

Electrical Testing Specification

Pre-commissioning & Commissioning

Underground Developments

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Authorisations

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Document control

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15.02.2016	1.0	Original Version	Greg Hall	Angus Ketley
08.04.2016	2.0	Alignment with Final commissioning Process	James Goodger	Angus Ketley
30.09.2016	3.0	Updated document title. Updated nomenclature to include commercial and industrial subdivision. Updated testing process flow. Included Test Certificate UD-E-TC-006	Frank Pontes	Angus Ketley

Responsibilities

This document is the responsibility of Engineering and Design, Tasmanian Networks Pty Ltd, ABN 24 167 357 299 (hereafter referred to as "TasNetworks").

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Table of contents

1.	Purpose.....	3
2.	Scope	3
3.	Compliance	3
4.	References	3
5.	Definitions.....	4
6.	Prerequisites.....	6
7.	Audits.....	6
8.	Electrical testing	7
8.1	General	7
8.2	Equipment	7
8.3	Test requirements	7
8.3.1	Pre-Commissioning tests.....	8
8.3.2	Commissioning tests.....	9
8.3.3	Staged energisation tests	10
9.	Testing flowchart	11
10.	Acceptance criteria	12
11.	Certificate of Completion	12
12.	Energisation	12
	Appendix A.....	13

1. Purpose

This document defines the minimum electrical testing requirements for electrical infrastructure associated with Underground Developments that will be connected to TasNetworks' distribution network.

2. Scope

This document covers the electrical testing requirements for the following infrastructure:

- High voltage underground cables
- High voltage cable terminations
- Kiosk substations
- Low voltage underground cables
- Low voltage cable terminations
- Low voltage cabinets
- Low voltage turrets
- Earthing systems
- Public lighting

3. Compliance

Unless prior approval has been provided by TasNetworks for an alternative testing methodology, the Developer shall comply fully with the requirements of this document.

4. References

This specification should be read, where applicable, in conjunction with the following documents:

- Specification for URD Design – R393265
- Distribution design standard: Kiosk Substations – R392029
- Distribution design standard Public Lighting – R391752
- Distribution design standard: Underground system – R392089
- UD Construction Specifications – R561368
- Construction Audit Process – R389952
- Construction Audit Checklist – R389973

5. Definitions

AC	Alternating current
As-built Plan	The Development plan that incorporate and variations or additions that occurred during construction.
Auditor	An employee or representative of TasNetworks engaged for the purposes of undertaking an audit of an installation, or activities related to an installation.
Audits	An inspection or review undertaken for the purposes of making an assessment of compliance.
Authorisation	A legal approval or consent to perform a task related to the Development.
Cabinet	A steel box mounted at ground level for the termination of low voltage mains cables and to enclose service fuses and other devices for control. Similar in principle to a turret but of greater electrical capacity.
Cable	One or two or more insulated cores laid up together with fillings, reinforcements and protective coverings.
Commissioning test	Electrical tests to be completed during the final commissioning process immediately prior to energisation
Consumer installation	The electrical system owned and operated by an electricity consumer for the purpose of utilising electricity, normally contained within the consumer’s premises.
Designer	The company/person undertaking the design for the Development.
Developer	Any party external to TasNetworks and its representatives who is undertaking electrical work.
Development	Work in predefined location where the Developer has formed an agreement with TasNetworks.
Micro-Ohm test	A test of electrical resistance where the resistance is very low typically, micro to milli ohms.
Electrical testing	Any electrical testing undertaken on electrical infrastructure related to the Development for the purposes of demonstrating that the infrastructure is fit for energisation.
Final Commissioning	Final process to conclude all necessary tests to be undertaken in both isolation and stage energisation prior to hand over

High voltage (HV)	Voltages in excess of 1000 volts.
High voltage cable	Insulated electrical cables designed to operate at voltages above 1000 volts.
Laws	Legally binding law, legislation, statute, acts, ordinances, regulations, by-laws, orders, awards and proclamations that are enacted, issued or promulgated by the State of Tasmania or any relevant local authority.
Liaison Officer	An employee or representative of TasNetworks who acts as the Developer’s contact with TasNetworks for the construction, testing and commissioning stages of the Project.
Low Voltage (LV)	AC voltages in the range of 50 to 1000 volts.
Low Voltage cable	Insulated electrical cables designed to operate at AC voltages below 1000 volts.
Kiosk substation (Padmount)	A distribution substation enclosed within a cubicle or container mounted on a concrete base. The substation would usually comprise high voltage switchgear, transformer and a low voltage switchboard.
Insulation resistance (Megger)	A manually, battery or motor operated instrument for measuring the insulation resistance of cables and other equipment. To “megger” means to use such an instrument for this purpose. The results of the measurements are megohms thus the term megger has become universal.
Phasing	The arrangement of jointing and terminating of cables so that the system is correctly maintained when final connections are made. Colours and numbers on cable cores are not indicative of system phasing and are there for convenience of identification only. Standard phasing is R-W-B from left to right.
Point Of Connection	For underground installations the ‘Point of Connection’ will usually be in TasNetworks’ underground connection point i.e. turret, cabinet, pillar.
Pre-Commissioning	Electrical tests completed during gate 6 of the construction auditing process.
Pre-testing audit	An Audit undertaken prior to the commencement of electrical testing.
Project	The activity for the purposes of undertaking the Development.
Project Manager	The person responsible for the delivery of the Project.
Routine Audit	A pre-defined Audit.

Ring Main Unit (RMU)	The electrical equipment used for switching high voltage feeders and protecting transformers. See also 'Isolator'. A RMU typically consists of two isolators either side of a circuit breaker to a transformer.
Service cable	A low voltage underground cable used for the reticulation of low voltage supply.
Service fuse	The protection between a service cable and consumer's mains. Takes the form of a fuse up to 100 amps per phase or a circuit breaker above 100 amps per phase. TasNetworks owns these devices.
Public light	A light standard with luminaire installed in a street. The streetlight includes internal cabling and a protective device, typically a fuse or circuit breaker.
Termination (Underground)	A HV or LV cable end fitting or joint where a cable terminates and connects onto electrical equipment.
Test certificate	A record of electrical testing of electrical equipment.
Turret	A box mounted at ground level and made usually of fibreglass for the termination of mains cables and enclosure of service fuses. Used mostly in URDs.
Underground consumer mains	Wiring owned and maintained by the consumer that is connected at the service fuses or circuit breaker and connects to the main switchboard of an installation.
Very Low Frequency (VLF) test	A high voltage alternating current electrical test undertaken to prove the integrity of high voltage equipment. The test frequency is typically 0.1 Hz.
URD	Underground residential development.
UD	Underground development which includes URD and commercial and industrial subdivisions.

6. Prerequisites

The Developer shall not commence electrical testing until all construction activities have been completed for the installation being tested.

If alterations are made to the installation following testing, then the installation shall be retested. If following testing other works are undertaken that may impact upon the integrity of the installation, then it shall be retested.

7. Audits

TasNetworks will undertake routine audits of the Development. Routine Audits shall be undertaken at pre-defined points. The routine audits are defined in the Construction Specification.

Where a Routine Audit is required the Project Manager shall notify the Liaison Officer a minimum of three working days prior to the date of the audit.

Audits are required prior to the commencement of the following project stages:

- Low voltage electrical testing – Prior to the commencement of testing
- High voltage electrical testing - Prior to the commencement of testing

The Auditor may request to be present for all or part of the electrical testing.

If the Auditor has not witnessed the testing or believes the test results are not satisfactory they may request the testing to be repeated.

TasNetworks reserves the right to undertake unscheduled audits of the development without prior notification to the Developer.

8. Electrical testing

8.1 General

For all electrical testing the testing results shall be recorded on the test certificates listed in Appendix A. Under no circumstance will the AEC break factory terminations or connections on both HV and LV equipment within the Kiosk substation.

The electrical test certificates are as follows:

- High Voltage Cables – UD-C-TC-001
- Kiosks equipment including earthing performance - UD-PC-TC-002
- HV and LV switchboard – UD – C-TC-003
- Cable tests - UD-PC-TC-004
- Turrets and Cabinets - UD-C-TC-005
- UG Furniture – UD-E-TC-006

The test certificates shall be completed in full.

For manufacture's test certificate, the format, content and acceptance criteria shall be with prior approval from TasNetworks.

8.2 Equipment

All equipment used for the purposes of electrical testing shall be fit for purpose and compliant with legislative requirements.

Where appropriate, calibration testing of electrical test equipment shall be undertaken, with calibration certificate made available to the Liaison Officer on request.

8.3 Test requirements

The electrical testing requirements have been segregated into pre-commissioning, commissioning and stage energisation tests.

8.3.1 Pre-Commissioning tests

8.3.1.1 Kiosk factory test certificates

Manufacturer's test certificate shall be provided to cover the kiosk substation and equipment within it.

The minimum factory testing requirements and content of the test certificates are:

- Enclosure inspection certificate
- Equipment type and model
- Serial number
- Paint finish
- Earthing system
- Locking mechanism
- Operation of interior light

HV switchgear test certificate

- Equipment type and model
- Serial number
- Type test for equipment
- Insulation resistance
- AC high voltage withstand test
- Contact resistance (Ductor)
- Timing tests
- Earth switch resistance
- Protection relay operation
- High voltage cable terminations:

Transformer test certificate

- Serial number
- Rating
- Phases
- Frequency
- Nominal Voltage Ratio
- Volts Ratio on all tap positions
- Polarity
- No load current at service voltage and normal frequency
- No load losses at service voltage and normal frequency
- Load losses at principal tapping at 75°C and normal frequency
- Impedance voltage at rated current and at normal frequency on the tapping corresponding to the service voltage.
- Resistance of all windings (cold).
- Insulation Resistance
 - HV to Frame

- LV to Frame
- HV to LV
- Applied High Voltage Test
 - HV to LV Frame and Earth
 - LV to HV Frame and Earth
- Oil dielectric strength and properties
- Induced over voltage withstand test
- Temperature Rise Test (Type test certificate acceptable)
- Noise level test (Type test certificate acceptable)

LV Switchboard test certificates

- Type test for equipment
- Insulation resistance
- Phasing
- Circuit breaker contact resistance (Ductor)

LV cables:

- Insulation resistance

8.3.1.2 Testing requirements

Kiosk tests

- Transformer winding
 - Earthing system performance (if applicable). The earthing system shall be tested to demonstrate compliance with the design parameters and AS 2067:2016.
- HV protection
- LV circuit breaker

HV and LV cable test

- Insulation resistance

8.3.2 Commissioning tests

Refer to the Final Commissioning Process in the Construction Audit Process document for more detail.

HV switchgear

- Insulation resistance test
- Operation of line and transformer switches
- Operation of earth switch
- Contact resistance (Ductor test)

Low voltage switchboard

- Insulation resistance test
- Circuit breaker contact resistance (Ductor)
- Phasing

- Contact resistance of bus bar

Following connection of all cables to termination points, the following tests will be undertaken:

HV cables

- Insulation resistance test
- VLF test
- Phasing

Turrets

- Insulation resistance
- Phasing
- Polarity

Cabinets

- Insulation resistance
- Phasing
- Polarity

Public lights

- Insulation resistance
- Polarity

8.3.3 Staged energisation tests

Once all previous tests have been completed (also refer to Section 9) and proven to be acceptable, TasNetworks will close the upstream protection/isolation. The Developer's contractor will then need to complete stage energisation.

Turrets

- Toptronic test (network analyser test during staged energisation)

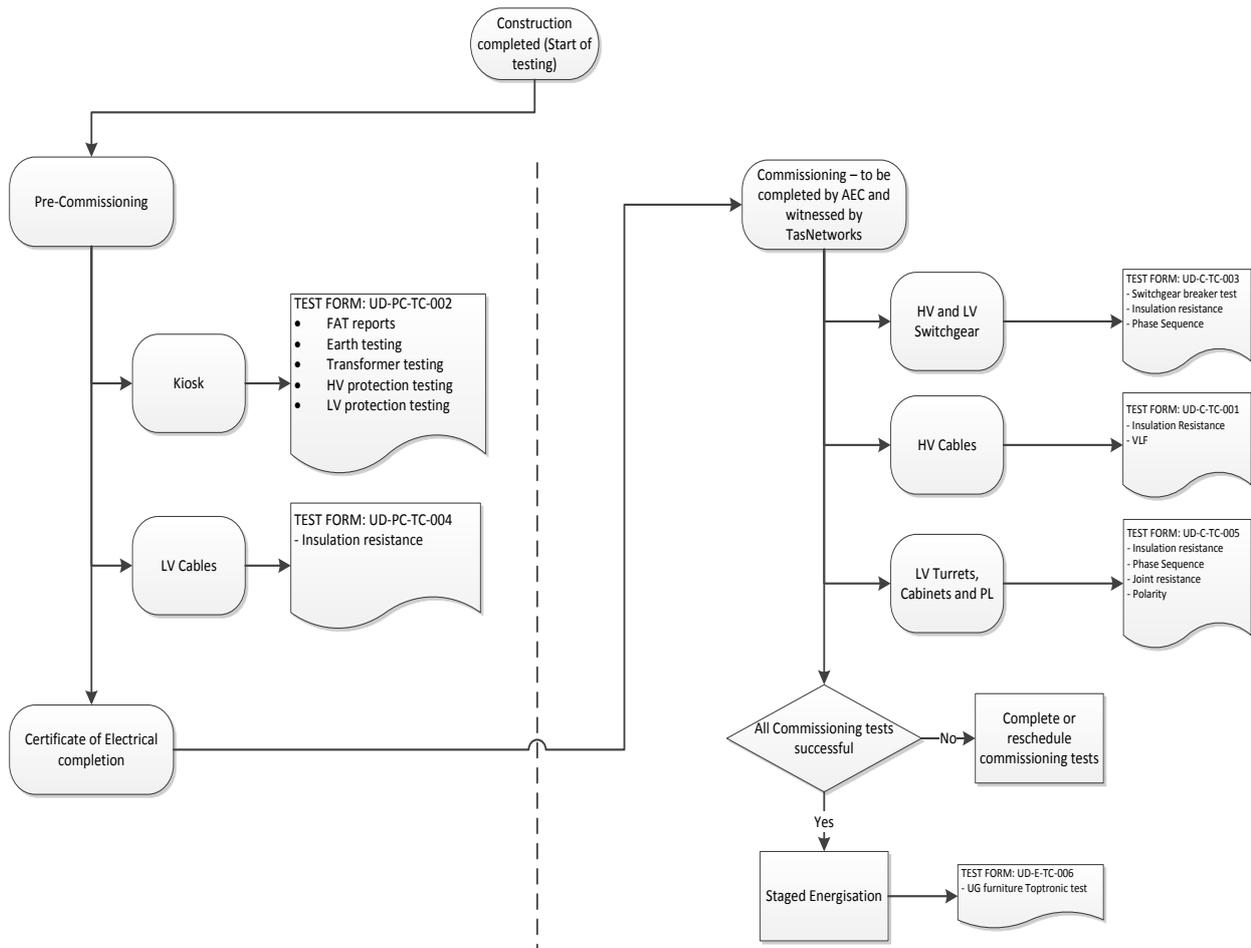
Cabinets

- Toptronic test (network analyser test during staged energisation)

Public lights

- Toptronic test (network analyser test during staged energisation)

9. Testing flowchart



10. Acceptance criteria

The acceptance criteria and minimum and/or maximum values for acceptance are defined in Table 1.

Table 1 – Acceptance criteria

Equipment	Test	Value
HV cables	Insulation resistance	>10 GΩ
	Earth sheath	≤ 0.5 Ω
HV switchgear	Insulation resistance	>10 GΩ
	Contact resistance (Ductor)	< 300 μΩ
Transformer	Impedance 11 & 22 500 kVA	4 %
	11 & 22 750 kVA	5 %
LV switchgear	Contact resistance (Ductor)	< 300 μΩ
	Insulation resistance	> 500 MΩ
LV earths	Impedance to earth	< 500 Ω
LV Circuit	A-N loop resistance	≤ 0.5 Ω
	Insulation resistance	> 500 MΩ

All factory tests that are repeated at site shall be within 10% of the factory test results.

Where the testing undertaken is not to the satisfaction of TasNetworks, TasNetworks reserves the right to request retesting.

11. Certificate of Completion

The Developer shall provide a Certificate of Completion – Electrical to TasNetworks demonstrating that for all the infrastructure installed, the installation is complete, compliant with the design and relevant standards, and the relevant electrical testing has been completed, with the pre-commissioning test results meeting the requirements of this specification.

The Certificate of Completion – Electrical is provided in the Construction Specification. The certification shall include the pre-commissioning test certificates for all the testing that has been undertaken. All the test certificates templates have been provided in Appendix A of this document.

12. Energisation

The connection of the Development to the TasNetworks' distribution network will be undertaken by TasNetworks. The staged energisation of the Development will be undertaken by the Developers' chosen AEC. Refer to the Final Commissioning Process in the Construction Audit Process document for more detail.

Issue of the Certificate of Acceptance for the network will only occur when the installation has been completed and supporting assurance provided to the satisfaction of TasNetworks.

Appendix A

The following section contains the test certificates required by the Developer's nominated contractor to complete as part of pre-commissioning, commissioning and staged energisation of the development.



HV Cable Test Certificate
UD-C-TC-001
DE-ENERGISED

UD Commissioning
 Voltages: 11 and 22kV
 Version: 3
 Date: September 2016



Certificate no:	Location:
Reference cable plan or drawing id.	
Cable origin asset id:	Cable destination/s asset id(s):

Cable Characteristics:

Number of cores:	Metallic sheath (lead, al, cu):
Conductor size (mm ²) and material:	Armouring Type (steel wire, tape or other)
Voltage Rating (11 or 22):	Oversheath Type (Hessian, pvc, pvc/Hdpe):
Insulation Type (pvc, xlpe, xlpe/tr):	General Condition:

Phase termination to network connection point:

HV cable phase orientation correct (Crossed phases will not be accepted)

Yes No

Phase termination between HV assets:

HV cable phase orientation correct (Crossed phases will not be accepted)

Yes No

Test equipment: Type:..... Serial no.

DOC./VERSION NO.	FORM	AUTHORISED BY	ISSUE DATE	PAGE
R343633 V3.0	UD-C-TC-001	Engineering & Design	September 2016	Page 1 of 2



HV Cable Test Certificate
UD-C-TC-001
DE-ENERGISED

UD Commissioning
 Voltages: 11 and 22kV
 Version: 3
 Date: September 2016



An individual test certificate shall be used for each cable once all terminations by AEC/TasNetworks have been completed

Cable Id as per SLD:	Destination/Load Connection:	Upstream Connection:

Insulation resistance:

Insulation resistance prior to VLF HiPot Test @5kv for 1 min Minimum result >10 GΩ	Insulation resistance after VLF HiPot Test @5kv for 1 min Minimum result >10 GΩ	Screen test @1kv for 1 min (If applicable. On-metallic screen cables only) Minimum result (Sc-E) >1 GΩ
1 to 2+3+E	1 to 2+3+E	
2 to 1+3+E	2 to 1+3+E	
3 to 1+2+E	3 to 1+2+E	

VLF HV Test:

Test voltages: 19.8 kV (Peak) or 14 kV (RMS) for 11 kV, 34 kV (Peak) or 24 kV (RMS) for 22 kV

Core:	KVAC (RMS)	Applied for (minutes):	Leakage Current (ma)	Pass/Fail

Note:

1. the certificate number + cable id is recommended to be used for reporting in TasNetworks' switching sheet
2. It is recommended a minimum of 15 mins to be applied during VLF testing

Remarks/Comments:

I certify that all work and tests have been completed in accordance with applicable work practices, construction standards, Australian Standards, associated legislation & codes of practice and understand this is a license condition.

Testers Name:	Company:	EP Licence No:	Date:	Signed :

DOC./VERSION NO.	FORM	AUTHORISED BY	ISSUE DATE	PAGE
R343633 V3.0	UD-C-TC-001	Engineering & Design	September 2016	Page 2 of 2



Kiosk Test Certificate
UD-PC-TC-002
DE-ENERGISED

UD Pre-Commissioning
Sizes: 100 – 1500kVA
Voltages: 11 and 22kV
Version: 3
Date: September 2016



Substation id: T.....	Feeder:	Location:
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Reference drawings:

Manufacturer’s test report for kiosk

Test report id	
Date	
Manufacturer	
Rating (kVA)	
Voltage (kV)	

HV switchgear test report

Has manufacturer’s test report been sighted and approved, including test results for:

- Insulation resistance
- AC high voltage withstand test
- Contact resistance (Ductor)
- Timing tests
- Earth switch resistance
- Protection relay operation

Yes No

LV switchboard

Has manufacturer’s test report been sighted and approved, including test results for:

- Type test for equipment
- Insulation resistance
- Phasing
- Circuit breaker contact resistance (Ductor)

Yes No

Transformer test report

Has manufacturer’s test report been sighted and approved, including test results for:

- Insulation resistance
- AC high voltage withstand test
- Oil dielectric strength and properties
- Ratios (all tap positions)
- Winding resistance
- Impedance
- Phase sequence

Yes No

DOC./VERSION NO.	FORM	AUTHORISED BY	ISSUE DATE	PAGE
R343633 V3.0	UD-PC-TC-002	Engineering & Design	September 2016	Page 1 of 4

Transformer

Note tests must be performed with MEN link temporarily removed. Reinstate after completion of transformer test

Winding	Test voltage	@ 1 minute	@ 10 minute
HV to LV + Earth	5kV		
HV to Earth	5kV		
LV to HV + Earth	1 kV		

Phasing of cables correct

Connections checked

Name plate present

Bushing secure with no cracks, chips etc

Breather transport bungs removed (if applicable)

Check for oil leaks

Oil bunding present

Oil level in middle of range:

High voltage switchgear

Functional test for interlocking of each earth switch

Yes No

Pass/Fail	
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All results in milliohms

Line Earth switch(s)	Record each earth switch resistance to Kiosk/switching station earth	
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DOC./VERSION NO.	FORM	AUTHORISED BY	ISSUE DATE	PAGE
R343633 V3.0	UD-PC-TC-002	Engineering & Design	September 2016	Page 2 of 4



Kiosk Test Certificate
UD-PC-TC-002
DE-ENERGISED

UD Pre-Commissioning
Sizes: 100 – 1500kVA
Voltages: 11 and 22kV
Version: 3
Date: September 2016



Earth resistance

Test equipment Type: Serial no.

Location	Resistance (Ohms)
HV/LV Earth	

Earthing connections checked as per drawings Cable screens earthed (if applicable)

Transformer neutral earthed Transformer tank earthed Switchgear frames earthed

Door earthed Check all accessible earthing/bonding bolts for tightness

The test requirements for demonstrating that the earthing system is fit for purpose shall be developed by the Designer. Where current injection (CIT) test requires temporary interconnection to the remainder of the earthing system, the AEC and TasNetworks Liaison Officer shall coordinate to obtain TasNetworks field staff to issue an Apparatus Interface Statement in accordance with PSSR. The AEC shall provide test results and analysis within a single earthing report of the earth test findings.

HV Protective devices

HV Protection testing must be completed either using the VAP6 test unit, or via primary injection testing, as no factory connection can be broken to perform testing. Note primary injection points can be accessed via the CT blocks behind the RM6 panel.

Protection functionality installed: Over current Earth fault (if applicable)

DOC./VERSION NO.	FORM	AUTHORISED BY	ISSUE DATE	PAGE
R343633 V3.0	UD-PC-TC-002	Engineering & Design	September 2016	Page 3 of 4



Kiosk Test Certificate
UD-PC-TC-002
DE-ENERGISED

UD Pre-Commissioning
 Sizes: 100 – 1500kVA
 Voltages: 11 and 22kV
 Version: 3
 Date: September 2016



Test equipment: Type: Serial no.

	Setting	Minimum pick up	Variance (%)
Over current			
Earth fault (if applicable)			
	Setting	Minimum pick up	Variance (%)
Over current			
Earth fault (if applicable)			

Low Voltage Switchgear

Insulation Resistance Test @ 1kV With Transformer isolator open A+B+C (Supply side of circuit breaker) to A+B+C (Network side of circuit breaker)	
Circuit breaker 1 (open)	
Circuit breaker 2 (open)	
Circuit breaker 3 (open)	
Circuit breaker 4 (open)	

Phase sequence

A-B-C C-B-A

Remarks/Comments:

I certify that all work and tests have been completed in accordance with applicable work practices, construction standards, Australian Standards, associated legislation & codes of practice and understand this is a license condition.

Testers Name:	Company:	EP Licence No:	Date:	Signed :
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DOC./VERSION NO.	FORM	AUTHORISED BY	ISSUE DATE	PAGE
R343633 V3.0	UD-PC-TC-002	Engineering & Design	September 2016	Page 4 of 4



**HV and LV Switchgear
Test Certificate**
UD-C-TC-003
DE-ENERGISED

UD Commissioning
 Sizes: 500 – 1500kVA
 Voltages: 11 and 22kV
 Version: 3
 Date: September 2016



High Voltage switchgear

Insulation resistance (prior to HV cable termination)

Test equipment: Type: Serial no.

All results in Mega Ohms

Kiosk:

HV switchgear
(at 5kV)

All switches closed/ circuit breakers open	A to B+C+Earth	B to A+C+Earth	C to B+C+Earth

Correct operation of:

- Line switch 1
- Circuit Breaker
- Line switch 2
- Line switch 3
- Earth switches

Switching station:

HV switchgear
(at 5kV)

All switches / circuit breakers closed	A to B+C+Earth	B to A+C+Earth	C to B+C+Earth

Correct operation of:

- Line switch 1
- Line switch 2
- Line switch 3
- Line switch 4
- Earth switches

Tap changer position:

- | | | | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| (+10%) | (+7.5%) | (+5%) | (+2.5%) | (0%) | (-2.5%) | (-5%) | (-7%) |
| <input type="checkbox"/> |

DOC./VERSION NO.	FORM	AUTHORISED BY	ISSUE DATE	PAGE
R343633 V3.0	UD-C-TC-003	Engineering & Design	September 2016	Page 1 of 4



**HV and LV Switchgear
Test Certificate**
UD-C-TC-003
DE-ENERGISED

UD Commissioning
Sizes: 500 – 1500kVA
Voltages: 11 and 22kV
Version: 3
Date: September 2016



Low voltage switchboard

Test equipment: Type: Serial no.

Insulation resistance @1000 volts for 1 minute (All results in Mega ohms)

Device	A to B+C+Earth	B to A+C+Earth	C to A+B+Earth
All circuit breakers and transformer links open			

Completion of testing

At the completion of testing all high voltage and low voltage switches/circuit breakers shall be left in the open position.

High voltage:	Open	Low voltage:	Open
Line switch 1	<input type="checkbox"/>	Isolator	<input type="checkbox"/>
Circuit breaker	<input type="checkbox"/>	Circuit breaker 1	<input type="checkbox"/>
Line switch 2	<input type="checkbox"/>	Circuit breaker 2	<input type="checkbox"/>
Line switch 3	<input type="checkbox"/>	Circuit breaker 3	<input type="checkbox"/>
Earth switch	<input type="checkbox"/>	Circuit breaker 4	<input type="checkbox"/>

Remarks/Comments:

I certify that all work and tests have been completed in accordance with applicable work practices, construction standards, Australian Standards, associated legislation & codes of practice and understand this is a license condition.

Testers Name:	Company:	EP Licence No:	Date:	Signed :
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DOC./VERSION NO.	FORM	AUTHORISED BY	ISSUE DATE	PAGE
R343633 V3.0	UD-C-TC-003	Engineering & Design	September 2016	Page 2 of 4



Cable Test Certificate
UD-PC-TC-004
DE-ENERGISED

UD Pre - Commissioning
 Voltages: 400 and 230 V
 Version: 3
 Date: September 2016



Certificate no:	Location:
Reference drawings:	

Insulation resistance (All results in Mega ohms)
 Each cable shall have its insulation resistance measured before termination.

HV Distribution circuits @5000 volts for 1 minute

Cable ID or label	R-Screen	W-Screen	B-Screen	R-W	R-B	W-B	Screen -E

LV Distribution circuits @1000 volts for 1 minute

Cable ID or label	R-N	W-N	B-N	R-W	R-B	W-B	R-E	W-E	B-E	N-E

Streetlight circuits @500 volts for 1 minute
 (Neutral and earth to be disconnected at supply/cabinet)

Cable origin (Turret/cabinet)	Cable destination (Streetlight)	Active-Earth	Active-Neutral	Neutral - Earth

Remarks/Comments:

I certify that all work and tests have been completed in accordance with applicable work practices, construction standards, Australian Standards, associated legislation & codes of practice and understand this is a license condition.

Testers Name:	Company:	EP Licence No:	Date:	Signed :
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DOC./VERSION NO.	FORM	AUTHORISED BY	ISSUE DATE	PAGE
R343770 V3.0	UD-PC-TC-004	Engineering & Design	September 2016	Page 1 of 1

	LV Turrets, cabinets & streetlights Test Certificate	UD Commissioning Voltages: 400 and 230 V Version: 3 Date: September 2016	
	UD-C-TC-005 DE-ENERGISED		

Certificate no:	Location:
Sheet:	
Reference drawings:	

Insulation resistance (All results in Mega ohms)

Each LV circuit shall have its insulation resistance measured once all terminations have been completed.

Turrets/cabinets (street light fuse out)

Asset id.	Insulation resistance (MΩ)								Phasing correct (Y/N)
	R-E	W-E	B-E	W-N	B-N	R-W	R-B	W-B	

Streetlight (t)Asset id.	Insulation resistance (MΩ)		Polarity correct (Y/N)
	Active-Earth	Active - Neutral	

Remarks/Comments:				
I certify that all work and tests have been completed in accordance with applicable work practices, construction standards, Australian Standards, associated legislation & codes of practice and understand this is a license condition.				
Testers Name:	Company:	EP Licence No:	Date:	Signed :

DOC./VERSION NO.	FORM	AUTHORISED BY	ISSUE DATE	PAGE
R343884 V1.0	UD-C-TC-005	Engineering & Design	September 2016	Page 1 of 1

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