

ISSC 38
Guide for Testing of Connections to
Low Voltage Electricity Networks

July 2021

PREFACE

This document - *Guide for Testing of Connections to Low Voltage Electricity Networks* (Guide) has been prepared by a working group of representatives from New South Wales Distribution Network Service Providers (DNSP), National Electrical and Communications Association (NECA) and the NSW Department of Planning, Industry and Environment (the Department).

This Guide supports the requirements set in Australian Standard 4741:2010 Testing of connections to low voltage electricity networks which sets the minimum safety principles to test for correct polarity or neutral connection integrity within a low voltage electricity network and to a customer electrical installation supplied from that network.

This Guide sets minimum industry standards, but is advisory only. It does not substitute for, or override, any legislation, regulation, code or safety rules implemented by jurisdictional regulators or Network Operators.

DISCLAIMER

While due care has been exercised in the compilation of this Guide, much of the content has been sourced externally to the Industry Safety Steering Committee (ISSC) and the Department. Thus the Department cannot accept responsibility for the content.

This Guide is designed on the basis that it will be used in its entirety, and persons who use or observe parts of the publication without paying heed to the entirety of the publication do so at their own risk.

This Guide has been prepared on the basis that the user will be appropriately trained, qualified, authorised and competent. This Guide is not intended for use by untrained or unqualified persons, and anyone in that category using the Guide does so at their own risk.

This Guide does not purport to ensure compliance with all relevant statutes and regulations, such as work health and safety laws. Users must satisfy themselves as to the requirements of all relevant laws.

CONTENTS

1.	REGULATORY BASIS	1
2.	SCOPE	1
3.	DEFINITIONS	1
4.	MANAGING HEALTH AND SAFETY	3
5.	TRAINING & AUTHORISATION	3
6.	TEST EQUIPMENT	3
7.	VISUAL INSPECTION & SAFE TO APPROACH TEST	6
8.	TEST PROCEDURES	6
8.1	POLARITY TEST	6
8.2	NEUTRAL INTEGRITY TEST	7
8.2.1	<i>Voltage Method</i>	7
8.2.2	<i>Impedance</i>	8
8.2.3	<i>Current Method</i>	9
8.3	PHASE ROTATION TEST	11
8.4	PHASE CONFIRMATION	11
8.5	FINAL CHECKS BEFORE LEAVING WORK LOCATION	11
8.6	RECORDS	11
9.	DNBP CONTACT DETAILS	11
APPENDIX A	RELEVANT DOCUMENTATION	12

1. Regulatory Basis

This Guide supports the New South Wales Electricity Supply Industry in the prevention of occupational illness, injuries and fatalities of persons working on or near electricity networks, members of the public and customers supplied from the electricity network. This is consistent with the intentions of the *NSW Work Health and Safety Act (2011)*, the *NSW Work Health and Safety Regulation (2017)*, the *Electricity Supply Act 1995* and the *National Electricity Network Safety Code (ENA DOC 01-2019)*.

In 1997 the New South Wales Government moved away from prescriptive regulations to outcome driven regulations in the electricity supply industry. All regulations in New South Wales have a five-year life. After five years the need for the regulation is considered and also assessed for its relevance to the industry and the general community.

2. Scope

This Guide has been developed to assist companies in developing their own procedure compliant with AS4741-2010 to test for correct polarity and neutral connection integrity within a low voltage electricity network and to a customer electrical installation (e.g. service work) supplied from that network.

It provides advice on:

- Tests that are required to be carried out
- Test results to be obtained
- Reporting requirements

Note:

- The DNSP may impose any conditions additional to those contained in this guide it considers necessary or appropriate.

3. Definitions

Active Conductor - Any conductor that is maintained at a difference of potential from the neutral or earthed conductor.

Competent - Having the skills, knowledge and attributes a person needs to complete a task.

Connection Point - The definition of Connection Point fulfils the requirements of defining the Connection Point in the Electricity Supply Act. Means the junction where the Distribution System is connected (by means of a Connection Device) to the Customers Installation.

DNSP – Distribution Network Service Provider owns and maintains the distribution electricity network.

Electrical Installation - Electrical equipment installed for the purposes of conveyance, control, measurement or use of electricity, where electricity is or is to be supplied for consumption. It includes electrical equipment supplied from a distributor's system or a private generating system.

Electricity Network - Low voltage system used to distribute electricity to electrical installations.

Independent earth - An effective earthed reference point used for testing purposes, spaced a minimum of two metres away from any conductive object embedded in the ground connected to the system under test.

Industry Safety Steering Committee (ISSC) means a committee established by the Minister for Energy and Environment formed of representatives of the electricity transmission and distribution industry, trade unions and other relevant stakeholders to examine and provide recommendations and documentation for use by the industry to improve safety for the public and workers.

Integrity - The state of being sound, unimpaired and fit for purpose.

Isolated - Disconnected from all possible sources of electricity supply by means that both prevent unintentional energization of the apparatus and are assessed as a suitable step in the process of making safe for access purposes.

May - Indicates the existence of an option.

Multiple earthed neutral (MEN) system - A system in which the neutral conductor is connected to the general mass of the earth at multiple locations within the electricity network and electrical installations.

Neutral conductor - Conductor of a low voltage system which is earthed at its origin.

Polarity - The voltage of a conductor relative to another conductor or the general mass of earth.

Phase rotation - The connection of three-phase conductors that will ensure three-phase motors run in a determined direction.

Phasing - The identification of active conductors of the same phase (having no significant angular displacement).

Qualification - A planned combination of learning outcomes that have a defined purpose.

Shall - Indicates that a statement is mandatory.

Service Line means electricity line (either overhead or underground) supplying electricity from the overhead or underground network to the customer's connection point.

Should - Indicates a recommendation.

Voltage - Differences of potential normally existing between conductors and between conductors and earth as follows:

- (a) Extra-low voltage Not exceeding 50 V a.c. or 120 V ripple-free d.c.
- (b) Low voltage Exceeding extra-low voltage, but not exceeding 1 000 V a.c. or 1 500 V d.c.
- (c) High voltage Exceeding low voltage

4. Managing Health and Safety

One of the objectives of this Guide is to provide assistance for companies to meet the requirements of AS4741:2010 in order to protect the health and safety of persons carrying out work on or near the electricity network and occupants of electrical installations through risk management principles and safe systems of work. Principles in clause 1.4 of AS4741:2010 as well as other hazards associated with carrying out tests such as working on or near live equipment need to be considered in safe systems of work.

5. Training & Authorisation

All workers required to perform the tests must be electrically qualified and meet the minimum competency and authorisation requirements of AS4741:2010 clause 1.6. Workers must have competence in National training package UETTDRRF11 - Testing of connections to low voltage electricity networks or equivalent.

In addition, companies Safety Management Systems need to consider the need for periodic assessment of competency of workers performing connections in accordance with this guideline.


6. Test Equipment

Before the use of any test equipment, the requirements in section 3 of AS4741:2010 must be followed.

Notes:

1. All test instruments used on the low voltage electricity network must be appropriately rated.
2. Users must ensure that good electrical contact by test probes is always achieved considering mains and apparatus that are exposed to weather may be covered with non-conductive coverings such as dust, oxide etc.
3. Users must be assessed as competent in the instruments use.

The table below lists examples of instruments used to complete testing described within this guide.

Test Type	Instrument
Safe to Approach	<p data-bbox="504 1482 909 1518">Non-contact proximity tester</p>  <p data-bbox="504 1742 1378 1877">Proximity type non-contact voltage detectors are used for checking the absence of hazardous LV a.c voltage on poles and exposed metalwork such as meter boxes etc. They should be capable of detecting voltages as low as 50V.</p>


Polarity	Test Lamps  <p>Test lamps are used on low voltage mains and apparatus to test for the presence or absence of supply. They are also used to distinguish between phase to neutral or phase to earth voltages (230 V) and phase to phase voltages (400 V).</p> <p>Note: Test lamps may not give a visible glow for voltages less than 90V.</p> <p>As test lamps are low impedance (approx. 2000Ω) work procedures must consider the potential low impedance safety risks.</p>
	Multimeter  <p>Multimeters can be used to confirm polarity.</p> <p>Work procedures must address risks such as incorrect operation (i.e. measuring of voltage when meter has been configured for current measurement) and incorrect readings due to high impedance, incorrect scale setting etc.</p>

Neutral Integrity**Loop Impedance Meter**

A loop impedance meter is used to provide the impedance of an active and neutral circuit back to the supplying transformer. The incoming service neutral must be disconnected from the installation earthing conductors to prevent a parallel return path through the earth resulting in an incorrect loop impedance reading.

Test Load

A test load is used to provide a load between an active and neutral to allow measurements of voltage or current to be taken. The load should be 9 amps or greater.

Independent Earth	Independent Earth
	 <p data-bbox="504 837 1385 1003">An independent earth is used to establish an effective electrical connection to earth. It must be installed no closer than 2m from other conductive structures. No uninsulated contact with the independent earth stake or lead should be made when undertaking measurements.</p>

Note: All photos are modified versions of images taken by the authors

7. Visual Inspection & Safe to Approach Test

On arrival at the work location, a visual inspection must be carried out as per AS4741:2010 section 2.

In addition, it is recommended before any contact is made with the switchboard or metal structures (such as raiser brackets, service poles, downpipes etc) a safe to approach test using a non-contact proximity tester with a specified operating range down to 50Vac is used to provide an indication if a hazardous voltage maybe present.

8. Test Procedures

Companies must follow a documented procedure which complies with AS4741 and considers the requirements of this guideline.

The following tests must be carried out when required as per AS4741:2010 clause 4.1.

Contact the DNSP if test results are outside of the expected range.

8.1 Polarity Test

Where required as per section 4.1 of AS4741:2010, before the connection of a conductor to an energised active or distribution neutral it must be proven correct by electrical testing. The requirements in section 4.3 of AS4741:2010 must be followed.

Note:

- One method to disconnect active supplies to the installation is the removal of service protective devices.

- The incoming neutral must be disconnected from the earthing conductors of the installation and connected to an effective earth as this will prevent a hazardous voltage rise on the service neutral conductor during a polarity test.

It is recommended to carry out a safe to approach test on metal surrounds and structures as part of the final confirmation step before leaving the location.

8.2 Neutral Integrity Test

As per section 4.4 of AS4741:2010 this test is to prove the neutral connections of the supply to electrical installations, within the limits of the test.

AS4741:2010 provides 3 examples of tests which could meet this requirement however other tests may be used which achieve the same requirements as per section 4.4 of AS4741:2010. A combination of tests should also be considered to minimise the possible disadvantages (such as requirement to remove the neutral when undertaking the impedance method) of individual tests. The 3 examples from AS4741 include:

- a) Voltage
- b) Impedance
- c) Current

8.2.1 Voltage Method

Appendix B of AS4741 specifies the method to be followed.

This method uses a test load and voltage measurements between the incoming neutral and independent earth to confirm if the neutral connections are effective.

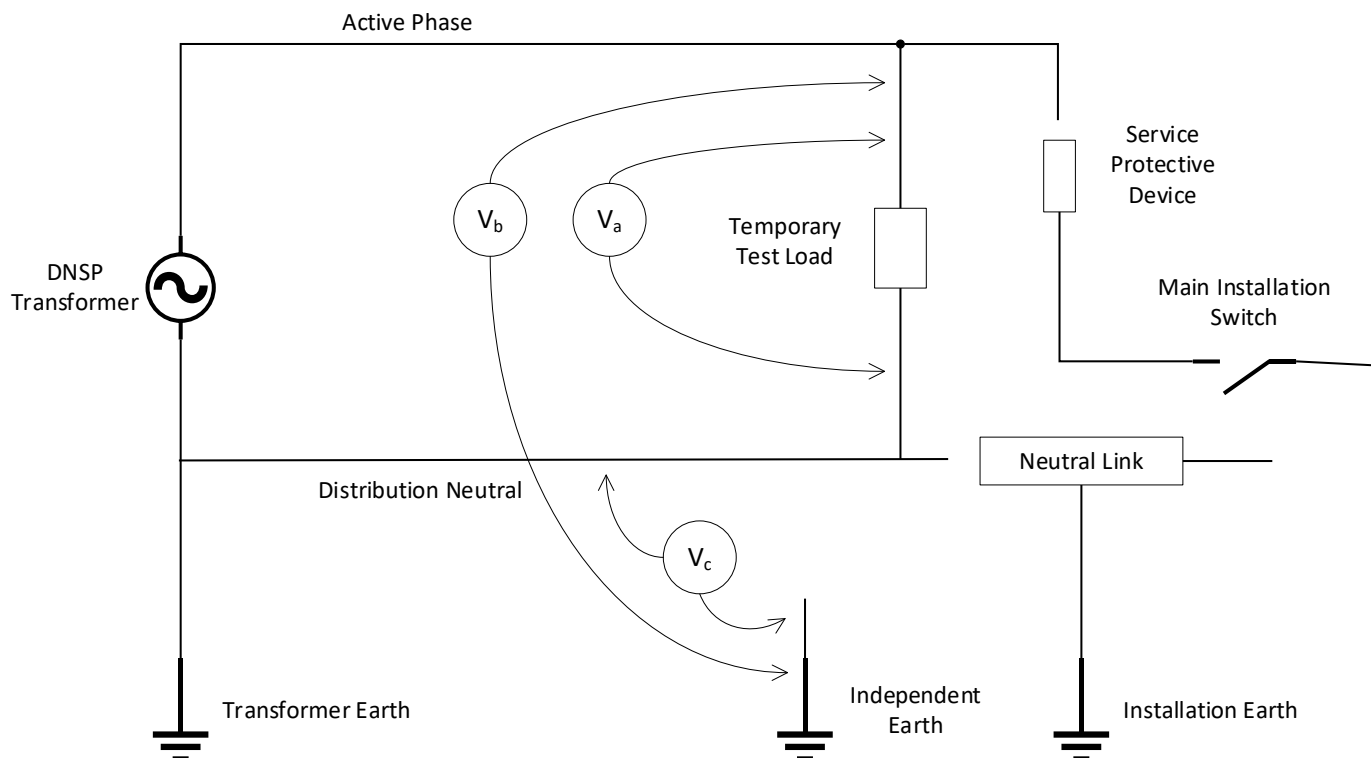


Figure 1: Voltage method

Test Setup

The following process is used to obtain the required conditions to perform the test.

1. Supply to the installation to be disconnected. A common but not only available method to achieve this is by operating the service protective device.
2. Incoming neutral to be separated from the installation neutral link preventing any connection with the installation earth(s).
3. Connect a test load between an active phase and the incoming neutral.
4. Install an independent earth stake no closer than 2m from any other conductive structure. The installation earth may be used in place of the temporary earth stake if it has been confirmed as an effective earth.

Test

Voltage measurements are to be taken as follows:

V_a – measure voltage from active phase to incoming neutral,

V_b – measure voltage from active phase to independent earth stake,

V_c – measure voltage from incoming neutral and independent earth.

Results

The following results should be obtained to confirm suitable neutral integrity:

V_a – This voltage should be approximately equal to the nominal supply voltage obtained from DNSP.

V_b – This voltage should be approximately equal to the nominal supply voltage obtained from DNSP.

V_c – Contact the DNSP to confirm an acceptable voltage value.

Considerations

When developing a procedure for carrying out the voltage method test as per above, all considerations within section B2 of AS4741 must be considered.

8.2.2 Impedance

This method uses a loop impedance meter to measure the supply circuit impedance (also known as the external loop impedance).

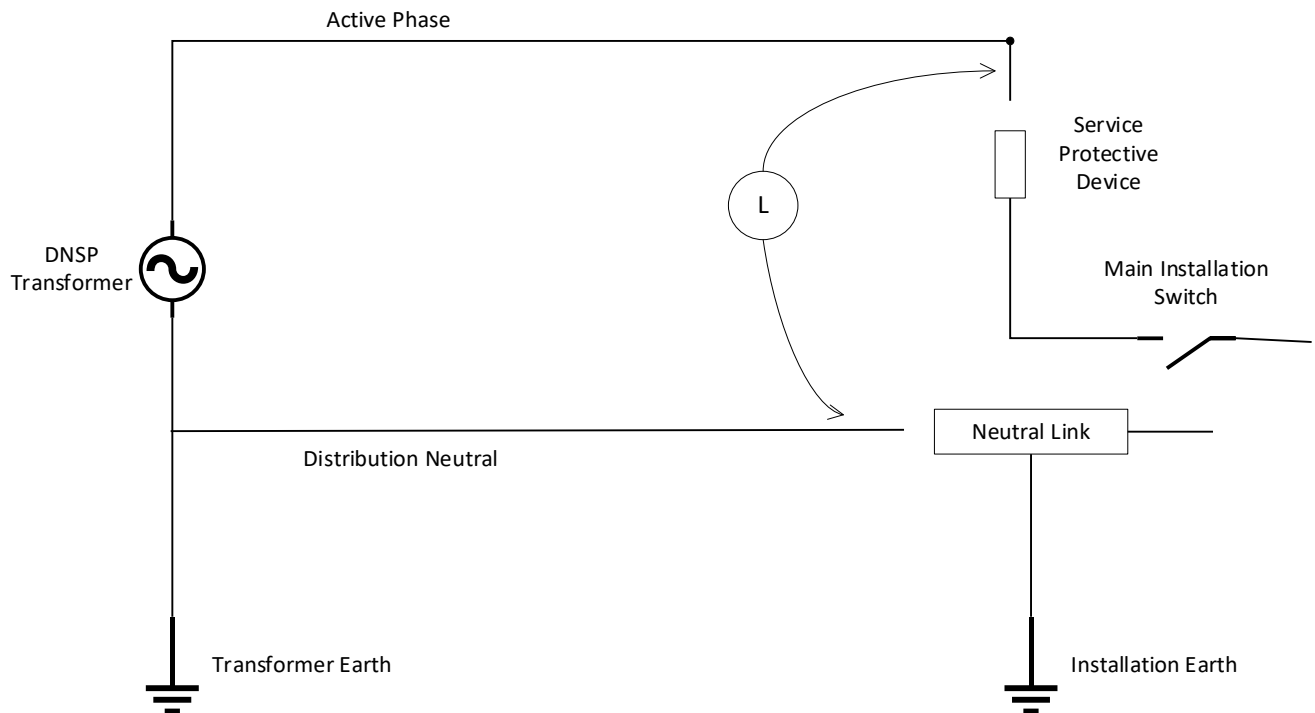


Figure 2: Loop Impedance Method

Test Setup

The following process is used to obtain the required conditions to perform the test.

1. Supply to the installation to be disconnected. A common but not only available method to achieve this is by operating the service protective device.
2. Incoming neutral to be separated from the installation neutral link preventing any connection with the installation earth(s). If the neutral is not separated, more than one return path will be included in the measurement giving a false indication of the service neutral impedance.

Test

Connect a loop impedance meter (L) between an active phase and the incoming neutral. A loop impedance measurement is then taken.

Results

Contact the DNSP to confirm an acceptable loop impedance value.

Note: For a 2 or 3 phase installation with a loop impedance value greater than the acceptable value, undertake the loop impedance test using other active phases to identify if the high impedance is within the neutral conductor.

Considerations

When developing a procedure for carrying out the Loop Impedance method test as per above, all considerations within section B3 of AS4741 must be considered.

8.2.3 Current Method

This method compares the ratio of the current in the active phase compared to the current in the neutral by applying an appropriate test load.

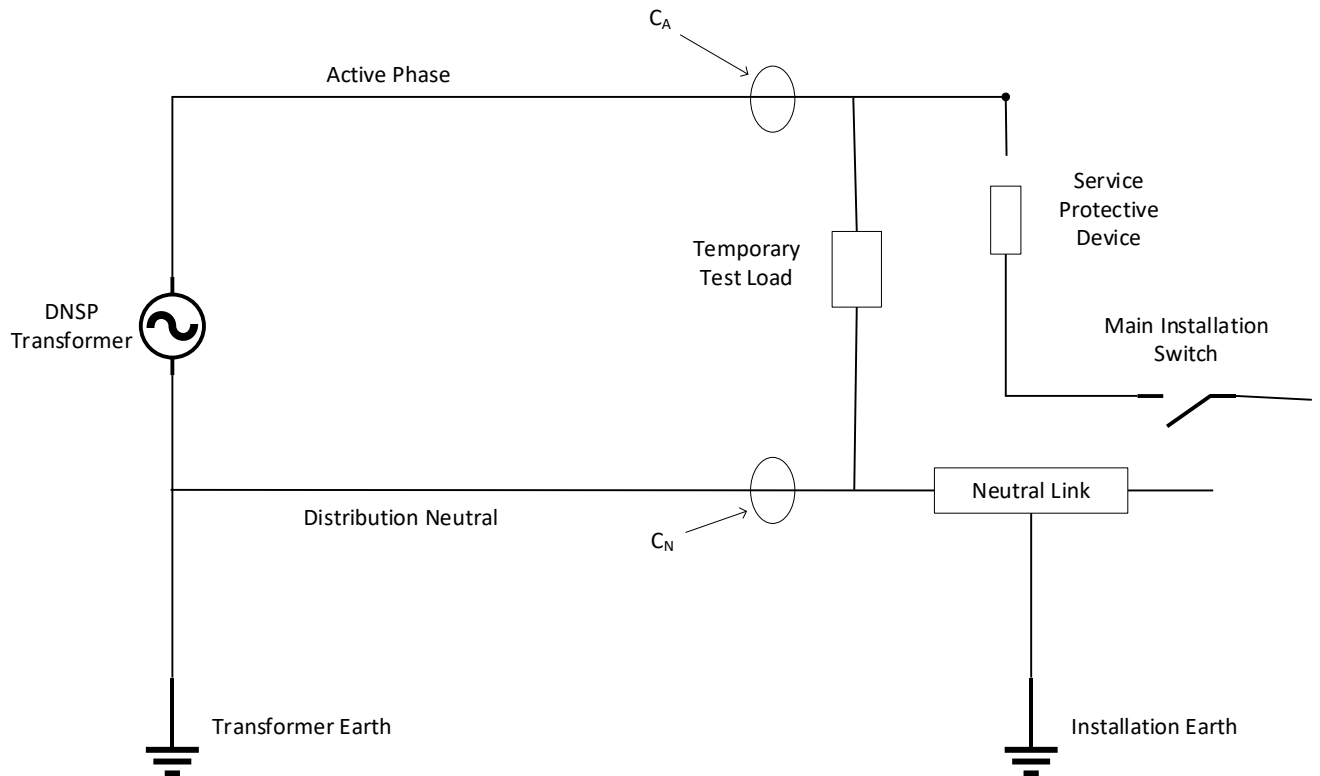


Figure 3: Current Method

Test Setup

The following process is used to obtain the required conditions to perform the test.

1. Supply to the installation to be disconnected. A common but not only available method to achieve this is by operating the service protective device. Do not disconnect the incoming neutral.
2. Connect a test load between the active phase and the incoming neutral.

Test

Measure the ratio of current returning through the neutral conductor. This is generally achieved using a tong clip on ammeter. For example:

- As per diagram above measure C_A using ammeter to confirm current through test load. Then measure C_N to determine the ratio of current returning via the neutral conductor. The remaining current will be returning via earth connection(s) within the installation.

Results

Contact the DNSP to confirm an acceptable ratio value of current returning through the neutral conductor.

Considerations

When developing a procedure for carrying out the Current method test as per above, all considerations within section B4 of AS4741 must be considered.

8.3 Phase Rotation Test

As per section 4.5 of AS4741, where connections have been carried out on the active conductors supplying an installation with more than one phase, correct phase rotation shall be verified. Carry out the process as described in section 4.5 of AS4741.

It should be noted that a phase rotation instrument may give an incorrect result on a 3-phase supply where only 2 phases are available (i.e. one phase not electrically connected).

8.4 Phase Confirmation

Workers need to perform a test to confirm the correct phasing prior to interconnection of conductors within a low voltage electricity network.

8.5 Final Checks Before Leaving Work Location

Where connections have been removed to carry out testing, ensure all connections are reinstated and supply is reconnected (where required). The installation is to be left in a safe manner.

In addition, it is recommended before leaving the work location a safe to approach test (refer to section 7) is carried out on the switchboard and metal structures (such as raiser brackets, service poles, downpipes etc) to provide an indication that no hazardous voltage is present.

8.6 Records

Records should be maintained by the company carrying out testing to confirm compliance to this guideline. Contact the DNSP (refer to section 9) to confirm any records to be supplied to the DNSP.

9. DNSP Contact Details

For further questions regarding this guide, contact details for each DNSP are provided below:

Ausgrid

Email: serviceandinstallationcompliance@ausgrid.com.au

Endeavour Energy

Email: inspection@endeavourenergy.com.au

Essential Energy

Email: ASPinfo@essentialenergy.com.au

Appendix A Relevant Documentation

- AS/NZS 4741 – Testing of connections to low voltage electricity networks.