification tests

A.3 Maintaining test equipment

A.3.1 Basic checks of equipment function

A.3.1.1 General

The following subclauses provide guidance on basic checks of equipment function. In accordance with Clause 2.3.2, these checks should be carried out before each use of the equipment.

A.3.1.2 Voltage indicators

The check is as follows:

(a) Select 600 V range.

(b) Measure voltage on a circuit known to be live.

(c) Confirm reading approximately 230 V.

NOTE For tests on installations where there are no known live circuits, a portable independent source (Clause 2.2.2.6), or an insulation resistance test instrument may be used as an alternative source (use d.c. range).

A.3.1.3 Ohmmeter

The check is as follows:

(a) Select low-ohm range.

(b) With the leads shorted together the reading should be zero Ω (adjust as required).

(c) With the leads open the reading should indicate an open circuit.

A.3.1.4 Insulation resistance test instrument

The check is as follows:

(a) Select 500 V range.

(b) With the leads shorted together the reading should be zero Ω (adjust as required).

(c) With the leads open the reading should be infinity (>100 MΩ).

A.3.1.5 Trailing lead

For use with a meter that allows “zeroing”; connect the meter to both ends of the lead and “zero” the meter.

For use with other meters; note the resistance of the lead.

NOTE The resistance of the lead should be checked before each set of tests. The resistance of the lead may be recorded on the reel for future reference.

A.3.2 Periodic checks of correct equipment function

A.3.2.1 General

The following subclauses of provide guidance on periodic checks of meter accuracy. In accordance with Clause 2.3.2, these checks should be carried out at least every 12 months.

As varying accuracy over time may indicate a progressive problem, the results of these checks should be recorded for purposes of comparison. Figure A.7 shows an example of a form for recording checks of meter accuracy.

A.3.2.2 Ohmmeters

The check sequence is as follows:

(a) Connect test leads to 2 × 1.0 Ω resistors connected in parallel.

(b) Confirm reading within 0.48 to 0.52 [5 % = 0.025].

A.3.2.3 Insulation resistance test instrument

Equipment and procedure for check the voltage of an insulation resistance test instrument is shown in Figure A.5.

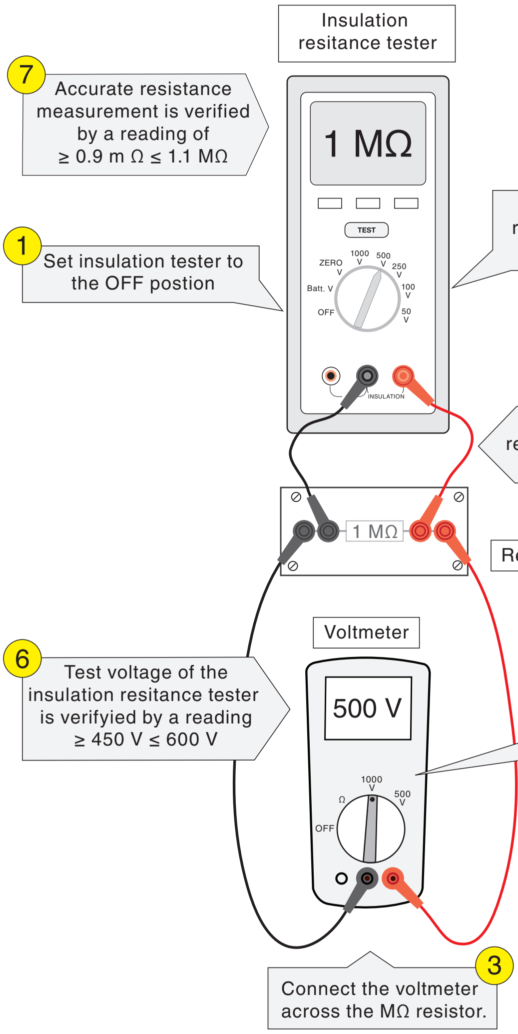


Figure A.5 — Checking insulation resistance test voltage

A.3.2.4 EFLI meter

A.3.2.4.1 Test using known resistance

The equipment required is as follows:

(a) Assembly of plug, lead, and connector including a heavy duty resistor of approximately 5 Ω.

(b) A circuit known to be live, and not protected by RCD.

The check sequence is as follows:

(i) Measure the EFLI of the source. Note the reading.

(ii) Repeat the test using the resistor assembly. Note the reading.

(iii) Confirm 2nd reading greater than the first by approximately the value of the resistor.

NOTE 1 A typical EFLI test instrument applies a load of approximately 23 A to the circuit, over a few cycles. The resistor needs to be capable of carrying this current, e.g. a wire-wound resistor.

NOTE 2 If no non-RCD circuit available; the source may be buffered through a small isolating transformer modified to connect output neutral and earth together, thus simulating an MEN supply.

NOTE 3 Some RCD test instruments have a “no RCD trip” function, which, while giving less accurate results, is suitable for testing RCD-protected circuits. However the point of this check is to confirm accuracy of the high-current test, as used on non-RCD circuits.

A.3.2.4.2 Test using known circuit

Measure EFLI of known, non-RCD-protected circuit. The EFLI may vary slightly due to voltage variations between tests; but should be close to the same each time.

A.3.2.5 RCD initiation device

The equipment required is as follows:

(a) A source not protected by RCD.

(b) Equipment to measure the current imbalance between active(s) and neutral (e.g. clamp-type amp meter with milliamp range).

The check sequence is as follows:

(i) Connect the test initiation device.

(ii) Confirm, for the 10 mA and 30 mA a.c. settings, that the current imbalance applied by the tester to the circuit under test exceeds rated residual current but does not exceed 120 % of the rated residual current.

NOTE 1 Since the purpose of the ‘RCD initiation device’ is simply to confirm that the RCD has been installed such that it will react to a current imbalance; accuracy of the current it applies to the RCD is not important. However too low a current must be avoided in order to ensure tripping of correctly-connected RCDs when voltage is low.

NOTE 2 A source not protected by RCD is required; as if an RCD-protected circuit is used the RCD is likely to operate before a reading can be obtained.

NOTE 3 While similar checks can be performed for other settings; confirmation at rated residual current is sufficient.

The scope of this Standard is limited to the testing required to verify that an MEN (TN-C-S) installation complies with safety requirements. The safety requirements are set out in AS/NZS 3000:2018 Section 8.

While other Standards, e.g. AS/NZS 3003 and AS/NZS 3012, may require periodic trip time testing, AS/NZS 3000 does not require it for initial testing. Accordingly, this Standard provides such testing as an optional extra (Clause 4.9.5.3); and this clause does not need to include any routine check of accuracy. Outside of a laboratory, due to variables including voltage and characteristics of protected circuits, such testing can only ever be indicative; and cannot confirm compliance (or otherwise) of the RCD with product Standards.

A.3.2.6 Portable independent source

The equipment required is as follows:

(a) Voltage indicator.

(b) Frequency meter or oscilloscope.

The check sequence is as follows:

(i) Connect checking equipment to output of source.

(ii) Confirm voltage and frequency.

NOTE The portable source is primarily intended for enabling the testing of RCDs when normal supply to the installation is not available. Many RCD test instruments will not operate on an unsuitable or unstable supply, and some may be damaged. Where an RCD test instrument is intended to be used; the advice of the manufacturer should be sought and the voltage and frequency of the portable source should be confirmed as suitable before any testing is undertaken.

The RCD initiation device shown in Figure A.3 is unlikely to have problems in this regard.

A.3.2.7 Trailing lead

Measure and record the resistance of the lead with a low range ohmmeter.

A.4 Record of checks of accuracy

Example forms for recording periodic checks of accuracy are shown in Figures A.6 and A.7.

<table>
<tr><td colspan="7">Insert company logo or banner</td></tr>
<tr><td colspan="2">For:</td><td colspan="3">By:</td><td colspan="2">Date:</td></tr>
<tr><td colspan="2">TEST METHODS:
Reference
Measured
Comparison
Test Box</td><td colspan="5">Function tested using a circuit of known value
Value measured using an independent meter
Value measured by meter under test and by a second, independent, meter
Meters checked using proprietary meter-checker (record make and model)</td></tr>
<tr><th>Make</th><th>Model</th><th>Serial No./ID</th><th>Function</th><th>Setting</th><th>Result</th><th>Test method</th></tr>
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Figure A.6 — Record of test instruments checked

Voltage tester

Make	Model	Serial No / ID	Test voltages	9 V d.c.	SLV
			Indicated voltages		

Earth continuity meter Also EFLI when no-supply method used

Make	Model	Serial No / ID	Range	Test resistances	0.5	1.0	2.0
				Indicated resistances			

Continuity long test lead

Make	Model	Serial No / ID	Length	Resistance

Insulation resistance meter

Make	Model	Serial No/ID	Test resistances	10 k	1 M	10 M
			Tolerance			
			Indicated resistances			
			Voltage maintained			

Leakage current meter

Make	Model	Serial No / ID	Applied load (mA)	1	15	30
			Reading			

Earth fault loop impedance tester

Make	Model	Serial No / ID	added	Initial reading
				Amended reading

RCD tester

Make	Model	Serial No/ID	Setting (mA)	5	10	15	30	100
			Applied load					
			Tolerance					
			Recorded trip time					

Phase rotation meter (2-probe type)

Make	Model	Serial No / ID	R > W	W > B	B > R	R < W	W < B	B < R

Phase rotation meter (3-probe type)

Make	Model	Serial No/ID	R > W > B	R > B > W
			☐	☐

Figure A.7 — Record of checks of meter accuracy

Appendix B
(informative)

Installation test record forms

The forms below may be used to record the results of tests undertaken.

INSTALLATION COMMISSIONING TEST FORM — EXAMPLE

Installation Address	

I the undersigned, certify that I have undertaken a full visual inspection and tests of the electrical work performed on the installation as required by AS/NZS 3000:2018 Wiring Rules.

Name and signature of person performing the test		**Lic No**		**Date**	

NOTE: The visual checks are applied in conjunction with the mandatory requirements of AS/NZS 3000, plus any other relevant Standards. Visual checks may be required during the installation process where electrical equipment is not visible due to a finished construction (e.g. roofing, walls, floors, concrete, buried).

VISUAL INSPECTION			
Before the inspection, do a risk assessment to identify hazards and risks – Refer to AS/NZS 4836			
CONSUMER MAINS / SUB-MAINS / OH or UG / BURIED FINAL SUB-CIRCUITS			
	Requirements	**Comments / observations**	**Pass/Fail or N/A**
1	Overhead POA meets the correct height and position *Check any required certification of support metal work and IP rating of connection device, mechanical protection, or adequate separation of supply conductor reinforced insulation from conductive supports or building materials.* *Also refer to local supply network (DNSP) requirements.*		
2	Underground cables and enclosures installed to correct depth Caution — To be verified and, if practical, document at time of installation		
3	Underground “Warning” tape installed *Underground marking tape to comply with AS/NZS 2648.1* Caution — To be verified and, if practical, document at time of installation		
4	Type of underground conductors (TPS-XLPE) *State service and installation rules may require specific insulation type*		
5	Spacing from other underground services (water/telecoms/drainage) *Minimum separation of other underground services*		
6	Correct cable selection size/ circuit protection rating (current rating, installation kA rating) *Refer to AS/NZS 3008 for cable ratings*		

INSTALLATION COMMISSIONING *(continued)*

7	Conduit adequately sealed (glued) at joints and conduit boxes/fittings Caution — To be verified at the time of installation for required IP rating		
8	Inspect and assess pillar or mains connection box for terminations, fusing size of SPD and correct location to local DNSP requirements *Where possible check incoming DNSP neutral (PEN) conductor markings for correct polarity identification*		
9	Unprotected supply mains may require additional mechanical protection requirements by State service and installation rules Caution — To be verified and, if practical, document at the time of installation		
	EARTHING		
10	Earth electrode connections treated (protection against corrosion)		
11	Earth electrode exposed to weather (location) and correct separation distance from other services		
12	Electrode installed to correct depth Caution — To be verified at the time of installation		
13	Main earth secured and protected connections to earth electrode *Mechanical protection may be needed in exposed areas subject to damage*		
14	"Warning: Do not disconnect" tag installed at earth electrode		
15	Correct size of protective earth conductor Refer to wiring rules minimum size for associated actives / EFLI minimum resistance		
16	Other equipotential bonding required to conductive services (gas/water)		
17	Structural metalwork forming the frame of any structure containing an electrical installation is bonded *The size of the earthing conductor will be determined in association with the associated active conductors*		

INSTALLATION COMMISSIONING *(continued)*

BATHROOM / SHOWER EQUIPOTENTIAL BONDING			
18	Conductive reinforcing of concrete for showers or bathrooms, floors or walls have been bonded as required Caution — To be verified at the time of installation and, where practical, documented		
SWIMMING POOL AREA EQUIPOTENTIAL BONDING			
19	Conductive pool shell reinforcing steel and any conductive adjacent deck bonded Caution — To be verified at the time of installation and, where practical, documented		
20	Conductive fixtures and fittings installed in direct or indirect contact with the general mass of earth and within arm's reach are bonded where required Caution — To be verified at the time of installation and, where practical, documented		
21	Minimum $4mm^2$ earth bonding conductor *Earthing conductors require the same level of mechanical protection as live conductors* Caution — To be verified at the time of installation and, where practical, documented		
22	Common bonding connection point provided with location marked at circuit switchboard or other visible location		
ELECTRICAL WIRING / ACCESSORIES / ELECTRICAL EQUIPMENT			
23	No un-terminated cables *Check from constructed plans that all equipment has been installed* Ensure all installation cables are terminated, all final sub-circuits are accounted for, and unused cables double insulated and not connected to a supply		
24	Electrical equipment suitably IP rated		
25	Cable installation mechanically protected *RCD protection may only be used in specific instances in lieu of additional mechanic protection*		
26	Approximate cable route length to qualify further testing for volts drop and EFLI and suitable over current protection		

INSTALLATION COMMISSIONING *(continued)*

27	Fixed or secured in place		
28	No exposed single insulated cable		
29	No access to live parts without the use of a tool or key		
30	No subsequent damage to electrical cables or equipment		
31	Cooktop clearance to electrical accessories (150 mm minimum)		
32	Hotplate functional switch provided		
33	Air Conditioner lockable isolator fitted		
34	Gas-elect appliance double pole isolation fitted		
35	Hot water system isolator fitted		
36	Bathroom area zone compliance and I.P. rating of electrical equipment		
37	Swimming pool zone compliance and I.P. rating of electrical equipment		
ROOF SPACE / UNDER FLOOR AREA			
38	Adequate mechanical protection in roof-space and wall cavities *Protection against mechanical damage* Caution — Mains/sub-mains may require earthed mechanical protection		
39	Accessories/outlets — Fixed in position		
40	Appliances/lights — Not damaged		
41	Cables clipped, secured, supported *Re assess subsequent ceiling/wall insulation to verify any cable de-rating which may need to apply*		
42	Junction boxes fitted (termination of cables)		
43	Cable sheathing entering fittings / no accessible single insulated L.V. cables		
44	Sheathed cables protected over beams or horizontal building materials where likely to be disturbed		
LUMINAIRES AND CEILING MOUNTED EQUIPMENT			
45	Correct class of fitting installed *Non-IC type cannot be installed to domestic installations*		

INSTALLATION COMMISSIONING *(continued)*

46	Adequate clearances from flammable materials based on class of fitting *Refer to manufacturer's installation instructions*		
47	Transformers and drivers (auxiliary equipment) installed correctly *May need to be fixed in position*		
48	Ceiling fans securely mounted and at correct height from floor		
49	Smoke alarm and interconnections not switched *Refer to State legislation / building code / manufacturer's instructions for correct type, location, and position from other equipment*		
	SWITCHBOARDS		
50	Switchboard is readily accessible and not in a restricted location		
51	Minimum clearance of 1.0m from closed face (600 mm domestic)		
52	Main switch(es) labelled		
53	Suitably IP rated for location		
54	Cable entries are bushed		
55	Cable entries are sealed, limiting fire spread and vermin infestation		
56	Cable segregation / clearances behind panels are adequate *Ensure conductors are not compressed or pinched and segregated by fixed distance or barrier/enclosure between ELV, comms cables and metering (where required)*		
57	Pole fillers securely fitted		
58	All access covers / doors are fitted *Ensure all bolts or screws for covers/panels are installed, door latches operational. Check for debris, cable off cuts, unused fixings, and tools.*		
59	All equipment labelled		
60	Location of earth electrode identified at the switchboard *For buried earth electrodes document route location*		
61	Underground cable location recorded *Marking and recording of underground cable location and route plan at the switchboard*		

INSTALLATION COMMISSIONING *(continued)*

62	Current ratings of main switch and circuit protection are verified *Verify protection and isolation device specifications for compliant kA and current ratings*		
63	Uniform orientation of protective devices or clear on/off indication		
64	RCDs installed as required (all final sub-circuits in domestic installations)		
65	Max three circuits per RCD in domestic and residential		
66	Metal switchboard enclosure earthed *Unprotected consumers mains supply may require earth conductor size to be verified*		
67	Correct size MEN link installed		
68	All terminations secured and correct termination method and tension rating applied *Conductors supported to ensure no undue tension on connection terminals*		
69	Main earth and neutral termination identified Multiple circuits having a common neutral require identification labels		
70	Sub-boards have either running earth or for outbuildings, separate MEN permissible (MEN installed)		
71	Supply neutral conductors' termination method at distribution board and subsequent distribution boards not reliant on terminations only, for continuity *Visual inspection of the entire neutral supply to all downstream switchboards*		
72	Date of energization indelibly marked on the switchboard		
73	Switchboard MEN connection installed after testing complete		
74	Other specific visual inspections, not included above, that reference other associated electrical standards, e.g. **Solar (AS/NZS 5033/ AS/NZS 4777.1/ AS/NZS 5139), Generators (AS/NZS 3010), Construction Sites (AS/NZS 3012)**		

INSTALLATION COMMISSIONING TEST FORM

TESTS				
NOTE: The below tests are based on the mandatory requirements of Section 8 of AS/NZS 3000:2018. The recommended testing processes of AS/NZS 3017, *Verification by inspection and testing*, can be used to assist this process. It is critical that the testing sequence as listed below is followed to ensure electrical safety outcomes before energization.				
EARTH RESISTANCE AND CONTINUITY				
Test and expected results				**Comments / observations**
1	Main earth conductor	(≤0.5 Ω)		
2	Eq bonding conductor — Gas/Water pipe	(≤0.5 Ω)		
3	Eq bonding conductor — Pool	(≤0.5 Ω)		
4	Eq bonding conductor — Bathroom	(≤0.5 Ω)		
5	Eq bonding conductor — Building Frame	(≤0.5 Ω)		
INSULATION RESISTANCE				
6	Consumer mains	(≥1MΩ) see note 2		
7	Sub-mains (if they exist)	(≥1MΩ) see note 2		
POLARITY AND CORRECT CIRCUIT CONNECTIONS				
8	Consumer mains			
9	Sub-mains			
10	Short circuit check			
			Pass/Fail or N/A	
11	Verify correct circuit connections to equipment terminals			
12	Actives are switched (final sub-circuit neutrals where required)			
13	Circuits are not interconnected (no transposed conductors)			

INSTALLATION COMMISSIONING *(continued)*

TESTS			
PHASE SEQUENCE VERIFICATION			
14	Mains / Sub-mains / Multi-phase outlets have uniform phase rotation		
15	Correct equipment operation		
TEST EQUIPMENT			
All test equipment used must be suitable for its intended use - refer to AS/NZS 3017 for guidance			
16	Test instruments used are in-test and visually confirmed to be safe, suitable and in working order		

MEN connection has been re-instated at the conclusion of all tests. (Recommend taking photo)

Circuit or equipment description	Circuit ID	Protection size and type Example C20	Cable Size mm^2	Earth Continuity Test 1* Ω	Insulation Resistance 2* MΩ	Polarity Test 3* Actives Neutral Earth Correct Circuit Connections 3*	Fault Loop Impedance (If required) 4*	Operational Test of RCD 5* Test button Timed test mSec	Isolation Test of RCD 5*
						Correct or N/A		*Pass or insert comment*	*Correct or N/A*

NOTE 1 Earth continuity

Under the subsequent tests for earth fault-loop impedance, the maximum allowable resistance of the protective earthing conductor associated with any circuit depends on the type and rating of the protective device and the impedance of the live conductors that comprise the fault path.

Resistance values (*R*e) for earthing conductors are given in AS/NZS 3000 as a function of the rating of the associated overcurrent protective device. These values may be used when testing for correct resistance of earth continuity.

NOTE 2 Insulation resistance

For shorter cable runs, the insulation resistance should be significantly greater than 1 MΩ. PVC insulated cables with a route length of 50 m can be expected to have insulation resistances of at least 20 MΩ at a temperature not exceeding 20°C but only 6 MΩ at a temperature of 30°C. If low resistance measurements are of 1–2MΩ, a visual inspection would be required. Damage or subsequent cable failure after installation is highly likely.

NOTE 3 Polarity and correct circuit connections

The polarity testing shall show that all active, neutral and protective earthing conductors in the electrical installation are identified as connected to supply voltage and correct phase, the PEN supply and the earthing system respectively.

The correct circuit connections testing shall show that the active, neutral and protective earthing conductors of each circuit are correctly connected to electrical equipment so that none of the following conditions exist:

(a) Short-circuit between the conductors

(b) Transposition of conductors that could result in the earthing system and any exposed conductive parts of the electrical installation becoming energized

(c) Interconnection of conductors between different circuits.

NOTE 4 Earth fault loop impedance

EFLI verification is specifically required for all supply or final sub-circuits. This can be met by testing minimum earthing resistance in conjunction with the correct selection of protective device or by two specific test methods.

Circuit isolated — An impedance (resistance) measurement test between the active and earth conductors located at the protective device termination and the connection point to the load conductors.

Circuit energized — By using an earth fault loop impedance instrument.

Where an EFLI instrument is being considered to test energised directly connected loads, the increased risk of electric shock under a risk assessment may require the alternative use of the de-energised resistance method.

NOTE 5 RCD operation

The function of the RCD shall be verified either by the operation of the integral test device, or by using special test equipment. A timed result can be used to confirm operation.

Additionally, isolation of all switched poles shall be verified after the RCD has operated to disconnect the designated circuit.

Isolation of all poles shall be verified by voltage tests or, after removing supply, by continuity checks through each pole.

It is industry best practice to repeat the push button test (x2) to confirm internal circuitry has not been damaged by incorrect polarity energisation.

State and Territory legislation may also have additional requirements to the test procedures.

Bibliography

AS 60269.1, *Low-voltage fuses, Part 1: General requirements*

AS 60529, *Degrees of protection provided by enclosures (IP Code)*

AS/NZS 3003, *Electrical installations — Patient areas*

AS/NZS 3008 *(series),* Electrical installations — Selection of cables

AS/NZS 3012, *Electrical installations — Construction and demolition sites*

AS/NZS 3100, *Approval and test specification — General requirements for electrical equipment*

AS/NZS 4777.1, *Grid connection of energy systems via inverters, Part 1: Installation requirements*

AS/NZS 4836, *Safe working on low-voltage electrical installations*

AS/NZS 5139, *Electrical installations — Safety of battery systems for use with power conversion equipment*

AS/NZS 60990, *Methods of measurement of touch current and protective conductor current*

HB 113, *Residual current devices — What they do and how they do it*

HB 187, *Guide to selecting a safe multimeter*

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