



NS161

Specification for Testing of Underground Cables

November 2010



SUMMARY

Network Standard NS161 is Ausgrid's specification for testing pilot, low voltage and high voltage distribution and sub-transmission cable installations. This specification applies to cable installations which are new, repaired or modified.

ISSUE

Ausgrid staff: This document is for issue to all staff involved with commissioning and testing of underground cables.

Where this standard is issued as a controlled document replacing an earlier edition; remove and destroy the superseded document.

Accredited Service Providers: This document is issued on an uncontrolled basis. Users are responsible for ensuring that the document they are using is current and includes any amendments issued since the date on the document. Ausgrid will not accept any liability for work carried out to a superseded standard. Ausgrid may not accept work carried out which is not in accordance with current standard requirements.

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As Ausgrid's standards are subject to ongoing review, the information contained in this document may be amended by Ausgrid at any time.

It is possible that conflict may exist between standard documents. In this event, the most recent standard is to prevail.

This document has been developed using information available from field and other sources and is suitable for most situations encountered in Ausgrid. Particular conditions, projects or localities may require special or different practices. It is the responsibility of the local manager, supervisor, assured quality contractor and the individuals involved to ensure that a safe system of work is employed and that statutory requirements are met.

Ausgrid disclaims any and all liability to any person or persons for any procedure, process or any other thing done or not done, as a result of this Network Standard.

INTERPRETATION

In the event that any user of this Standard is uncertain about any information or provision, the user should request clarification from Ausgrid. Ausgrid's interpretation shall then apply as though it was included in the Standard.

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NS161
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1 INTRODUCTION

1.1 General

The purpose of performing cable tests is to prove the circuit is safe to energise or commission. The tests specified in this Standard are minimum requirements. Additional testing may be required in some cases due to local conditions. Where additional tests are required, they will be specified by Ausgrid prior to commissioning.

Where tests are specified, they shall be carried out in accordance with the requirements of this Standard unless otherwise stated by Ausgrid.

This Network Standard should be read in conjunction with Ausgrid's Network Standards NS130, Specification for Underground Cable Laying, and NS156, Working Near or Around Underground Cables.

1.2 Definitions

Accredited Service Provider	An Accredited Service Provider is as defined in document ES 9, Agreement for Electricity Supply to Developments.
Client	A Client is an individual or an entity who has responsibility for the design and construction of the electricity reticulation installation, and who enters into an agreement/contractual arrangement with accredited personnel and/or Ausgrid for developing the installation. A client could be a developer, Service Provider or customer.
Ausgrid's Representative	A person appointed by Ausgrid to act as a liaison person between the Client and Ausgrid, and who has responsibility for ensuring that all works which are of interest to Ausgrid are carried out in accordance with Ausgrid's requirements.

1.3 Technical Definitions

Cable Installation	A continuous length of installed cable including joints and terminations, but not including switches.
CCPU	Cable Covering Protection Units
EPR type cable	Ethylene Propylene Rubber insulated cable. Single or multicore cable with a nominal phase-to-phase voltage equal to or greater than 11kV to less than or equal to 132kV.
Fluid Filled type cable	A paper insulated cable, hermetically sealed and flooded with an evacuated low viscosity fluid from tanks, under a positive pressure, to fill voids within the cable. Single or multicore cable with a nominal phase-to-phase voltage of equal to or greater than 33kV to less than or equal to 132kV.

Gas Pressure (GP) type cable	A paper insulated cable, pressurised with dry nitrogen from cylinders via regulators (typically at 1400 kPa) to suppress the onset of electrical ionisation. Generally a multicore cable with a nominal phase-to-phase voltage of equal to or greater than 33kV to less than or equal to 132kV.
High Voltage (HV) Installation	An installation where the nominal phase-to-phase voltage is greater than 1000 V and less than 33kV
IR	Insulation Resistance
IRT	Insulation Resistance Tester ('megger' or similar)
Low Voltage (LV) Installation	An installation where the nominal phase-to-phase voltage is less than or equal to 1000 V
MIND type cable	Mass Impregnated Non Draining paper insulated cable. Single or multicore cable with a nominal phase-to-phase voltage of less than or equal to 33kV.
Phase Identification	Phase identification is a test to identify the same phase conductors of a cable at both ends of the cable.
Phasing	Phasing is a test to prove that energised conductors on each side of a switch or open point can be safely joined together by closing the switch or open point
PILC type cable	Paper Insulated Lead Covered cable. Single or multicore cable with a nominal phase-to-phase voltage of less than or equal to 33kV.
Pilot cable	Pilot cable comprising of copper conductors is used for communications, signalling and protection purposes.
SAO	Reconnection and System Alteration Order
Sub-transmission Voltage Installation	An installation where the nominal phase-to-phase voltage is equal to or greater than 33kV and less than or equal to 132kV.
SVL	Sheath Voltage Limiter
Switch	Any device that is designed and used for making or and breaking an electric circuit
UPC/UCC	Pilot cable associated with sub-transmission circuits but not necessarily running in the same trenches.
XLPE type cable	Cross Linked Polyethylene insulated cable. Single or multicore cable with a nominal phase-to-phase voltage of equal to or greater than 11kV to less than or equal to 132kV.

2 REFERENCES

2.1 Ausgrid References

- NS129 - 11kV Joints and Terminations - Paper Insulated Lead Covered Cables
- NS130 - Specification for Laying of Underground Cables Up to 22 kV Details
- NS156 - Working Near or Around Underground Cables
- NS177 - 11kV Joints (including Transition Joints) & Terminations -Polymeric Insulated Cables

2.2 Other References

- IEC 60141 – 1 Tests on Oil Filled and Gas-Pressure Cable and their Accessories.
- IEC60502 – 2 Power cables with extruded insulation and their accessories for rated voltages from 1kV up to 30kV - Part 2: Cables for rated voltages from 6kV up to 30kV.
- IEC 60229 Tests on cable oversheaths which have a special protective function and are applied by extrusion.
- IEEE P400.2/D5 Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF).
- ENA D(b)31 Guide for the Maintenance of High Voltage Paper/Oil Insulated Cables and Accessories, Energy Networks Association formerly the Electricity Supply Association of Australia.
- 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 - 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 - For working voltages 19/33 (36)kV up to and including 87/150 (170)kV.
- AS 1931.2 – High-voltage test techniques - Measuring systems.
- AS 60840 Power cables with extruded insulation and their accessories for rated voltages above 30kV ($U_m = 36kV$) up to 150kV ($U_m = 170kV$) Test methods and requirements

3 RESPONSIBILITIES

Ausgrid's testing group or specialised Accredited Service Providers are responsible for ensuring that the tests as specified in this standard are carried out in accordance with Ausgrid's requirements. The entities described above shall arrange for an Access Permit for Test and Ancillary Work in accordance with the requirements specified in Ausgrid's Electrical Safety Rules prior to commencement of the tests.

Ausgrid reserves the right to witness any HV tests required by this Standard carried out by specialised Accredited Service Providers.

All test equipment and instrumentation used for testing shall have been calibrated by a NATA Accredited Organisation and have a current test sticker affixed. The Accredited Service Provider is responsible for ensuring that test equipment and instrumentation used is traceable.

All test results shall be documented by Ausgrid's testing group or the Accredited Service Provider.

The following information shall be recorded as a minimum:

- testing organisation name
- test date and location
- accurate description of cable or equipment tested
- cable 'passed' or 'failed' tests
- details of test completed and result expressed as a value at a reference temperature (where applicable)
- test equipment numbers and calibration dates.

Within one week of the tests, the Accredited Service Provider shall provide Ausgrid's Representative (generally, the manager responsible for the asset) 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.

4 TYPES OF INSTALLATIONS

4.1 New Installations

A new installation is where a new section of cable has been installed between substations, or points of isolation. By comparison, a modified installation involves a joint onto existing cable at one end at least (see Clause 4.3).

4.2 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.

4.3 Modified Installations - System Modifications

A modified installation applies to any cable which has been attached to existing cables by jointing. Testing a modified installation would subject existing cables to the 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.

5 GENERAL TEST REQUIREMENTS

Section 6 through to Section 9 state the specific tests that are required to be performed on each particular cable installation. Test requirements are included for commission, after repair and after modification situations. Unless otherwise stated, each test is required on the complete Cable Installation. Where testing is required before jointing each section of cable, this is stated in the test requirement.

Tests should be performed in the sequence stated in Section 6 through to Section 9.

Unless otherwise specified, test procedures shall generally be in accordance with the relevant Australian Standards. See Section 2, References.

5.1 Conductor Resistance Test

To determine the effectiveness of the conductor joints and terminations by measuring the dc loop resistance. This can be compared with the manufacturer's conductor resistance usually expressed in ohms/km in the cable specification.

5.2 Continuity Check

A continuity check is used to confirm the connection between ends of the cable.

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

5.3 Core Identification Check (for pilot cables)

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

The core is positively identified, when the loop circuit is completed.

The process is repeated until all the cores are identified. Each core shall be marked as it is identified.

5.4 Cross Bonding/Current Injection Test

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.

This test involves injection of a 3 phase current into the cores of the cable, and measuring of voltages and currents induced into the sheaths at each cross-bonding point along the complete cross bonding section. An injection current of greater than 50 A should be used. Sheath currents and voltages are to be measured at each cross-bonding point, earth point and termination. The cross-bonding connections shall be rearranged to prove incorrect connection, and checked again after correct restoration.

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

Current and voltage measurements are to 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.

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

5.5 Cross Talk Check (for pilot cable)

This test determines if an appreciable voltage is induced on any pilot pair from current flowing in another pilot pair.

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 200 V or a current of 3 A.

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

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

5.6 Dielectric Dissipation Factor (DDF) and Partial Discharge (PD) Measurement

This test is generally only applicable only to 5kV / 6.6kV belted cables proposed to be operated at 11kV, and shall be made with alternating voltage having power frequency. Its waveform should be a sine curve and have both half cycles alike.

Sections of the cable installation shall be tested excluding joints. The test shall be applied between each conductor in turn and the other conductors connected to the lead alloy sheath.

Dielectric dissipation factor shall be measured at 2kV, 3kV, 4kV, 5kV, 6.5kV, 7kV, 8.5kV, 10kV and 12kV. The values of DDF determined by the test from 2kV to 7kV should be constant, and should not exceed 0.02.

The inception and extinction voltages and the respective magnitudes of partial discharge shall be measured. The magnitudes of partial discharge shall also be recorded at 6.3kV and 7.6kV.

Partial Discharge measurements can also be made on 33 kV to 132 kV cables using a power system frequency (30-300Hz). Measurements are to be made at the high voltage test values, recording inception and extinction voltages and magnitudes where applicable.

5.7 High Voltage (HV) Test

The high voltage test involves applying either a -

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

from each phase conductor to earth and between phases (where applicable) for a specified period of time. The remaining phases not under test shall be earthed.

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

The insulation resistance shall be measured prior to HV testing.

In performing the high voltage test, the voltage must be slowly increased to the levels indicated in Section 6 through to Section 9 of this document, and maintained at these levels for the relevant time periods.

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.

High Voltage dc tests shall only be applied to HV XLPE insulated cables and/or accessories for the purpose of fault location.

For XLPE and EPR cables, it is accepted that for the present, unipolar pulsed test voltages shall be required for fault location.

For XLPE and EPR cables that require confirmation of the cable's integrity prior to energisation, a pulsed dc test can be applied if the cable can not be remotely energised or high voltage testing is not available on site. This test involves measuring the insulation resistance of the cable before and after the application of the high voltage dc pulses. 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. The cable is deemed to have passed the test if there is no disruptive discharge or puncturing of the insulation.

Pulsing voltages for 11kV and 33kV are 8kV_{dc} and 24kV_{dc} respectively.

If new cable is being installed into existing switchgear, the test voltage values for existing cable in the relevant tables in Sections 6 through to Section 9 of this document may be used.

For cables of a known poor condition, (e.g. PILC 33kV 'S' feeders), the test voltage may be reduced to those figures given in Appendix A.

5.8 Insulation Resistance (IR) Test

The Insulation Resistance 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 and phase-to-earth insulation resistances of power cables, and core to earth, core to core and metallic screen to earth on pilot cables.

Because of cable capacitance, the IRT shall be applied until a stable reading is obtained.

Tables in the relevant cable sections give IR limits for new and existing cable circuits. New cable circuits must achieve the minimum IR figures given. Existing cable circuits must meet the "Existing" IR figures to be returned to service with no extra notification. Existing cable circuits meeting only the "Advisory" IR limits, may be returned to service, but notification must be made to the manager responsible for Maintenance and Replacement Planning. If the advisory IR limits cannot be met, the cable must not be returned to service unless authorised by System Control in consultation with the Manager responsible for Transmission or Distribution cables depending on the cable asset.

5.9 Phase Identification

Phase identification should be checked by the use either of 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 may be used.

Refer also to Ausgrid's Electrical Safety Rules - Phasing.

Phase identification checks must be carried out by jointing staff to ensure cables have been correctly connected as indicated on existing system diagrams or System Alteration Order.

Phase identification may relate to either conductors or sheaths.

5.10 Phase Rotation Check

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

5.11 Remote Energisation

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.

Reconnection and System Alteration Orders (SAOs) must provide details of where work has been carried out. This enables operating staff to determine the most appropriate energisation point.

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

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.

5.11.1 When Remote Energisation Shall Not Replace The High Voltage Test

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 performed¹;
- cable installation difficulties were experienced;
- the type and/or condition of cable installation is in doubt;
- where Ausgrid's representative considers it necessary².

5.11.2 Remote Energisation Precautions

Staff responsible for completing the jointing work must take precautions before signing off access permits (where issued) and energisation, to ensure that remote energisation poses no risk to staff or the public.

An example of an acceptable safety system is to implement the following safety precautions before the cable is remotely energised:

- All new and existing cable exposed for the work and all joints are backfilled or covered with at least two layers of sandbags prior to energising.
- Excavations in the immediate proximity of substations are backfilled.

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.

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

- Where the joints are sandbagged, a safety observer is present near the joint pits while the feeder is being energised to ensure no members of the public are at risk.
- All other excavations are safely barricaded and protected, and arrangements are in place for regular checking to ensure that they remain safely barricaded and protected.
- It shall be confirmed that no staff are present in substations where cable jointing or repair work is being energised, prior to energisation.

5.12 Sequence Impedance Measurements

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

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.

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

5.13 Serving Test

5.13.1 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 9.

5.13.2 High Voltage Cables

For 11kV XLPE or EPR cables, only an IR test between the metallic sheath or screen wires to earth is performed to test the integrity of the outer sheath.

The IR test voltage and acceptable limits are stated in section 8.

5.14 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.

5.15 Sheath Voltage Limiters (SVL)

There are various types of SVLs available (previously referred to as Cable Covering Protection Units – CCPUs). 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.

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

6 PILOT CABLE INSTALLATIONS

This section describes 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).

6.1 Required Tests

Table 6.1 lists the tests that shall be performed on all new, repaired and modified distribution pilot cable installations. These include BV and translay pilots

Table 6.1

Test	New Cable	After Repair	After modification
Continuity	√	√	√
Core Identification	√	√	√
IR Test	√	√	√

Table 6.2 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 6.2

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

* where required

6.2 Continuity and Core Identification

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

6.3 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 6.3 provides acceptable IR results for different types of pilot cable.

Table 6.3

Cable type	IRT Voltage (V_{dc})	New cable	Existing	Advisory
Translay or BV	500	100M Ω	0.25M Ω	0.1M Ω
Intertrip pilot	500	100M Ω	0.25M Ω	0.1M Ω
UPC/UCC and other high insulation pilots	1000	100M Ω	1M Ω	0.6M Ω

6.4 Sub-Transmission General Tests

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

6.4.1 High Voltage Tests

For sub-transmission pilots, the high voltage tests in Table 6.4 shall be performed.

Table 6.4

UPC/UCC Pilot Cable test	Test Duration	New Cable Test Voltage	Existing Cable (more than 1 year old) Test Voltage
core-to-core	1 minute	10kV _{dc}	1.0kV _{dc}
cores-to-screen	1 minute	15kV _{dc}	2.5kV _{dc}
screen-to-earth	1 minute	15kV _{dc}	2.5kV _{dc}

7 LV CABLE INSTALLATIONS

This section describes electrical tests for Low Voltage cables. These include low voltage distributors, street light cable installations and customer service cables.

7.1 Required Tests

Table 7.1 lists the tests that shall be performed on all new, repaired and modified LV distributor, service and street light cable installations.

Table 7.1

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

* where required

7.2 IR Tests

IR tests shall be performed phase to phase and phase to earth.

Table 7.2 provides acceptable IR results for low voltage cables.

Table 7.2

IRT voltage (V _{dc})	New cable	Existing	Advisory
500	200MΩ	20MΩ	0.1MΩ

7.3 General Tests

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

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

8 HV (5 and 11 kV) CABLE INSTALLATIONS

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

8.1 Required Tests

Table 8.1 lists the tests that shall be performed on all new, repaired and modified HV feeder cable installations.

Table 8.1

Test	New Cable	After repair or modification
IR Test	√	√
Phase Identification	√	√
DDF and PD	√*	√*
HV Test	√**	√**
Serving Test	√***	√***

* Where required

** Where remote energisation cannot be performed (Clause 5.8)

*** XLPE and EPR cables only

8.2 IR Tests

IR tests shall be performed phase to phase, phase to earth and screen to earth (for direct laid cables). 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.

Table 8.2 provides acceptable IR results for HV cable insulation.

Table 8.2

IRT voltage (V _{dc})	New cable	Existing
500-1000	200MΩ	100MΩ

Table 8.3 provides acceptable IR results for the metallic sheath or screen wire insulation.

Table 8.3

Cable Type	IRT voltage (V _{dc})	New cable	Existing
XLPE or EPR	500-1000	200MΩ	100MΩ

Note: Values below 500kΩ can indicate sheath damage. Values between 1MΩ and 10MΩ may not indicate damage in a single location. Fault finding can therefore be very difficult.

8.2.1 IR Test Exceptions

The only situation (Note 1) where it is considered impractical to IR test the final cable circuit is where switchgear is of a design where the feeder tails cannot be 'laid back' (e.g. Hazemeyer RMI units) and 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 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.

Note 1: While this relaxation of requirements is allowed in this situation, the conditions imposed by Ausgrid's Electrical Safety Rules for proving mains and apparatus de-energised and phasing of the cables must still be complied with, and may still require placing more than one substation in low voltage parallel.

Note 2: 'normally' in this context means that the substation can only be held in LV parallel or supported by mobile generator outside normal business hours.

Note 3 Reference should also be made to important ESR requirements specified in ESR clauses 6.21, 8.2.1 and 8.5.4 re appropriate isolations, insulation mediums for when test voltages are applied and where earths cannot be removed for application of test voltages that would prevent IR tests taking place

8.3 High Voltage Tests

Care should be taken to determine all the various types of cables that are connected to the circuit being tested, to prevent DC test voltages being applied to XLPE and EPR cable types.

High Voltage DC Tests shall only be applied to HV XLPE insulated cables and/or accessories for the purpose of fault location.

For XLPE and EPR cables, it is accepted that for the present, unipolar pulsed test voltages shall be required for fault location.

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

Where a HV cable installation consists of long runs of cable, or where the condition of the cable is in doubt, the project manager should 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 8.4 shows the test voltage type, test voltage level and test period for testing of 5kV cable circuits.

Table 8.4

Cable Test	Test Voltage		Application	Test Period
		In-service cable		
dc test	PILC	7.5kV _{dc}	All phases to earth	15 minutes
	PILC	10.5kV _{dc}	Between phases	15 minutes
VLF ac test	PILC/XLPE	7.5kV peak (5.5kV _{rms})	Each phase in turn with others earthed	15 minutes
50Hz ac test	PILC/XLPE	5.5kV _{rms}	Each phase in turn with others earthed	5 minutes

Table 8.5 shows the test voltage type, test voltage level and test period for testing of 11kV PILC cable circuits.

Table 8.5

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

Table 8.6 shows the test voltage type, test voltage level and test period for testing of XLPE and EPR cable circuits.

Table 8.6

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

8.4 Voltage Upgrading of Cable Installations

Cables that are proposed to have their operating voltage up-rated usually from 5/6.6kV to 11kV, in addition to the above tests, should have a PD and DDF test and a HV test performed. The results shall be assessed by the Executive Manager/Maintenance and Replacement Planning to ensure the cable is capable of the new service voltage.

9 SUB-TRANSMISSION CABLE INSTALLATIONS

This section describes electrical tests for sub-transmission cable installations. Non-electrical tests may be required, which are separately documented in fault location and maintenance procedures. The need for, and scope of, non-electrical tests will be determined by Ausgrid.

The testing requirements for sub-transmission cable installations vary not only due to the nominal operating voltages but also with the different types of cable construction employed.

9.1 Required Tests

Table 9.1 provides the tests that are required prior to each sub-transmission cable being energised.

Table 9.1

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.

** Where appropriate for single core cables.

9.2 IR Tests

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 if required.

Table 9.2 provides acceptable IR results for different types of sub-transmission cable conductor insulation.

Table 9.2

Cable type	IRT voltage (V _{dc})	New cable	Existing
Sub-transmission	500-1000	200MΩ	100MΩ

9.3 Serving Tests

Table 9.3 shows the test voltage level, and test period for serving tests on sub-transmission cables.

Table 9.3

Cable Type	New Installations		Existing Installations	
	33kV & 66kV	132kV	33kV & 66kV	132kV
MIND	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	15kV/1min	2.5kV/1 min.	2.5kV/1 min
FLUID FILLED	Not Applicable	15kV/1min	Not Applicable	2.5kV/1 min

Table 9.4 provides acceptable IR results for different types of sub-transmission cable serving insulation.

Table 9.4

IRT voltage (V _{dc})	New cable	Existing
500-1000	200MΩ	100MΩ

9.4 High Voltage Tests

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

Table 9.5 shows the test voltages and test times for 33kV and 66kV sub-transmission cables.

Table 9.6 shows the test voltages and test times for 132kV sub-transmission cables.

9.5 General Tests

An additional check for gas pressurised sub-transmission cables after jointing but prior to installing the coffin, is to pressurise the joint sleeves and check there are no

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

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.

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

Where gas pressure cable has experienced crush damage to the cable sheath or serving, a serving test shall be performed.

Table 9.5

System Voltage	Test Type	MIND	GP	XLPE	Test Voltage for new cable installations	Test Voltage for existing cable installations
33kV	dc test	√	√		75kV _{dc} for 15 minutes	60kV _{dc} for 15 minutes
	VLF ac test	√	√	√	75kV _{peak} (53kV _{rms}) for 15 minutes	60kV _{peak} (42.5kV _{rms}) for 15 minutes
	ac resonant test	√	√	√	33kV _{rms} for 5 minutes	26kV _{rms} for 5 minutes
	System voltage test	√	√	√	Power system voltage “soak” for 24 hours	Power system voltage “soak” for 24 hours
66kV	dc test	√	√		135kV _{dc} for 15 minutes	120kV _{dc} for 15 minutes
	VLF ac test	√	√	√	135kV _{peak} (95kV _{rms}) for 15 minutes (reduced test values may be limited to the maximum rating of the test equipment)	120kV _{peak} (85kV _{rms}) for 15 minutes (reduced test values may be limited to the maximum rating of the test equipment)
	ac resonant test	√	√	√	72kV _{rms} for 1 hour (AS 60840)	58kV _{rms} for 1 hour (AS 60840)
	System voltage test	√	√	√	Power system voltage “soak” for 24 hours	Power system voltage “soak” for 24 hours

Table 9.6

System Voltage	Test Type	GP	Fluid Filled	Fluid Filled with Submarine section	XLPE	XLPE with Submarine section	Test Voltage for new cable installations	Test Voltage for existing cable installations
132kV	dc test	√	√				264kV _{dc} for 15 minutes	264kV _{dc} for 15 minutes
				√			264kV _{dc} for 15 minutes	150kV _{dc} for 15 minutes
	VLF ac test	√	√	√	√	√	At this stage, VLF testing for 132kV cables is not covered by any standard. Where required, reduced test values limited to the maximum rating of available test equipment for 15 minutes may be used.	At this stage, VLF testing for 132kV cables is not covered by any standard. Where required, reduced test values limited to the maximum rating of available test equipment for 15 minutes may be used.
	ac resonant test	√	√	√	√	√	132kV _{rms} for 1 hour (AS 60840)	106kV _{rms} for 1 hour (AS 60840)
	System voltage test	√	√	√	√	√	Power system voltage "soak" for 24 hours	Power system voltage "soak" for 24 hours

APPENDIX – TESTING OF SELECTED 132kV AND 33kV CABLE CIRCUITS

The normally accepted test voltages applied in Section 8 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 and 33kV cable installations that have special conditions, and suggests maximum test voltages to be applied should the occasion arise. Included in the schedule are ex-ECNW (also known as Elcom and Pacific Power), ex-SCC and ex-SE feeders, as well as those installed since Ausgrid's inception.

Please note that this advice supersedes memo Testing of Ex Elcom 132kV Cables of 24 July 1990, bearing the signature of M-MT/Bradley.

Table A1

System Voltage	FEEDER	DESTINATION	CABLE MAKE	SUGGESTED TEST VOLTAGE (kV _{dc})	REASONS FOR REDUCED TEST VOLTAGE
132 kV	900	Rozelle-Mason Park	BICC	150	Submarine cable involved
132 kV	90W	Rozelle-Pymont	BICC	150	Submarine cable involved
132 kV	90XA	Meadowbank-Homebush Bay TP	Fujikura & BICC	150	Submarine cable involved
132 kV	90XB	Meadowbank-Homebush Bay TP	Fujikura & BICC	150	Submarine cable involved
132 kV	919	Willoughby-Surry Hills Tee-Dalley St	Sumitomo	150	Submarine cable involved
132 kV	928/3	Dalley St-Lane Cove	Sumitomo	150	Submarine cable involved
132 kV	92FA	Homebush Bay TP-East Bay TP	BICC	150	Submarine cable involved
132 kV	92FB	Homebush Bay TP-East Ryde TP	BICC	150	Submarine cable involved
132 kV	92L/1	Surry Hills-Dalley St	Pirelli	150	Suspect joints involved
132 kV	92L/3	Dalley St-Lane Cove	Pirelli	150	Submarine cable involved
132 kV	92M	Lane Cove-Surry Hills Tee Dalley St	Pirelli	150	Submarine cable involved
33 kV					
33 kV					
33 kV					

To: Supervisor / _____

CABLE INSULATION RESISTANCE (IR) TEST REPORT

(To be read in conjunction with NS 161 – Specification for Testing of Underground Cables)



Time: Date: Location/Project:

Procedure: Phase-to-Phase and Phase-to-Earth IR readings are to be taken before and after jointing works.			
Equipment: 500V IRT with minimum range 200MΩ			
Instrument No:		Calibration Date:	/ /

Minimum IR Values for Power Cables (from NS 161 Clause 9.4.2)

Cable Type	New Cable	Existing Cable ⁽¹⁾	Advisory ⁽²⁾
Low Voltage	200MΩ	20MΩ	0.1MΩ
High Voltage	200MΩ	100MΩ	5MΩ

- ¹ 'Existing Cable' are cables that have been in service or 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 must be reported to your Supervisor.
- ² If 'Advisory' values are not achieved, the matter must be referred to your Supervisor who will make a decision with the System Operator 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 Work:	A-B		A-N		A-E	PASS / FAIL
	A-C		B-N		B-E	
	B-C		C-N		C-E	
After Work:	A-B		A-N		A-E	PASS / FAIL
	A-C		B-N		B-E	
	B-C		C-N		C-E	

Comments:

Cable Type/Description:						
Before Work:	A-B		A-N		A-E	PASS / FAIL
	A-C		B-N		B-E	
	B-C		C-N		C-E	
After Work:	A-B		A-N		A-E	PASS / FAIL
	A-C		B-N		B-E	
	B-C		C-N		C-E	

Comments:

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