

Guide for service and submain polarity testing

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1. Scope

This guide applies when electrical industry workers are required to perform testing of low voltage electrical installations. The *Electrical Safety Act 2002* requires that after electrical equipment or installation is installed, a person tests and examines it to ensure it is electrically safe. The processes outlined in this guide are to assist employers and workers to implement appropriate measures to ensure that the electrical equipment or installation is electrically safe.

This guide does not include testing of high voltage electrical equipment.

Recommendations in this guide relate to the testing of an electrical supply to an electrical installation via a consumer main or submain.

Workplace hazards and associated controls required are not covered within this guide but are to be identified and control measures implemented by risk assessment and subsequent application of the hierarchy of control.

Where there is a conflict between legislation, standards and this guide, legislation including the Act, Regulations and Codes of practice takes precedence followed by the applicable standards.

2. Introduction

Installers of electrical equipment or electrical installations have a duty under electrical safety legislation to ensure that:

- the way the electrical equipment or electrical installation is installed or repaired is electrically safe

and

- the process followed for installing or repairing the electrical equipment or electrical installation ensures that, when installed or repaired, it will be electrically safe

and

- after the electrical equipment or electrical installation is installed or repaired, the electrical worker tests and examines it to ensure it is electrically safe.

This guide outlines some methods of testing the low voltage supply to an electrical installation incorporating a multiple earthed neutral (MEN) system of earthing. When selecting a testing method, you must consider any risk associated with the tasks and the effectiveness of the method selected in the particular circumstance.

The testing methods outlined comply with the principles of testing as prescribed under AS/NZS 3000:2018 Electrical Installations – 'Wiring Rules'. Additional information and guidance are provided in AS/NZS 3017:2022 Electrical installations – Verification by inspection and testing, and AS 4417:2010 Testing connections to low voltage electricity networks.

There have been many incidents attributed to incorrect testing of an electrical supply to an electrical installation via a consumer main or submain.

Incorrect testing has resulted in electrical installations being energised with transposed polarity connections, open circuit or high resistance neutral conductors or missing MEN connections. These faults will likely result in the electrical installation earthing system becoming energised to a dangerous potential.

Note: where a definition has not been provided, refer to Electrical Safety Regulation 2013 section 9 dictionary, and/or AS/NZS 3000 section 1.4 definitions, and/or AS/NZS 4836 section 1.4 terms and definitions, and/or the normative standard applicable to the installation.

3. Safe systems of work

3.1. Overview

A person conducting a business or undertaking (PCBU) has a duty to ensure the electrical safety of all persons and property likely to be affected by the electrical work, including the testing of electrical installations and electrical equipment. A PCBU must ensure that work on energised electrical equipment is not performed unless permitted in particular circumstances outlined in Part 3, Division 1 of the *Electrical Safety Regulation 2013*.

The *Electrical safety code of practice – Managing electrical risks in the workplace* provides practical guidance for safe working practices, assisting in the compliance with electrical safety legislation requirements. All electrical workers should be familiar with this code. Also available to assist in developing safe systems of work is the standard AS/NZS 4836 ‘safe working on low-voltage electrical installations’.

The methods for testing an electrical installation outlined in this guide follow the principles of ‘no work on or near energised electrical equipment’ wherever practical. However, where electrical testing work is performed on or near energised electrical equipment, a safe system for performing the testing must be in place. This includes performing the work in accordance with a safe work method statement prepared for the work.

When installing and testing circuits added to existing switchboards, risks associated with work on or near exposed energised parts must always be considered and appropriate control measures must be in place prior to commencing the work. So far as reasonably practicable, de-energisation of all sources of supply should be implemented. Testing such as polarity testing including neutral integrity testing, upon connection to a distribution network, require work on energised electrical equipment to ensure the safe connection of the electrical installation to supply.

Note: In high fault current applications, the use of current limited test points or other methods to control the risk posed by arcing faults should be considered.

For guidance on safe systems of work refer to the guide, Safe working on or near energised electrical equipment.

Take caution and assume all exposed parts are energised, until isolated and proved de-energised.

4. The multiple earth neutral (MEN) system

The testing methods described in this guide are designed to ensure the safety of electrical installations which use the MEN system of earthing. The MEN system provides for an interconnection between the supply neutral and the mass of earth at multiple points on the supply system and at each consumers installation.

In each consumer installation there shall be such a connection (the MEN point). This connection is made at the main switchboard. Where an installation incorporates submains to separate outbuildings there may arise the need for a separate MEN connection at the outbuilding switchboard. If the earthing at the outbuilding is not affected by means of direct connection to the installations earthing system, then a separate earth electrode and MEN connection is required at the outbuilding.

The different methods of earthing are provided for in clause 5.5.3 of AS/NZS 3000:2018 Electrical installations 'Wiring Rules'.

Refer to AS/NZS 3000:2018+A3 — Appendix B — Multiple Earthed Neutral (MEN) System for further guidance.

If the MEN connection is omitted from an installation, a failure of the insulation in any part of the installation, typically in an appliance such as a stove or hot water system, will cause the entire earthing system to be raised to a dangerous potential. The MEN link ensures that in a fault situation, sufficient fault current will flow to earth and operate the protective devices, provided appropriate protective devices are installed. Do not rely on the resistance of the earth between an installations earth electrode and the supply neutral to be low enough to allow the protective devices to operate in a fault situation. This resistance is almost NEVER low enough to ensure safety.

The effectiveness of the MEN system relies on the fact that the earthing system is required to be effectively connected to the neutral in every case. Refer to Appendix A for a diagram of MEN system showing earth fault current path.

The consumer main neutral conductor and the neutral conductor of a submain supplying an outbuilding incorporating a separate MEN connection has combined functions as a neutral conductor as well as an earthing conductor. These conductors are known as protective earth neutral (PEN) conductors.

The removal of the MEN connection at a switchboard when supply is energised should be avoided except, when necessary, such as for testing polarity of consumer mains. When testing final subcircuits, removal of the final subcircuit neutral connection at the neutral link or by turning off an RCBO or RCD which switches all poles, will remove the neutral earth bond from the circuit under test.

Where whole of installation tests are conducted with supply not connected/isolated, the MEN connection is removed for testing purposes and re-installed prior to energising the installation. Refer AS/NZS 3017 Electrical installations – Verification by inspection and testing, section 4. It is recommended that a failsafe process is implemented to ensure that the MEN connection is installed prior to energising any supply.

Note: Whilst an energised Earth fault loop impedance (EFLI) is not mandatory, it is recommended that where supply is available, EFLI testing is carried out at a point within every installation after work is performed. An EFLI test measures the impedance of the circuit from the supply transformer. When the test is conducted on a suitable final subcircuit (e.g. at a socket outlet), the circuit includes critical conductors and connections, such as the MEN connection and PEN conductors. Recording a suitably low-test result will provide confidence that in the event of an earth fault, the required current will flow to operate the circuit protective devices and prevent a dangerous time/touch voltage relationship occurring on exposed conductive parts.

5. Electrical safety risks from incorrect testing

5.1. Importance of tests

Identification by testing, using a recognised test procedure is the only way to positively identify active and neutral conductors associated with supply authority mains. This includes underground and overhead consumer mains or submains.

Failure to test is the major contributing factor in electrical incidents involving incorrect neutral connections.

A transposition of any active or neutral conductor associated with supply authority mains, service lines, consumer mains or submains will likely result in the electrical installation earthing system becoming energised to a dangerous potential.

Additionally, a high impedance or open circuit in the neutral conductor of a supply authority mains, service lines, consumer mains or submain incorporating a PEN conductor, will likely result in the electrical installation earthing system becoming energised to a dangerous potential. residual current devices (RCDs) do not provide protection against potentials caused by reverse polarity or high impedance PEN conductors.

Polarity and neutral integrity tests shall be conducted when a distribution system is initially energised or any addition or alteration to the distribution system is made which could affect polarity or the continuity of a PEN conductor.

Examples include:

- a new low voltage service is installed
- an existing service is disconnected and reconnected
- new consumer mains or submains are installed
- consumer mains or submains are repaired, replaced or altered
- low voltage bridges are connected or reconnected on low voltage mains
- a switchboard is replaced or moved.

After completing test procedures, a final confirmation test should be conducted using a proximity tester, to ensure that no part of the earthing system is energised.

Note: An approved test procedure must not be shortened by omitting parts of the procedure. Correct polarity and neutral integrity can only be positively identified using appropriate testing procedures.

Phase rotation checks in polyphase installations should also be conducted, to ensure the correct operation of equipment.

Polarity testers which are connected to a final subcircuit do not confirm mains polarity and will indicate that polarity is correct even if there is a reverse polarity.

5.2. Electrical risk from reverse polarity service

In the event of a reverse polarity supply main or service line the following will occur:

- The service fuse will not be in the active supply conductor.
- The service fuse will be in the neutral conductor.
- The active supply will be connected to the neutral link irrespective of whether the main switch(es) is ON or OFF.
- The installation earthing system and all earthed conductive parts will be energised to supply potential, approximately 230Vac above the general mass of earth (depending on the earth resistance of the installation earth electrode).
- Persons contacting the energised conductive parts within the installation are at risk of **injury or death** from electric shock.
- Current exported through the earth electrode and/or earthed conductive parts in contact with the ground will return via other earth electrodes and MEN connections connected to the same distribution system. Persons at other installations may receive electric shocks due to raised ground potentials and current return paths. A common example is a person operating an external water tap.

- In circumstances, where the earth electrode impedance is low, the current flow to earth may be sufficient to burn off the main earthing conductor.

Without appropriate tests being carried out, this dangerous condition may not be immediately recognised as operation of the electric installation including appliances may appear normal.

5.3. Risk from reverse polarity consumer main

In the event of a reverse polarity consumer main or submain supplying an outbuilding incorporating a separate MEN connection, the following will occur:

- The active supply will be connected to the neutral link irrespective of whether the main switch(es) is ON or OFF.
- The installation earthing system and all earthed conductive parts will be energised to supply potential, approximately 230Vac above the general mass of earth (depending on the earth resistance of the installation earth electrode).
- Persons contacting the energised conductive parts within the installation are at risk of **injury or death** from electric shock.
- Current exported through the earth electrode and/or earthed conductive parts in contact with the ground will return via other earth electrodes and MEN connections connected to the same distribution system. Persons at other installations may receive electric shocks due to raised ground potentials and current return paths. A common example is a person operating an external water tap.
- In most circumstances, the installations earth electrode resistance will not be low enough to operate the service fuse.

An earth return impedance of 35Ω, or more is not unusual. If we calculate the current in this situation $\frac{230V}{35\Omega} = 6.57A$, the current will not operate the service fuse.

Without appropriate tests being carried out, this dangerous condition may not be immediately recognised as operation of the electric installation including appliances may appear normal.

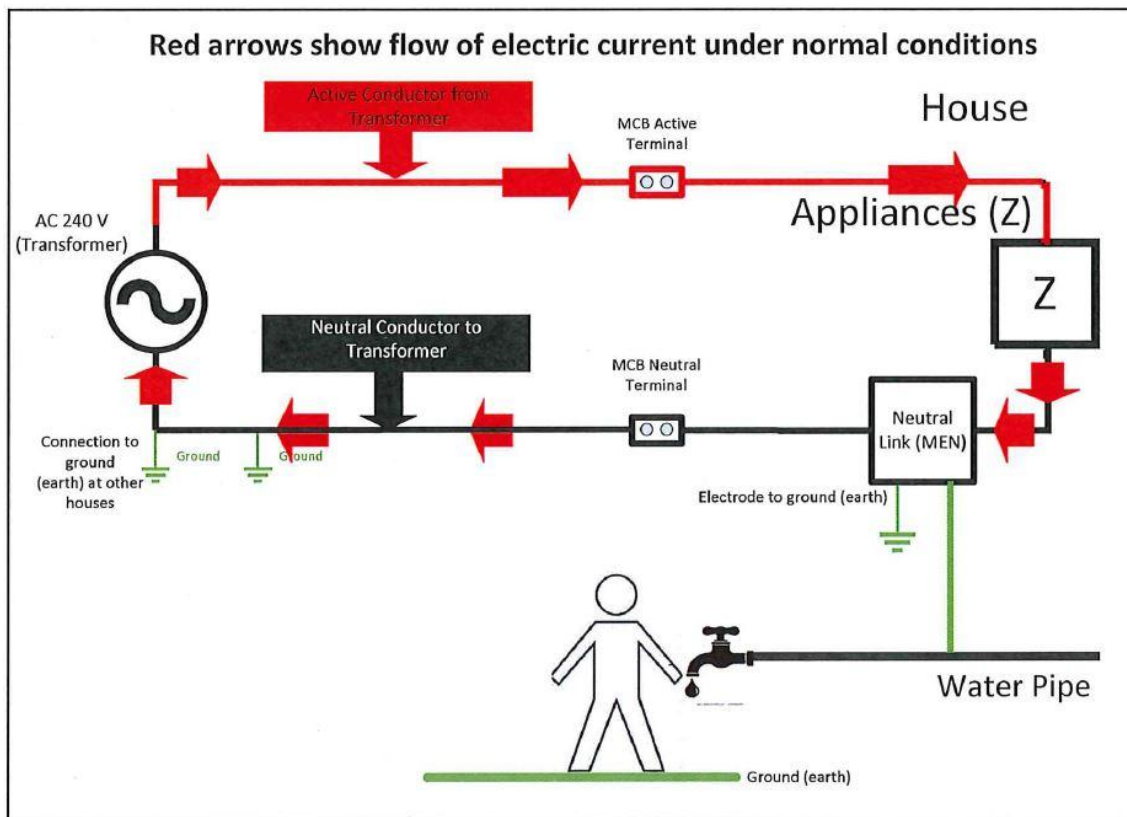
5.4. Risk from high impedance neutral conductor

In the event of a high impedance or open circuit neutral conductor of a consumer main or submain supplying an outbuilding incorporating a separate MEN connection, the following will occur:

- Current will return to the distribution system via the installation earth electrode.
- The neutral link and the installation earthing system will become energised to a potential above the general mass of earth when current is consumed by the installation. The increase in potential is proportional to the installation current draw and the impedance of the installation earthing system to distribution system neutral through the ground.

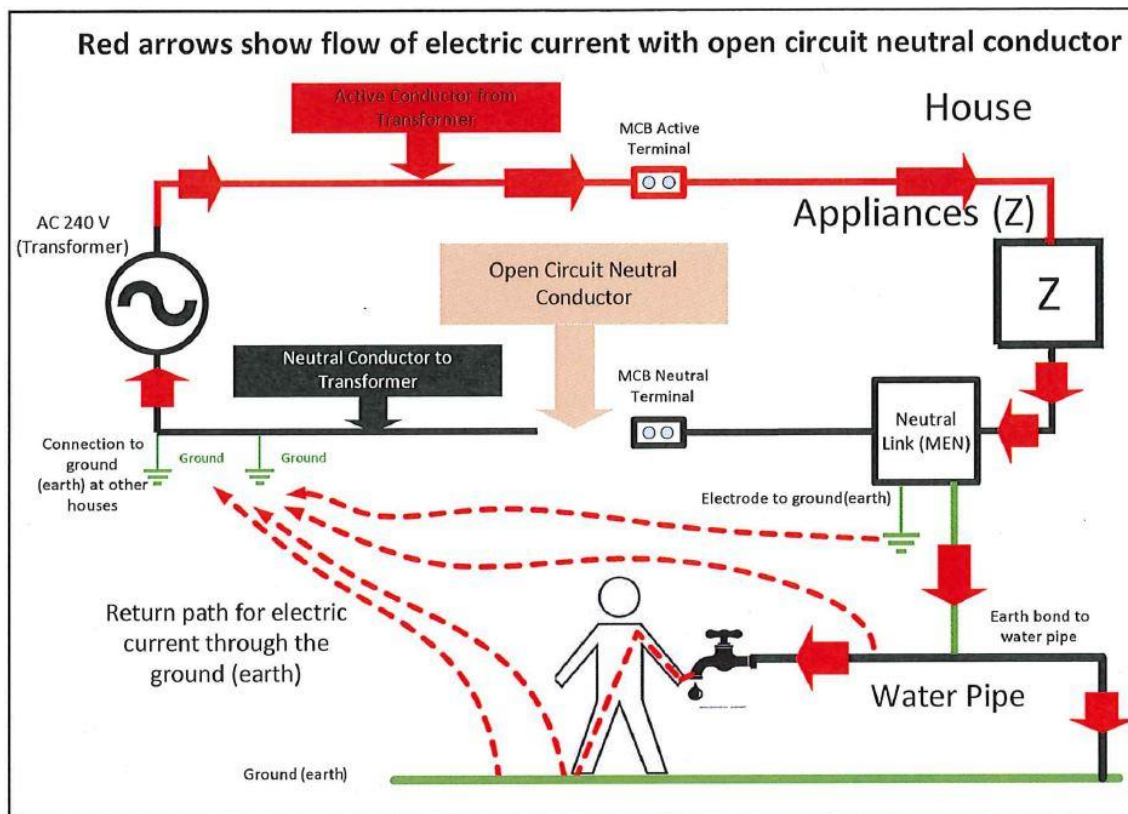
- In almost all circumstances, in the event of a fault between active and earth or active and neutral, the current will be insufficient to operate overcurrent protective devices.
- In almost all circumstances, in the event of a fault between active and earth or active and neutral, the potential on the installation earthing system will rise and all earthed conductive parts will be energised at up to supply potential, approximately 230Vac above the general mass of earth.
- In polyphase installations, the neutral (star point) will move with respect to the phase currents. i.e., Voltage will decrease on the phase with most current and increase on the phase with least current. This may cause damage to electrical equipment and may create a risk of fire due to the electrical equipment being subjected voltages outside of its design parameters.
- When lightly loaded, the installation may appear to operate as normal. Noticeable dimming of lights when load is applied may be a warning sign of a neutral integrity issue.
- On circuits with RCDs installed, the RCDs will operate normally in the event of a fault to earth. In the event of an active—neutral fault, protection will not operate, and the earthing system will be energised to supply potential, approximately 230Vac above the general mass of earth.

Figure 1 shows the electric current flow under normal conditions and Figure 2 shows the electric current flow with an open circuit supply neutral condition.



Figures 1 and 2 © State of Western Australia (Department of Mines, Industry Regulation and Safety). Used with permission.

Figure 1 - Electrical current flow under normal condition. The voltage between the water tap and the ground is typically less than 6Vac.



Figures 2 and 2 © State of Western Australia (Department of Mines, Industry Regulation and Safety). Used with permission.

Figure 2 - Electric current flow in open circuit neutral condition. A voltage up to 230Vac is present between the tap and the ground.

The amount of voltage rise is dependent on the integrity of the neutral conductor and the effectiveness of the earthing system within an installation.

Without appropriate tests being carried out, this dangerous condition may not be immediately recognised as operation of the electric installation including appliances may appear normal.

5.5. Correct polarity and neutral integrity

With correct supply polarity and neutral integrity, the following conditions will apply:

- The main switch(es) control(s) all supply to the electrical installation.

Note: Supply to meters and distribution entity equipment may not be controlled by the main switch. Alternative sources of supply shall be controlled by a main switch for the alternate energy source, e.g. (solar, standby generator).

- The installation earthing system and all earthed conductive parts will be at the potential of the greater mass of earth. (a small potential difference consistent with the voltage drop of PEN conductors may be present).
- In the event of an earth fault, most of the fault current returns to the supply transformer via the neutral conductors.

- In the event of a fault current to earth or neutral, sufficient current will flow to operate circuit protection devices, to disconnect supply.

5.6. Alternate supplies

In recent years there has been a substantial increase in the number of electrical installations where alternate supplies are installed. All these systems influence the electrical installation and must be considered when performing work on the electrical installation.

Examples of alternate supplies may include:

- photovoltaic (PV) systems, AS/NZS 4777 Grid connection of energy systems via inverters
- battery energy storage systems (BESS), AS/NZS 4777 Grid connection of energy systems via inverters
- generators, AS/NZS 3010 Electrical Installations-Generating sets
- uninterruptible power supplies (UPS), AS/NZS 4777 Grid connection of energy systems via inverters
- neutral back feed from intermixed circuits
- luminaires supplied from emergency sources
- wind generation systems.

(Standards listed are relevant to the connection of the alternate supply to an electrical installation.)

The neutral earth connection for an alternate supply is the installation MEN connection at the installation main switchboard.

Neutral and earth circuits may become energised under fault conditions or when the MEN connection is removed, whilst the alternate supply is energised.

Alternate supplies shall be isolated at their source prior to removal of the MEN connection.

Only an isolated alternate supply may be connected via a detachable connection.

Example: An isolated winding generator, RCD protected and centre tap generators shall not be connected to an electrical installation inlet socket.

6. Test equipment

6.1. Essential requirements

Electrical safety legislation requires that a PCBU must ensure tools, testing equipment and personal protective equipment:

- are suitable for the work
- have been properly tested

- are maintained in good working order.

Listed below is the basic equipment necessary to enable an electrical worker to conduct service or submain polarity testing on low voltage electrical installations.

The minimum test equipment required comprises:

- a voltage indicator
- a voltmeter
- suitable probes
- a suitable instrument for measuring fault-loop impedance
- a means of making a temporary connection to the mass of earth (independent earth).
- a phase rotation tester (3 phase supply only).

A clamp-on ammeter is also recommended for measuring load current and will be required if alternate methods of verifying neutral integrity are used.



Figure 3 - Example of independent earth.

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

6.2. Safety in the use of test equipment

When performing any test to detect or confirm energised conductors, the following procedures should be adopted as a matter of habit:

- Ensure instrument is suitable for use on low impedance sources, such as main switchboards i.e. testing at a commercial switchboard will require a category IV meter with category IV test leads.
- Always confirm the correct operation of the test device at the start of testing.
- Always confirm the correct operation of the test device at completion of testing, to guard against failure during testing.
- Check that the correct function and range has been selected on the test equipment.

- When using testers in a manner that requires the completion of a circuit to earth, ensure that the earth is effective. This applies in particular to test lamps and solenoid type testers, which draw over 25mA, a level that presents a safety risk. If, for example, such an instrument was used for testing from an energised conductor to an unearthed metal switchboard enclosure, the enclosure would become energised. Alternatively, connection to an earthing system which has an unusually high main earth resistance to earth, could also result in the whole earthing system, including any appliances connected to it (e.g. stove or HWS) becoming energised.
- To prevent personal injury and/or damage to equipment, all test instruments should be capable of withstanding the impulse voltages and fault current levels that may be experienced in the particular Installation Category e.g. the rating for test instruments and test probes used on 400/230V mains voltage equipment connected on the supply side of a main switchboard should be Installation Category IV.
- When carrying out testing procedures prior to connection to supply, particular care should be taken to ensure there is no risk of injury to yourself or others.
- When carrying out any testing with the MEN link disconnected, when supply is available, a temporary shock hazard may arise. The earthing system, including the water piping and associated equipment can be raised above earth potential.
- Take appropriate measures such as using a remote earth as the testing reference point instead of the installation earth or using a high impedance test instrument such as a voltmeter to perform the tests.
- Ensure that alternate energy supplies are isolated at their source, prior to commencing testing. The neutral earth connection for an alternate supply is the installation MEN connection. Neutral and earth circuits may become energised under fault conditions or when the MEN connection is removed, whilst the alternate supply is energised.
- Where possible the testing procedure may verify a positive meter result for the first and last test i.e. 230V or 0 Ω .

7. Inspection and testing

AS/NZS 3000:2018 Electrical installations 'Wiring Rules' (Clause 8.1.2).

Requirements

Prior to placing an electrical installation, or any part thereof, in service following construction, alteration, addition or repair thereof, it shall be verified, as far as practicable, that the installation is safe to energise and will operate correctly in accordance with the requirements of the wiring rules AS/NZS 3000.

To confirm that the requirements of the standard have been met, after completion and before being placed in service, the installation shall be:

- inspected in accordance with clauses 8.1.3 and 8.2 as far as reasonably practicable
- tested in accordance with clause 8.3.

Precautions shall be taken to ensure the safety of persons and to avoid damage to property and the electrical installation equipment during inspection and testing.

Where the electrical installation is an alteration, or repair to an existing electrical installation, it shall be verified that the alteration, or repair complies with the standard and does not impair the safety of the existing electrical installation.

7.1. Mandatory testing

AS/NZS 3000 clause 8.3.7 states that polarity testing shall be carried out to ensure that no shock hazard arises from the incorrect connection of active, neutral, and earthing conductors.

Regarding consumer mains and submains supplying an outbuilding, this testing is to prevent transposition of active and neutral conductors of the consumer mains, or submains supplying an outbuilding with an MEN connection, resulting in the electrical installation earthing system becoming energised.

Guidance may be obtained from AS/NZS 3000, AS/NZS 3017 and the guide for testing low voltage electrical installations.

Note: Low impedance test equipment e.g. test lamps, may not operate correctly when used in conjunction with an independent earth electrode not connected to the electrical installation earthing system, so use of a voltmeter is recommended.

The neutral (PEN) conductor is always the last to be disconnected and the first to be connected.

7.2. Polarity test of consumer mains using a voltage indicator (supply connected)

Sequence:

Prove polarity

Prior to conducting the following polarity testing all relevant visual inspection, and earth continuity and insulation testing shall be completed. PEN conductors shall be subject to earth continuity testing.

Warning!

The following tests involve energised electrical equipment. ensure a safe system of work is in place before commencing any testing where supply is connected.

Ensure persons are protected from contact with energised parts during testing. ensure that the available fault current has been assessed and appropriate measures taken with regard to the available incident energy.

1. Ensure appropriate verification and inspection tests have been carried out including the consumers mains and main switchboard.
2. Check operation of voltage indicator.
3. Turn main switch (es) OFF, including alternate supplies. (Ensure alternate supplies are also isolated at the source if possible). Use a voltage indicator to confirm isolation at each main switch.
4. Turn OFF all circuit protective devices at the switchboard.
5. Disconnect any bonding conductor provided to bond the service neutral to a service support.
6. Disconnect the main earth or MEN as applicable and then the main neutral from the neutral link.
7. An independent earth shall be positioned in the ground remote (greater than 2 metres) from any conductive metallic surfaces that are in contact with the general mass of earth, including the earth stake.
8. Ensure consumers mains are connected to the entity service conductors and energise the consumer mains.
9. Test between the main neutral and line terminal of the main switch(es) for the grid connection. Results should indicate PHASE (230V) VOLTAGE.
10. Test between the main neutral and independent earth. Results should indicate NO VOLTAGE.
11. Test between main earth conductor and independent earth. Results should indicate NO VOLTAGE.
12. Test between the line terminal of the main switch and independent earth. Result should indicate PHASE (230V) VOLTAGE.
13. If a multiphase installation, test between line terminals at main switch. Results should indicate LINE (400V) VOLTAGE.

Prove neutral integrity (EFLI Method)

14. Connect a fault loop impedance tester neutral and earth leads to the main neutral (PEN) conductor.
15. Connect the fault loop impedance tester active lead to a line terminal of the main switch.
16. Carry out Fault Loop Impedance test. The result should be less than 1Ω. The length and size of the supply conductors and consumer mains and submain should be considered.



Figure 4 – Example of neutral integrity test.

Where the EFLI tester has a “no trip” low current test and a “trip” high current test selection, this test shall be performed using the “trip” high current setting.

Note: Alternative tests include the Voltage Method or Current Method as per AS:4741 Appendix B3 or AS/NZS 3017 section 4.12.

Reconnection

If correct indications were obtained for all tests, reconnect main neutral (PEN conductor) and then the MEN connection. Ensure connections are correctly made.

If a bonding conductor was removed at the point of attachment, use a proximity tester to:

- test an active conductor. RESULT Indication
- test the neutral bond tail. RESULT No indication
- test the service bracket. No indication
- connect the bond and confirm the bonded metalwork is not energised. RESULT No indication
- test an active conductor. RESULT Indication.

17. Turn main switch(es) ON.

18. Check for correct phase rotation.

19. Close all other circuit protection devices and alternative supplies as found prior to carrying out testing.

20. To verify main neutral connection and MEN integrity, a fault loop impedance test at a convenient socket outlet is recommended.
21. Apply a proximity tester to any part of the earthing system to confirm it is not energised.

7.3. Polarity test of consumer mains using an ohmmeter (supply not connected)

Sequence:

Prove polarity

1. Ensure appropriate verification and inspection tests have been carried out including the consumers mains and main switchboard.
2. Ensure all conductors from the supply are NOT connected to the installation
3. Turn main switch(es) OFF, including alternate supplies. (Ensure alternate supplies are also isolated at the source if possible). Use a voltage indicator to confirm isolation at each main switch.
4. Bridge conductors where metering and service equipment is not installed.
5. Set meter to read Ω – set 0 Ω with leads connected together.
6. Measure the resistance of the active conductor of the consumer mains between the point of connection and the line side of the main Switch. Repeat for each active supply conductor. RESULT 0 Ω .
7. Measure the resistance of the neutral conductor of the consumer mains between the point of connection and the neutral bar. RESULT 0 Ω .
8. After completing the tests remove metering and service equipment bridging conductors

Important: This test does not verify correct connection to the network or the integrity of the neutral conductor connections. Final connection to supply shall not occur until verification is confirmed. Refer section 6.2 (supply available).

7.4. Polarity test of submain with MEN connection at outbuilding (supply connected)

Note: for the purpose of sections 6.4 to 6.7 only, the term MSB refers to the switchboard immediately upstream. Where the outbuilding switchboard under test (DSB) is supplied via an intermediate switchboard upstream, the term MSB refers to the intermediate switchboard.

Sequence:

Prove polarity

1. Ensure appropriate verification and inspection tests have been carried out.
2. Identify the submain protection device and place it in the OFF position.

3. Check the correct operation of voltage indicator.
4. Confirm correct identification of supply isolation device. Measure the voltage between the line side of the main switch and neutral bar at the outbuilding switchboard.
5. Turn main switch(es) at outbuilding OFF, including alternate supplies. (Ensure alternate supplies are also isolated at the source if possible). Use a voltage indicator to confirm isolation at each main switch.
6. Turn OFF all circuit protective devices at the outbuilding.
7. Disconnect the main earth or MEN as applicable and then the submain neutral (PEN conductor) from the neutral link in the outbuilding.
8. An independent earth shall be positioned in the ground remote (greater than 2 metres) from any conductive metallic surfaces that are in contact with the general mass of earth, including the earth stake.
9. Energise the submain to the outbuilding.
10. Test between the main neutral (PEN conductor) and line terminal of the main switch (es). Results should indicate PHASE (230V) VOLTAGE.
11. Test between main neutral (PEN conductor) and independent earth. Results should indicate NO VOLTAGE.
12. Test between main earth conductor and independent earth. Results should indicate NO VOLTAGE.
13. Test between the line terminal of the main switch and independent earth. Result should indicate PHASE (230V) VOLTAGE.
14. If a multiphase installation, test between line terminals at main switch. Results should indicate LINE (400V) VOLTAGE.

Prove Neutral Integrity (EFLI Method) at the outbuilding switchboard

15. Connect a fault loop impedance tester neutral and earth leads to the submain neutral (PEN) conductor.
16. Connect the fault loop impedance tester active lead to a line terminal of the main switch.
17. Carry out Fault Loop Impedance test. The result should be less than 1Ω. The length and size of the supply conductors, consumer mains, and submains should be considered.

Where the EFLI tester has a “no trip” low current test and a “trip” high current test selection, this test shall be performed using the “trip” high current setting.

Note: Alternative tests include Voltage Method and Current Method as per AS:4741 Appendix B3 or AS/NZS 3017 section 4.12.

Reconnection

18. Place the submain protection device in the OFF position.
19. If correct indications were obtained for all tests, reconnect the submain neutral then the MEN connection. Ensure all connections are correctly made.
20. Place the submain protection device in the ON position.
21. Turn main switch(es) ON.
22. Check for correct phase rotation.
23. Close all other circuit protection devices and alternative supplies as found prior to carrying out testing.
24. To verify the submain neutral connection and MEN integrity, a fault loop impedance test at a convenient socket outlet is recommended.
25. Apply a proximity tester to any part of the earthing system to confirm it is not energised.

7.5. Polarity test of submain with MEN connection at outbuilding (supply not connected)

Note: for the purpose of sections 6.4 to 6.7 only, the term MSB refers to the switchboard immediately upstream. Where the outbuilding switchboard under test (DSB) is supplied via an intermediate switchboard upstream, the term MSB refers to the intermediate switchboard.

Sequence:

Prove polarity

1. Ensure appropriate verification and inspection tests have been carried out.
2. (At main switchboard (MSB)) confirm isolation of all main switches.
3. (At MSB) confirm isolation of the submain Circuit Protective Device (CPD).
4. (At distribution switchboard (DSB)) turn isolation/main switch (es) OFF, including alternate supplies. (Ensure alternate supplies are also isolated at the source if possible). Use a voltage indicator to confirm isolation at each main switch.
5. (At DSB) turn OFF all circuit protective devices.
6. (At DSB) disconnect the submain neutral from the neutral link.
7. (At DSB) disconnect main earth conductor.
8. (At MSB) install a temporary bridge between the load side of the submain CPD and the neutral bar.
9. Set meter to read Ω – set 0 Ω with leads connected together.
10. (At DSB) measure resistance between the line side active conductor and the disconnected main neutral conductor. RESULT $\approx$ 0 Ω . If polyphase repeat test for each phase conductor.

11. (At MSB) remove the temporary bridge.
12. (At DSB) measure resistance between the line side active conductor and the disconnected main neutral conductor. RESULT $\approx \infty \Omega$. If polyphase repeat test for each phase conductor.
13. Set insulation tester to 500V range.
14. (At DSB) measure resistance between the line side active conductor and the disconnected main earth conductor. RESULT $\approx \infty \Omega$. If polyphase repeat test for each phase conductor.
15. (At DSB) measure resistance between disconnected submain neutral conductor and disconnected main earth conductor. RESULT $\approx$ A LOW INSULATION VALUE. (The actual measured value will depend upon soil resistance at the location).
16. After completing the tests reconnect the submain neutral and earthing conductors at the distribution board.

7.6. Polarity test of submain incorporating a protective earthing conductor (supply connected)

Note: For the purpose of sections 6.4 to 6.7 only, the term MSB refers to the switchboard immediately upstream. Where the outbuilding switchboard under test (DSB) is supplied via an intermediate switchboard upstream, the term MSB refers to the intermediate switchboard.

Sequence:

1. Ensure appropriate verification and inspection tests have been carried out.
2. (At main switchboard (MSB)) identify the submain protection device, place it in the OFF position and ensure appropriate isolation and lockout.
3. Check operation of voltage indicator.
4. (At distribution switchboard (DSB)) confirm correct identification of supply isolation device. Measure the voltage between the line side of the main switch and neutral bar. RESULT 0V
5. (At DSB) turn isolation/main switch (es) OFF, including alternate supplies.
6. (At DSB) turn OFF all circuit protective devices.
7. (At DSB) disconnect the submain neutral from the neutral link.
8. (At MSB) place the submain protection device in the ON position.
9. (At MSB) test between load side of submain protective device and neutral bar. RESULT PHASE (230V) VOLTAGE.
10. (At DSB) test between line side of isolation switch and the submain neutral conductor. RESULT PHASE (230V) VOLTAGE.
11. (At DSB) test between the earth bar (submain earth) and the submain neutral conductor. RESULT NO VOLTAGE.

12. (At DSB) test between line side of isolation switch and the earth bar (submain earth). Results should indicate PHASE (230V) VOLTAGE.
13. (At MSB) place submain protection device in the OFF position.
14. (At DSB) reconnect the submain neutral to the neutral link.
15. (At MSB and DSB) energise/re-energise the distribution switchboard.
16. To verify earthing system integrity, a fault loop impedance test may be carried out at a convenient socket outlet supplied from the DSB.

7.7. Polarity test of submain incorporating a protective earth conductor (supply not available)

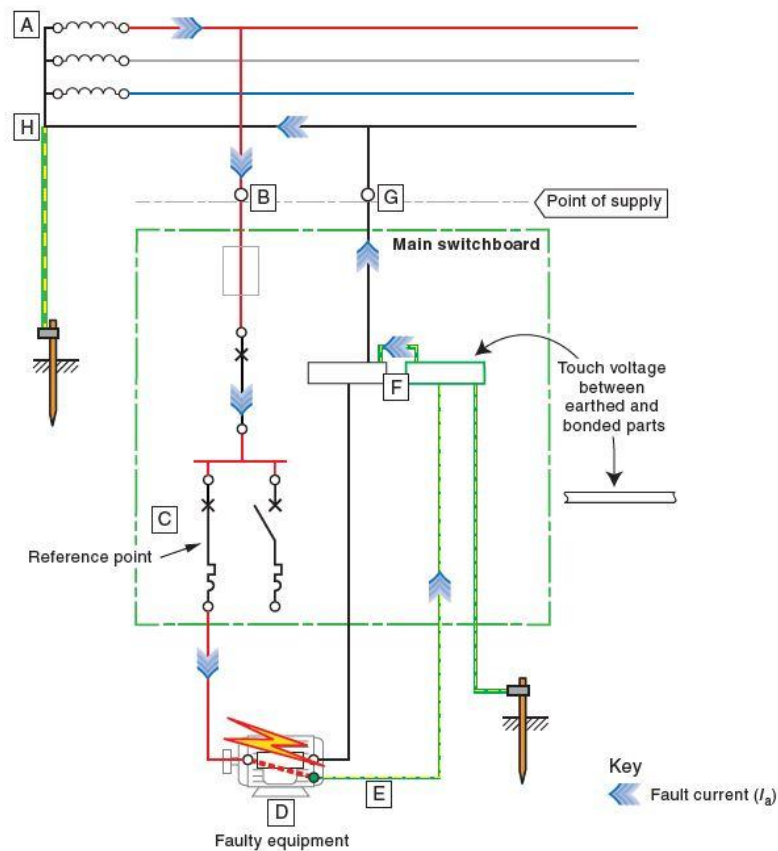
Note: for the purpose of sections 6.4 to 6.7 only, the term MSB refers to the switchboard immediately upstream. Where the outbuilding switchboard under test (DSB) is supplied via an intermediate switchboard upstream, the term MSB refers to the intermediate switchboard.

Sequence:

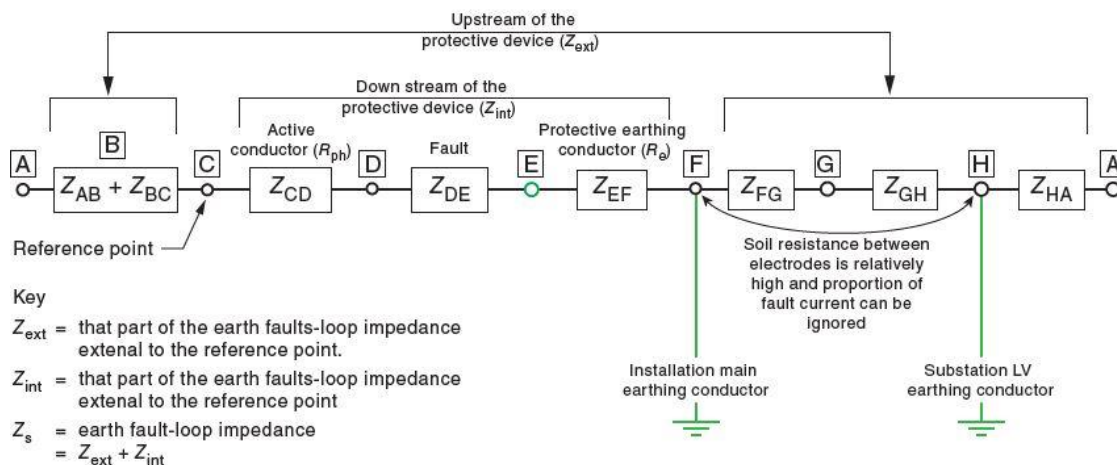
1. Ensure appropriate verification and inspection tests have been carried out.
2. (At main switchboard (MSB)) identify the submain protection device, place it in the OFF position and ensure appropriate isolation and lockout.
3. (At distribution switchboard (DSB)) turn isolation/main switch (es) OFF, including alternate supplies.
4. (At DSB) turn OFF all circuit protective devices.
5. (At DSB) disconnect the submain neutral from the neutral link.
6. (At DSB) disconnect submain earth conductor from the earth bar.
7. Set meter to read Ω – set $0\ \Omega$ with leads connected together.
8. (At DSB) measure resistance between the disconnected submain earthing conductor and the line side of the protective devices or DSB isolator as applicable. RESULT $\approx \infty\ \Omega$. If polyphase repeat test for each phase conductor.
9. (At DSB) measure the resistance between the disconnected submain earthing conductor of the distribution board and the disconnected submain neutral conductor. RESULT $\approx 0\ \Omega$
10. After completing the tests reconnect the submain neutral and earthing conductors at the DSB.
11. Reverse isolation as required.

Note: Where the submain is short, a trailing lead may be used between the MSB and DSB to test polarity. Refer to AS/NZS 3017:2022 Figure 4.8 for more detail.

8. Appendix A—MEN system showing earth fault current path

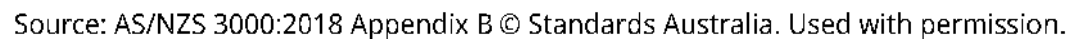


At the instant of the fault, current will flow through the earth fault-loop and its magnitude is only limited by the total system impedance Z_s that is obtained from all the individual impedances in the earth fault-loop as follows:



Source: AS/NZS 3017:2022 Figure 4.23 © Standards Australia. Used with permission.

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