



**Electrical Contractors course
Qualified Technical Person (QTP)**

WORKBOOK

UEEEL0002

UEEEL0029

UEEEL0030

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Glossary of Terms

Building wire	Single insulated cable used in switchboards, control wiring and other common applications
FLI	Fault loop impedance
FLR	Fault Loop Resistance
Line Voltage	Voltage measured between two active conductors
Multicore cable	A cable with basic insulation and a second layer (supplementary) of insulation. Common examples are TPS and orange circular cables.
M.E.N	Multiple Earth Neutral
Nominal Voltage	A term used to identify the level of voltage assigned to a circuit. In Australia our nominal supply voltages are 230V and 400V both voltages have a tolerance of +10/- 6%
Orange circular	A multicore, double insulated cable used for various applications that is UV stabilised.
O.L	Open Loop (a result given on various meters)
Phase Voltage	Voltage measured between phase and earth or phase and neutral.
SDI	Single double insulated cable
TPI	Thermoplastic insulated cable (single insulated or building wire)
TPS	Thermoplastic sheathed cable (typical cable used in domestic and commercial installations)

Queensland Electrical Contractors licence

In Queensland you must hold an electrical contractor's licence to perform electrical work for others as a sole trader, partnership or company. Electrical contractor's licences are issued for one year and it is your responsibility to ensure you maintain eligibility requirements such as public liability insurance and the employment of the nominated Qualified Technical Person - QTP and Qualified Business Person - QBP (if not the applicant) throughout that time.

Upon successful completion of this course, you will be awarded the following units of competency:

UEEEL0002 - Apply currency of safe working practices and compliance verification of electrical installations

UEEEL0030 - Conduct compliance inspection of single-phase LV electrical installations

UEEEL0029 - Conduct compliance inspection of LV electrical installations with demand exceeding 100 A per phase

These units meet the current qualification requirement for a nominated Qualified Technical Person (QTP) on an Electrical Contractors licence application (Form 18). The nominated QTP must also have held an unrestricted electrical workers licence for a period of at least 2 years prior to nomination.

Role of a QTP on an Electrical Contractors licence

It is important that you understand your role as a Qualified Technical Person (QTP). All electrical work performed by a licensed electrical contractor must be performed or supervised by a qualified technical person (QTP) endorsed on the licence. The duties that you perform as a QTP will vary depending on the size/circumstances of the electrical contracting business. For further information on the responsibilities of an Electrical Contractor licence holder and QTP (if a different person) read the following on the worksafe website (these documents can also be found using the link sent with your venue details):

[Role of a Qualified Technical Person](#)

[Form 18 – Electrical Contractors licence application](#)

[Supervising electrical apprentices](#)

[Electrical Contractors Guide – Developing a safe system of work for electrical work](#)

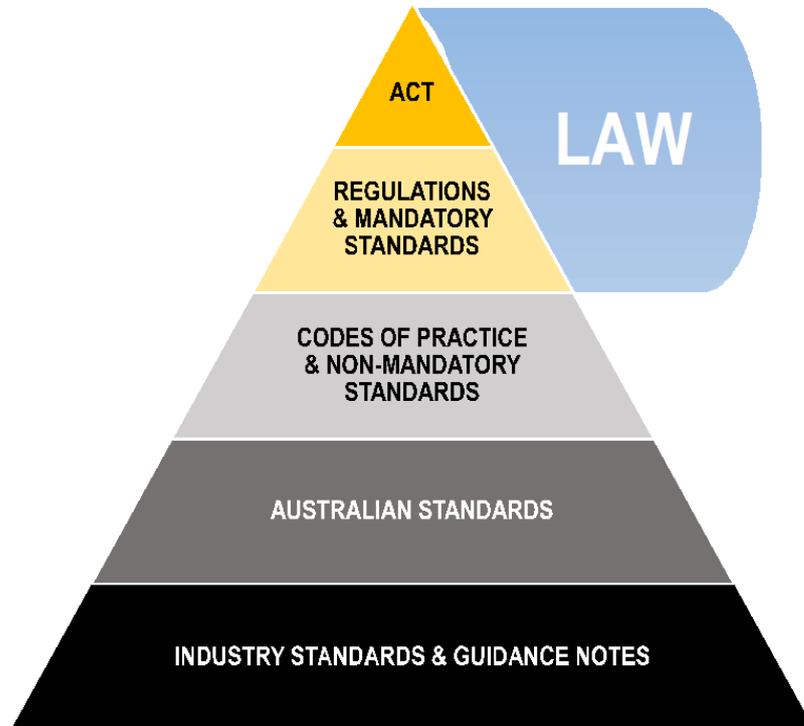
[Managing electrical risks in the workplace Code of Practice 2021](#)

[Electrical Safety – Works code of practice 2020](#)

Please contact our office immediately (0407 164 909) if any of the links above do not take you to the correct document.

Legislation

Each state and territory have legislation in place to ensure electrical installations are installed correctly, tested and are electrically safe. Legislation in Australia is hierarchical in a sense that any given piece of legislation derives its legal force from a hierarchically superior piece of legislation.



In Queensland the Electrical Safety Act 2002 (Qld), supported by the Electrical Safety Regulation 2013 (Qld) and codes of practice contain information on how to identify and manage electrical safety risks. They can help you to make your workplace safer. The Electrical Safety Regulation 2013 (Qld) helps you to identify specific ways to meet your electrical safety duties under the Electrical Safety Act 2002 (Qld) and establishes requirements for:

- electrical work
- electrical licensing
- working near overhead and underground electric lines
- electrical installations
- in-scope electrical equipment
- works of an electricity entity
- electricity supply
- safety management systems for prescribed electricity entities
- cathodic protection systems
- incident notification and reporting.

As an electrical contractor it is important that you are familiar with the electrical safety act and regulations. We have highlighted some key areas of the legislation below:

Electrical Safety Act 2002 – The purpose of this Act is to establish a legislative framework for preventing person from being killed or injured by electricity and/or preventing property from being destroyed or damaged by electricity.

Section 10 – Meaning of electrical risk, electrically safe and electrical safety

Section 18 – Meaning of electrical work

Section 28 – What is reasonably practicable in relation to ensuring electrical safety

Section 30 to 40AA – Primary duty of care of a PCBU (person conducting a business or undertaking) and duties of persons undertaking various types of electrical work

Section 40 – Penalties, see section Part 2B (full section on Industrial Manslaughter)

Section 55 – Licences, requirements for Electrical Workers Licence and Electrical Contractors Licence

Section 137 – Functions and powers of inspectors

Section 138 – Powers of entry for inspectors

Electrical Safety Regulations 2013 – The purpose of the regulations is to support the Act by identifying specific ways to meet your electrical safety duties such as ensuring the electrical safety of licensed electrical workers, other workers and the general public.

Section 14 – cannot work live.

Section 15 – duty to determine if it is live or not.

Section 16 – de-energised equipment not to be inadvertently re-energised

Section 17 – Precautions to prevent re-energisation.

Subsection 2, must have both – LOCK AND TAG if not in complete control

Section 18 – can't work on live unless.....

Section 19 – prelim steps for working on energised equipment

Section 20 – no unauthorised access to work area

Section 21 – contact with electrical work – close switchboard if leaving to do tests, go to car etc.

Section 22 – The way the work must be done – can use this for info in your SWMS. –SEE SUBSECTION 4 – Safety observer not required if testing only.

Section 23 – record keeping for risk assessments and SWMS

Section 25 – testing

Section 26 – cert of test

Section 27 – don't connect defective equipment

Section 28 – CPR requirements

Section 30 – who can sign docs

Section 33 – Licencing

Section 67 – Details to be included in register

Section 70 – Requirement for electrical worker to comply with wiring rules

Section 84 – Safety Switches – switches must be installed within 3 months of purchase.

Section 86 – MUST NOT PERFORM WORK UNLESS SAFETY SWITCH INSTALLED. Or work includes the installation of a safety switch on the socket outlet circuits

Section 279 - Apprentices - Employers must ensure that apprentices/trainees are supervised at all times.

Electrical Safety and Other Legislation Amendment Regulation 2024 - Changes to the Electrical Safety Regulation 2013 were introduced by the Electrical Safety and Other Legislation Amendment Regulation 2024 (ESOLA Regulation) which implements further recommendations from the Electrical Safety Act 2002 review.

These changes include:

- That the roof space of a domestic building is de-energised before any person can access the roof space.
- Electrical work must NOT be performed within 3m of an exposed energised part of electrical equipment, unless an exemption applies. Where an exemption applies, PCBUs will be required to comply with additional safety requirements for energised electrical work.
- Electrical contractors must notify the regulator within 10 business days where a qualified business person or qualified technical person on their licence is no longer employed or performing their role

Codes of Practice

Codes of practice are practical guides on how to comply with your legal duties under the legislation. In Queensland there are four electrical safety codes of practice:

- Electrical safety code of practice 2020 – Working near overhead and underground electric lines.
- Electrical safety code of practice 2021 – Managing electrical risks in the workplace
- Electrical safety code of practice 2020 – Works
- Electrical safety code of practice 2020 – Electrical equipment rural industry

There are other codes of practice that relate to areas such as managing the risks of falls, managing respirable crystalline silica dust exposure and hazardous manual tasks. It is important that you are aware of these codes of practice, see the worksafe website (www.worksafe.qld.gov.au) for a full list of codes of practice.

Remember, these codes don't cover every risk which may arise. It's best for you to consider all hazards connected to your work, not only those that are regulated. If you're a duty holder, you can use another method to meet your legal duties. But you need to make sure your approach gives the same or a higher standard of work health and safety than the relevant code of practice.

Electrical Standards

In all states of Australia, legislation enforces the use of AS/NZS 3000 (commonly known as the Wiring Rules). Within the Wiring Rules, Section 8, covers the requirements for testing and inspecting low voltage electrical installations. In Queensland the Electrical Safety Regulations require that electrical work complies with AS/NZS 3000 and AS/NZS 3012 - Construction and demolition sites. AS/NZS 3000 contains minimum requirements for visual inspection and testing and references other standards that must be followed when undertaking specific work. These include but are not limited to:

AS/NZS 3008.1.1 – Selection of Cables

AS/NZS 3017 – Verification Guidelines

AS/NZS 61439.1-6 – Low-voltage Switchgear and Control gear Assemblies

AS/NZS 3019 – Periodic verification

AS/NZS 3760 - Testing and Tagging

AS/NZS 2293.1 – Emergency lighting design

AS/NZS 3002 - Shows and Carnivals

AS/NZS 3003 - Patient areas

AS/NZS 3004.1 – Marinas

AS/NZS 4836 - Working safely on LV installations.

Work Health and Safety

Risk assessments and Safe Work Method Statements

SWMS and risk assessment must be completed for any high risk construction work that you complete. High risk construction work includes working at heights greater

than 2m, work likely to involve or disturb asbestos, confined space, trench deeper than 1.5m, working near energised installations or services. A full list can be found in Section 291 of Work Health and Safety Regulation 2011. Section 299 of the Work Health and Safety Regulations states that a SWMS must include Hazards, risks, controls and how the controls will be implemented, monitored and reviewed.

Section 19 and 22 of the Electrical Safety Regulations 2013 state that a SWMS and risk assessment must be prepared before electrical work on energised electrical equipment commences at a workplace. ALL electrical work is on energised electrical equipment until it is proven dead so any electrical work must have a SWMS and risk assessment prepared prior to undertaking the work.

From 1 January 2025 requirements for electrical work 'on' energised electrical equipment (live work) now apply to electrical work 'near' energised electrical equipment. To comply with new laws PCBUs must not perform electrical work within 3m of an exposed energised part of electrical equipment, unless an exemption applies. Where an exemption applies, PCBUs will be required to comply with additional safety requirements for energised electrical work.

We recommend referring to Managing electrical risks in the workplace COP 2021 and working to AS/NZS 4836 - Safe working on or near low-voltage and extra-low voltage electrical installations and equipment. This code of practice and standard provides sound guidance regarding identification of electrical hazards, reducing risk and risk control.

The QTP plays an important role in supporting the Electrical Contractor to create a safe system of work. It is the licensed electrical contractor who is responsible for providing SWMS and risk assessment templates/documents to workers and other persons affected by the electrical work. The Electrical Contractor also has a responsibility to communicate and consult with workers to develop and revise the SWMS and risk assessment documents. An Electrical Contractor may create SWMS and risk assessment documents themselves using online templates or by purchasing generic SWMS and risk assessments online that they then adapt to meet the needs of their business.

The managing electrical risks in the workplace Code of Practice 2021 is a guide on how to manage electrical risks in workplaces and is a practical guide to achieving electrical safety. Section 2 of the code of practice details the following steps involved with the risk management process:

Step 1 – Identify the hazards

(Appendix B - Risks associated with electrical work from AS 4836 contains examples of electrical hazards when completing electrical work)

Step 2 - Assess and prioritise risks

(The method for assessing and prioritising the risks is normally stated on your risk assessment – see appendix C for an example)

Step 3 – Controlling the risks.

(Using the Hierarchy of control to implement controls)

AS/NZS 4836:2023 pg. 15

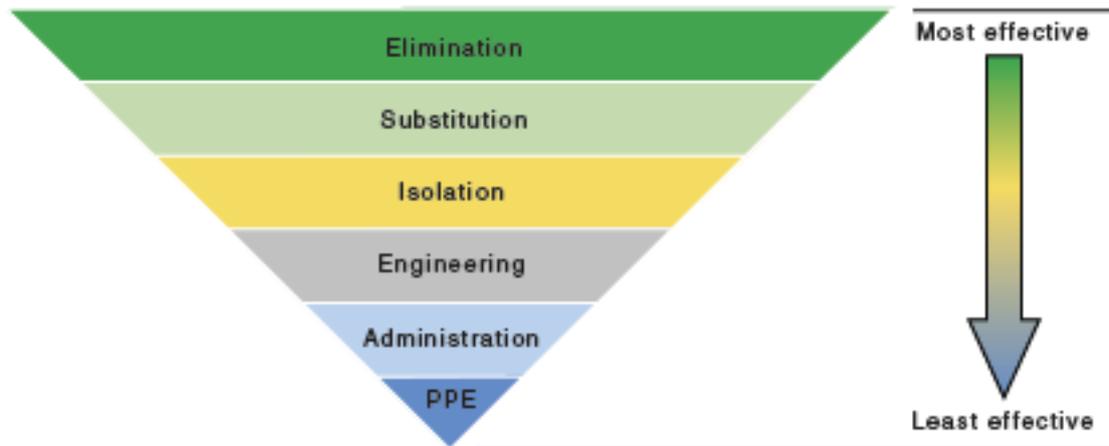


Figure 2.3 – Hierarchy of control

Step 4 – Maintaining and reviewing control measures.

During this course we will provide you with a SWMS to follow when you complete the mandatory test procedures and a risk assessment for you to complete prior to starting the work. The risk assessment is based on four different work scenario's we have created for the testing.

Electrical Safe Working practices

Regard all electrical work as extremely hazardous whether the voltage be high (above 1000V ac), low (50V ac – 1000V ac) or extra-low voltage (less than 50V ac). The primary hazard of electricity is an electric shock affecting normal breathing and heart function. In addition, as current flows through the body, body tissue is burnt.

The secondary hazard is that of falling or being thrown by an electric shock.

The other main hazard of electricity is ARC FLASH

Electric arc flash is a serious hazard which has the potential for personnel injury, equipment damage and loss of business objectives. In Australia, it has been found that there is a need for increased awareness and greater education within the Energy Industry to eliminate or minimise the risk of injury to persons from an arc flash. During the course you will watch a video regarding the hazards of arc flash and we refer you to the "[Electrical ARC Flash hazard management guideline](#)" and AS/NZS 4836:2023 "Safe working on or near low-voltage electrical installations and equipment".

Controlling low-voltage hazards

Most incidents involving low-voltage hazards are preventable. The most effective are those which eliminate or reduce the consequences of the hazard. The essential element for creating a safe work environment is the de-energising, proving dead, lockout and proving dead of electrical equipment before making repairs or fault finding a condition. In addition, the implementation of safe work practices (do not work alone) and proper training will assist the system electrician in controlling low-voltage hazards. Sometimes it is not practicable to disconnect low-voltage equipment and circuits before working on them.

For example, it may be necessary to have equipment operating in order to test it. In such cases the work must be performed by system electricians who are qualified and authorised to do the task. They must follow written safe work procedures. In order for a system electrician to work 'live' the regulatory requirements of the Electrical Safety Regulations, the Code of Practice and the Electrical Safety Act must be met.

By applying the four steps of risk management (identify, assess, control and maintain and review), it can help you identify the hazards and control the risks of the workplace.

High-voltage hazards

The term high voltage applies to electrical equipment that operates at more than 1000 V ac or 1500 V dc. The state or territory Electrical Safety Act, regulations, AS/NZS 3000:2018 *Wiring Rules*, codes of practice and HV isolation and access procedures manuals must always be consulted when any high-voltage work is intended to be undertaken. These provide advice on ways to discharge safety obligations.

Isolation of electrical circuits is a basic safety procedure that protects workers, electrical production and consumption devices or service lines. This means that the power is turned off and isolated at the source so that no energy can enter or leave those devices or service lines. Isolation procedures must include a warning to all workers that the equipment in a particular area is being worked on and must not be operated or the area entered.

Extra-low voltage (ELV)

Extra-low voltage is defined as voltage not exceeding 50 V rms ac or 120 V or less ripple-free dc. Voltages at these levels are usually not hazardous but hazards may exist under certain conditions. For example, extra-low voltage may be hazardous in a confined location with moisture or heat on the work area.

Extra-low voltage can cause death when the resistance of the body (large area contact) is lowered. Primarily, current, rather than voltage, is the measure of shock intensity. The passage of even a very small current through a vital part of the human body can cause death. For dc powered equipment, although the voltage levels are usually not hazardous, energy hazards (>5 joules) may still exist.

High currents

Electrical workers need to be aware that if working on live circuits, fault current of up to **20 times** the rated current of the supply can flow during fault conditions. High current means greater damage to the body as a result of heating within tissues. The thermal heating of tissues increases with the square of the current (I^2R) and produces severe burns.

Higher currents are expected when you are **closer** to a supply distribution transformer. This is due to the reduction of impedance within the overhead and supply cables.

Toxic gasses

The arcing and burning associated with a low-voltage electrical fault may cause toxic gasses to be emitted which can have an adverse effect on a person. The effect may be severe if 'carcinogens' are present. Electrical hazards represent a serious, widespread occupational danger; all electricians are exposed to electrical energy during the performance of their daily duties, and electrocutions do occur.

Record Keeping

Record keeping is an important part of maintaining a safe working environment. An Electrical Contractor must, as a minimum keep the following records for each job:

- Risk assessment
- SWMS
- Certificate of Test
- Incident/accident reports

An Electrical Contractor must also keep a record of:

- Their employees induction and safety training,
- A register of their workers competencies (licence details and expiry)
- A record of their workers inclusion in the safety system (toolbox talks reviewing SWMS).

It is best practice to keep a record of test results and photographs documenting work completed. Also, for tax purposes an Electrical Contractor may need to retain any invoices received from suppliers or supplied to customers.

Risk assessments and SWMS

Section 23 of the Electrical Safety Regulations 2013 states that a risk assessment should be kept for at least 28 days and a SWMS until the work to which it relates is completed. However, if there is a serious electrical incident or dangerous electrical event occurs in connection with the work then the person must keep the risk assessment and SWMS for at least 2 years.

Certificate of test

Section 26 of the Queensland Electrical Regulations 2013 explains that a certificate of testing and safety must be given to the person for whom the electrical work was performed as soon as practicable after testing the electrical work.

The certificate must state the name and address of the person for whom the work was performed, the electrical equipment tested, the day the electrical equipment was tested and the number of the electrical contractor licence under which the electrical equipment was tested.

A certificate of testing and safety can be integrated into an invoice. The picture below is an example of an integrated invoice and test certificate.

Certificate of Test Tax Invoice	
Date:	1/7/2023
Tax Invoice No:	05436
Electrical Contractors Licence:	72345
Client:	Mr John Doe
Client Information:	23 Orland Drive, Coomera, Queensland, 4209
Details of work:	Install new GPO in rear bathroom which is connected into power circuit two (P2), install new sub-mains to shed and install 4 lights and 4 GPO's.
Date when work was tested:	Installed and tested on the 23 rd of May 2023
Total:	\$1900.00
GST:	\$172.72
I certify that the electrical installation, to the extent it is affected by the electrical work, has been tested to ensure it is electrically safe and in accordance with the requirements of the wiring rules and any other standard applying to the electrical installation under state legislation.	

CERTIFICATE OF:

TESTING AND COMPLIANCE

(Electrical installations)

Work Performed for:

TESTING AND SAFETY

(Electrical equipment)

NAME: **Mrs Jane Doe**

ADDRESS: **123 Fake St, Sparky-Ville, Queensland**

Electrical installation / equipment tested (detailed list of all work done):

Three phase 16mm² consumer mains from pillar to MSB in house

10mm² Sub-main from MSB to DB1 in rear shed

2 X 20A power circuits from MSB in house

2 X 16A light circuits within house

1 X 15A power circuit in shed

1 X 16A lighting circuit in shed

Date of test: **31 / 5 / 2023**

Electrical Contractors licence number: **73283**

Name on Contractors Licence: **John Cablejerker**

Electrical contractor phone number: **(07) 5665 7915 0422 349 244**

For **electrical installations**, this certifies that the electrical installation, to the extent it is affected by the electrical work, has been tested to ensure that it is electrically safe and is in accordance with the requirements of the wiring rules and other standards applying under the Electrical Safety Regulations 2002 to the electrical installation.

For **electrical equipment**, this certifies that the electrical equipment, to the extent it is affected by the electrical work, is electrically safe.

Testing Installations

In all states of Australia, legislation enforces the use of AS/NZS 3000:2018 (commonly known as the Wiring Rules). Within the Wiring Rules, Section 8, covers the requirements for testing and inspecting low voltage electrical installations. Further explanation of the test procedures in section 8 of the wiring rules can be found in AS/NZS 3017 *Electrical Installations - Verification guidelines*.

Test Equipment

To carry out all the mandatory tests set out by AS/NZS 3000 the following equipment is required:
Insulation resistance tester (1000V capability);

- Ohmmeter;
- Voltage indicator;
- Suitable probes (correct CAT III or IV);
- Trailing leads (50-100 meters of single insulated cable)
- A range of resistors of known values;
- A suitable instrument for measuring fault-loop impedance; and
- A suitable instrument or device for checking the operation of an RCD.

Additional equipment that should be consideration as required,

Proving unit

Class 1 PPE – insulated glove kit 500v

AS3017:2007 – Clause 1.7.2 – Page 8

(I) Voltage indicators such as high impedance volt meters, neon, and LED devices, should only be used to verify the presence of a voltage. They should not be used to verify the conductivity of a cable, as they will operate satisfactorily with high resistances within the circuit under test.



Test Instruments

As per section 8 of the Managing Electrical Risks in the Workplace COP 2021 a person conducting a business or undertaking (PCBU), must ensure that the person carrying out energised electrical work has tools, testing equipment and PPE that are suitable for work, that have been properly tested and that are maintained in good working order. Workers carrying out electrical testing must be appropriately trained and competent in test procedures and in the use of testing instruments and equipment.

This includes:

- being able to use the device safely and in the manner for which it was intended
- being able to determine, by inspection, that the device is safe for use, for example, the device is not damaged and is fit for purpose
- understanding the limitations of the equipment, for example, when testing to prove an alternating current circuit is de-energised—whether the device indicates the presence of hazardous levels of direct current
- being aware of the electrical safety implications for others when the device is being used, for example, whether the device causes the electric potential of the earthing system to rise to a hazardous level
- knowing what to do to ensure electrical safety when an inconclusive or incorrect result is obtained.

Checks carried out on test instruments.

Test instruments that are to be used or connected to electrical equipment should meet the following conditions:

- be suitable for the work in terms of their function, operating range and accuracy
- be in good condition and working order, clean and have no cracked or broken insulation. Particular care must be taken regarding the condition of the insulation on leads, probes and clips of test equipment
- pose no danger of electrocution to workers or damage to the electrical equipment during testing
- have suitably insulated leads and connection probes that enable connection or contact with energised parts to be made with minimal risk to the electrical worker
- provide suitable protection against hazards arising from over-voltages that may arise from or during the testing or measurement process.

AS 61010.1: Safety requirements for electrical equipment for measurement, control and laboratory use – General requirements provides a classification for instruments on the basis of their immunity to over-voltage, which may be experienced in different parts of electrical equipment. Instruments should be rated as Category III or IV to enable their use on all parts of the equipment.

Test probes and other equipment should be designed and selected so that they cannot inadvertently short circuit between live conductors or live conductors and earth. The terminals of test equipment should be shrouded and all other test sockets on measuring instruments should be designed to prevent inadvertent contact with any live test socket or conductor when equipment is in use. Where appropriate, test leads and testing devices need to be provided with suitable fuse protection. Testing equipment, where used in hazardous flammable areas, should be designed and clearly marked as being suitable for use in these conditions. Testing equipment used for detecting an energised source should be checked to prove that it is functioning correctly immediately before and after the test has taken place. The standard test regime is to test a known source of energy, test the de-energised circuit for zero volts, and then test the known source again.

Table 9.1 — Test instrument category and typical use

Over-voltage category	Circuit voltage	Suitability	Examples
I	ELV	Measurements on circuits not directly connected to mains	ELV DC 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, LV DC circuits
IV	LV	Measurements performed at the source of an LV installation	Mains and main switchboards

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

A category III or IV multimeter is a tool that will be used during the testing procedure. It will serve as your ohmmeter and voltmeter. Before testing is conducted, a risk assessment should be completed to help identify any potential hazards. You should also isolate the supply and verify isolation with a voltmeter.

Cat III or IV – Meter, Leads and Probes.



Suitability of the meter

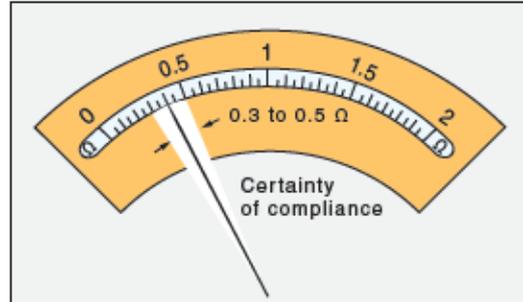
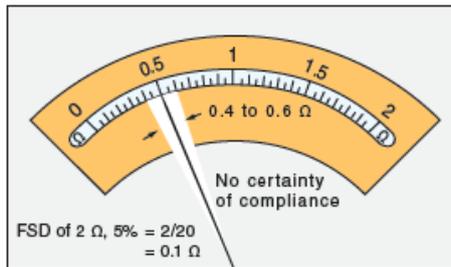
AS/NZS 3017:2023 Clause 2.2.2.2 **Lower range ohmmeter**

The Meter shall be either –

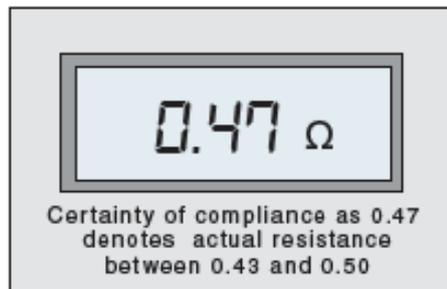
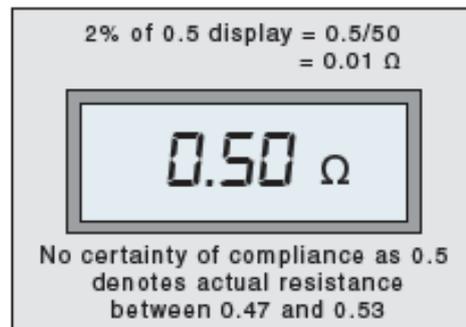
An analogue type of meter with a range having full scale deflection of the needle of no more than 2Ω : or

A digital type or electronic-analogue meter having readings, in ohms to at least 2 decimal places.

Analogue Ohmmeter
Specified accuracy of $\pm 5\%$ full-scale deflection (FSD)



Digital Ohmmeter
Specified accuracy 2% of display ± 3 digits



Testing for dead

Ensuring that the power is de-energized removes the hazard of electric shock when working around electrical equipment. Refer to section 5 of the Managing Electrical Risks in the Workplace COP 2021 for the standard steps for isolation. Being able to test for dead (de-energised) is an important skill and electrical workers should be aware of correct methods of testing for dead. See Appendix E of this workbook that refers to AS/NZS 4836 figure 4.2 – Confirm and secure isolation of energized installations and follow the steps below when testing for dead.

Step 1. Prepare risk assessment and ensure SWMS is followed for live work. Always assume live until tested dead.

Identify and assess the Perspective Fault Current (PFC) and the Arc flash boundary.

Establish the work zone.

If any person is required to work within 3m of energised exposed conductors or parts, a competent person shall identify appropriate risk treatments.

Safety shall not be compromised because of operational pressures to carry out the work.

The figure 2.2 below depicts the 500mm work zone for work on low-voltage and extra low voltage equipment within an enclosed switchboard panel. The 500mm work zone is shown in the circle. Energised conductors and live conductive parts do not pose a significant risk when the door of the cabinet in which they are contained is closed. Therefore, when the cabinet door is closed, the internal components are not considered to be part of the work zone and may remain energised even if they are within the exclusion zone, of 3m.

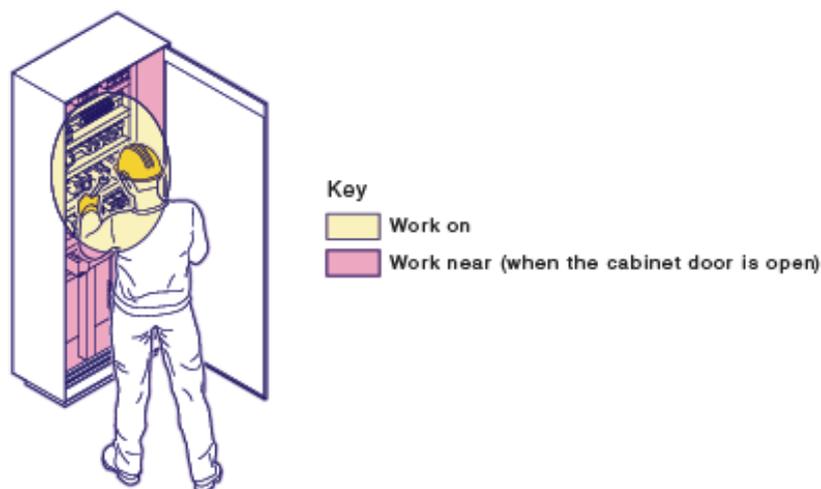
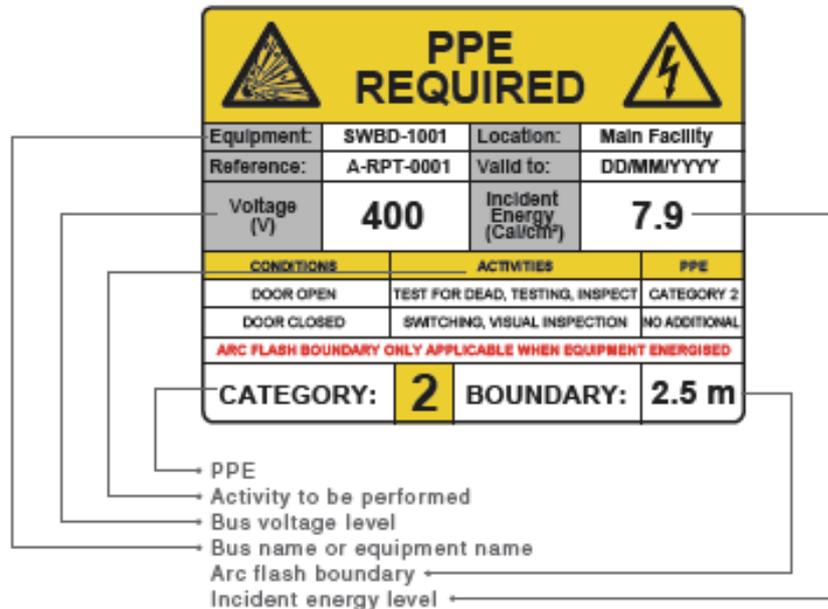


Figure 2.2 — 500 mm electrical work zone for work on low-voltage and extra-low voltage equipment within an enclosed switchboard panel



[SOURCE: Modified with permission from Australian Energy Council, *Electrical Arc Flash Hazard Management Guideline*, 2019, Diagram 12]

For non-domestic switchboards the above sample labelling is required as detailed AS/NZS 61439 and AS/NZS 4836

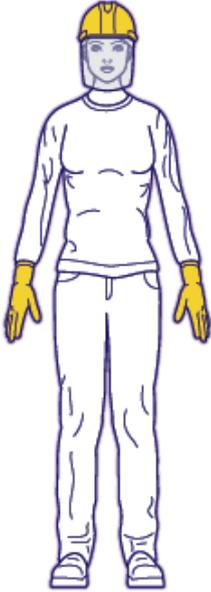
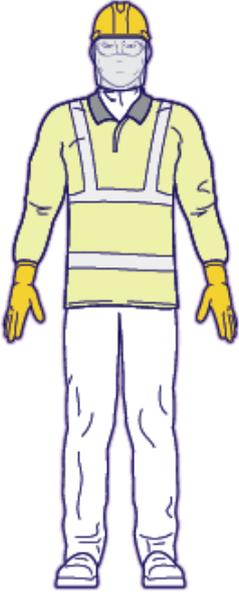
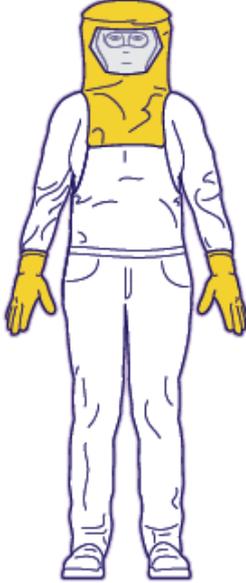
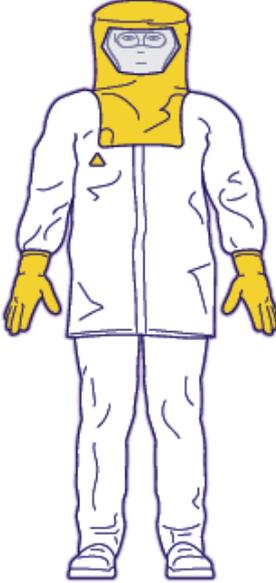
- That clearly identifies the PPE category required in this case = Category 2
- And the Arc Flash boundary required to be established in this case = 2.5m

When labelling is not provided, as an engineering study is absent, then you need to refer to AS/NZS 4386 – table B1 and make an assessment of these prior to carrying out any switching, examination or testing of the switchboard.

Note this is page 1 of 4 in AS/NZS 4836:2023 pages 67 to 70.

Step 2. Prepare to test/work on live equipment.

Ensure that you are wearing appropriate PPE for the type of work you are completing. Below is an extract from AS/NZS 4836 with recommendations of the levels of PPE and when each level should be used.

<p>4 cal/cm² PPE CATEGORY 1</p>	<p>8 cal/cm² PPE CATEGORY 2</p>	<p>25 cal/cm² PPE CATEGORY 3</p>	<p>40 cal/cm² PPE CATEGORY 4</p>
			<p data-bbox="1134 562 1445 689">HAZARD - Be aware of heat stress when wearing Cat 4 clothing</p> 

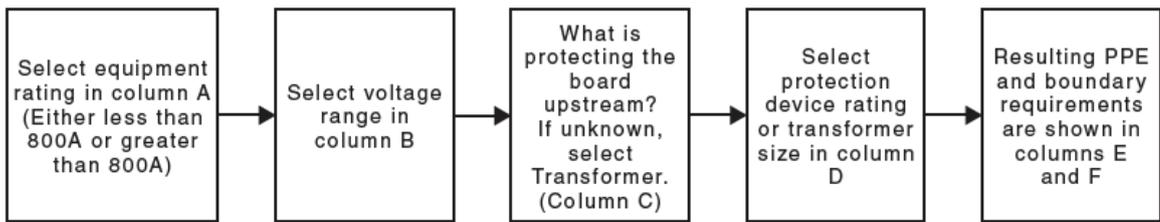


Table B.1 — Incident energy and arc flash boundary recommendations in absence of an engineering study

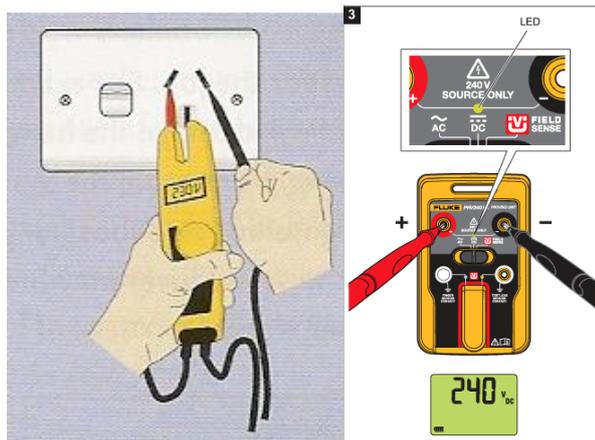
A	B	C	D	E	F	
Equipment	Nominal voltage	Upstream device type	Upstream device rating	Minimum arc rating PPE, cal/cm ²	Arc flash boundary	
Switchboards rated ≤ 800 A (IEEE 1584 equipment type: Panel/MCC) Minimum working distance: 46 cm	230 V (1φ)	Transformer	≤ 15 kVA	NOTE 1	< 0.46 m	
			≤ 75 kVA	8	1.5 m	
			≤ 250 kVA	40	3.0 m	
		Fuse	≤ 150 A	NOTE 1	< 0.46 m	
			≤ 600 A	8	1.5 m	
			≤ 800 A	40	3.0 m	
			Circuit breaker T/M or M	≤ 80 A	NOTE 1	< 0.46 m
				≤ 300 A	8	1.5 m
				≤ 800 A	40	3.0 m
		Switchboards rated ≤ 800 A (IEEE 1584 equipment type: Panel/MCC) Minimum working distance: 46 cm	400 V (3φ)	Transformer	≤ 10 kVA	NOTE 1
≤ 40 kVA	4				1.0 m	
≤ 75 kVA	8				1.5 m	
≤ 400 kVA	40				3.5 m	
Fuse	≤ 63 A			NOTE 1	< 0.46 m	
	≤ 250 A			8	1.5 m	
	≤ 800 A			40	3.5 m	
Circuit breaker (At maximum settings, instantaneous enabled)	≤ 100 A			4	1.0 m	
	≤ 250 A			8	1.5 m	
	≤ 630 A			40	2.5 m	
Circuit breaker Short time pickup: ≤ 10x rated Short time delay: ≤ 100 ms No instantaneous	≤ 100 A			40	1.5 m	
	≤ 400 A			40	2.5 m	
	≤ 630 A			40	3.0 m	
Circuit breaker Short time pickup: ≤ 10x rated Short time delay: ≤ 300 ms No instantaneous	≤ 630 A			40	3.0 m	

Step 3. Set meter to correct setting and range if applicable.

- Ensure meter is CAT III minimum. CAT IV for Consumers mains/ Main switchboard.
- Volts a.c. selected.
- Select correct range if applicable.

Step 4. Test meter on known source.

- Use a local power source that is known (GPO or similar) to check operation of meter. A broken meter will read 0 even when testing a live circuit.



Step 5. Without changing meter setting, test for dead on equipment.

- Test between all conductors
- If the meter goes to sleep or batteries fail, go back to step 4

Step 6. Re-confirm the operation of your meter on known source.

- Check meter again at the known source to ensure that the meter still works.



Visual Inspection

Clause 8.1.2 of AS/NZS3000 states that prior to placing an electrical installation into service, the repair, construction or addition shall be verified as far as practicable. The installation must meet the wiring rules as a minimum and must be INSPECTED and TESTED.

The inspection of an electrical installation should be performed in line with Clause 8.2 of AS/NZS 3000 – VISUAL INSPECTION. This sub-section details that a visual inspection shall be made on all electrical installations to verify that the work complies with the wiring rules.

Clause 8.2.2 provides a checklist of the areas and items to be checked within the installation. The main areas are:

General:

- Basic protection
- Fault protection
- Protection against hazardous parts
- Protection against spread of fire
- General condition of the electrical equipment

Consumer Mains:

- Current-carrying capacity
- Voltage drop, e.g. size of conductors
- Underground installation conditions
- Aerial installation conditions
- Connection of wiring
- Protection against external influences

Switchboards:

- Location
- Protection devices
- Isolating devices
- Connecting devices
- Connection and fixing of wiring and switchgear
- Identification and labelling of electrical equipment
- Protection against external influences

Wiring systems:

Conductor size
Identification of cable cores
Adequate support and fixing
Connections and enclosures
Particular installation conditions
Segregation from other services and electrical installations
Protection against external influences

Electrical Equipment:

Isolation and switching devices for protection against injury from mechanical movement devices and motors
Isolation and switching devices for protection against thermal effects, e.g. motors, room heaters, water heaters
Switching devices for particular electrical equipment
Particular installation conditions
Compliance with required standard
Connection, support and fixing
Protection against external influences including ingress of moisture where required by any clause
Suitability for intended voltage, current and frequency

Earthing:

MEN connection
Earth electrode
Earthing conductors
Equipotential bonding conductors
Connections, joints and terminations
Protection against external influences
Connection to earthing arrangements for other systems
Creation of earthed situation that may require earthing of additional electrical equipment

A Visual Inspection and safety audit can be achieved by following AS/NZS 3019 sections 3,4 & 5 in conjunction with Mandatory testing in Section 8 AS/NZS 3000.

Forms to follow and record your results can be found in Appendix A of AS/NZS 3019 and Appendix B of AS/NZS 3017:2022. We have used these standards to create the forms you will use in class today.

Mandatory tests

Clause 8.3.3.1 of AS/NZS 3000 lists the mandatory tests that shall be carried out on low voltage electrical installations:

- (a) Continuity of the earthing system (earth resistance of the main earthing conductor, protective earthing conductors and bonding conductors), in accordance with Clause 8.3.5.
- (b) Insulation resistance, in accordance with Clause 8.3.6.
- (c) Polarity, in accordance with Clause 8.3.7.
- (d) Correct circuit connections, in accordance with Clause 8.3.8.
- (e) Verification of impedance required for automatic disconnection of supply (earth fault-loop impedance), in accordance with Clause 8.3.9.
- (f) Operation of RCDs, in accordance with Clause 8.3.10.

Test Sequence

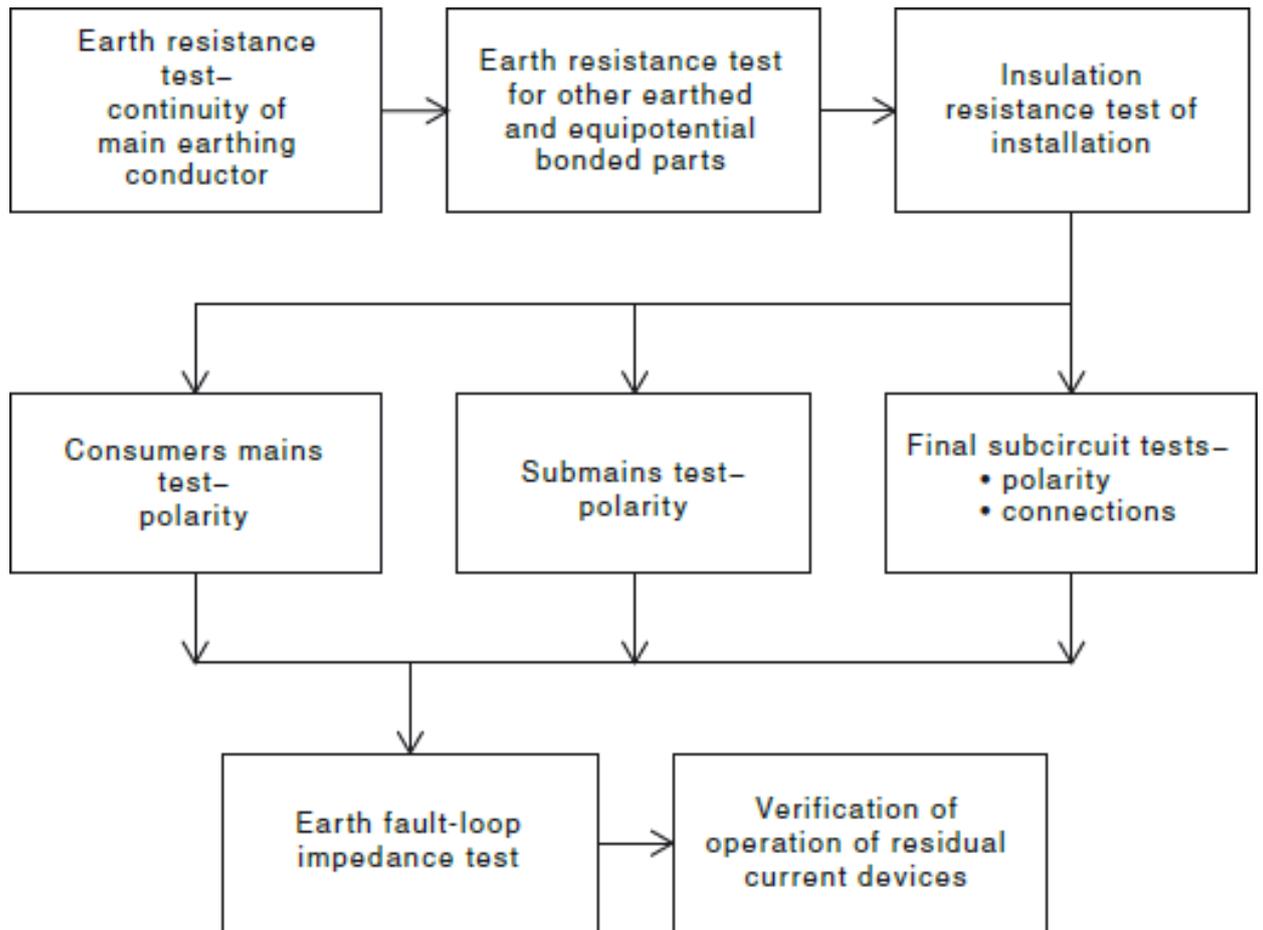


FIGURE 8.1 TESTING SEQUENCE

Mandatory Test (a) Continuity of the earthing system

The reason for checking earth continuity and resistance is to ensure that the earthing system has been installed as per the Wiring Rules and the resistance of the protective earthing conductor is low enough to permit the passage of sufficient current to cause circuit protective devices to operate.

The main earthing conductor must be tested separately and shall be not more than 0.5 Ω . Resistance of any equipotential bonding conductor shall be tested and cannot measure more than 0.5 Ω .

Definition of main earth conductor:

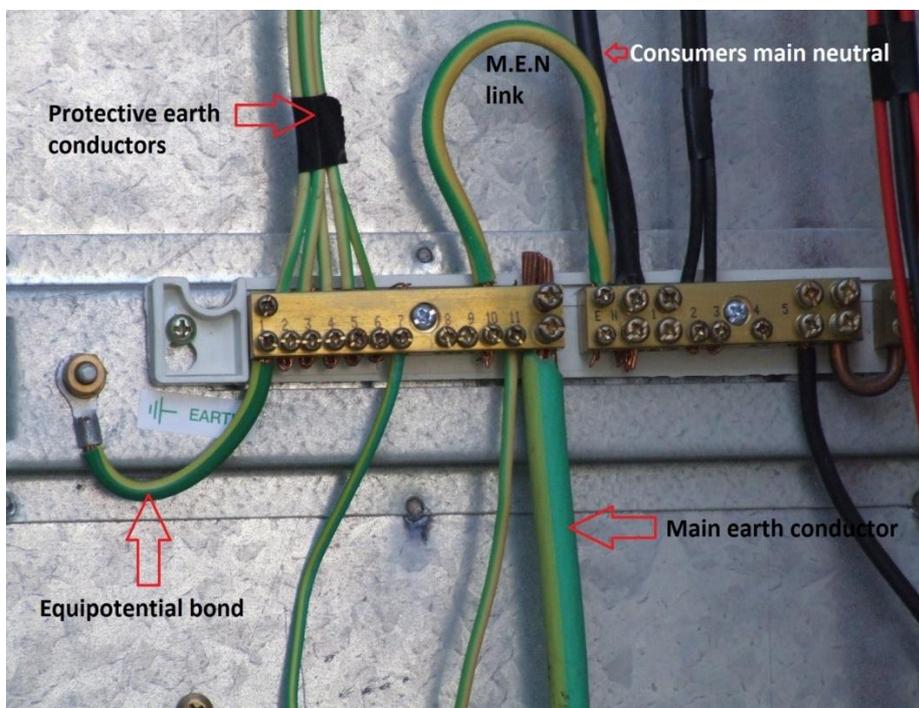
A conductor connecting the main earthing terminal/connection or bar to the earth electrode. (Clause 1.4.81)

When testing the resistance of the protective earthing conductors, the result shall be low enough to permit the passage of current necessary to operate the circuit protective device. These results must be checked against table 8.2 (Re) of the Wiring

Rules to ensure that if a fault occurs between active and earth, the fault-loop resistance is low enough and will operate circuit protection device.

Definition of protective earthing conductor:

A conductor, other than a main earthing conductor, connecting any portion of the earthing system to the portion of the electrical installation or electrical equipment required to be earthed, or to any other portion of the earthing system. (Clause 1.4.100)



****All tests are to be carried out de-energised unless otherwise stated****

To test the **main** earth conductor:

1. Check for dead (de-energized)
2. Disconnect the main earth conductor from the main switchboard
3. Zero ohmmeter to ensure accuracy (this may include trailing lead)
4. Test from one end of the main earth conductor to the other
5. Result must be no greater than 0.5Ω

All **protective** earthing points must be tested and proven within an installation.

To test the protective earthing conductors:

1. Disconnect the MEN link
2. Zero ohmmeter to ensure accuracy (this may include trailing lead)
3. Testing from the main earth bar, check all earth conductors against table 8.2 of AS/NZS 3000 **Re** (*you may want to record results for fault loop resistance*)
4. Reconnect the MEN link

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TABLE 8.2
MAXIMUM VALUES OF RESISTANCE OF FINAL SUBCIRCUITS
AT 80% RATED CURRENT RELATING TO Z_s
IMPEDANCE VALUES IN TABLE 8.1

A1	Protective device rating, amps	Conductor size		Circuit breakers						Fuses					
				Disconnection times											
		Active mm ²	Earth mm ²	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	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			

Any structural items that require bonding to earth (equipotential) require testing.

To test the **equipotential** bonding conductors:

1. Zero ohmmeter to ensure accuracy (this may include trailing lead)
2. Test from either ends of the equipotential bonding conductor
3. Result must be under 0.5Ω

EXAMPLE OF TESTING THE MAIN EARTH CONDUCTOR

Disconnect the main earth conductor to ensure no parallel paths

Testing the earthing system

1. **MAIN EARTH – FIGURE 4.3**
 - a. Result must be no greater than $0.5\text{ohms} \pm 2\%$ (check the accuracy of your meter) **0.5Ω**
2. **SWITCHBOARD EARTH – FIGURE 4.4**
 - a. Result must be no greater than $0.5\text{ohms} \pm 2\%$ (check the accuracy of your meter) **0.5Ω**
3. **EQ BOND EARTHs – FIGURE 4.4**
 - a. Result must be no greater than $0.5\text{ohms} \pm 2\%$ (check the accuracy of your meter) **0.5Ω**
 - b. **Don't forget to disconnect the earth from the earth bar as there may be alternative paths.**
4. **PROTECTIVE EARTH POINTS – FIGURE 4.4**
 - a. **TABLE 8.2 (re)**

Zero or null the meter against your trailing lead.

Note if you are using an analogue meter then you should regularly check this as you may bump the adjustment knob while testing (say every third test)



Don't forget the resistance is effected by temperature, so don't assume its correct from the last time you used it.

Mandatory Test (b) Insulation Resistance

As detailed in the Wiring Rules, Clause 8.3.6, we are required to conduct an insulation resistance test. This test ensures that the insulation resistance between all live conductors and earth is satisfactory.

The insulation resistance between the conductors of consumers mains and sub-mains; and live and earthed parts of an electrical installation, or parts thereof, including consumers mains and sub-mains shall be not less than 1 MΩ.

To test the installation for insulation resistance:

1. Check that the installation has been de-energised at the point of supply
2. Remove the MEN link
3. Ensure ALL circuit breakers, RCDs, RCBOs and fuses are **OFF**.
4. Ensure all control switches, light switches, Isolators are in the **ON** position.
5. Set the insulation resistance tester to the 500V scale and test as per FIGURE A.5
 - a. Some connected equipment may be damaged by overvoltage in this case damage can be avoided by.
 - i. Connect the Live conductors together (bridging Active and Neutral)
 - ii. Testing the equipment with a test voltage of 250V
6. Test from earth bar to neutral bar. Result must be over 1MΩ. (subject to the following)
 - a. Sheathed heating elements not less than 0.01 MΩ
 - b. RCDs with a functional earth not less than 0.05 MΩ
 - c. As listed in any other Australian Standard
 - d. For Consumers Mains not less than 2 MΩ (check Supply Authority -QECM)
7. Operate any switching combinations (two way, intermediate) and repeat the test.
8. If results are below 1MΩ, determine which part of the circuit has the low value. Carry out any fault rectifications and repeat the test.
9. Reconnect the MEN link
10. Test the insulation tester on the known value to ensure correct function.

NOTES 1 to 3 - For shorter cable runs less than 50m in length, over 50MΩ unless effected by temperature.

NOTE 4 - For XLPE cable runs less that 50m in length, over 1500MΩ

When testing individual circuits, ensure that the neutral and active conductors are isolated from other circuits and the neutral bar by; .

- by turning off the circuit breaker
- If single pole RCBO removing the neutral when required,
- If RCBO with a functional earth removing both the Neutral and Active.

When testing three phase circuits, insulation resistance must be checked between all active conductors with the meter set to 1000V (recommended).

Single Phase testing generally involves 3 tests

Three Phase testing generally involves 10 tests

Mandatory Test (c) Polarity

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

This testing is to ensure:

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

NOTE: It is highly recommended that the polarity test be performed on a de-energised system. This is to eliminate the risk of electric shock. A de-energised polarity test is sometimes called a "point to point" test. This is to ensure that no transposition of conductors is present before energization of the electrical installation resulting in an unsafe situation.

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;
- (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 consumer's mains neutral shall be connected to the neutral bar of the main switchboard.

To test the polarity of the consumer mains:

1. Zero ohmmeter to ensure accuracy (this may include trailing lead)
2. Turn main switch off (ensures no back-feed through other circuits)

3. Connect one probe of the ohmmeter to the neutral conductor at the point of supply and the other probe to the neutral bar.
4. Result should be relative to the length and size of the conductor. (*use table 8.2*)
5. Repeat test with active conductor(s) and test from the point of supply to the line side of the main switch.
6. Result should be relative to the length and size of the conductor. (*use table 8.2*)

To test the polarity of the sub-mains:

1. Zero ohmmeter to ensure accuracy (this may include trailing lead)
2. Disconnect the neutral conductor at both ends (ensures no back-feed)
3. Connect one probe of the ohmmeter to the neutral conductor at the supply end and the other probe to the load end.
4. Result should be relative to the length and size of the conductor. (*use table 8.2*)
5. Repeat test with active conductor(s) (make sure load side is isolated from circuits).
6. Result should be relative to the length and size of the conductor. (*use table 8.2*)

To test the polarity of the sub-circuit:

1. Zero ohmmeter to ensure accuracy (this may include trailing lead)
2. Make sure all switches are ON in the circuit to be tested
3. Connect one probe of the ohmmeter to the load side of the sub-circuit circuit breaker and the other probe to the active terminal of the load (GPO, light appliance).
4. Result should be relative to the length and size of the conductor. (*use table 8.2*)
5. Open a switch in the sub-circuit and ensure the continuity of the active conductor becomes open circuit ($M\Omega$ or O.L*)
6. Checking the polarity of the load also includes the neutral (earth has already been proven). Repeat the continuity check with the neutral in all loads, checking the switch doesn't operate the neutral conductor.
7. Repeat test with all active and neutral conductors in the installation, continuing to check the polarity and switching arrangements of each circuit.

* O.L indicates Open Loop. Open Loop is above the level that the multimeter can measure.

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.

Polarity for Phase sequence of multi-phase equipment

Remember – Red White Blue all the way through!

- Using a phase rotation meter, to determine the phase rotation and confirm with the manufacture’s requirement of the equipment.
- If the circuit under test has phase sensitive equipment connect, you can energise the circuit and check the operation is in the correct direction of travel, if safe to do so.

Changing phase rotation is carried out in the equipment **NOT** the installation fixed wiring.

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

Mandatory Test (d) correct circuit connections

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

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

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

- (a) There is no short-circuit between the conductors;

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

- (b) There is no transposition of conductors that could result in the earthing system and any exposed conductive parts of the electrical installation becoming energised; and

- (c) There is no interconnection of conductors between different circuits.

To test correct connection: "Walk the Dog".

1. Zero ohmmeter to ensure accuracy (may include trailing lead) or Buzz function.
2. Turn off all circuit breakers at the switchboard.
3. Using an ohmmeter, conduct a resistance check between live conductors of different circuit.
 - a. Plant the left hand on the left terminal of outgoing circuits.
 - b. and test with right hand moving from Left to Right to each and every Active, Neutral and Active bar/ neutral bar.
 - c. When you get to the end move your left hand over ONE terminal and repeat
 - d. Until your left hand gets to last outgoing Active, Neutral and Active bar/ neutral bar.
 - e. DON'T GO TO FAST ALLOW THE METER TIME TO TEST.
4. Result should be infinity (large Ω) – NO BUZZ

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.

Mandatory Test (e) earth fault-loop impedance

Fault Loop Impedance

Fault loop impedance (F.L.I) is an important aspect of testing and verification. If a circuit's F.L.I meets the requirements of AS/NZS 3000, it ensures that when a fault occurs between active and earth, the circuit breaker will disconnect fast enough so that the cable doesn't suffer any damage.

In the event of a fault, it is only the cables impedance that limits the current flow. So if we can keep the cables impedance low, we can expect to receive high fault currents which will trip the circuit breakers quickly. The more fault current there is, the quicker a circuit breaker will operate.

The tripping requirements for circuits are detailed in AS/NZS 3000 clause 1.5.5.3 (d). It explains the tripping requirement for final sub-circuits and how they must disconnect within 0.4 seconds.

1.5.5.3 Protection by automatic disconnection of supply

(a) *General* Automatic disconnection of supply is intended to limit the prospective touch voltage arising between simultaneously accessible conductive parts in the event of a fault between a live part and exposed conductive parts or a protective earthing conductor.

(b) *Disconnection times* The maximum disconnection time for 230/400 V supply voltage shall not exceed the following:

(i) 0.4 s for final sub-circuits that supply—

(A) socket-outlets having rated currents not exceeding 63 A; or

(B) hand-held Class I equipment; or

(C) portable equipment intended for manual movement during use.

(ii) 5 s for other circuits including sub-mains and final sub-circuits supplying fixed or stationary equipment.

Section 8 of AS/NZS 3000 has tables that stipulate the maximum values of fault loop impedance and resistance. Table 8.1 is used when testing live and values of impedance checked with a F.L.I meter. Table 8.2 is fault loop resistance; this table is used if your measurements were taken de-energised. Resistance can only be recorded when the circuit is not producing inductive reactance – it must be de-energized.

Resistance and impedance are both measured in ohms (Ω), resistance is often referred as the opposition to current flow. Impedance is said to be the TOTAL opposition to current flow, this may include inductive and capacitive reactance.

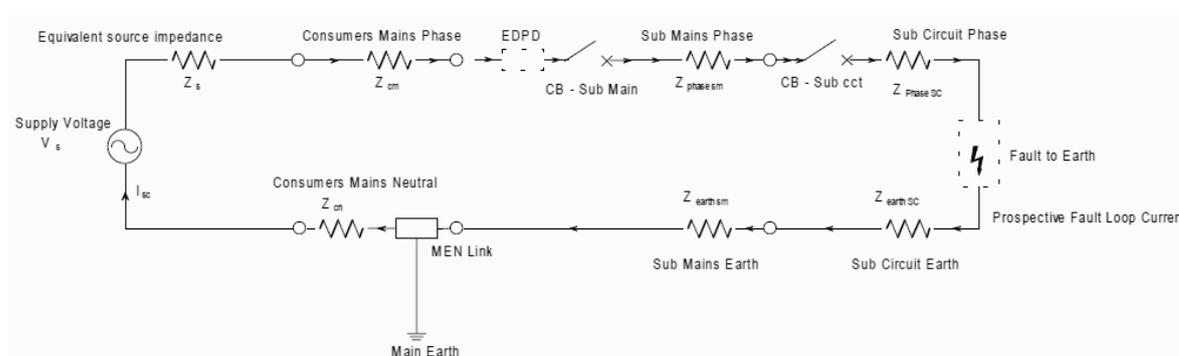
The lower the value of fault loop impedance, the higher the value of fault current and hence the faster the disconnection time.

Fault loop further explained.

A fault loop is the circuit that is travelled when a fault occurs. The fault loop is a fault considered between active and earth. All cable impedance and equipment impedance must be calculated to determine the amount of fault current that will occur and is required with determining the circuit protection device.

The picture below breaks down the fault loop into individual elements of the circuit.

The supply transformer is on the left hand side and is connected to the consumer mains. The rest of the circuit details the cables and connections down to the point of the fault. The return path is through the earth cable, back to the MEN link and then through the consumer mains neutral.



There are a few things that can vary the amount of F.L.I in circuits.

Cable size

Length of cable

Size of supply transformer

Cable size:

Cross-sectional area is indirectly proportional to the impedance.

E.g., bigger cables = smaller impedance.

Length of cable:

Length is directly proportional to the impedance.

E.g., longer cables = bigger impedance.

Size of supply transformer:

Larger transformers have less impedance due to their large winding sizes.

Checking Fault Loop Impedance/Resistance

The fault loop can be checked in two ways, energized and de-energized. When the fault loop is tested live, we call it fault loop impedance. When the fault loop is tested dead, we call it fault loop resistance.

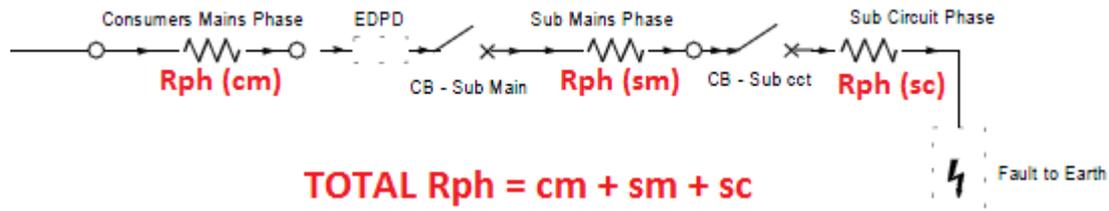
Testing Fault Loop Impedance:

To test F.L.I, you will require a special test meter called a fault loop impedance meter. You can buy these meters as an individual meter or as part of a multi-function meter. The test is very simple, push the button and read the result on the screen. Once a result is displayed, it must be checked against table 8.1 of AS/NZS 3000

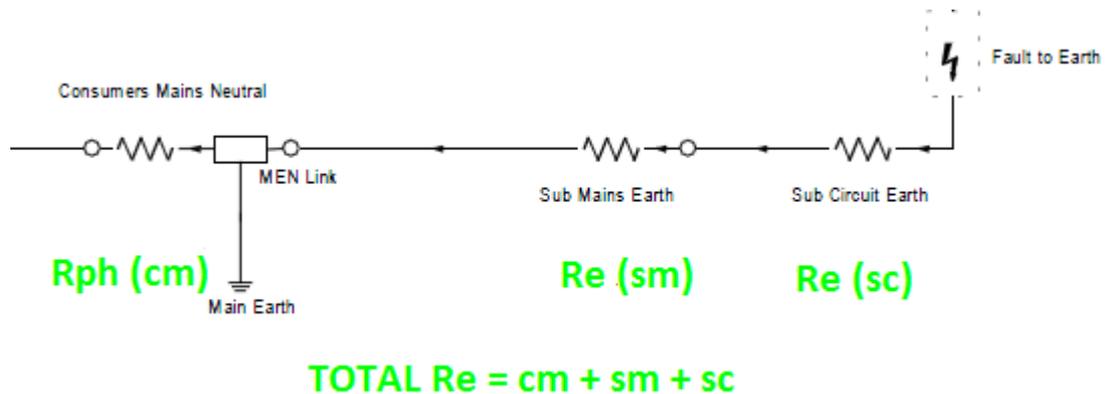
TABLE 8.1					
MAXIMUM VALUES OF EARTH FAULT-LOOP IMPEDANCE FOR THE TOTAL CIRCUIT INCLUDING THE SUPPLY TRANSFORMER (Z_s AT 230 V) VALUES RELATING TO OPERATION OF PROTECTIVE DEVICES ON THE FINAL SUBCIRCUIT					
Protective device rating Amps	MCBs on the final subcircuit			Fuses on the final subcircuit	
	Type B	Type C	Type D		
	Disconnection times				
	0.4 s			0.4 s	5 s
Maximum earth fault-loop Impedance Z_e 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

Testing Fault Loop Resistance:

Testing the resistance of the fault loop is a process that involves measuring the resistance of the conductors with an ohmmeter. All active to earth conductors from the point of supply through to the furthest point in each circuit must be measured. This value must comply with the “R_{ph}” value from table 8.2 of AS/NZS 3000. (*R_{ph}* = resistance of the phase through to earth)



The return path resistance must also be considered. This can be checked when testing the earth continuity and should be checked against “R_e” of table 8.2 from AS/NZS 3000. (*R_e* = resistance of the earth only)



The standard circuit breaker that is used is a Type C

Protective device rating, amps	Conductor size		Circuit breakers						Fuses				
	Active mm ²	Earth mm ²	Disconnection times										
			0.4 s		0.4 s		n Δ	5 s					
			Type B MCB		Type C MCB			Type D MCB		HRC fuses			
			R _{phs}	R _s	R _{phs}	R _s	R _{phs}	R _s	R _{phs}	R _s			
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	0.4	0.3	0.6	0.4	

Fault loop as per AS/NZS 3000:2018

8.3.9.2 Method of measurement – FIGURE 4.24

(a) Supply not available

Where supply is not available, the resistance of the conductors of each individual circuit may be measured by an ohmmeter as follows:

- (i) Connect the active conductor and protective earthing conductor together at the origin of the particular circuit (normally where the protective device is fitted).
- (ii) At the most distant point on the circuit, connect one lead of the ohmmeter to the active conductor and the other lead to the associated protective earthing conductor.

The measured value of resistance (R_{phe}) shall not exceed the value in Table 8.2 for the appropriate conductor size and type of protective device

(b) Supply available

Where supply is available, the required impedance should be measured using an instrument that has a facility for measuring and indicating low values of impedance.

NOTE: Earth continuity and resistance tests should be carried out on protective earthing conductors in accordance with Clause 8.3.3 before measuring the earth fault-loop impedance.

The MEN connection is to be left intact.

Measurements should be carried out with the instrument connected between the most distant point on the active conductor and the corresponding point on the associated protective earthing conductor, e.g. at a socket-outlet.

NOTE: This test—

- (a) verifies the integrity of the MEN connection and the upstream neutral (PEN) conductors; and
- (b) measures the value of Z_s for the complete circuit; and
- (c) should be performed in such a manner that the safety of the instrument operator is not placed at risk.

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 point **furthest** from the supply on **each branch** of the final subcircuit.

As per 8.3.9.2.3 and 8.3.9.3 of AS3000 both the FLR and FLI should be measured at the furthest point on all circuits, calculated and found to comply with tables 8.1 and 8.2 for all FSC's with most installation circuit wiring arrangements.

AS/NZS 3000 Table 8.2 or AS/NZS 3017 Table 4.6

Table 4.6 — Maximum values of resistance of final subcircuits

Protective device rating, A	Conductor size		Circuit breakers						Fuses			
	Active mm ²	Earth mm ²	Disconnection times									
			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.]

Mandatory Test (f) operation of RCD

Residual Current Devices (RCDs)

Residual current devices are designed and installed to protect people by automatically disconnecting the supply if the earth leakage current exceeds 30mA. RCD's with a sensitivity of 30mA are designed to operate before the human heart enters fibrillation (Some situations require lower thresholds refer AS 3000).

RCD's operate by monitoring the active and neutral conductors with a toroidal coil. This coil absorbs the magnetic energy produced by both active and neutral conductors. If both active and neutral conductors carry equal amounts of current, the magnetic field from the active cancels the neutral magnetic field. The result is that the toroidal coil senses no leakage current and doesn't trip. In the event that the active conductor supplies 10amps and only 9.5amps comes back via the neutral conductors, the toroidal coil senses the differential and trips, disconnecting the circuit.

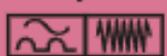
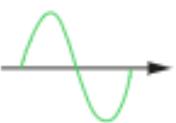
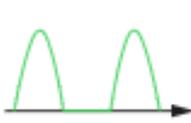
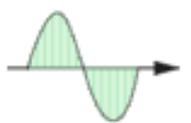
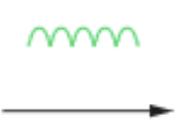
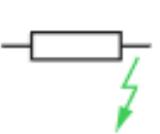
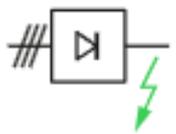
RCD's, for domestic and residential type electrical installations, shall be installed at the switchboard from which the circuit originates. Care must be taken in the connection arrangement for the RCD as instructed by the manufacturer. In the case where an RCD is protecting more than one circuit a protected neutral link may be required.

AS/NZS3000:2018 stipulates the requirements of RCD's in sub-section 2.6
ADDITIONAL PROTECTION BY RESIDUAL CURRENT DEVICES

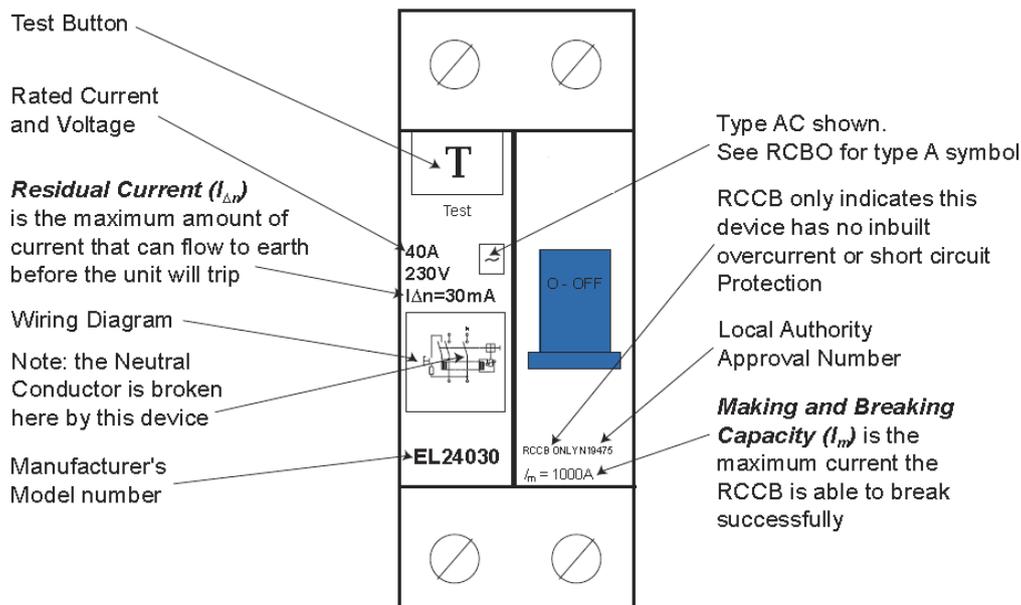
With the increased adoption of electronics, renewables and emerging technologies by end users, there is a greater impact due to dc waveforms on the ac supply. It is now **mandatory** (AS 3000, clause 2.6.2.2) that Type A RCDs are used as the general type for installations.

Type I RCDs are acceptable for patient areas, where tripping is ensured, as for Type A; and with rated residual alternating current not exceeding 10mA with an interrupting time not exceeding 40mS at rated residual current; and non-patient areas not exceeding 300mS.

Refer to clause 2.6.2.2.1 Notes for the full list of common types of RCDs in Australia.

Type	AC			
	AC 	A 	F 	B 
I fault				
Load				
	linear	single phase rectifier	single phase frequency converter	3 phase rectifier

Type A 



Testing of an RCD is carried out to ensure that the RCD operates and disconnects the designated circuit. The function of the RCD is verified by the operation of the integral test device and by the use of special test equipment. Currently there is no requirement in AS/NZS 3000 to check for correct trip times or currents.

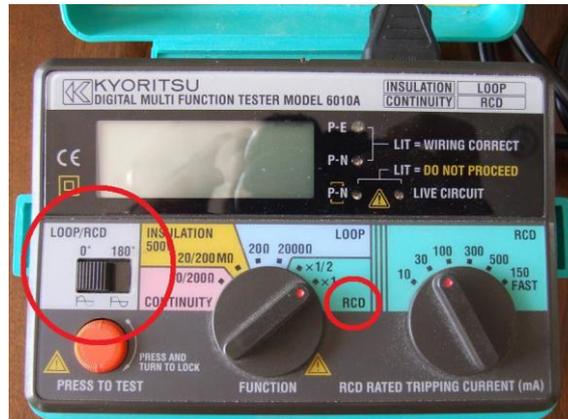
There are 5 main standards that specify the procedures for inspecting and testing RCDs; AS/NZS 3000, 3017, 3019, 3190 and 3760. Depending on the site you are completing the testing at there may also be site specific requirements such as AS/NZS 3003 that must be referred to when testing RCD operation in medical areas.

When testing by special equipment to determine the tripping current and time of the RCD refer to Table 2.3 – Maximum tripping times and Appendix H – Tripping time accuracy from AS/NZS 3760. The current, time and accuracy for each type has been summarised in the table below.

Type	Residual tripping current	Maximum tripping time	Accuracy
Type I (Patient)	10	40	± 2 ms
Type II (General)	30	300	± 8 ms

Measurements for a final sub-circuit should be made with the instrument connected at the furthest point on an installation. By doing this, it will ensure the RCD is functioning correctly and the worst case for fault loop impedance due to the most amount of cable being in a circuit.

Some RCDs may have a different result (approximately 10 milliseconds) depending on which point on the wave the test is initiated. In case of doubt, the operating time at both 0° and 180° should be tested.



Generally, to meet AS3000, AS3017, AS 3019, AS3190 AND AS3760 you must test and record the following information as described in the steps for RCD testing below. However, it is important to note that depending on the site you are working at other tests may need to be performed or different results required to confirm RCD operation. For example, Medical areas require a special tester that carries out the tests below and an additional 6 random injected angles to the sin wave between 4.5-10.5 mA rated tests to meet AS3003: 2018

Steps for RCD testing

1. 0 deg @ ½ or 15mA = result Should not trip
2. 180 deg @ ½ or 15mA = result Should not trip
3. 0 deg @ 1 or 30mA = up to 300ms
4. 180 deg @ 1 or 30mA = up to 300ms
5. 0 deg @ 5x or 150mA = up to 40ms
6. 180 deg @ 5x or 150mA = up to 40ms
7. Ramp mA rest record value less than the specified RCD device value.
8. Designation confirmation does the correct RCD circuit trip. (eg. did P1 trip P1)
9. Are poles isolated – measure that voltage is 0V
10. Integral Push button test operated the RCD x 2

Nb. Most RCD testers in the Auto Mode will conduct steps 1-6.

Generally testing of RCDs would be required every 2 years for domestic and office areas, and every 12 months for commercial areas. Push button test are normally every 6 months (all areas).

During the construction or demolition of buildings, AS/NZS 3012 is required to be adhered to. All appliances and cords must also meet the minimum standards of AS/NZS 3760:2010

Other important areas of AS/NZS 3000

Section 6 - Damp situations

Damp situations includes containers of water such as (but not limited to) sinks, baths, toilets, pools and spa pools. Section 6 of AS 3000 details the minimum protection requirements for the installation of electrical equipment in damp situations.

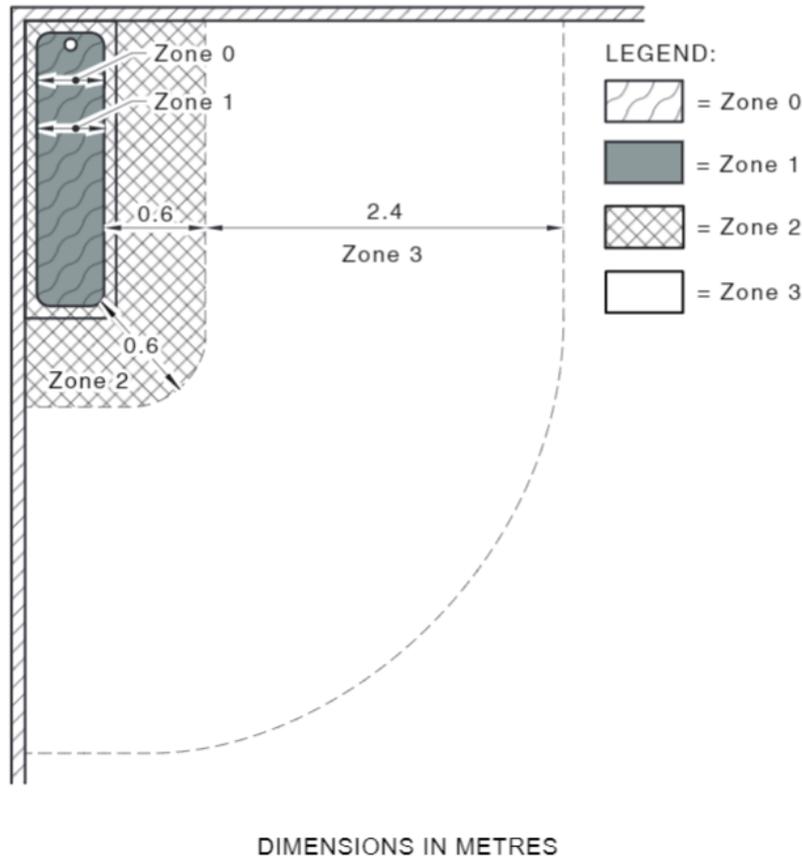


FIGURE 6.1 ZONE DIMENSIONS (PLAN)—
BATH WITHOUT SHOWER OR FIXED BARRIER

Clause 6.2.4.2 of AS3000 states that socket outlets shall not be installed on Zone 0 or Zone 1 of a damp situation. See table 6.1 for details of protection required when selecting electrical equipment for baths, showers and other damp areas and table 6.2 for pools and tubs.

Clause 7.7 Installation of equipment within a hazardous area

Clause 7.7.2.4.2 states that electrical equipment shall be installed within a hazardous area as per AS/NZS 60079.14. Electrical workers must also complete additional training for installation of equipment in hazardous areas.

Clause 4.5.2.3 Recessed luminaires

This clause states the importance of installing recessed luminaires in a manner designed to prevent excessive temperature rise of the luminaire and auxiliary

equipment and the risk of fire from ignition of combustible materials. Figure 4.9 states the minimum clearances which may require a barrier or guard constructed of fire-resistant materials. These clearances should be used as a minimum and when the manufacturer has specified a clearance that is more than those in Figure 4.9 then the clearances specified by the manufacturer should be used.

Clause 4.5.2.3.2 describes the requirement for a warning sign to be installed in the roof space adjacent to the access point. A sign is not required for IC or IC-4 classified recessed luminaires.

Other important standards

AS/NZS 3760:2010 covers the requirements of in-service safety inspection and testing of electrical equipment (test and tag). Within this standard, table 4 details the requirements for testing and inspection for electrical equipment. It stipulates that in typical places of work (excluding construction sites), class 1 type equipment must be tested every 6 months and class 2 type every 12 months.

AS/NZS 3012:2019 Electrical Installations- Construction and demolition sites states All handheld equipment used on construction and demolition sites must be tested every 3 months.

Class 1 type equipment is equipment in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in that accessible conductive parts are connected to the protective earthing conductor in the electrical installation. An example of a class 1 piece of equipment is a motor that has a metallic frame. The frame will be connected to earth, making it class 1 equipment.

Class 2 type equipment is equipment in which protection against electric shock does not rely on basic insulation only. This means the item is double insulated. An example of a class 2 type of equipment is a power drill that has plastic surrounding or frame.

	<i>Class I</i>	<i>Class II</i>	<i>Class III</i>
Principal characteristics of the equipment	Protective conductor provided	Additional insulation and no connect for protective earthing conductor	Designed for supply at separate extra-low voltage (SELV)
Precautions for safety	Connection to the protective earthing conductor	None necessary	Connection to separate extra-low voltage
Usual symbols			

AS/NZS 5033:2021 Installation and safety requirements for photovoltaic (PV) arrays
This standard sets out general installation and safety requirements for photovoltaic (PV) arrays, including d.c. array wiring, electrical protection devices, switching and earthing up to but not including energy storage devices, power conversion equipment or loads. Also known as PV standards.

AS/NZS 4777:2020 Grid connection of energy systems via inverters Inverter requirements

This standard specifies device specifications, functionality, testing and compliance requirements for electrical safety and performance for inverters designed to facilitate connectivity between energy sources and/or energy storage systems and the grid, connected at low voltage. Includes electric vehicles operating in a vehicle to grid mode and stand-alone inverters that are connected to an electrical installation that may be connected to the grid at low voltage. KEYWORDS: inverter, energy storage, grid connection

All Australia Standards can be obtained through SAIGLOBAL website.

AS/NZS 5139:2019 Electrical installations - Safety of battery systems for use with power conversion equipment

This standard specifies requirements for general installation and safety requirements for battery energy storage systems (BESSs), where the battery system is installed in a location, such as a dedicated enclosure or room, and is connected with power conversion equipment (PCE) to supply electric power to other parts of an electrical installation.

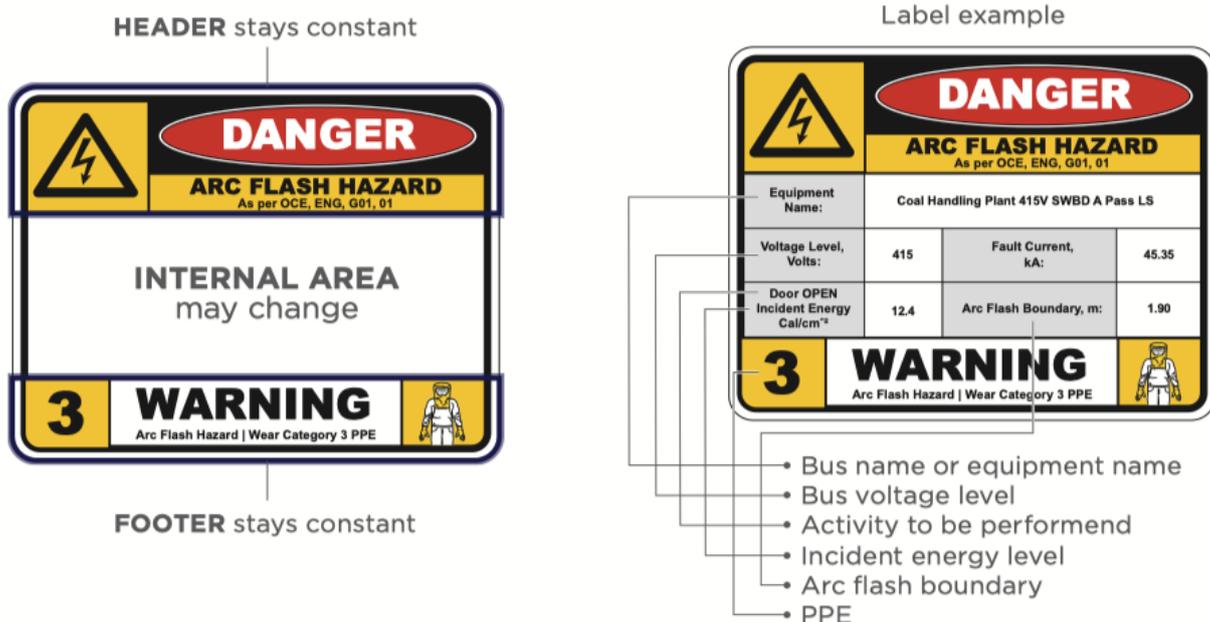
AS/NZS 61439 Switchboard labelling

To clearly communicate the arc flash risk on electrical equipment, it is recommended that electrical equipment is properly labelled.

It is recommended that the Energy Industry considers all labels as needing to meet the requirements of Danger Signage (Danger signs communicate a hazard, condition or situation that is likely to be life threatening).

It is recommended that the Energy Industry considers all labels provide the critical risk information clearly, concisely and consistently. Whilst minimum size of labels cannot be recommended, it is a recommendation of this Guideline that labels are located so they are clearly visible, well placed and include all the information required in international arc flash documents and in a format consistent with Australian requirements. The details included in the labels are shown in the illustration below however as a minimum, it is recommended that all Arc Flash Hazard labels across the Australian Energy Industry include (as a minimum):

- Bus Name or Equipment Name;
- Bus Voltage Level;
- Activity to be performed;
- Incident Energy Level;
- Arc Flash Boundaries; and
- PPE Level Required for varying activity and switchboard status (for example door open / door closed).
- PPE – which protect people from the incident energy if all other controls fail and an arc flash occurs.



Other regulatory considerations

Electrical Equipment Safety System (EESS)

The EESS is a regulatory framework aimed at increasing consumer safety when interacting with household electrical equipment. The EESS outlines the safety requirements for registration of Responsible Suppliers and equipment in a centralised national database (National Register). Apparatus captured in the framework includes socket outlets, light switches, safety switches, household type circuit breakers, standard power and lighting cable. Only equipment registered on the database can be legally installed in Australia.

National Metering Installation Requirements (NMIR) and Queensland Electricity Connection Manual (QECM).

The requirements of the National Service Provider are contained in the National Metering Installation Requirements and in Queensland the Queensland Electricity Connection Manual (QECM). Both of these manuals can be found online and are supplied on the course resources link you received on your venue details.

Section 4.2 of the Queensland Electrical Connection manual sets out when a EWR must be submitted and 4.6 states that the connection to supply by the power supplier does not imply that the installation is safe. It is the responsibility of the Electrical Contractor for the standard and compliance of the electrical work completed.

Section 8.7.2 of the connection manual sets out the customers responsibility (your responsibility as the Electrical Contractor for the customer) to ensure adequate over-load protection of the consumer mains.

The worksafe website: www.worksafe.qld.gov.au

The worksafe website and the “eSAFE” newsletter highlight areas of concern for the Electrical Safety Office that have arisen from investigation of electrical incidents. We recommend all Electricians join the mailing list for the eSAFE newsletter:

Shocks and Tingles (Reference the Electrical Safety Office website):

If anyone at a property feels a tingle or shock from electrical equipment, a tap, or other metal fittings, it should NOT be ignored—it's a sign that something's not right and could be fatal.

If the shock is from using or touching permanent electrical equipment (like a stove or electric hot water system), The ESO advise the resident to contact a licensed electrician and stop using it immediately.

If the shock is from a tap, pipe or other metal fitting call Energex, Essential Energy or Ergon Energy immediately and ask them to check your property.

You should carry out a safety audit of the property following the mandatory testing steps and record findings and test results. Seek permission to rectify faults or disconnect and report findings to the Service Provider.

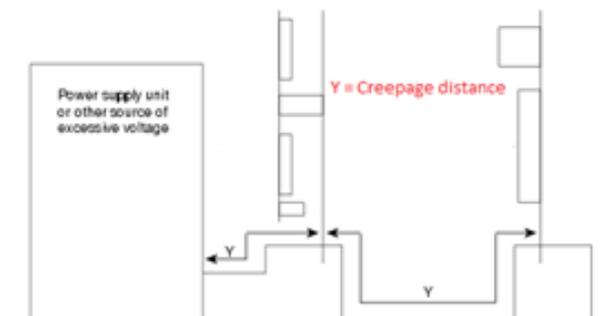
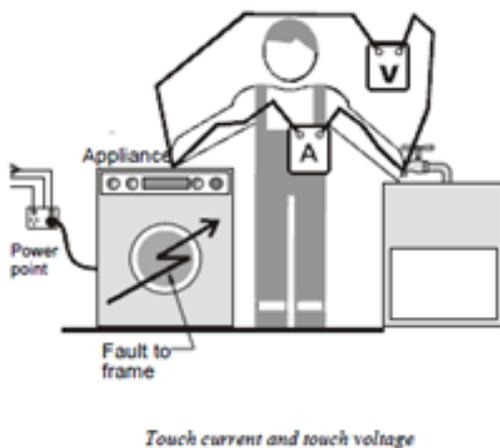
Possible causes of shocks and tingles

Touch voltage : Voltage appearing between simultaneous accessible parts

Step voltage: The difference in potential voltage between two places on the ground

Induced voltage: Voltage created due to the building and collapsing of a magnetic field

Creepage: The distance between items considered for tracking and arcing



Cable Selection

When designing a wiring system, there are two ways in which you can select a cable.

1. Based on voltage drop

When basing the cable selection on voltage drop, generally you have identified a long cable run where voltage drop will be a problem. When analysing the voltage drop formula, if any of the following three variables change then the voltage drop will change:

Cable length

Current to be carried – either load or max demand

Cable – type, configuration and maximum temperature

Three phase formula for voltage drop:

$$Vd = \frac{L \times I \times Vc}{1000}$$

Single phase calculation for voltage drop:

$$Vd = \frac{L \times I \times Vc \times 1.155}{1000}$$

L = Length of cable

I = Max Demand/Amps

Vc = Factor

Vd = Voltage Drop

When adding single and three phase voltage drops the three phase must be converted to a single-phase equivalent.

Once a cable has been selected on voltage drop requirements, it must then be checked against AS 3008 to ensure the current carrying capacity is suitable.

Once you have calculated voltage drop use the following formula to determine voltage drop percentage:

$$\%Vd = \frac{Vd}{V} \times 100$$

**Now check your answer using Simplified method –Table C8
from AS/NZS 3000, page 481**

C4.2 Examples

To find the minimum cable size for given circuit conditions:

What size cable would be necessary to carry 50 A over a route length of 75 m with a maximum voltage drop of 2.5%?

STEP	PROCESS	CALCULATION
1	Determine required Am by multiplying current by route length	$50 \times 75 = 3750 \text{ Am}$
2	Determine required capacity for permitted voltage drop, Am per %V _d	$3750/2.5 = 1500 \text{ Am per \%V}_d$
3	Look up Am per %V _d value in Table C8 which is not less than required value	Single-phase circuit: 35 mm² (1773 Am per %V _d) Three-phase circuit: 16 mm² (1643 Am per %V _d)

2. Based on current carrying capacity

In general, cables are selected to carry a required amount of current. This is usually either the maximum demand of the main or the calculated load of a circuit.

Section 3 of AS3008.1.1:2025 has the current carrying capacity of cables sized from 1mm up to 630mm. When selecting cables, Table 3.5 of AS3008 is where you start the selection process.

There are four tables that make up the table 3 series.

Table 3.5 is used when cables are installed unenclosed in air.

Table 3.6 is used when cables are installed enclosed

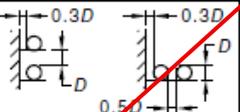
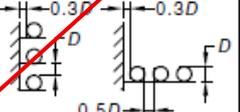
Table 3.7 is used when cables are buried direct in the ground.

Table 3.8 is used when cables are installed in underground wiring enclosures.

Remember:

- **The correct selection of cables will allow for the heat that is produced to dissipate from the cable so that no permanent damage is caused from overheating.**
- The amount of heat produced is relative to the resistance/impedance of the cable and the amount of load passing through the cable.
- The resistance of the cable depends on the size and length of the cable
- The temperature rating of the cable is the maximum temperature at which the cable insulation can operate for extended periods of time **Ref Table 3.2 AS3000:2018.**
- Check difference between X90 cables and V90 cables. **Ref Table 3.2 AS3000:2018.**
- The Table 3 series in the AS/NZS 3008.1.1:2025 provides a comprehensive guide to which current-carrying capacity and de-rating/rating tables to use to determine minimum conductor size.

Table 3.5 — Installation methods — Cables unenclosed in air

Methods of installation for cables deemed to have the same CCC					
	1	2	3	4	5
Item	Cable ^a	Reference drawing ^b	CCC table	Installation method ^{c, d, e}	CF table
1	Two single-core		3.9 , 3.10 , 3.11 Columns 1 and 2	Cables with minimum cable separation in air as shown for horizontal and vertical mounting and installed — (a) spaced from a wall or vertical surface; (b) supported on ladders, racks, perforated trays, cleats, or hanger; or (c) suspended from a catenary wire.	3.34
2	Three single-core		3.12 , 3.13 , 3.14 Columns 1 and 2		
3					

Column 3 gives references for C.C.C

Column 4 explains how the cable is installed

Tables 3.9 to 3.32

The pictures below represent some of the different types of cables commonly used in the electrical industry. By understanding how cables are represented in AS3008, the process of using table 3 becomes easier.

Single phase

Orange circular/Flat TPS

Touching a surface

Single phase

TPI/Building Wire

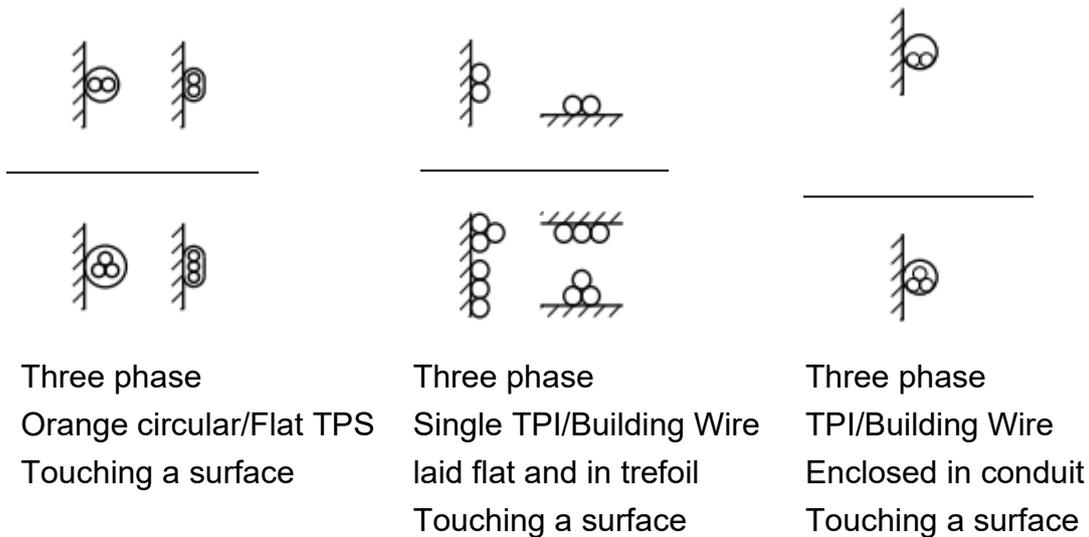
Touching a surface

Single phase

TPI/Building Wire

Enclosed In conduit

Touching a surface



Once you can interpret the pictures correctly, you can confirm the installation method by reading through column five. E.g., Cables on tray will be “Spaced from surface”.

Table 3.5 — Installation methods — Cables unenclosed in air

Methods of installation for cables deemed to have the same CCC					
	1	2	3	4	5
Item	Cable ^a	Reference drawing ^b	CCC table	Installation method ^{c, d, e}	CF table
9	2-core		3.15 , 3.16 , 3.17 ^d Columns 1 and 2	Cables with minimum spacings in air as shown and installed — (a) spaced from a wall or vertical surface; (b) supported on ladders, racks, perforated or unperforated trays, cleats or hangers; (c) in a switchboard or similar enclosure; or (d) suspended from a catenary or as a self-supported overhead cable.	3.35
10	3-core		3.18 , 3.19 , 3.20 ^d Columns 1 and 2		3.35
11	3-core				3.33
12	2-core		3.15 , 3.16 , 3.17 ^c Columns 3 and 4	Cables installed — (a) clipped direct to a wall, floor, ceiling or similar surface; (b) buried direct in concrete or masonry above the ground or in plaster or render on a wall; (c) in a ventilated trench or open trunking; or (d) spaced from a wall or vertical surface.	3.33
13	3-core		3.18 , 3.19 , 3.20 ^d Columns 3 and 4		

Three phase 400V
Multicore TPS

Single phase 230V multi-core TPS

Column three gives reference to many different tables. The first table always referenced is for common V-90 insulation type cables. The second table listed references X-90 insulation and other special compound insulation type cables. The third applies to R-HF-110, R-E-110 or X-HF-110 insulated type cables.

The columns referenced allow for copper and aluminium conductors. Again, the first referenced is often used as this is stranded copper conductors.

Cable selection based on current carrying capacity.

What cable is required for a shed that has a maximum demand of 75 amps? (230V building wire, enclosed 0.5m underground)

Step 1. Start at table 3(n)

Table 3.8 for cables installed underground enclosed.

Table 3.8 — Installation methods — Cables in underground wiring enclosures

Step 2. Identify which item represents the cable in question.

Item 1 represents single phase building wire

The first table referenced is V-90 insulation and the first column is stranded copper

Two single-core		3.9 3.10 3.11 Columns 17 and 18
-----------------	--	--

Step 3. Go to table 3.9, column 17 to obtain the current carrying capacity.

n air, 25 °C in ground							
13	14	15	16	17	18	19	20
Thermal insulation		Buried direct in ground		Buried in PVC underground conduits			
Completely							
Cu	Al	Cu	Al	Cu	Al	Cu	Al
5	-	17	-	13	-	15	-
6	-	22	-	16	-	19	-
6	-	24	-	18	-	21	-
8	-	31	-	23	-	26	-
12	-	43	-	32	-	36	-
16	-	56	-	41	-	47	-
20	-	71	-	52	-	58	-
27	-	94	-	69	-	77	-
36	28	122	95	89	69	99	77
48	38	158	123	116	90	129	100
59	46	190	147	139	108	155	120
-	-	225	174	168	130	186	145
-	-	277	215	206	160	228	177

Please include your workings for all workbook questions, e.g. Table 3(X) Item 1 – Table X Col XX – XXmm=XXA

De-rating Cables

De-rating cables is the process of lowering or raising the current carrying capacity of a cable due to its installed environment. Installing cables so that it allows for rapid dissipation of heat will mean that we do not have to de-rate the cables. Touching a surface is different from being installed on cable tray (spaced from surface) so have different heat dissipation. Australian installation conditions where the nominal ambient air and soil temperatures are 40°C and 25°C, respectively.

The three main de-rating items are:

- **Grouping of cables**

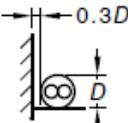
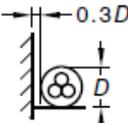
When cables are grouped together, the heat produced by each individual cable affects the other cables within the group, and the amount of surface exposed to allow heat transfer is reduced.

- **Ambient temperature**

Since the current carrying capacity is dependent on the ability of the cable to transfer heat to the surrounding environment, the temperature of the environment can have a significant effect on the rating of the cable.

- **Depth of Laying (Underground)**

As cables are buried deeper than the standard depth of 500mm, the ability of the ground to transfer heat away from the cables decreases. As the depth increases, the ground's ability to store heat increases, trapping heat around the cable, and increasing cable operating temperature.

9	2-core		3.15 , 3.16 , 3.17 ^d Columns 1 and 2	Cables with minimum spacings in air as shown and installed — (a) spaced from a wall or vertical surface;	3.35
10	3-core		3.18 , 3.19 , 3.20 ^d Columns 1 and 2	(b) supported on ladders, racks, perforated or unperforated trays, cleats or hangers; (c) in a switchboard or similar enclosure; or	3.35
11	3-core			(d) suspended from a catenary or as a self-supported overhead cable.	3.33
12	2-core		3.15 , 3.16 , 3.17 ^c Columns 3 and 4	Cables installed — (a) clipped direct to a wall, floor, ceiling or similar surface; (b) buried direct in concrete or masonry above the ground or in plaster or render on a wall; (c) in a ventilated trench or open trunking; or	3.33
13	3-core		3.18 , 3.19 , 3.20 ^d Columns 3 and 4	(d) spaced from a wall or vertical surface.	

D = outside diameter of a cable, or in the case of a flat multicore cable, the maximum dimension of the cable.

Correction Factor Tables

All the de-rating/rating tables are located in AS3008.1.1:2025 from Table 3.33 through to Table 3.48

When you have obtained the de-rating/rating figure you must multiply the current carrying capacity (C.C.C) by that de-rating figure.

Table 3.47 — CF for depth of laying — Single-core and multicore cables in underground wiring enclosures

Correction factors — a.c. and d.c.		
Depth of laying, m ^a	1	2
	Single-core ^b	Multicore
0.5	1.00	1.00
0.6	0.98	0.99
0.8	0.95	0.98
1.0	0.93	0.96
1.25	0.91	0.95
1.5	0.89	0.94
1.75	0.88	0.94
2.0	0.87	0.93
2.5	0.86	0.92
3.0 or more	0.85	0.91

^a For depths less than 0.5 m, see [Table 3.8](#).

^b CFs apply to single-core cables enclosed separately or grouped in a single wiring enclosure.

NOTE The ambient temperature at the surface is considered to be 40 °C and not 25 °C at a depth of 0.5 m.

Example 1:

2.5mm² 230V V90 TPS on cable tray unenclosed has a C.C.C of 27A, located in ambient temp of 60 degrees, using table 3.44 you de-rate it by a figure of 0.77.

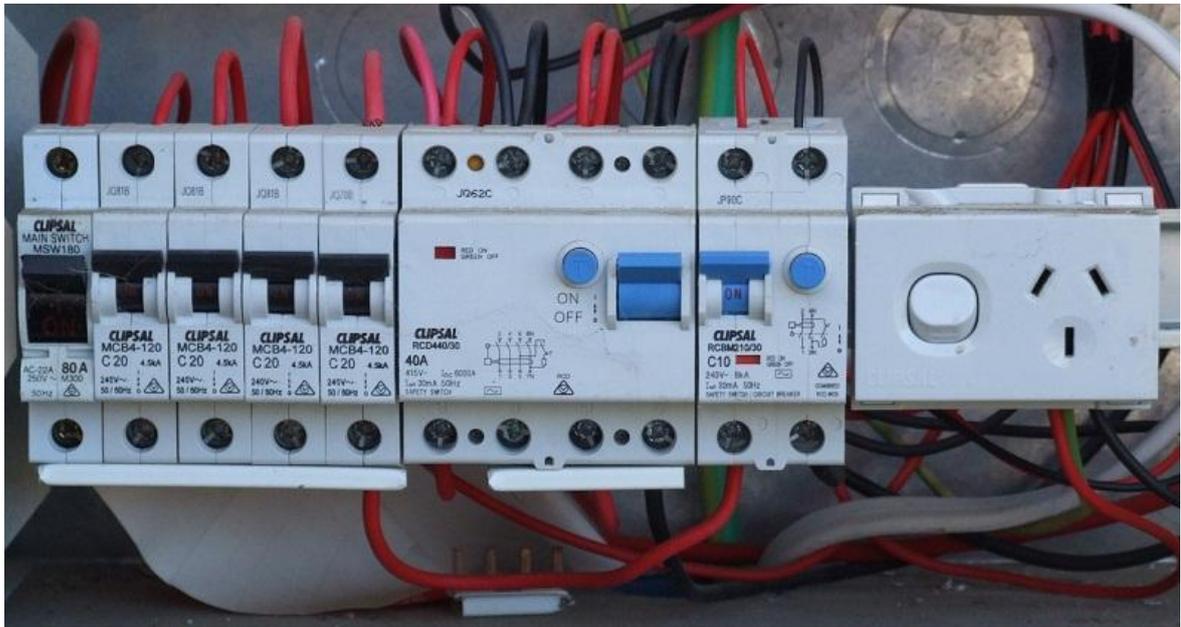
Answer = 27 X 0.77 = 20.79A CCC

Example 2:

6mm² V75 TPS touching surface, unenclosed has a C.C.C of 44A, located in a group of 5 circuits bunched on a surface, you de-rate it with table 3.33 and obtain a figure of 0.6

Answer = 44 X 0.6 = 26.4A CCC

Circuit Protection



AS/NZS3000:2018 details the minimum protection requirements within an electrical installation.

Sub-section 1.5 details the fundamental principles and states that persons, livestock and property shall be protected. Along with functioning correctly, it also states that the principle dangers are from (a) shock currents (b) excessive temperatures and (c) explosive atmospheres.

An important requirement is therefore, to ensure that every circuit incorporates protection against the dangers of electric shock. Clauses 1.5.4, 1.5.5, 1.5.6 and 1.5.7 specify essential requirements regarding protection against electric shock including basic protection (direct contact) and fault protection (indirect contact).

Clause 1.5.4 outlines the basic protection requirements against direct contact and outlines the methods that are required by AS/NZS 3000:2018. Protection consists of four standard methods. These are:

- a) Insulation, in accordance with Clause 1.5.4.3.
- b) Barriers or enclosures, in accordance with Clause 1.5.4.4.
- c) Obstacles, in accordance with Clause 1.5.4.5., and
- d) Placing out of reach, in accordance with Clause 1.5.4.6.

Clause 1.5.5 outlines the requirements for protection against indirect contact. Method for protection include:

- a) Automatically disconnecting the supply on the occurrence of a fault, in accordance with Clause 1.5.5.3
This method is commonly used; circuit breakers and fuses provided automatic disconnection.
- b) Prevent a fault current to flow by using Class II equipment, in accordance with Clause 1.5.5.4
This method requires double insulation or by equipment having insulation with appropriate supplementary insulation.
- c) Prevent a fault current from passing through a body by electrical separation of the system, in accordance with 1.5.5.5.
- d) Limit the fault current than can flow to lower than shock current

Protection against the effects of overload currents AS 3000 Cl. 2.5.3

When selecting an overload protection device for a circuit, an analogy can be drawn to a simple three step ladder. The largest quantity should be on the top of the rung of the ladder and the smallest on the bottom.

I_z	C.C.C	Current carrying capacity
I_N	C.P.D	Circuit protection device
I_B	M.D	Maximum demand of the circuit

You must satisfy Clause 2.5.3.1 of AS3000:2018 as far as correct co-ordination of these following formulas:

Condition 2.1 $I_B \leq I_N \leq I_z$

Condition 2.2 $I_z \leq 1.45 \times I_N$

I_B = max. Demand or load of the circuit

I_N = current rating of the circuit protection device (C.P.D)

I_z = current carrying capacity of the cable (C.C.C)

I_2 = the current required to operate the CPD in the set time as per clause 2.5.3.1

Condition 2.3 $I_B \leq I_N \leq 0.9 I_z$

(HRC fuses)

Condition 2.1 explained further:

$$I_B \leq I_N \leq I_z$$

LOAD less than or equal to C.P.D less than or equal to C.C.C

Condition 2.2 explained further:

$$I_2 \leq 1.45 \times I_z$$

TRIPPING CURRENT less than or equal to 1.45 X CCC

Circuit breakers (1.45 X) $\leq 1.45 X$

Fuses (1.6 X) $\leq 1.45 X$

Condition 2.3 explained further:

$$I_B \leq I_N \leq 0.9 I_z$$

LOAD less than or equal to HRC Fuse less than or equal to 0.9 C.C.C

Example 1:

A power circuit in a domestic installation supplies a circuit with a load of 18A and has been wired in 2.5mm² cable with a current carrying capacity of 26A. If the circuit has been protected by a 20A type “C” circuit breaker, does it comply with the co-ordination requirements of AS 3000?

Condition 2.1 $I_B \leq I_N \leq I_z$

$I_B = 18A$

$I_N = 20A$

$I_z = 26A$



PASS

Condition 2.2

$$I_2 \leq 1.45 \times I_z$$



$$(1.45 \times 20) \leq 1.45 \times 26$$

$$\text{Answer} = 29 \leq 37.7$$

PASS

Example 2:

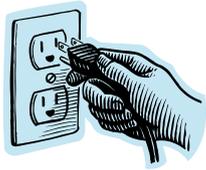
A 230V motor in a workshop draws 32Amps and has been wired in 10mm² cable with a C.C.C of 52A. If the circuit has been protected by a 40A HRC fuse, does it comply with the co-ordination requirements of AS 3000?

Condition 2.3 $I_B \leq I_N \leq I_z \times 0.9$

$$I_B = 32A$$

$$I_N = 40A$$

$$I_z = 52 \times 0.9 = 46.8 A$$



≤



≤



PASS

Condition 2.2 $I_z \leq 1.45 \times I_N$



(1.6 X

) ≤ 1.45 X



$$(1.6 \times 40) \leq 1.45 \times 52$$

$$\text{Answer} = 64 \leq 75.4$$

PASS

AS61439.3. Part 3 Distribution boards intended to be operated by ordinary persons (DBO)

Notes for DBO's

Intended to be operated by ordinary persons.

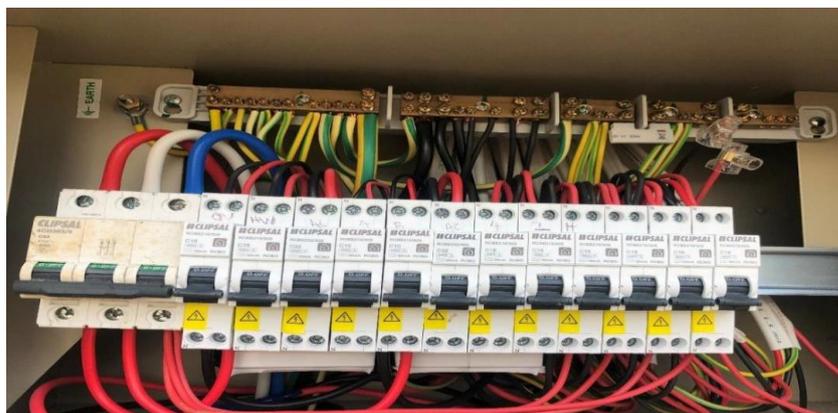
(e.g. domestic, household applications)

- Rated voltage to earth does not exceed 300Vac.
- Current does not exceed 125A.
- Type A DBO single phase
- Type B DBO three phases
- Clause 10.11.5.3.3 Incoming circuits and main busbars see clause 8.6.1, 8.6.2, 8.6.3, 8.6.4 of part 1

Clause 8.6.3 Bare and insulated conductors

- Wiring installed inside the assembly are given in the tables included in Annex H.
- Only one conductor should be connected to a terminal.
- The manufacturer is responsible for the bus bar assembly.
- No intermediate joint spliced or soldered.
 - Note the temperature rise during a fault K far exceeds the melting point of the solder and it just falls apart in fault conditions. (Unless it is adequately secured, and you can guarantee that it will not via an engineered, tested, system.)

Notice the reduced Max. operating current, compared to AS3008.1.1:2025 for cables in a switchboard.



Annex H (informative)

Operating current and power loss of copper conductors

The following tables provide guidance values for conductor operating currents and power losses under ideal conditions within an ASSEMBLY. The calculation methods used to establish these values are given to enable values to be calculated for other conditions.

Table H.1 – Operating current and power loss of single-core copper cables with a permissible conductor temperature of 70 °C (ambient temperature inside the ASSEMBLY: 55 °C)

Conductor arrangement							
		Single-core cables in a cable trunking on a wall, run horizontally. 6 of the cables (2 three-phase circuits) continuously loaded		Single-core cables, touching free in air or on a perforated tray. 6 cables (2 three-phase circuits) continuously loaded		Single-core cables, spaced horizontally in free air	
Cross-sectional area of conductor	Resistance of conductor at 20°C, R_{20}^a	Max. operating current I_{max}^b	Power-losses per conductor P_v	Max. operating current I_{max}^c	Power-losses per conductor P_v	Max. operating current I_{max}^d	Power-losses per conductor P_v
mm ²	mΩ/m	A	W/m	A	W/m	A	W/m
1,5	12,1	8	0,8	9	1,3	15	3,2
2,5	7,41	10	0,9	13	1,5	21	3,7
4	4,61	14	1,0	18	1,7	28	4,2
6	3,08	18	1,1	23	2,0	36	4,7
10	1,83	24	1,3	32	2,3	50	5,4
16	1,15	33	1,5	44	2,7	67	6,2
25	0,727	43	1,6	59	3,0	89	6,9
35	0,524	54	1,8	74	3,4	110	7,7
50	0,387	65	2,0	90	3,7	134	8,3
70	0,268	83	2,2	116	4,3	171	9,4
95	0,193	101	2,4	142	4,7	208	10,0
120	0,153	117	2,5	165	5,0	242	10,7
150	0,124			191	5,4	278	11,5
185	0,099 1			220	5,7	318	12,0
240	0,075 4			280	6,1	375	12,7

a Values from IEC 60228:2004, Table 2 (stranded conductors).
b Current carrying capacity I_{30} for one three-phase circuit from IEC 60364-5-52:2009, Table B.52.4, col. 4 (Method of installation: item 6 in Table B.52.3). $k_2=0,8$ (item 1 in Table B.52.17, two circuits).
c Current carrying capacity I_{30} for one three-phase circuit from IEC 60364-5-52:2009, Table B.52.10, col. 5 (Method of installation: Item F in Table B.52.1). Values for cross-sections less than 25 mm² calculated following Annex D of IEC 60364-5-52:2009. $k_2=0,88$ (item 4 in Table B.52.17, two circuits).
d Current carrying capacity I_{30} for one three-phase circuit from IEC 60364-5-52, Table B.52.10, col. 7 (Method of installation: item G in Table B.52.1). Values for cross-sections less than 25 mm² calculated following Annex D of IEC 60364-5-52:2009. ($k_2=1$)

How to determine prospective short-circuit current (PSC or PFC)

When selecting protection devices, consideration must be given to the prospective short-circuit current (PSC) at the location the device is to be installed in ([AS/NZS 3000:2018 clause 2.5.4.1](#)). The PSC can be determined by measurement or by calculation.

Many multi-function testers can measure the PSC.

PSC can also be calculated by undertaking a **Live** Fault Loop Impedance measurement ($Z_s\Omega$) and dividing the voltage by this measurement.

Example (Main board ETI – Brisbane actual measurements)

Voltage tests as 230 volts and the measured fault loop impedance between incoming line and neutral is 0.07 Ω

Apply Ohms Law

$$\text{Max PSC} = \frac{E}{R} = \frac{V}{Z_s\Omega}$$

$$230/0.07 = 3285 \text{ A or } 3.3\text{kA (rounded up)}$$

Now consider AS3000 Clause 1.6.2 and use the nominal voltage +10% worst case.

$$253/0.07 = 3615 \text{ A or } 3.7\text{kA (rounded up)}$$

This will determine the KA rating of your protection devices, MCBs and RCBOs

And for the Arc flash assessment, PPE level and Boundary requirements covered on pages 19 & 20.

Three Phase Supplies

Where there is a three-phase supply, the PSC is likely to be between line conductors. In this case, the PSC can be calculated by multiplying the single-phase reading by the square root of 3 or 1.73.

Therefore, in the example above, the 3 phase PSC would be $3615 \times 1.73 = 6253 \text{ A or } 6.3\text{kA}$.

Maximum Circuit Lengths (Appendix B5 AS3000:2018)

AS3000:2018 provides Guidance Tables B1 and B2 for maximum circuit length limits. Guidance Table B2 contains comparison of circuit route lengths based on voltage drop at various levels and earth fault loop impedances (EFLI) for C curve MCBs with a disconnection time within 0.4 seconds. The figures in bold indicate where the voltage drop is the limiting factor. If the figures are in *italics*, then the circuit route length should be based on the values of the EFLI. The route length is the phase conductor from point of connection to point of use (note 3 Guidance Table B1).

Guidance Table B2 includes both voltage drop calculations based on circuit conductor resistance at 75 degrees, and for final subcircuits with distributed loads.

Final subcircuits with distributed loads, AS3000:2018 Clause 3.6.2 Exception 1 (such as socket outlets or lighting circuits), where the outlets or points are distributed along the circuit route, use half the current rating of the protective device in the calculation for the route length. Guidance Table B2 provides both full load and distributed load calculations for each circuit (ie select the MCB rating as installed).

Example:

Select the maximum circuit length from Table B2 for a typical domestic 230V power circuit run in 2.5mm² TPS V90 with a 20A Type C RCBO.

Voltage drop in the consumer mains has been calculated, and 4% is left of the allowable 5% for the circuit.

Answer:

The circuit length is found by using Table B2 AS3000:2018.

The circuit can be considered a distributed load, as the outlets are spaced along the circuit.

A1

TABLE B2

COMPARISON OF CIRCUIT ROUTE LENGTH BASED ON LOOP IMPEDANCE AND VARIOUS VOLTAGE DROPS

Circuit breaker rating I_n	Phase and neutral	Earth	Circuit length based on EFLI (MCB Curve C) ^a	Circuit length based on voltage drop (single phase 230 V) ^b							
				5% VD at I_n^c	5% VD on distributed circuit ^d	4% VD at I_n^c	4% VD on distributed circuit ^d	3% VD at I_n^c	2.5% VD at I_n^c	1.0% VD at I_n^c	1.0% VD on distributed circuit ^d
A	mm ²	mm ²	m	m	m	m	m	m	m	m	m
6	1	1	91	37	82	30	66	22	19	7	16
10	1	1	55	22	49	18	40	13	11	4	10
10	1.5	1.5	82	35	77	28	62	21	17	7	15
16	1.5	1.5	51	22	48	17	38	13	11	4	10
16	2.5	2.5	85	40	88	32	71	24	20	8	18
20	2.5	2.5	68	32	71	26	56	19	16	6	14
25	4	2.5	67	41	91	33	73	25	21	8	18

AS/NZS 3000:2018
454

Answer = 56 meters

Guidance Table B1 provides typical maximum circuit route lengths above which the impedance of the conductors could limit the short circuit current to a level below that required to operate the circuit protection device with a disconnection time within 0.4 seconds.

The maximum circuit length obtained from Table B1 only satisfies the fault protection requirements of Clause 1.5.5.3. The overload, short circuit and voltage drop requirements will need to be considered independently. In most cases, voltage drop requirements are more stringent than loop impedance requirements. Using loop impedance route lengths or impedance values in isolation is likely to result in non-compliance with AS3000 voltage drop requirements.

Example:

Determine from Table B1 and Table B2 if a 230V 2.5KW air conditioner 22 metre circuit run in 2.5mm² TPS V90 with a 20A Type C RCBO, where the allowable remaining voltage drop is 3% for the circuit.

Answer:

Step 1: The circuit length is found by using Table B1 AS3000:2018.

TABLE B1
MAXIMUM ROUTE LENGTHS FOR DIFFERENT SIZES OF CONDUCTORS AND PROTECTIVE DEVICES USING APPROPRIATE MEAN TRIPPING CURRENTS (I_a)^a

Conductor size		Protective device rating A	Circuit-breaker ^a (see Note 1)			Fuses (see Note 2)
Active mm ²	Earth mm ²		Type B	Type C	Type D	
Maximum route length (L_{max}), m						
1	1	6	170	91	55	204
1	1	10	102	55	33	114
1.5	1.5	10	153	82	49	170
1.5	1.5	16	96	51	31	82
2.5	2.5	16	160	85	51	136
2.5	2.5	20	128	68	41	93
4	2.5	25	126	67	40	90

Step 2: Consider voltage drop requirements of AS3000 Table B2:

TABLE B2											
COMPARISON OF CIRCUIT ROUTE LENGTH BASED ON LOOP IMPEDANCE AND VARIOUS VOLTAGE DROPS											
Circuit breaker rating I_n	Phase and neutral	Earth	Circuit length based on EFLI (MCB Curve C) ^a	Circuit length based on voltage drop (single phase 230 V) ^b							
				5% VD at I_n ^c	5% VD on distributed circuit ^d	4% VD at I_n ^c	4% VD on distributed circuit ^d	3% VD at I_n ^c	2.5% VD at I_n ^c	1.0% VD at I_n ^c	1.0% VD on distributed circuit ^d
A	mm ²	mm ²	m	m	m	m	m	m	m	m	m
6	1	1	91	37	82	30	66	22	19	7	16
10	1	1	55	22	49	18	40	13	11	4	10
10	1.5	1.5	82	35	77	28	62	21	17	7	15
16	1.5	1.5	51	22	48	17	38	13	11	4	10
16	2.5	2.5	85	40	88	32	71	24	20	8	18
20	2.5	2.5	68	32	71	26	56	19	16	6	14
25	4	2.5	67	41	91	33	73	25	21	8	18

Answer = Complies with Table B1 loop impedance however **not compliant with Table B2** voltage drop.

Maximum demand

Maximum demand is the maximum current which the consumers mains or sub-main conductors can carry for a sustained period without overheating. The maximum demand is not necessarily the sum of all the loads in an electrical installation. Diversity is applied in determining maximum demand on the basis that all loads may not operate at the same time or for sustained periods.

The maximum demand of an electrical installation needs to be known so that:

- The electricity distributor can arrange for the electrical installation to be supplied.
- Switching, protection and metering arrangements can be made.
- Optimum cable sizes can be selected.

The equipment and accessories used within an electrical installation must also be suitable for the maximum demand of that portion of the electrical installation supplied or controlled by that equipment.

How can the maximum demand be determined?

The 2018 edition of the Wiring Rules nominates four methods for determining the maximum demand of consumers mains or sub-mains.

The methods are:

- Calculation (most common)
- Assessment
- Limitation
- Measurement

Using the calculation method

The calculation method may be used as a basis for determining the expected maximum demand of an electrical installation. It may be calculated by following the guidance in Appendix C of the Wiring rules as appropriate to the electrical installation type. Table C1 is used for domestic installations and Table C2 is used for all other installations. All similar load groups should be added together. Examples of how to use these table are given in AS3000:2018 page 456 onwards.

**TABLE C1
MAXIMUM DEMAND—SINGLE AND MULTIPLE DOMESTIC ELECTRICAL INSTALLATIONS**

1	2	3	4	5
Load group	Single domestic electrical installation or individual living unit per phase ^a	Blocks of living units ^{a,b,c}		
		2 to 5 living units per phase	6 to 20 living units per phase	21 or more living units per phase
Loading associated with individual units				
A. Lighting				
(i) Except (ii) and load group H below ^{d,e,f}	3 A for 1 to 20 points + 2 A for each additional 20 points or part thereof	6 A	5 A + 0.25 A per living unit	0.5 A per living unit
(ii) Outdoor lighting exceeding a total of 1000 W ^g	75% connected load	No assessment for the purpose of maximum demand		
B.				
(i) Socket-outlets not exceeding 10A ^{e,h} . Permanently connected electrical equipment not exceeding 10 A and not included in other load groups ⁱ	10 A for 1 to 20 points + 5 A for each additional 20 points or part thereof	10 A + 5 A per living unit	15 A + 3.75 A per living unit	50 A + 1.9 A per living unit
(ii) Where the electrical installation includes one or more 15 A socket-outlets, other than socket-outlets provided to supply electrical equipment set out in groups C, D, E, F, G, and L ^{h,j}		10 A		

Earthing Systems

The selection of an earthing conductor should ensure that the conductor size is appropriate for the size of the largest active conductor supplying the section of the electrical installation protected by the earthing conductor. In some cases it may be appropriate to increase the size of a protective earthing conductor to ensure the fault-loop impedance is sufficiently low.

AS3000 section 5 covers earthing, the clause below explains the selection of earth conductor sizes.

5.3.3.1.2 Selection

The cross-sectional area of any copper protective earthing conductor required for the protection of any portion of an electrical installation shall be determined either— from Table 5.1 in relation to the cross-sectional area of the largest active conductor supplying the portion of the electrical installation to be protected; or by calculation, in accordance with Clause 5.3.3.1.3.

Select the minimum size conductor based on thermal consideration, for a copper cable with compression joints connected to a supply where protection is provided by an air circuit-breaker with a clearance time of 1 s and a breaking capacity of 10 kA.

Calculate the minimum conductor size for the following two types of cable:

- (a) PVC insulated.

The solution is as follows:

- (a) PVC insulated

(i) To find the value of constant (K) the initial conductor temperature and the final conductor temperature must be known. For PVC it is assumed that the initial operating temperature is 75°C (for V-75, V-90 and V-90HT). From Table 53, and assuming that the cable is smaller than 300 mm², the final operating temperature can be selected as 160°C. From Table 52 the value of K can be selected as 111 for a copper conductor.

(ii) As the circuit-breaker protecting the circuit is rated at 10 kA breaking capacity, we can assume a value of 10 000 A for I.

(iii) As the clearance time of the circuit-breaker is 1 s, it can be assumed that the value of t, which is the total time the fault current is flowing, is also 1 s.

$$S = \sqrt{\frac{I^2 t}{K^2}}$$

(iv) Rearranging Equation 5.3(1) we get—

Substituting the values for I, t and K, the minimum cross-sectional area is calculated

$$S = \sqrt{\frac{(10\,000^2 \times 1)}{(111)^2}}$$

as— $= 90.1 \text{ mm}^2$

Therefore, the minimum cable size would be 95 mm².

TABLE 5.1
MINIMUM COPPER EARTHING CONDUCTOR SIZE

Nominal size of active conductor mm ²	Nominal size of copper earthing conductor,	
	mm ²	
	With copper active conductors	With aluminium active conductors
1	1*	—
1.5	1.5*	—
2.5	2.5	—
4	2.5	—
6	2.5	—
10	4	—
16	6	4
25	6	6
35	10	6
50	16	10
70	25	10
95	25	16
120	35	25
150	50	25
185	70	35
240	95	50
300	120	70
400	≥120 [†]	≥95 [†]
500	≥120 [†]	≥95 [†]
630	≥120 [†]	≥120 [†]

* These earthing conductors may be used only where incorporated in a multi-core cable or flexible cord, other than a lift travelling cable, in accordance with Clause 5.3.3.4 (b) and (c).

† A larger earthing conductor may be required to satisfy Clause 5.3.3.1.1.

The earthing arrangements used for a given electrical installation will be influenced by the selection of other parts of the earthing system such as earth electrode, earth bars, MEN link.

There are certain items and circumstances where the minimum sizes for earth conductors are stipulated. For example, the minimum size of a main earthing conductor is 4 mm². Also, where consumers mains are electrically unprotected the metallic switchboard surround is to be earthed by a conductor not smaller than the consumers mains neutral conductor.

Earthing conductors may consist of the following:

Single insulated conductors installed unenclosed or installed in a common enclosure with live conductors.

An earthing conductor in a multi-core cable.

Metallic sheath, armour or screen of a cable.

A metallic wiring enclosure with the appropriate conductivity.

Busbars

Outbuildings

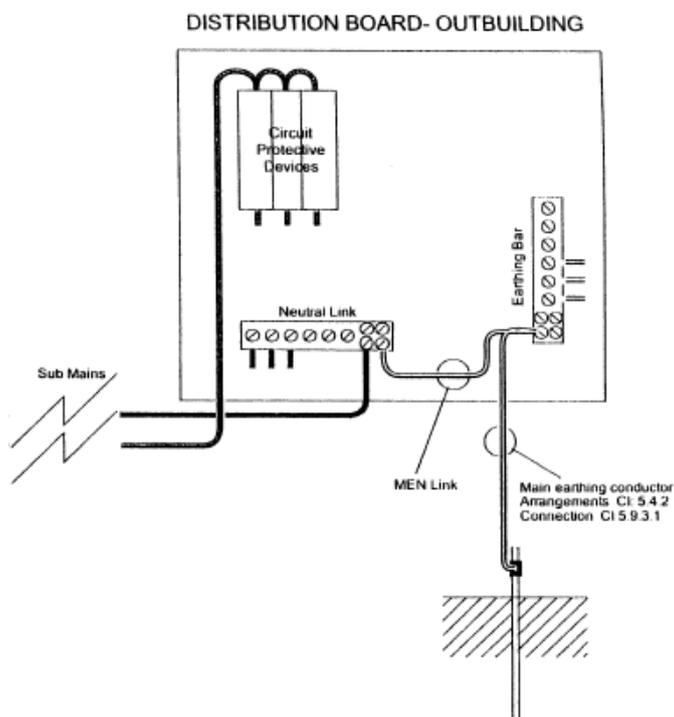
AS/NZS 3000:2018 Clause 5.5.3.1

All parts of an electrical installation in or on an outbuilding that are required to be earthed in accordance with Clause 5.4 shall be earthed by one of the following methods:

(a) Connection to the electrical installation earthing system. The earthing system in the outbuilding shall be connected to a protective earthing conductor connected in accordance with Clause 5.5.2.1.

(c) Separate MEN installation. The earthing system in the outbuilding shall be connected to the sub-main neutral conductor supplying the outbuilding. In this case the sub-main neutral conductor supplying the outbuilding is a combined protective earthing and neutral (PEN) conductor.

Is the below installation satisfactory for an outbuilding?

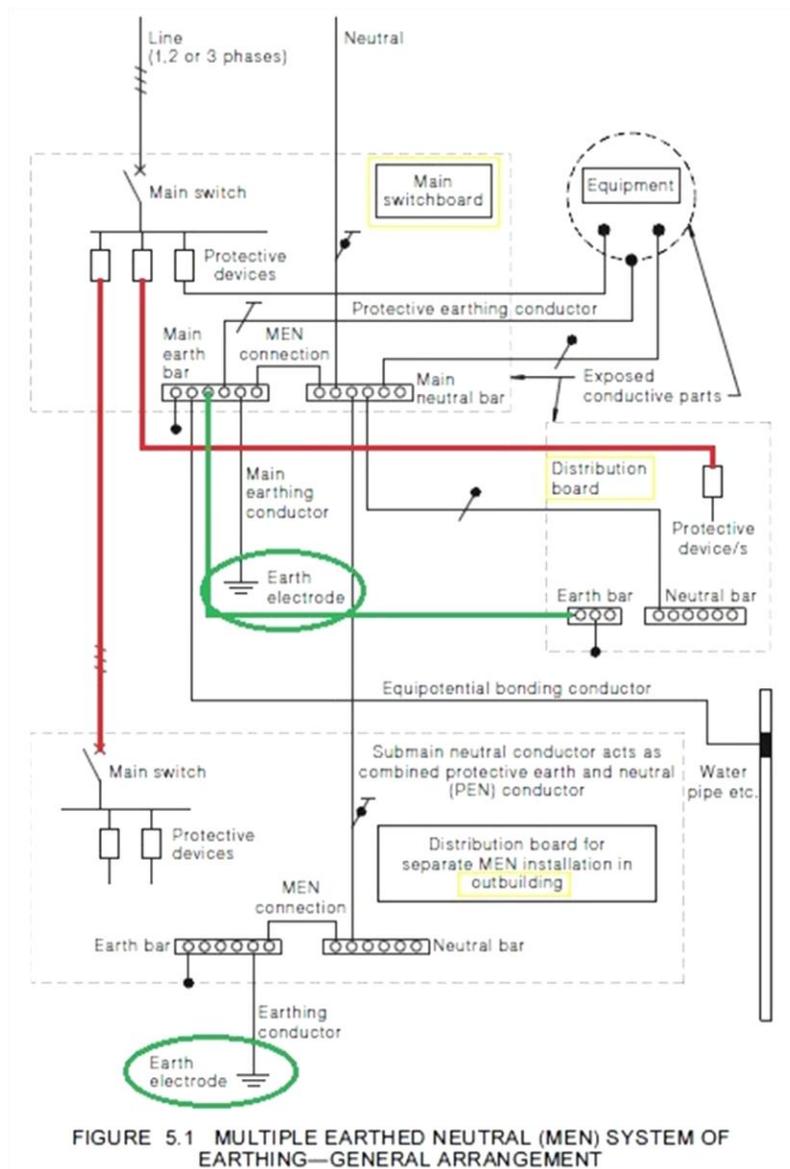


One of the situations where an outbuilding is implemented is when the distance from one distribution board to another is significant. With long cable runs, the impedance of the protective earth conductor becomes too high and affects the fault loop impedance. By installing an additional earth electrode, fault loop impedance is measured to the local electrode, not the initial electrode.

The above installation requires another sub-board fed from this distribution board, list two methods of earthing systems to supply the new sub-board.

TABLE J1
SYMBOLS USED IN THIS STANDARD

	Switch (general symbol) 07-02-01		Disconnecter (isolator) 07-13-06
	Switch disconnector (on-load isolating switch) 07-13-08		Fuse-switch 07-21-07
	Fuse 07-21-01		Circuit-Breaker 07-21-01
	Neutral conductor		Protective earth conductor
	Interlock 02-12-11		Combined protective earth and neutral (PEN) conductor





Congratulations, you have finished the workbook!

Appendix A - SWMS

Version 8: Updated 27 July 2023

SWMS: Electrical Testing of an installation

PCBU name (Your business name):	Moore Spark Electrical (ABN: 21 859 000 555)	Principal contractor (if applicable)	N/A
PCBU contact details:		Date SWMS provided to PC (if applicable)	N/A
Works Manager:	0419133887		
Contact phone:			

Work activity (job description)	Workplace location (address)
<p>Electrical Testing</p> <ul style="list-style-type: none"> <input type="checkbox"/> Risk of a person falling more than 2 metres <input type="checkbox"/> Work on a telecommunication tower <input type="checkbox"/> Demolition of load-bearing structure <input type="checkbox"/> Likely to involve disturbing asbestos <input type="checkbox"/> Temporary load-bearing support for structural alterations or repairs <input type="checkbox"/> Work in or near a confined space <input type="checkbox"/> Work in or near a shaft or trench deeper than 1.5 m or a tunnel <input type="checkbox"/> Use of explosives <input type="checkbox"/> Work on or near pressurised gas mains or piping <input type="checkbox"/> Work on or near chemical, fuel or refrigerant lines <input checked="" type="checkbox"/> Work on or near energised electrical installations or services <input type="checkbox"/> Work in an area that may have a contaminated or flammable atmosphere <input type="checkbox"/> Tilt-up or precast concrete elements <input type="checkbox"/> Work on, in or adjacent to a road, railway, shipping lane or other traffic corridor in use by traffic other than pedestrians <input type="checkbox"/> Work in an area with movement of powered mile plant <input type="checkbox"/> Work in areas with artificial extremes of temperature <input type="checkbox"/> Work in or near or other liquid that involves a risk of drowning <input type="checkbox"/> Diving work <p>High risk construction work:</p>	

SWMS: Electrical Testing of an installation

Version 8: Updated 27 July 2023

Task Step	What are the tasks involved?	What are the hazards and risks?	What are the control measures?
1	Conduct pre-start at worksite	Lack of Awareness	<p>Conduct pre-start at worksite that covers:</p> <ul style="list-style-type: none"> - Permits to be completed and approved - Responsibilities of contractors and workers identified - Supervisors of workers identified - Notify those potentially affected by power outage - Forms to be used for the job identified, e.g. SWMS and Risk assessment <p>(All contractors and workers to attend)</p>
2	Conduct/confirm workplace risk assessment, prepare to work and secure area	<p>Failure to allow an effective escape/entry route in an emergency</p> <p>Pets</p> <p>Competent to complete work</p>	<p>Complete forms required for work and use the risk assessment to determine whether a safety observer is required. If the work requires a second person, the work shall not take place without one.</p> <p>Persons working on the job are attired correctly determined by a risk assessment. As a minimum the person working must wear their work uniform and footwear as provided by Moore Spark Electrical. Safety glasses and insulating gloves are to be worn until electrical isolation is proven.</p> <p>Inspect the work area and identify potential hazards</p> <p>Develop controls to reduce or eliminate potential hazards</p> <p>Secure work area – barricades</p> <p>Maintain good housekeeping</p> <p>Ensure worker completing electrical testing holds a valid unrestricted electrical workers licence and their skills have been verified by the QTP within the last 12 months.</p>
3	Is a Safety Observer required?	Observer unable to give assistance	<p>Nb. A safety observer must be used when there is no reasonable alternative to performing energised electrical work (live work). The only exception to not requiring a safety observer is when the live work consists only of testing and a risk assessment shows there is no serious risk associated with the proposed work.</p> <p>If required ensure Safety Observer holds current CPR & LV rescue training (completed within last 12 months). Instruct Safety Observer regarding:</p> <ul style="list-style-type: none"> - Planned work process - Emergency Procedures - Isolation point/s - Operation of LVR kit - Focus on the role of observing

SWMS: Electrical Testing of an installation

Version 8: Updated 27 July 2023

			<p>Equipment required depending upon Risk Assessment consists of: Low Voltage Rescue Kit, Rubber Matting, low voltage insulating "00" gloves, Inner Gloves, Leather Outer Gloves, 1000V Insulated Tools, Fire extinguisher.</p> <p>If Rubber Matting is to be used it must conform to AS/NZS 2978.</p> <p>If a hand-held fire extinguisher is required, it must be appropriate for electrical fires and shall be in the vicinity of the work area in an appropriate place as determined by the risk assessment.</p> <p>Hanging of insulating mats over exposed electrical components where possible.</p> <p>Means of communication must be immediately available to ensure contact with medical or other assistance as required.</p>
4	Check test equipment is operating correctly	<p>Failure to use correct test equipment or test equipment is faulty leading to electric shock</p> <p>Incorrect test results</p>	<p>Visual inspection that test equipment including checking insulation and leads are in good condition</p> <p>Use known source to check meter reading</p> <p>Use Cat III or Cat IV rated test equipment only</p>
5	Visual inspection	<p>Defective installation causing electric shock</p> <p>Alternate sources of supply</p>	<p>Visual inspection including:</p> <ul style="list-style-type: none"> -Basic protection (protection against direct contact with live parts) -Fault protection (protection against indirect contact with exposed conductive parts) -Protection against hazardous parts (guarding/screening) -Protection against spread of fire -General condition of equipment. <p>Note: Any visual defects identified shall be rectified prior to carrying out work.</p> <p>Visually inspect for any alternate sources of supply such as stand-by systems, generators, battery storage or PV systems</p>
6	Identify, isolate, lock out, tag out and prove the isolation of all energy sources	Inadvertent contact with energised components	<p>Check labelling, wiring schedules and drawings</p> <p>Confirm by switching where appropriate</p> <p>Discharge where necessary any stored energy e.g. capacitors</p> <p>Test before you touch:</p> <ol style="list-style-type: none"> 1. Test meter on known source

SWMS: Electrical Testing of an installation

			<p>2. Test for dead</p> <p>3. Test on known source to re-confirm the operation of the meter Secure isolation points with locks and tags</p> <p>Check your test equipment again on a known source. Check for wear or damage of test equipment.</p> <p>Use manufactures brand Type A probes, check for tight connections prior to use.</p> <p>Hang test equipment adjacent to where probes are being used, do not over extend the leads.</p> <p>Ensure worker completing electrical testing holds a valid unrestricted electrical workers licence and testing skills have been verified by the QTP within the last 12 months.</p> <p>Ensure PPE is worn for the level or risk involved, refer to AS4836 for the minimum level of PPE for the installation you are testing.</p>
7	Conduct Testing	<p>Electric shock</p> <p>Leads pulling out of test equipment</p> <p>Incorrect results</p>	
8	Complete Job and replace covers, escutcheon plates etc	Inadvertent contact with energised components	<p>Re-isolate supply before installing covers</p> <p>Ensure all covers & protection is restored to working order and fitted correctly</p> <p>Remove all barricading and signage</p> <p>Leave area clean and tidy</p>
9	Close/sign off permits	Records not completed leading to stress	<p>Ensure permits are signed off and area is handed back safe and clear</p> <p>Record and retain test results</p> <p>Issue Certificate of testing and compliance</p> <p>Return SWMS to Supervisor/Office and advise of any reviews or improvements</p> <p>Return completed risk assessment to supervisor/office</p>

Queensland legislation – All Electrical work in Queensland should comply with:

- Work Health and Safety Act 2011
- Work Health and Safety Regulations 2011
- Electrical Safety Act 2002
- Electrical Safety Regulations 2013
- Code of Practice – How to Manage work health and safety risks 2021
- Any other relevant legislation
- Code of Practice 2021 – Managing Electrical risks in the workplace 2021
- AS/NZS 3000:2018 - Electrical Installations – Wiring rules
- AS/NZS 3017: 2007 – Electrical installations – verification guidelines
- AS/NZS 4836 Safe working on or near low-voltage electrical installations and equipment

Please note, this SWMS has been developed for the purpose of evidence collection for the QTP course and is not intended to be used by the student in their workplace.

Appendix B - Risks associated with electrical work extracted from AS 4836:2023

Isolation and access

- Correctly isolating supply but not discharging residual energy (e.g. a capacitive charge may be present in power supplies, single-phase motors or high power factor fluorescent fittings).
- Insulation and equipment failing or partially breaking down.
- Earth connection failing to stop an electric shock in earthed conductive parts when step and touch potentials exist.
- Carrying out the task causes a person, something a person may be handling or something a person is in contact with to intrude into minimum safe approach distances.
- A power system conducting fault current or being subject to high inrush currents.
- Instructions or markings on the parts being inadequate, incorrect or both.
- Using equipment not designed for, or incapable of, an operation (e.g. opening a 'no load – bus tie' under load conditions or relying on an open circuit breaker as an isolation point).
- Another person energising circuits while a worker is working on them, or a vehicle hitting a pole.
- Natural elements (e.g. lightning or wind) causing static charges, overhead mains to clash or a high voltage circuit to fall onto a low-voltage circuit.
- The inter-core capacitive effects of long multi-phase cables.
- Changes to wiring not being reflected in drawings i.e. the drawings are not 'as built' (e.g. a live control or supervision circuit being present though the drawing indicates otherwise).
- If there has been an error in wiring, opening the isolator may not de-energise the switchboard (e.g. if incorrect connection (incorrect polarity) occurred in the service to an installation, opening the main switch will open the neutral circuit rather than the active circuit).
- Intentionally disabling an interlock to perform a task (e.g. opening the shutter of a 'rackable' circuit breaker for testing to prove it has been de-energised in the orifice).
- Inadvertently disabling an interlock while performing a task (e.g. in a switchboard with an integrated circuit breaker, isolator and earth switch, the operator accidentally moving the isolator into the earthed position).
- Poor direction and insufficient knowledge. For example a worker is instructed to apply a set of earths and short circuits at a Ring Main Unit (RMU). The worker correctly observes the isolator is open, however, they assume the earth switch can be closed because the isolator is open. As most RMUs are configured so the earth switch earths the cable, not the busbar, the worker could be earthing and short-circuiting a live circuit.

- When applying a set of portable earths and short-circuits, accidental or inadvertent contact is made with live parts. If this occurs, the worker is using a device that is conducting fault current.
- The threshold value (lowest level of indication or reading) of a test device causing a misleading interpretation of a test to prove it is de-energised. Depending on the device used, an indication that parts are not energised in a high voltage situation does not mean that low-voltage and direct current voltages are absent.
- Application of earthing and short-circuiting devices that depend on a conductive path through a fuse or circuit breaker that is not fit for purpose.
- Ineffective connection to the general mass of the earth (e.g. the electrode, grid or temporary electrode that the earth and short circuits relies upon in a situation where a single phase becomes energised).
- Application of the short circuit portion of portable earthing devices prior to the earth tail being connected to the earth.
- Arcing and splattering associated with the application of earths and short circuits. The arcing or splattering may result from using the device in situations that range from energised conductors to residual energy such as capacitance. If the parts are energised, the worker can draw the arc from one phase to the other, causing a phase-to-phase fault.

A potential electric shock path existing once the earth tail is connected to earth. A worker may touch another live part and the earthed connector at the same time (e.g. in a Common Multiple Earthed Neutral (CMEN) area). Even when working on high voltage, contact between the earthed connector and a low-voltage phase can cause an electric shock.

Working near sources of arcing, explosion or fires

Arcs, explosions and electrical faults can cause burns. Workers should be protected from the effects of burns. Examples of situations where arcs, explosions and electrical faults can cause burns include:

- materials providing a conductive path between sources of potential, (e.g. uninsulated tools falling across busbars)
- abnormal conditions on circuits such as:
 - o lightning striking mains
 - o circuits of different voltages touching each other (e.g. high voltage contacting low-voltage circuits)
 - o high voltage in the secondary circuit of a current transformer if an open circuit occurs when current is flowing in the primary circuit.
- abnormally high voltages when synchronising different supplies. For example if the waveforms are 180° out of phase, twice the peak-to-peak voltage may be imposed.
- voltage multiplication effects, including:

- o ferro-resonance where the capacitive and inductive components of underground cables and transformers can significantly increase voltages when single-phasing occurs
- o re-strike can occur if capacitors are energised, de-energised and re-energised in rapid succession.
- leakage or electrical discharge causing insulation to be compromised (e.g. a combination of a build-up of contaminants on insulators, wet weather or tracking through air voids in pitch filled insulating chambers).
- failure of insulating mediums.

Working in unsafe atmospheres

After faults and fires, often in emergencies, electrical workers may be exposed to unsafe atmospheres. Toxic gases and lack of oxygen can cause illness and death. General workplace health and safety control measures should be used in these situations.

The method of extinguishing fires should be addressed. Typically, carbon dioxide or powder type devices are used against electrical fires. Extinguishers including water, foam and wet chemical should not be used as they significantly increase the risk of electric shock.

Modifying or repairing existing low-voltage electrical installations

- Electrical drawings/tables not reflecting 'as installed' installations.
- More than one source of supply or energised circuit available on the premises or at the equipment.
- The supply becoming energised during the work.
- Machinery starting automatically after supply is restored.
- Managing metallic shavings (swarf) ingress into conductive parts of equipment.
- A conductor considered to be de-energised is found to be energised.
- Old installations (e.g. where several modifications have been made, circuits have not been identified, or insulation has deteriorated).
- Voltages on disconnected conductors, particularly neutrals.
- The rise in the earth potential due to a high impedance return path to the distribution neutral in installations where the Multiple Earthed Neutral (MEN) system is used,
- Lack of information about isolation, sources of supply or the location of electrical conductors.
- Lack of clear safe access to locate electric cables (other hazards may be present such as exposed conductors).
- Damage to conductors in metallic conduits where earthing continuity of the conduit has not been maintained.

- Equipment located in hazardous areas, which includes bolt-on or screw-on covers, can be dangerous if opened without obtaining specialist advice.
- Working alone on energised equipment.
- Drilling into switchboards/electrical enclosures.
- Contact with cables in walls, floors or roof spaces.
- Contact with cables during excavation work or cutting/drilling concrete.
- Exposure to asbestos material/switchboards.
- Variable frequency devices.
- Multiple circuits located within the one conduit.
- Use of conductive/flammable cleaning solvents creating an explosive atmosphere.

Testing and fault finding low-voltage equipment and installations

Risks arise as it is difficult to find faults or malfunctions in electrical equipment when the circuits are not energised or when the equipment is not operating, especially if feedback circuits or sensors are involved.

Risks can include:

- electrical drawings/tables not reflecting 'as installed' installations
- exposed energised terminals or conductors
- terminals or conductors being energised under different conditions of operation of the equipment
- loose or disconnected test leads or wiring becoming energized
- test equipment and leads bringing electrical hazards closer to the worker
- test equipment inappropriate for the task (particularly test probes)
- inadequate test points
- inadvertent attempts by other people to start machinery
- incorrect or poorly maintained testing instruments
- inadequate knowledge of equipment or causes of faults
- lack of information about circuits or equipment
- equipment located in hazardous areas, which includes bolt-on or screw-on covers, can be dangerous if opened without obtaining specialist advice
- testing or fault finding alone on energised equipment
- testing or fault finding in cramped or restricted work situations
- rotating or moving machinery (crush hazards)
- overriding interlocks or forcing control equipment
- re-setting protective devices in energised switchboards
- electrical installations where unauthorised electrical work has been undertaken.

High fault currents —working, testing or fault finding energised

When working, testing or fault finding on energised electrical equipment, a fault current of up to 20 times the rated current of the supply transformer can flow for a short duration during fault conditions.

Arcs can have the energy to cause an explosion and/or melt metallic switchboard cubicles and equipment. Arcs may cause severe burns to the skin and flash burns to the face and eyes. Inhaled hot gases and molten particles can cause serious internal burns to the throat and lungs. Injury can also occur through the impact from flying debris and dislodged components. Circuit protection devices may not operate in such circumstances.

Testing, fault finding or working on or near low voltage equipment

- Voltages between phases and between phases and neutral.
- Voltages between phases and earth.
- Voltages across open switch contacts (e.g. voltage across a light switch on an incandescent lighting circuit or the voltage across a bus tie where one side is de-energised).
- Voltages on disconnected conductors (particularly neutrals).
- Voltages from sources near the work being performed, for example:
 - o working on a remote area power supply where both a.c. and d.c. voltages may be present
 - o repairing lights on a shop fascia when overhead powerlines are nearby
 - o working on transducer circuits when other a.c. and d.c. circuits are present
 - o working on a power system with multiple circuits that may be of multiple potentials.
- Voltages on the circuit being worked on from other sources including:
 - o illegal connections or reconnections
 - o uninterruptible power supplies (UPS) and backup supplies
 - o motor generators or alternators
 - o d.c. on a.c. circuits or a.c. on d.c. circuits
 - o harmonics (e.g. 3rd harmonic 150 Hz in neutrals and earths where there is a large fluorescent light load and switch mode power supplies)
 - o back Electromotive Forces (EMF) from collapsing magnetic fields or rotating machinery
 - o solar panels or photovoltaic.
- Voltages across undischarged capacitors.
- Voltages across the secondary terminals of transformers, including current transformers.
- Voltages caused by static electricity, leakage or discharge, or lightning.

- Voltages between energised exposed conductors and the surrounding environment (including metalwork, damp situations, other conductive surfaces and persons nearby).
- Voltages between parts, or open-circuited parts of one earth system, or voltages between different earthing systems.
- Induced voltages from sources other than the circuit being worked on, (e.g. nearby circuits or radio frequency transmitters).
- Multiple supply sources (more than one source of supply or energised circuit may be available on the premises), for example 'essential services' on a switchboard, emergency backup generators or UPS.
- Electrical testing or operating equipment with open enclosures in hazardous areas, as defined by AS/NZS 3000: Electrical installations (known as the Australian/New Zealand Wiring Rules).
- The potential (voltage) between parts of the earth in MEN systems can change, sometimes causing electric shocks. The changing earth potential can be due to a number of causes including a high impedance return path to the low-voltage distribution neutral, faults on other parts of the power system or lightning strikes.
- Incorrect wiring connections (e.g. transposing active and neutral, commonly referred to as incorrect polarity).
- Switched off circuits becoming energised.
- Faulty equipment (e.g. the frame of faulty equipment becoming energised).
- Step and touch potentials and transferred earth potentials. Transferred earth potentials often result from system faults.
- Hygroscopic materials that become conductive (e.g. fertiliser dust).

Other hazards

- Working at heights and danger of falling objects.
- Removal of cover plates near energised equipment (e.g. escutcheon plates).
- Confined spaces (where there may be a hazardous atmosphere).
- Inadequate light to work safely.
- Lack of ventilation leading to uncomfortable, hot and humid working conditions.
- Excessive worker fatigue (e.g. due to pressure of deadlines or other factors).
- Obstacles to getting the equipment switched off.
- Using a gas flame near exposed electrical conductors (a flame is a conductor).
- Using conductive or flammable cleaning solvents.

- Temperature rise as a result of combustion.
- Cramped working conditions, including cable trenches and cable pits.
- Explosive atmospheres.
- Use of conductive tools and equipment (e.g. metallic tape measures and rulers).
- Electric tools and equipment (e.g. hand lamps, drills, saws, torches and test instruments).
- Personal effects (e.g. rings, jewellery, watches, pens, cigarette lighters, matches, hearing aids, mobile phones and pagers, transistor radios and similar).
- General work activities (e.g. welding, cutting, brazing, using hand saws, drilling of all types, hammering and chiselling).
- Hot metal surfaces due to drilling, grinding or welding.
- Excavation associated with electrical work.
- Molten metal from arcs.
- Asbestos material/switchboards.
- Polychlorinated biphenyl (PCB) in transformers, capacitors, electric motors.

Appendix C – Risk Matrix

	CONSEQUENCE				
	Insignificant [1]	Minor [2]	Moderate [3]	Major [4]	Catastrophic [5]
Almost Certain [5]	Moderate (5)	High (10)	High (15)	Catastrophic (20)	Catastrophic (25)
Likely [4]	Moderate (4)	Moderate (8)	High (12)	Catastrophic (16)	Catastrophic (20)
Possible [3]	Low (3)	Moderate (6)	Moderate (9)	High (12)	High (15)
Unlikely [2]	Low (2)	Moderate (4)	Moderate (6)	Moderate (8)	High (10)
Rare [1]	Low (1)	Low (2)	Low (3)	Moderate (4)	Moderate (5)

If the residual risk	=	Catastrophic (16++)	then	Work unable to proceed seek other methods (Significant)
	=	High (10 - 15)	then	Permission from high level management for work to proceed (Significant)
	=	Moderate (4 - 9)	then	Permission from worker in charge for work to proceed (Insignificant)
	=	Low (1 - 3)	then	Work able to proceed (Insignificant)

1. Eliminate	2. Substitute	3. Isolate	4. Redesign	5. Administrative	6. PPE Last Resort
Eliminate the hazard	Substitute with a less hazardous material, process or equipment	Isolate the hazard	Redesign equipment or work process	Introduce administrative controls	Use appropriate Personal Protective Equipment

C = Consequence	L = Likelihood
5 = Catastrophic = Fatality, permanent disability, long term widespread impacts, huge financial loss.	5 = Almost Certain = It is almost certain that the risk will occur in most circumstances.
4 = Major = Permanent disability or extensive injuries, medium to long term widespread impact, major financial loss.	4 = Likely = The risk is likely to occur in most circumstances.
3 = Moderate = Lost time injury, reversible medium term local impact, high financial loss.	3 = Possible = There is uncertainty that the risk could occur.
2 = Minor = Medical treatment, reversible short – medium term impact to local area, medium financial loss.	2 = Unlikely = The risk could occur at some time but there is confidence that it will not.
1 = Insignificant = First aid, limited impact to minimal area, low financial loss.	1 = Rare = The impact/risk may occur only in exceptional circumstances.

Appendix D - Templates for Test Results

AS/NZS 3019 Form 1 REPORT OF PERIODIC ASSESSMENT	
Installation details	
Client	
Address of installation	
This report covers the following: (tick one and complete as required)	
<input type="checkbox"/> Basic visual inspection in accordance with Section 3 of AS/NZS 3019	
<input type="checkbox"/> Assessment by detailed visual inspection and limited testing in accordance with Sections 3 and 4 of AS/NZS 3019.	
<input type="checkbox"/> Assessment by visual inspection and additional testing in accordance with Sections 3, 4 and 5 of AS/NZS 3019.	
<input type="checkbox"/> Assessment of enhanced safety in accordance with Sections 3, 4, 5 and 6 of AS/NZS 3019.	
Estimated age of installation (years):	
Evidence of alterations or additions since last assessment (Y, N or Not Apparent):	
If yes, estimate when carried out (years ago)	
Date of last assessment: / /	Previous records available (Y or N):
Previous Records available:	
Limitations of inspection: (Detail any limitations of the periodic inspection)	
Observations: (Detail items requiring attention)	
Items requiring URGENT attention:	
Other items requiring attention:	
REPORT	
Having carried out an assessment of the above installation in accordance with the requirements of AS/NZS 3019, I hereby confirm that, subject to the type of assessment and limitations as detailed above, the installation satisfies the requirements of AS/NZS 3019 for the issue of this report.	
Name of person who carried out the assessment:	
License or registration type and number:	
Signature:	
Date: / /	This report consists of _____ pages
Recommended period for next periodic assessment is ___ years, provided that any observations detailed above "requiring URGENT attention" are repaired without delay.	
ATTENTION	
This report is a valuable document on the safety status of the electrical installation and should be retained for future reference. Placing in or near the main electrical switchboard is recommended.	
For safety reasons, the electrical installation should be re-inspected at the recommended period by a competent person and this copy given to the person carrying out the next assessment.	

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 <i>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.</i> <i>Also refer to local supply network (DNSP) requirements.</i>		
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 <i>Underground marking tape to comply with AS/NZS 2648.1</i> Caution — To be verified and, if practical, document at time of installation		
4	Type of underground conductors (TPS-XLPE) <i>State service and installation rules may require specific insulation type</i>		
5	Spacing from other underground services (water/telecoms/drain age) <i>Minimum separation of other underground services</i>		
6	Correct cable selection size/ circuit protection rating (current rating, installation kA rating) <i>Refer to AS/NZS 3008 for cable ratings</i>		

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 <i>Where possible check incoming DNSP neutral (PEN) conductor markings for correct polarity identification</i>		
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 <i>Mechanical protection may be needed in exposed areas subject to damage</i>		
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 <i>The size of the earthing conductor will be determined in association with the associated active conductors</i>		

INSTALLATION COMMISSIONING (continued)

BATHROOM / SHOWER EQUIPOTENTIAL BONDING	
18	<p>Conductive reinforcing of concrete for showers or bathrooms, floors or walls have been bonded as required</p> <p>Caution — To be verified at the time of installation and, where practical, documented</p>
SWIMMING POOL AREA EQUIPOTENTIAL BONDING	
19	<p>Conductive pool shell reinforcing steel and any conductive adjacent deck bonded</p> <p>Caution — To be verified at the time of installation and, where practical, documented</p>
20	<p>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</p> <p>Caution — To be verified at the time of installation and, where practical, documented</p>
21	<p>Minimum 4mm² earth bonding conductor</p> <p><i>Earthing conductors require the same level of mechanical protection as live conductors</i></p> <p>Caution — To be verified at the time of installation and, where practical, documented</p>
22	<p>Common bonding connection point provided with location marked at circuit switchboard or other visible location</p>
ELECTRICAL WIRING / ACCESSORIES / ELECTRICAL EQUIPMENT	
23	<p>No un-terminated cables</p> <p><i>Check from constructed plans that all equipment has been installed</i></p> <p>Ensure all installation cables are terminated, all final sub-circuits are accounted for, and unused cables double insulated and not connected to a supply</p>
24	<p>Electrical equipment suitably IP rated</p>
25	<p>Cable installation mechanically protected</p> <p><i>RCD protection may only be used in specific instances in lieu of additional mechanic protection</i></p>
26	<p>Approximate cable route length to qualify further testing for volts drop and EFLI and suitable over current protection</p>

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 L.P. rating of electrical equipment		
37	Swimming pool zone compliance and L.P. rating of electrical equipment		
ROOF SPACE / UNDER FLOOR AREA			
38	Adequate mechanical protection in roof-space and wall cavities <i>Protection against mechanical damage</i> 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 <i>Re assess subsequent ceiling/wall insulation to verify any cable de-rating which may need to apply</i>		
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 <i>Non-IC type cannot be installed to domestic installations</i>		

INSTALLATION COMMISSIONING (continued)

46	Adequate clearances from flammable materials based on class of fitting <i>Refer to manufacturer's installation instructions</i>	
47	Transformers and drivers (auxiliary equipment) installed correctly <i>May need to be fixed in position</i>	
48	Celling fans securely mounted and at correct height from floor	
49	Smoke alarm and interconnections not switched <i>Refer to State legislation / building code / manufacturer's instructions for correct type, location, and position from other equipment</i>	
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 <i>Ensure conductors are not compressed or pinched and segregated by fixed distance or barrier/enclosure between ELV, comms cables and metering (where required)</i>	
57	Pole fillers securely fitted	
58	All access covers / doors are fitted <i>Ensure all bolts or screws for covers/panels are installed, door latches operational. Check for debris, cable offcuts, unused fixings, and tools.</i>	
59	All equipment labelled	
60	Location of earth electrode identified at the switchboard <i>For buried earth electrodes document route location</i>	
61	Underground cable location recorded <i>Marking and recording of underground cable location and route plan at the switchboard</i>	

INSTALLATION COMMISSIONING (continued)

62	Current ratings of main switch and circuit protection are verified <i>Verify protection and isolation device specifications for compliant kA and current ratings</i>	
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 <i>Unprotected consumers mains supply may require earth conductor size to be verified</i>	
67	Correct size MEN link installed	
68	All terminations secured and correct termination method and tension rating applied <i>Conductors supported to ensure no undue tension on connection terminals</i>	
69	Main earth and neutral termination identified	
70	Multiple circuits having a common neutral require identification labels 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 <i>Visual inspection of the entire neutral supply to all downstream switchboards</i>	
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 ($\leq 0.5 \Omega$)	
2	Eq bonding conductor – Gas/Water pipe ($\leq 0.5 \Omega$)	
3	Eq bonding conductor – Pool ($\leq 0.5 \Omega$)	
4	Eq bonding conductor – Bathroom ($\leq 0.5 \Omega$)	
5	Eq bonding conductor – Building Frame ($\leq 0.5 \Omega$)	
INSULATION RESISTANCE		
6	Consumer mains ($\geq 1M\Omega$) see note 2	
7	Sub-mains (if they exist) ($\geq 1M\Omega$) 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

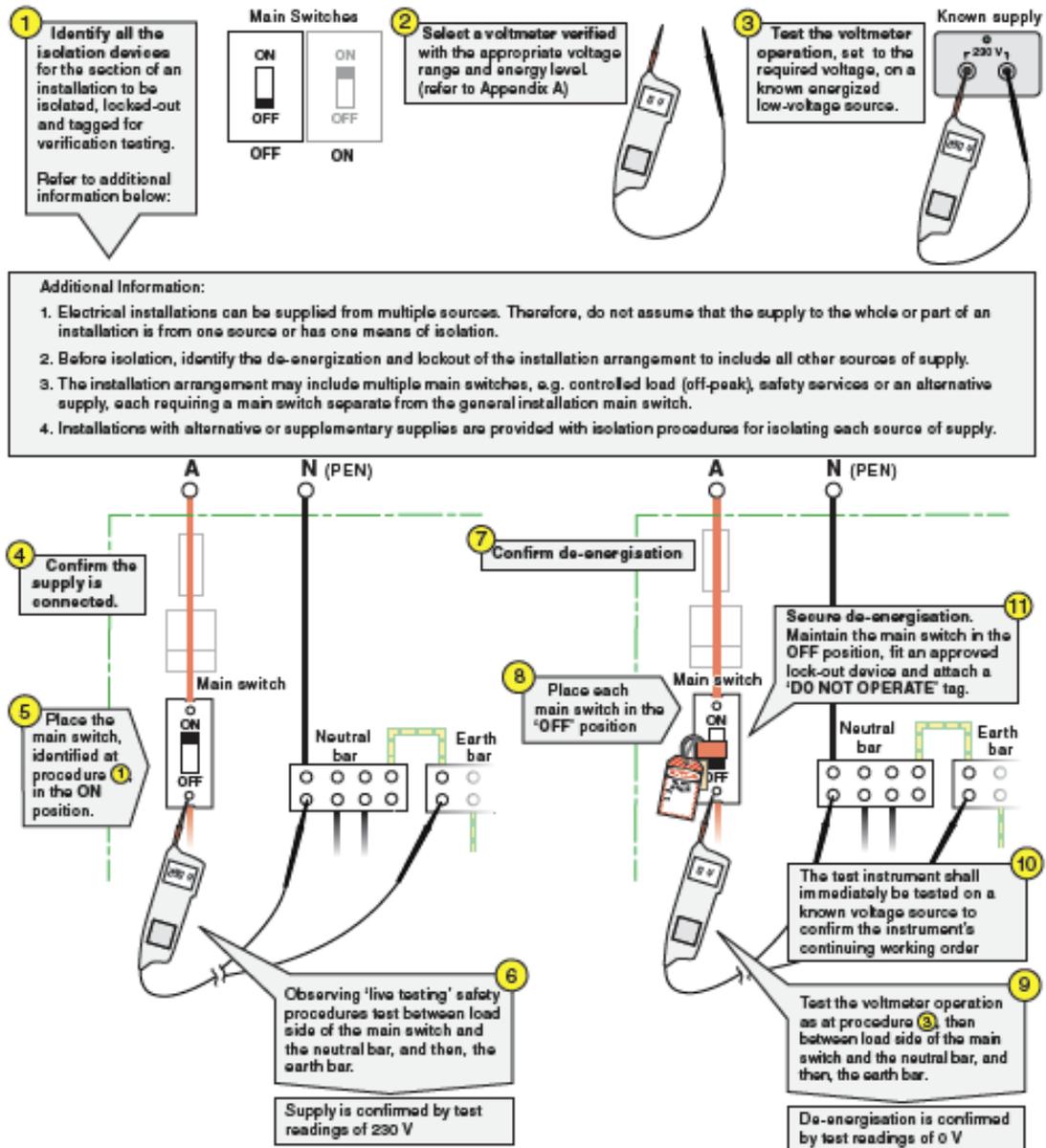
MEN connection has been re-in stated at the conclusion of all tests. (Recommend taking photo)

Appendix E – Diagrams of test procedures

Warning – this appendix should be used in conjunction with AS/NZS 3017:2022 and AS/NZS 4836:2023

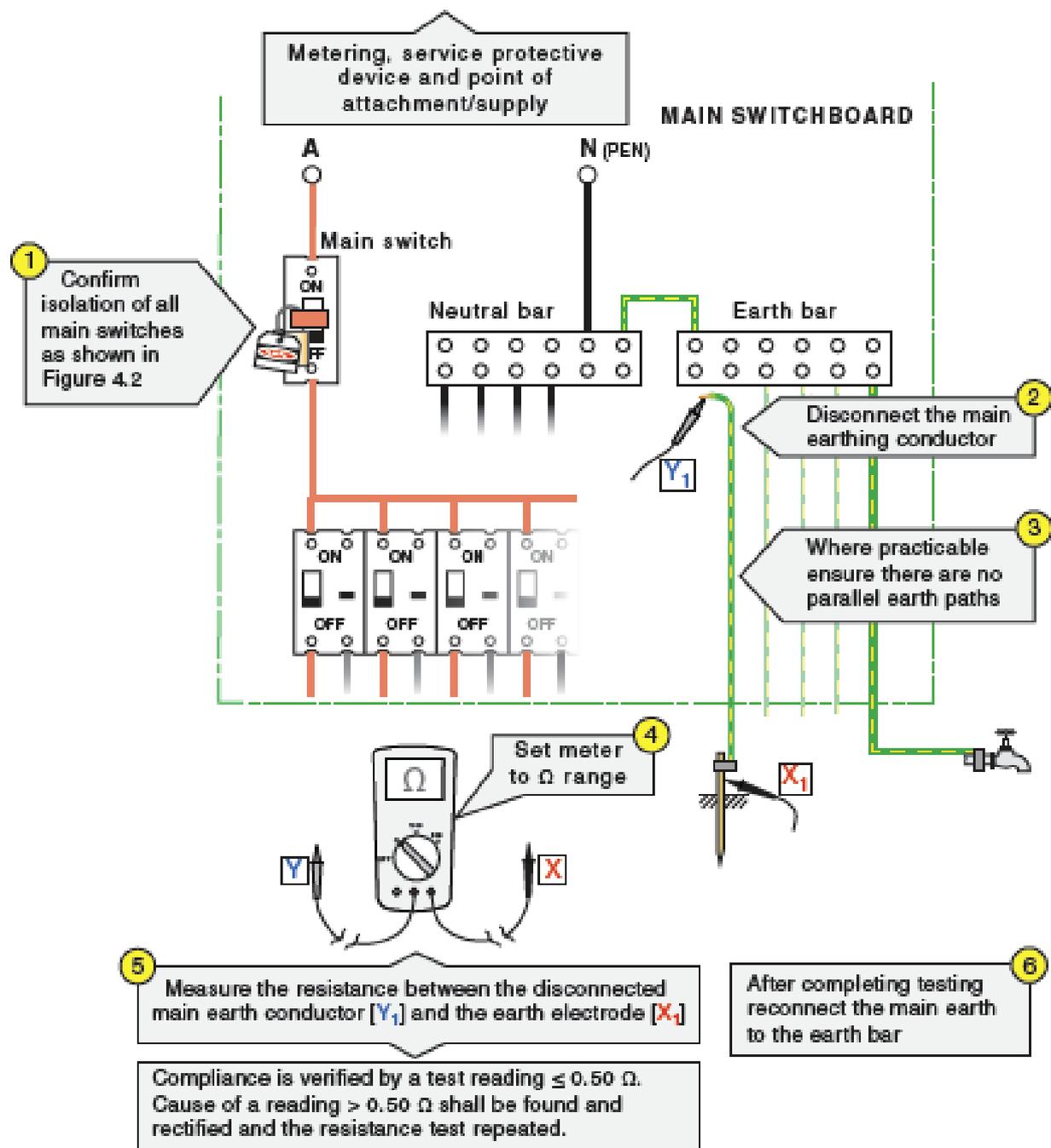
4.3.5.3 Isolation

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.

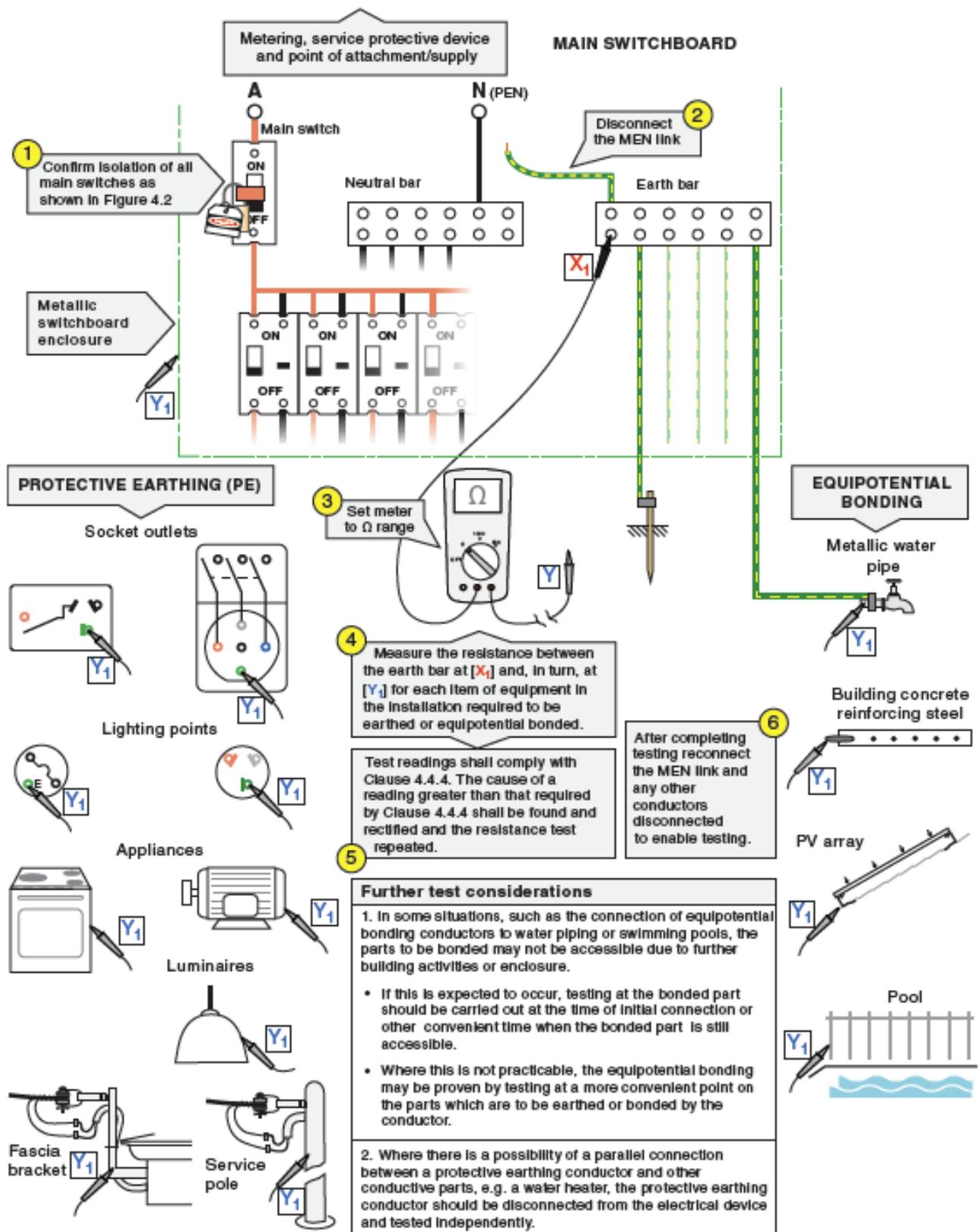
Figure 4.2 — Confirm and secure isolation of energized installation



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

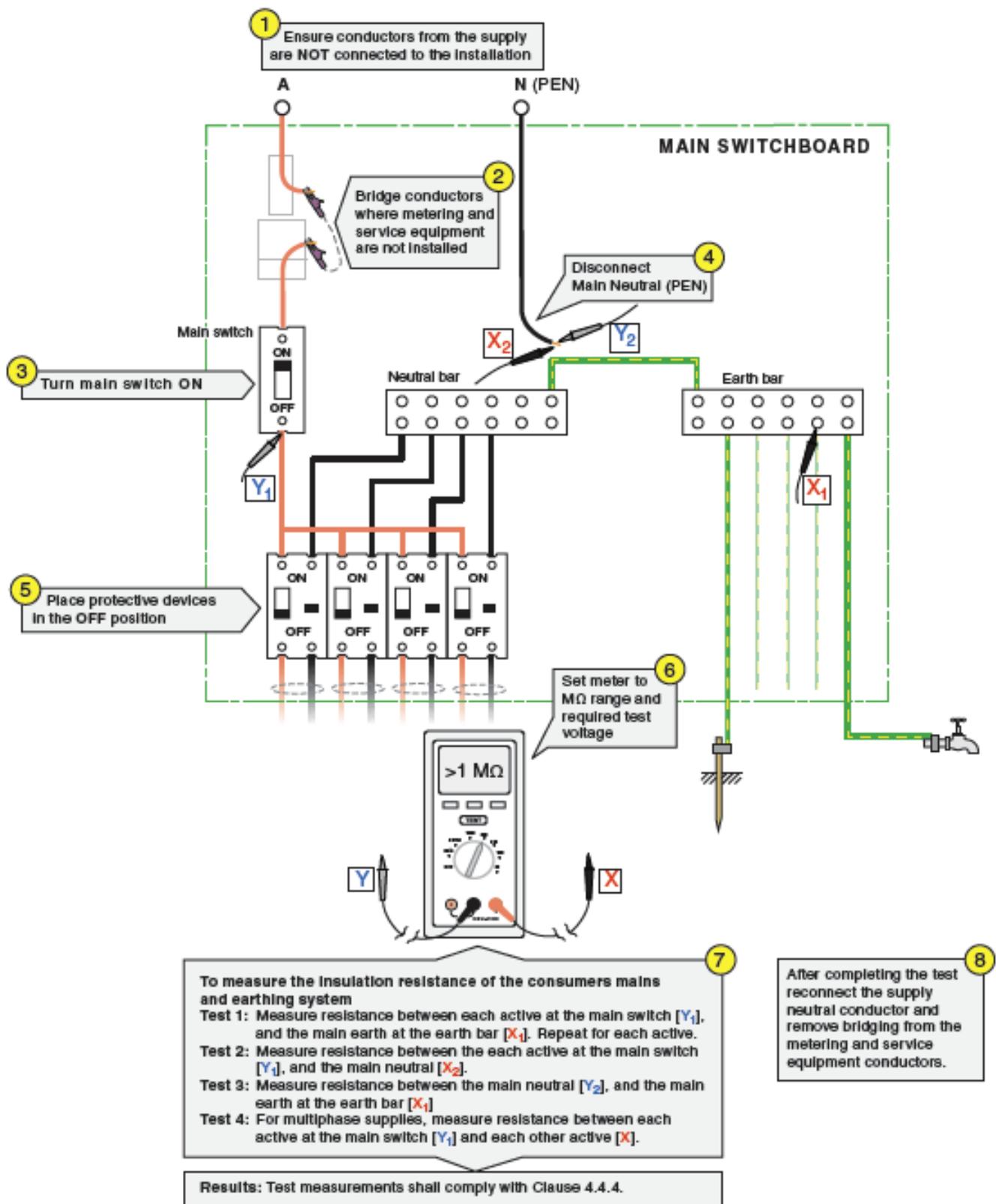
NOTE 2 When a trailing lead is used, the resistance of the trailing lead shall be considered.

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



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

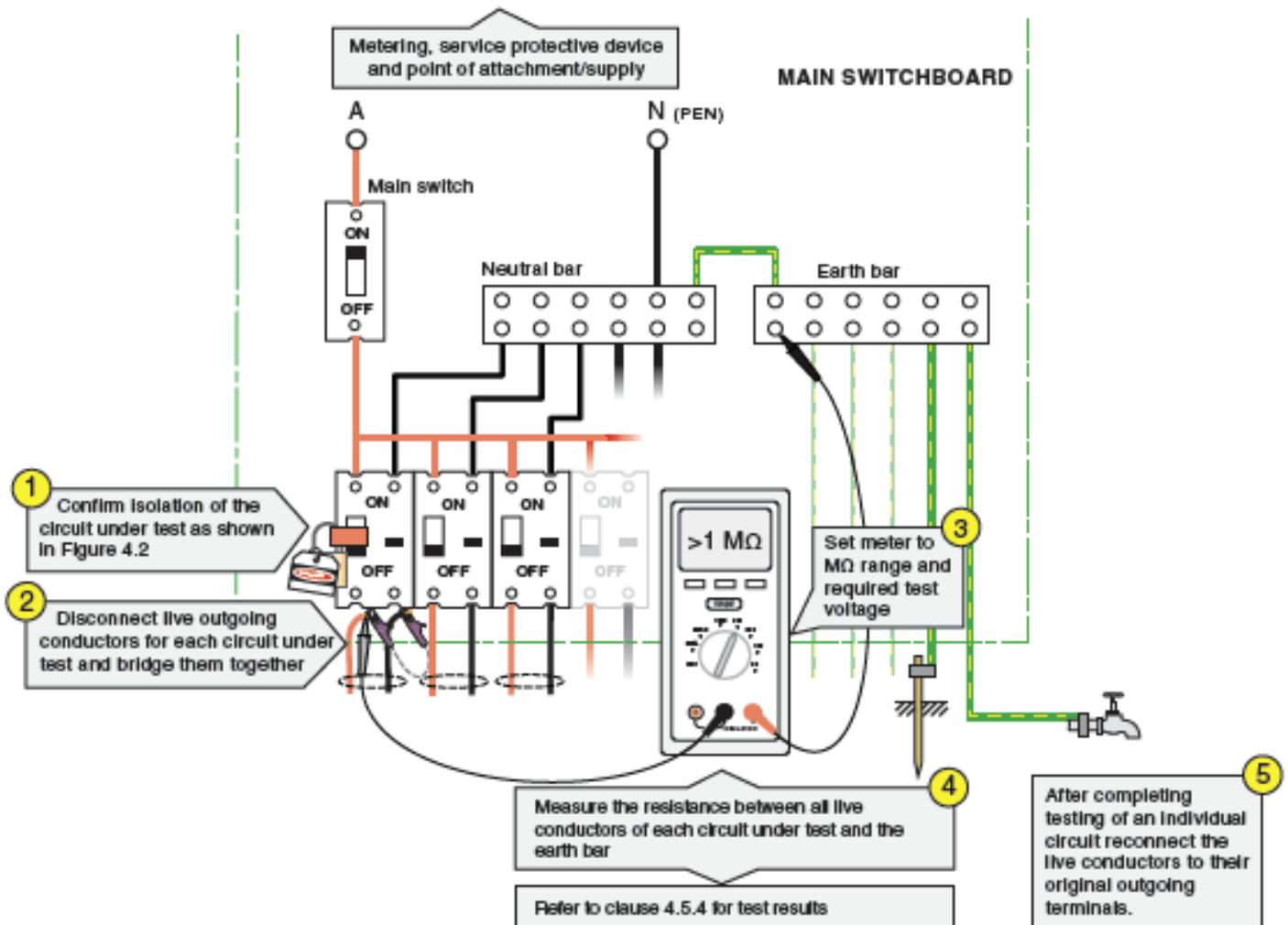
Figure 4.4 — Resistance test for protective earthing and equipotential bonding conductors — Circuit(s) isolated



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

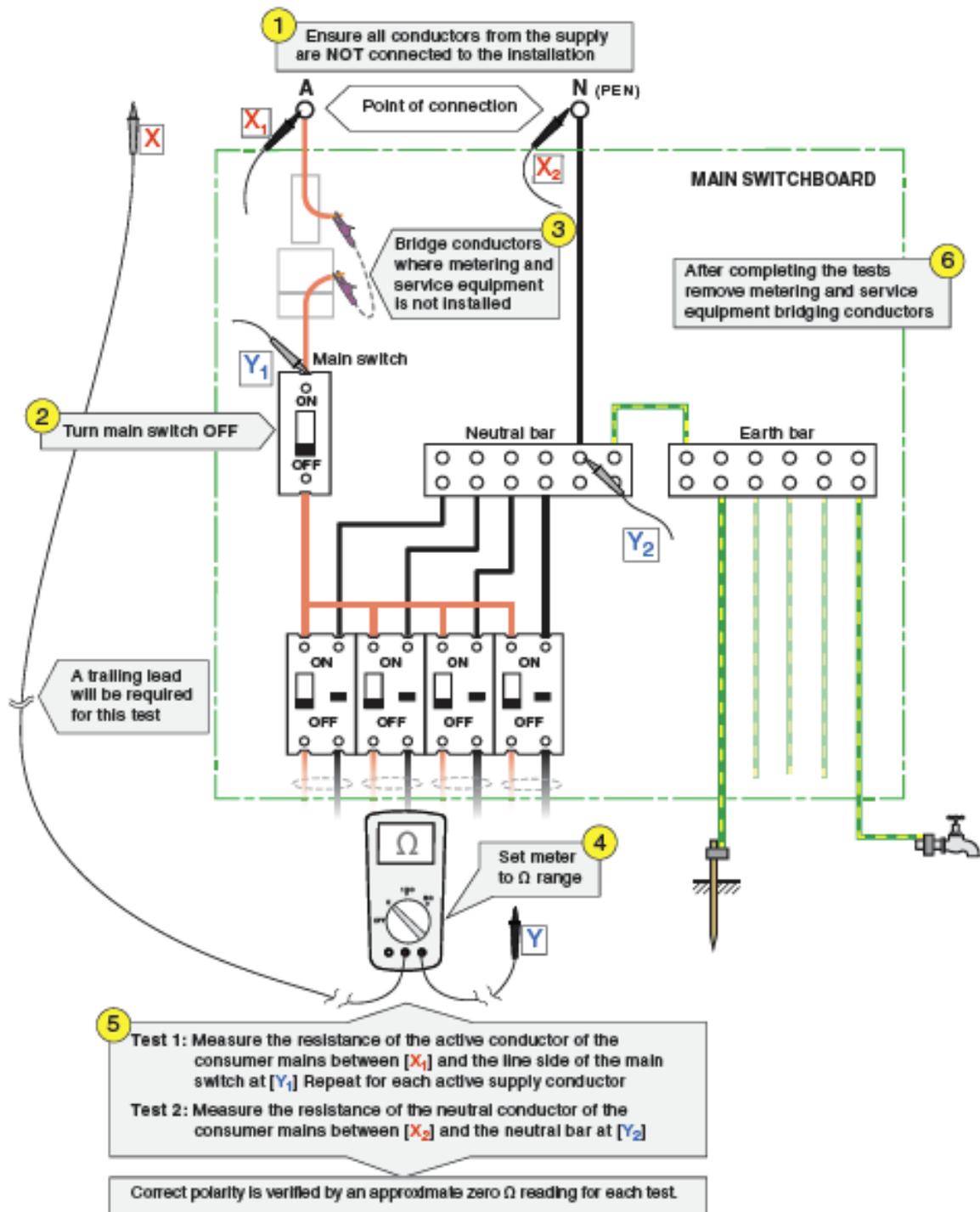
Figure 4.6 shows a method of testing the insulation resistance of individual final subcircuits.



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 temporarily 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.

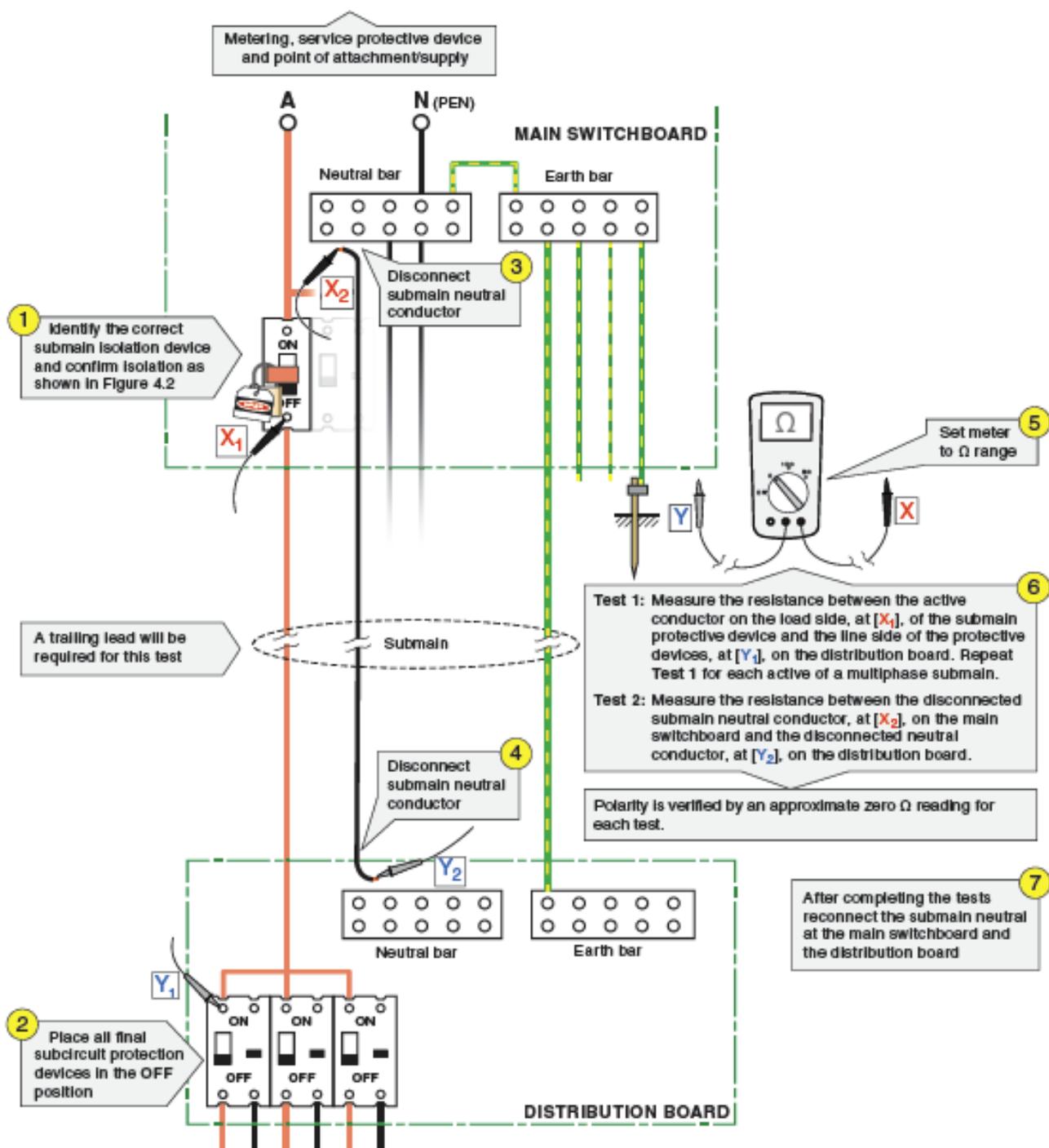
NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

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



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

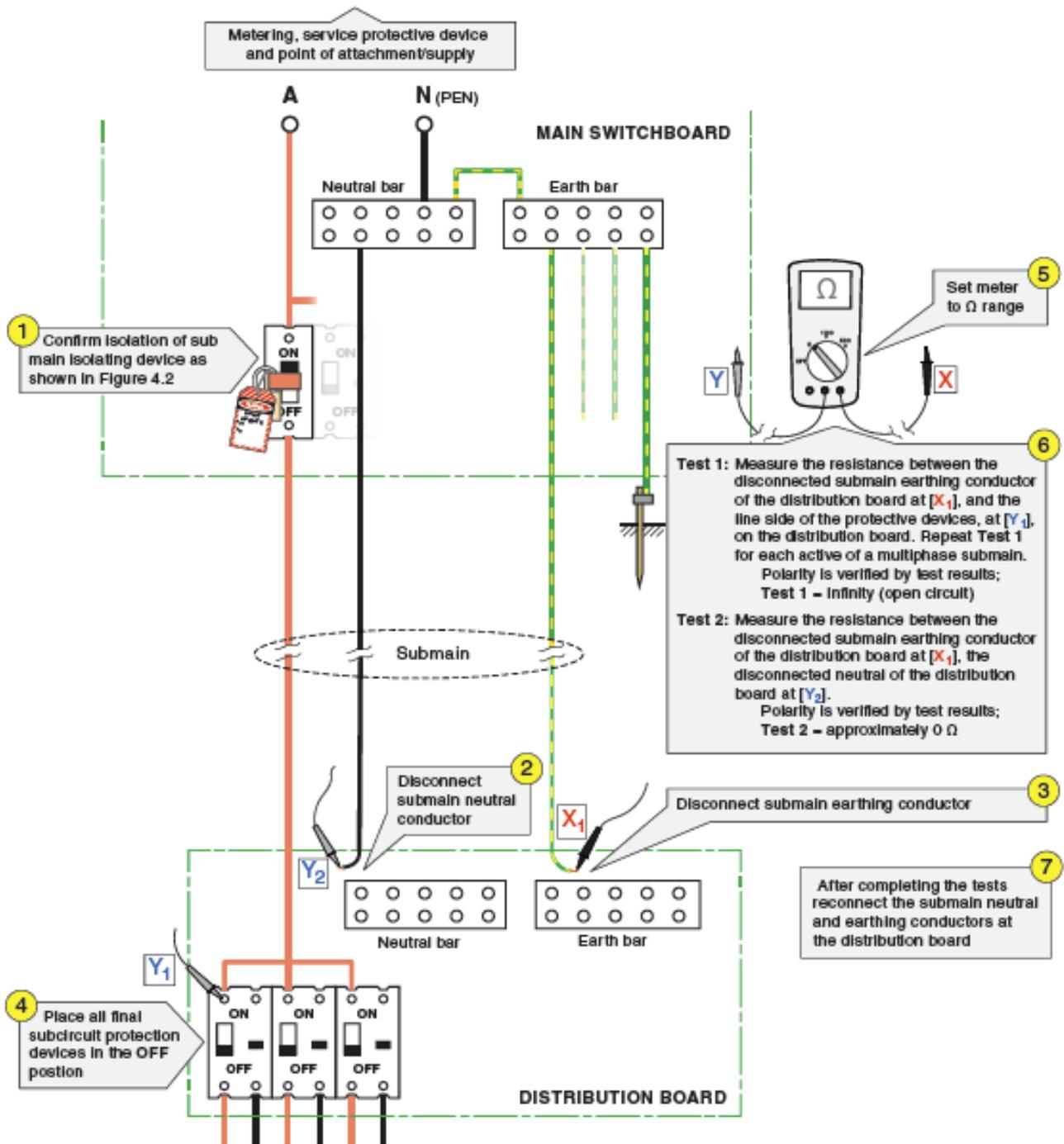
Figure 4.7 — Polarity test of consumer mains — Installation not connected to supply



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

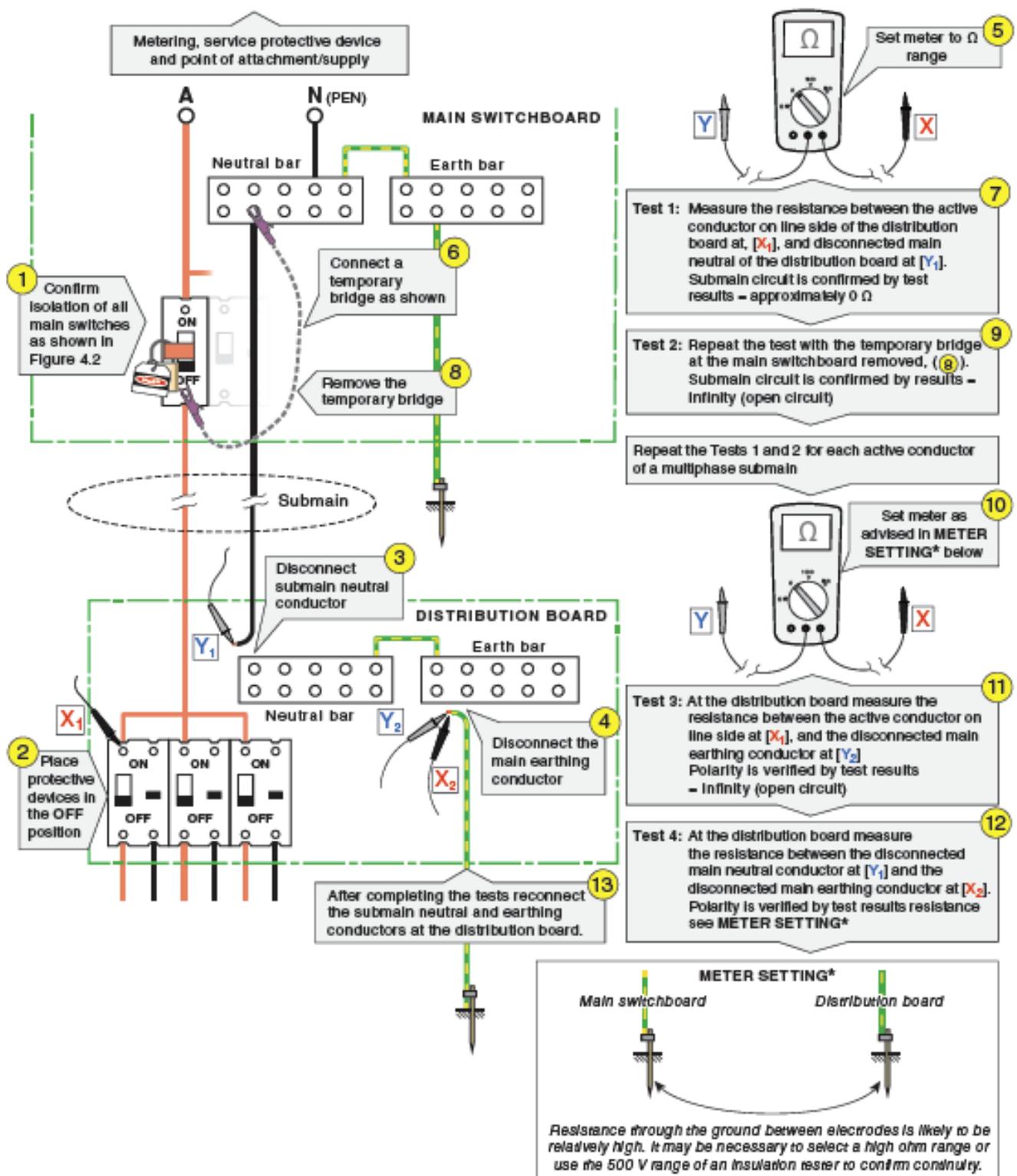


NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

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.

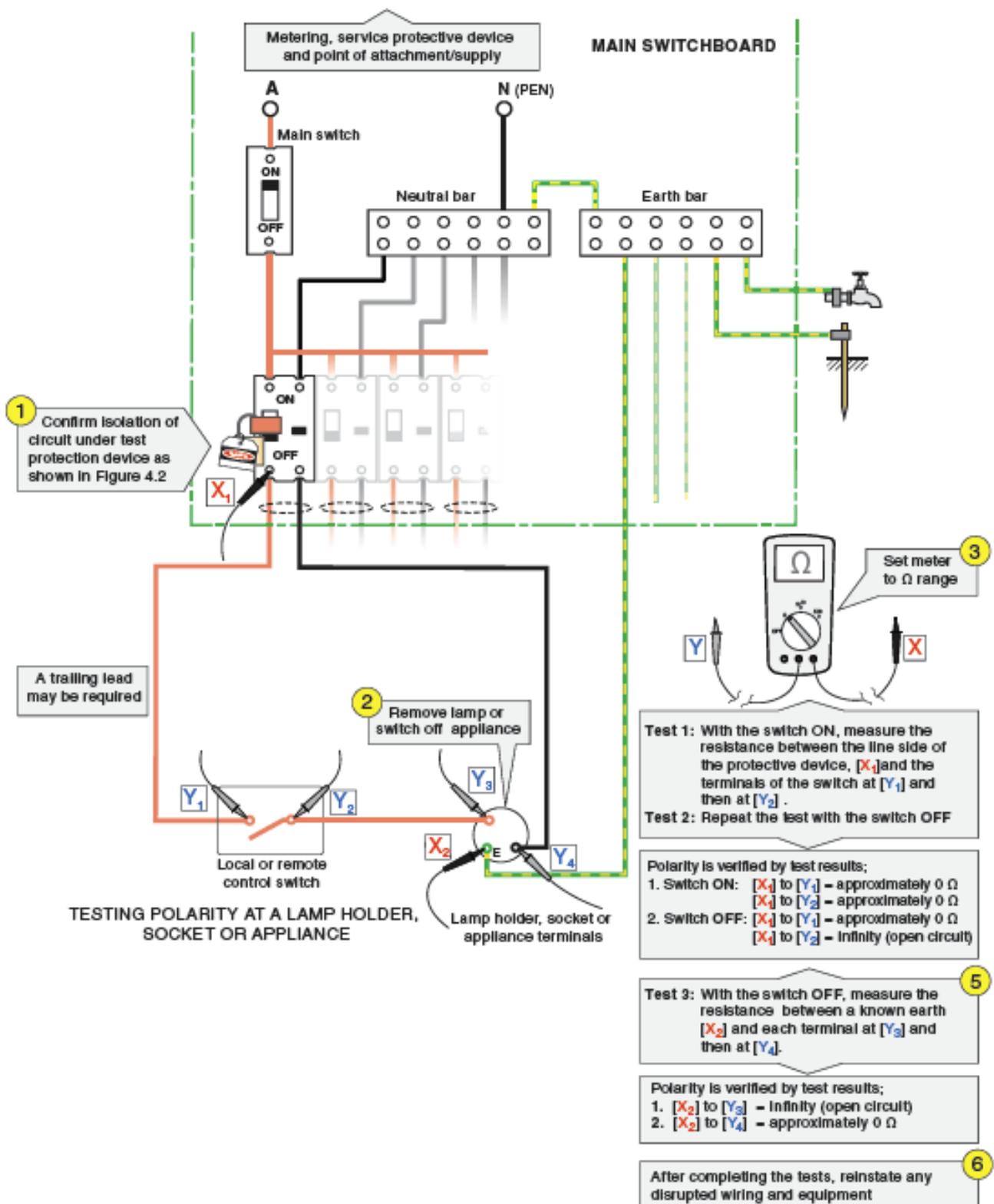


NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

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.

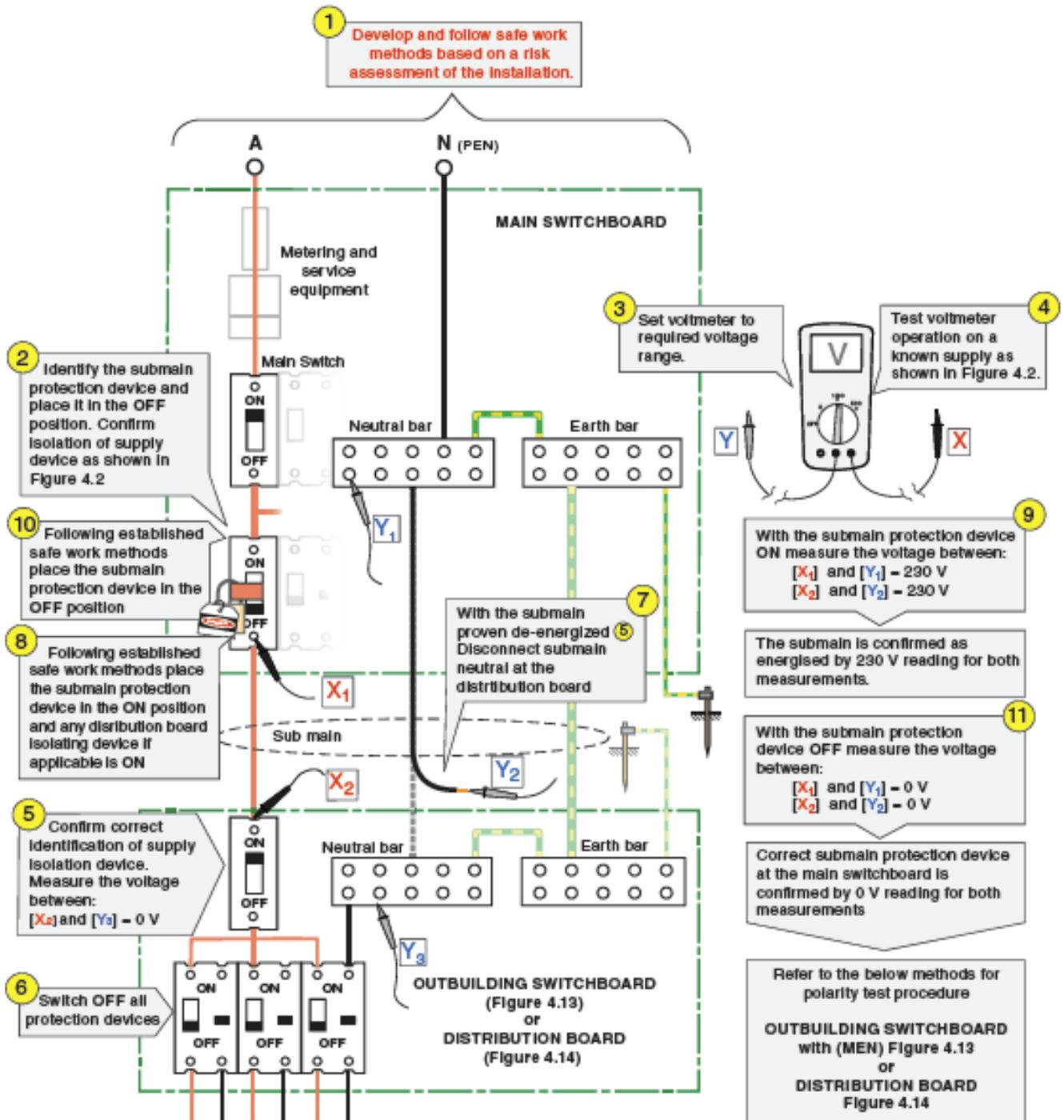


NOTE 1 Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

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

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

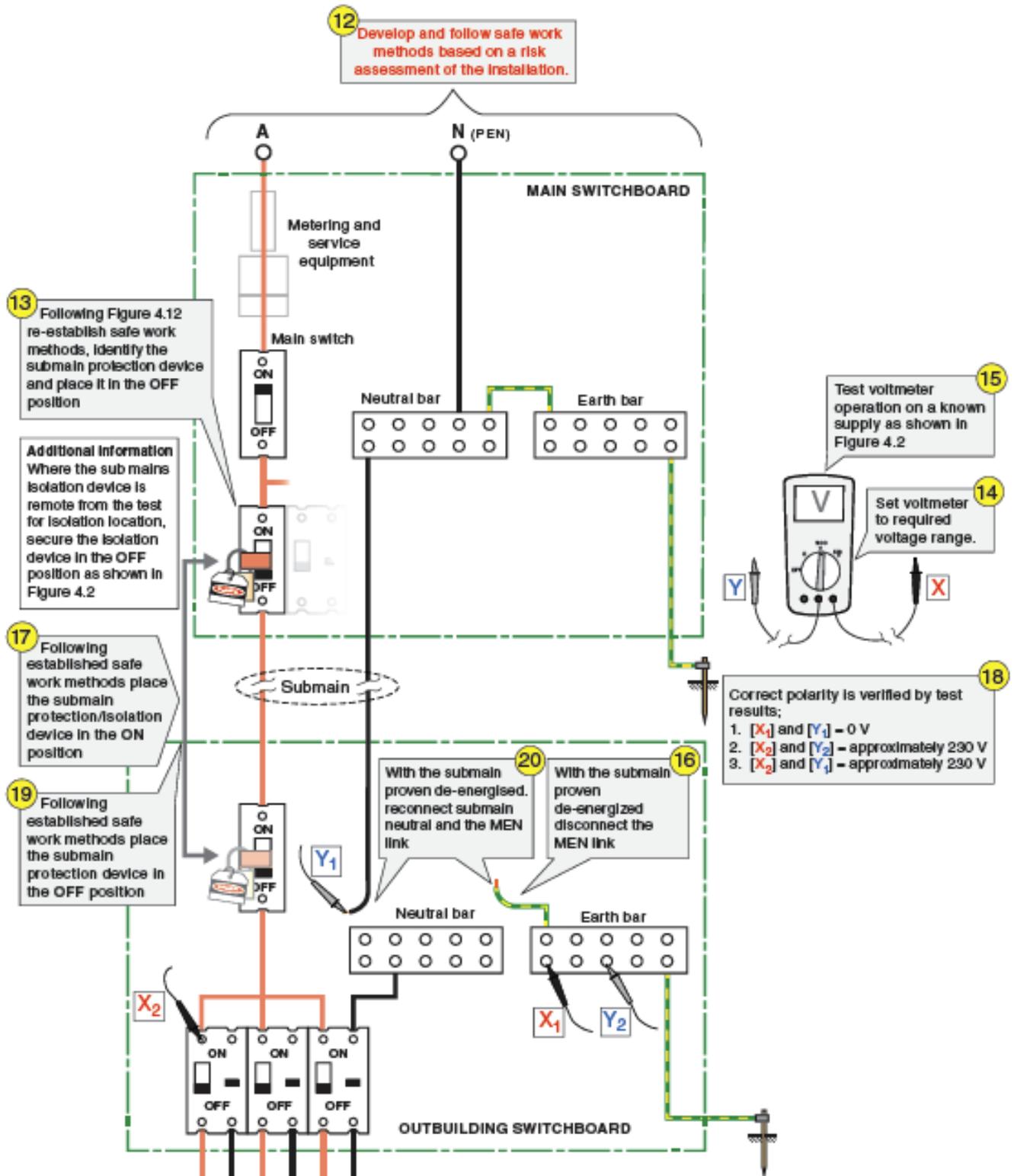


NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

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

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.

This testing procedure is a continuation of Figure 4.12

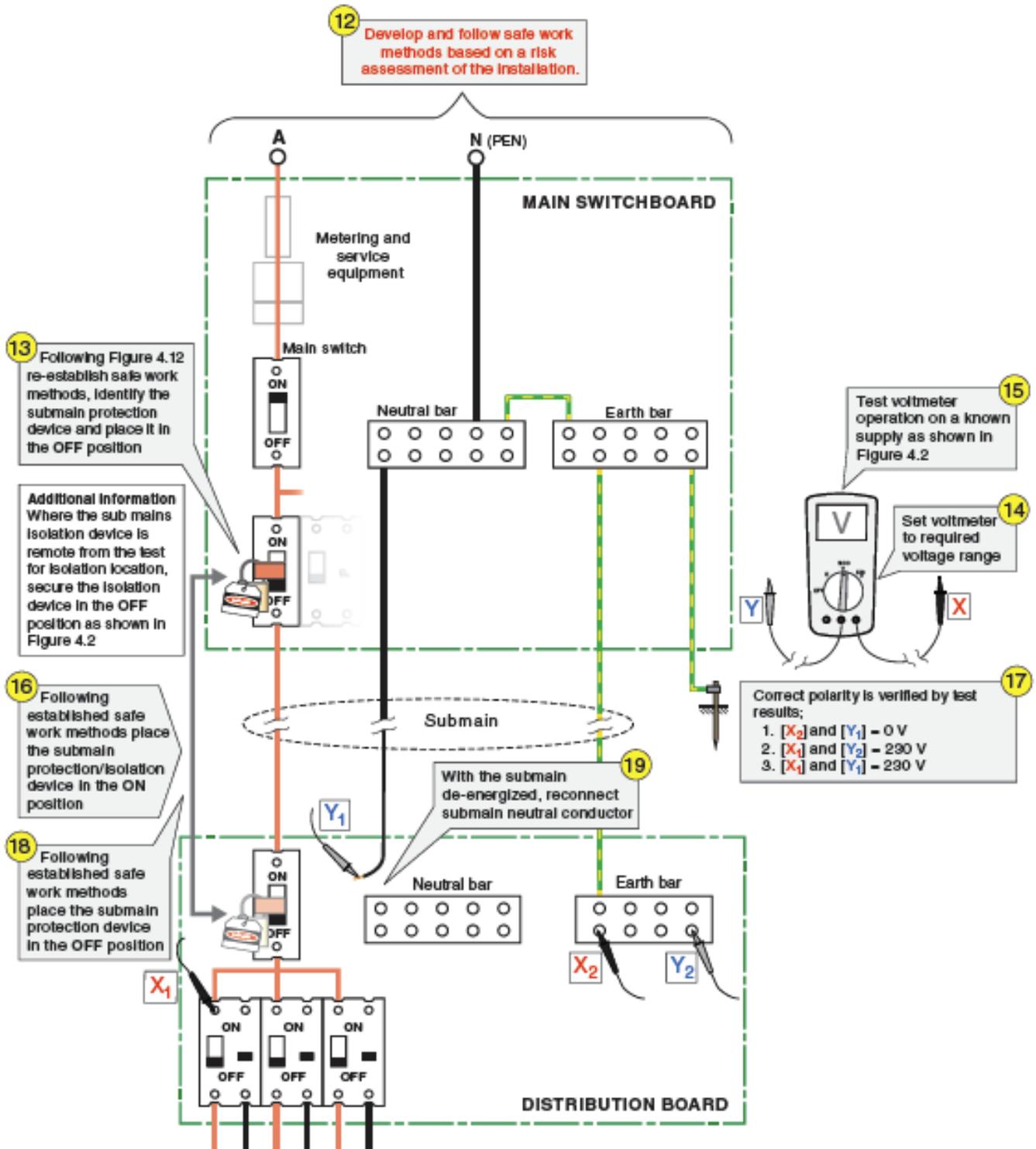


NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

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

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

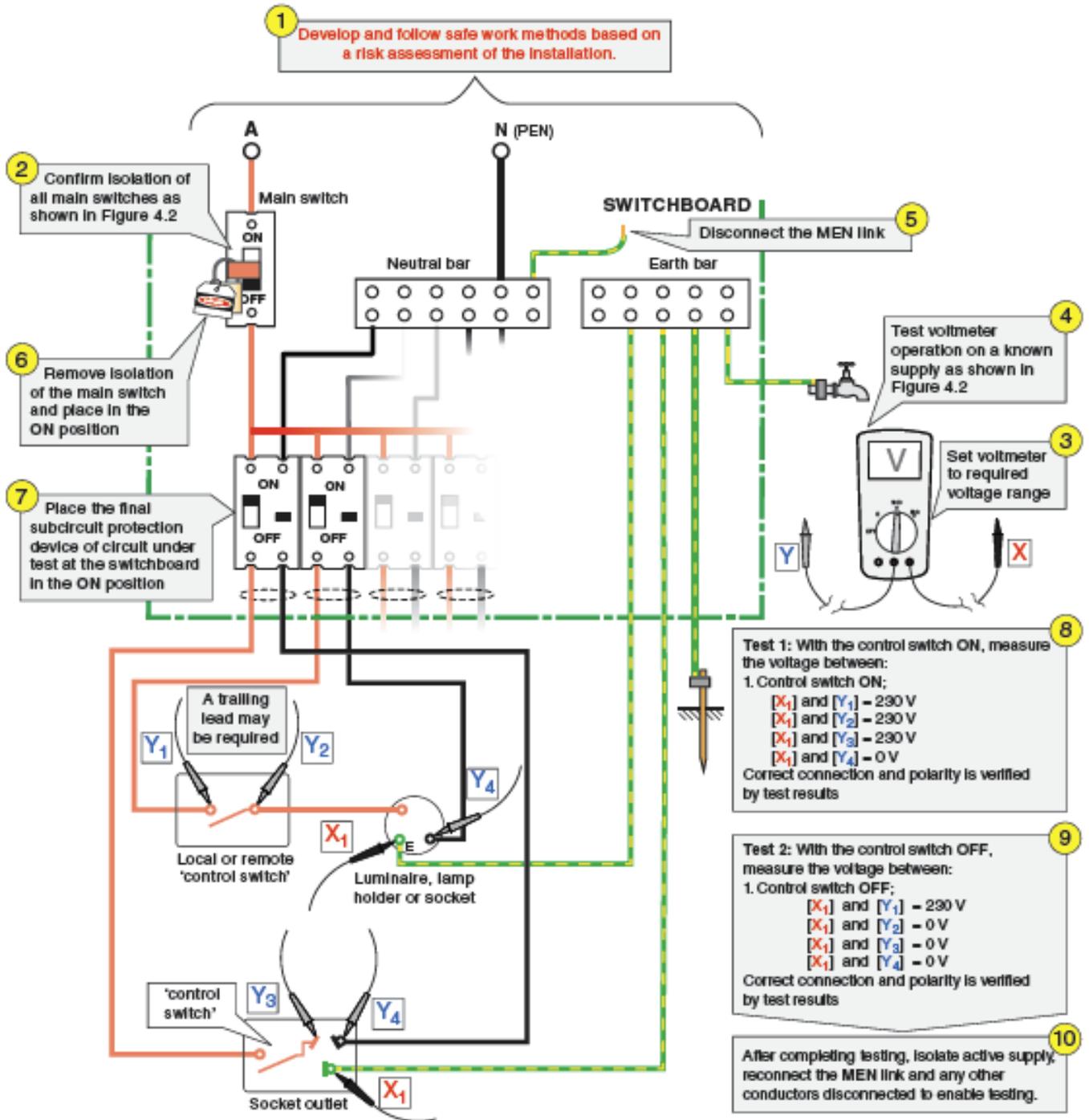
This testing procedure is a continuation of Figure 4.12



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

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

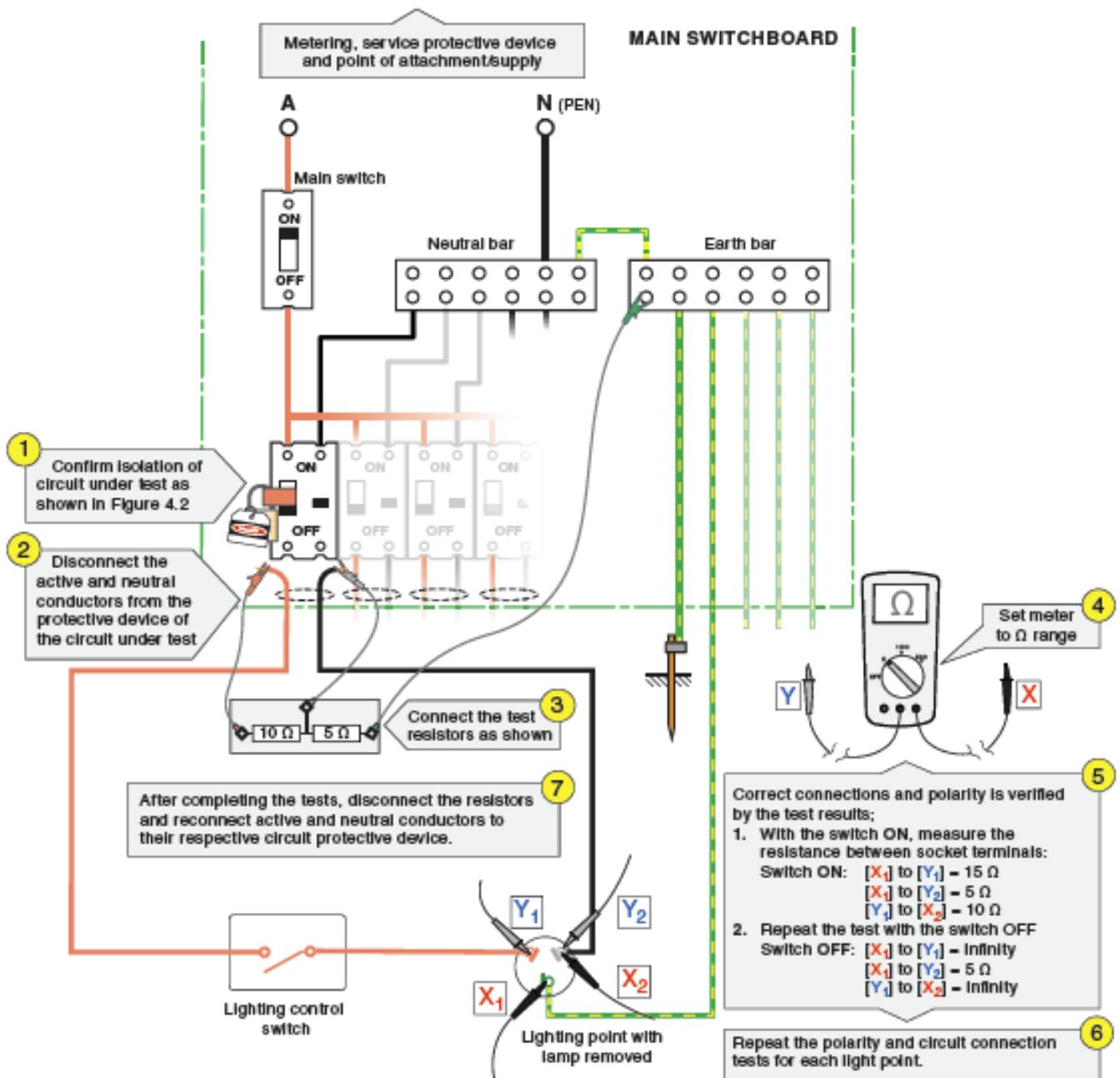


NOTE 1 Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

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

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

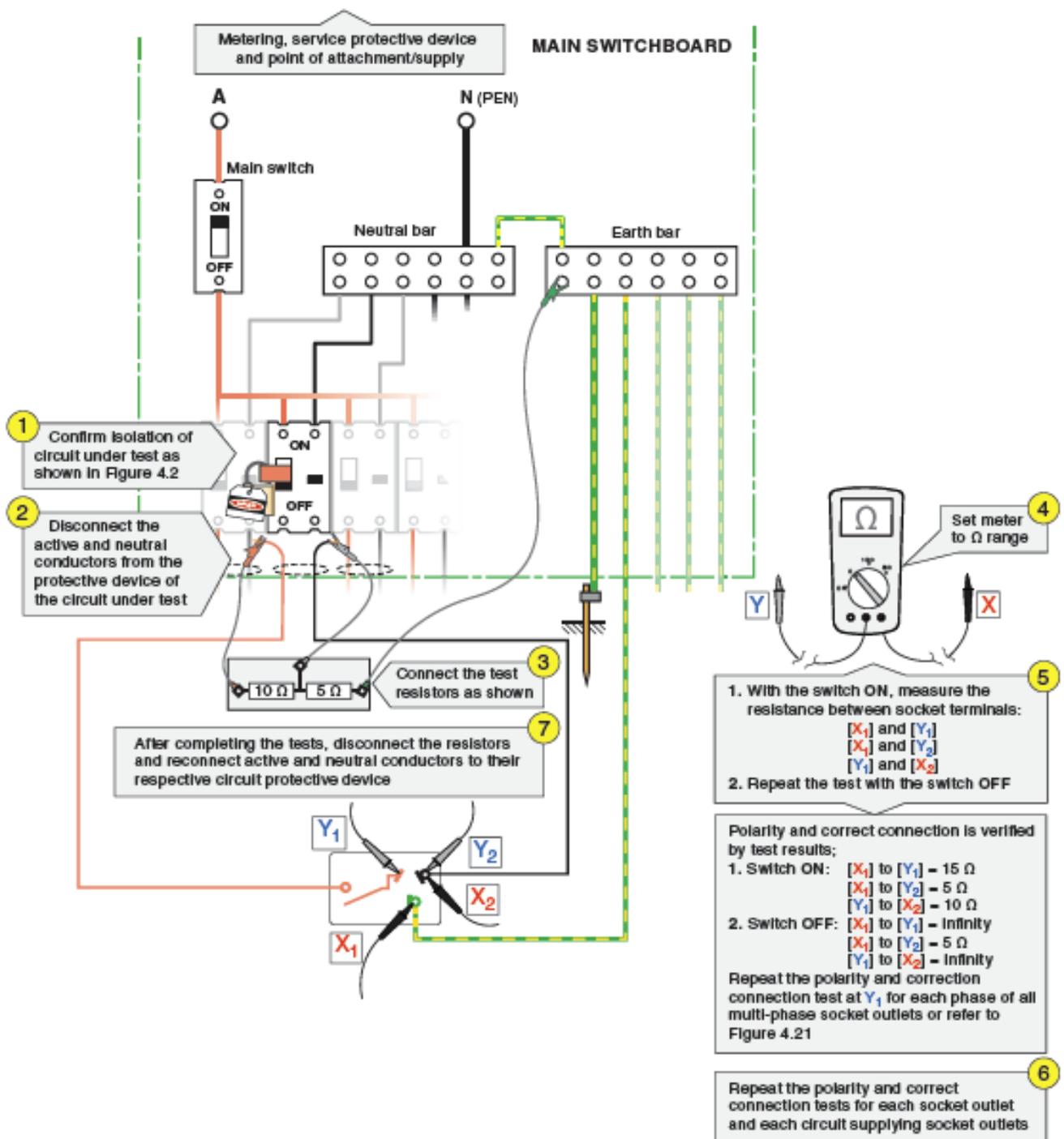


NOTE 1 Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

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

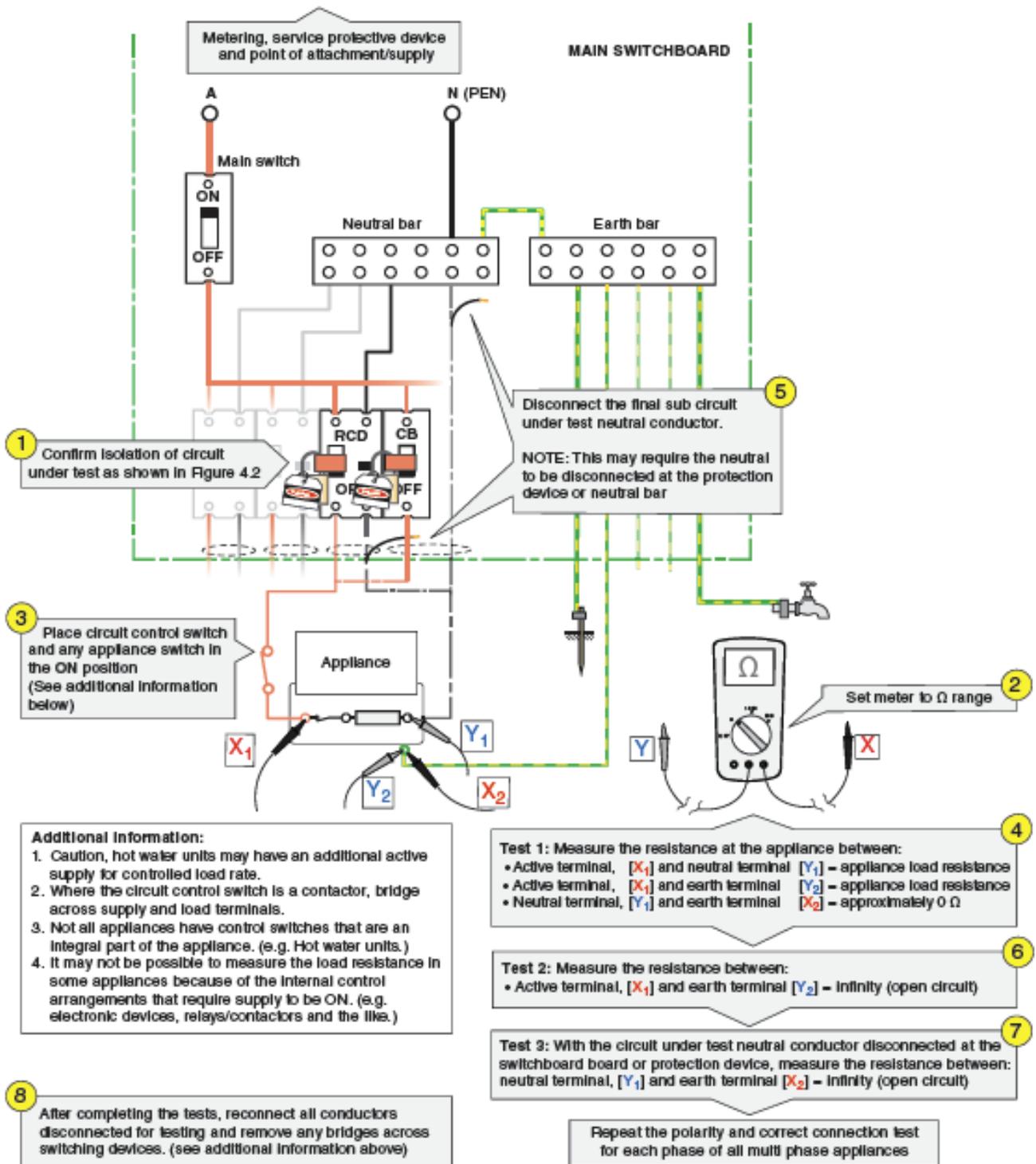
Figure 4.16 — Polarity test and correct connection of lighting points using resistors — Circuit isolated

4.6.5.12 Polarity test of socket-outlet subcircuits using resistors



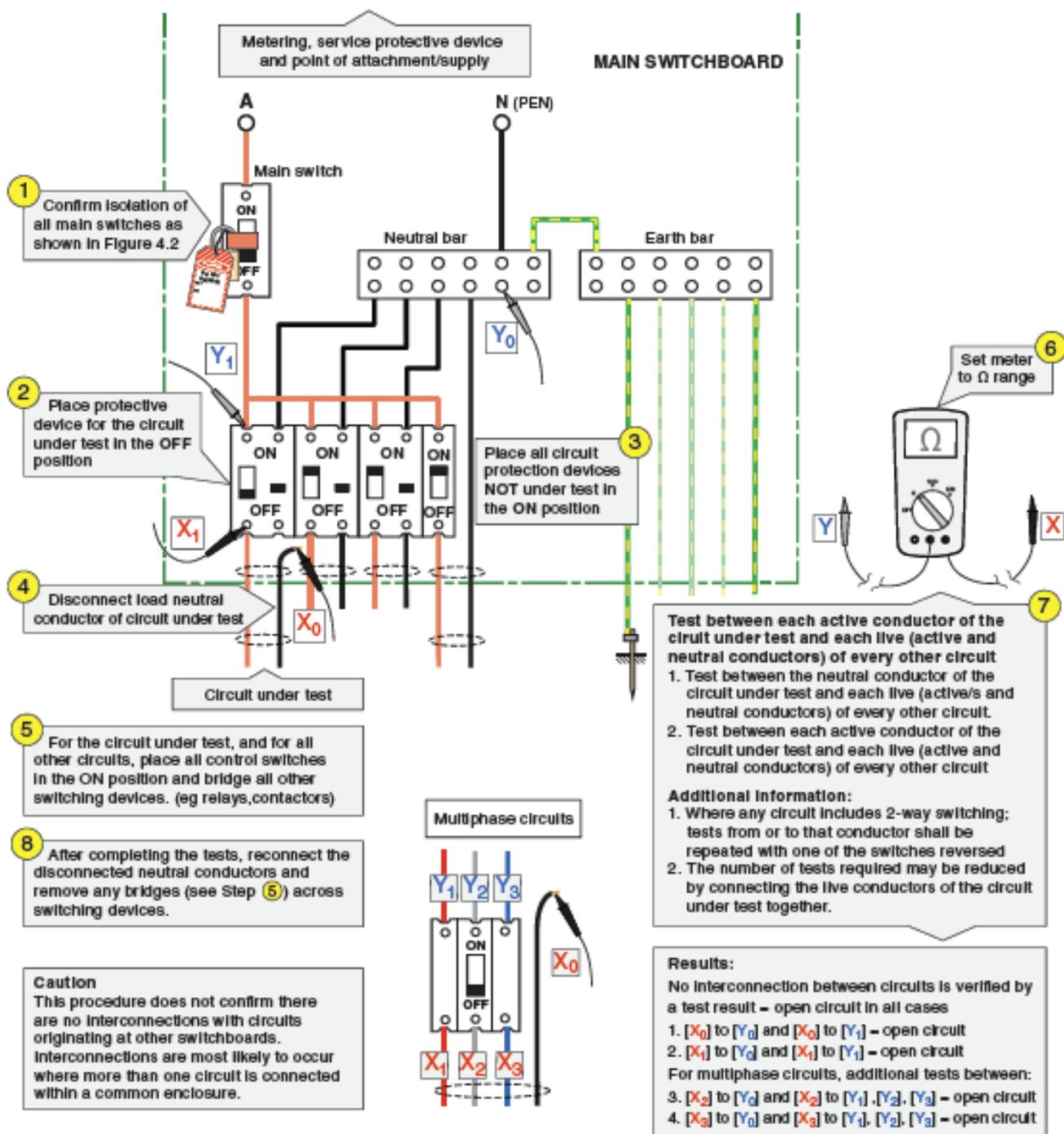
NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

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



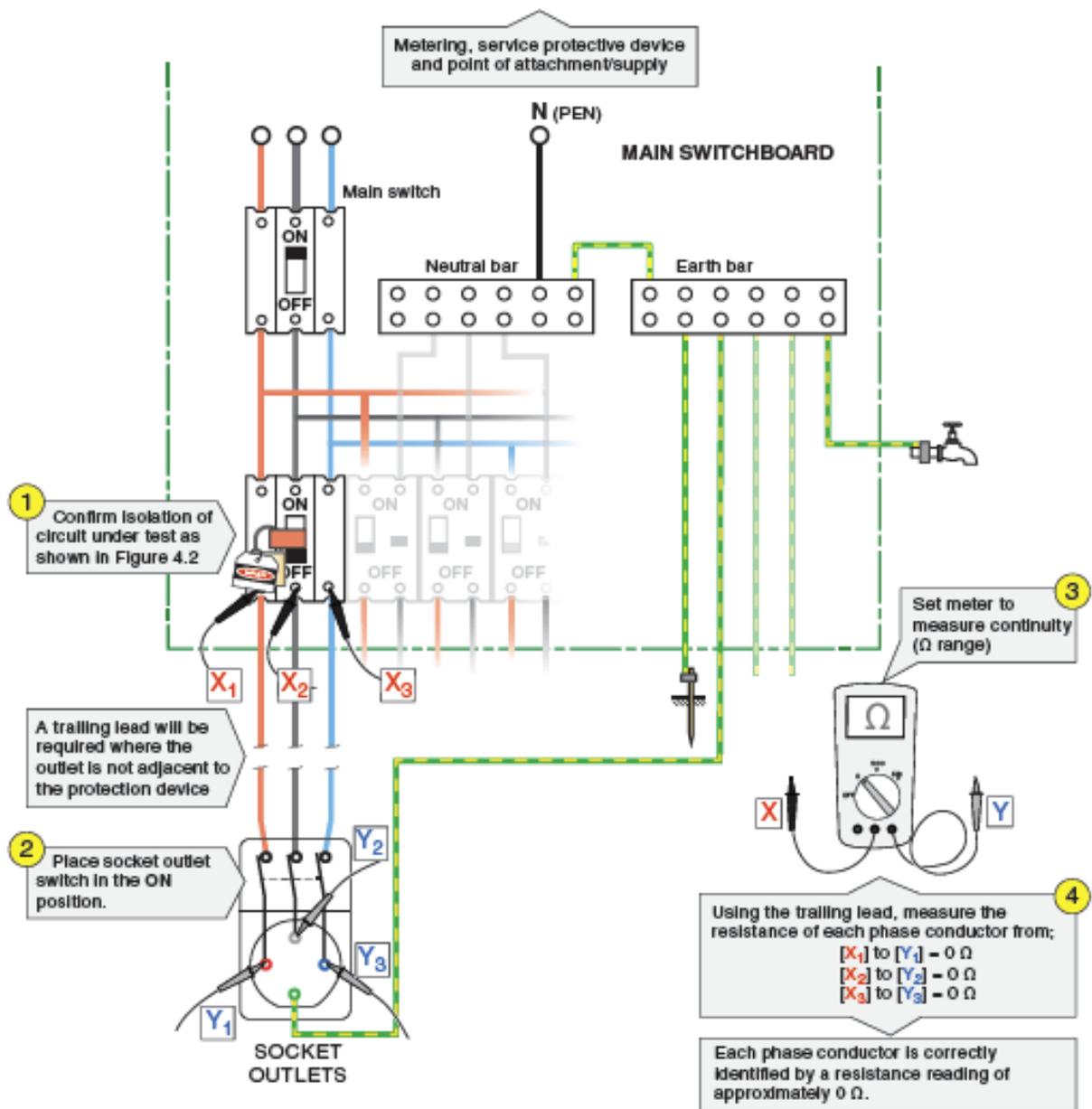
NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

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



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

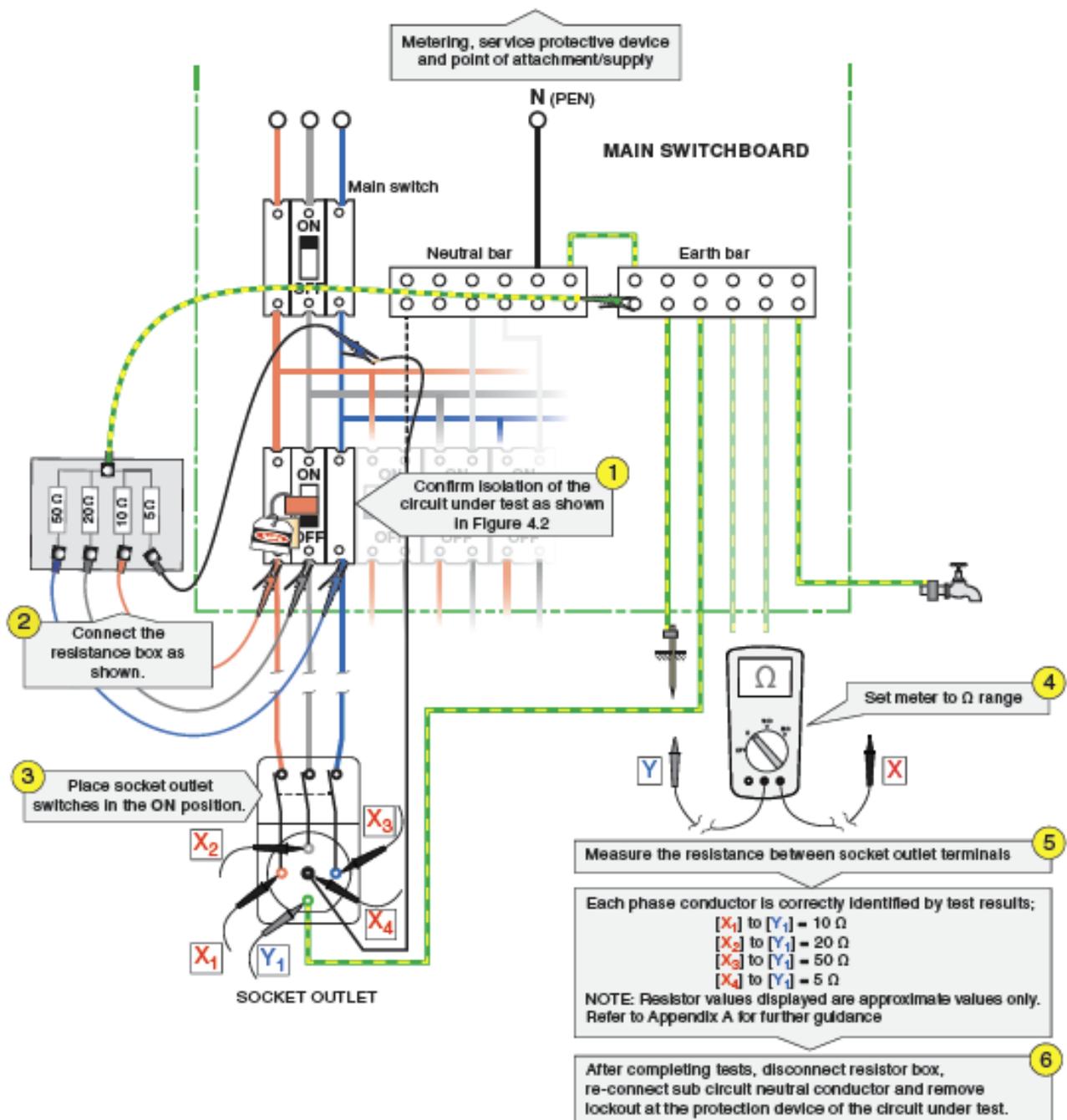
Figure 4.19 — Interconnection test between conductors of different circuits — Circuits isolated



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

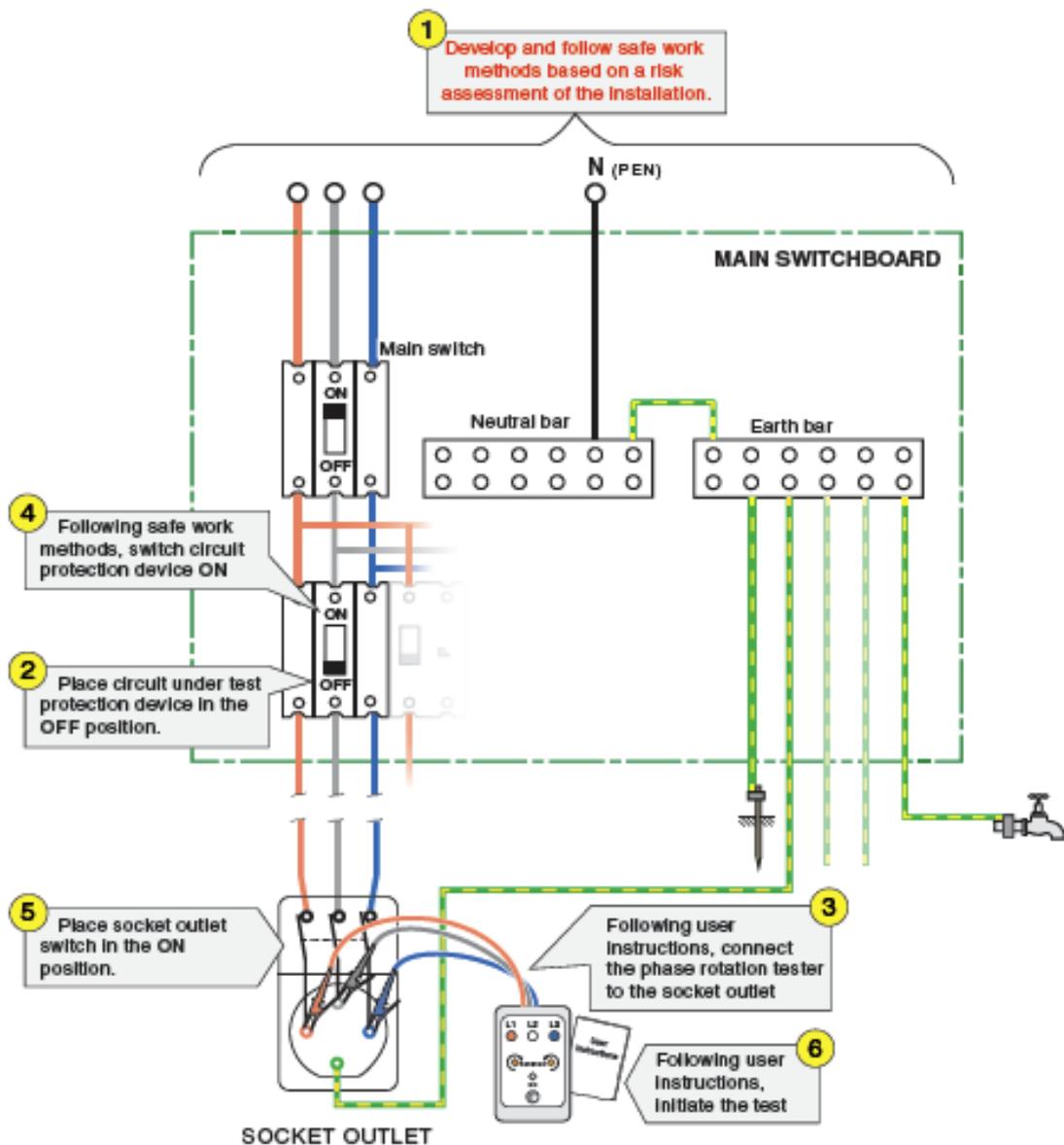
NOTE 2 When a trailing lead is used, the resistance of the trailing lead shall be considered.

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



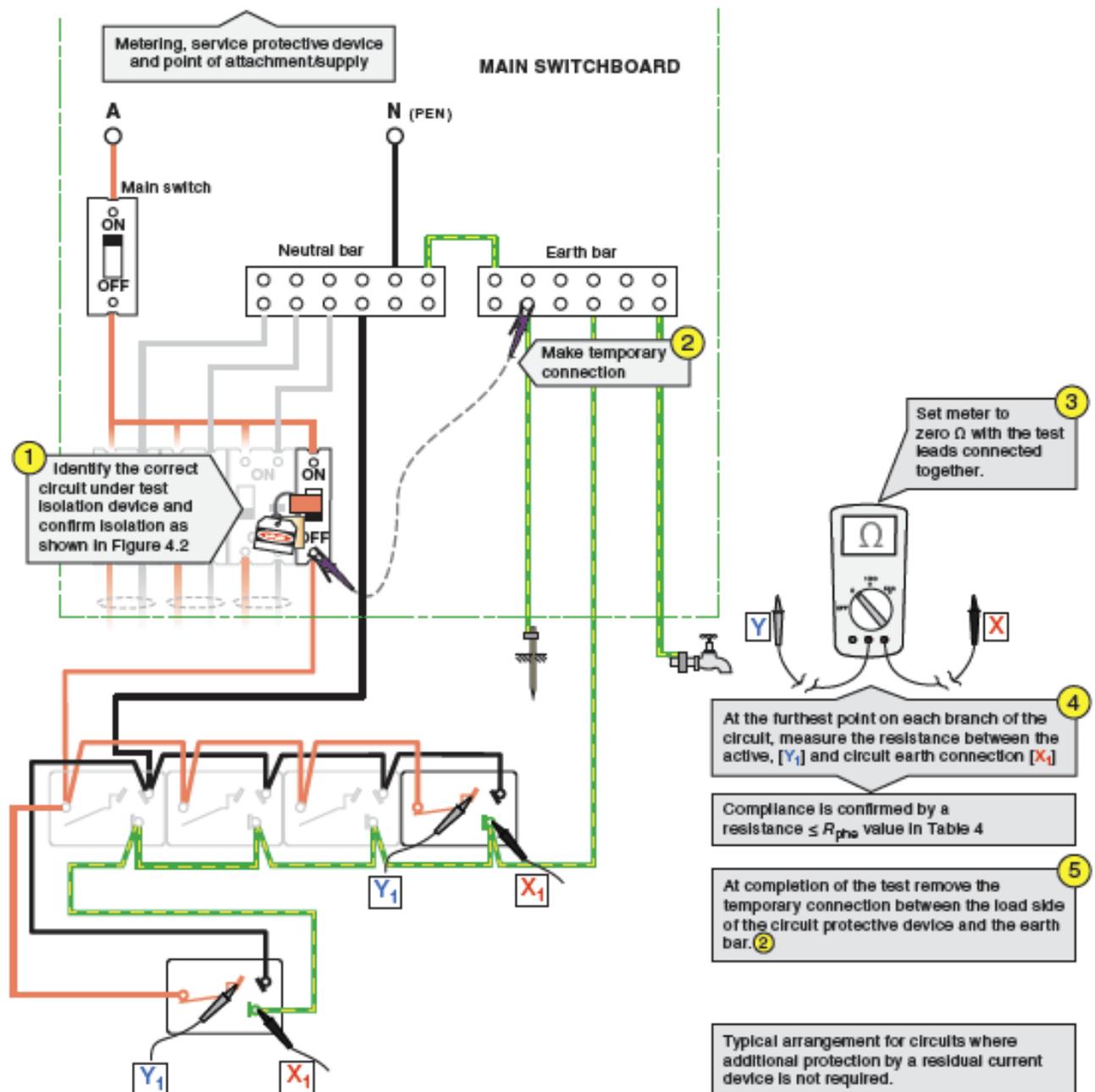
NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

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



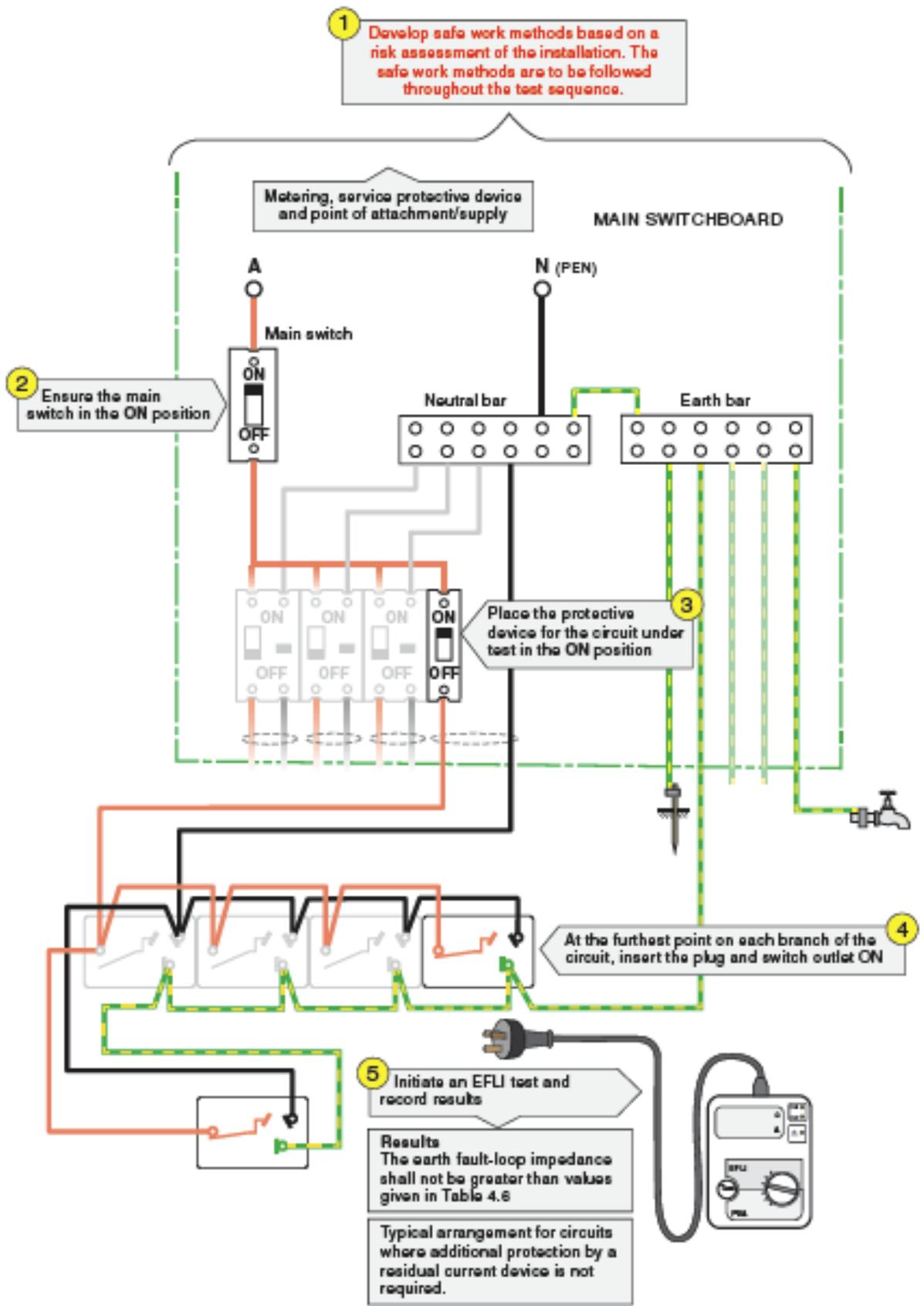
NOTE Test sequence numbers follow procedures for safety and test preparation, conducting tests as well as the results that verify compliance and finally a reminder to reinstating the installation after testing is completed.

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



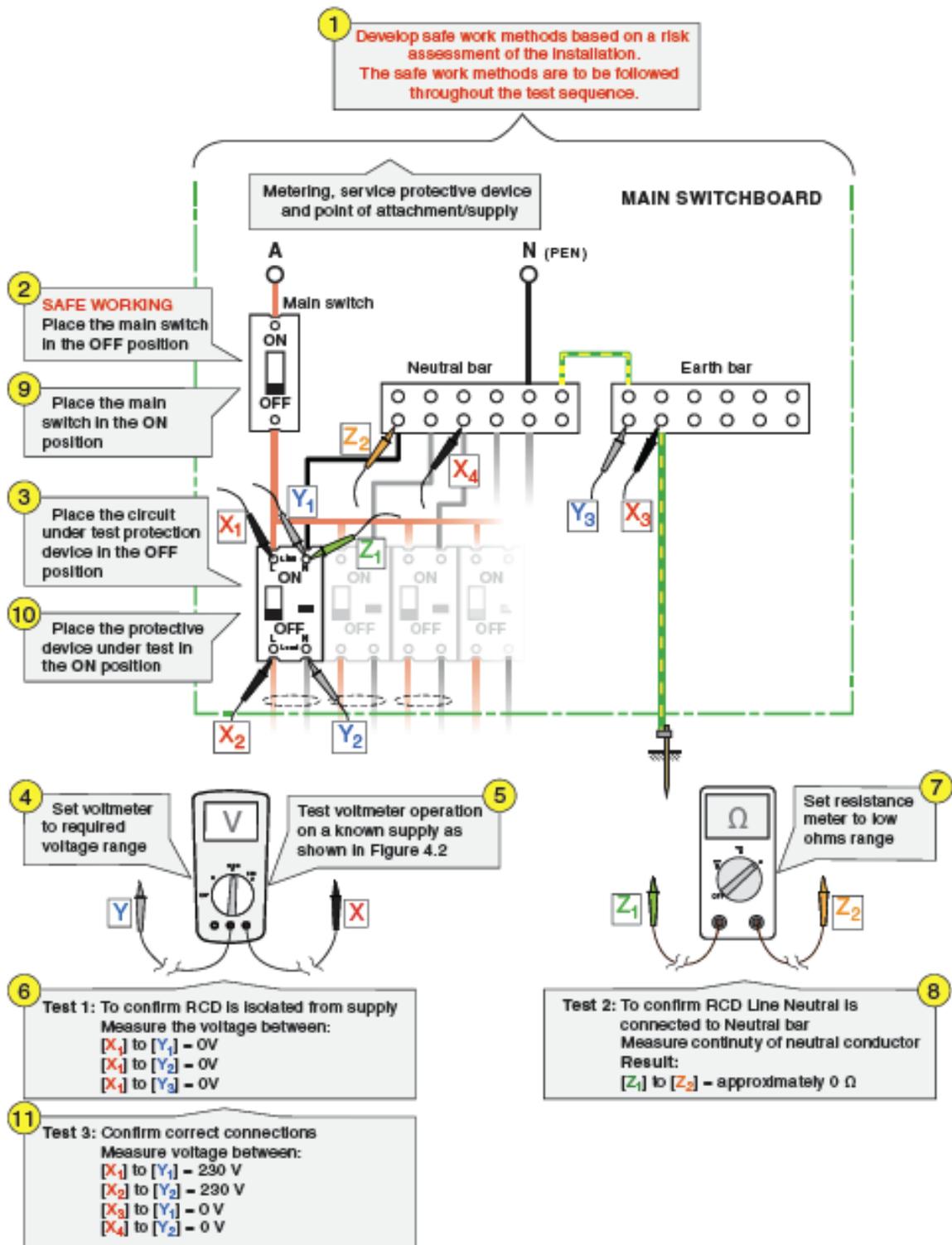
NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

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



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



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.

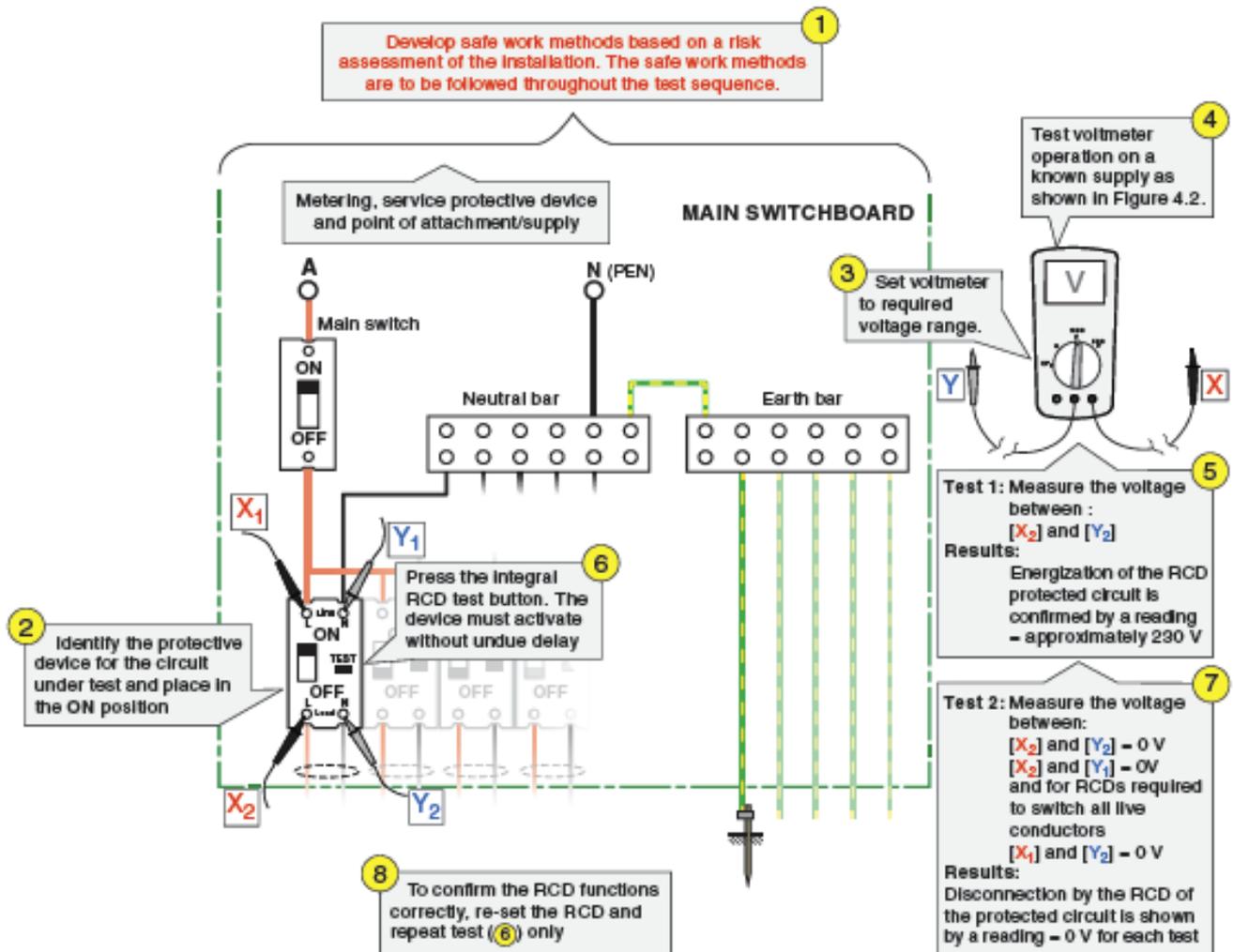
Figure 4.26 — Test for correct connection of RCDs at the distribution board — Circuit energized

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 *Idn* 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.

**See Figure 4.26 — Test for polarity and correct connection of RCDs at the distribution board
Circuit energised prior to performing this test**



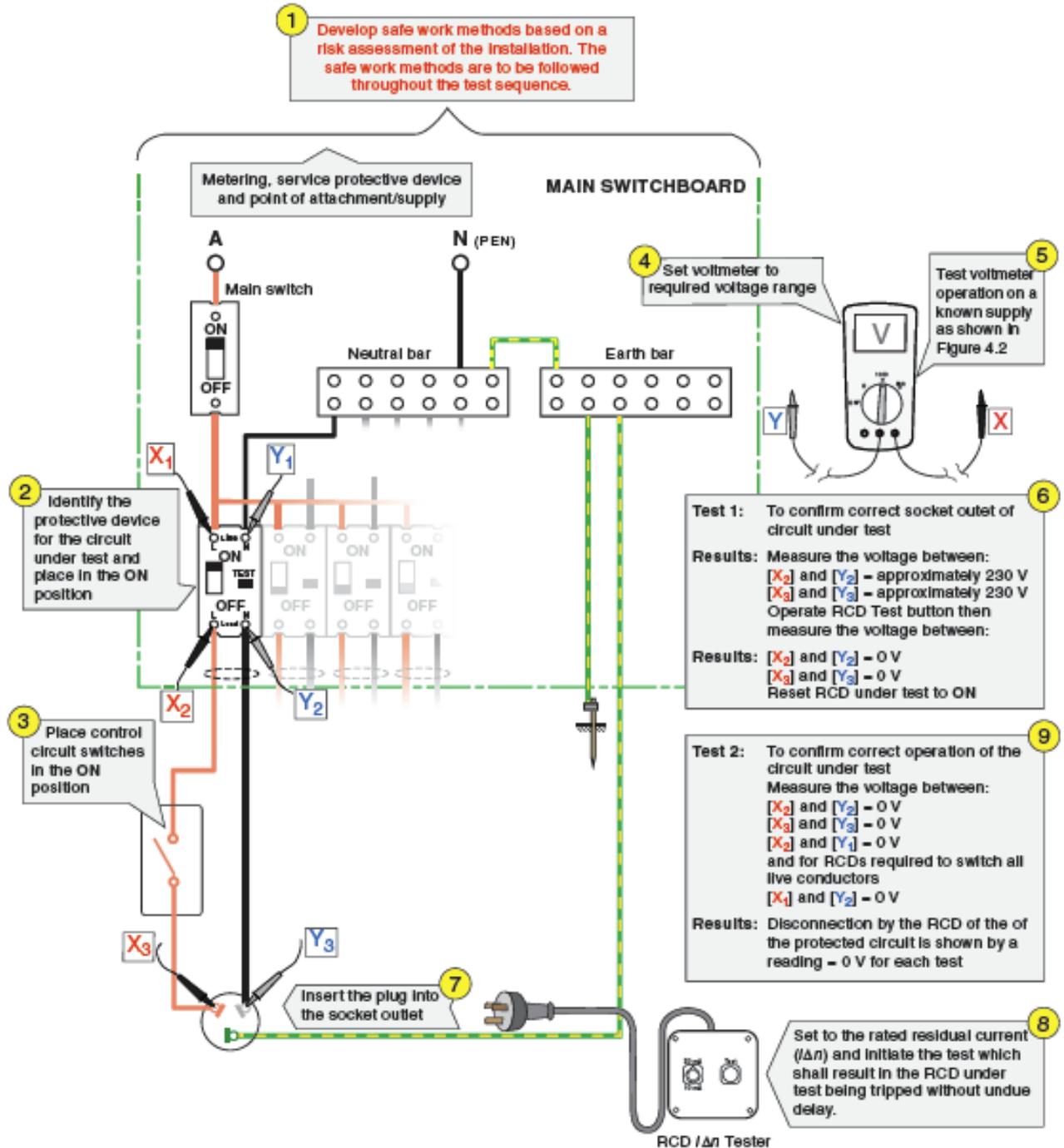
NOTE 1 Numbers indicate the sequence of safety preparation, tests and compliant results and reinstatement after completion.

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

See Figure 4.26 — Test for polarity and correct connection of RCDs at the distribution board circuit energised prior to performing this test



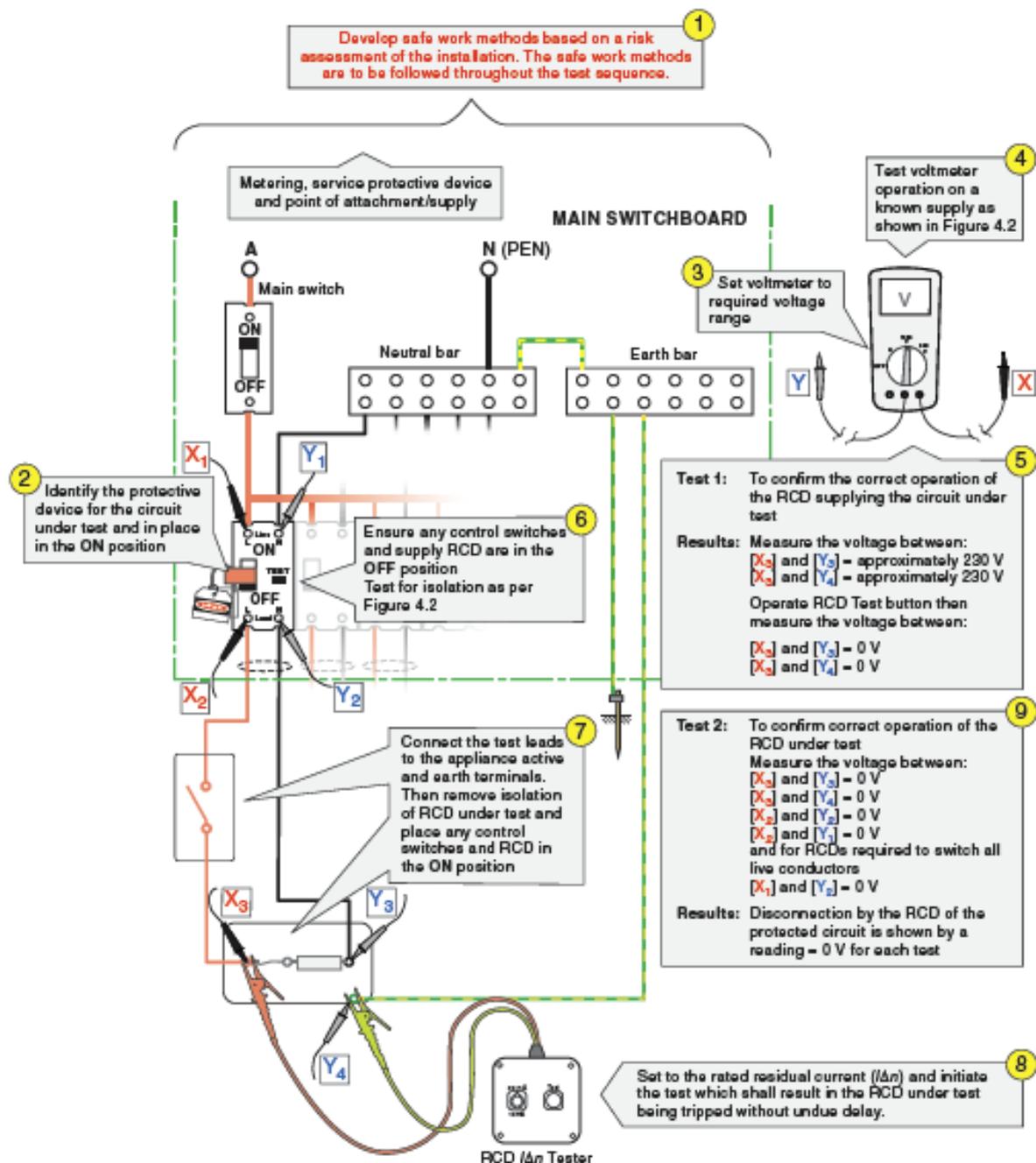
NOTE 1 Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement of completion.

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

See Figure 4.26 — Test for polarity and correct connection of RCDs at the distribution board
Circuit energised prior to performing this test



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 RCD 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

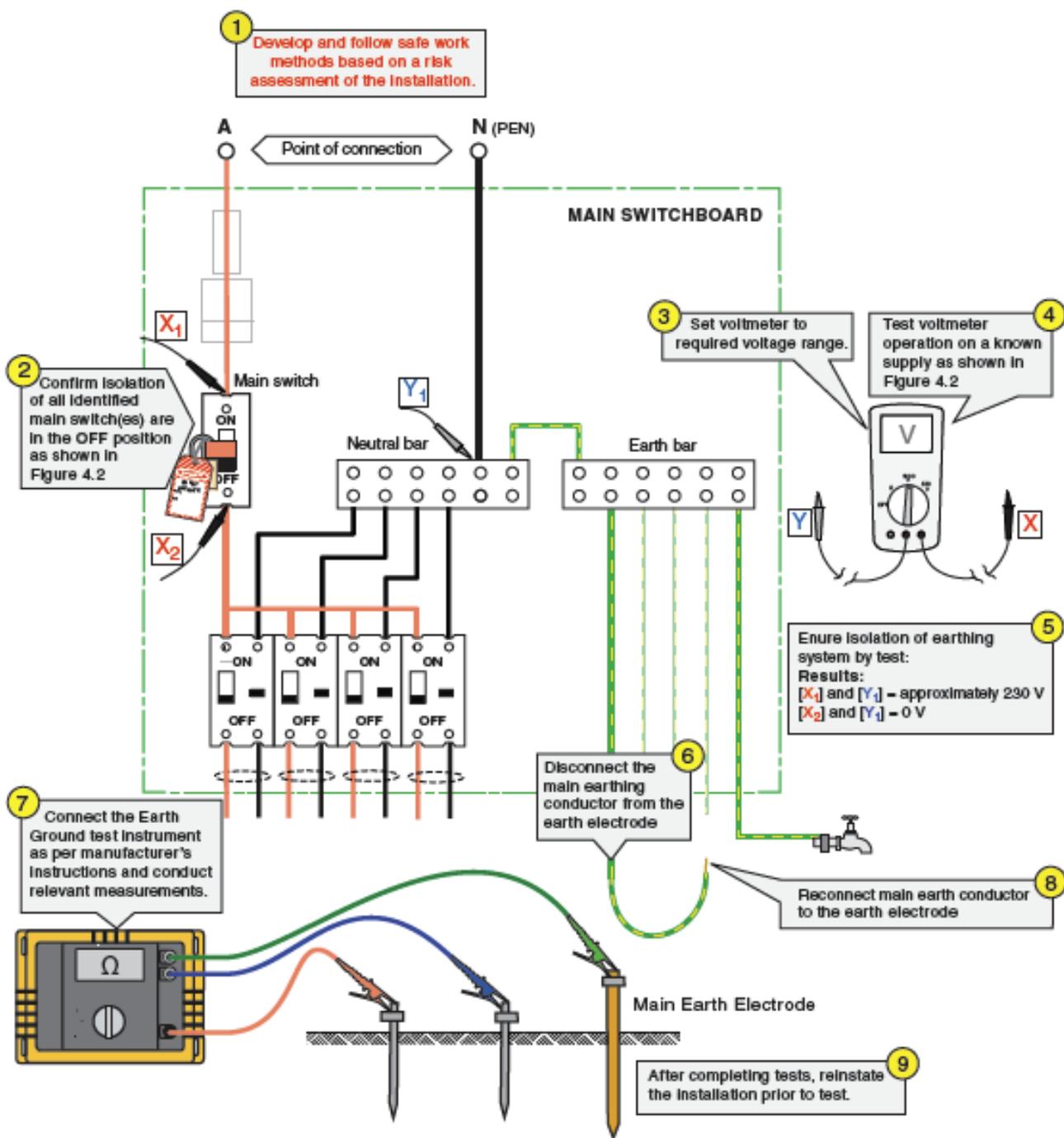
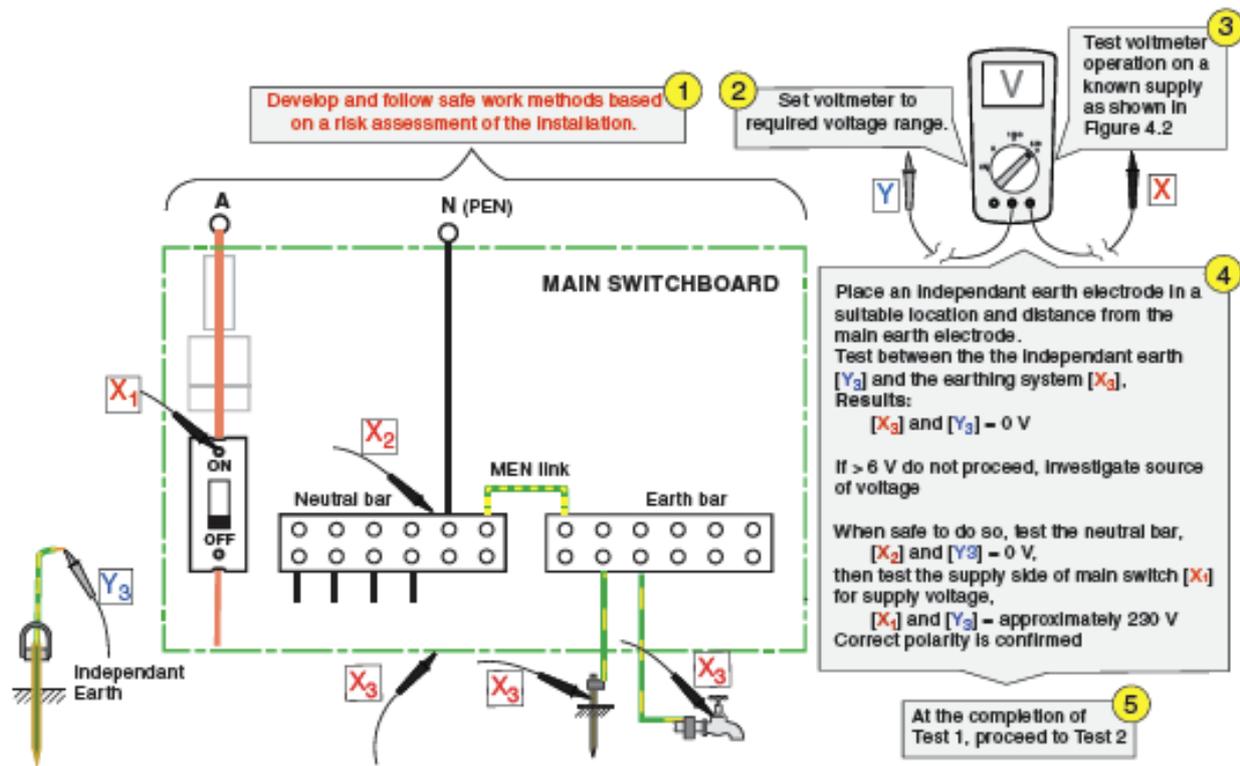


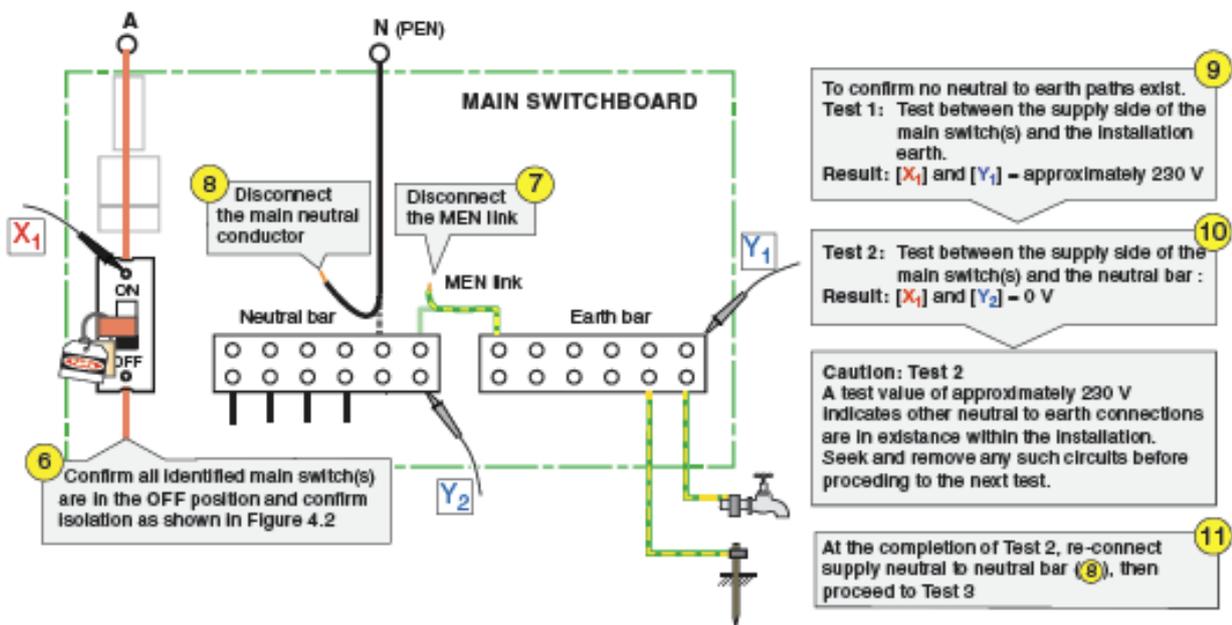
Figure 4.30 — Measurement of the resistance of the earth electrode — Fall of potential method

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 EXTRANEIOUS, EXPOSED, CONDUCTIVE PARTS OF THE INSTALLATION TO RISE.



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.

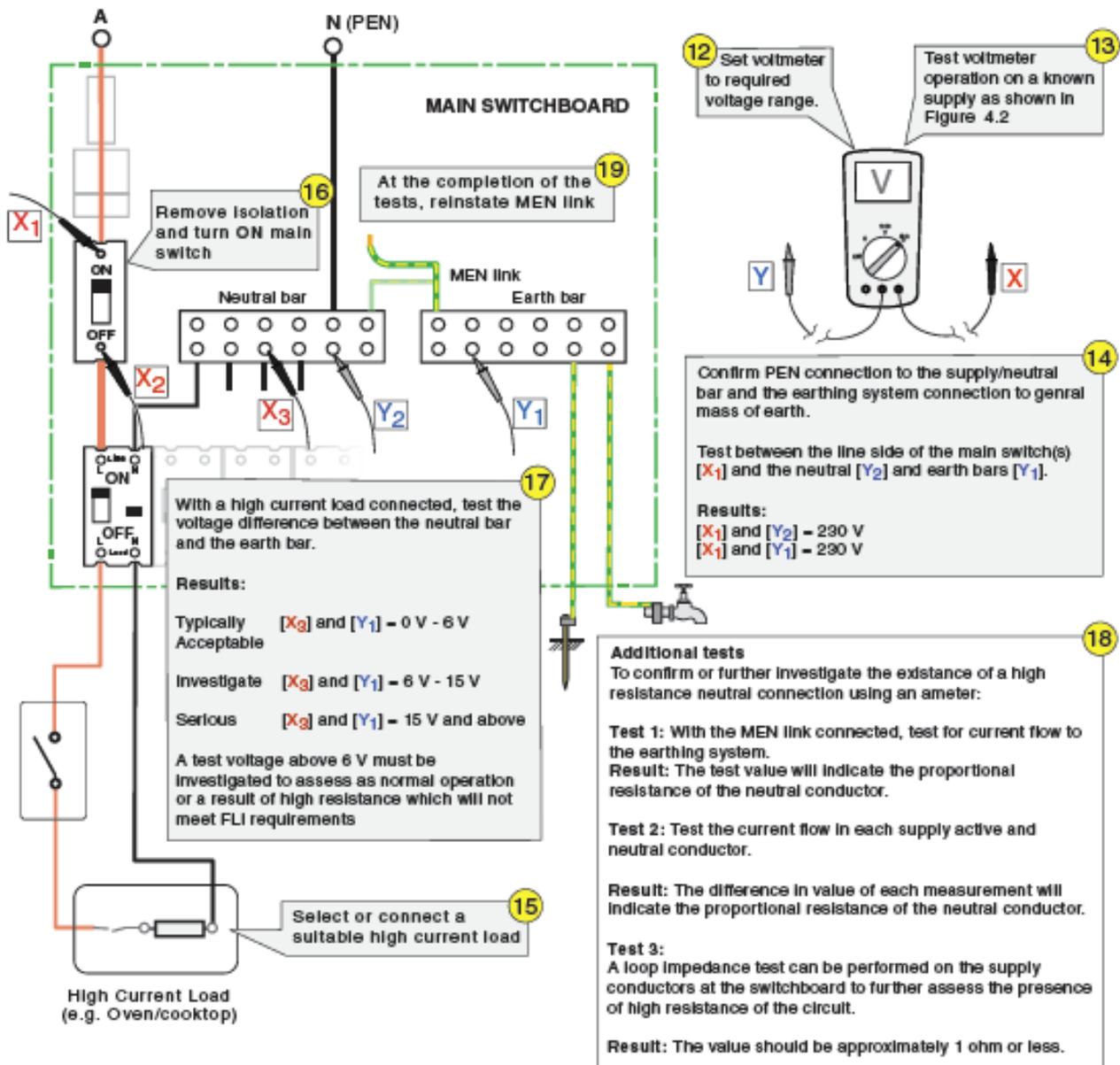
NOTE Numbers indicate the sequence of safety preparation, test preparation, tests and compliant results and reinstatement after completion.

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.

Test 3. Test for Neutral (PEN) resistance integrity using Voltage Method
Continuation from Test 1 and 2



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

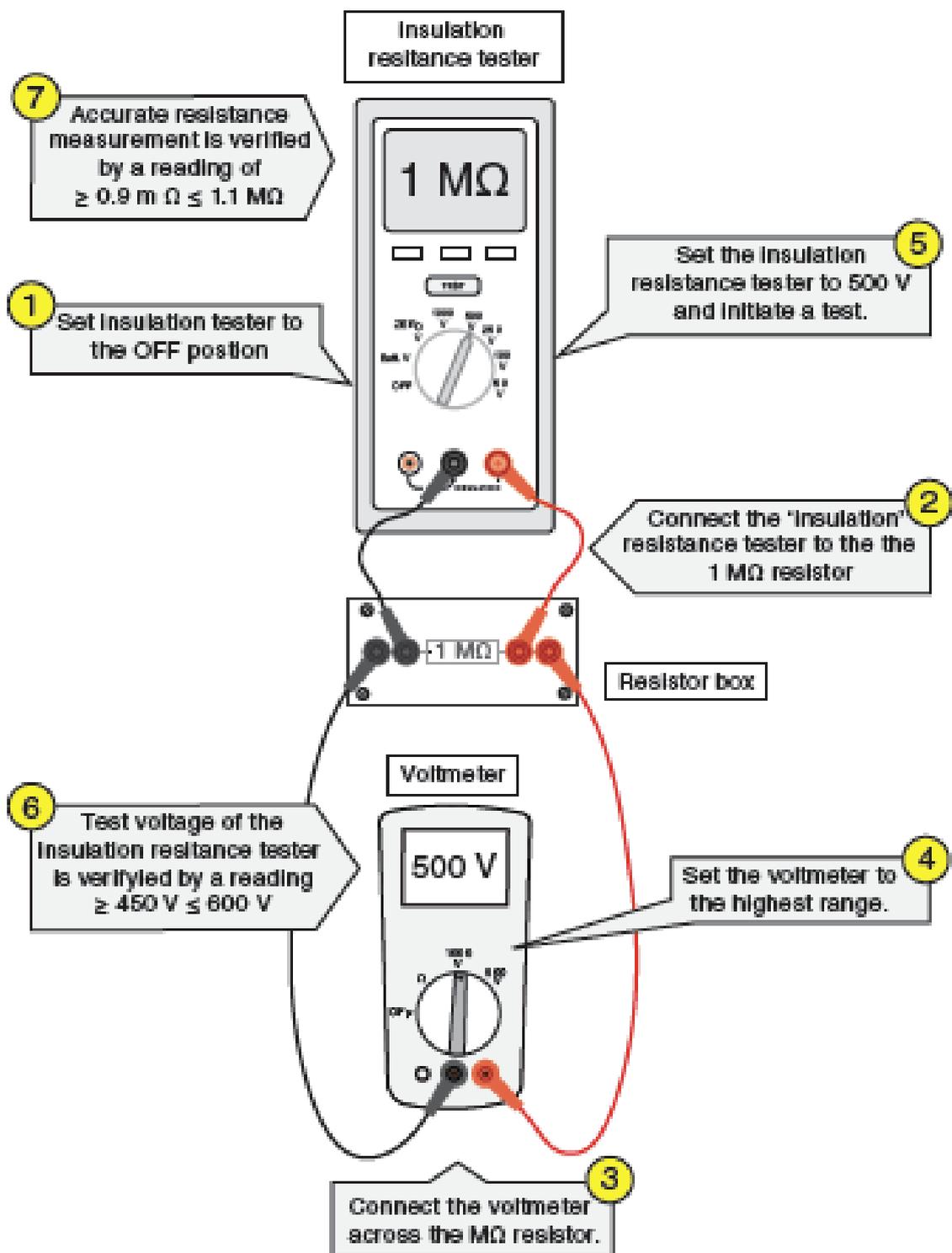


Figure A.5 — Checking insulation resistance test voltage

<i>Insert company logo or banner</i>						
For:		By:			Date:	
TEST METHODS: Reference Measured Comparison Test Box		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)				
Make	Model	Serial No./ID	Function	Setting	Result	Test method

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

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

AS/NZS 3000: 2018 inc Ammendments 1,2 & 3