TESTING & COMMISSIONING PROCEDURE

SUBTRANSMISSION UNDERGROUND CABLES

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1 PURPOSE

The purpose of this document is to identify generic requirements applicable to the testing & commissioning of new Subtransmission Underground Power Line systems associated with Essential Energy's network infrastructure.

This procedure applies to all new underground cable installations that are to be connected to Essential Energy's network. The use of this procedure is for Accredited Service Providers, Essential Energy staff and accredited sub-contractors.

The purpose of undertaking underground cable testing is to prove cable integrity after installation and jointing work is completed and before connection to the Essential Energy Network.

The tests specified within this procedure are the mandatory minimum requirements. Additional testing may be required depending upon project/site conditions. Additional test requirements will be identified by Essential Energy within the project specific commissioning program.

2 KEY TERMS & DEFINITIONS

ASP means an accredited service provider, being a person or body accredited under part 10 of the Electricity Supply (General) regulation 2001, (NSW).
Accreditation of service providers is administered by the department of Industry & Investment.
A list of ASP's is available on the Industry & Investment website.

ASP3 means a level 3 service provider accredited to carry out design works.

ASP1 means a level 1 service provider accredited to carry out construction works. An ASP1 must have specific accreditation to carry out underground cable installations.

DIP means design information package.

EE means Essential Energy.

QCC means EE appointed Quality Control Coordinator.

HIRAC Hazard Identification, Risk Assessment and Control

3 TESTING & COMMISSIONING

All electricity works shall be designed to be safe for the electrical conditions likely to be experienced during service and the physical environment in which they will operate. EE needs to ensure that appropriate tests have been completed before an installation is commissioned into service for compliance with the design & specifications. This will require close cooperation between the ASP1 and EE.

EE will appoint a commissioning manager or QCC auditor for coordination purposes.

3a Commissioning Plan

Prior to energising or commissioning any subtransmission underground cable installation a detailed commissioning plan shall be prepared by the ASP and submitted to EE for approval.

The commissioning plan must include:

- Single line diagram of final installed network.
- Detailed step by step procedure of the activities (checks & tests) with the sequence clearly documented.
- A proposed timetable.
- Supervisor and employees involved including their contact details.
- A summary of pre commissioning checks & tests completed and results.
- Written confirmation that all works undertaken by the ASP for the installation meets the required Australian standards, NSW S & I Rules, EE standards and cable manufacturer's requirements for testing of product, plant, equipment and drawings/specification.
- Completed set of "as installed" design documents and plans.

3b Tests

Before any tests are performed, EE and the ASP must agree on the procedures to be used for the tests and any modification to or deletion from this procedure.

Tests must be carried out in the presence of representatives nominated by the ASP and EE. The ASP must provide the results of tests to EE as requested by EE, within a maximum time period of 2 weeks.

All test results shall be documented and submitted to EE including the following detail:

- Testing organisation details.
- Date, time and location of test.
- Description of cable tested.
- Description of test equipment used including calibration dates.
- Test procedure.
- Test results.

If tests indicate that corrective works are required to ensure cable integrity the ASP must then:

- Undertake, at their cost, all rehabilitation, modification or remediation work required to the reasonable satisfaction of EE.
- Report back to EE in writing when all corrective work has been completed and renegotiate a suitable program to recommence tests.

3c Test Equipment.

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 ASP is responsible for ensuring that test equipment and instrumentation is traceable.

3d Authority for Placing Major Electrical/Plant Equipment into Service (CEPG2047)

CEPG2047 applies to all new Major Electrical Plant/Equipment.

The purpose of procedure CEPG2047 is to ensure that EE's Network Operations department receives written notification that all construction and pre-commissioning checks on major plant/equipment are complete and ready for service.

Prior to final commissioning and energising of the high voltage equipment, direct lines of communication must be established between the ASP's nominated person, for site commissioning and ongoing operations, and the designated EE Systems Operations Centre.

The CEPG2047 written notification shall be completed by the ASP and submitted to EE's QCC auditor for co-ordination with EE's system operations.

3e "As Installed" Detail

On completion of construction and prior to final commissioning of the cable installation the ASP is to provide the following "As Installed" detail to EE :

- Route plan including line schedule & profile.
- Details of other services crossings.
- Cable laying details including depth and trench profiles.
- Termination and jointing records.
- Test reports and/or test certificates.
- Inspection reports.
- Any modified or additional drawings, information or instructions necessary for the satisfactory completion of the work.

"As Installed" detail shall be provided to EE in electronic form as well as hard copy. Electronic documentation is required in the following formats :

- All documentation - Adobe Acrobat "pdf" .
- Drawings – Microstation "dgn" or compatible.

4 PRELIMINARY CHECKS

4a QA Checks

During the installation a system of records shall be maintained which provides objective evidence that requirements have been met, including construction in accordance with applicable standards, construction drawings/plans and specifications.

All records shall be available for audit and review by EE during the installation. The records should provide full traceability of all quality characteristics and activities.

During construction activities QA mechanisms such as check sheets, checklists, inspection & test plans (ITPs) shall be utilised for an EE representative to witness and sign off.

EE's QCC auditor shall be present to witness the installation at hold points, as required by EE, and work shall not proceed past a hold point without EE consent.

4b Notification

EE's QCC auditor shall be notified a minimum of 10 working days prior to the commencement of the cable installation or any tests to be undertaken.

The ASP will be responsible for ensuring that the completed work is QA checked and tested and all records and reports are forwarded to the QCC promptly.

EE's QCC auditor shall be present to witness the testing procedures, and only with EE approval shall proceed to test.

5 Worksite Hazard Identification, Risk Assessment and Control (HIRAC)

Tests on underground cables are potentially hazardous to both personnel undertaking the test and the general public in the vicinity.

A Worksite safety management plan shall be prepared for the project and activities, and will be implemented with an accompanying HIRAC.

The HIRAC will be carried out, by the ASP's authorised person, to determine the precautions that need to be adopted.

As an example, for public areas EE suggest warning signs are likely to be needed to be displayed and barricades erected around the test area (including all exposed cable terminations) prior to commencing any testing activity.

6 SUBTRANSMISSION CABLE TESTS

The required tests for subtransmission cables are :

- IR Test (conductor).
- Conductor Resistance Test.
- Phase identification (conductor)
- Phase Identification (sheath)
- Cross Bonding Test.
- Sequence Impedance Measurements.
- Serving Test.
- Sheath Resistance Test.
- SVL Test.
- High Voltage Test (conductor)

Note – These test requirements are for XLPE type cable as this is EE's standard cable type. Alternate cable types may require variations or additions to the tests required.

6a IR Test

The Insulation resistance (IR) test measures the dc resistance of the insulation of the cable installation using an Insulation Resistance Tester. It involves measuring both the ph-ph & ph-earth insulation resistances. Because of cable capacitance, the IRT shall be applied until a stable reading is obtained.

IR tests shall be performed after laying and prior to jointing each section of cable.

Acceptable IR values are:

System Voltage	Min IR @ 1kV DC Ph-Ph, PH-Earth	Min IR @500V Screen - Earth
33kV	800 megohms	100 megohms
66kV	800 megohms	100 megohms
132kV	800 megohms	100 megohms

Screen to Earth test will record an IR after one (1) minute. This test shall be performed first to assist in the reconnection process of the screen to earth connection.

Phase to Screen and Phase to Phase testing requires the measurement of IR at 1kV after one (1) minute duration.

Note : IR tests shall be applied for a period of 1 minute for cables less than 100m and 3 minutes for cables greater than 100m in length.

6b Conductor Resistance Test

This is carried out to determine the effectiveness of the conductor joints and terminations by measuring the dc loop resistance. Results are compared with the manufacturer's conductor resistance usually expressed in ohms/km in the cable specification.

6c 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.
Phase identification checks must be carried out by jointing staff to ensure cables have been connected correctly in line with the system phasing diagrams.
Phase identification relates to both conductors and sheaths.

6d Cross Bonding Test

Cross bonding tests on the cable sheaths shall be performed to verify the integrity of the cross bonding system. 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 50A 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.

6e Sequence Impedance Measurements

These tests are carried out for protection settings, earth potential rise and fault analysis. The tests are circuit dependent.
The cable measurements shall include DC resistance, positive, negative and zero sequence impedances, and shall be expressed at a reference temperature of 20deg C.

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

6f Serving Tests

A high voltage DC test between the metallic sheath to earth is performed to test the integrity of the outer sheath. An IR test is performed to and after the high voltage test to assess the insulation integrity of the cable.

The test voltage level and test period for serving tests on subtransmission cables are :

- 33kV & 66kV – 10kV/1min.
- 132kV – 15kV/1min.

6g Sheath or Screen Resistance Test

The dc resistance of the metallic sheath and connections is measured and compared with the manufacturer's sheath resistance usually expressed in ohms/km in the cable specification.

6h Sheath Voltage Limiters (SVL)

SVL's are connected to the 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.

6i HV Tests

The requirement is to complete the prescribed tests as specified. All cables must be fully discharged for a time duration equal to the test time upon completion of each test by means of discharge function on test equipment or an independent earth.

HV tests shall be carried out after laying & bedding has been completed.

The following table shows the test voltages and times required for cable system voltage.

System Voltage	Test Type	Test Voltage & time
33kV	VLF ac test	75kV$_{peak}$ (53kV$_{rms}$) for 15 min.
	ac resonant test	33kV$_{rms}$ for 5 min.
	System voltage test	Power system voltage "soak" for 24hrs.
66kV	VLF ac test	135kV$_{peak}$ (95kV$_{rms}$) for 15min. (reduced test values may be limited to the maximum rating of the test equipment).
	ac resonant test	72kV$_{rms}$ for 1 hr (AS60840)
	System voltage test	Power system voltage "soak" for 24hrs.
132kV	VLF ac test	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 15min may be used.
	ac resonant test	132kV$_{rms}$ for 1 hr (AS60840).
	System voltage test	Power system voltage "soak" for 24hrs.