LOW VOLTAGE CABLE AND APPARATUS TESTING MANUAL

SPECIFIES THE REQUIREMENTS FOR AUTHORISED ELECTRICAL WORKER TESTING ON THE EVOENERGY LOW VOLTAGE NETWORK

Defines mandatory and additional testing requirements for voltage, current, polarity, insulation resistance, neutral integrity and phase rotation on the low voltage mains and service connections. Mandatory testing of the low voltage network and connected installations must be conducted to mitigate safety risks to staff and the public.

CONTENTS

SECTION 1

INTRODUCTION

1. INTRODUCTION

1.1 Purpose

This manual provides the necessary information for authorised electrical workers to perform mandatory network testing to ensure the safety of persons connected to the Evoenergy distribution system, and to ensure a safe and reliable electricity supply to the customer.

1.2 Scope

This manual provides details of mandatory low voltage testing to be performed by electrical workers both within the distribution network and at the network boundary. The manual does not cover specific testing performed by specialist sections such as Protection and Quality of Supply.

It is the responsibility of all qualified electrical workers to understand and where required, perform the processes included within this manual. Mandatory testing of the low voltage network and connected installations must be conducted to mitigate safety risks to staff and the public.

Mandatory testing must be conducted by authorised workers holding ESI trade qualifications, and up to date training and authorisation to perform testing as a part of the following tasks:

- Installation, repair, and replacement of overhead or underground distribution network service lines and their subsequent energisation by connection to the low voltage distribution network
- Reconnection of a customer installation to the low voltage distribution network
- Installation, repair, replacement and augmentation of distribution network underground or overhead mains conductors and cables
- Installation, or reconnection of distribution network overhead or ground-mounted distribution transformers
- Installation, or reconnection of low voltage distribution network switchboards
- Installation, fault repair and replacement of low voltage distribution network assets
- Power quality and electric shock investigations
- Connection of portable generating sets to the low voltage distribution network or installation

The contents of this manual must be applied in conjunction with all other relevant policies and procedures including

- Worksite hazard identification
- Risk assessment and control utilising appropriate SWMS, JRA and the *Electrical Safety Rules*
- Commissioning and related network procedures

This manual has been developed to align with the requirements of Evoenergy *Electrical Safety Rules, AS4741 Testing of Connections to Low Voltage Electricity Networks* and *AS3017 Electrical Installations - Verification Guidelines*

1.3 Training and Authorisation

Authorisation to test the low voltage network requires training and assessment as per the *Evoenergy Electrical Safety Rules*

- Staff required to perform any of the tests nominated in this manual on the low voltage network must be trained and assessed in the testing required

- In order to maintain competency, refresher training must occur annually with a theoretical and practical assessment as required by the *Evoenergy Electrical Safety Rules*.
- Apprentices under training can perform the testing detailed in this manual under the following circumstances:
    i. The apprentice has been trained in the mandatory requirements that apply to the situation as detailed in the *Electrical Safety Rules and PO0144 Apprentice Training Management Procedure*, particularly live work
    ii. The supervising tradesperson deems that it is safe to do so
    iii. The apprentice is under direct supervision while testing is carried out
    iv. The supervising tradesperson verifies the test results prior to any connections being made

1.4 Record Keeping - Cityworks

Our goal when maintaining and working on assets is to ensure a safe and reliable network. To assist with these safety and compliance obligations, the current inspection form in Cityworks must be utilised for LV testing records.

This includes the proactive recording of testing information to confirm the integrity of the asset and leaving the network safe for fellow workers and the public.

- The LV testing form must be used for recording both pre work and pre commissioning testing results
- The LV testing form is located in Cityworks as an inspection form
- The form will be automatically generated in certain Cityworks work orders.
- If there is no LV testing form in a work order or you require additional information to be captured, you can manually create one as per Appendix B - Cityworks screenshots.

1.5 Service and Installation Rules

The *Evoenergy Service and Installation Rules* and Electricity Network Boundary Code 2017 define the network boundary and provisions for service equipment in customer enclosures. If these provisions are not available, for example service neutral links in switchboards, Evoenergy will allow ESI trade qualified approved test personnel to employ other measures to ensure a safe connection to the network. These measures are for testing only and must not be used for any other purpose

This section allows approved test personnel to break the seals on meters to gain access to terminals for testing

All broken seals must be reinstated by an Evoenergy authorised person

1.6 Images in this manual

For clarity, images in this manual have been designed to show only the required details of the test being performed, while noting key requirements such as whether the Service Protection Device (SPD) is in or out, main switch is on or locked and tagged off and expected values. It is up to Evoenergy workers to assess by inspection the configuration of the installation in the location that they are testing and determine the LV test points. This can include:

1. The line and load side of the SPD
2. The main switch/open point
3. The main earth location
4. LV apparatus connections
5. The Network Boundary
6. The UG PoE/Switchboard
7. The OH PoA/OH connection point
8. LV mains connections

1.7 Reference Documents

AUSTRALIAN STANDARDS	
AS 4741	Testing Of Connections To Low Voltage Electricity Networks
AS/NZS 3017	Electrical Installations - Verification by inspection and testing
AS/NZS 3000	Wiring Rules
AS 61010	Safety Requirements For Electrical Equipment For Measurement, Control and Laboratory Use
AS60038	Standard Voltages
ACT UTILITIES TECHNICAL REGULATOR CODES	
	Electricity Network Boundary Code 2017
EVOENERGY POLICIES AND PROCEDURES	
PO07173	Evoenergy Distribution Service and Installation Rules
PO0677	Electrical Safety Rules
PO07476	Earthing Construction Manual
PO070523	Standard Supply Voltage for LV System
PO07244	Lock Out Tag Out Procedure
PO0605	Evoenergy Personal Protective Clothing and Equipment (PPCE) Manual
PO0144	Apprentice Training Management Procedure

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SECTION

DEFINITIONS

2. DEFINITIONS

Ø Phase

Ω Ohm

MΩ Megohm **-** 1 Million ohms.

∞ Infinity, Infinite

≈ Approximately Equal

< Less than

> Greater than

Active (or active conductor) – Any conductor that is maintained at a difference of potential from the neutral or earthed conductor.

Apparatus – Equipment, instruments, conductors and/or combinations of, for the supply, transformation, consumption and measurement of electricity

Authorised Worker - means a worker with technical knowledge or relevant trade experience who has been approved, in writing, or has the delegated authority to act on behalf of Evoenergy, to perform the duty concerned.

Bonded means connected together in such a manner as to ensure that all bonded parts are maintained at the same electrical potential.

Cable – A conductor, or two or more conductors laid up together either with or without fillings, reinforcements or protective coverings.

Cable core OR core– The conductor within a cable including its insulation but not including any mechanical protective covering. May be referred to as a 'tail' at ends of cable

Competent - means the ability to perform particular tasks and duties to the standard of performance expected in the workplace. Competency requires the application of specified skills, knowledge and attitudes relevant to effective participation for completing a task.

Conductor – means a wire, cable, bar, tube or form of metal designed for carrying electric current.

Consumer mains – Those conductors between the point of supply and the main switchboard as defined by the ACT Service and Installation Rules.

Cross – Two conductors transposed. Also see **Roll**

De-energised – Not connected to any source of electrical supply, but not necessarily isolated, earthed, discharged or out of commission.

Discharged - means having been connected to the general mass of earth in such a manner as to remove any residual electrical energy in a conductor or conducting object.

Earth potential rise (EPR) – A voltage difference between a reference point and a system earth. EPR may cause hazardous voltages on equipment, apparatus, structures or enclosures.

Electrical installation – Electrical equipment installed for the purpose of conveyance, control, measurement or use of electricity, where electricity is supplied for consumption. It includes electrical equipment supplied from a distribution network or a private generating system.

Electricity distribution network – means an interconnected system or transmission and/or distribution conductors and electrical apparatus (see Mains).

Electrical equipment – Wiring systems, switchgear, control gear, accessories, appliances, luminaires, and fittings used for such purposes as generation, conversion, storage, transmission, distribution or utilisation of electrical energy.

Energised – Connected to a source of electrical supply, or subject to hazardous capacitive or induced voltages.

Existing - apparatus that has previously been in service

Exposed conductive part – A conductive part of electrical equipment which:

- Can be touched with the standard test finger as specified in *AS/NZS 3100*: and
- Is not a live part but can become live if basic insulation fails

Hazard – A source of potential harm.

Independent earth – An effective earthed reference point used for testing purposes, spaced a minimum of 2 metres away from any conductive object embedded in the ground connected to the system under test.

Indication only – Output of a test device that does not provide a precise or measured value

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

Integrity – The state of being sound, unimpaired and fit for service.

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

JRA – Job risk assessment as per procedure *PO06100 Job Risk Assessment*

Known earth – A network earthing point as described in Section 6.1 of the *Electrical Safety Rules*

Known live source – A conductor known to be energised at a voltage of ≈230 volts AC

Low voltage (LV) – A nominal voltage exceeding 50 Volts AC or 120 Volts ripple free DC, but not exceeding 1000 Volts AC or 1500Volts DC.

Main earthing conductor – A conductor connecting the main earthing terminal/connection or bar to the earth electrode or to the earthing system at the source of supply

Mains – A cable or conductor in the electrical distribution network that has more than one service connected to it, excluding tee connected fused underground service cables

May – Indicates the existence of an option.

Meter Protection Device (MPD) – A fuse or other protection and isolation device located on the un-metered side of the installation intended for the isolation and protection of the meter and its associated customer installation

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

Must or must not - is to be interpreted as ‘mandatory’.

Network – Electrical distribution system

Network Area – Where an installation is supplied directly from a pit or pillar, the clearly defined area on a customer’s main switchboard or PoE where network service protection devices and dedicated neutral link are installed

Network boundary – The boundary between the electrical distribution network and a consumer’s premises as defined by the *Electricity Network Boundary Code 2017*

Network connected - The electrical installation is connected to the distribution network.

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

Network not connected – No conductor of the electrical installation including the neutral, is connected to the distribution network.

New - apparatus that has not previously been commissioned

Open Point - A break in the circuit. The open point is open if the network is not connected, there is a gap or opening in the conductors or a mechanical apparatus has been opened.

Overhead Line - means any aerial conductor or exposed conductors with associated supports, insulators and other apparatus erected, or in the course of erection, for the purpose of the conveyance of electrical energy, excluding poles or supporting structures or anything in an electrical station.

Phasing – The identification by testing of active conductors of the same phase and differing phases

Point of Attachment (PoA) – The point at which aerial conductors or cores of a service line are terminated on a consumer's structure.

Point of Entry (PoE) – The point at which the underground service is terminated in a customer's structure.

Point of supply – The junction of the electricity distribution network conductors with the consumer's electrical installation.

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

PPCE – Personal Protective Clothing and Equipment as per *PO0605 Personal Protective Clothing and Equipment*

Reasonably practicable - means that which is, or was at a particular time, reasonably able to be done to ensure health and safety, taking into account and weighing up all relevant matters including:

- the likelihood of the hazard or the risk concerned occurring;
- the degree of harm that might result from the hazard or the risk;
- what the person concerned knows, or ought reasonably to know, about the hazard or risk, and ways of eliminating or minimising the risk;
- the availability and suitability of ways to eliminate or minimise the risk; and
- after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

Reversed polarity – A dangerous condition that exists when active and neutral conductor connections are transposed resulting in a direct connection of a bonded or earthed conductor to an energised conductor.

Risk – The possibility that harm (death, injury or illness) might occur when exposed to a hazard

Roll – A transposed conductor connection in a cable joint leading to either incorrect polarity and/or incorrect phasing and rotation

Rotation – Rotation of a three phase supply

- CCW –Phases A – B – C in a counter clockwise direction
- CW– Phases A – B – C in a clockwise direction

Service – A dedicated radial cable or conductor, that may be installed underground or overhead, between the network point of connection and the customer's network boundary.

Service neutral link – Labelled neutral link in customer installation (meter box or point of entry) for the termination of the service neutral. As per *Service and Installation Rules*

Service Protection Device (SPD) – The first protection device located on the network side or forming part of the Connection Point

Should – Indicates a recommendation.

Source of supply – Where used in relation to any electrical installation, the generator, convertor, transformer or group of generators, convertors, or transformers, to which the supply mains conveying the electricity to that particular electrical installation are connected and that generates, converts, or transforms the electrical energy supplied to that electrical installation.

Testing – Implementation of measures of an electrical installation or distribution network by means of which its effectiveness is proved.

Touch current – Electric current that passes through the human body when it touches one or more accessible parts of electrical equipment or electrical installation, under normal or fault conditions.

Touch voltage – Voltage appearing between simultaneously accessible parts.

Verification – All measures by means of which compliance of an electrical installation or distribution network with the relevant Australian and business standards is checked.

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

- *Extra low voltage* Not exceeding 50V AC or 120V ripple free DC
- *Low voltage* Exceeding extra low voltage, but not exceeding 1000V AC or 1500V DC
- *High Voltage* Exceeding low voltage

SECTION 3

RISK IDENTIFICATION AND MITIGATION

3. RISK IDENTIFICATION AND MITIGATION

3.1 Hazards and risks of un-tested or incorrect distribution network connections

Electrical workers have a duty of care to all people to protect them from the effects of incorrect connections within and to the electricity distribution network.

Incorrect connections can cause some or all of the following consequences:

- Yourself, colleague, customer, contractor or member of the public receiving an electric shock causing injury or death
- Damage to the customer's installation or apparatus
- Disciplinary action against individuals or teams in accordance with the Relevant Enterprise Agreement
- Fines for legal and compliance breaches
- Reputational damage
- Supply quality issues
- Unplanned network outages
- Financial loss from unavailability of embedded generation
- Fines, penalties, suspension and cancellation of Construction Occupation License imposed by Worksafe ACT, ACCESS Canberra or the ACT Chief Electrical Inspector
- Damage to the environment

3.1.1 Reversed polarity

- Risks posed by reversed polarity:
  - The neutral conductor is at active potential and the connection of the neutral to the earth at the MEN point causes earth potential rise (EPR) where the earthed metallic components of the installation and connected appliances become live causing electric shock
  - Circuit protective devices will open the neutral, not the active, causing a dangerous situation of a circuit or appliance to have a connected, unprotected active and an open circuit neutral
  - RCDs may fail to operate in the event of earth leakage, potentially leading to an electric shock
  - The installation's main earth conductor and/or equipotential bond may burn off leaving the installation in a dangerous situation with no reference to earth
  - Voltages may move outside the voltage tolerance, causing damage to equipment
  - In the event of any of the above situations, network circuit protective devices are unlikely to operate
- Reversed polarity risk mitigation:
  - Identify all of the conductors prior to energisation by testing as described in this manual
  - Confirm polarity by post energisation tests
  - Proximity test conductive structures and enclosures prior to access and after re-energisation.

3.1.2 Low insulation resistance

- Risks posed by low insulation resistance:
  - Short circuit upon energisation, causing fire, electric shock, equipment damage and unplanned outages
  - Electric shock from step touch or transfer potential

- Higher operating temperature in cables and equipment, leading to insulation failure, reduced service life, unplanned outages, fire, electric shock

- Low Insulation resistance risk mitigation:
  - Cables and equipment must be tested in accordance with this manual to ensure insulation resistance readings equal to or greater than the minimum values specified in Table 7 prior to energisation

3.1.3 High impedance or open circuit neutral

- Risks posed by high impedance or open circuit neutral:
  - The return current flows through the earthing system causing a voltage rise in the earthing system. This causes earthed metallic components of the installation and connected appliances to become live causing electric shock
  - Temperature rise in high impedance joints can cause fire
  - The installation's main earth conductor and /or equipotential bond may burn off leaving the installation in a dangerous situation with no connected earth leading to failure of protective equipment to operate causing fire and electric shock
  - Voltages may move outside the voltage tolerance, causing damage to equipment
- Open circuit and high resistance neutral risk mitigation:
  - Neutral integrity must be verified by testing in accordance with this manual
  - Proximity test metallic structures and enclosures prior to access and after work is complete

3.1.4 Earth potential rise

- Risks posed by earth potential rise:
  i. Electric shock from metallic equipment bonded to earth
  ii. Burnt off main earth connection to premises
- Earth potential risk mitigation:
  - Identify all of the conductors prior to energisation by testing as described in this manual
  - Confirm polarity by post energisation tests
  - Proximity test metallic structures and enclosures prior to access and after work is complete

3.1.5 Incorrect phase rotation

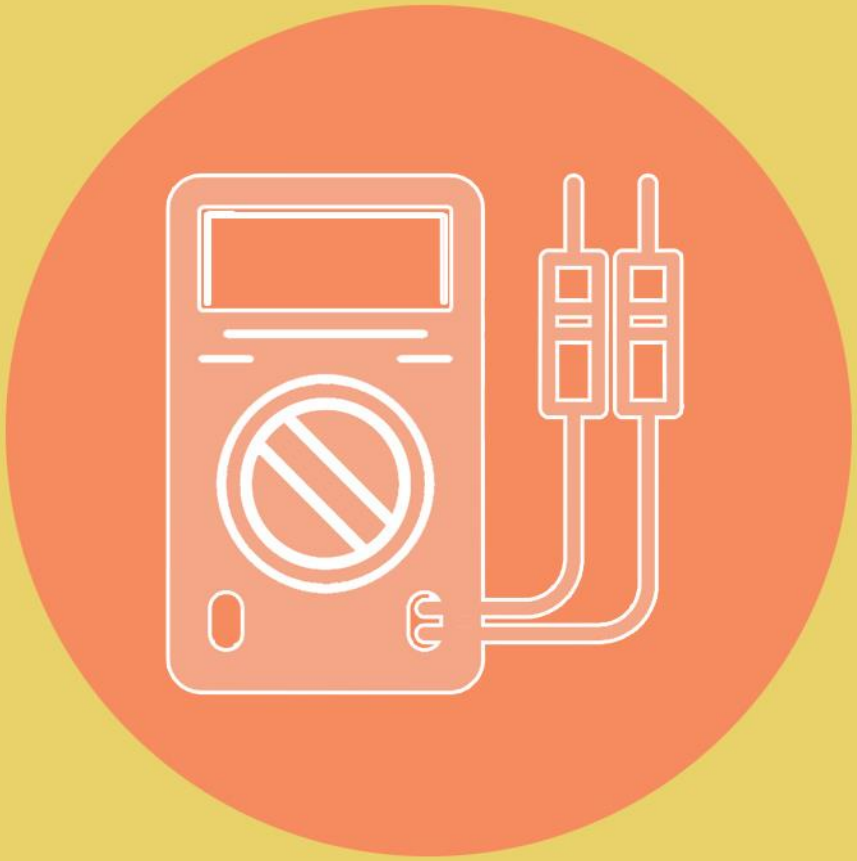
- Risks posed by incorrect phase rotation:
  - Three phase motors will attempt to rotate in the opposite direction than was intended. This can lead to equipment not operating, failure of rotating equipment and significant danger to the operators and the public.
- Incorrect phase rotation risk mitigation:
  - Test and record phase rotation prior to de-energisation, verify rotation upon re-energisation
  - Do not energise three phase circuits where phase rotation cannot be verified.

3.1.6 Incorrect phasing between circuits

- Risks posed by incorrect phasing between circuits:
  - The closing of an open point in the network with incorrect phasing will cause a short circuit fault between two phases that will create an arc flash. The arc flash can cause electric shock and burns to people in the vicinity and the short circuit can cause significant damage to equipment and unplanned outages
- Incorrect phasing between circuits risk mitigation:
  - Ensure that phasing across open points is carried out upon initial and re-energisation of circuits connected to an open point

3.1.7 Voltage outside of specified voltage tolerance

- Risks posed by voltage outside of tolerance
  - Damage to insulation of cables, conductors and equipment both in the network and connected customer installations
  - Damage to equipment, particularly electronics
  - Higher currents being drawn by equipment leading to fire or premature equipment failure
  - Unwanted circuit breaker tripping
  - Poor performance or failure of equipment
- Voltage outside of specified tolerance risk mitigation
  - Calibrated voltage tester used for polarity and voltage testing
  - Verification of measured voltages at customer installation



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SECTION

TEST EQUIPMENT

4. TEST EQUIPMENT

4.1 Personal Protective Equipment for Testing

PPCE items below are MANDATORY and are the MINIMUM requirements as per the *PPCE matrix* and *Personal Protective Clothing and Equipment*.

- Safety uniform.
- Low voltage insulating electrical gloves with arc-rated outer gloves.
- Safety glasses, face shield or goggles.
- Safety helmet.

Further PPCE controls identified during the JRA process must be utilised to control hazards identified.

4.2 Labels and Tags for Testing

Testing requires the installation of identification, out of service and danger tags. These tags are listed in APPENDIX B. Installation requirements can be found in Evoenergy procedure *Lock Out/ Tag Out Procedure - PO0677 and the Electrical Safety Rules*

4.3 Test Equipment

Test instruments and equipment used in the Evoenergy distribution network must be approved by Evoenergy; AND

- be rated CAT IV as per AS61010-0.31 to the voltage of the network that will be tested +20%. For low voltage test instruments this will be 300 volts for single phase test instruments and 600 volts for instruments measuring across multiple phases. CAT IV ratings must apply to the test instrument and to the associated test leads and probes. The CAT IV rating is to prevent instrument failure leading to flashover and electric shock, caused by voltage transients
- CAT IV rating must be verified by type test certificates
- be calibrated in accordance with Evoenergy procedure Tools Equipment Testing and Inspection - PO06150
- contractors test equipment is subject to the above conditions and details of test equipment must be submitted to Evoenergy for approval which must be given in writing prior to any testing occurring

4.4 Approved Test Equipment

Below are examples and are not considered the only fit for task equipment approved by Evoenergy

Proximity tester

Greenlee GT12A Proximity Tester

Tong ammeter/voltage tester;

Fluke 374 Tong Ammeter

Stock No 1191074

Insulation resistance and continuity tester

Kyoritsu 3132A Insulation Resistance and Continuity Tester

Stock No 1197125

Independent earth;

Pacific Test Equipment - Trailing Earth Lead

Stock No 1187960

Voltage proving unit;

Fluke PRV 240 Voltage Proving unit

Stock No 1203582

Temporary load bank.

T mac Temporary Load Test Unit

Stock No 1197147

Fault loop impedance tester

CABAC T2726 Neutral integrity tester

Stock No 1197103

Phase rotation tester;

SEW 890 PR Phase Indicator

Stock No 1189237

Pole leakage detector

Pole Leakage Detector (PLD)

Stock No 1197114

Non-calibrated voltage testers including test lamps are NOT an Evoenergy approved means for testing the LV Network

- MODIEWARK

GLM MINI AC NON-CONTAC
HIGH/LOW VOLTAGE DETECTOR
MODEL- SWER & POLE
Stock No 1209885

Non-Contact Voltage Test Pencil - KLEIN

Stock No 1191074

4.5 Safe Use of Test Equipment

4.5.1 General

Low voltage test instruments must be selected, used, stored and maintained in a way that minimises the chance of failure while testing on energised sources and prevents testing from causing hazards to people and property. Recommendations from manufacturer instructions for safe use, maintenance and storage, must be followed.

4.5.2 Calibration, operational checks and inspection

Calibration must occur in accordance with the Evoenergy procedure *Tools Equipment Testing and Inspection - PO06150* and Appendix A. Calibration, operational checks and inspection

4.5.3 Guards and clearances

Test equipment may have integral guarding and barriers that prevent operator inadvertent contact with live parts, add creepage distance, and prevent the test probe from causing a short circuit.

Manufacturer guards, barriers or covers must not be altered or tampered with.

4.5.4 Storage

Test equipment is sensitive to environmental conditions and to mechanical damage and must be stored as per the manufacturer's recommendations.

The tester, test leads and components should be stored in the supplied protective case, kept dry and away from heat and sunlight and in a place where the equipment cannot fall or be crushed.

Test equipment must not be left on the dashboards of vehicles. Equipment must be stored where it will not be subjected to mechanical damage

4.5.5 Cleaning

Test equipment is sensitive to chemicals and must only be cleaned as per the manufacturer's recommendations. Dust may be removed with a soft cloth, slightly dampened with water with tester turned off.

4.5.6 Batteries

Batteries must be in good condition for test apparatus, it is recommended spare batteries be carried for test equipment. To prevent batteries with differing amounts of charge being used all batteries must be replaced at once.

4.5.7 Replacement of fuses

Fuses may only be replaced with parts that meet the manufacturer specification (noted in the instruction manual)

4.5.8 Damaged test equipment

Where a piece of test equipment or its accessories are found to be faulty or unserviceable, the item shall have an **Out of Service Tag** attached and the item removed from service as per *Lock Out/Tag Out procedure PO07244.* In these circumstances, any Worker is authorised to attach an Out of Service tag. The Out of Service Tag shall be prominently displayed and clearly labelled with contact name, phone number, date and details of why the tag has been applied – for example, a description of what is wrong with the item. Out of Service Tags shall be attached using a zip tie or other method that will prevent the tag from being inadvertently removed.

4.5.9 Leads

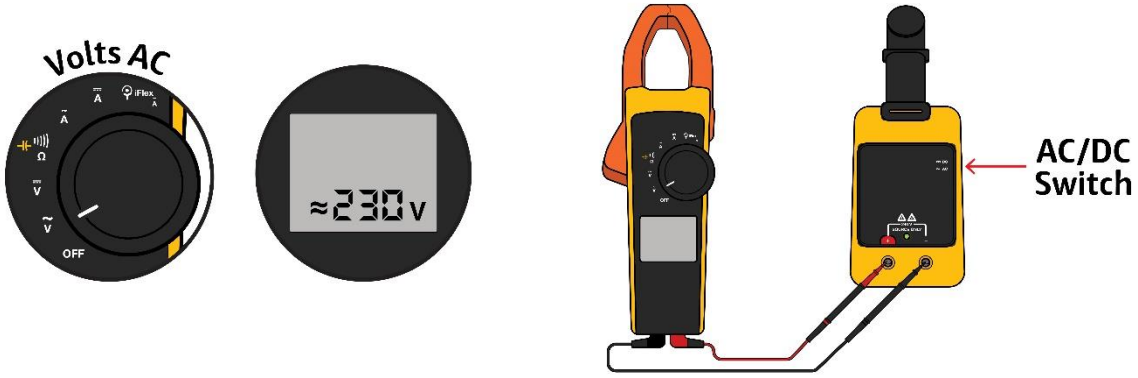
The integrity of test leads is essential to the safe operation of test equipment. Some test apparatus such as multimeters and clamp meters have removable leads, should these leads require replacement, correct leads must be procured. Correct leads will be rated CAT IV as per *AS61010-0.31* to the voltage of the network that will be tested +20% and approved by the manufacturer`. For low voltage test instruments this will be 300 volts for single phase test instruments and 600 volts for instruments measuring across multiple phases. Test leads must be shrouded at the meter end and have removable or retractable tip guards as a minimum

4.5.10 Repair

Repair of test equipment must only be conducted by manufacturer approved service agents

4.5.11 Voltage Proving Unit

The Fluke PRV240 voltage proving unit provides both AC and DC functionality. Ensure that your tester is proven on the appropriate voltage that you will be testing for.



5
SECTION

PRE AND POST INSPECTIONS

5. PRE AND POST INSPECTIONS

If the pre or post-test inspection identifies defects or hazards that are likely to cause electrical shock or damage to property, or may impact the safety or integrity of the tests, revisit JRA and assess the identified risks and applicable controls. If these risks cannot be adequately mitigated by the implementation of controls, testing should not proceed and your supervisor must be notified.

5.1 Pre-test visual inspection

A visual inspection must be carried out before, or in association with, testing in order to prevent electrical shock or damage to property.

The following is a list of items that must, where applicable, be included as part of the pre-test visual inspection:

- The location is correct
- Isolation is correct
- Labels are installed
- No visible damage to equipment
- Equipment is ready for testing
- Wiring is complete with no visible damage
- Connections are correct, complete and mechanically sound
- Alternative supplies are identified and managed
- Persons and animals are clear of any object that may become energised during testing
- Workers notified of testing in progress

5.2 Post-test inspection

An inspection must be carried out on the completion of testing to ensure that the test location is left in a safe state.

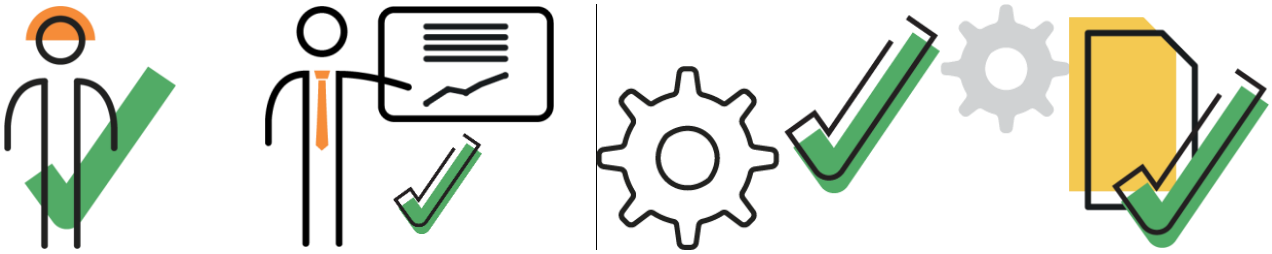
The following is a list of items that must be included as part of the post-test inspection:

- Neutral identification tags have been installed on overhead neutral conductors identified as part of testing
- Ensure all test equipment has been removed
- Danger tags are applied if required and removed if redundant
- Ensure the neutral is connected prior to installation energisation
- All temporary markings have been removed
- All required test results recorded on testing form
- All covers removed for testing are undamaged, in place, and secured (sealed) if required
- Check all connections and terminations related to the work are correctly mechanically tightened. All connections must be secondary validated by a combination of visual inspection and tug or pull tests
- All enclosures are secured and locked if required
- Danger and out of service tags are fully filled out and applied where required

SECTION 6

FUNDAMENTALS OF TESTING

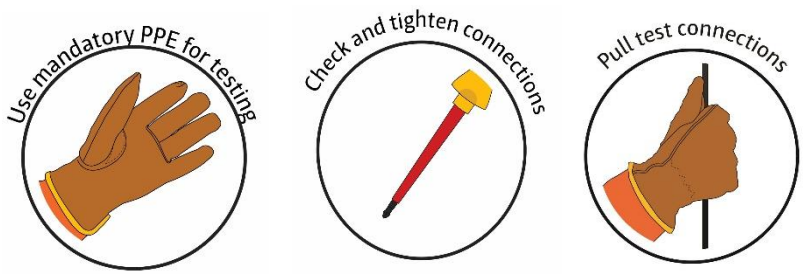
6. FUNDAMENTALS OF TESTING

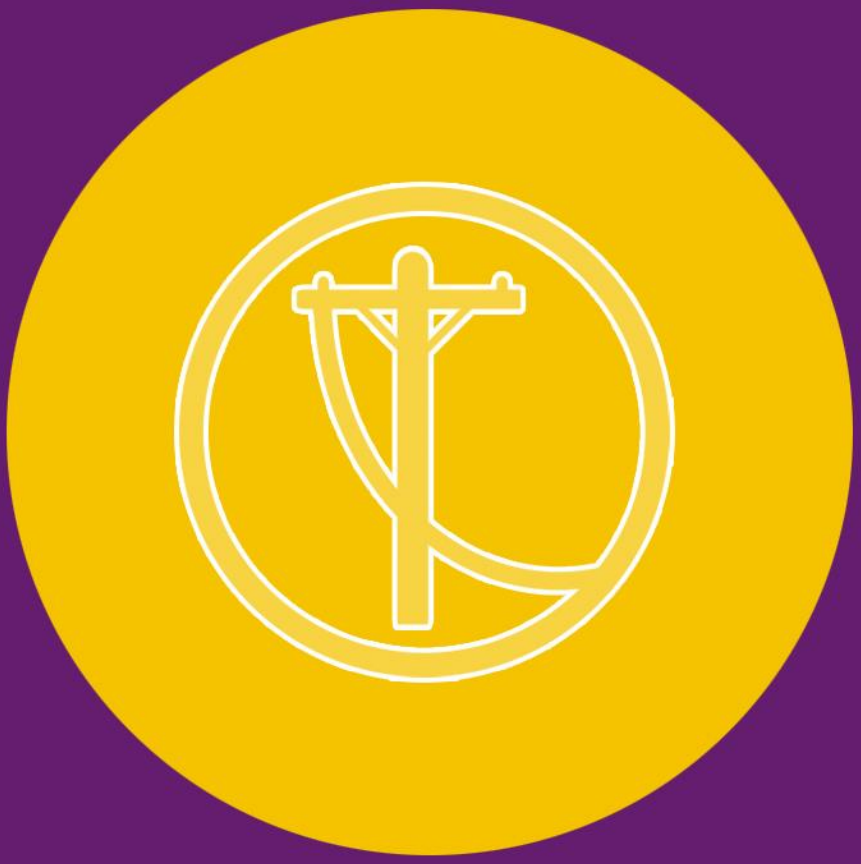


All tests listed in this document follow the basic principles of sufficiently trained workers being able to assess the correct test points, use the correct equipment, perform condition checks, and set up and use test equipment as per below

- Must follow the Evoenergy Life Saving Rules
- Mandatory PPCE must be worn during testing *see Personal Protective Clothing and Equipment*
- Must proximity test conductive structures and enclosures before contact
- JRA must be completed - including review and implementation of controls from relevant SWMS in accordance with *Job Risk Assessment*
- Be able to identify the network boundary if at a customer installation
- Can correctly assess test points
- Pre and Post inspections must be completed
- Test equipment must be fit for task and in working order
- Test equipment must be installed correctly for adequate test results
- Test equipment must be set on correct setting/range for the test being completed
- Must be trained and qualified and up to date in the test being applied
- Can understand and verify tests and processes listed in this manual
- All connections must be correctly tightened and pull tested

The test personnel should expect a result and if the measured result is not as expected, take appropriate action.





7

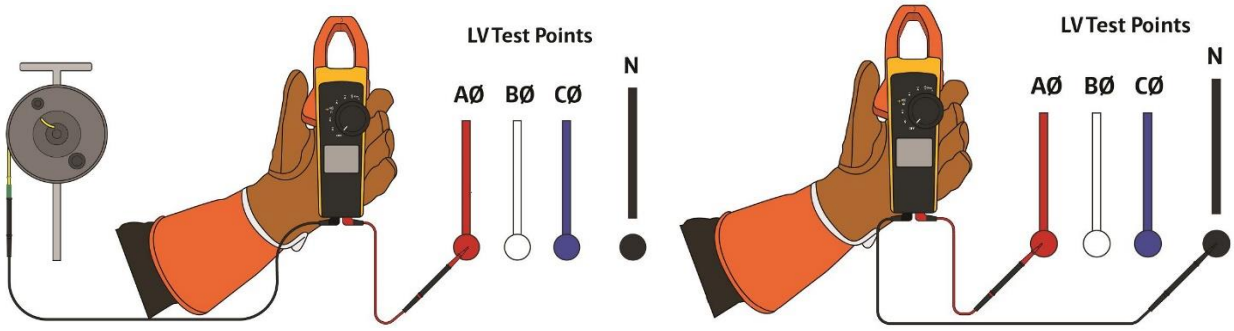
SECTION

OVERHEAD TESTING

7. OVERHEAD TESTING

This section applies to testing to allow safe energisation of overhead works related to conductoring, pole changes, service replacement, relocation and reconnection.

7.1 OH Mains Tests



All test results must be recorded in Cityworks.

PRIOR TO DISCONNECTION

1. Complete JRA, including review and implementation of controls from relevant SWMS in accordance with PO06100 Job Risk Assessment (pre-start) including mandatory PPCE
2. Perform Test 1 - PROXIMITY. OR Test 12 – POLE LEAKAGE DETECTION for pole inspectors
3. Perform Pre-test inspection
4. Perform Test 10 – PHASE ROTATION.
   - On mains if service neutrals remain unbroken
   - On each service if neutral broken

ISOLATE POWER (EAP)

5. Perform Test 2 - PROVE DE-ENERGISED.

Any voltage may indicate alternative supplies are present. Alternate supplies must be isolated prior to the installation being energised

6. Perform Test 8 – INSULATION RESISTANCE TESTING for in-service cable baseline results
7. Install LV bonders as per *Earthing Construction Manual*

PERFORM WORK

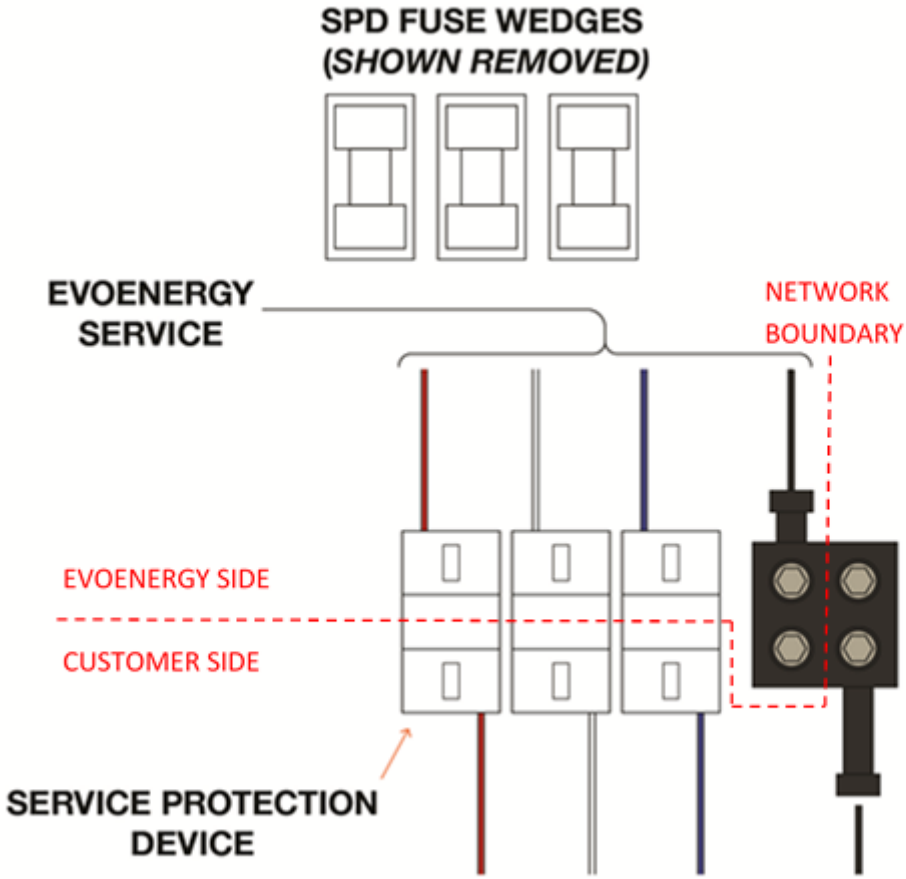
8. Ensure cable ends are disconnected at each end/connection point
9. Remove bonders for testing as per Earthing Construction Manual
10. Perform Test 8 – INSULATION RESISTANCE TESTING.
11. Check and confirm equipment/apparatus is safe to energise.

RESTORE POWER (EAP)

12. Perform Test 3 - NEUTRAL IDENTIFICATION and attach neutral identification tag
13. Perform Test 6 – POLARITY.
14. Perform Test 5 – VOLTAGE TESTING
15. Perform Test 10 - PHASE ROTATION.
16. Perform Test 9 – NETWORK PHASING.
17. Connect all cable ends as required by network.
18. Perform Test 1 - PROXIMITY.
19. Complete Post-test inspection.

7.2 OH Services Tests

The network boundary at an overhead Point of Attachment (PoA) is the customer side of the Service Fuse Holders and the customer side of the House Service Connector as per the Electricity Network Boundary Code 2017



All test results must be recorded in Cityworks.

Mandatory testing must be performed at the PoA end of the service

PRIOR TO DISCONNECTION

1. Complete JRA, including review and implementation of controls from relevant SWMS in accordance with Job Risk Assessment (pre-start) including mandatory PPCE
2. Perform Test 1 - PROXIMITY.
3. Perform Pre-test inspection.
4. Perform Test 10 - PHASE ROTATION.

SERVICE ISOLATED

5. Perform Test 2 - PROVE DE-ENERGISED.

Any voltage may indicate alternative supplies are present. Alternate supplies must be isolated prior to the installation being energised

PERFORM WORK

6. Ensure cable ends are disconnected at each end/connection point.
7. Perform Test 8 – INSULATION RESISTANCE TESTING.
8. Check and confirm equipment/apparatus is safe to energise
9. Confirm PoA end of service remains open.

RESTORE POWER

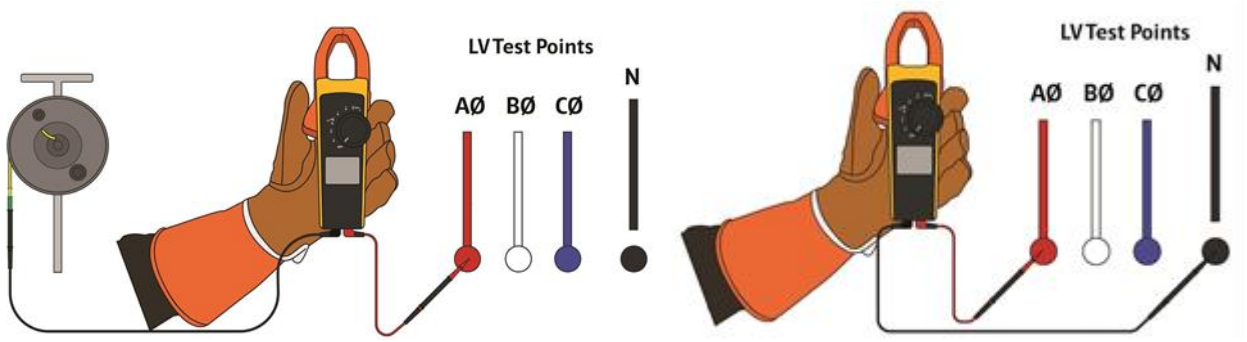
10. Perform Test 3 - NEUTRAL IDENTIFICATION.
11. Perform Test 6 – POLARITY.
12. Perform Test 5 – VOLTAGE TESTING.
13. Perform Test 10 - PHASE ROTATION.
14. Voltage test between the service neutral and the installation neutral to ensure 0 Volts
15. Voltage test colour to colour across the service fuse holders (between the service and the consumer mains) to ensure 0 Volts.
16. Connect service neutral.
17. Perform Test 4 - NEUTRAL INTEGRITY. At switchboard (preferred) or at PoA.
    - Test 4A – NEUTRAL INTEGRITY BY FAULT LOOP IMPEDANCE; AND
    - Test 4B - NEUTRAL INTEGRITY BY INDEPENDENT EARTH AND VOLTMETER as detailed in 9.4.3
18. Connect neutral conductor.
19. Replace service fuses.
20. Perform Test 1 – PROXIMITY.
21. Complete Post-test inspection.

SECTION 8

UNDERGROUND TESTING

8. UNDERGROUND TESTING

8.1 UG Mains Tests



All test results must be recorded in Cityworks.

PRIOR TO DISCONNECTION

1. Complete JRA, including review and implementation of controls from relevant SWMS in accordance with *Job Risk Assessment (pre-start)* including mandatory PPCE
2. Perform Test 1 - PROXIMITY
3. Perform Pre-test inspection
4. Perform Test 10 – PHASE ROTATION.
   - On mains if service neutrals remain unbroken
   - On each service if neutral broken

ISOLATE POWER (EAP)

5. Perform Test 2 - PROVE DE-ENERGISED.

Any voltage may indicate alternative supplies are present. Alternate supplies must be isolated prior to the installation being energised

6. Perform Test 8 – INSULATION RESISTANCE TESTING for in-service cable baseline results
7. Install LV bonders as per *Earthing Construction Manual*

PERFORM WORK

8. Ensure cable ends are disconnected at each end/connection point

9. Remove bonders for testing as per *Earthing Construction Manual*
10. Perform Test 7 – CONTINUITY TESTING
11. Perform Test 8 – INSULATION RESISTANCE TESTING
12. Confirm cables connected at one end
13. Check and confirm equipment/apparatus is safe to energise

RESTORE POWER (EAP)

14. Perform Test 3 - NEUTRAL IDENTIFICATION.
15. Perform Test 6 – POLARITY
16. Perform Test 5 – VOLTAGE TESTING
17. Perform Test 10 - PHASE ROTATION.
18. Perform Test 9 – NETWORK PHASING
19. Connect all cable ends
20. Perform Test 1 - PROXIMITY.
21. Complete Post-test inspection.

8.2 UG Services Tests

The network boundary at an underground point of entry is the customer side of the service fuses and the customer side of the service neutral link as per the Electricity Network Boundary Code 2017

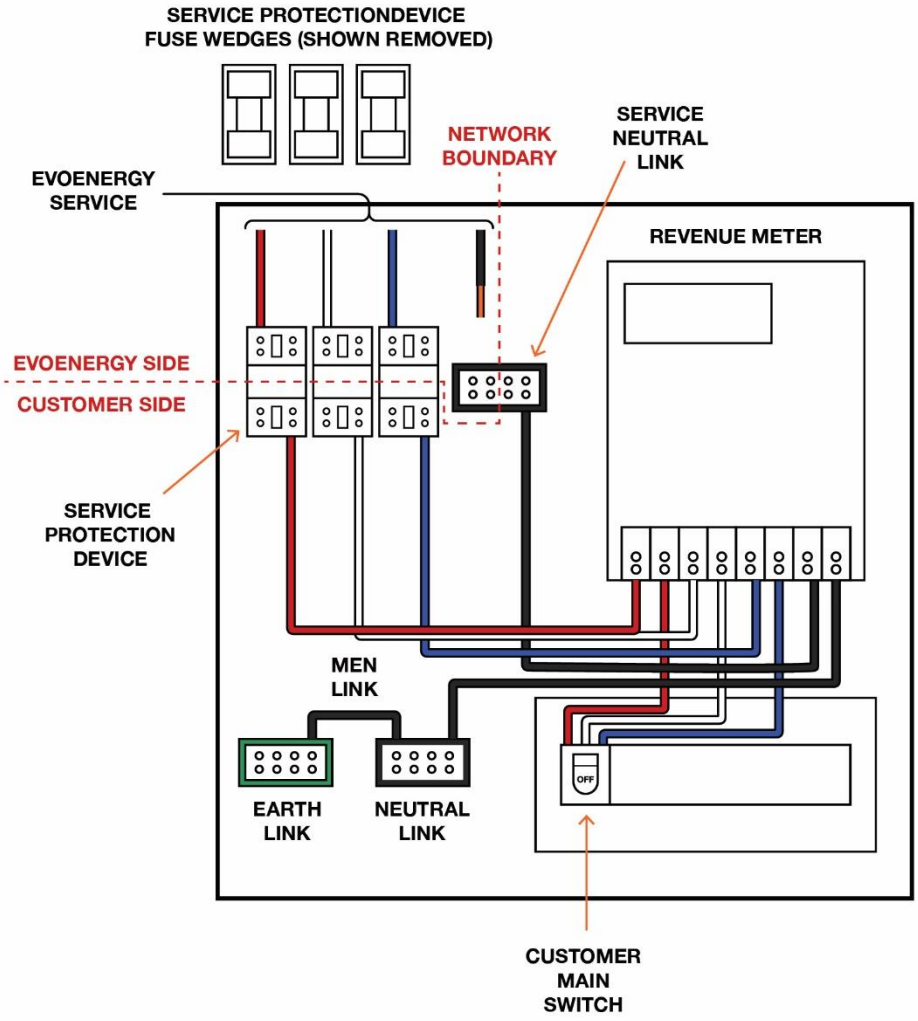


FIGURE 2. SERIES NEUTRAL METER CONNECTION

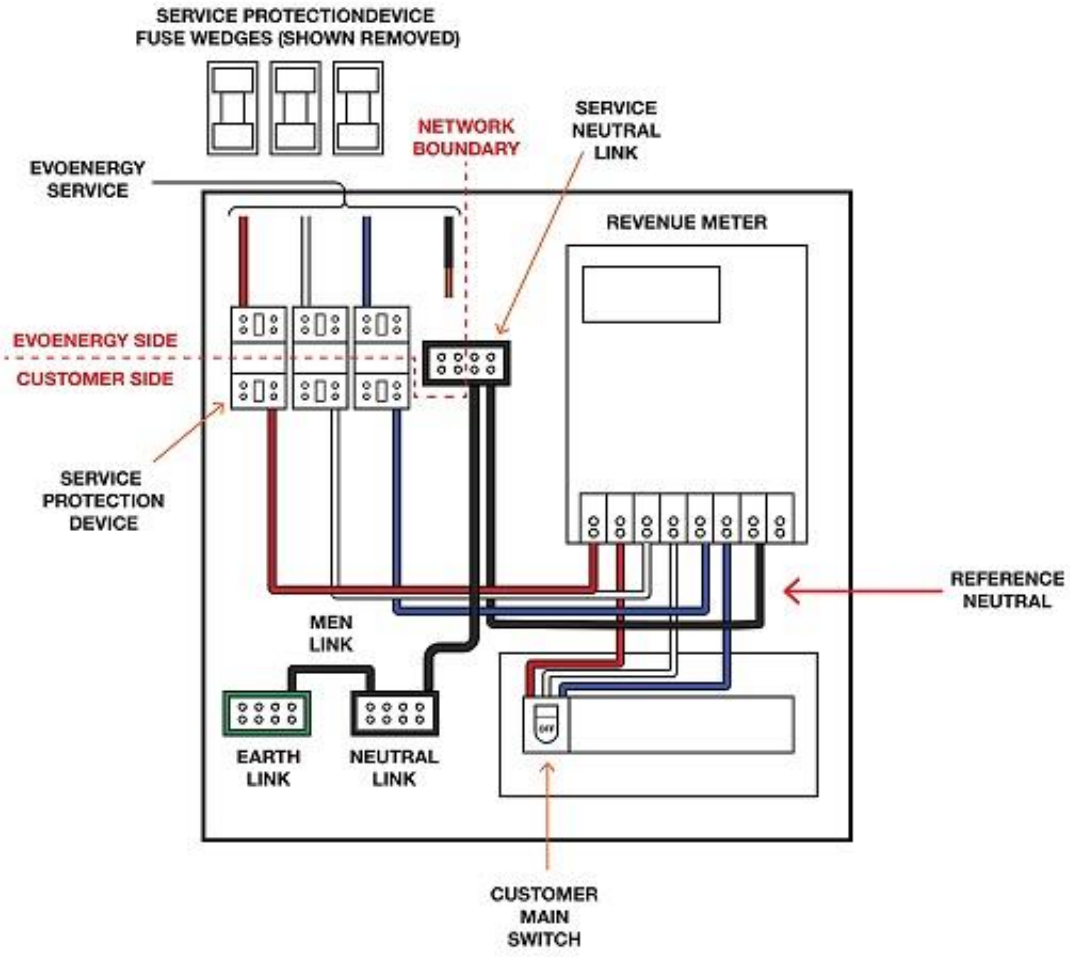


FIGURE 3. REFERENCE NEUTRAL METER CONNECTION

All test results must be recorded in Cityworks.

PRIOR TO DISCONNECTION

1. Complete JRA, including review and implementation of controls from relevant SWMS in accordance with *Job Risk Assessment (pre-start)* including mandatory PPCE
2. Perform Test 1 - PROXIMITY.
3. Perform Pre-test inspection
4. Perform Test 10 - PHASE ROTATION.

POWER ISOLATED

5. Perform Test 2 - PROVE DE-ENERGISED.

Any voltage may indicate alternative supplies are present. Alternate supplies must be isolated prior to the installation being energised

6. Perform Test 8 – INSULATION RESISTANCE TESTING for in-service cable baseline results

PERFORM WORK

7. Ensure cable ends are disconnected at each end/connection point
8. Perform Test 8 – INSULATION RESISTANCE TESTING
9. Perform Test 7 – CONTINUITY TESTING
10. Check and confirm equipment/apparatus is safe to energise

RESTORE POWER

11. Confirm cables connected at one end
12. Perform Test 3 - NEUTRAL IDENTIFICATION
13. Perform Test 6 – POLARITY
14. Perform Test 5 – VOLTAGE TESTING
15. Perform Test 10 - PHASE ROTATION.
16. Perform Test 4 - NEUTRAL INTEGRITY.
    - Test 4A – NEUTRAL INTEGRITY BY FAULT LOOP IMPEDANCE AND
    - Test 4B - NEUTRAL INTEGRITY BY INDEPENDENT EARTH AND VOLTMETER as detailed in 9.4.3.
17. Voltage test between the service neutral and the installation neutral to ensure 0 Volts
18. Voltage test colour to colour across the service fuse holders (between the service and the consumer mains) to ensure 0 Volts. (checking for alternate supply difference of potential)
19. Connect service neutral
20. Replace service fuses
21. Perform Test 1 – PROXIMITY.
22. Complete Post-test inspection

SECTION 9

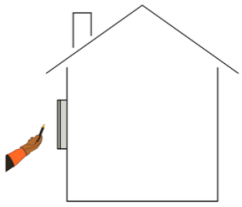
LOW VOLTAGE TESTS

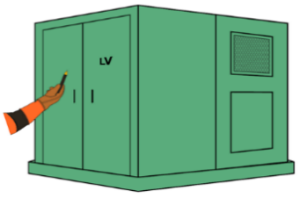
9. LOW VOLTAGE TESTS

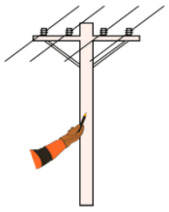
9.1 Test 1 - Proximity Testing

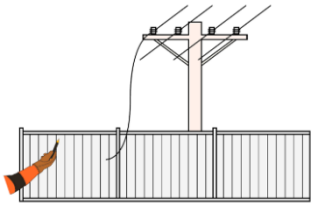
Appendix A – Non-contact test

Appendix B – Indication only









9.1.1 General

Proximity testing must be conducted:

- on approach to conductive structures/ enclosures such as meter boxes, PoE enclosures, padmount substations, conductive poles (see 9.14 Test 12 Pole leakage detection), roof gutters, riser brackets etc. Conductive elements mounted to non-conductive poles should also be checked
- after the energisation of equipment within or connected to the conductive structure/enclosure, or in the vicinity of equipment that may be energised.
- at conductive structures near to fallen conductors such as fences and hand rails

Proximity testing is a non-contact, indication only test for the presence of a hazardous voltage in a conductive structure or enclosure prior to physical contact being made by a worker.

The proximity detector is only effective on AC and will indicate a voltage has been detected when the tip of the device is placed in the proximity of 50-1000 Volts. The tip should be on or near the object being tested

As it is a non-contact device that utilises capacitive coupling to detect voltage, it can be affected by adjacent live equipment. If a live structure or enclosure is detected, verify the voltage present with a voltmeter and independent earth. If a voltage is present the worker must control the hazard by isolation or barricading, danger tag the isolating equipment, notify your supervisor and record in Cityworks

Proximity testing is not a suitable method to prove de-energised.
Test 2 - Prove de-energised is the only approved method to prove a LV cable, conductor, apparatus or structure is de-energised for access.

9.1.2 Proximity Testing Equipment Required

- PPCE as per Personal Protective Clothing and Equipment - PO0605
- Greenlee GT12A Proximity Tester

9.1.3 Steps for proximity testing with Greenlee GT-12A

1. Visually inspect the tester for any damage, if damage is identified, remove tester from service, install out of service tag and report to supervisor
2. Turn tester on, LED in tip will flash every two seconds confirming ON status and battery OK condition. If LED remains on or instantly turns off – replace batteries

Hold the start button until LED in tip flashes once – this enables the beeper. If start button is held until the LED in the tip flashes twice – beeper is disabled.

USE THIS INSTRUMENT WITH THE BEEPER ENABLED

3. Where reasonably practicable, test the proximity tester on known source
4. The red LED in the tip will flash continuously while the device beeps at the same rate if an AC voltage between 50 and 1000 Volts is present
5. If the device does not detect an AC voltage between 50 and 1000 Volts, the LED in the tip will continue to flash at a rate of once every two seconds and there will be no beeping
6. If the instrument does not perform as described in point 5 above: replace batteries and re-test. If instrument still does not perform as inspected, remove from service, report and replace.
7. To test a conductive structure, place tip of instrument on or as near as possible to structure, hold for 3 seconds and move to another location on the structure. Test either side of hinged and bolted sections.
8. The red LED in the tip will flash continuously while the device beeps at the same rate if an AC voltage between 50 and 1000 Volts is present
9. If the device does not detect an AC voltage between 50 and 1000 Volts, the LED in the tip will continue to flash at a rate of once every two seconds and there will be no beeping
10. After use, inspect instrument for any damage and test instrument again on a known live source to verify operation

9.1.4 Escalation process for live structure/enclosure

PARAMETER	VALUE	ESCALATION STEPS
IF ENCLOSURE OR STRUCTURE IS FOUND TO BE LIVE BY PROXIMITY TEST	>50 volts	1. Notify anyone on-site that may contact the structure or enclosure and take steps to prevent any person coming in contact with the structure 2. Confirm by TEST 2 - PROVE DE-ENERGISED with a voltmeter and independent earth, also test structures and enclosures in close proximity that may be connected to the local earthing system

9.2 Test 2 - Prove de-energised

Live test

Test before you touch

All low voltage cables, conductors and equipment must be proven de-energised prior to being worked on

This test must be conducted in the following circumstances:

- Prior to the access of LV equipment as per *Energised Low Voltage Works Manual*
- Prior to the application of LV bonders as per the *Earthing Construction Manual*
- Prior to working on pilot cables
- When a proximity test on a structure or enclosure has indicated a voltage is present
- As required by the *Electrical Safety Rules*

9.2.1 Prove de-energised - equipment required

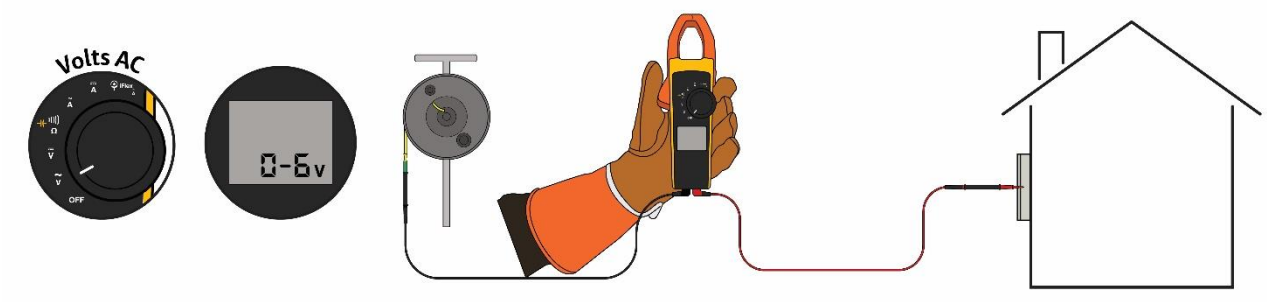
- PPCE as per Personal Protective Clothing and Equipment
- Pacific Test Equipment - Trailing Earth Lead
- Fluke 374 Voltage tester
- Fluke PRV 240 Voltage Proving unit
- Insulating materials (e.g. LV insulating mats/covers) where required as identified in the JRA or relevant SWMS, and applied per Evoenergy procedures

9.2.2 Steps for proving de-energised

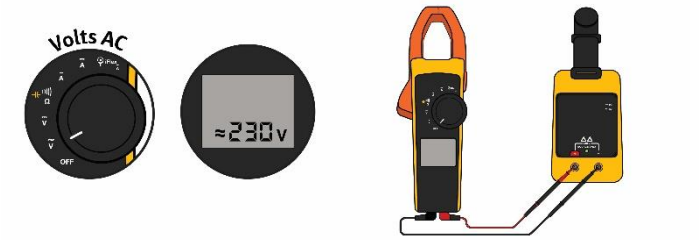
9.2.2.1 Structures and enclosures

1. Perform testing fundamentals checks
2. Ensure tester is switched to the correct function and range for AC voltage, e.g. 0-600V
3. Test the voltage tester on a known low voltage source or approved proving unit
4. Install independent earth at a minimum distance of 2 metres from any conductive object embedded in the ground connected to the system under test and connect to voltage tester lead

5. Voltage test between enclosure/structure and independent earth, note that coatings on such equipment such as paint may affect the reading so find an inconspicuous area to use the point of the test probe to dig in or scratch coating



6. Test the voltage tester on a known low voltage source or approved proving unit



7. Isolate and danger tag if voltage present and record any measured voltage.

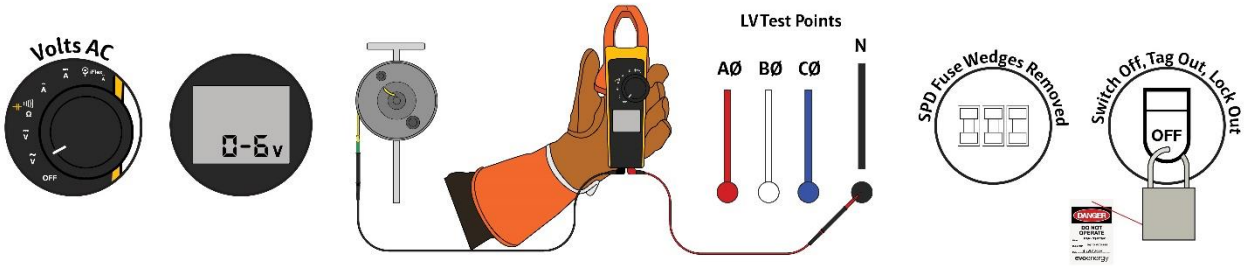
- Investigate or report issue as per 9.2.3 Escalation process for live structure/enclosure

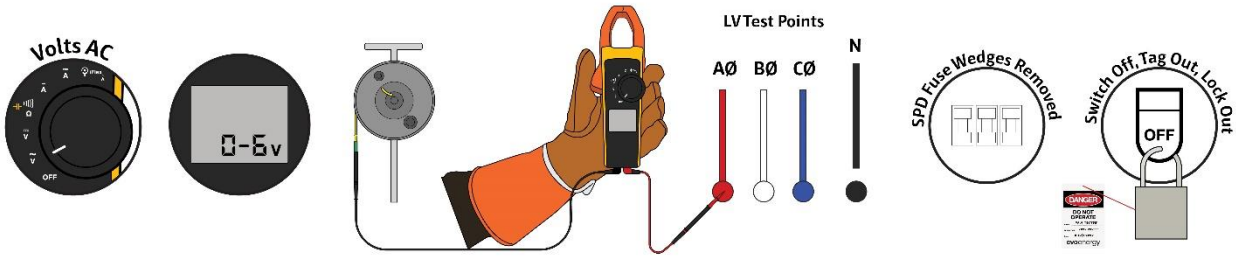
9.2.2.2 Electrical apparatus

1. Perform testing fundamentals checks
2. Ensure tester is switched to the correct function and range for AC voltage, e.g. 0-600 volts
3. Test the voltage tester on a known low voltage source or approved proving unit.

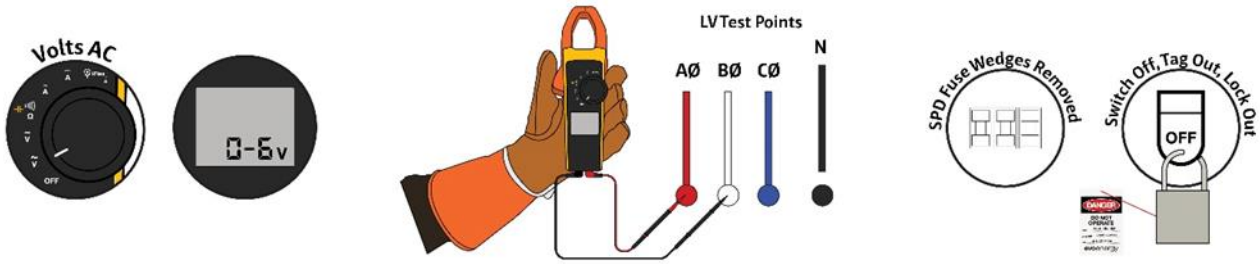
4. Install independent earth at a minimum distance of 2 metres from any conductive object embedded in the ground connected to the system under test and connect to voltage tester lead

5. Voltage test between independent earth and neutral, and, independent earth and each phase. A reading of ≈0 volts must be indicated on the voltage test device

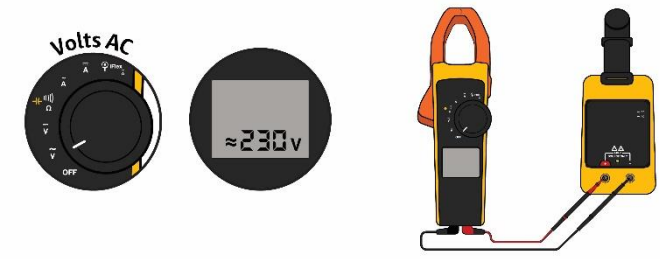




6. Disconnect independent earth and voltage test between each phase until each combination is tested. A reading of ≈0 volts must be indicated on the voltage test device.



7. Prove voltage tester on known low voltage source or approved proving unit



9.2.3 Escalation process for live structure/enclosure

PARAMETER	VALUE	ESCALATION STEPS
IF TEST 2 CONFIRMS ENCLOSURE OR STRUCTURE IS LIVE	> 6 volts	1. If reasonably practicable, isolate source immediately and notify Network Controller 02 62707557 or call Evoenergy Call Centre 131093 2. Apply locks and or danger tags at point of isolation 3. Re-test Test 2 - PROVE DE-ENERGISED at point originally tested 4. Revisit JRA, include the voltage level found with isolation and testing as the control 5. Investigate and repair if reasonably practicable, or call supervisor for assistance 6. Record relevant information, take photographs and report incorrect polarity to supervisor and in Guardian
IF ISOLATION IS NOT REASONABLY PRACTICABLE OR TESTER DOES NOT HAVE APPROPRIATE Trade Certificate		1. Notify anyone on-site that may contact the structure or enclosure and take steps to prevent any person coming in contact with the structure 2. If you are working alone, call your supervisor for assistance 3. Notify Low Voltage Network Controller 02 62707557 or call Evoenergy Call Centre 131093 4. Guard the structure to prevent persons from receiving a shock until the site can be de-energised, rectification works are completed and the structure is re-tested and proven safe to energise 5. Record relevant information, take photographs and report incorrect polarity and or energised structure/encloser to supervisor and in Guardian

9.3 Test 3 - Neutral Identification

Live test

Do not break neutral until actives are opened

9.3.1 General

The distribution network neutral conductor must be identified, confirmed by testing and tagged prior to any connection being made to the network neutral. Active conductors must be identified by testing to ensure correct phases present and voltage is within tolerance

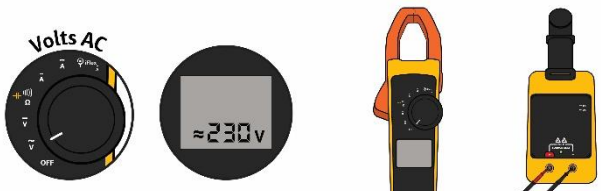
The neutral conductor must be the FIRST conductor to be connected and the LAST to be disconnected in all circumstances

9.3.2 Neutral identification equipment required

- PPCE as per Personal Protective Clothing and Equipment
- Pacific Test Equipment - Trailing Earth Lead
- Fluke 374 Voltage tester
- Fluke PRV 240 Voltage Proving unit
- Insulating materials (e.g. LV insulating mats/covers) where required as identified in the JRA or relevant SWMS, and applied per Evoenergy procedures
- Neutral identification tags

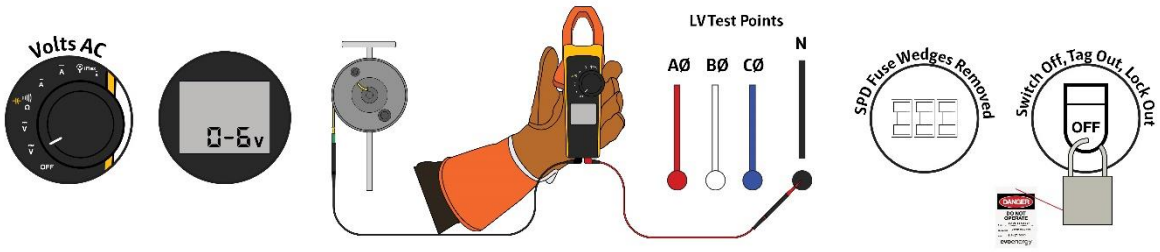
9.3.3 Neutral identification steps

1. Perform testing fundamentals checks
2. Ensure voltage tester is switched on the correct function and voltage range for AC voltage, e.g. 0 – 600 Volts
3. Test and verify the voltage tester on a known live low voltage source or approved proving unit.

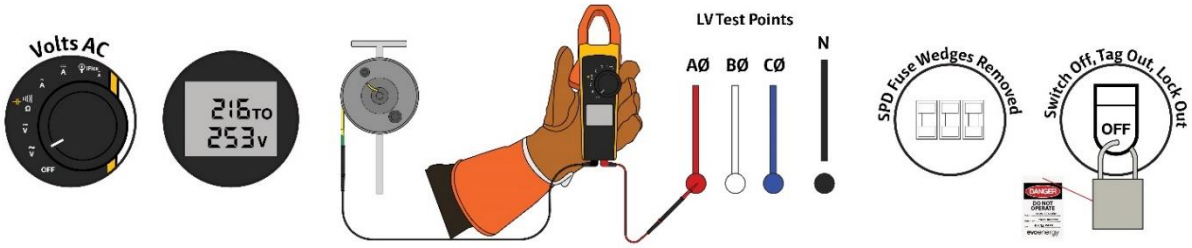


4. Install independent earth at a minimum distance of 2 metres away from any conductive object embedded in the ground connected to the system under test and connect independent earth to voltage tester lead
5. Isolate supply.

6. Voltage test between each core or conductor to the independent earth
   - ≈0 Volts should be measured between a neutral conductor and an independent earth

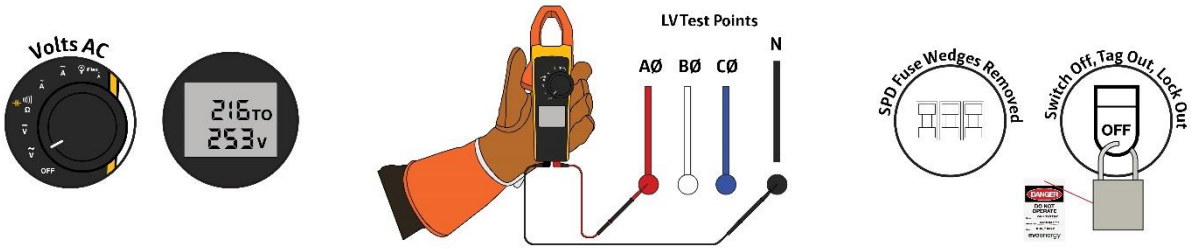


   - ≈230 volts between any phases and the independent earth



   - 230 volts between any phases and neutral

7. Once identified, the neutral must be tagged by a neutral identification tag.



9.3.4 Escalation process if neutral cannot be positively identified

PARAMETER	ESCALATION STEPS
UNABLE TO IDENTIFY NEUTRAL CONDUCTOR	1. Do not energise installation until neutral can be identified 2. Apply danger tags/ lock to prevent inadvertent energisation 3. Ensure test equipment is operational 4. Re-test installation 5. If neutral still cannot identified, contact supervisor for assistance

9.4 Test 4 - Neutral Integrity

Live Test

Neutral integrity is critical in maintaining a safe network

The integrity of an electricity distribution system neutral is essential to ensure the safety of persons, and property.

Neutral integrity testing is used to:

- Confirm that the neutral has been correctly identified
- Identify ineffective neutral connections

Neutral integrity must be tested in the following circumstances:

- After installing, jointing, re-terminating or replacing UG or OH services and network mains
- When a high neutral to earth voltage is measured
- Electric shock investigation
- Investigation of power quality complaints such as high, low, large deviations (flicker) or phase voltage imbalances.

This manual details two tests to verify the integrity of the neutral connected to an installation, both may be required depending on results of fault loop impedance test, see 9.4.3
Test 4A - NEUTRAL INTEGRITY BY FAULT LOOP IMPEDANCE utilises a fault loop impedance test device to measure the impedance of the neutral circuit between the installation and the transformer that supplies it.
Test 4B NEUTRAL INTEGRITY BY INDEPENDENT EARTH AND VOLTMETER measures the potential (voltage) difference between the neutral conductor and independent earth with a voltmeter.

Fault loop impedance (Z_{LN}) measures of the impedance of the entire loop including the active (line), neutral and transformer winding. Separate neutral impedance and line impedances measured by some instruments may be used to assist in identifying the cause of a high fault loop impedance reading.

9.4.1 Fault Loop Impedance theory

The multiple earthed neutral system (MEN) requires a low impedance neutral to maintain the neutral and earth at the same potential and to ensure adequate fault current flows to operate protective fuses and circuit breakers in the event of a phase to earth fault at an installation.

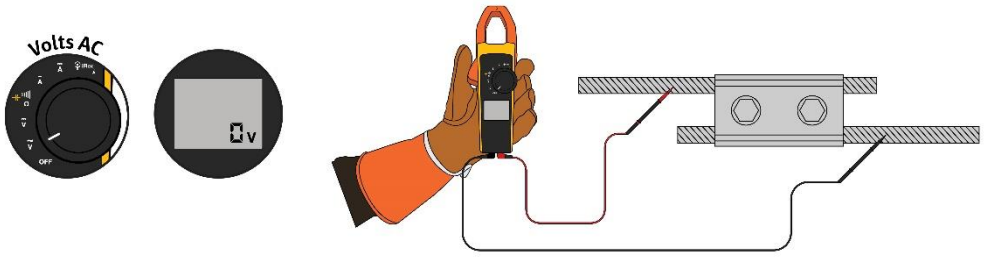
Loop impedances should be kept as low as possible to ensure operation of upstream protective devices.

Values of fault loop impedance, Z_{LN} for standard services should be below 0.5Ω.
Direct sub fed commercial services should be below 0.2Ω
See 9.4.3.Neutral Integrity Decision Tree for values and escalation process.

9.4.2 Causes of high loop impedance

High loop impedance can be caused by one, or a combination of factors listed below,

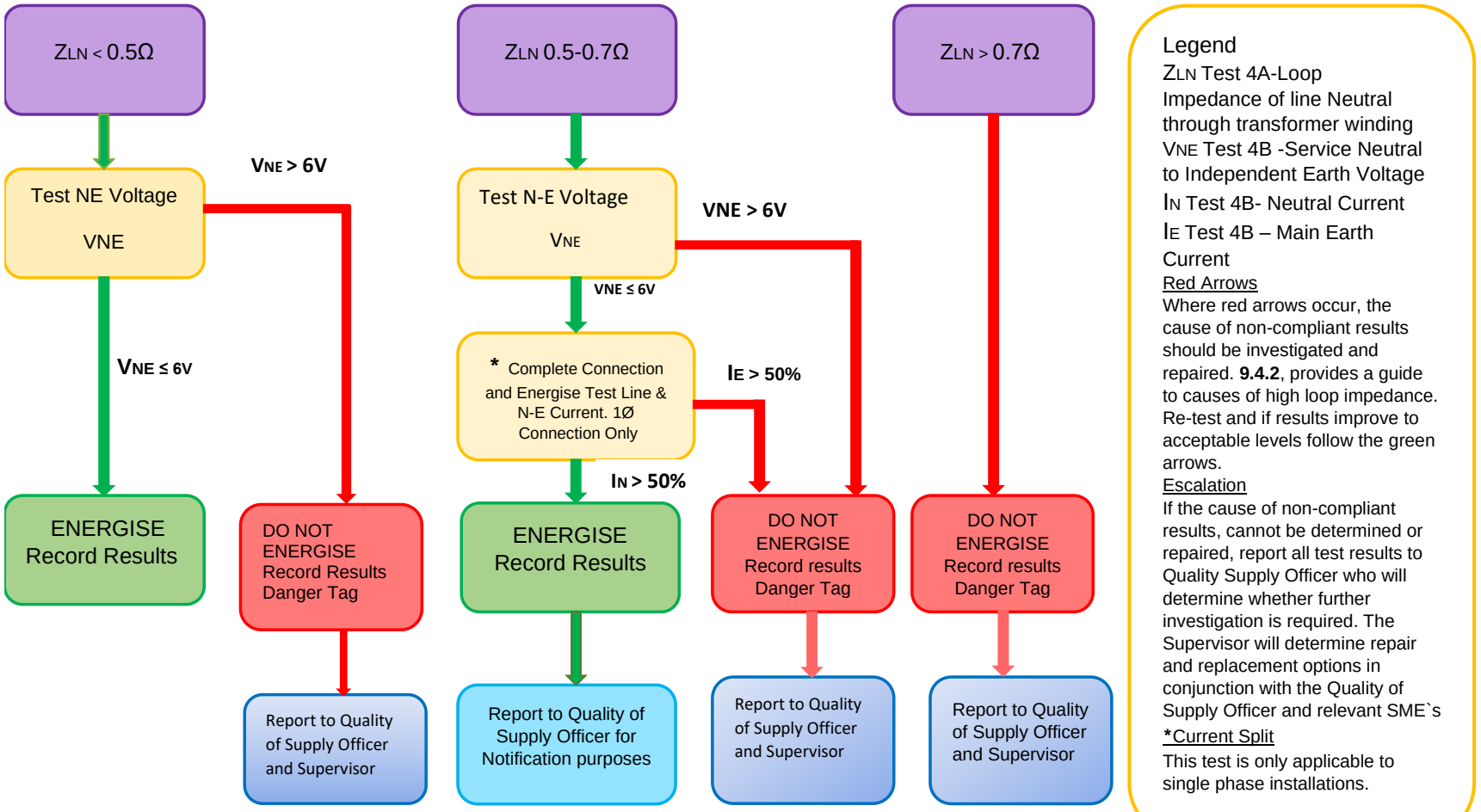
- Loose connection
  - Incorrect connector for size of cable.
  - Connector not correctly installed
  - Thread bound up prior to reaching full level of conductor compression
  - Shear-bolt sheared before reaching specified torque
  - Loosened by vibration, wind etc.
  - Mechanical failure of connector or fastener (over tightened, faulty etc.)
  - Connector not correctly installed
  - Cables/conductors not twisted in tunnel terminals
- High resistance/open circuit connection
  - Incorrect connector i.e. aluminium only on copper conductor, bi-metal installed the wrong way around with copper to aluminium and aluminium to copper
  - Failure to make neutral connection
  - Cables/conductors not inserted into connector far enough to make adequate contact
  - Moisture ingress into sealed connection (HSC)
  - Poor contact or burnt fuse/fuseway contacts
  - Failure of teeth to pierce insulation and make adequate contact with conductor
  - Copper above aluminium in bare overhead arrangement degrading connection
  - Arcing from insulation breakdown degrading conductor
  - Crimped with incorrect or faulty tool or dies
  - Broken conductor or connector
  - Transformer fault
- Voltage drop
  - Long circuit length from substation with large voltage drop in mains and service cables/conductors



Checking connections:
Measuring voltage drop across a connector, should ≈0V, any volts dropped are a result of impedance from a poor connection *see image above.*

9.4.3 Neutral Integrity Decision Tree

9.4.3.1 Neutral integrity for services NOT directly connected to a substation



Legend

ZLN Test 4A-Loop Impedance of line Neutral through transformer winding

VNE Test 4B -Service Neutral to Independent Earth Voltage

IN Test 4B- Neutral Current

IE Test 4B – Main Earth Current

Red Arrows

Where red arrows occur, the cause of non-compliant results should be investigated and repaired. **9.4.2**, provides a guide to causes of high loop impedance. Re-test and if results improve to acceptable levels follow the green arrows.

Escalation

If the cause of non-compliant results, cannot be determined or repaired, report all test results to Quality Supply Officer who will determine whether further investigation is required. The Supervisor will determine repair and replacement options in conjunction with the Quality of Supply Officer and relevant SME`s

*Current Split

This test is only applicable to single phase installations.

9.4.3.2 Neutral integrity for services DIRECTLY connected to a substation

9.5 Test 4A - Neutral Integrity by Fault Loop Impedance Tester

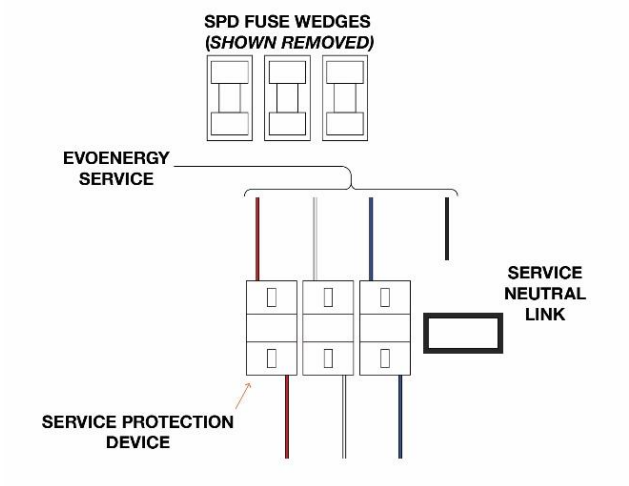
Live test

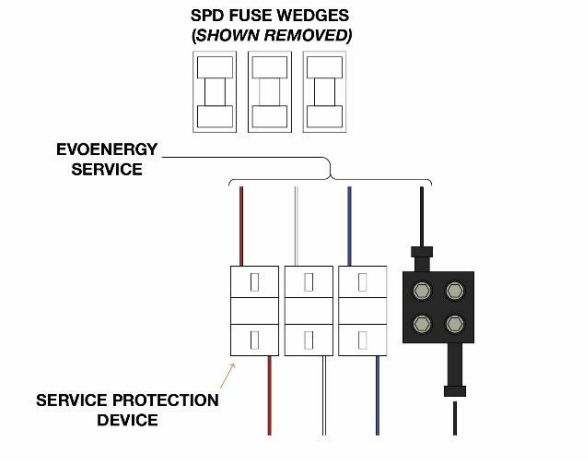
9.5.1 Neutral integrity by fault loop impedance - equipment required

- PPCE as per Personal Protective Clothing and Equipment
- CABAC T2726 Neutral integrity tester
- Insulating materials (e.g. LV insulating mats/covers) where required as identified in the JRA or relevant SWMS, and applied per Evoenergy procedures

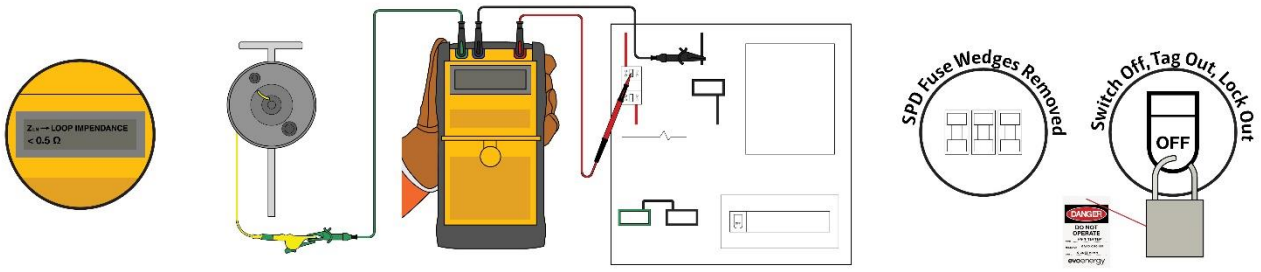
9.5.2 Neutral integrity by fault loop impedance steps

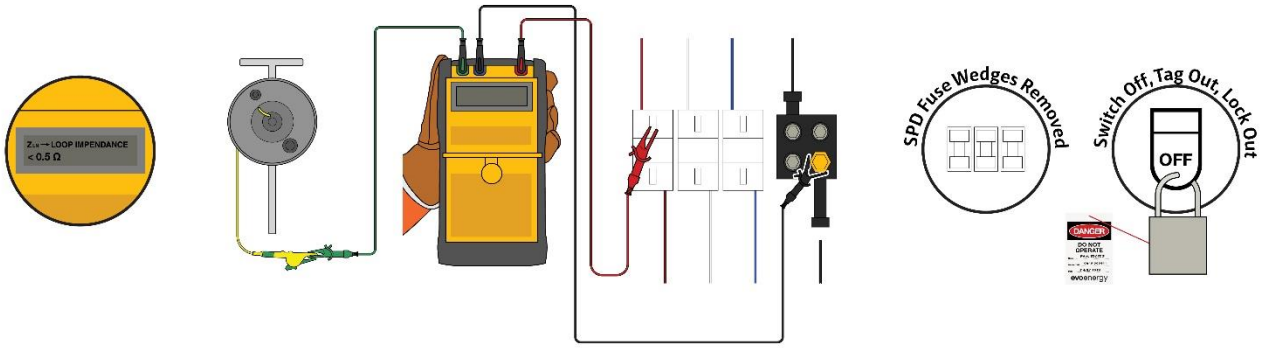
1. Perform testing fundamentals checks
2. Install independent earth at a minimum distance of 2 metres away from any conductive object embedded in the ground or connected to the system under test and connect independent earth to voltage tester lead
3. Isolate the supply to the installation and disconnect the service neutral from the installation (MEN break).
   - For meter box and PoE, disconnect the service neutral conductor NOT the MEN link.
   - For PoA, Terminate the service in the house neutral connector, leave the consumer mains out. Remove one of the consumer main shear-bolts and temporarily replace with the approved test bolt.





4. Connect and test the fault loop impedance as per the following:
    - E terminal (green), via green test lead, to an independent earth AS4741 mentions that the earth reference shall be an effective independent earth. The installation may be used as the independent earth, if the earthing system is proven to be isolated from the neutral.
    -
    - N terminal (blue), via black test lead, to service neutral (for PoA, connect alligator clip to head of test bolt).
    - L terminal (red), via red test lead, to each service phase

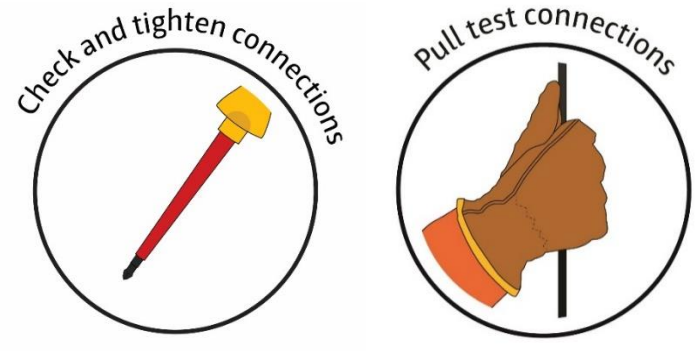




5. Record the impedance values in Cityworks.
6. If the measured value is above the values in 9.4.3 Neutral Integrity Decision Tree, the result must be approved by the Quality of Supply Officer.

Do not re-energise the installation until advised that it is safe to do so. If reasonably practicable visually inspect the service and mains between the installation and the transformer, pay particular attention to connections and terminations being loose, burnt, damaged or missing

7. If an issue on the neutral is identified and rectified, re-perform this test to verify neutral integrity, keep any failed connectors or components and raise a Guardian incident, including relevant information and photographs.
8. Restore the service neutral (remove test bolt and replace with shear-bolt from house neutral connector for PoA) – ensure all connections under test are re- tightened and pull tested.



9. Perform Post-test inspection

9.6 Test 4B - Neutral Integrity By Independent Earth And Voltmeter

Live Test

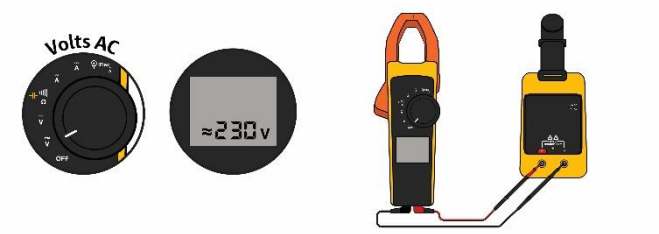
Used in conjunction with fault loop impedance testing

9.6.1 Neutral integrity by independent earth and voltmeter - equipment required

- PPCE as per Personal Protective Clothing and Equipment
- Pacific Test Equipment - Trailing Earth Lead
- Fluke 374 Tong Ammeter
- Fluke PRV 240 Voltage Proving unit
- Insulating materials (e.g. LV insulating mats/covers) where required as identified in the JRA or relevant SWMS, and applied per Evoenergy procedures

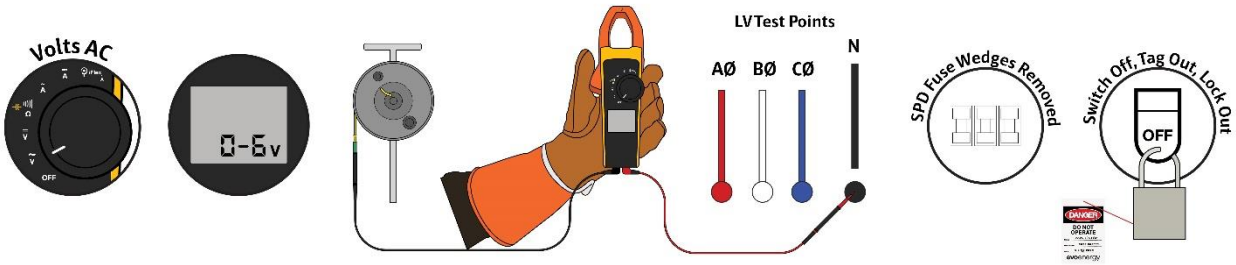
9.6.2 Neutral integrity by independent earth and voltmeter steps

1. Perform testing fundamentals checks
2. Ensure voltage tester is switched to the correct function and voltage range for AC voltage, 0 – 600 V
3. Test and verify the voltage tester on a known low voltage source or approved proving unit.



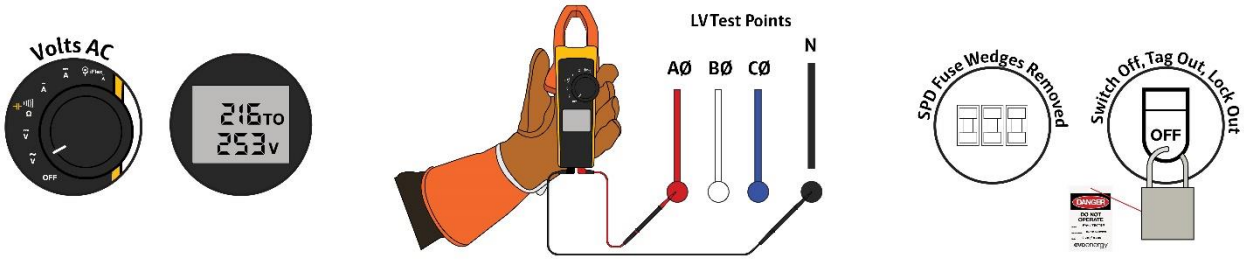
4. Install independent earth at a minimum distance of 2 metres away from any conductive object embedded in the ground or connected to the system under test
5. Perform Test 6 - Polarity to confirm the polarity of the supply is correct
6. Isolate the supply and disconnect the neutral.

7. PART A - Measure and record the voltage between the supply neutral and the independent earth

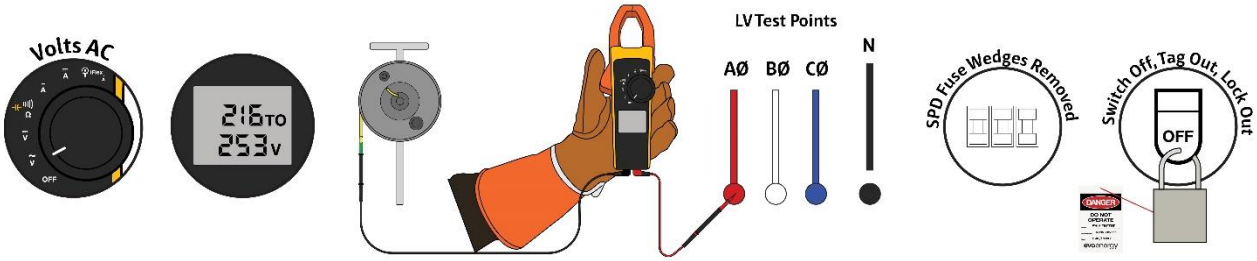


8. Measure and record the voltages between

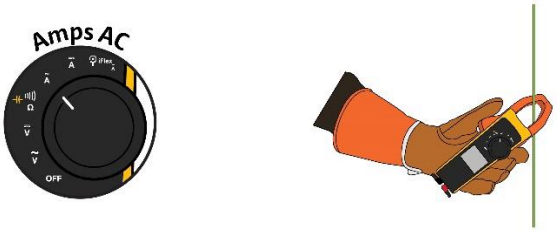
   i. each phase and neutral;



   ii. each phase and independent earth.

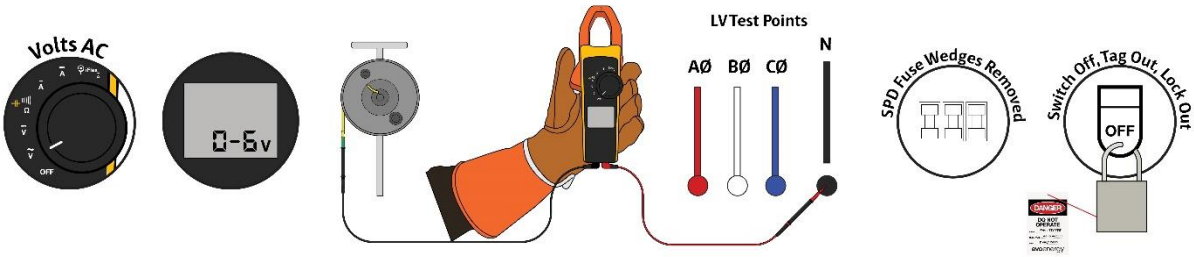


9. Measure the current on the main earth with an approved tong ammeter and record the result. If access is not available – escalate to Quality of Supply



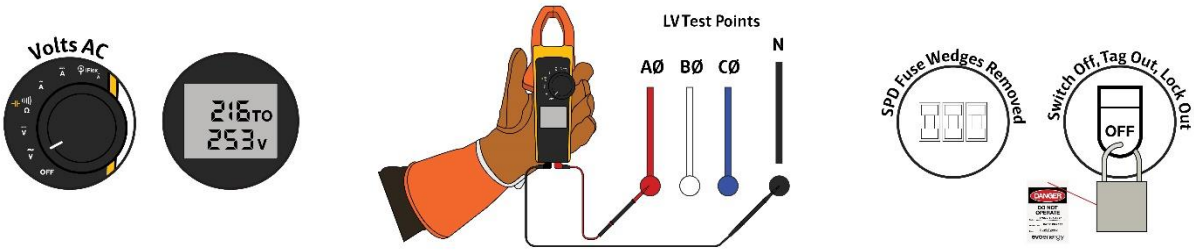
10. PART B - Install an approved load bank so that it is the only load on the service (individually on each phase) Use the test bolt for house neutral connector if testing at PoA.

11. Measure and record the voltage between the supply neutral and the independent earth

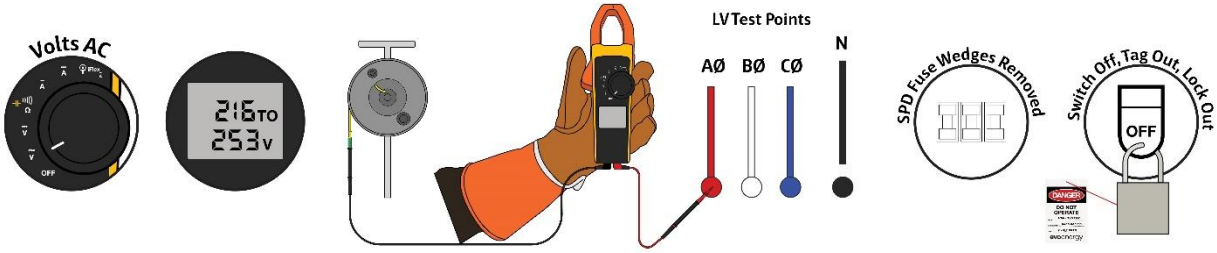


12. Measure and record the voltages between

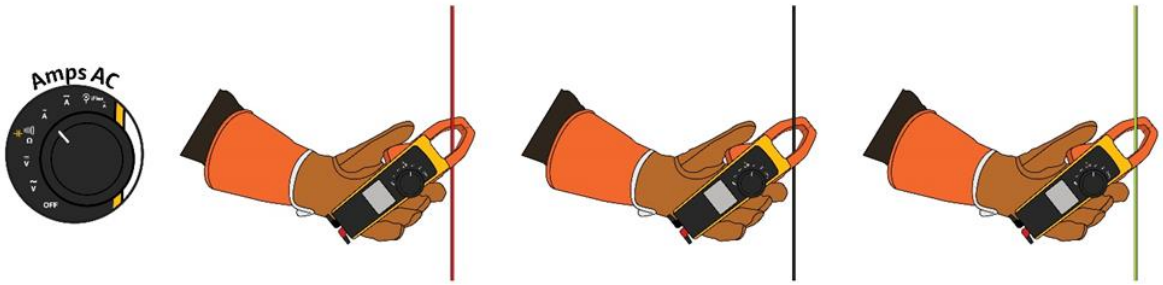
i. each phase and neutral and;



ii. each phase and independent earth.



13. PART C - Measure the currents flowing through both the supply neutral and the main earth.



The neutral must be carrying more than 50% of the total current to be considered acceptable

9.7 Test 5 - Voltage testing

Voltage testing is essential to ensure:

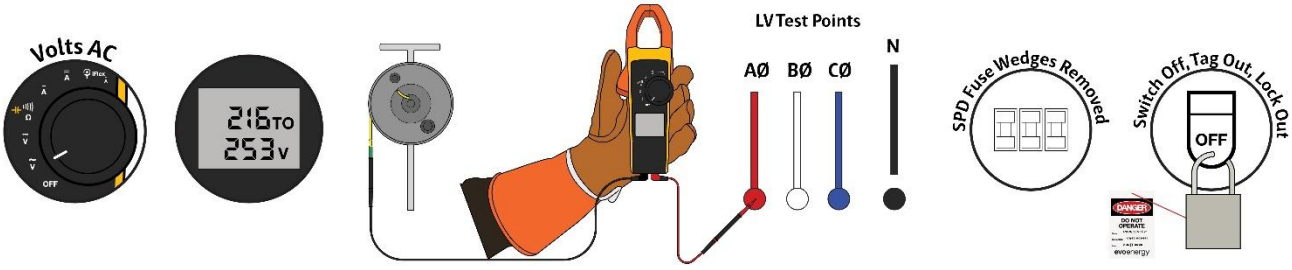
- The state of energisation of any cable, conductor or piece of equipment
- The correct polarity of cable cores and conductors prior to energising a customer installation or at any point within the network
- The voltage supplied to a customer installation is within the voltage tolerance defined in *AS60038 and AS61000.3.100*

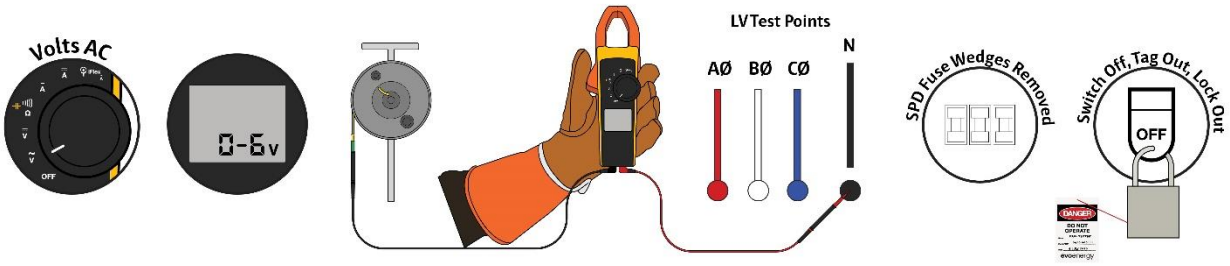
9.7.1 Voltage testing - equipment required

- PPCE as per Personal Protective Clothing and Equipment
- Pacific Test Equipment - Trailing Earth Lead
- Fluke 374 Voltage tester
- Fluke PRV 240 Voltage Proving unit
- Insulating materials (e.g. LV insulating mats/covers) where required as identified in the JRA or relevant SWMS, and applied per Evoenergy procedures

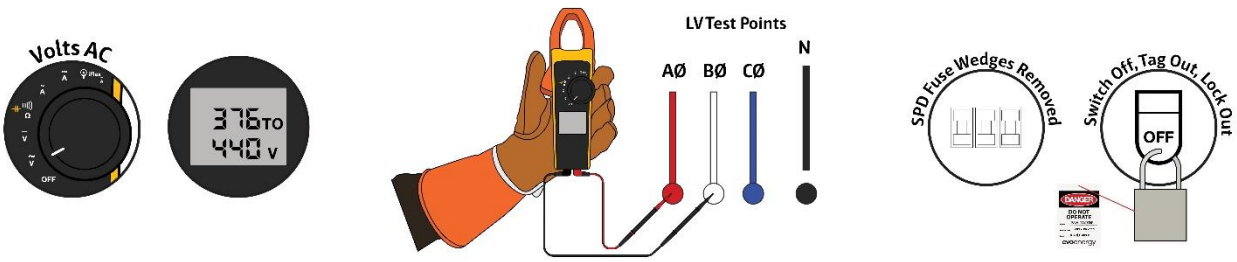
9.7.2 Steps for voltage testing

1. Perform testing fundamentals checks
2. Ensure tester is switched to the correct function and range for AC voltage, 0-600 Volts
3. Test and verify the voltage tester on a known low voltage source or approved proving unit.
4. Install independent earth at a minimum distance of 2 metres away from any conductive object embedded in the ground connected to the system under test and connect independent earth to voltage tester lead
5. Voltage test between each phase, and neutral cable conductor, to independent earth. See 9.7.3 for acceptable voltage tolerances.

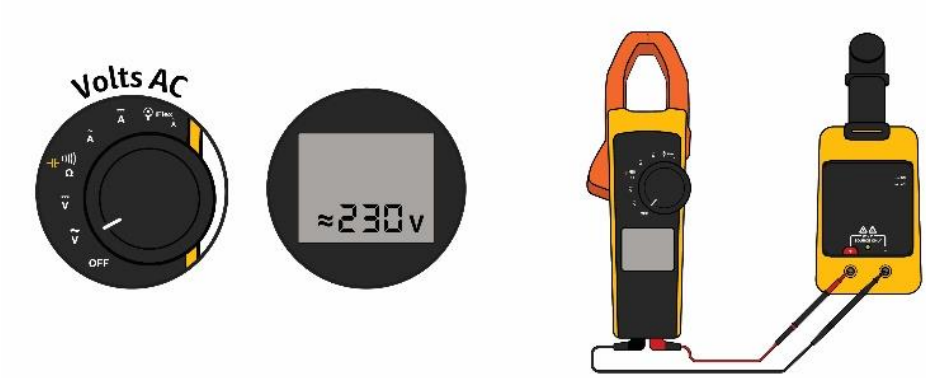




6. Disconnect independent earth and then voltage test between each conductor until each combination of pairs is tested. See 9.7.3 for acceptable voltage tolerances



7. Record results in Cityworks
8. Prove voltage tester on known low voltage source or approved proving unit



9.7.3 Voltage Tolerance

The nominal voltage for a low voltage system in Australia, in accordance *Australian Standard AS60038* is:

- 230 Volts measured from a phase to earth or neutral and
- 400 Volts measured between any two phases.
- The voltage tolerance is +10%, -6% of the nominated supply voltage.

Non-compliance with the Australian Standard voltage tolerances listed in Table 5 may cause damage to network and customer's equipment

Australian Standard Voltages and Voltage Tolerances for Low Voltage Systems

TEST TYPE	CONNECT VOLTAGE TEST DEVICE BETWEEN	NOMINAL VOLTAGE READING	VOLTAGE TOLERANCE
N to E	Independent Earth and Supply Neutral	0 volts	0 – 6 volts
Ø to E	Independent Earth and Supply Active(s)	230 volts	216 – 253 volts
Ø to N	Supply Neutral to Supply Active(s)	230 volts	216 – 253 volts
Ø to Ø	Supply Active/s	400 volts	376 – 440 volts
Ø to Ø	Supply Actives of same phase	0 volts	0 – 30 volts

9.7.4 Voltage tolerance escalation process

PARAMETER	VALUE	ESCALATION STEPS
VOLTAGE TOLERANCE	>253 volts, A - N	• Perform neutral integrity (Test 4A), record results on Cityworks form, note date, time and weather conditions. • Forward form to Quality of supply for action
	<216 volts, A - N	• Perform neutral integrity (Test 4A), record results on Cityworks form, note date, time and weather conditions. • Forward form to Quality of supply for action
3Ø VOLTAGE BALANCE	> +10%(23v), -6%(14v), Ø - Ø	9. Perform neutral integrity (Test 4A) 10. Forward form to Quality of supply for action

9.8 Test 6 - Polarity Testing

Live Test

Essential test for proving neutral

In order for polarity testing to be effective the neutral at the installation being tested must be separated from the earthing system at the PoE/PoA. The earth reference for testing purposes is achieved by the use of an approved independent earth or system earth as denoted in the earthing hierarchy described in the Electrical Safety Rules.

Polarity testing is essential to ensure:

- The prevention of electric shock by identifying conditions where active and neutral conductors have been incorrectly connected (transposed).

Note: If the neutral is to be disconnected from the earthing system at an installation, the actives must be de-energised first

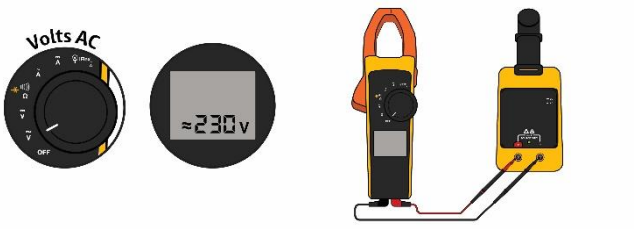
The transposition of active and neutral conductors will result in the energisation of the earthing system and consequently the energising of exposed conductive parts connected to the earthing system.

9.8.1 Polarity testing – equipment required

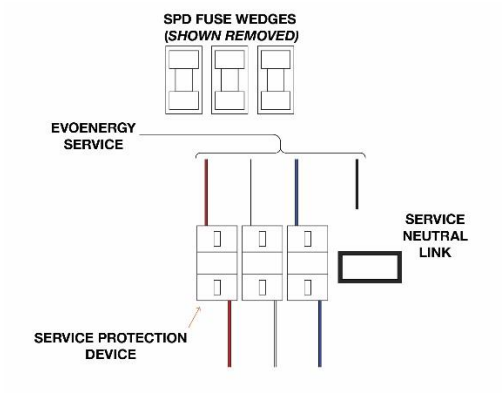
- PPCE as per Personal Protective Clothing and Equipment
- Pacific Test Equipment - Trailing Earth Lead
- Fluke 374 Voltage tester
- Fluke PRV 240 Voltage Proving unit

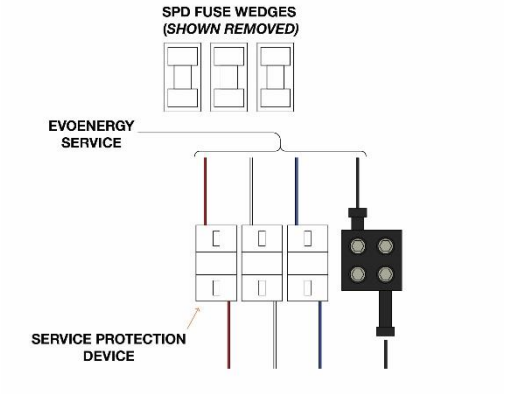
9.8.2 Polarity testing steps

1. Perform testing fundamentals checks
2. Ensure tester is switched to the correct function and range for AC voltage, 0-600 Volts
3. Test and verify the voltage tester on a known low voltage source or approved proving unit.

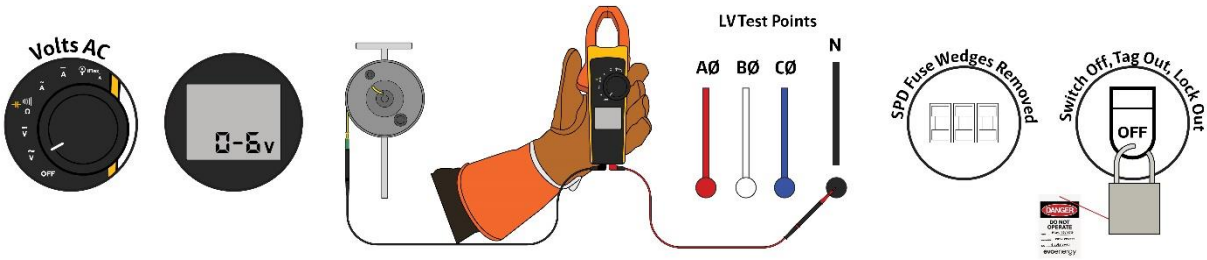


4. Install independent earth at a minimum distance of 2 metres away from any conductive object embedded in the ground connected to the system under test and connect independent earth to voltage tester lead
5. Ensure that the neutral under test is disconnected.

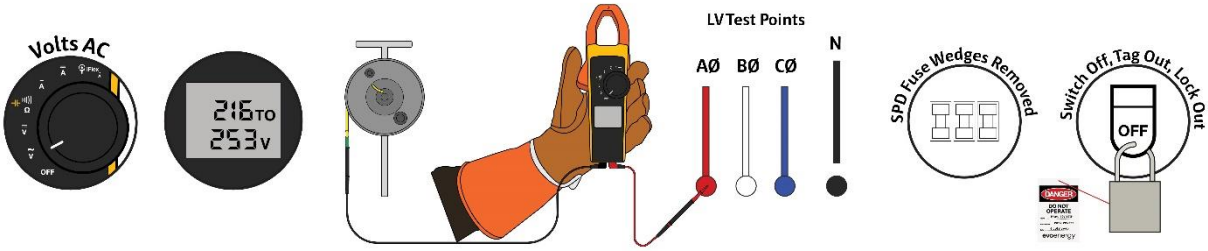




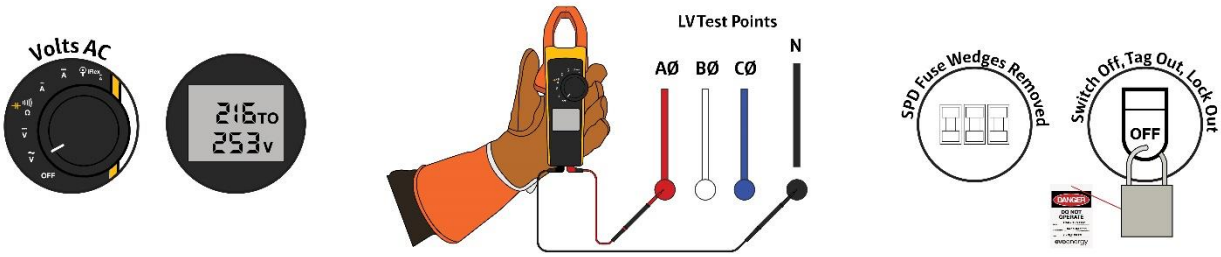
6. Perform Test 3 – Neutral identification and mark neutral
7. Perform tests and record in Cityworks:
    i. Independent earth to neutral –≈ 0 volts



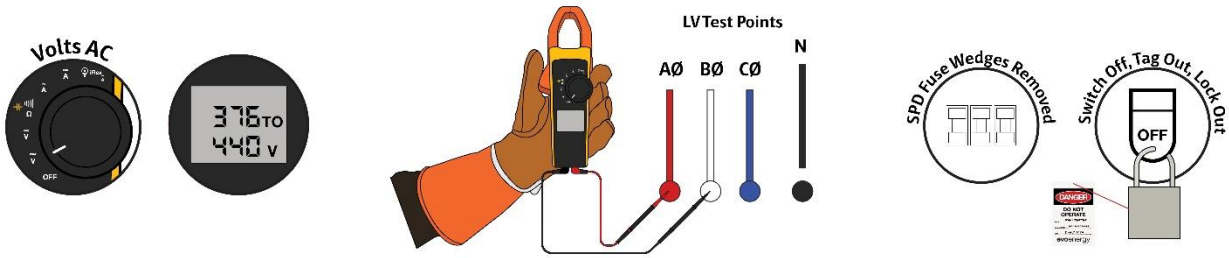
    ii. Independent earth to each phase – 230 volts



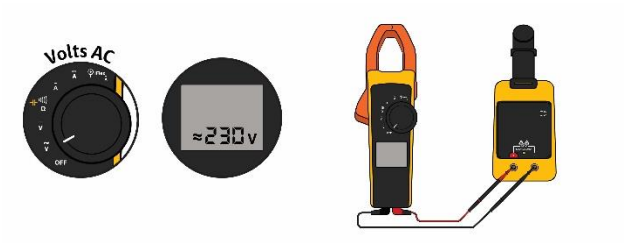
iii. Neutral to each phase - 230 volts



iv. Each combination of phase to phase – 400 volts



8. Prove voltage tester on known low voltage source or approved proving unit



9.8.3 Polarity testing escalation process

PARAMETER	MEASUREMENT	ESCALATION STEPS

INCORRECT POLARITY	System voltage on neutral conductor	• Do not energise. Apply danger tags/lock out as required
		• Notify supervisor
		• Investigate and identify source of incorrect polarity by one or a number of the following:
		  • Visual inspection (Pre-test)
		  • Continuity test (Test 7)
		  • Insulation resistance (Test 8)
		  • Voltage test at remote end (Test 5)
		• Rectify polarity
		• Re-test and confirm polarity correct

		• Record relevant information in Guardian

9.9 Test 7 - Continuity Testing

De-energised test

Identifies open circuit situations

Continuity testing is conducted prior to insulation resistance testing to ensure testing there are no open circuit cores within the cable and to identify and verify the cores have not been transposed in a cable joint or other connection in the circuit

Continuity testing is also utilised to verify cable “colours” to ensure the correct cores are joined in an inline joint so that correct polarity and phasing can be achieved. Insulation tape must be used to mark cores

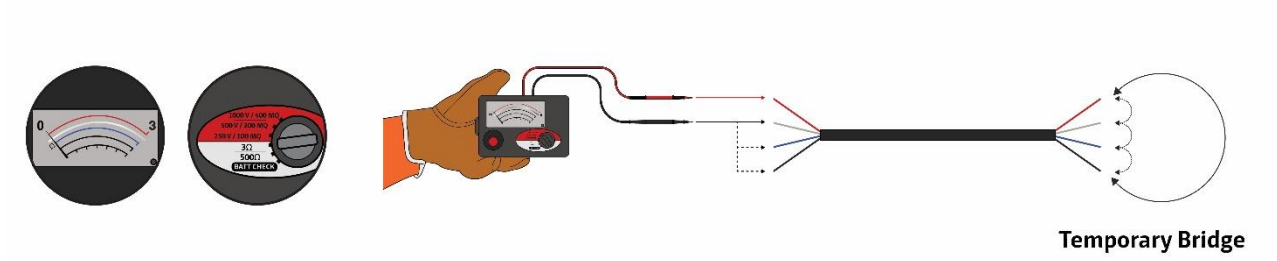
Coloured cable cores do not guarantee that there has not been a “roll” in a cable joint

9.9.1 Continuity testing – equipment required

- PPCE as per Personal Protective Clothing and Equipment
- Kyoritsu 3132A Insulation Resistance and Continuity Tester
- Test leads, ideally with alligator clamps for creating temporary short circuits for testing
- Communication device such as mobile phone or walkie talkie for long cable runs
- Insulating materials (e.g. LV insulating mats/covers) where required as identified in the JRA or relevant SWMS, and applied per Evoenergy procedures

9.9.2 Continuity testing steps

1. Perform testing fundamentals checks
2. Isolate equipment to be tested and perform Test 2 - PROVE DE-ENERGISED
3. Ensure that the equipment under test is isolated from equipment that may affect the test results
4. Install the shorting test leads at the remote end. If a long length of cable is being tested, a second person with a communication device may be required to operate the short circuit test leads.



5. Select the cores or conductors to be tested. Using an approved insulation resistance tester set on the Ω setting, test between each core until each combination of pairs is tested.

Results should be within 10% of each other – if not it may indicate a loose connection and/or a high resistance joint.

A reading of ∞ will indicate non-continuity

9.10 Test 8 - Insulation Resistance Testing

De-energised test

Hazardous voltages may exist

Insulation resistance testing is a final step prior to energisation of cables and/or equipment and must be carried out after the cables have been terminated and/or backfilled, the backfill compacted, the cables clamped. It is used to prove;

- Equipment is safe to energise
- The apparatus, conductor, associated joints and terminations are not damaged or degrading to a point that may cause a short in the circuit, or a current leakage resulting electric shock or temperature rise, further damaging insulation.

Existing cables shall be insulation resistance tested upon de-energisation and prior to re-energisation to ensure that no damage has occurred while the cable was de-energised

9.10.1 Insulation resistance tester - Safety

Insulation resistance testers can deliver voltages hazardous to humans and can be damaging to electrical equipment. It is essential that the person conducting the testing is fully aware of the scope of the test, i.e. all connected equipment subject to test voltages.

Insulation resistance testing can also cause equipment, particularly cables to retain a voltage after the testing is complete. This is due to the capacitance characteristic of combinations of conducting and insulating materials. Long cable runs in particular can store a vast amount of energy and must be discharged when testing is complete

9.10.2 Insulation resistance tester - Controls

As per the *Electrical Safety Rules* the person conducting the test must mitigate the risk of electric shock by assessing the situation and applying applicable controls including:

- Communication – Tell people that testing is to be conducted and that they must stand clear until notified of completion
- The use of safety observers – To prevent persons coming into contact with equipment under test
- Insulated covers and or mats – To insulate people from equipment under test
- Signage/Danger tags - To warn people of equipment under test
- Secured cabinets and enclosures – Where reasonably practicable, close and lock doors to prevent contact
- Discharge tested equipment after test – ensure that residual voltage cannot cause electric shock

9.10.3 Precautions when insulation resistance testing

Electrical and electronic equipment can be irreparably damaged by voltages in excess of the equipment's rated value. Test voltages must only be applied to equipment on the Evoenergy side of the network boundary.

Fuses, circuit breakers or main switches must be opened to prevent test voltages being applied to consumer equipment.

Cables and apparatus should not be subjected to insulation resistance tests at a test voltage that is higher than the rated insulation value specified by the manufacturer of the equipment. This can cause damage and premature failure of the insulation. Voltage values stated in 9.10.5 must be adhered to and care must be taken to ensure that insulation resistance testers are set to the correct test voltage prior to testing.

9.10.4 Insulation resistance testing of OH and UG mains and services.

Insulation resistance testing of OH and UG mains and services is mandatory in the following circumstances:

- Prior to energising new installations
- After the installation of any new or replacement service or mains cable or apparatus
- Prior to and after the replacement, augmentation, repair or relocation of service or mains cable or apparatus
- When a cable or apparatus is suspected to have a fault
- When there is any doubt about condition, particularly the integrity of insulation of a cable or apparatus

Note: Wet and humid conditions can lower the value of insulation resistance test results

9.10.5 Effective insulation resistance testing

As this test is a resistance measurement, it is essential that the test probes and clamps make an effective connection with the material being tested thus preventing an elevated insulation resistance reading. This can be achieved by:

- Brushing of conductors to remove contaminants and oxidisation
- Being aware that dirt, oil, rust, surface coatings such as paint, powder coat, galvanisation, plating anodising etc. can cause elevated insulation resistance readings. Select an appropriate place to attach probes and clean surface if necessary

LV apparatus must not be tested at voltages that exceed the apparatus insulation rating.

TABLE 1. INSULATION RESISTANCE TEST VOLTAGES, DURATIONS AND EXPECTED INSULATION RESISTANCE VALUES FOR LOW VOLTAGE EQUIPMENT

EQUIPMENT TYPE	TEST VOLTAGE (V)	TEST DURATION (MINS)	NEW EQUIP [3] (MΩ)	EXISTING EQUIP [4] (MΩ)	PERSON AUTHORISED [1]
CONSUMER MAINS [2]	500	1	50	50	Licensed Electrician
CUSTOMER INSTALLATION [2]	500	1	1	1	Licensed Electrician
LV UG & OH SERVICES	500	1	100	20	Authorised Worker
LV UG & OH MAINS	500	1	100	20	Authorised Worker
LOW VOLTAGE SWITCHGEAR	500	1	100	20	Authorised Worker

1. A worker with technical knowledge or sufficient experience who has been approved or has the delegated authority to act on behalf of the electrical distribution company to perform the duty concerned
2. This testing is beyond the network boundary and not normally undertaken by Evoenergy staff
3. New is defined as apparatus that has not previously been commissioned
4. Existing applies to apparatus that has previously been in service
5. When test results do not meet the above requirements see section 11 for Advanced Testing.

Insulation resistance tests must be minimum 1 minute duration

9.10.6 Insulation resistance testing of de-energised existing cables

Where a cable has had an Insulation Resistance Test within three hours of de-energisation, this pre-work IRT value (baseline) must be reached or exceeded before re-energisation. An appropriate priority defect must be raised in line with Section 11.1.3. Low Voltage Insulation Test Escalation Process. If the baseline value cannot be met or exceeded, follow the flow chart outlined in Section 11.1.3. Low Voltage Insulation Test Escalation Process.

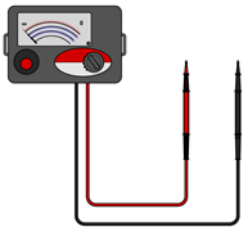
Equipment

- PPCE as per Personal Protective Clothing and Equipment
- Kyoritsu 3132A Insulation Resistance and Continuity Tester
- Pacific Test Equipment - Trailing Earth Lead
- Insulating materials (e.g., LV insulating mats/covers) where required as identified in the JRA or relevant SWMS, and applied per Evoenergy procedures

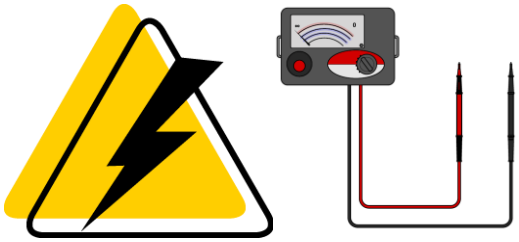
9.10.7 Insulation resistance testing steps

1. Perform testing fundamentals checks
2. Isolate equipment to be tested and perform Test 2 - PROVE DE-ENERGISED
3. Ensure that the equipment under test is isolated from equipment that may be adversely affected by the testing or may affect the test results

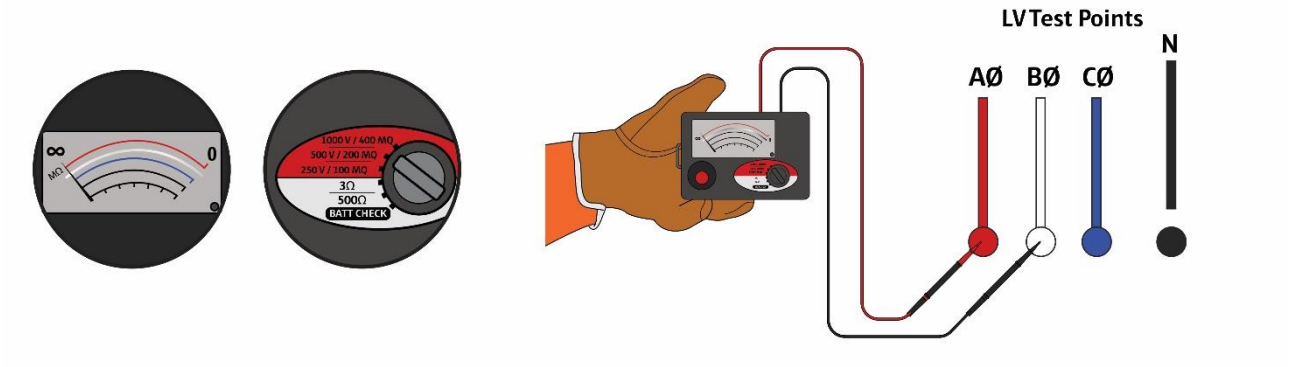
4. Select the test voltage on the insulation resistance tester as defined in 9.10.5
5. Connect the test leads together and press test button. The result should be 0Ω. If the result is not 0, check and replace the batteries and adjust the zero point as described in the manual for the insulation resistance tester



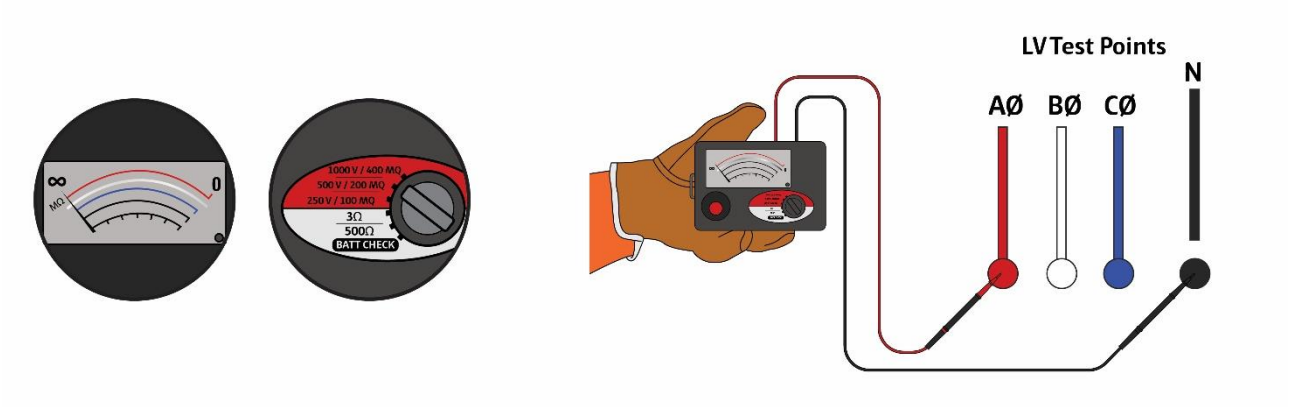
6. Notify people in vicinity the type testing taking place and the equipment under test. Ensure people cannot receive a shock from the test, implement controls identified by the JRA,



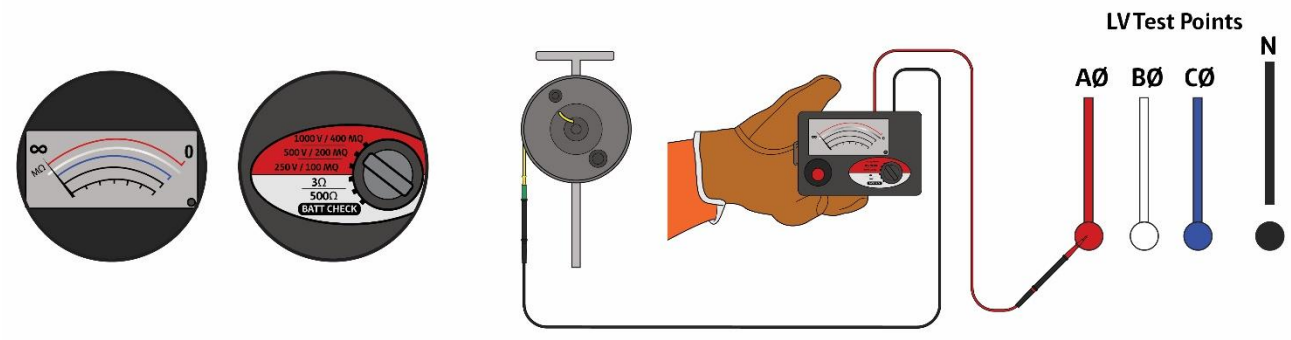
7. Perform tests and record in Cityworks
    - Test each combination phase to phase



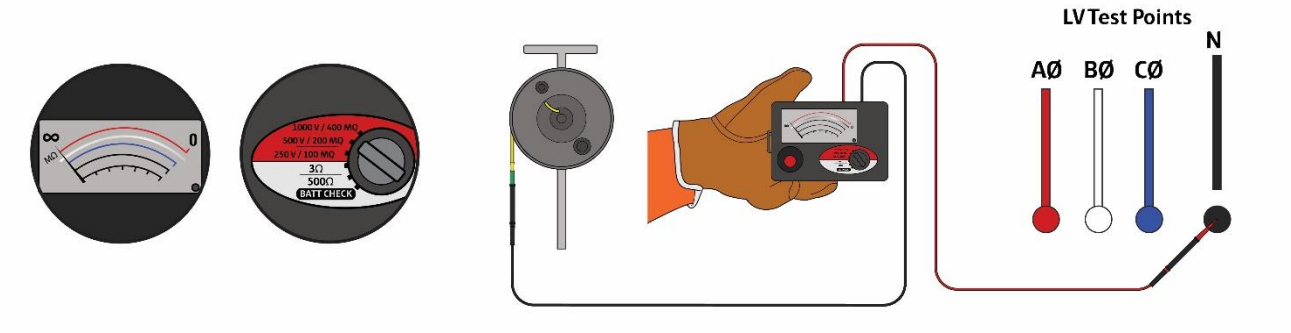
    - Test each combination phase to neutral



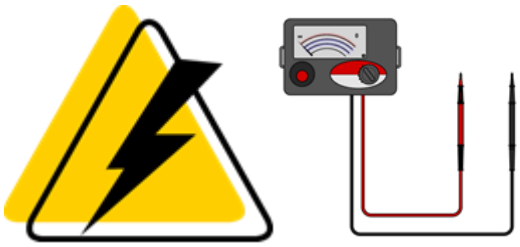
- Test each combination phase to earth



- Test neutral to earth



8. Discharge tested equipment, this can be done by the insulation resistance tester – refer testers cover for instructions



9. Notify people on-site testing and discharging is complete

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9.11 Test 9 - Network Phasing

Live Test

Must be done before connecting two potential sources of supply

The paralleling of network circuits can cause serious injury. Connection of different phases will result in a short circuit explosive/arc flash environment.

9.11.1 Phasing must be carried out

- Prior to closing of links, switches and bridges that will connect one or more active phases
- Across network open points after work to conductors or cabling that may affect the phases connected to either side of the open point

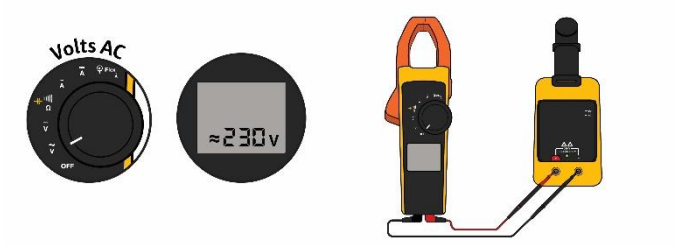
9.11.2 Network phasing equipment required

- PPCE as per Personal Protective Clothing and Equipment
- Pacific Test Equipment - Trailing Earth Lead
- Fluke 374 Voltage tester
- Fluke PRV 240 Voltage Proving unit
- Insulating materials (e.g. LV insulating mats/covers) where required as identified in the JRA or relevant SWMS, and applied per Evoenergy procedures
- Neutral identification tags

9.11.3 Steps for Network Phasing

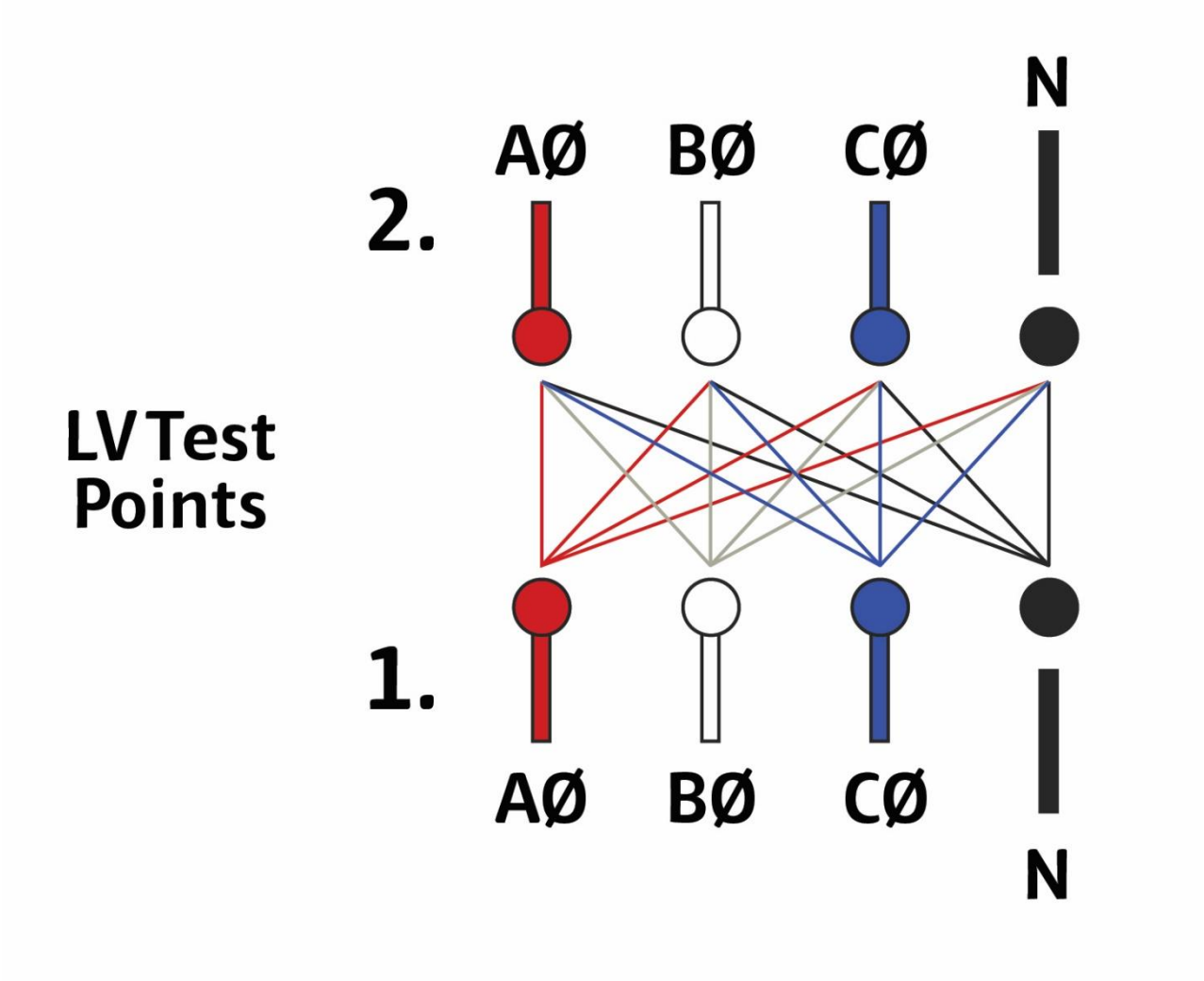
Sides of test will be described as Side 1 and Side 2

1. Perform testing fundamentals checks
2. Test and verify the voltage tester on a known low voltage source or approved proving unit if known source is not available



3. Identify the neutrals on both sides of the open point by performing Test 3 – Neutral identification.

4. Test voltage between each side (1) & (2) and record results



i. (1) neutral to (2) neutral (0V)
ii. (1) neutral to (2) A, B, C (230V)
iii. (1) A phase to (2) A (0V)
iv. (1) A phase to (2) B (400V), C (400v), N (230V) and back to A (0V)
v. (1) B phase to (2) B (0V)
vi. (1) B phase to (2) A (400V), C (400V), N (230) and back to B (0V)
vii. (1) C phase to (2) C (0V)
viii. (1) C phase to (2) A (400V),B (400v), N (230V) and back to C (0V)

9.12 Test 10 - Phase Rotation

Non-contact OR live test

Essential for 3 phase equipment

Phase rotation testing ensures that three phase machines rotate in the correct direction. This ensures safe and correct operation of rotating machinery.

Three phase machinery rotating in the wrong direction can cause death or serious injury to operators, failure of machines to operate or operate correctly. This may affect refrigeration and air-conditioning equipment, pumps etc.

Note: Correct network phasing DOES NOT ensure correct phase rotation

9.12.1 Phase rotation testing must be carried out

After any network alteration that may alter the order of phase connections to an installation. Alterations made on both the HV and LV networks can affect phase rotation.

For existing network installations, the phase rotation should be tested and recorded prior to being de-energised. Phase rotation must be recorded in Cityworks.

Note: All new installations must be connected with a CLOCKWISE rotation

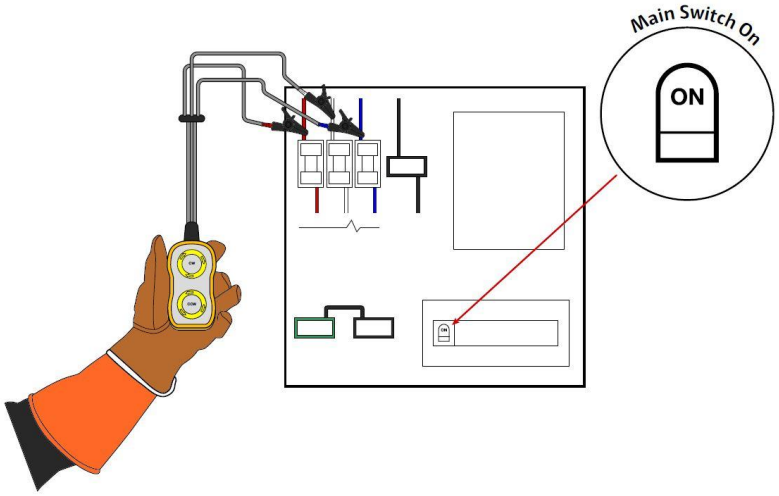
For reactive outages, if the phase rotation prior to loss of supply is unknown, the supply must only be reconnected if the connected three phase equipment can be inspected to ensure correct rotation/operation. If the there is no access or the rotation of the equipment cannot be ascertained the service must not be connected and danger tagged until it can be proven safe to energise.

9.12.2 Phase rotation testing equipment required

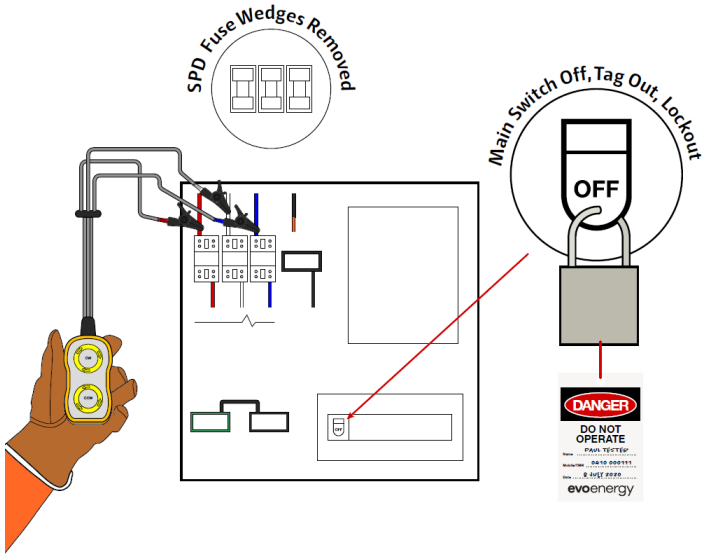
- PPCE as per Personal Protective Clothing and Equipment
- SEW 890 PR Phase Indicator
- Greenlee GT12A Proximity Tester
- Insulating materials (e.g. LV insulating mats/covers) where required as identified in the JRA or relevant SWMS, and applied per Evoenergy procedures

9.12.3 Steps for phase rotation testing

1. Perform testing fundamentals checks
2. Perform Test 1 - PROXIMITY on conductive structures and enclosures associated with the equipment being tested
3. Connect the phase rotation tester probes or clamps to the supply to be tested. The leads are coloured red, white and blue and should be connected to the same coloured phase to be tested. If there is no colouring on the supply being tested, i.e. all black conductor insulation, the conductors must be marked red, white and blue with insulating tape in the following sequence: left to right, red, white, blue.



4. Ensure that the installation is disconnected from the network while work is conducted, so that when the network is restored, the installation remains disconnected until testing is completed and rotation can be proved.
5. Record the phase rotation test results in Cityworks
6. When restoration of the network is completed, perform the following tests and record in Cityworks:
    - Test 1 Proximity test
    - Test 2 Neutral identification
    - Test 4A or 4B Neutral integrity
    - Test 6 Polarity test
7. Once the above tests are satisfactorily completed, re-perform step 5 to test the phase rotation.



9.13 Test 11 - Current Measurement With a Tong Ammeter

Non-contact test

Determines circuit load

9.13.1 General

Measuring the current flowing in an active, neutral or earth conductor is useful in determining circuit load, or current share.

The measurement of current flowing in a conductor can indicate the potential for drawing a dangerous electric arc if the circuit is opened at a certain point or if the current flowing exceeds the rated braking current of a piece of electrical apparatus. If the maximum rated breaking load is less than the measured current, the load must be reduced or the circuit isolated at an adequately rated apparatus

9.13.2 Effective current measurement

The tong ammeter will only provide an accurate result if measuring one conductor's current at a time. If measuring more than one conductor, conductors must be individually tonged and results added together for the final overall measurement.

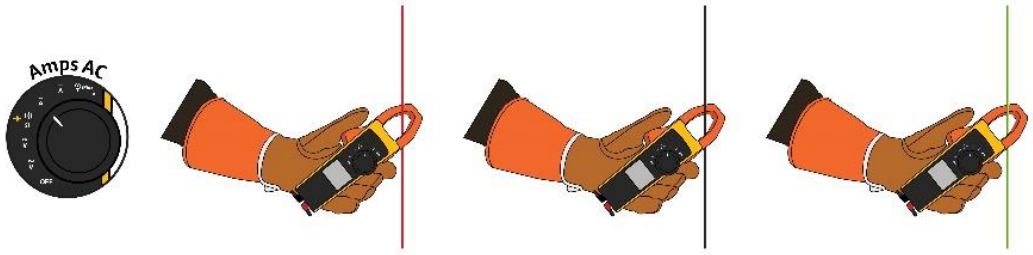
Ensure that the tong is fully closed when taking a measurement otherwise the magnetic circuit will not be complete and false readings of zero or lower than actual current may occur.

9.13.3 Current measurement equipment required

- PPCE as per Personal Protective Clothing and Equipment
- Fluke 374 Tong Ammeter
- Greenlee GT12A Proximity Tester
- Insulating materials (e.g. LV insulating mats/covers) where required as identified in the JRA or relevant SWMS, and applied per Evoenergy procedures

9.13.4 Steps for current measurement with a tong ammeter

1. Perform testing fundamentals checks
2. Perform Test 1 - PROXIMITY on conductive structures and enclosures associated with the equipment being tested
3. Ensure tester is switched to the correct function and range for AC current
4. Ensure that the voltage test leads have both been removed from the input jacks and are not wrapped around the tester while performing current measurements
5. Open the tong and close around the conductor to be tested and ensure the tong is fully closed and the two halves of the tong are not misaligned. Centre the conductor between the marks on each tong



9.14 Test 12 - Pole Leakage Detection

Non-contact test

Performed by all Worker approaching conductive structures

9.14.1 General

Pole leakage detection conducted with an approved pole leakage detector forms part of asset inspection tasks, however may be utilised at any time that there is uncertainty about a pole having a higher potential than the surrounding ground.

The pole leakage detection equipment is suitable only for conductive poles such as concrete, steel and CCA treated timber and poles that have a continuous earthing conductor run down the pole such as substation poles, poles that have surge arrestors, catenary earthing wires, or uninsulated stay wires.

9.14.2 Pole leakage detection equipment required:

- PPCE as per Personal Protective Clothing and Equipment
- Approved pole leakage detector

9.14.3 Steps for pole leakage detection

1. Perform testing fundamentals checks
2. Insert the earth spike into the ground a minimum of 150mm at a minimum distance of 1m away from the pole
3. Attach free end of earth lead to screwed terminal on earth spike assembly. Attach telescopic probe by screwing it into the top of the instrument housing.
4. Prove the operation of the instrument by applying the probe to the test terminal on the side of the earth spike assembly. A deflection of between 3 and 8 divisions proves correct instrument operation. If the above deflection is not indicated by the instrument, replace the battery. Re-check for full-scale deflection, if not achieved with a new battery, there is a fault with the instrument and it must be danger tagged and removed from service
5. To perform leakage test, apply test probe to pole

PARAMETER	VALUE	ESCALATION STEPS
GREEN ZONE	No leakage present,	
ORANGE ZONE	Audible sound is heard, Some leakage present	Hazard exists, risk assessment to determine next action.
RED ZONE	Audible sound There is dangerous leakage current	Contact supervisor, System Control and prevent any person from approaching pole, beware that step potential may be caused and keep 2 metres of exclusion around pole

9.15 Test 13 - Pole Leakage Detection – High Voltage Pole with Modiewark GLM MINI

1. Switch the unit to the “ON” position, a Green LED power light will immediately illuminate, indicating good battery condition and circuitry connectivity.
2. For power pole testing place the Sensitivity Switch to HIGH (to the RIGHT) and the Sensitivity Dial to the far RIGHT to position 12.
3. Confirm the low battery LED is still GREEN and continue to step 4. If the (orange) LED illuminates, replace battery before use or recharge NIMH battery with approved charger and repeat steps 1 - 3.
4. Press the Self-Test Button to check the unit is operating correctly. A repeating tone will be heard indicating a correct operation. A two second delay will occur between the self-test operation and the normal unit detection operation. The GLM Mini is ready for operation.
5. It is recommended that regular checks using the self-test function be made before and during the safe approach of electrical voltage testing.
6. Always hold the GLM MINI with your thumb placed on the indicated position with your arm outstretched. This allows maximum effectiveness and detection.
7. For the initial calibration procedure on a high voltage system, it is recommended that the minimum distance from the pole under test be 10 metres and stand directly below the conductor.
8. If trees are in close proximity or low voltage wires are below the high voltage conductors, stand at right angles (still 10 metres from the pole) to the line and pole to enable the detection of high voltage.

Note: Electric fields from power lines can be disturbed and redirected by objects that are grounded.

A tree near a power line will lower the strength of an electric field which may cause adjustments to the settings on the GLM Mini.

Other factors which influence the electric field and the initial calibration setup include rainy and humid conditions.

9. After correct test instrument procedure has been carried out, raise the tester above the head and adjust the sensitivity dial until the voltage in the line above is detected

Method: Placing your right hand on the tester as indicated use the other hand to move the Sensitivity Dial slowly to the left until the alarm is a strong and continuous sound.

10. If Tester does not alarm If overhead mains cannot be detected by the GLM Mini at arm’s length at **HIGH 12**. It is our recommendation that with the self-test function showing correct battery voltage and circuit operation, the self-test function can then be used as a dependable correct safety procedure to approach the pole.

Note: If the sensitivity switch and dial are adjusted correctly to pick up the live conductors. A strong field would produce a switch setting of low sensitivity position and the sensitivity dial would be in a position suited, to the onsite conditions. A low field would produce a switch setting of high sensitivity position and sensitivity dial would be in a position suited, to the onsite conditions.

11. When the overhead line conductor is located (by the activation of the alarm), lower the tester to chest height, at this point no alarm should be heard. The overhead field will be broken and the approach to the pole can be made. If the tester continues to alarm at chest height raise it above the head again and adjust the sensitivity dial one position to the left to desensitise it, then repeat step 11.

Method: By leaving the hand placed on the tester with the thumb as indicated, remove the other hand and lower the unit to chest height. ***Note:*** When using the unit on power lines where lower voltage mains, i.e., 415V AC are beneath the HV conductors
a null or dead zone will occur. To overcome this situation, move out from beneath the HV line until the alert tone is heard.

12. Verify the calibration of the overhead mains again to check voltage is still present and lower to chest height where the alert tone should dissipate. The tester should not alarm in this position or pole test will not be correct.

13. With the tester at arm's length approach the pole to be tested.

Method: Whilst approaching the pole keep arm out stretched and your other arm beside your body; walk calmly and slowly towards the pole, to a point where the Test Area Label is 25mm (1 inch) from pole. If the Tester alarms while approaching the pole, stop and raise the GLM mini towards the overhead conductors to make sure the GLM Mini is not picking up overhead field, if field is still broken above (no alert tone) proceed to step 15.

14. If the tester does not alarm there is no significant voltage running through the pole.

Method: At this point to verify results touch the pole with unit on the end marked Test Area only. The contact will increase sensitivity.

15. If an alert signal is heard do not panic but check your results proceed to step 16.

Method: To check your results take a step back until signal has discontinued then take a step forward to verify activation of unit. Please note the further you are away from the pole and the tester is alarming, the higher the leakage in that pole. A set of calibration tables are available for switch positions and voltages if required.

16. Follow standard isolation procedures with a ten-metre perimeter, assess the area around pole to ensure no conductive material have contacted pole. I.e., Fences, machinery and water, as where you are standing may be live.

Note: If a voltage cannot be detected by the GLM Mini at arm's length at HIGH 12, then three possible situations can exist:

The overhead mains are not alive.

The overhead mains voltage does not have a strong enough field to be picked up.

Low voltage mains are below the High voltage conductors causing a null.

In these circumstances it is our recommendation that because the self-test function checks battery and circuitry it can be relied upon (after the self-test procedures have been carried out) that safe pole approach can be carried out.

9.16 Test 14 - Pole Leakage Detection – Low Voltage Pole with Modiewark GLM MINI

9.16.1 General

In situations where a test is required to check the voltage leak of a pole, where low voltage (415 volts) is the overhead supply, the following procedure is recommended.

1. Switch the unit to the “ON” position, a green LED power light will immediately illuminate, indicating good battery condition and circuitry connectivity.
2. For low voltage pole testing place the Sensitivity Switch to HIGH (to the RIGHT) and the Sensitivity Dial to the far RIGHT to position 12. This setting will allow testing with the Modielive mark 3 testing unit which is supplied separately. If applicable.
3. Confirm the low battery LED is still (green) and continue to step 4. If the (orange) LED illuminates, replace battery before use or recharge NIMH battery with approved charger and repeat steps 1 - 3.
4. Press the Self-Test Button to check the unit is operating correctly. A repeating tone will be heard indicating a correct operation. A two second delay will occur between the Self-Test operation and the normal unit detection operation. The GLM Mini is ready for operation.
5. It is recommended that regular checks using the self-test function be made before and during the safe approach of electrical voltage testing.
6. Always hold the GLM mini with your thumb placed on the indicated position, with your arm outstretched. This allows maximum effectiveness and detection.
7. For the initial calibration procedure on a low voltage mains pole keep the pole to be tested at a minimum distance of three metres (3m) at the initial setup.
8. Place yourself directly under the low voltage line away from hazards such as trees, other electric fields keeping a distance of 3m from the pole under test.

Note: Electric fields from power lines can be disturbed and redirected by objects that are grounded. A tree near a power line will lower the strength of an electric field which may cause adjustments to the settings on the GLM Mini. Other factors which influence the electric field and the initial calibration setup include rainy and humid conditions.

9. After correct test instrument procedure has been carried out, raise the tester above the head and adjust the sensitivity dial until the voltage in the line above is detected.

Method: Placing your right hand on the Tester as indicated use the other hand to move the Sensitivity Dial slowly to the left until the alarm is a strong and continuous sound.

10. If Tester does not alarm If overhead mains cannot be detected by the GLM Mini at arm’s length, at **HIGH 12**. It is our recommendation that with the self-test function showing correct battery voltage and circuit operation, the self-test function can then be used as a dependable correct safety procedure to approach the pole.

Note: If the sensitivity switch and the sensitivity dial are adjusted correctly to pick up the live conductors.

• A strong field would produce a switch setting of low sensitivity position and the sensitivity dial would be in a position suited, to the onsite conditions.

• A low field would produce a switch setting of high sensitivity position and the sensitivity dial would be in a position suited, to the onsite conditions.

11. When the overhead line conductor is located (by the activation of the alarm), lower the tester to chest height, at this point no alarm should be heard. The overhead field will be broken and the approach to the pole can be made. If the Tester continues to alarm at chest height raise it above the head again and adjust the sensitivity dial one position to the left to desensitise it, then repeat step 11.

Method: By leaving the hand placed on the Tester with the thumb as indicated, remove the other hand and lower the unit to chest height.

12. Verify the calibration of the overhead mains again to check voltage is still present and lower to chest height where the alert tone should dissipate. The tester should not alarm in this position or pole test will not be correct.

13. With the tester at arm's length approach the pole to be tested.

Method: Whilst approaching the pole keep arm out stretched and your other arm beside your body; walk calmly and slowly towards the pole, to a point where the Test Area Label is 25mm from pole. If the tester alarms while approaching the pole, stop and raise the GLM mini towards the overhead conductors to make sure the GLM mini is not picking up overhead field, if field is still broken above (no alert tone) proceed to step 15.

14. If the tester does not alarm there is no significant voltage running through the pole.

Method: At this point to verify results touch the pole with unit on the end marked Test Area only. The contact will increase sensitivity.

15. If an alert signal is heard do not panic but check your results proceed to step 16.

Method: To check your results take a step back until signal has discontinued then take a step forward to verify
activation of unit. Please note the further you are away from the pole and the tester is alarming the higher the leakage in that pole. A set of calibration tables are available for switch positions and voltages if required.

16. Follow standard isolation procedures with a ten-metre perimeter, assess the area around pole to ensure no conductive material have contacted pole. E.g., Fences machinery and water, as where you are standing may be live.

Note: **If a voltage cannot be detected by the GLM Mini at arm's length at HIGH 12 then three possible situations can exist:**

• The overhead mains are not alive.

• The overhead mains voltage does not have a strong enough field to be picked up.

• Low voltage mains are below the High voltage conductors.

In these circumstances it is our recommendation that because the self-test function checks battery and circuitry it can be relied upon (after the self-test procedures have been carried out) that safe pole approach can be carried out.

IF A VOLTAGE IS DETECTED, THERE IS NO NEED TO BRING THE DETECTOR ANY CLOSER TO THE VOLTAGE

10

SECTION

Direct Current (DC) Testing

10. DIRECT CURRENT (DC) TESTING

10.1 Test DC1 - Prove de-energised (DC)

Live test

Test before you touch

All DC cables, conductors and equipment must be proven de-energised prior to being worked on

This test must be conducted in the following circumstances:

- Prior to the access of Secondary and battery equipment as per *Energised Low Voltage Works Manual*
- Prior to working on secondary cables
- As required by the *Electrical Safety Rules*

Note:

- In some Evoenergy installations such as zone substations, the DC source negative is connected to earth and there is a y+60VDC and a y-60VDC rail measuring at y120VDC across the two rails. A negative reading carries the same potential as a positive reading and poses the same risk.
- In environments where there is both AC and DC voltages present, prove de-energised tests should be undertaken with the tester in DC AND AC voltage functions

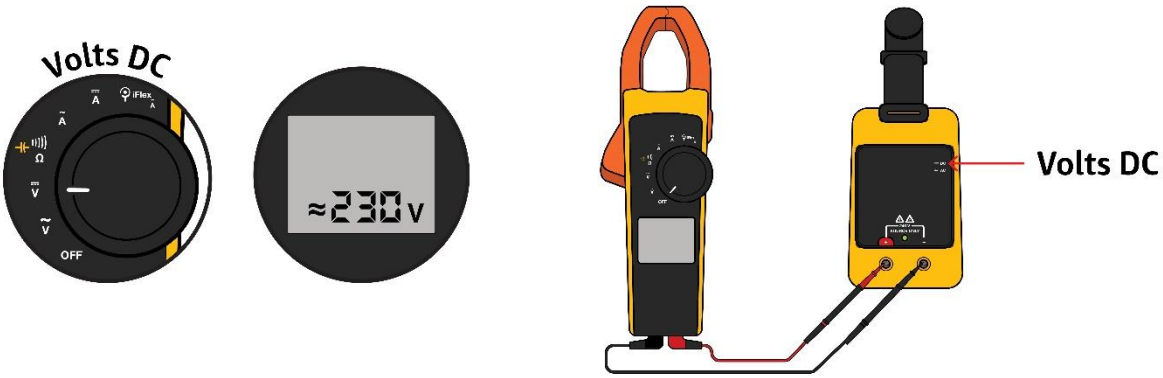
10.1.1 Prove DC de-energised - equipment required

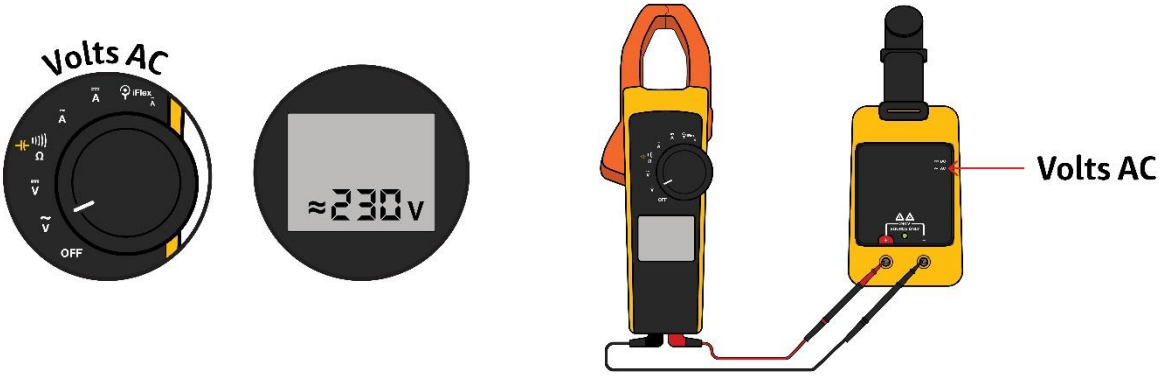
- PPCE as per Personal Protective Clothing and Equipment
- Fluke 374 Voltage tester
- Fluke PRV 240 Voltage Proving unit
- Insulating materials (e.g. LV insulating cable caps, mats/covers) where required as identified in the JRA or relevant SWMS, and applied per Evoenergy procedures

10.1.2 Steps for proving DC de-energised

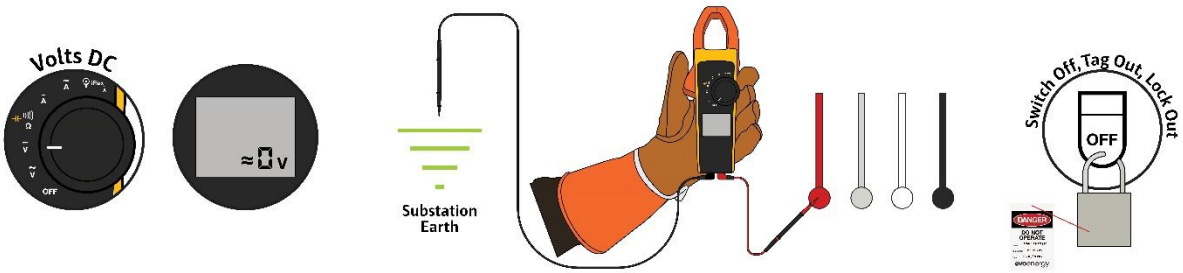
10.1.2.1 Electrical apparatus

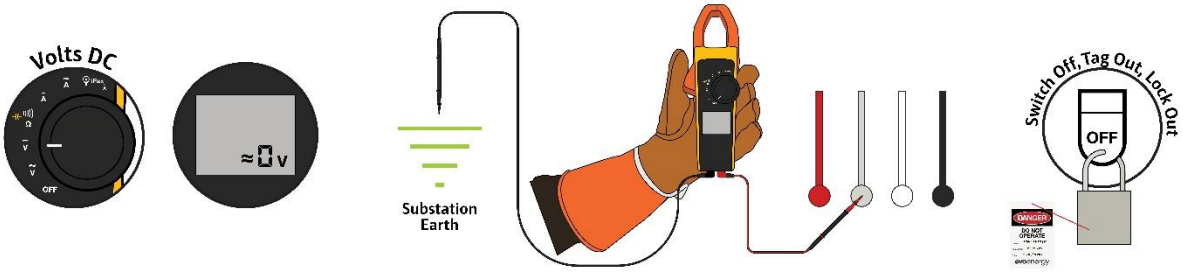
1. Perform testing fundamentals checks
2. Ensure tester is switched to the correct function and range for DC voltage.
3. Test the voltage tester on a known DC source or approved proving unit switched to DC, then switch both the tester and proving unit to AC and re-test.

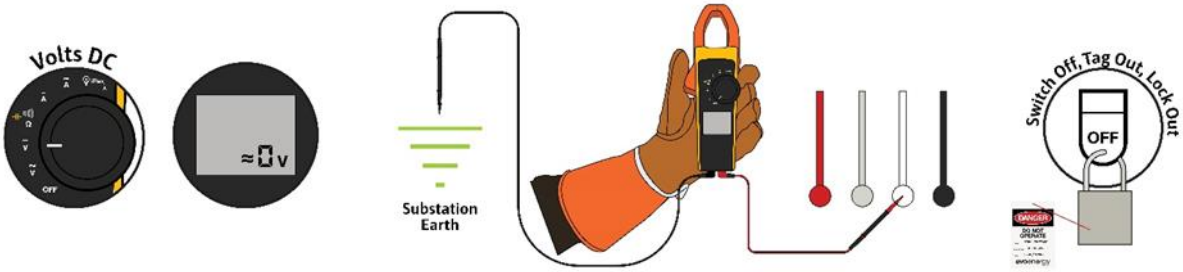


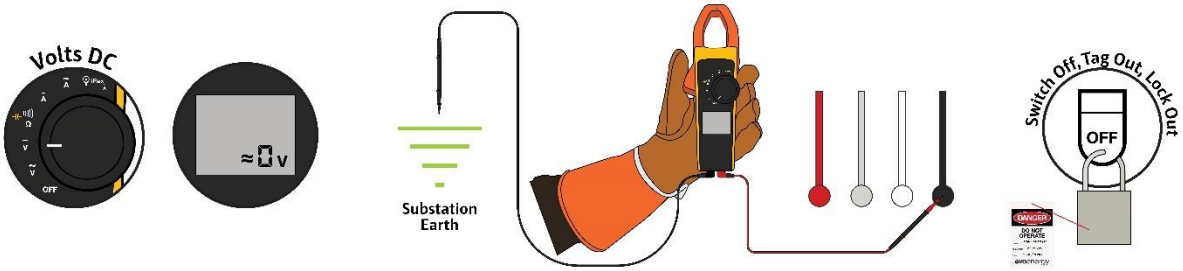


4. Voltage test between a known earth, and any DC conductor and repeat test in AC volts function. A reading of ≈0 volts for both AC and DC should be indicated on the voltage test device.

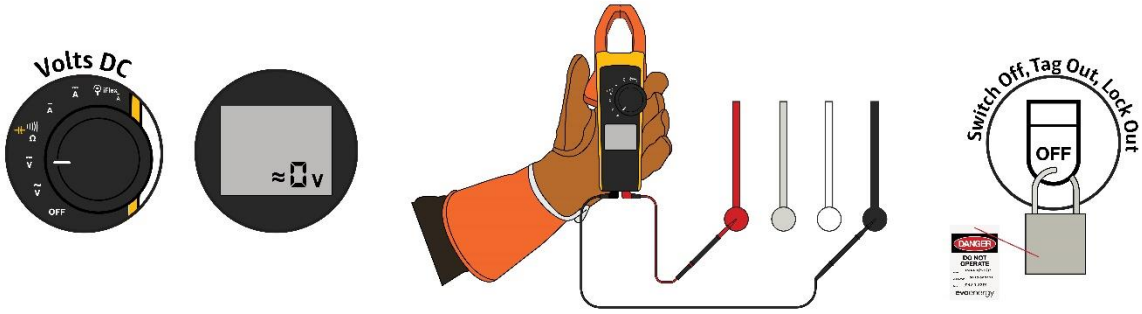




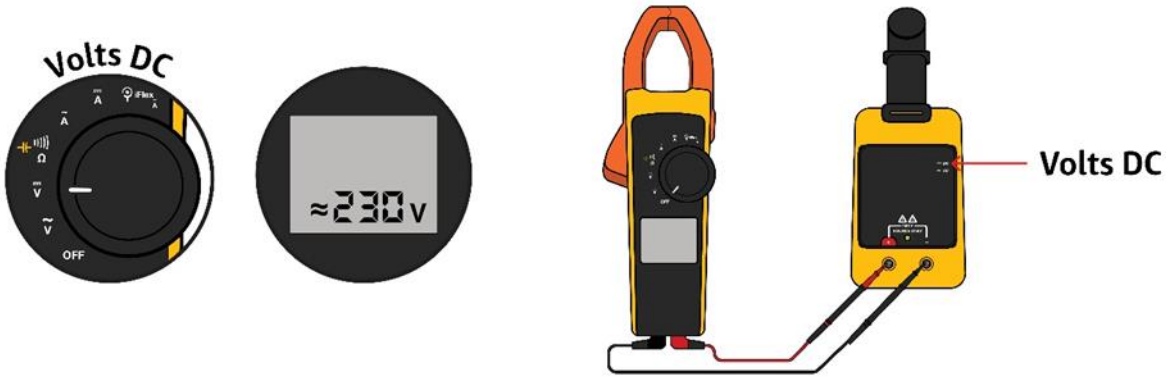




5. Disconnect from known earth and voltage test between each DC conductor until each combination is tested in both AC and DC volts. A reading of ≈0 volts must be indicated on the voltage test device for each test.



6. Prove voltage tester on known low voltage source or approved proving unit switched to in both AC and DC functions



10.2 Test DC2 - Voltage Testing (DC)

DC Voltage testing is essential to ensure:

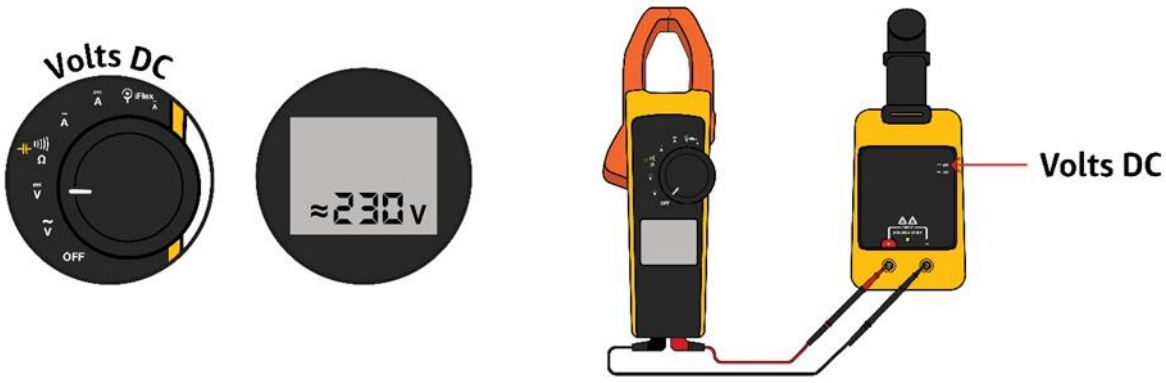
- The state of energisation of any cable, conductor or piece of equipment
- The correct polarity of cable cores and conductors and terminals

10.2.1 DC Voltage testing - equipment required

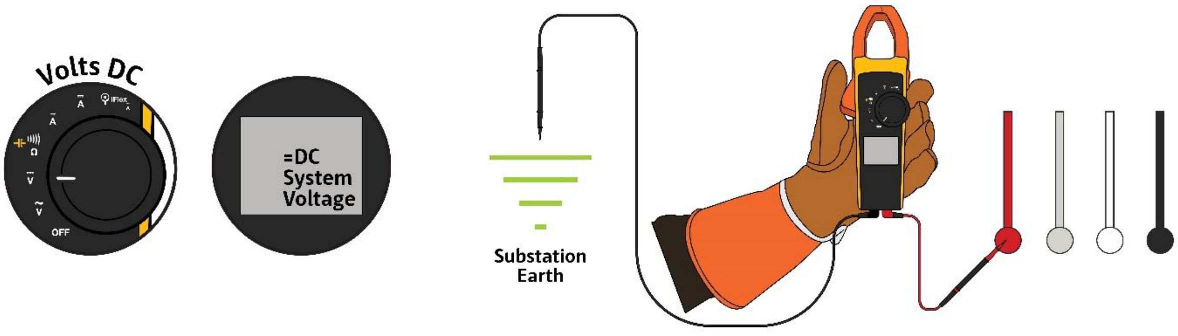
- PPCE as per Personal Protective Clothing and Equipment
- Fluke 374 Voltage tester
- Fluke PRV 240 Voltage Proving unit
- Insulating materials (e.g. LV insulating cable caps, mats/covers) where required as identified in the JRA or relevant SWMS, and applied per Evoenergy procedures

10.2.2 Steps for DC voltage testing

1. Perform testing fundamentals checks
2. Ensure tester is switched to the correct function and range for DC voltage
3. Test and verify the voltage tester on a known low voltage source or approved proving unit switched to DC



4. Voltage test between each conductor or terminal and note results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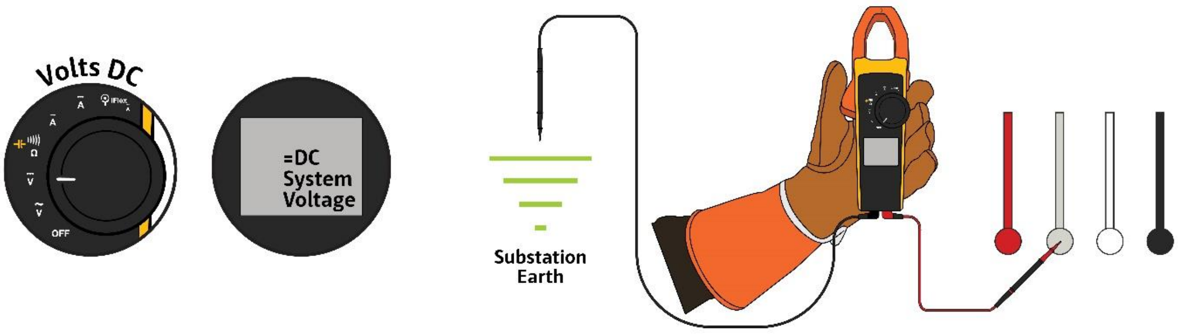
Substation
Earth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Substation
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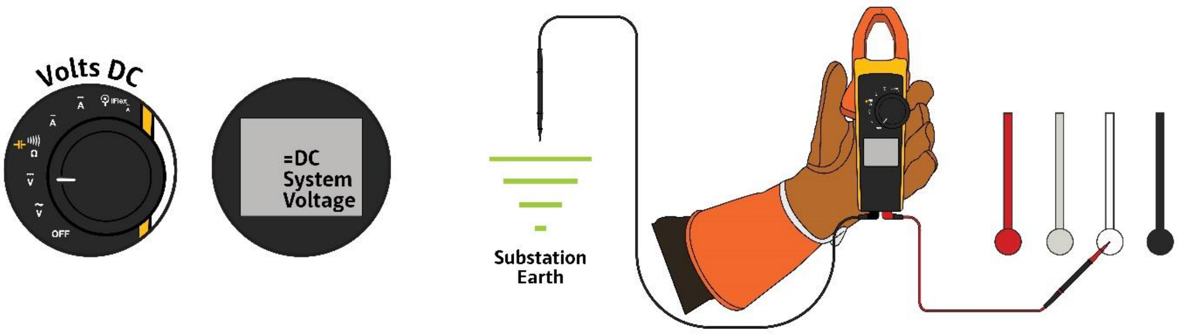
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System
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Substation
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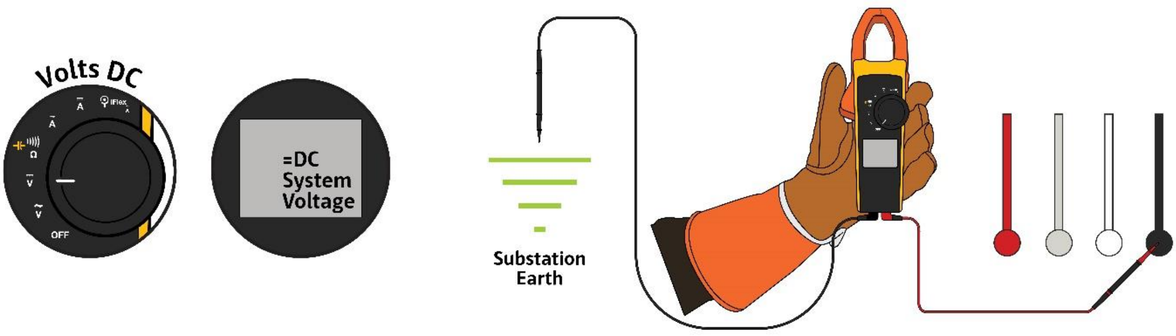
Volts DC
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Earth

11

SECTION

Advanced Low Voltage Testing

11. ADVANCED LOW VOLTAGE TESTING

Section 11 contains details of low voltage tests that can be applied to cables and apparatus in circumstances where additional detail is required such as:

- Where expected values have not been met during mandatory insulation resistance testing and further diagnostic information is required for an engineering decision on insulation condition in regard to re-energisation
- Where specific testing has requested as part of the works
- Where the responsible engineer has agreed to substitute advanced test(s) as an alternative to mandatory testing

11.1 Time-resistance tests

Insulation resistance tests of one minute duration as described in Section 9.10 are considered a spot reading or short-time resistance test. A further indication of the condition of the insulation can be achieved by testing and recording readings at different intervals and over a longer time period.

The typical time resistance test used by Evoenergy is a combination of two different tests:

1. Dielectric absorption test

   A one minute, four reading test at 500 volts that provides an indication of the presence of accumulated moisture in the cable. Values are recorded at 15, 30, 45 and 60 seconds. The test is performed between each phase and the earth connected to the remaining phases and neutral. The recorded insulation values must steadily climb over the four readings recorded across a minute.

2. Polarisation index test

   A ten minute, ten reading test at 500 volts with values recorded every minute. The test is performed between each phase and the earth connected to the remaining phases and neutral. All three phases and neutral are tested. The recorded insulation values must steadily climb over the ten minute period

Both tests can be carried out together as they utilise the same test connections and voltage. The two tests may provide indication of cable moisture content and degradation of cable insulation.

It is assumed for the purpose of this testing that Test 9.10 Insulation resistance testing has occurred and that all relevant steps from Section 9.10 have been implemented.

11.1.1 Time-resistance testing – Equipment required

- PPCE as per Personal Protective Clothing and Equipment
- Kyoritsu 3132A Insulation Resistance and Continuity Tester
- Pacific Test Equipment - Trailing Earth Lead
- Insulating materials (e.g. LV insulating mats/covers) where required as identified in the JRA or relevant SWMS, and applied per Evoenergy procedures
- Test leads, ideally with alligator clamps for creating temporary short circuits for testing
- A time measuring device such as a stopwatch or mobile phone

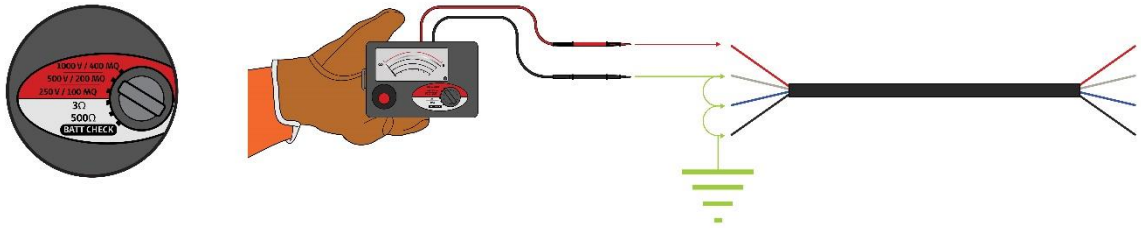
11.1.2 Steps for Time-resistance testing

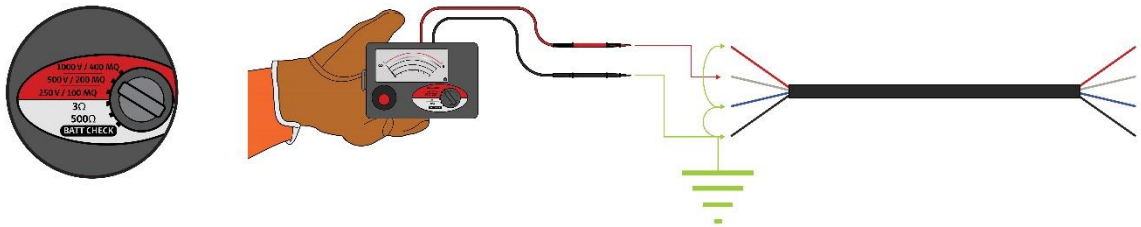
1. Perform testing fundamentals checks

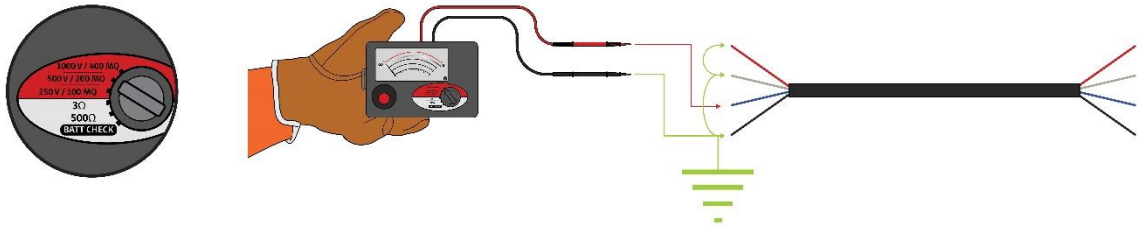
2. Isolate equipment to be tested and perform Test 2 - PROVE DE-ENERGISED note that if a short-time resistance test (Test 9.10) has already been performed, the cables and equipment must be discharged prior to time-resistance testing.
3. Ensure that the equipment under test is isolated from equipment that may be adversely affected by the testing or may affect the test results
4. Install test leads connecting the earth to the remaining phases and neutral that are not being tested
5. Select the test voltage of 500 volts on the insulation resistance tester
6. Connect the test leads together and press test button. The result should be 0Ω. If the result is not 0, check and replace the batteries and adjust the zero point as described in the manual for the insulation resistance tester

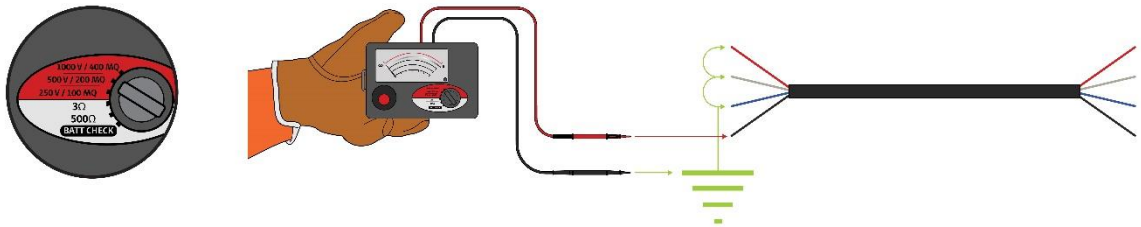
Ensure that insulation resistance tester batteries are in good condition to test each phase for ten minutes. If batteries go flat during these tests, the entire test will need to be re-done after discharging the cable or equipment.

7. Notify people in vicinity the type testing taking place and the equipment under test. Ensure people cannot receive a shock from the test, implement controls identified by the JRA,
8. Perform the test on each active core and neutral





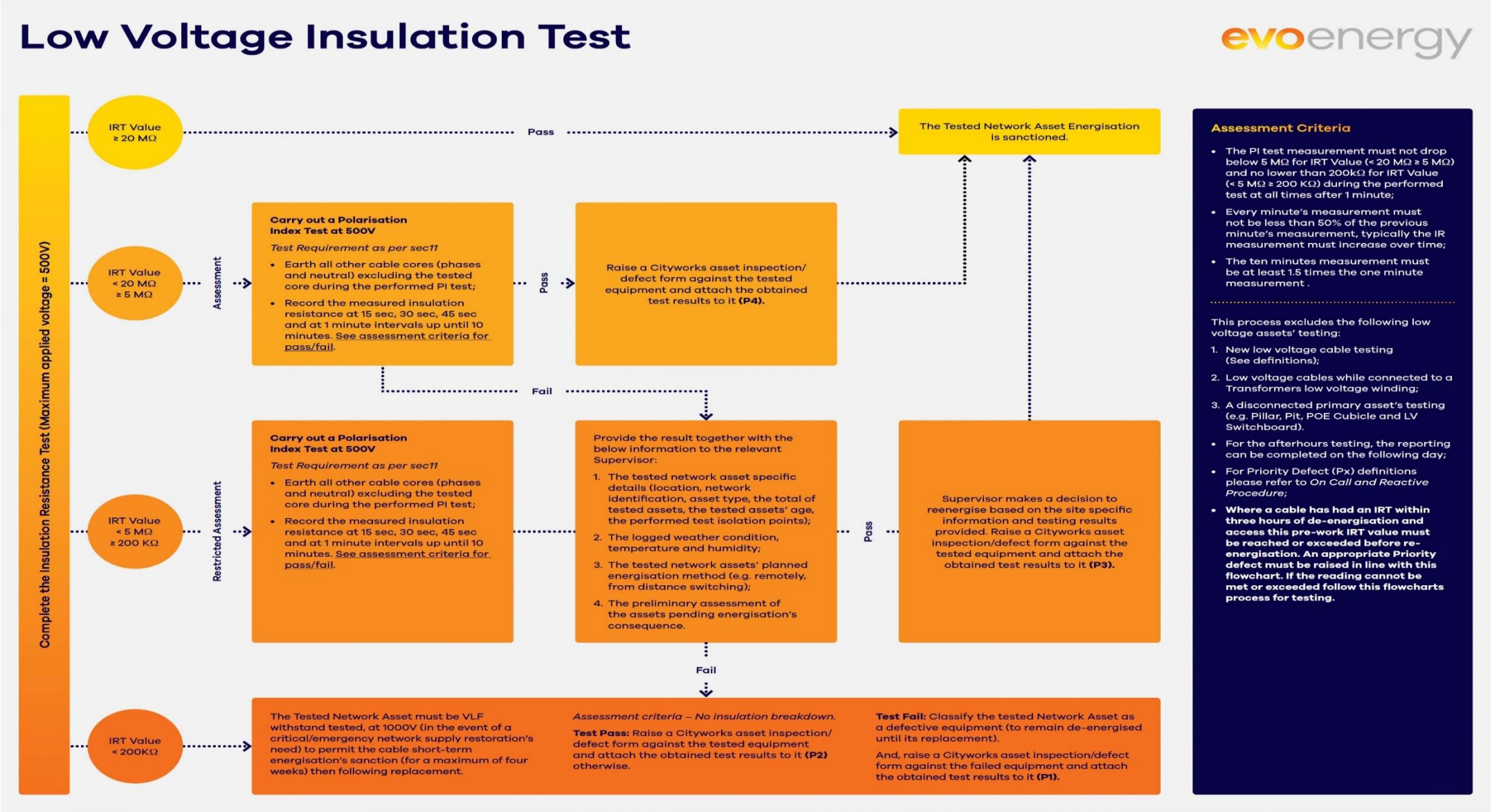




9. Record the results at each interval specified by either the polarisation index or dielectric absorption test noting Ω kΩ or MΩ and submit to the requestor.

   Note that the expected values in Table 1 Section 9.10 are not normally applicable to time resistance testing as these tests do not have a pass/fail value but show a trend in the readings over the time period. This trend may be view numerically or graphically.

11.1.3 Low Voltage Insulation Test Escalation Process



VERSION CONTROL

VERSION	DETAILS	APPROVED
7.0	Complete rewrite	Wayne Cleland
8.0	Added neutral integrity at PoA and amended insulation resistance testing escalation path	Wayne Cleland
9.0	Update to new template and amended insulation resistance testing escalation path. Inclusion of Advanced testing section	Wayne Cleland
10	Update to align with training package. Minor changes	Wayne Cleland
11	Updated to include Modiewark GLM MINI pole leakage test. Changed PPE to PPC, Change PI test to Timed IR test, Document name change.	Brendan Commons
12	Update proximity pen picture to reflect new testing unit to replace old tester.	Brendan Commons
13	Section 9.10.6 amended to point to Section 11.1.3 Low Voltage Insulation Test Escalation Process	Brendan Commons

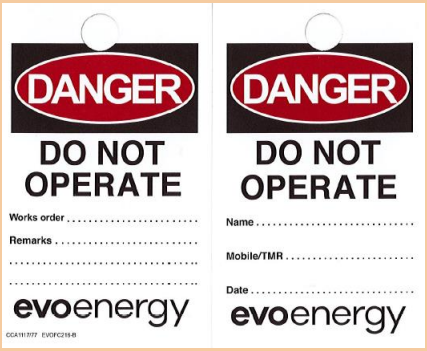
DOCUMENT CONTROL

DOCUMENT OWNER	DOCUMENT CUSTODIAN	PUBLISH DATE	REVIEW DATE
Group Manager Strategy and Operations	Electrical Work Practices Team Lead	31/05/2023	31/05/2025

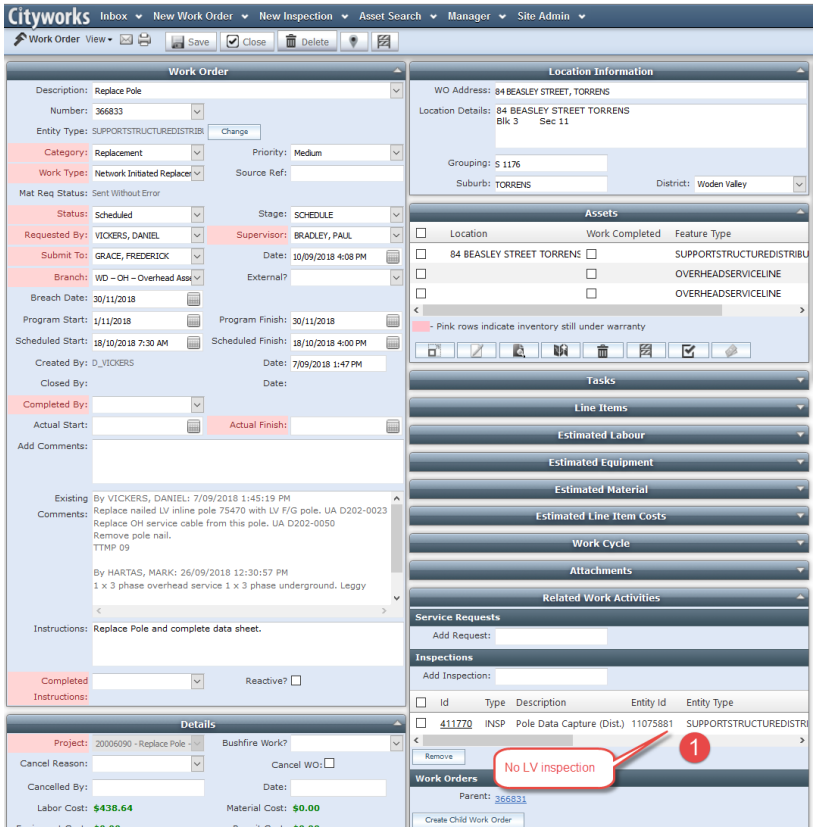
APPENDIX A – OPERATIONAL CHECKS AND INSPECTION

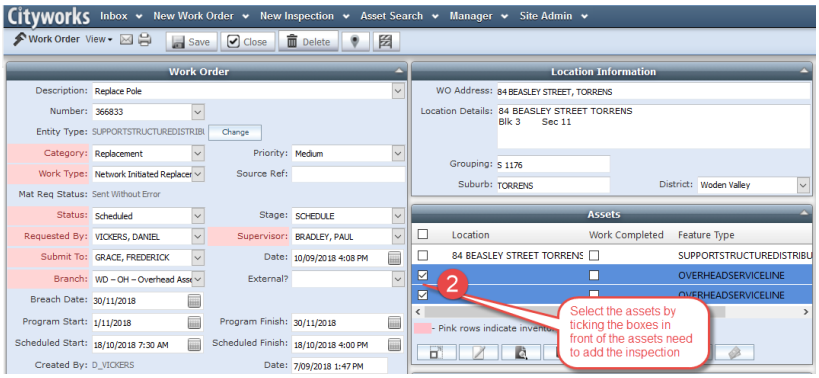
EQUIPMENT	PRE OPERATIONAL CHECKS	PERIOD
PROXIMITY TESTER	• Check batteries • Check test lead insulation • Check for damage on instrument	Not required
TONG AMMETER / VOLT METER	• Check batteries • Check test lead insulation • Check lead continuity • Check for damage on instrument • Prove voltage test	12 months
PHASE ROTATION TESTER (CONTACT OR NON-CONTACT)	• Check batteries • Check test lead insulation • Check for damage on instrument	Not required
INDEPENDENT EARTH	• Continuity check <10Ω • Check connections • Inspect insulation	Not required
INSULATION RESISTANCE TESTER	• Check batteries • Check test lead insulation • Check for damage on instrument • Check lead continuity	12 months
FAULT LOOP IMPEDANCE TESTER	• Check batteries • Check test lead insulation • Check lead continuity • Check for damage on instrument	12 months
TEMPORARY LOAD BANK	• Check batteries • Check test lead insulation • Check for damage on instrument	Not required
POLE LEAKAGE DETECTOR	• Check batteries • Check for damage on instrument • Check probe and leads	Not required

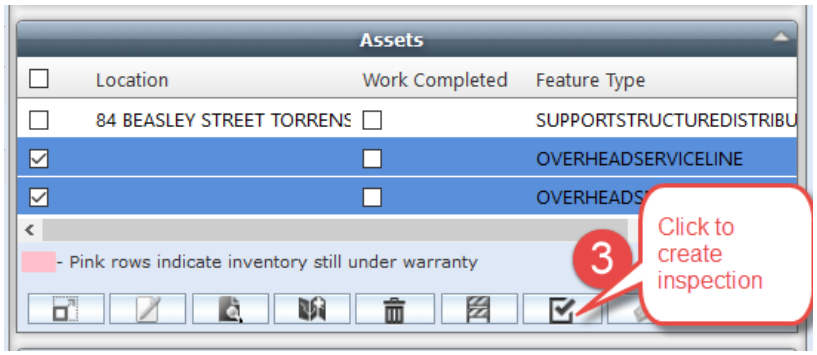
APPENDIX B – LABELS AND TAGS FOR TESTING

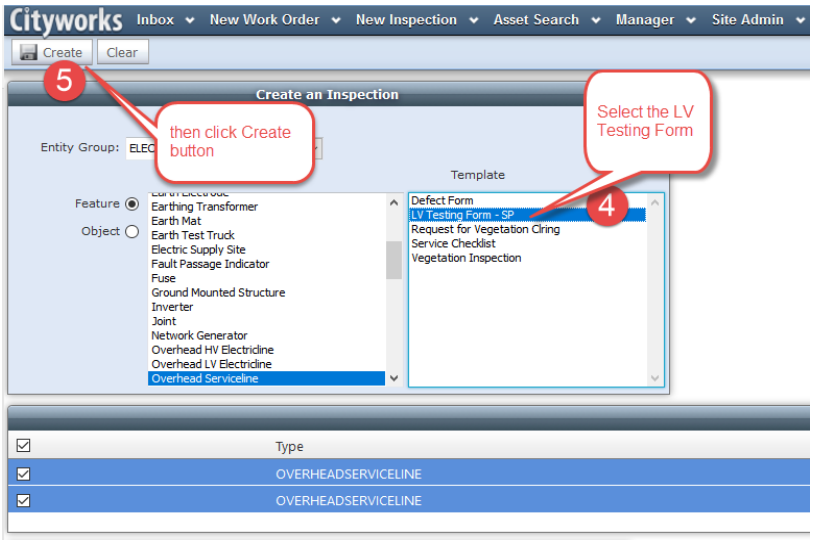
LABEL/TAG TYPE	WHERE USED	IMAGE	STOCKCODE
CROSSARM NEUTRAL IDENTIFICATION TAG	Low voltage crossarms		1197422
ZIP TIE NEUTRAL IDENTIFICATION TAG	Neutral cables, cable cores and conductors		1197433
DANGER TAG	Electrical apparatus		Laminated- 1204429 Paper- 1204418
OUT OF SERVICE TAG	Damaged or defective test equipment		1195926
DANGER LIVE STICKER	Service protection devices when the service has been energised		1204649

APPENDIX C – CITYWORKS SCREENSHOTS





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Object
Earthing Transformer
Earth Mat
Earth Test Truck
Electric Supply Site
Fault Passage Indicator
Fuse
Ground Mounted Structure
Inverter
Joint
Network Generator
Overhead HV Electricline
Overhead LV Electricline
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LV Testing Form - SP
Request for Vegetation Cling
Service Checklist
Vegetation Inspection
4
Type
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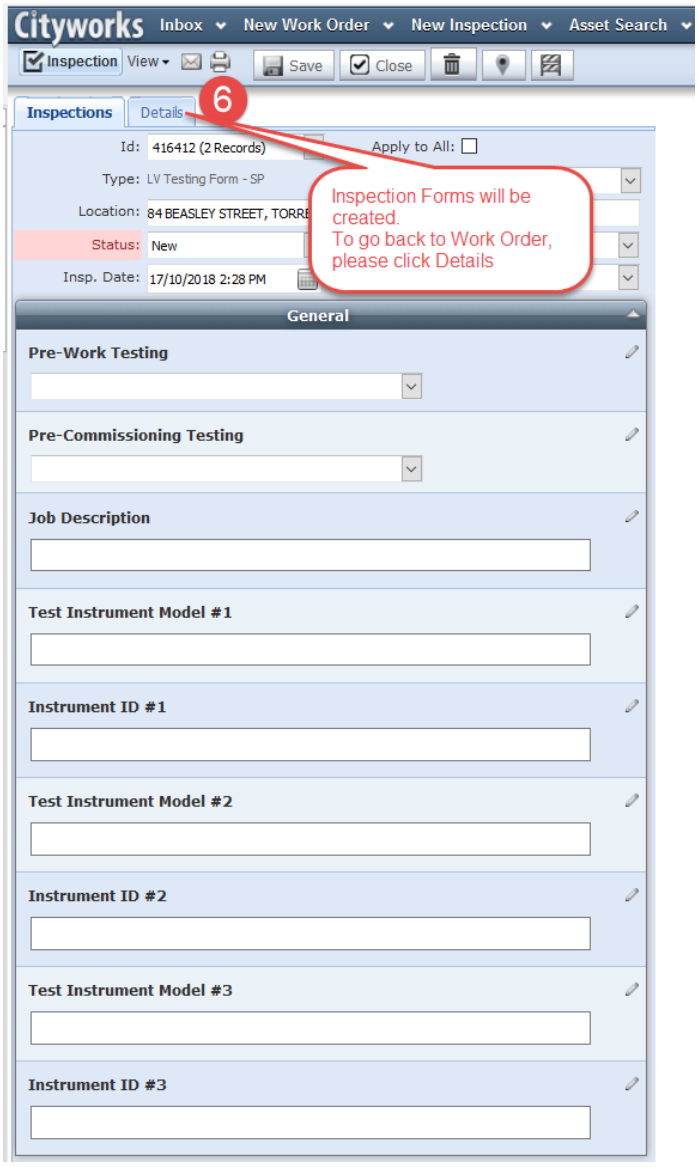
OVERHEADSERVICELINE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84 BEASLEY STREET, TORRE
Status:
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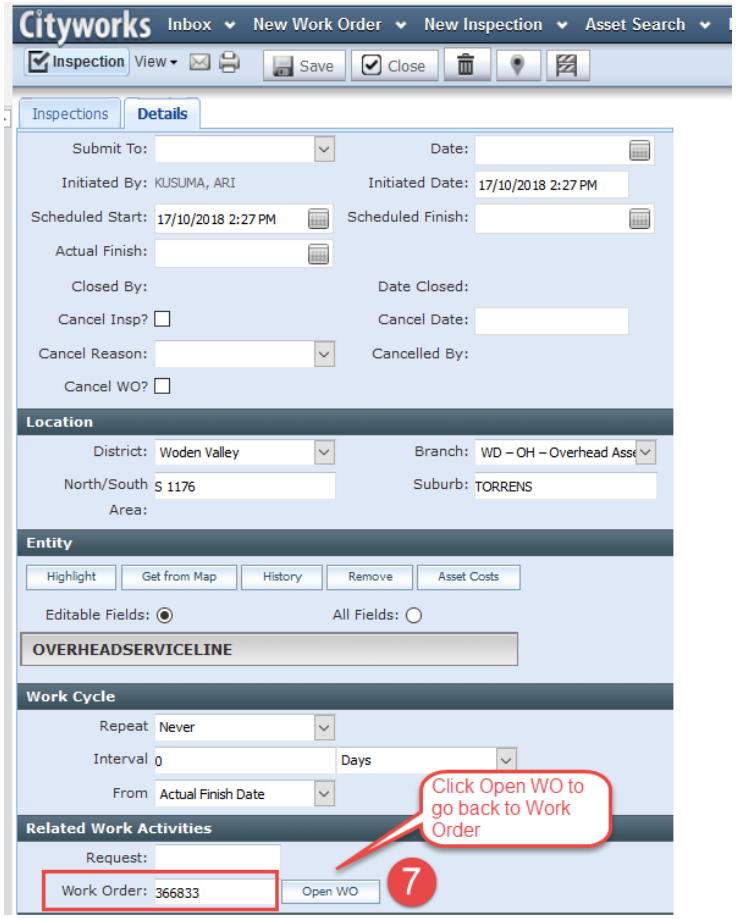
Pre-Work Testing
Pre-Commissioning Testing
Job Description
Test Instrument Model #1
Instrument ID #1
Test Instrument Model #2
Instrument ID #2
Test Instrument Model #3
Instrument ID #3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Date Closed:
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Cancel Reason:
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Branch: WD – OH – Overhead Asse
North/South Area: S 1176
Suburb: TORRENS
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OVERHEADSERVICELINE
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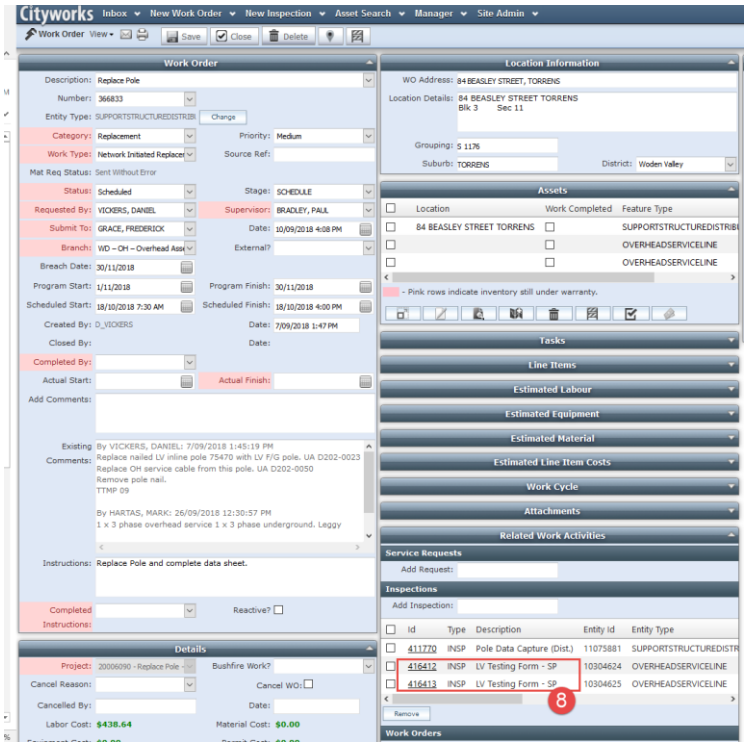
7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Inspections
Details
Work Orders
8