

**1. SCOPE**

This document details SP Energy Networks requirements for electrical insulation testing of HV Equipment up to and including 33kV.

**2. ISSUE RECORD**

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**3. ISSUE AUTHORITY**

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**4. REVIEW**

This is a [Reference](#) document which has a 5 year retention period after which a reminder will be issued to review and extend retention or archive.

**5. DISTRIBUTION**

This document is part of the Construction Virtual Manual maintained by Document Control and does not have a maintained distribution list. It is published on the SP Energy Networks website.

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**7. REFERENCE AND RELATED DOCUMENTS**

ENA TS 09-02	Specification for the supply, delivery & installation of land-based power cables with operating voltages in the range 11 kV to 400 kV and associated auxiliary cables
ENA EREP 135	Performance review of vacuum interrupters in UK distribution networks
ENA ER C55	Insulated sheath power cable systems
TSE-06-201	Approved Equipment Register – Test Instruments
DOC-00-265	Plant Maintenance Manual (PMM) – Volume 1

**8. DEFINITIONS**

For the purpose of this Specification the following definitions shall apply:

Company:	Refers to SP Distribution plc, SP Transmission plc and SP Manweb plc.
SP Energy Networks	The brand name for the division of the ScottishPower group of companies that encompasses SP Distribution plc, SP Transmission plc, SP Manweb plc and SP Power Systems Limited.
SP Transmission plc	The Transmission Licence Holder for the transmission service area formally known as ScottishPower.
SP Distribution plc	The Distribution Licence Holder for the distribution service area formally known as ScottishPower.
AC Pressure Test:	AC Power Frequency overvoltage test to ascertain suitability of plant for energisation.
DC Pressure Test:	DC overvoltage test to ascertain suitability of plant for energisation.
Equipment:	Switchgear, transformers, cables, overhead lines, surge arresters, voltage transformers, current transformers, unit substations.
Energisation:	The application of Voltage to an item(s) of Equipment from the system.
High Voltage:	An AC voltage exceeding 1000 volts measured between the phase conductors.
Insulation Resistance Test:	Impedance test to ascertain condition of insulation prior to energisation.
Approved:	Equipment which is Approved in accordance with SP Energy Networks documents for use or installation on the Company network.
New:	Approved Equipment which has not previously been connected to the system and which has been routine tested in a Manufacturing Facility with a Quality Management System in accordance with the relevant standard prior to delivery.
Combined Equipment:	Equipment connected with other Equipment.
Previously In Service:	Equipment which, has previously been connected to the system and is deemed suitable for re-use and has been electrically tested in accordance with the requirements detailed in this document.
Site Assembled Connections	Connections made/modified on site or insulation which has in some way been affected subsequent to factory testing or testing undertaken for Previously in Service Equipment. This does not include cable connections.

## 9. GENERAL REQUIREMENTS

Electrical tests shall be carried out by suitably Authorised or trained Persons using SP Energy Networks Approved Equipment. The testing shall be conducted in accordance with the requirements of the current ScottishPower Safety Rules, Electrical & Mechanical, where applicable.

The pressure test voltage shall be increased gradually to the specified value and maintained for the specified time.

### 9.1 Safety Precautions for Pressure Testing

Special precautions shall apply for high voltage testing to ensure safety:

- In locations permanently set aside for pressure testing, the control point shall be such that the operator has full view of the apparatus under test to ensure that no one is in the danger zone.
- Where testing is to be done on site, then this shall be done in accordance with the ScottishPower Safety Rules.
- For reasons of both safety and accuracy, it is essential that the Equipment under test be earthed both before and after the application of the test potential.

### 9.2 Special Precautions with Vacuum Switchgear

Vacuum switchgear may generate x-rays when the open contact gap is stressed at high voltage, however under normal system voltage and pressure test values detailed within this document, there are no harmful emissions. As an additional safeguard to personnel, the Equipment must be tested with the vacuum interrupters contained in the manufacturers' normal housing and all personnel be positioned not less than 2 metres away from the unit under test.

### 9.3 Procedure in Cases Where Pressure Testing is not Possible

In exceptional circumstances where on-site testing is not possible but is required by this document, then prior to any Equipment being Energised, written authority shall be obtained from the Control Centre Manager or his nominated representative.

### 9.4 Testing Methods and Test Voltages

SP Energy Networks testing policy requires a combination of both AC and DC Pressure Testing and Insulation Resistance Testing. Irrespective of whether AC or DC testing is carried out the insulation will retain a high voltage charge upon completion of the test. For safety reasons this shall be safely discharged through an impedance to earth.

## 10. TESTING REQUIREMENTS

Testing electrical equipment prior to energisation is a mandatory requirement based on the ESQC regulations 2002, which places obligations on to electricity distribution companies to “ensure their equipment is sufficient for the purposes in which it is used”.

SPEN requirements for electrical testing of Company Equipment outlined in this document have been developed giving due consideration to the risks to be mitigated by testing, the practicality of performing the testing and the potential unintended impacts that stress tests on equipment could potentially cause.

Testing requirements advised are intended not to overstress Equipment. Where type or routine tests prove electrical performance, associated tests are not deemed appropriate to repeat under inadequate site conditions as this does not typically detect manufacturing defects but does potentially increase the risk to personnel on site.

It is however necessary to complete testing to confirm that no damage has occurred during transportation and installation of the Equipment.

When New Equipment is to be connected to the system for the first time or where Previously in Service Equipment is to be re-used, then prior to connection to the system, the Equipment shall be electrically tested as per the guidance which follows. Typically, previously in Service Equipment shall be tested prior to installation at site.

## 10.1 Switchgear

The requirement for Insulation testing of switchgear assets is detailed in Table 1. Associated test levels are detailed in Table 2 and the test required are detailed in Figure 1.

*Table 1: Switchgear Insulation Tests*

Switchgear	New	Previously In Service
11kV, RMU's, switches and extensible secondary switchgear	On Site 5kV DC Insulation Resistance Test (Ph-Ph and Ph-E) <i>(Note 2)</i>  No AC pressure test	AC pressure test <i>(Note 3)</i> , <i>Figure 1</i>  On site: 5kV DC Insulation Resistance Test (Ph-Ph and Ph-E) <i>(Note 2)</i>
Primary and 33kV extensible switchgear.  Outdoor 33kV circuit breakers.	AC pressure test of supplied equipment on Site. <i>Figure 1</i>  AC pressure test of all assembled Connections at site on the case on board extensions, <i>Figure 1</i>	On site: 5kV DC Insulation Resistance Test (Ph-Ph and Ph-E) <i>(Note 2)</i>  AC pressure test on Site including all assembled in case of extensions, <i>Figure 1</i>
Air-break switch disconnectors and Pole mounted expulsion fuses	No AC pressure test	No AC pressure test
PMAR's and pole mounted enclosed metal switches	No AC pressure test	AC pressure test <i>(Note 3)</i> , <i>Figure 1</i>
33kV RMU's	AC pressure test on Site Assembled Connections at site <i>Figure 1</i>	AC pressure test prior to site, <i>Figure 1</i>  On Site 5kV DC Insulation Resistance Test (Ph-Ph and Ph-E) <i>(Note 2)</i>  AC pressure test on Site Assembled Connections at site, <i>Figure 1</i>

**Notes:**

Where a New panel is being extended to an existing Board, the existing switchboard busbars shall be tested at Previously in Service Test Values,

1. These requirements do not replace guidance in tender specifications for equipment supply in regard to Site Acceptance Testing – Any additional testing defined in tender specifications will still be required.
2. Results should be in the GΩ range ( $\Omega \times 10^9$ ), where values are below this range they shall be reviewed, and further action taken as required.
3. Can be completed on site or prior to despatch to site.

Where required, Pressure test voltages shall be AC at power frequency in accordance with Table 2 applicable to discrete switchgear apparatus (not connected to other system assets). When the switchgear is connected to the network (connected to other system assets) the combined shall be DC pressure tested in accordance with Section 12 and test values detailed in Section 12, Table 12.

Table 2: Test Voltages for Switchgear

Rated Voltage (kV)	AC test voltage (kV rms)	
	New Equipment	Previously In Service
11	22.4	12.0
22	40.0	25.0
33	56.0	36.0
Test Duration – 1 minute		

The test setups for switchgear pressure testing shall be as shown in Figure 1. In tests 1, 2 and 3 the tests voltage shall be carried out on the conductors of all sections of the switchgear by closing the switch device in order to test the complete assembly. Where circumstances preclude this, the test shall be applied to each discrete portion, as necessary.

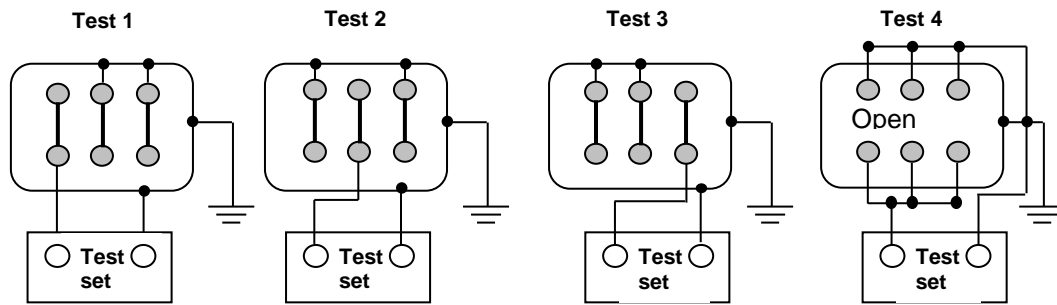


Figure 1: Test Connections for Pressure Testing Switchgear

Voltage transformers shall be isolated during the pressure testing of the switchgear by being withdrawn or on non-withdrawable units, by removing the HV connection / opening disconnecting links / switches.

Note: Attention should be given to the capability of VPIS/VDS components to withstand test voltages. If there is any doubt, shorts should be applied between terminals and earth prior to testing.

10.1.1 Switchgear – Vacuum Interrupter Power Frequency Withstand Testing (Across Gap)

When accessible, vacuum interrupters should be tested in line with ENA EREP 135 recommendations where prescribed in the SPEN maintenance policy and associated procedures.

Where possible, a visual inspection of the VI should be carried out prior to testing – Any visual defects (decolouration, cracks, corrosion of metallic parts or signs of electrical stress) should be considered before a decision on whether to proceed with electrical testing is taken.

Power Frequency withstand testing should be completed at a minimum of 80% of the rated VI voltage as per Figure 2.

During commissioning, manufacturers may stipulate their own test voltage requirements. Reference should be made for specific switchgear type.

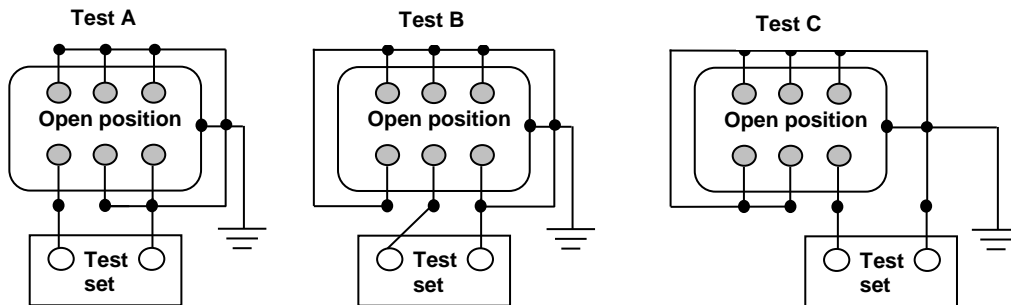


Figure 2: Dielectric Testing of VI interrupter

## 10.2 Transformers, Regulators & Reactors

The requirement for Insulation testing of Pole Mounted and Secondary Ground Mounted Transformers assets is detailed in Table 3. Associated Tests required are detailed in Figure 4, Figure 6, and Figure 7 in the sections below.

Unless otherwise specified, the test shall comprise.

- HV winding test 5kV applied for 1 minute between HV winding and LV winding (which is shorted to earth)
- LV winding test 1kV applied for 1 minute between LV winding and HV winding (which is shorted to earth)

The test voltage shall be derived from a suitably Approved constant voltage insulation test set.

- HV side windings. Insulation resistance test, with a 5kV Megger for 1 minute. Expected values for newer transformers shall be c500 MΩ, and for older transformers c100-200 MΩ, where values are below 100 MΩ they shall be reviewed, and further action taken as required.
- LV side windings. Insulation resistance test, with a 1kV Megger for 1 minute. Expected values for newer transformers shall be c500 MΩ, and for older transformers c100-200 MΩ, where values are below 100 MΩ they shall be reviewed, and further action taken as required.

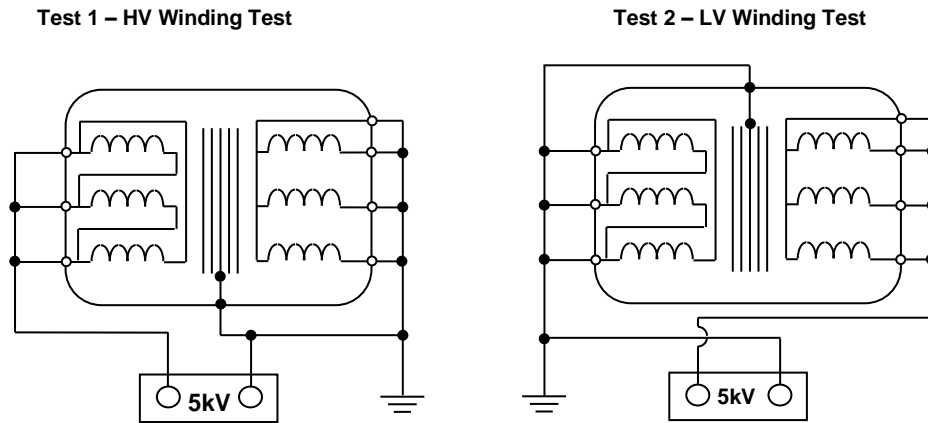
Note: Test results may be affected by moisture on exterior bushings

*Table 3: Transformers, Regulators & Reactors Insulation Tests*

<b>Transformers, Regulators &amp; Reactors</b>	<b>New</b>	<b>Previously In Service</b>
Primary	No AC pressure test. Insulation Resistance Test (Megger) on site, in accordance with <a href="#">Figure 3</a> .	No AC pressure test. Insulation Resistance Test (Megger) on site, in accordance with <a href="#">Figure 3</a> .
Ground Mounted Secondary	No AC pressure test. Insulation Resistance Test (Megger) on site, in accordance with <a href="#">Figure 4</a>	No AC pressure test. Insulation Resistance Test (Megger) on site, in accordance with <a href="#">Figure 4</a>
Pole Mounted – Three Phase	No AC pressure test. Insulation Resistance Test (Megger) on the pole, in accordance with <a href="#">Figure 4</a>	No AC pressure test. Insulation Resistance Test (Megger) on the pole, in accordance with <a href="#">Figure 4</a>
Voltage Regulators	No AC pressure test. Insulation Resistance Test (Megger) on site, in accordance with <a href="#">Figure 5</a>	No AC pressure test. Insulation Resistance Test (Megger) on site, in accordance with <a href="#">Figure 5</a>
Reactors	No AC pressure test. Insulation Resistance Test (Megger) on site, in accordance with <a href="#">Figure 6</a>	No AC pressure test. Insulation Resistance Test (Megger) on site, in accordance with <a href="#">Figure 6</a>
Pole Mounted – Single Phase > 500VA and Split Phase	No AC pressure test. Insulation Resistance Test (Megger) on the pole, in accordance with <a href="#">Figure 7</a>	No AC pressure test. insulation Resistance Test (Megger) on the pole, in accordance with <a href="#">Figure 7</a>
Pole Mounted – Single Phase < 500VA	No AC pressure test. Insulation Resistance Test (Megger) on the pole, in accordance with <a href="#">Figure 8</a>	No AC pressure test. Insulation Resistance Test (Megger) on the pole, in accordance with <a href="#">Figure 8</a>

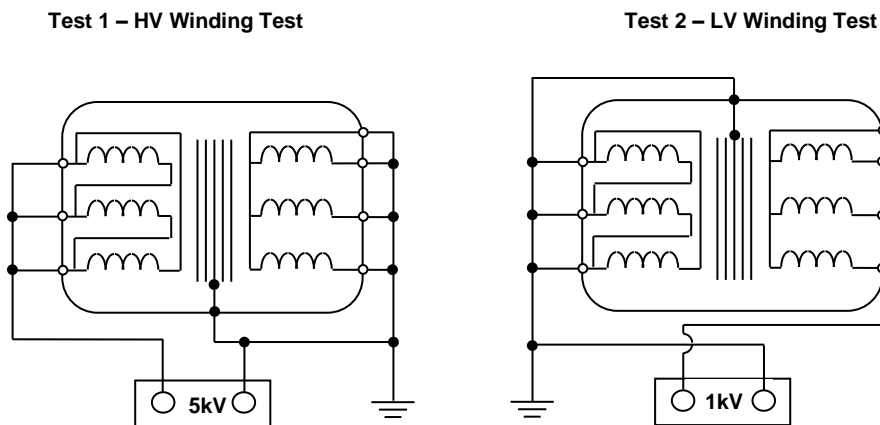
Note: Mid Central Electric PM transformers (Single Phase < 500VA) HV winding insulation resistance test requires a termination lead with SACC-MINMS-5CON-PG13 – Connector (For testing purposes A and E pins need to be wired out and terminals need be shorted to carry out this HV winding test) – This test is still mandatory for these units. Testing of the LV winding which is directly earthed on one side is not possible without breaking connections internal to the tank so should be omitted from the test regime. *Figure 7*

In addition to the pre-commissioning checks required for new primary transformers, each transformer shall be subjected to an on-site insulation resistance test prior to commissioning. The test connections to be used for Primary Transformers are detailed in Figure 3.



*Figure 3: Insulation Resistance Testing Connections for of Primary Transformers*

The test connections required for insulation resistance testing of 3 phase Ground mounted secondary and 3 phase pole mounted transformers is detailed in Figure 4.



*Figure 4: Insulation Resistance Testing Connections for Three Phase PM and Secondary Ground Mounted Power Transformers*

The test connections required for insulation resistance testing of voltage regulators are detailed in Figure 5.

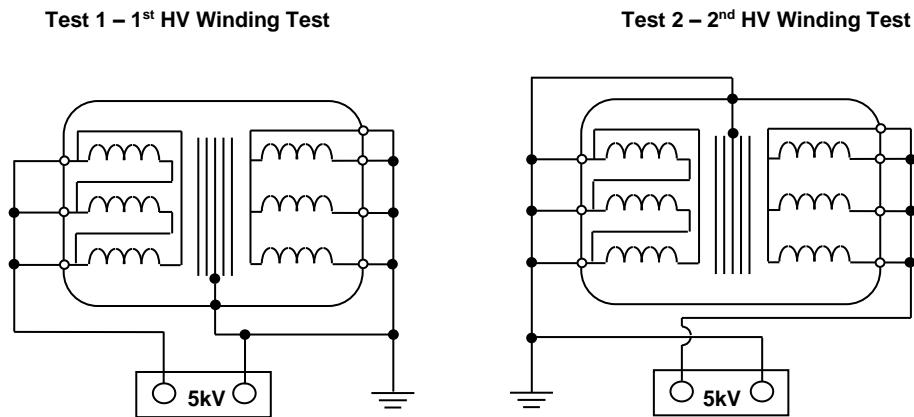


Figure 5: Insulation Resistance Testing Connections for Voltage Regulators

Test connections for insulation resistance testing for a typical shunt reactor are detailed in Figure 6.

Shunt and Series Reactors have only 1 set of windings and are tested with all three phases connected together and tested to the main tank earth.

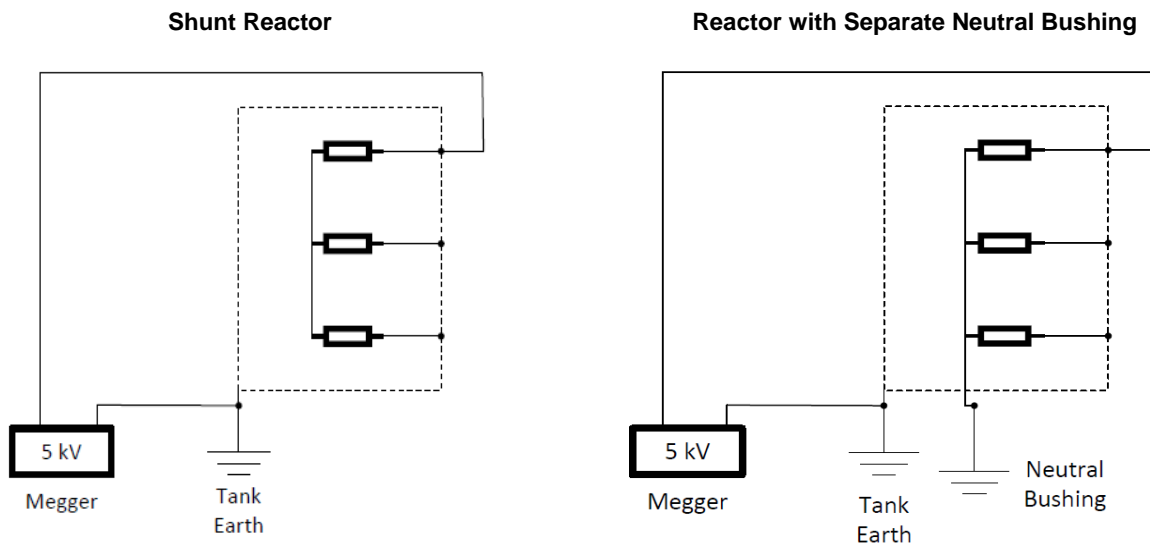


Figure 6: Insulation Resistance Testing Connections for Reactors

The test connections required for insulation resistance testing of single phase (>500VA) and Split phase pole mounted transformers is detailed in Figure 6.

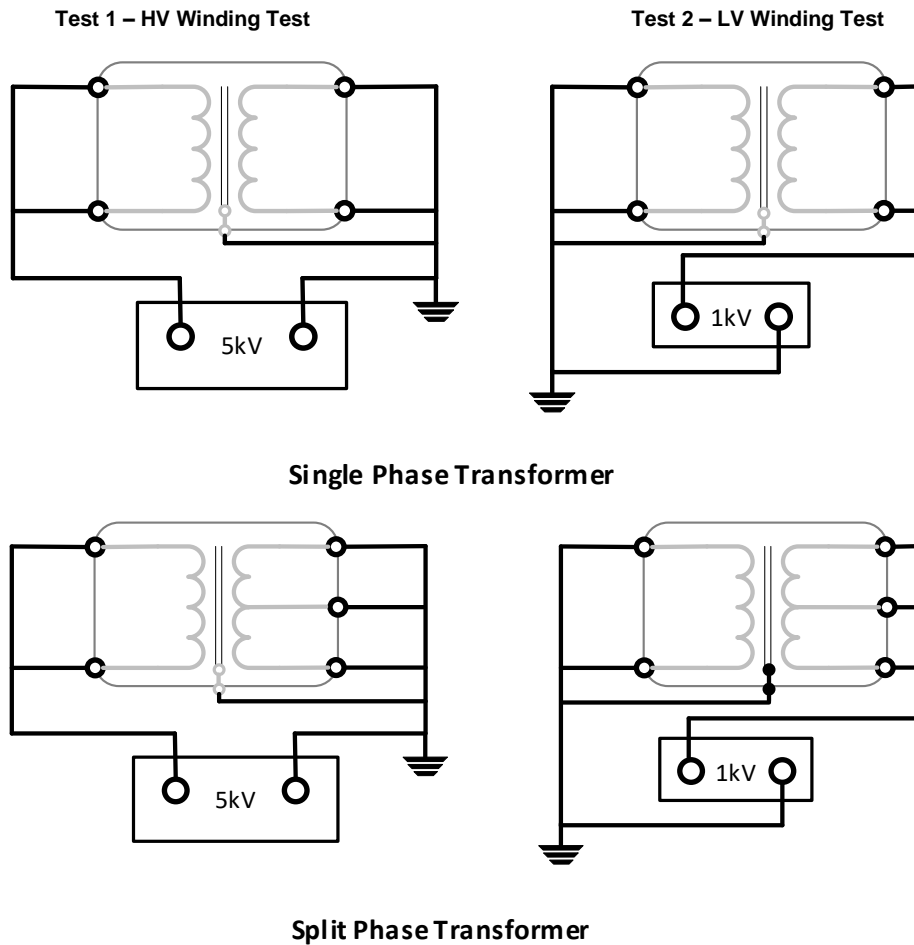


Figure 7: Insulation Resistance Testing Connections for Single Phase and Split Phase PM Transformers

The test connections required for insulation resistance testing of single phase <500VA, (Mid Central Electric Transformers) is detailed in Figure 8.

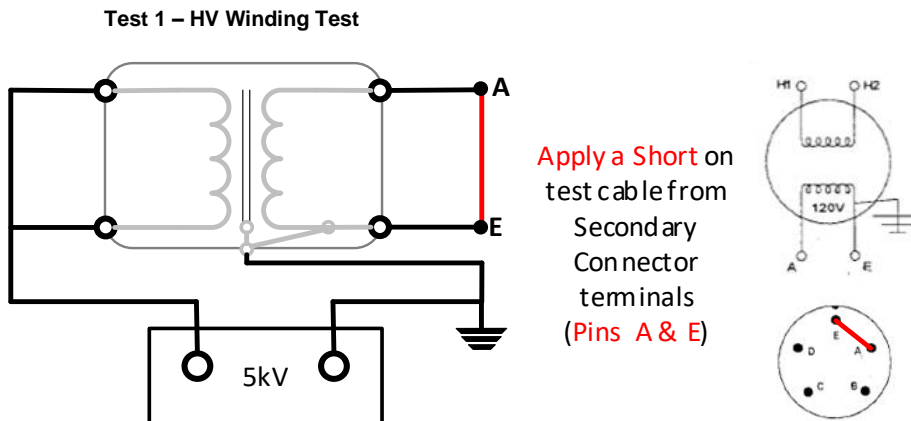


Figure 8: Insulation Resistance Test Connections for 500VA Pole Mounted Transformers

### 10.3 Cables

It is not normally required to pressure test cables prior to connection to the system, however it may be prudent in certain circumstances to pressure test the new cable section prior to connection to the system where it is considered appropriate to do so. A 5kV insulation resistance test shall be carried out as a minimum requirement.

Where deemed necessary by Table 4, DC test voltages shall be used for pressure testing cables. The respective test voltages and test connections are indicated in the following sections. Where installed, VTs should be disconnected from circuit prior to testing.

*Table 4: Cables Test Requirements*

<b>Cables</b>	<b>New</b>
Cable section (all Voltages)	No Pressure Test 5kV Insulation Resistance Test Oversheath Test
Cable Circuit repairs / deviations <30m (6.6 & 11kV)	5kV Insulation Resistance Test
Cable Circuit new installations (all Voltages), all Repairs/Deviations (33kV) and repairs / deviations >30m (6.6kV & 11kV)	DC Pressure Test

Where deemed necessary by Table 4, the test voltages for complete cable circuits shall be in accordance with the values given in Table 5. The test connections are shown in Figure 9, Figure 10 and Figure 11.

The current observed during a DC pressure test will initially include the charging current. After full voltage is reached the charging current will decay and the remaining leakage current is used to indicate the condition of the cable. The leakage current of a healthy cable should be less than 0.2mA although it may be greater depending on the length of cable and termination arrangements.

*Table 5: Test Voltages cables*

		<b>DC test voltage (kV)</b>	
<b>Voltage (kV)</b>	<b>Cable Type</b>	<b>Phase – Phase</b>	<b>Phase – Earth</b>
6.6	Belted Paper	10	6
	Mixed Cable	(Note 1)	6
	Screened XLPE		6
11	Belted paper	17	10
	Mixed Cable		10
	Screened Paper		10
	Screened XLPE		10
22	Screened Paper	(Note 1)	20
	Screened XLPE		20
33	Screened Paper		30
	Screened XLPE		30
	Mixed Cable		30
			Test duration – 5 minutes

*Note 1* Phase to phase tests are not carried out for cables where phases are individually screened.

Where the circuit to be tested includes both belted and screened cable types, the test connections appropriate to screened cables shall be used and only the appropriate phase to earth tests shall be carried out.

The cable under test must be discharged to earth after each pressure test and the conductors must all be connected to earth whilst the test lead connections are being modified.

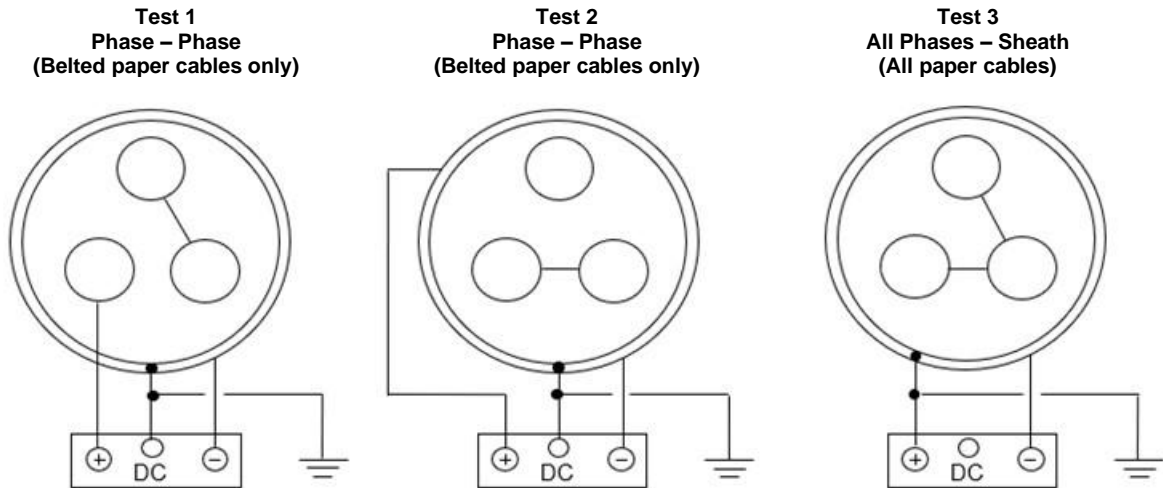


Figure 9 Test Connections for Pressure Testing Complete Paper Insulated Cable Circuits

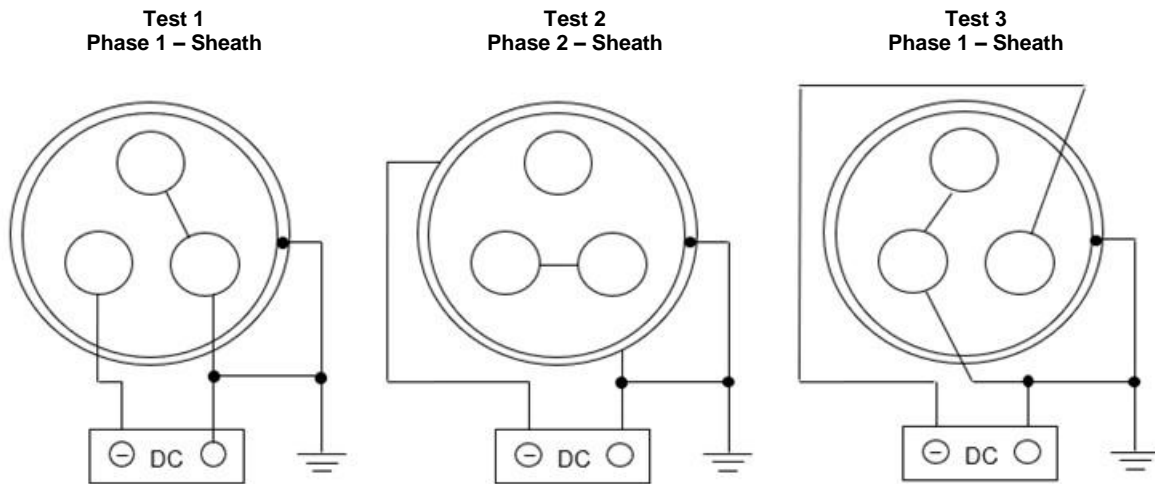


Figure 10: Test Connections for Pressure Testing Three Core Polymeric Cable Circuits

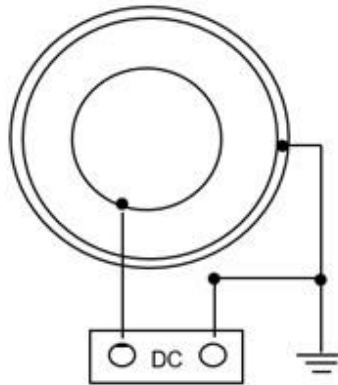


Figure 11: Test Connections for Pressure Testing Single Core Polymeric Cables

### 10.3.1 Cable Oversheath Tests for 33kV and 11kV XLPE Cables

The oversheaths of 33kV and 11kV XLPE insulated cables shall be tested and proved to be intact after laying and backfilling but before jointing/connection as per ENA TS 09-02, Section 7.18.12. The following tests shall be carried out to ensure that the oversheath has an adequate level of insulation resistance.

- a) Each new section of cable shall be tested after installation and blinding of the cable, prior to jointing to other new cable sections and/or being connected to the network.
- b) Where the new cable circuit comprises one or more new cable sections, the new circuit shall additionally be tested after jointing of all the new cable sections but prior to being connected to the existing network.

For single core cables, all cores shall be tested in turn.

The HV test equipment shall comprise an HV D.C. test set equipped to measure the leakage current using the test voltage and duration values specified in Table 6.

The values of maximum leakage current are given in Table 7 and are applicable to new cable lengths. A Purchaser's Specification may specify alternative test values and/or acceptance criteria to those given in Table 6 and Table 7. In a situation where testing of the new cable circuit cannot be carried out without including existing cable sections, the acceptable values for the maximum leakage current shall be subject to agreement between the Engineer and Contractor.

Subject to the approval of the Engineer, an insulation resistance tester may be utilised as an alternative means of testing. In this case, the minimum value of insulation resistance shall be 500 MΩ irrespective of cable length, unless otherwise agreed with the Engineer.

**NOTE:** Specially bonded cable circuits complying with the requirements of ENA ER C55 [N17] may require further tests in addition to the oversheath tests described here, as specified by the Engineer. For cables that are subjected to induced voltages refer to Clause 7.18.11 of ENA TS 09-02 before initiating any oversheath testing.

A suitable example testing arrangement using a D.C. test set is shown in Figure 12.

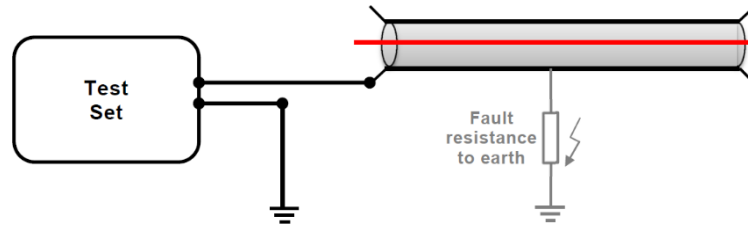


Figure 12: Example Testing Arrangement

An alternative testing arrangement is shown diagrammatically in Figure 13. In this arrangement, the test set utilises a source of up to 10 kV D.C. with positive and negative polarity to facilitate the testing of cable sheaths. The bi-polar function ensures the elimination of external thermoelectric and galvanic influence. Additionally, with a suitably equipped test set and using the connections shown, combined sheath testing and pre-location of the earth fault can be carried out.

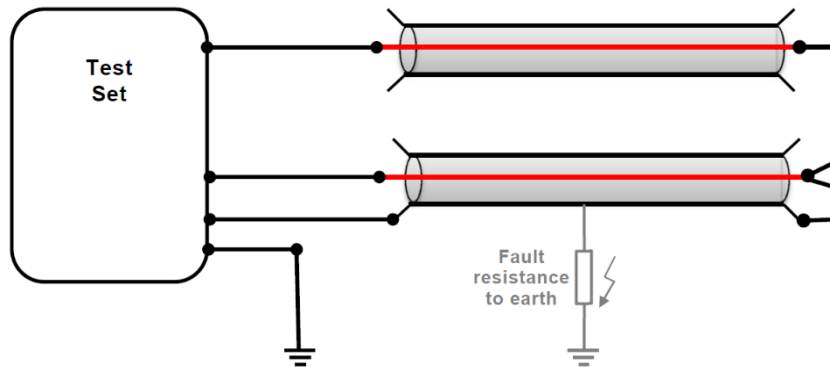


Figure 13: Alternative Testing Arrangement

The following test method is applicable.

- i. Using the test method agreed with the Engineer, apply the test voltage and duration specified in Table 6.
- ii. Record the maximum leakage current (or minimum insulation resistance, if using an insulation tester) during the test.
- iii. If the section of cable does not carry the voltage specified for the required duration or fails to meet the leakage current criteria in Table 7 (or, has a value of insulation resistance < 500 MΩ if using an insulation tester) the oversheath test has failed.

In the event of a failed test at any stage of the installation, the oversheath fault(s) shall be located and repaired. The above test procedure shall be repeated. A new cable length or new cable circuit shall not be accepted until successful oversheath test results have been achieved. The number of re-tests allowed before a cable section is rejected shall be subject to agreement between the Engineer and Contractor.

*Table 6: Test Voltages and Durations for Cable Oversheath Testing*

Nominal Phase Voltage	Min DC Test Voltage (kV)	Test Duration (min)
11	5	1
33	5	1

Notes:

- 1) Purchasers Specification may specify different testing voltages.
- 2) It is necessary to allow cable time to charge, the test time starts when the test set has reached the required voltage.
- 3) Insulation resistance measurement can be taken only when the IR value has stabilised.
- 4) Insulation resistance measurement can be taken only when the IR value has stabilised.

*Table 7: Test Acceptance Criteria for Cable Oversheath*

Cable Length (m)	Acceptance Criteria			
	PVC sheathed cables		PE sheathed cables	
	Maximum Leakage Current (mA)	Minimum Insulation Resistance (MΩ) at 5kV	Maximum Leakage Current (mA)	Minimum Insulation Resistance (MΩ) at 5kV
50	0.04	1250	0.01	5000
100	0.08	625	0.02	2500
250	0.2	250	0.05	1000
500	0.4	125	0.1	500
750	0.6	83	0.15	333
1000	0.8	63	0.2	250

### 10.4 Voltage Transformers

The requirement for Insulation testing of Voltage Transformers is detailed in Table 8. Associated Tests required are detailed in the sections below.

For insulation resistance testing, a test voltage of 500V shall be applied for 1 minute between earth and all terminals of the secondary winding connected together.

*Table 8: Voltage Transformer Insulation Tests*

<b>Voltage Transformers and Metering Units</b>	<b>New</b>	<b>Previously In Service</b>
Unearthed Primary Winding	500V Insulation Resistance Test (megger) the secondary (LV) winding at site	AC Pressure Test prior to site, in accordance with Table 9 500V Insulation Resistance Test (megger) the secondary (LV) winding at site
Earthed Primary Winding	500V Insulation Resistance Test (megger) the secondary (LV) winding at site	500V Insulation Resistance Test (megger) the secondary (LV) winding at site

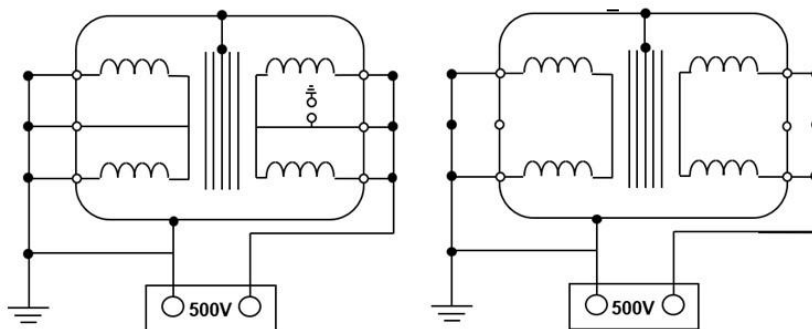
*Table 9: Test Voltages for VTs*

<b>Rated Voltage (kV)</b>	<b>AC test voltage (kV rms)</b>	
	<b>New Equipment</b>	<b>Previously In Service</b>
6.6		8.0
11	22.4	12.0
22	40.0	25.0
33	56.0	36.0
	Test Duration – 1 minute	

#### 10.4.1 Unearthed Primary Winding

Where required, insulation resistance testing of unearthed Primary VTs shall be completed as shown in Figure 14.

Where the yellow phase is earthed, the earth link shall be removed prior to testing. The test voltage of 500V shall be applied for 1 minute between earth and all terminals of the secondary winding connected together. All other terminals shall be earthed. **On completion of the test the yellow phase earth link shall be replaced, where appropriate**



*Figure 14: Insulation Resistance LV Winding Test of Unearthed Primary VT*

Where required, AC Pressure testing of unearthed Primary VTs shall be completed as shown in Figure 15.

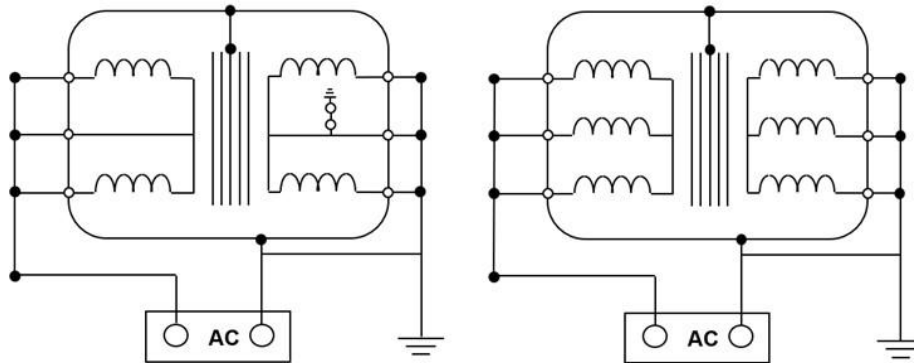


Figure 15: AC Pressure Test of Unearthed Primary VT

#### 10.4.2 Earthed Primary Winding

Where required, insulation resistance testing of an Earthed Primary VTs shall be completed as shown in Figure 16.

The test voltage of 500V shall be applied for 1 minute between earth and all terminals of the secondary winding connected together. All other terminals shall be earthed. The primary earth should not be removed for testing.

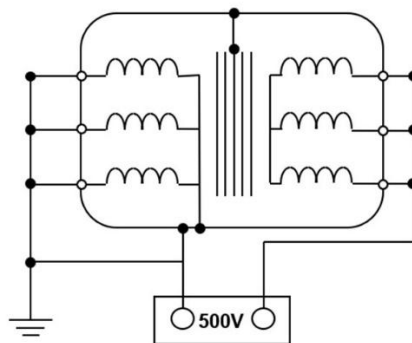


Figure 16: Insulation Resistance LV Winding Test of Earthed Primary VT

## 11. SURGE ARRESTORS

The requirement for Insulation testing of Surge Arrestors is detailed in Table 10.

Table 10: Surge Arrestors Insulation Tests

Rated Voltage	New	Previously in Service
All	No pressure test.	5kV Insulation Resistance Test (megger) on site. <i>Note 1</i>

*Note 1* – Expected results >10G  $\Omega$

For Surge arrestors currently in service reference should be made to the requirements in the Plant Maintenance Manual (PMM) DOC-00-265

## 12. TESTING OF COMBINED EQUIPMENT

### 12.1 Assets Connected to Cables

Electrical tests on Combined Equipment including cables shall be undertaken prior to energisation as detailed in Table 11, at the test voltages detailed in Table 12.

**No AC pressure tests** shall be performed on combined equipment which includes Cable Sections.

*Table 11: Combined Equipment Insulation Tests*

Combined Equipment	Tests
Cable + Switchgear (6.6/11kV RMU only) excluding Transformer (1 & 2)	DC pressure test <ul style="list-style-type: none"> <li>• Phase – Phase</li> <li>• Phase – Earth</li> </ul>
Cable + Switchgear (6.6/11kV RMU only) including Transformer (1, 2 & 3)	DC pressure test <ul style="list-style-type: none"> <li>• Phase – Earth</li> </ul>
Cable + Transformer	DC pressure test <ul style="list-style-type: none"> <li>• Phase – Earth.</li> </ul>

#### Notes

- 1) Surge Arresters may be left connected during DC Pressure Testing
- 2) Precautions shall be taken to disconnect VTs prior to AC and DC Pressure Testing.

*Table 12: Test Voltages for Combined Equipment*

Rated Voltage(kV)	DC test voltage (kV)	
	Phase – Phase	Phase – Earth
6.6	10.0	6.0
11	17.0	10.0
22	34.0	20.0
33	51.0	30.0
	Test Duration – 5 minutes	

The design specification for all existing switching devices are such that there is a substantial margin of safety across the isolating gap when it is stressed on either side by simultaneous application of system and test voltages for combined plant.

### 12.2 Closed Coupled Equipment – Unit Substations and Pad Mount Substation

The requirement for Insulation testing of unit Substations and Pad Mounted Substations is detailed in Table 13.

*Table 13: Assembled Unit Substations and Pad mount Substation Insulation Tests*

Unit Substations & Pad Mounts	New	Previously In Service
Unit Substation (including RMU, Transformer and LV)	On Site 5kV DC Insulation Resistance Test (Ph-Ph and Ph-E)  No AC pressure test.	12kV AC pressure test  On Site 5kV DC Insulation Resistance Test (Ph-Ph and Ph-E)

**13. APPENDIX 1: DERIVATION OF TEST VOLTAGES**

This appendix has been included to detail how the values for AC and DC Pressure Test voltages were derived.

<b>Rated Voltage of Equipment</b>	<b>System Voltage Ph-Ph</b>	<b>System Voltage Ph-Eh</b>	<b>New AC Pressure Test</b>	<b>Reduced Value AC Pressure Test</b>	<b>DC Pressure Test Ph-E (combined)</b>	<b>DC Pressure Test Ph-Ph (combined)</b>
	3300	1905		3630	2964	5134
12000	6600	3811		7260	5928	10267
12000	11000	6351	22400	12100	9880	17112
36000	22000	12702	40000	24200	19759	34224
36000	33000	19053	56000	36300	29639	51336

**Notes:**

- 1) The rated voltage of new equipment to be installed on 6.6kV networks is 12kV. The rated voltage new equipment to be installed on 22kV networks is 36kV.
- 2) Reduced Value AC Pressure Test, for Previously In Service Switchgear. System voltage \* 1.1.
- 3) DC Pressure Test, Phase – Earth. System voltage \* sqrt(2) \* 1.1) / sqrt (3)
- 4) DC Pressure Test, Phase – Phase. System voltage \* sqrt(2)

14. APPENDIX 2: SUMMARY OF COMMON TESTS

Pre-energisation Insulation Testing

Primary Voltage	Asset Type	Subtypes	Condition	Comments	Insulation Tests											
					Insulation Resistance			AC Pressure Test (1min)				DC Tests				
					5kV	1kV	500V	22.4kV	12kV	56kV	36kV	Ph-Ph (5min)	Ph-E (5min)	Sheath		
11kV	Transformer	PM > 500VA	All	Test HV Winding (5kV) and LV Winding (1kV)	✓	✓										
		PM < 500VA	All	Test HV Winding only	✓											
33kV	Transformer	Ground Mounted	New	No Site Test												
		Ground Mounted	Previously installed	Test HV Winding (5kV) and LV Winding (1kV)	✓	✓										
11kV	Switchgear	Pole Mounted	New	Inc PMARs, ABSw, PM HV Fuses	✓											
		Pole Mounted	Previously installed	Inc PMARs, ABSw	✓											
11kV	Switchgear	Secondary Equipment	New	Inc RMUs and Extensive Secondary Switchgear	✓											
		Secondary Equipment	Previously installed	Inc RMUs and Extensive Secondary Switchgear	✓											
33kV	Switchgear	Primary Equipment	New	All Types				✓	✓							
		Primary Equipment	Previously installed	All Types	✓				✓							
11kV	Cable	Belted Paper / XLPE / Mixed	Existing - modified	Repairs/Deviations < 30m	✓											
		Belted Paper / Mixed	Existing - modified	Repairs/Deviations > 30m								✓		✓		
33kV	Cable	XLPE Type	New Sections	Test prior to jointing	✓											
		XLPE Type	All circuits	All New circuits and modifications to existing circuits										✓		✓
11kV	VTs	Earthed Primary Winding	All	DC Test Secondary			✓									
		Unearthed Primary Winding	New	DC Test Secondary			✓									
33kV	VTs	Earthed Primary Winding	Previously installed	DC Test Secondary Winding + AC Test HV winding				✓								
		Unearthed Primary Winding	New	DC Test Secondary			✓									
All	Surge Arrestors		New	No requirements												
			Previously installed	Insulation Test	✓											
11kV	Combined - Cable Connected Assets	Cable & Switchgear (RMU)	All	Potentially applied for loop in works								✓		✓		
		Cable & Switchgear (RMU) & Transformer	All	Potentially applied for loop in works										✓		
33kV	Combined - Close Coupled	Cable & Transformer/Reactor	All	Cable connected transformer or reactor										✓		
		Cable & Transformer/Reactor	All	Cable connected transformer or reactor												✓
11kV	Unit Substations and Padmount Equipment		New	On Site, test at Switchgear / HV Connections	✓											
			Previously installed	AC test on Switchgear. On Site, test at Switchgear / HV Connections	✓					✓						

Please refer to the relevant sections of the main document for equipment omitted on this table and for further information on types listed.