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Document ID: NG SCT 36 2011

CABLE SYSTEMS

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PURPOSE AND SCOPE

This document contains the site commissioning tests and checks to be performed on the installation of a cable system using cables to TS 3.5.1 “132 kV, 275 kV and 400 kV oil-filled cable”, TS 3.5.2 “XLPE cable for rated voltages above 33 kV ($U_m = 36$ kV)” or TS 3.5.15 “Mass impregnated cable for HVDC voltages up to 800kV”.

PART 1 - REQUIREMENTS

1 GENERAL REQUIREMENTS

On completion of the site commissioning tests and checks the forms contained in the schedules of this document shall be completed and handed over to the relevant National Grid Representative as specified in the contract.

Schedule A - Hand Over Signature Sheet
Schedule B - Hand Over Document Schedule
Schedule C - General Data Record
Schedule D - Cable Ratings
Schedule E - Calibrated Test Equipment Record
Schedule F - Commissioning Test Record
Schedule G - Installation Check Record

2 SITE TEST REQUIREMENTS

Following installation the following commissioning tests shall be made on the completed cable system and recorded on the relevant forms in Schedule F or equivalent as agreed with National Grid:

Insulation Tests (Clause 2.1)
Cable Parameter Tests (Clause 2.2)
Earth Bonding Tests (Clause 2.3)
Hydraulic Tests For Oil-Filled Cables (Clause 2.4)
Temperature Monitoring Fibre Tests (Clause 2.5)
Backfill Materials (Clause 2.6)
Pipe And Duct Alignment (Clause 2.7)
Earth Electrode Resistance (Clause 2.8)
(Water Cooling Pipe Tests (Clause 2.9)

2.1 Insulation Tests

2.1.1 Insulation DC Voltage Withstand Test (AC Oil-Filled Cable Systems Only) (Form F.1)

A DC test voltage of negative polarity as shown in Table 1 shall be applied for 15 minutes between the conductor and the sheath, with the sheath earthed and the cable at ambient temperature. No breakdown of the insulation shall occur.

System Voltage (kV)	DC Test Voltage for New Cable Systems (kV)	Minimum DC Test Voltage for Systems with Old Cable (kV)
132	305	130
275	525	269
400	710	377

Table 1 – DC Voltage Withstand Capability for Main Insulation

If the cable system includes sections of existing oil filled cable then the following voltages levels should be used:

- For the first 5 years – full value
- For every year of age over 5 years derate the pressure test value by 2.5%
- The test voltage should not be less than the value shown in Table 1 (this value is 10% above the rated peak voltage for the cable system).

Note: for example a 400 kV cable system with a section of cable 30 years old would have a calculated reduction of test value of

$$\text{Calculated reduction of test voltage} = 2.5 \times (30 - 5) = 62.5\%$$

This would give a calculated test voltage of 266 kV (37.5% of 710 kV). However the minimum test voltage in Table 1 is given as 377 kV so the cable system would be tested at 377 kV.

2.1.2 Insulation DC Withstand Test (Mass Impregnated HVDC Cables Only) (Form F.1)

A DC test voltage of $1.4U_0$ negative polarity shall be applied for 15 min between the conductor and the sheath, with the sheath earthed and the cable at ambient temperature. No breakdown of the insulation shall occur.

2.1.3 Insulation AC Voltage Withstand Test (AC XLPE Insulated Cable Systems Only) (Form F.2)

The cable shall withstand an AC test voltage applied between the conductor and sheath, with the sheath earthed. Following the recommendation in Electra 173, the cable insulation shall be subject to an AC voltage test. The test voltage will normally be provided by a resonant test set operating close to power frequency. The requirements of the test are summarised in Table 2. No breakdown of the insulation shall occur.

System Voltage (kV)	Site Test Voltage (kV)	Frequency (Hz)	Duration (h)
66	72	20-300	1.0
132	132		
275	210		
400	260		

Table 2 – Site Test Voltages for New XLPE Cables

If the cable system contains sections of existing oil filled or XLPE cable then the test voltage should be reduced in line with Table 3.

System Voltage (kV)	Existing cable < 5 years old		Existing cable < 20 years old		Existing cable > 20 years old	
	Test V (kV)	Time (h)	Test V (kV)	Time (h)	Test V (kV)	Time (h)
66	72	1	61	1	54	1
132	132	1	114	1	95	1
275	210	1	180	1	180	1
400	260	1	To be agreed at contract			

Table 3 – Site Test Voltages for Cable Systems with Existing Cables

2.1.4 Partial Discharge Test (XLPE Insulated AC Cable Systems Only) (Form F.3)

During the AC voltage test described in Clause 2.1.3, the cable system shall be monitored for partial discharge using a method agreed with National Grid. The cable system should be free from detectable partial discharge and any partial discharge should be brought to the attention of the National Grid commissioning engineer immediately and included in the site test report. Where other plant interferes with the partial discharge measurements this plant shall be, where practicable, removed or its influence otherwise eliminated.

Note: In agreeing the partial discharge monitoring method National Grid will expect to be provided with evidence that shows that the method offers adequate sensitivity whilst not increasing the likelihood of cable system faults.

2.2 Cable Parameter Tests

2.2.1 Cable Conductor Resistances (Form F.4)

The ambient temperature and DC conductor resistance of each completed circuit shall be measured to at least three significant figures.

2.2.2 Circuit Positive and Zero Sequence Impedances (AC Cables Only Form F.5)

Where the route length exceeds 400 m, the positive and zero sequence impedances shall be measured and allowance made for conductor temperature with the sheath bonding and earthing connections as for normal circuit operation. For these measurements a three-phase current injection test set is required, preferably in the range 25-100 A. The measurement shall be carried out as follows:

a) Positive Sequence Impedance

If the three-phase supply star point can be isolated from earth the three single phase cores shall be bonded together and earthed at the end remote from the test. If the three-phase supply star point cannot be isolated from earth the three single-phase cores must be bonded together and left free of any earth at the end remote from the test. A current shall be injected into each core, the magnitude of which should be equalised so far as is possible. Measurement of current, voltage and either power or phase angle shall be made on each of the single cores. From these arrangements, the following are calculated:

Using Wattmeter

$$Z_p = \frac{V_p}{I_p}$$

Using Phase Angle Meter

$$Z_p = \frac{V_p}{I_p}$$

$$R_p = \frac{W_p}{I_p^2} \quad R_p = \left(\frac{V_p}{I_p} \right) \cdot \cos \theta$$

$$X_p = \sqrt{Z_p^2 - R_p^2} \quad X_p = \left(\frac{V_p}{I_p} \right) \cdot \sin \theta$$

and

$$Z_1 = \frac{\sum Z_p}{3} \Omega/\text{phase} \quad R_1 = \frac{\sum R_p}{3} \Omega/\text{phase} \quad X_1 = \frac{\sum X_p}{3} \Omega/\text{phase}$$

Where V_p = Measured phase voltage (V)
 I_p = Measured phase current (A)
 W_p = Measured phase power (W)
 θ = Measured phase angle (degrees)

b) Zero Sequence Impedance

For measurements of zero sequence impedances the three single phase cores at the test end are bonded together and at the remote end bonded together and to the cable metallic sheaths. Single-phase currents are injected into the cable cores at the test end to return via the metallic sheath. Measurements of current, voltage and either power or phase angle shall be made from which the following are calculated.

Using Wattmeter

$$Z_0 = \frac{3V}{I}$$

$$R_0 = \frac{3W}{I^2}$$

$$X_0 = \sqrt{Z_0^2 - R_0^2}$$

Using Phase Angle Meter

$$Z_0 = \frac{3V}{I}$$

$$R_0 = \left(\frac{3V}{I} \right) \cdot \cos \theta$$

$$X_0 = \left(\frac{3V}{I} \right) \cdot \sin \theta$$

Where V = Measured conductor to earth voltage (V)
 I = Measured total current (A)
 W = Measured total power (W)
 θ = Measured dielectric loss angle (degrees)

2.3 Earth Bonding System Tests For AC Cable Systems

2.3.1 Oversheath Voltage Withstand Test (Form F.6)

The fully insulated sheath system including cable oversheath, terminal base insulation, joint external and sectionalising insulation if present, together with the insulation of bonding leads and link boxes or pillars, shall withstand a direct voltage.

In the case of specially bonded systems the test shall be carried out after the temporary disconnection of SVLs which could be damaged by the test voltage. The SVLs must be reconnected on completion of the test.