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Testing of Underground Cables

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5	7/07/2026	Conversion to new network standard template. Clause on Remote Energisation Precautions has been moved to the ESR. Included Clause 5.2.1 IR test exception (LV). Table 1 added for Data Management requirements.	Duminda Thenuwara	Evan Riddell

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Scope

This document is Ausgrid's specification for testing pilot, low voltage and high voltage distribution and sub-transmission underground cable installations. The purpose of performing cable tests is to prove the circuit is safe to energise or commission. The specification applies to cable installations which are new, repaired or modified.

Reference Documents

All work covered in this document must conform to all relevant Legislation, Standards, Codes of Practice and Network Standards Ausgrid Documents.

Ausgrid documents

Electrical Safety Rules

ES 4 Accredited Service Provider Authorisation

NS129 11kV Joints and Terminations - Paper Insulated Lead Covered Cables

NS130 Laying of Underground Cables Up to and including 11kV

NS156 Excavating Near Ausgrid Underground Cables or Conduits

NS168 Design of 33kV, 66kV and 132kV Underground Cables

NS177 11kV Joints (including Transition Joints) and Terminations - Polymeric Insulated Cables

NS181 Approval of Materials and Equipment and Network Standard Variations

NS260 Sub-transmission Feeder Earthing

Other Standards and Documents

AS/NZS 1026 - Electric cables - Impregnated paper insulated – For working voltages up to and including 19/33 (36) kV.

AS/NZS 1429.1 - Electric cables - Polymeric insulated – Part 1: For working voltages 1.9/3.3 (3.6) kV up to and including 19/33 (36) kV.

AS/NZS 1429.2 - Electric cables - Polymeric insulated – Part 2: For working voltages above 19/33 (36) kV up to and including 87/150 (170) kV.

AS/NZS 60840 Power cables with extruded insulation and their accessories for rated voltages above 30kV (Um = 36kV) up to 150kV (Um = 170kV) - Test methods and requirements

IEC 60060 High Voltage Test Techniques

IEC 60141 – 1 Tests on Oil Filled and Gas-Pressure Cable and their Accessories

IEC 60229 Electric cables - Tests on extruded oversheaths with a special protective function.

IEC 60502 – 2 Power cables with extruded insulation and their accessories for rated voltages from 1kV (Um = 1.2kV) up to 30kV (Um = 36kV) - Part 2: Cables for rated voltages from 6kV (Um = 7.2kV) up to 30kV (Um = 36kV).

IEEE 400.2 Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF) (less than 1 Hz).

Acts and Regulations

Electricity Supply (General) Regulation 2014 (NSW)

Electricity Supply (Safety and Network Management) Regulation 2014 (NSW)

Work Health and Safety Act 2011 and Regulation 2025 (NSW)

Clause	Standard Requirements

1 General

1.1 An Access Permit for Test shall be arranged with the requirements specified in Ausgrid's Electrical Safety Rules prior to commencement of the tests.

1.2 Ausgrid reserves the right to witness any HV tests required by this Network Standard.

1.3 All test equipment and instrumentation used for testing shall have been calibrated by a NATA Accredited Organisation and have a current test sticker affixed.

1.4 All test results shall be documented. The following information shall be recorded as a minimum:

a) testing organisation name

b) test date and location

c) accurate description of cable or equipment tested

d) cable 'passed' or 'failed' tests

e) details of test completed, and result expressed as a value at a reference temperature (where applicable)

f) test equipment numbers and calibration dates.

1.5 Within one week of the tests, results shall be provided to the Ausgrid Representative with a test report covering items (a) to (f) inclusive; except that calibration dates on item (f) may be excluded where the Accredited Service Provider demonstrates to the satisfaction of Ausgrid that these details are readily available from the Accredited Service Provider's records system.

1.6 Definitions

Polymeric cables: according to this Network Standard, are defined as either TR-XLPE, XLPE or EPR insulated

Existing cable: cables that have been commissioned and in service, or cables that have been laid and not placed in service but are older than 1 year.

New cable: A cable that has been installed but not placed into service, or a cable that has been in service at a lower voltage for some time and is later uprated to a higher voltage (e.g. a cable that has been initially operating at 11kV and subsequently increased to 33kV).

2 Types of Installations

2.1 New installations

A new installation is where a new section of cable has been installed between substations, or points of isolation.

2.2 Repaired installations - maintenance or repairs after failure or damage

A repaired installation is where a cable has been maintained or repaired after failure or damage resulting from, for example, an electrical fault, fluid leaks or serving damage. The repaired cable may have had a section of cable pieced in.

2.3 Modified installations - system modifications

A modified installation applies to any cable which has been attached to existing cables by jointing. Testing a modified installation will subject existing cables to these tests.

For example, a new section of LV cable from a distribution centre to a link box would be a new installation, while an extension to an existing distributor (by jointing on a new piece of cable) would be a modified installation.

3 General test requirements

3.1 General

3.1.1 Sections 4 to 7 state the specific tests to be performed on each cable installation. Test requirements are included for commissioning, after repairs and after modifications. Unless otherwise stated, each test is required on the complete Cable Installation.

3.1.2 Tests should be performed in the sequence stated in Sections 4 to 7.

3.1.3 Unless otherwise specified, test procedures shall be in accordance with the relevant Australian Standards.

3.2 Conductor resistance test

3.2.1 Determine the effectiveness of the conductor joints and terminations by measuring the dc loop resistance.

3.2.2 The results of these tests can be compared with the manufacturer's conductor dc resistance usually expressed in ohms/km on the cable datasheet.

3.3 Continuity check

3.3.1 A continuity check shall be used to confirm the connection between ends of the cable.

3.3.2 This is only performed when a core or phase identification check or a loop resistance measurement is not required. This check is only required for fault location.

3.4 Core identification check (for pilot cables)

3.4.1 This test is performed by connecting one end of the core to a known conductor (e.g. screen).

3.4.2 The core is positively identified when the loop circuit is completed. The process is repeated until all of the cores are positively identified. Each core shall be marked as it is identified to ensure correct jointing/terminating.

3.5 Cross bonding/current injection test

3.5.1 Cross-bonding tests on the cable sheaths shall be performed to verify the integrity of the cross-bonding system. Usually only carried out on 132kV single core fully insulated circuits, this test ensures circulating sheath currents generated by induced voltages at full load will not adversely affect the cable rating.

3.5.2 This test involves injection of a 3 phase current into the cores of the cable, and measuring voltages and currents induced into the sheaths at each cross-bonding point along the complete cross bonding section.

3.5.3 An injection current of greater than 50A shall be used. Sheath currents and voltages are to be measured at each cross-bonding point, earth point and termination.

3.5.4 The cross-bonding connections shall be rearranged to prove incorrect connection, and checked again after correct restoration.

3.5.5 The procedure shall be repeated for each complete cross-bonding section of the cable run.

3.5.6 Current and voltage measurements shall be scaled up to the rated load current. Voltage values at isolated (not solidly earthed) cross-bonding points shall be less than the rated load current scaled voltages of the installation design.

3.5.7 Scaled voltage and current values for each cross-bonding point shall be reported to the business unit responsible for cable ratings.

3.6 Cross talk check (for pilot cable)

3.6.1 This test determines if a measurable voltage is induced on the cores of any pilot pair from current flowing in the cores of another pilot pair.

3.6.2 Each pair of cores shall be shorted at one end. At the open circuit end, inject with variac and isolating transformer with unearthed secondary into each pilot pair, a voltage of 200V or a current of 3A.

Note: Because the multimeter is expected to give a zero reading, the instrument shall be checked for correct operation before use.

3.6.3 At the open circuit end, measure the induced voltage in the other pairs. The induced voltage should be unreadable on the multimeter.

3.7 Dielectric dissipation factor (DDF) and partial discharge (PD) measurement

3.7.1 PD and DDF measurements can be made on 33kV cables under VLF test voltage. PD can also be measured on 132kV cables using a power system frequency (20-300Hz) when required. PD measurements are to be conducted at the high voltage test values, recording inception and extinction voltages and magnitudes where applicable.

3.8 High voltage (HV) test

3.8.1 The high voltage test involves applying one of the test options below between each phase conductor to earth and between phases (where applicable) for a specified period of time:

- dc voltage,
- Very Low Frequency (VLF) voltage,
- ac voltage (generated via a resonant test set),
- 50Hz ac voltage, or
- power system voltage “soak”.

3.8.2 The remaining phases not under test shall be earthed.

3.8.3 The tests involving dc voltage, VLF voltage or ac voltage via an external test supply shall be carried out by a suitably accredited testing organisation.

3.8.4 The insulation resistance shall be measured prior to HV testing.

3.8.5 In performing the high voltage test, the voltage shall be slowly increased to the levels indicated in Sections 4 to 7 of this Network Standard, and maintained at these levels for the relevant time periods.

3.8.6 The cable is deemed to have passed the test if there is no disruptive discharge or puncturing of the insulation. The test current shall be essentially constant throughout the test.

3.8.7 For polymeric cables, it is accepted for unipolar pulsed test voltages to be used for fault location.

3.8.8 For polymeric cables that require confirmation of the cable’s integrity prior to energisation, a pulsed dc test can be applied if the cable cannot be remotely energised or high voltage testing is not available on site.

3.8.9 This test involves measuring the insulation resistance of the cable before and after the application of the high voltage dc pulses.

3.8.10 The cable is to receive two high voltage dc pulses per phase, with the cable earthed for 1 minute in between each pulsing application and before and after each IR measurement.

3.8.11 The cable is deemed to have passed the test if there is no disruptive discharge or puncturing of the insulation.

3.8.12 Pulsing voltages for 11kV and 33kV shall not exceed maximum specified voltage.

3.8.13 If new cable is being installed into existing switchgear, the test voltage values for existing cable in the relevant tables in Sections 4 though to Section 7 of this document may be used.

3.8.14 Reduced test voltages for cables with known poor condition issues, are listed in Annexure A.

3.9 Insulation resistance (IR) test

3.9.1 The Insulation Resistance (IR) test measures the dc resistance of the insulation of the cable installation using an Insulation Resistance Tester (IRT). It involves measuring both the phase-to-phase, phase-to-neutral, phase-to-earth and metallic screen-to-earth insulation resistances of power cables, and core to earth, core to core and metallic screen to earth on pilot cables.

3.9.2 Due to the cable's capacitance, the IRT shall be applied until a stable reading is obtained. The readings shall be recorded on the cable IR test report (sample in Annexure B).

3.9.3 Tables in the relevant cable sections give IR limits for new and existing cable circuits.

3.9.4 New cable circuits shall achieve the minimum IR figures given. Existing cable circuits shall meet the "Existing" IR figures to be returned to service with no extra notification.

3.9.5 Existing pilot, low voltage, or 11kV cable circuits meeting only the "Advisory" IR limits may be returned to service, however Ausgrid shall be notified.

3.9.6 If the "Advisory" IR limits for pilot, low voltage, or 11kV cables cannot be met, the cable must not be returned to service unless authorised by Ausgrid. Alternatively, contact Network Test to arrange a cable test.

3.10 Phase identification

3.10.1 Phase identification shall be checked by the use of either:

- The phasing resistors; or
- A continuity check of each individual core wherever possible after all jointing work has been completed.

Alternatively, the current injection phasing method or other approved methods may be used.

Refer also to Phasing requirements of ESR.

3.10.2 Phase identification checks shall be carried out to ensure cables have been correctly connected as indicated on system diagrams or System Alteration Order (SAO).

Phase identification may relate to either conductors or sheaths.

3.11 Phase rotation check

For low voltage services and direct distributors where the load has a multi-phase supply, a phase rotation check shall be performed before disconnection if possible, and after reconnection of the load.

3.12 Remote Energisation

3.12.1 The cable installation is remotely energised at system voltage without load current for five minutes. The cable installation shall only be energised by remote control or by the operation of a switch remote from the actual locations on the circuit where work was performed.

3.12.2 Network Access Requests (NAR) shall provide details of where work has been carried out. This enables operating staff to determine the most appropriate energisation point.

3.12.3 Remote energisation is performed once the installation is completed. The phasing of the installation is checked as part of the return to service or system alteration checks by an operator.

3.12.4 The cable installation is deemed to have passed the test if the installation does not trip system protection and does not show other signs of malfunction.

3.13 When remote energisation shall not replace the high voltage test

3.13.1 Remote energisation shall not replace the High Voltage Test for a HV cable installation if any of the following conditions are met:

- the circuits cannot be energised by remote control or by the operation of a switch remote from the actual locations on the circuit where work was performed (See Note 1.).
- cable installation difficulties were experienced;
- the type and/or condition of cable installation is in doubt;

- where Ausgrid's representative considers it necessary (See Note 2.).

Note 1. It may be possible to place an additional distribution centre in LV parallel so that energisation may be undertaken at a distribution centre that is remote from the work site.

Note 2. Ausgrid may request HV testing where the cable being energised has been out of service or stored for long periods.

3.14 Sequence impedance measurements

3.14.1 These tests are carried out for protection settings, earth potential rise and fault analyses. The tests are circuit dependent.

3.14.2 Measurements shall be performed on all new feeders for voltages of 33kV and above (unless requested otherwise). The cable measurements shall include DC resistance, positive, negative and zero sequence impedances, and shall be expressed at a reference temperature of 20°C.

3.14.3 The measured values shall be compared with the calculated theoretical values, or those provided by the cable manufacturer.

3.15 Serving Test

3.15.1 Sub-transmission cables

For sub-transmission cables, a high voltage DC test between the metallic sheath or screen wires to earth is performed to test the integrity of the outer sheath. An IR test is performed prior to and after the high voltage test to assess the insulation integrity of the cable. The high voltage test voltages and acceptable IR limits are stated in Section 7.

3.15.2 High voltage cables

3.15.2.1 For 11kV polymeric cables, only an IR test between the outer most metallic layer and earth is performed to test the integrity of the outer sheath.

The IR test voltage and acceptable limits are stated in Section 6.

3.16 Sheath or screen resistance test

Measure the dc resistance of the metallic sheath or screen wires and connections and compare with the manufacturer's sheath resistance usually expressed in ohms/km in the cable specification.

3.17 Sheath voltage limiters (SVL)

3.17.1 There are various types of Sheath Voltage Limiters (SVL) available (previously referred to as Cable Covering Protection Units – CCPUs).

3.17.2 These units with non-linear voltage/current characteristics are connected to the metallic cable sheaths to limit the transient voltage rises to avoid puncturing the cable servings under fault conditions.

3.17.3 The units shall be tested to ensure their compliance with their original characteristics. The test shall be carried out in accordance with the manufacturer's recommendations.

3.18 Reports and Recording

The required testing shall be undertaken, and the resulting test values shall be entered into SAP in accordance with Table 1.

Table 1 Data Management

Recording results in Ausgrid ERP (SAP) system	Test Type	Data Management Principle
1 (Mandatory)	Planned maintenance tests[1]	Where a test is undertaken as part of a planned maintenance activity all test results shall be captured in SAP (as a measurement reading, or equivalent) against the asset. This enables the results of the test to be used for ongoing asset management and investment decision-making.
2 (Recommendation)	Compliance or commissioning test	Where a test is undertaken for compliance, commissioning or other purpose, the test results shall be retained for assurance and audit purposes, with any SAP integration considered where the data provides ongoing asset management value.

[1] Planned maintenance tests are those prescribed by a Maintenance Standard (e.g.UG0105) in accordance with Ausgrid's Network Technical Maintenance Plan (NTMP).

All "Planned Maintenance Tests" undertaken in accordance with Ausgrid's Maintenance Standards are to be recorded in Ausgrid's ERP System (SAP).

4 Pilot cable installations

This section describes the electrical tests for protection pilot cables. These include both distribution pilots (including translay and balanced voltage (BV) pilots) and sub-transmission pilot cables (including UPC and UCC pilots).

4.1 Required tests

Table 2 lists the tests that shall be performed on all new, repaired and modified distribution pilot cable installations. These include BV and translay pilots.

Table 2- Required tests distribution pilot cables

Test	New Cable	Before repair or modification	After repair or modification
Continuity	√	√	√
Core Identification	√	√	√
IR Test	√	√	√

Table 3 lists the tests that shall be performed on all new, repaired and modified sub-transmission pilot cable installations. These include UPC and UCC pilots.

Table 3 - Required test sub-transmission pilot cables

Test	New Cable	Before repair or modification	After repair or modification
Continuity	√	√	√
Core Identification	√	√	√
IR Test	√	√	√
HV Test	√	√*	√
Conductor Resistance	√	√*	√
Screen Resistance Check	√	√*	√
Cross Talk Check	√*	√*	√*

* where required

4.2 Continuity and core identification

Prior to and after jointing, continuity and core identification shall be performed on all cores.

4.2.1 IR Tests

Prior to and after jointing, Insulation Resistance tests are to be performed on all pilot cables. IR shall be measured core to core, core to earth and screen to earth (for cables with a metallic screen).

Table 4 provides acceptable IR results for different types of pilot cable.

Table 4 - Acceptable IR test results

Cable type	IRT Voltage (Vdc)	New cable	Existing	Advisory
Translay or BV	500	100MΩ	0.25MΩ	0.1MΩ
Intertrip pilot	500	100MΩ	0.25MΩ	0.1MΩ
UPC/UCC and other high insulation pilots	1000	100MΩ	1MΩ	0.6MΩ

4.3 Sub-transmission general tests

4.3.1 Conductor resistance, screen resistance and cross-talk checks.

Conductor resistance, screen resistance and cross-talk checks shall be performed on completed sub-transmission pilot installations.

4.3.2 High voltage tests

The high voltage tests in Table 5 shall be performed on completed sub-transmission pilot installations.

Table 5 - Required HV tests for Sub-transmission pilots

UPC/UCC Pilot Cable test	Test Duration	New Cable Test Voltage	Existing Cable (more than 1 year old) Test Voltage
core-to-core	1 min	10kVdc	1.0kVdc
cores-to-screen	1 min	15kVdc	2.5kVdc
screen-to-earth	1 min	15kVdc	2.5kVdc

5 LV cable installations

This section describes the electrical tests for Low Voltage (LV) cables. These include LV distributors, street light cable installations and service cables.

5.1 Required tests

Table 6 lists the tests that shall be performed on all new, repaired and modified LV distributor, service and street light cable installations.

Table 6 - Required LV tests

Test	New Cable	Before repair or modification	After repair or modification
IR Test	√	√	√
Phase Identification	√	√	√
Phase Rotation	√*	√*	√*

* where required

5.2 IR tests

IR tests shall be performed phase to phase, phase to neutral and phase to earth as follows:

- after laying a new section of cable;
- on each section of existing cable prior to jointing;
- after jointing works are completed.

Table 7 provides acceptable IR results for low voltage cables.

Table 7 - Acceptable IR test results for LV cables

IRT voltage (Vdc)	New cable	Existing	Advisory
500	200MΩ	20MΩ	0.1MΩ

5.2.1 IR test exception

An Insulation Resistance (IR) test is not required for modified existing low voltage (LV) cables, where:

- the isolation of the underground mains from all customer installations is not reasonably practicable, due to factors such as:
  - a point of isolation cannot be created at a customer main switchboard due to the main switchboard being inaccessible to Ausgrid; and/or
  - the time required to isolate the network from all customer installations and carry out the work would cause unacceptable customer interruption durations and/or timing; and
- an alternate electrical test method (other than an IR test) is used to confirm the absence of a phase-to-phase, or phase-to-neutral/earth, short circuit, as required by the Electrical Safety Rules Clause 9.4.1.

5.3 General tests

5.3.1 Phase rotation checks shall be carried out after energisation but before providing load capability to a customer.

5.3.2 In addition to these tests, all new service cable installations shall have tests performed in accordance with the requirements of ES 4 – Accredited Service Provider Authorisation.

6 HV (5 and 11 kV) cable installations

This section describes the electrical tests for High Voltage (HV) cables rated from 5kV to 11kV.

HV ABC Cables shall be tested (similar to underground XLPE cables) in accordance with this section.

6.1 Required tests

Table 8 lists the tests that shall be performed on all new, repaired and modified HV feeder cable installations.

Table 8 - Tests required on HV feeder cables

Test	New Cable	Before repair or modification	After repair or modification
IR Test	√	√	√
Phase Identification	√	√	√
HV Test	√*	√*	√**

* Prior to jointing a cable that has been out of service for more than one year or is suspected of damage or water ingress, a HV test shall be performed (Clause 6.3).

** Where remote energisation cannot be performed (Clause 3.12)

6.2 IR tests

6.2.1 IR tests shall be performed phase to phase, phase to earth and metallic screen to earth as follows:

- after laying a new section of cable;
- on each section of existing cable prior to jointing;
- after jointing works are completed.

6.2.2 IR Tests ensure a new, repaired or modified cable is fit for duty and assists in fault location prior to jointing.

Table 9 provides acceptable IR results for HV cables.

Table 9 - Acceptable IR results for HV feeder cables

IRT voltage (Vdc)	New cable	Existing	Advisory
500-1000Vdc	200MΩ	100MΩ	10MΩ

Notes:

1) Existing cables that passed a HV test but have an IR result less than 100 MΩ, are considered fit for service, and shall be placed into service.
2) New cables, or those that are older than 1 year but have not been placed into service, shall be investigated and remedial action taken if the metallic screen-to-earth IR falls below the values specified in the above table.
3) Existing cables that have been in service with a metallic screen-to-earth IR result less than 1MΩ, prior to jointing, shall be tested to locate the serving fault. Screen-to-earth IR results between 1 MΩ, and 100 MΩ, prior to jointing and does not vary after jointing, shall be deemed fit for service and shall be placed into service.

6.2.3 IR test exceptions

6.2.3.1 The only situation (Note 1) where it is considered impractical to IR test the final cable circuit is where the design of the switchgear prevents the feeder cables from being 'laid back' (e.g. Hazemeyer RMI units) and either:

- the feeder isolation cannot be extended to allow for IR testing, or
- the load on the substation with this switchgear cannot normally (Note 2) be transferred away to permit the substation to be interrupted for testing purposes.

In this case, the feeder may be remotely energised without an IR test provided the Remote Energisation precautions (Refer Clause 3.12) and the following additional precaution are implemented:

- All new and (as far as possible) existing cables are IR tested prior to making the final commissioning joint.

Notes:

1) The conditions imposed by Ausgrid's Electrical Safety Rules for proving mains and apparatus de-energised and phasing of the cables shall still be complied with and may still require placing more than one substation in low voltage parallel.
2) In this context 'normally' means that the substation can only be held in LV parallel or supported by mobile generator outside normal business hours.

6.3 High voltage tests

6.3.1 Various types of cables that are connected to the circuit being tested shall be determined to prevent DC test voltages being applied to polymeric cable types.

6.3.2 For polymeric cables, the application of unipolar pulsed test voltages is an accepted practice for fault location.

6.3.3 Where a HV cable installation consists of long runs of cable, or where the condition of the cable is in doubt, the Ausgrid representative shall speak with testing personnel before jointing. It may be possible to ascertain the condition of the cable by HV testing or fault location, before jointing.

Table 10 shows the test voltage type, test voltage level and test period for testing of 5kV cable circuits.

Table 10 Test requirements for 5kV cable circuits

Cable Test	Test Voltage		Application	Test Period
		In-service cable		
dc test	PILC	7.5kVdc	All phases to earth	15 mins
	PILC	10.5kVdc	Between phases	15 mins
VLF ac test	PILC/Polymeric	7.5kV peak (5.5kVrms)	Each phase in turn with others earthed	15 mins
50Hz ac test	PILC/Polymeric	5.5kVrms	Each phase in turn with others earthed	5 mins

Table 11 shows the test voltage type, test voltage level and test period for testing of 11kV PILC cable circuits.

Table 11 - Test requirements for 11kV PILC cable circuits

Cable Test	Test Voltage		Application	Test Period
	New cable	In-service cable		
dc test	25kVdc	17.5kVdc	All phases to earth	15 mins
	34kVdc	30kVdc	Between phases	15 mins
VLF ac test	25kV peak (17.5kVrms)	17.5kV peak (12.5kVrms)	Each phase in turn with others earthed	15 mins
50Hz ac test	15kVrms	12kVrms	Each phase in turn with others earthed	5 mins

Table 12 shows the test voltage type, test voltage level and test period for testing of 11kV polymeric cable circuits.

Table 12 - Test requirements for 11kV polymeric cable circuits

Cable Test	Test Voltage		Application	Test Period
	New cable	In-service cable		
VLF ac test	25kV peak (17.5kVrms)	17.5kV peak (12.5kVrms)	Each phase in turn with others earthed	15 mins
50Hz ac test	15kV rms	12kV rms	Each phase in turn with others earthed	5 mins

6.4 Voltage uprating of cable installations

Cables that are proposed to have their operating voltage up-rated usually from 5/6.6kV to 11kV shall be assessed during the project planning phase by HV testing to ensure that the cables are capable of withstanding the new service voltage. For large projects it may be possible to test only a limited number of cables, e.g. a selected sample based on age / failure history / load sensitivity.

7 Sub-transmission cable installations

7.1 Requirements

7.1.1 This section describes electrical tests for sub-transmission cable installations. Non-electrical tests for Fluid Filled cables are described in Section 8.

7.1.2 The testing requirements for sub-transmission cable installations vary according to operating voltage and cable type.

7.2 Required tests

Table 13 provides the tests that are required prior to each sub-transmission cable being energised.

Table 13 - Required pre-energisation tests for sub-transmission cables

Test	Commissioning	After repair	After modification
IR Test (conductor)	√	√	√
Conductor Resistance Test	√	√	√
Phase Identification (conductor)	√	√*	√
Sheath Resistance Test	√	√*	√
Phase Identification (sheath)	√**	√**	√**
Cross-bonding Test	√**		√**
SVL Test	√**	√**	√**
Sequence Impedance Measurements	√		√*
Serving Test	√	√	√
High Voltage Test (conductor)	√	√	√

* As appropriate for the particular repair or modification.
** Single core cables.

Note: Additional commissioning tests of the earthing/ECC system shall be carried out as per NS260 Clause 6.6.

7.3 IR tests

7.3.1 For repaired and modified cable circuits, IR tests shall be performed prior to jointing each section of cable, to ensure the existing cable is acceptable. It is advisable to IR test each section of new cable after laying and prior to jointing, to expedite the fault location process.

Table 14 provides acceptable IR results for different types of sub-transmission cables.

Table 14 - Acceptable IR results for sub-transmission cable conductor insulation

IRT voltage (Vdc)	New cable	Existing
500-1000	200MΩ	100MΩ

7.4 Serving tests

Table 15 shows the test voltage level, and test period for serving tests on different types of sub-transmission cables.

Table 15 - Requirements for serving tests on sub-transmission cables

Cable Type	New Installations		Existing Installations	
	33kV and 66kV	132kV	33kV and 66kV	132kV
PILC	Not Applicable	Not Applicable	Not Applicable	Not Applicable
XLPE	10kV /1min	15kV/1min	2.5kV/1 min	2.5kV/1 min
GAS PRESSURE	Not Applicable	Not Applicable	2.5kV/1 min	Not Applicable
OIL FILLED	Not Applicable	15kV/1min	Not Applicable	2.5kV/1 min

Table 16 provides acceptable IR results for different types of sub-transmission cable serving insulation.

Table 16 - Acceptable IR results for sub-transmission cable serving insulation

IRT voltage (Vdc)	New cable	Existing
500-1000	200MΩ	100MΩ

Note: Where serving test results are less than the IR limits defined in Table 16, they are to be compared to previous testing results. Further assessment or testing may be required depending on known issues with the cable or its life-cycle stage:

- if the IR value has decreased by 25% or more compared to the previous test result,
- if the IR value is less than 100kΩ for oil-filled cable.

7.5 High voltage tests

7.5.1 For new cables, these tests shall be performed after laying and bedding.

7.5.2 For existing and modified cables, the tests shall be performed after backfilling of joints, prior to surface restoration works.

7.5.3 Electrical tests shall be performed after cable damage where it is suspected that electrical failure has been involved, or there is a possibility of future failure at the damage area.

7.5.4 Tables 17, 18 and 19 show the test voltages and test times for 33kV, 66kV and 132kV sub-transmission cables.

7.5.5 For feeders that comprise a mix of new and existing cables and/or different cable types, the test voltage shall be the minimum value of the test voltages for each individual cable section.

7.5.6 The test type shall be chosen in descending order of those listed in Tables 17, 18 and 19, subject to test equipment limitations.

7.5.7 If test equipment limitations prevent the full dc, VLF ac or resonant test voltage being applied then the power system "soak" test shall be carried out instead.

7.5.8 Approval shall be sought from Ausgrid to reduce these testing requirements on a case by case basis for cables with known problem, if needed to extend their service life.

7.6 General tests

7.6.1 An additional check for Gas Pressure cables after jointing but prior to installing the coffin, is to pressurise the joint sleeves and check there are no leaks.

7.6.2 Prior to restoring the cable to service, check gas alarms and reset with all cylinders being at their operating pressures.

7.6.3 Where Gas Pressure cable has experienced crush damage to the cable sheath or serving, a serving test shall be performed.

7.6.4 An additional check for cross-bonded cable installations where an existing joint was disturbed and the connections removed during repairs, is to perform a phasing check from the box through to the next cross-bonding box.

7.6.5 SVL checks must be performed after repair where the cable has carried fault current.

Table 17 - Requirements for tests on new and existing 33kV cables

Test Type	PILC	GP	XLPE
dc test	*New*: 75kV dc for 15 mins. *Existing*: 45kV dc for 15 mins.	*New:* 75kV dc for 15 mins. *Existing:* 45kV dc for 15 mins.	XLPE cable shall not be dc tested.
VLF ac test	*New:* 75kV$_p$ (53kV$_{rms}$) for 15 mins. *Existing:* 60kV$_p$ (42.4kV$_{rms}$) for 15 mins.	*New:* 75kV$_p$ (53kV$_{rms}$) for 15 mins. *Existing:* 45kV$_p$ (31.8kV$_{rms}$) for 15 mins.	*New:* 75kV$_p$ (53kV$_{rms}$) for 15 mins. *Existing:* 60kV$_p$ (42.4kV$_{rms}$) for 15 mins. PD and DDF measurements for both new and existing 33kV XLPE cables.
ac resonant test	*New*: 33kV$_{rms}$ for 15 mins *Existing:* 26kV$_{rms}$ for 15 mins.	*New:* 33kV$_{rms}$ for 15 mins *Existing*: 26kV$_{rms}$ for 15 mins.	*New:* 33kV$_{rms}$ for 15 mins. Existing: 26kV$_{rms}$ for 15 mins.
system voltage	*New & existing:* Power system voltage "soak" for 24 hrs.	*New & existing:* Power system voltage "soak" for 24 hrs.	*New & existing:* Power system voltage "soak" for 24 hrs.

Table 18 - Requirements for tests on new and existing 66kV cables

Test Type	OF	XLPE
dc test	*New:* 135kV dc for 15 mins. *Existing:* 120kV dc for 15 mins.	XLPE cable shall not be dc tested.
ac resonant test	*New:* 72kV$_{rms}$ for 1 hr. *Existing*: 58kV$_{rms}$ for 1 hr.	*New:* 72kV$_{rms}$ for 1 hr. *Existing*: 58kV$_{rms}$ for 1 hr.
VLF ac test	New & existing: 90kV$_p$ (63.6kV$_{rms}$) for 15 mins – this is limited to the maximum rating of Ausgrid's test equipment so a system voltage test shall also be carried out.	New & existing: 90kV$_p$ (63.6kV$_{rms}$) for 15 mins – this is limited to the maximum rating of Ausgrid's test equipment so a system voltage test shall also be carried out.
system voltage	*New & existing:* Power system voltage "soak" for 24 hrs.	*New & existing:* Power system voltage "soak" for 24 hrs.

Table 19 - Requirements for tests on new and existing 132kV cables

Test Type	OF	OF with submarine section	XLPE
dc test	*New & Existing*: 264kVdc for 15 mins.	*New:* 264kVdc for 15 mins. *Existing:* 150kVdc for 15 mins.	XLPE cable shall not be dc tested.
ac resonant test	*New:* 132kV$_{rms}$ for 1 hr. *Existing:* 106kV$_{rms}$ for 1 hr.	*New:* 132kV$_{rms}$ for 1 hr. *Existing:* 106kV$_{rms}$ for 1 hr.	*New*: 132kV$_{rms}$ for 1 hr. *Existing:* 106kV$_{rms}$ for 1 hr.
VLF ac test	New & Existing: 90kV$_p$ (63.6kV$_{rms}$) for 15 mins – this is limited to the maximum rating of Ausgrid's test equipment so a system voltage test shall also be carried out.	New & Existing: 90kV$_p$ (63.6kV$_{rms}$) for 15 mins – this is limited to the maximum rating of Ausgrid's test equipment so a system voltage test shall also be carried out.	New & Existing: 90kV$_p$ (63.6kV$_{rms}$) for 15 mins – this is limited to the maximum rating of Ausgrid's test equipment so a system voltage test shall also be carried out.
System voltage	*New & Existing*: Power system voltage "soak" for 24 hrs.	*New & Existing*: Power system voltage "soak" for 24 hrs.	*New & Existing*: Power system voltage "soak" for 24 hrs.

8 Oil sample testing requirements

8.1 General

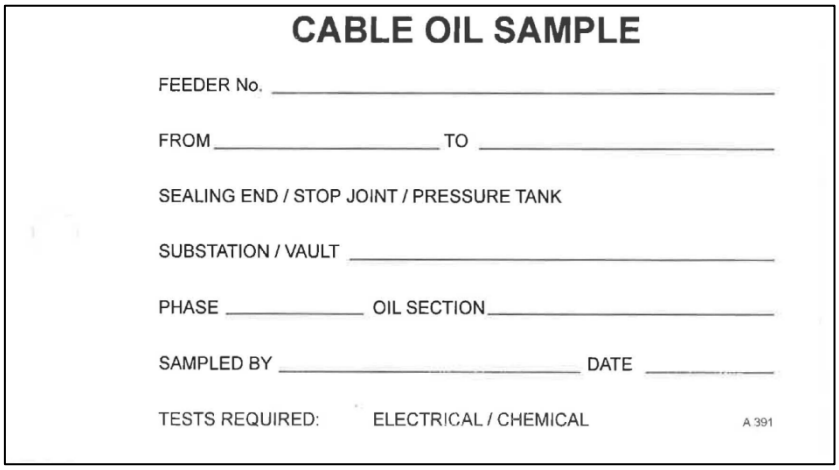
Oil samples shall be taken from all 132kV oil-filled cables and accessories during scheduled maintenance and submitted to Ausgrid's testing laboratory for analysis.

8.1.1 The purpose of the tests is to provide Ausgrid with data that can be used to determine degradation of a cable and other metrics for identifying possible failure modes, reliability and life cycle factors.

8.2 Sampling Requirements

8.2.1 Oil samples are to be collected in an approved container and labelled using the following tie-on tag, which is supplied by Ausgrid's testing laboratory.

8.2.2 Personnel collecting oil samples must ensure details recorded on the label are complete and correct before submitting for testing.


CABLE OIL SAMPLE

FEEDER No. _____

FROM _____ TO _____

SEALING END / STOP JOINT / PRESSURE TANK

SUBSTATION / VAULT _____

PHASE _____ OIL SECTION _____

SAMPLED BY _____ DATE _____

TESTS REQUIRED: ELECTRICAL / CHEMICAL A 391

8.3 Test Requirements

8.3.1 Oil samples shall be tested to determine the level of each component specified by Table 20.

8.3.2 Test results that exceed the Alert level shall be noted on the test report, and advice should be sought from the engineering group that provides support to Ausgrid, on any actions that may be needed.

Table 20 – Oil Test Requirements

Test	Component	Alert level
DGA	Hydrogen (H_2)	> 150 µl/l
	Oxygen (O_2)	> 100 µl/l
	Nitrogen (N_2)	> 100 µl/l
	Methane (CH_4)	> 30 µl/l
	Carbon Monoxide (CO)	> 100 µl/l
	Carbon Dioxide (CO_2)	> 100 µl/l
	Ethylene (C_2H_4)	> 20 µl/l
	Ethane (C_2H_6)	> 25 µl/l
	Acetylene (C_2H_2)	> 2 µl/l
	Propane (C_3H_8)	n/a
Moisture	H_2O	> 10 ppm
Dielectric	Dissipation Factor @ 90 Deg. C Resistivity @ 90 Deg. C Breakdown Voltage	> 0.02 < 60 GΩ < 65 kV
PCB	Polychlorinated bi-phenyls	> 2 ppm

8.4 Reports and Recording

Ausgrid's testing laboratory shall issue a written report for each oil sample tested. The report shall provide as a minimum the following information:

- Unique Report Number
- Customer details
- Sample details: Feeder Route | Feeder No.| Phase | Substation Vault | Oil Section | Sampling Point |Sample Date | Received Date.
- Test results for each component with the following column headings:- Test | Component | Results | Units | Test Method (reference Standard)
- Comments as applicable, including notes that alert levels have been infringed.
- Contact details and signature of Testing Officer

Annexure A: Testing of selected 132kV cable circuits

The normally accepted test voltages applied in Section 7 should be reduced where special circumstances warrant it; for example, in the case where submarine cables are involved, or where an installation contains elements (such as specific joints) which are known to be prone to failure.

Table A1 lists existing 132kV cable installations that have special conditions and suggests maximum test voltages to be applied should the occasion arise.

Table A1 - Reduced test voltages for selected 132kV cable installations

Feeder	Destination	Cable Make	Suggested Test Voltage (kVdc)	Reasons for reduced test voltage
92L/1	Dalley St - Surry Hills	Pirelli	150	Suspect joints

Annexure B: Sample IR test report



To: Supervisor _____

CABLE INSULATION RESISTANCE (IR) TEST REPORT

Time: _____ Date:_____

Location/Project: _____

Procedure:

Phase-to-Phase, Phase-to-Neutral, Phase-to-Earth and Metallic Screen-to-Earth IR readings are to be taken before and after jointing works.

Equipment:

500V Megger with minimum range 200MΩ

Instrument No.:_____ Calibration Date:_____

Minimum IR Values for Power Cables (from NS 161 Clauses 5.2 and 6.2):

Cable Type	New Cable	Existing Cable	Advisory
Low Voltage	200MΩ	20MΩ	0.1MΩ
High Voltage	200MΩ	100MΩ	10MΩ

"Existing Cable" are cables that have been commissioned and in service, or cables that have been laid and not placed in service but are older than 1 year. If "Existing Cable" values are not achieved but "Advisory" are, the cable may be returned to service but the results shall be reported to Ausgrid.

If "Advisory" values are not achieved, the matter shall be referred to Ausgrid as to whether the cable shall be returned to service. Alternatively, Network Test may be contacted to arrange a cable test.

Results:

Cable Type/Description: _____

Before	A-B		A-N		A-E		S-E		
	A-C		B-N		B-E				PASS / FAIL
	B-C		C-N		C-E				
After	A-B		A-N		A-E		S-E		
	A-C		B-N		B-E				PASS / FAIL
	B-C		C-N		C-E				

Comments:_____

Cable Type/Description: _____

Before	A-B		A-N		A-E		S-E		
	A-C		B-N		B-E				PASS / FAIL
	B-C		C-N		C-E				
After	A-B		A-N		A-E		S-E		
	A-C		B-N		B-E				PASS / FAIL
	B-C		C-N		C-E				

Comments:_____

Tested By:_____ Signature:_____