



BSI Standards Publication

Power cables with XLPE insulation and metal sheath, and their accessories, for rated voltages from 66 kV ($U_m = 72.5$ kV) to 132 kV ($U_m = 145$ kV)

(Implementation of HD 632)

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Foreword

Publishing Information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 December 2012. It was prepared by Subcommittee GEL/20/16, *Medium/high voltage cables*, under the authority of Technical Committee GEL/20, *Electric cables*. A list of organizations represented on these committees can be obtained on request to the committee manager.

Supersession

BS 7912:2012 superseded [BS 7912:2001](#), which has been withdrawn.

[BS 7912:2012+A1:2017](#) superseded BS 7912:2012, which has been withdrawn.

BS 7912:2012+A2:2023 supersedes [BS 7912:2012+A1:2017](#), which is withdrawn.

Relationship with other publications

BS 7912:2012 implemented the nationally applicable parts of Harmonization Document HD 632 S2:2008 published by the European Committee for Electrotechnical Standardization (CENELEC), in accordance with the decision of the CENELEC Technical Board.

Information about this document

BS 7912:2012 was a full revision of the standard, and introduced the following principal changes:

- alignment with the latest version of HD 632 part 1, being itself identical to Edition 4 of IEC 60840;
- inclusion of matter relating to [BS 7970](#), which was also revised in parallel.

Text introduced or altered by Amendments No. 1 and No. 2, respectively is indicated in the text by tags **A1** **A1** and **A2** **A2**. Minor editorial changes are not tagged.

Amendment A1 introduces the following principal changes:

- replacement of [subclause 4.6](#) with new text;
- replacement of [Clause 9](#) with new text;
- expansion/restructure of [Clause 10](#) to include accessories;
- replacement of [subclause 10.1.7](#) (previously **10.7**) with new text;
- addition of new [subclause 10.2](#);
- alteration to [subclause 14.1](#);
- replacement of [subclause D.1](#) with new text;
- replacement of [Figure D.1](#) with new figure.

Amendment A2 introduces the following principal changes:

- a) establishes that type test approvals for ranges of gas-immersed terminations only apply when the same gas/gas mixture and the same pressure is used as for the type test;
- b) explains what to do when intended use and type test differ in gas pressure or gas type:
 - 1) where the intended gas pressure exceeds that used in the type test, it defines the testing required to extend the approval up to a higher gas pressure;

- 2) where the gas/gas mixture is different to that type tested, it defines the testing required to extend the approval to include the new gas type.

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Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is “shall”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. “organization” rather than “organisation”).

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1 Scope

This British Standard specifies tests and requirements for power cables with XLPE insulation and metal sheath and their accessories for rated voltages from 66 kV ($U_m = 72.5$ kV) to 132 kV ($U_m = 145$ kV) for fixed installations.

NOTE 1 Cable systems to this standard do not normally have high electrical stresses at the conductor or insulation screen. If the calculated nominal electrical stresses at the conductor screen will be higher than 8.0 kV/mm and/or at the insulation screen higher than 4.0 kV/mm, then attention is drawn to the need to conduct a prequalification test in accordance with IEC 60840:2011, Clause 13.

This British Standard is applicable to single-core cables and three-core cables with separate cores and to their accessories for usual conditions of installation and operation. It is not applicable to special cables and their accessories, such as those designed for submarine cables, for which modification to the standard tests might be necessary or special test conditions might need to be devised.

NOTE 2 [Annex A](#) gives tests and requirements for cable bonding leads. [Annex B](#) gives tests and requirements for sheath voltage limiters (SVLs), while [Annex C](#) gives tests and requirements for link housings. [Annex D](#) gives an additional water blocking test for phase conductors. [Annex E](#) gives tests and requirements for gas-immersed terminations in case of changing insulation gas.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions, or limits the application, of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[BS 7870-2:2011](#), *LV and MV polymeric insulated cables for use by distribution and generation utilities – Part 2: Methods of test*

[BS 7970](#), *Electric cables – Metal foil and longitudinally welded aluminium sheath constructions of power cables having XLPE insulation for rated voltages from 66 kV ($U_m = 72.5$ kV) to 132 kV ($U_m = 145$ kV)*

[BS EN 60060-1](#), *High-voltage test techniques – Part 1: General definitions and test requirements*

[BS EN 60228](#), *Conductors of insulated cables*

[BS EN 60229:2008](#), *Electric cables – Tests on extruded oversheaths with a special protective function*

[BS EN 60230](#), *Impulse tests on cables and their accessories*

[BS EN 60287-1-1](#), *Electric cables – Calculation of the current rating – Part 1-1: Current rating equations (100% load factor) and calculation of losses – General*

[BS EN 60332-1-2:2004](#), *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

[BS EN 60811-201](#), *Electric and optical fibre cables – Test methods for non-metallic materials – Part 201: General test – Measurement of insulation thickness*

[BS EN 60811-202](#), *Electric and optical fibre cables – Test methods for non-metallic materials – Part 202: General test – Measurement of thickness of non-metallic sheath*

[BS EN 60811-401](#), *Electric and optical fibre cables – Test methods for non-metallic materials – Part 401: Miscellaneous tests – Thermal ageing methods – Ageing in an air oven*

[BS EN 60811-409](#), *Electric and optical fibre cables – Test methods for non-metallic materials – Part 409: Miscellaneous tests – Loss of mass test for thermoplastic insulations and sheaths*

[BS EN 60811-501](#), *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds*

[BS EN 60811-502](#), *Electric and optical fibre cables – Test methods for non-metallic materials – Part 502: Mechanical tests – Shrinkage test for insulations*

[BS EN 60811-503](#), *Electric and optical fibre cables – Test methods for non-metallic materials – Part 503: Mechanical tests – Shrinkage test for sheaths*

[BS EN 60811-505](#), *Electric and optical fibre cables – Test methods for non-metallic materials – Part 505: Mechanical tests – Elongation at low temperature for insulations and sheaths*

[BS EN 60811-507](#), *Electric and optical fibre cables – Test methods for non-metallic materials – Part 507: Mechanical tests – Hot set test for cross-linked materials*

[BS EN 60811-508](#), *Electric and optical fibre cables – Test methods for non-metallic materials – Part 508: Mechanical tests – Pressure test at high temperature for insulation and sheaths*

[BS EN 60811-509](#), *Electric and optical fibre cables – Test methods for non-metallic materials – Part 509: Mechanical tests – Tests for resistance of insulations and sheaths to cracking (heat shock test)*

[BS EN 60811-605](#), *Electric and optical fibre cables – Test methods for non-metallic materials – Part 605: Physical tests – Measurement of carbon black and/or mineral filler in polyethylene compounds*

[BS EN 60885-3](#), *Electrical test methods for electric cables – Part 3: Test methods for partial discharge measurements on lengths of extruded power cable*

[BS EN 61462](#), *Composite hollow insulators – Pressurised and unpressurised insulators for use in electrical equipment with rated voltage greater than 1 000 V – Definitions, test methods, acceptance criteria and design recommendations*

[BS EN IEC 62271-209](#), *High-voltage switchgear and control gear – Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV – Fluid-filled and extruded insulation cables – Fluid-filled and dry type cable-terminations*

IEC 60050-461, *International Electrotechnical Vocabulary – Part 461 – Electric cables*

3 Terms and definitions

For the purposes of this British Standard the terms and definitions given in IEC 60050-461 apply, together with the following.

3.1 rated voltage U_0

nominal power-frequency voltage between any conductor and armour or earth for which the cable and accessories are suitable

3.2 rated voltage U

nominal power-frequency voltage between phase conductors, for which the cable and accessories are suitable

3.3 maximum voltage U_m

maximum sustained power-frequency voltage between phase conductors, for which the cable and accessories are suitable

3.4 routine test

tests made by the manufacturer on each manufactured component (length of cable or accessory) to check that the component meets the specified requirements

3.5 sample test

tests made by the manufacturer on samples of completed cable or components taken from a completed cable or accessory, at a specified frequency to verify that the finished product meets the specified requirements

3.6 test after installation

test intended to demonstrate the integrity of the cable and its accessories after installation and before use

3.7 type test

tests made before supplying on a general commercial basis a type of cable system or cable or accessory covered by this standard, in order to demonstrate satisfactory performance characteristics to meet the intended application

NOTE Once successfully completed, these tests need not be repeated, unless changes are made in the cable or accessory with respect to materials, manufacturing process, design or design electrical stress levels, which might adversely change the performance characteristics.

4 Voltage designation and cable design features

4.1 Voltage designation

Where test voltages are specified in this British Standard as multiples of the rated voltage U_0 , the value of U_0 for the determination of the test voltages shall be as specified in [Table 1](#).

For cables and accessories of rated voltage not shown in [Table 1](#), it shall be permissible for the value of U_0 for determination of test voltage to be the same as for the nearest rated voltage which is given, provided that the value U_m for the cable and accessory is not higher than the corresponding value in the table. Otherwise, and particularly if the rated voltage is not close to one of the values in the table, the value of U_0 on which the test voltages are based shall be the specific rated voltage (i.e. U) divided by $\sqrt{3}$.

NOTE The test voltages in this British Standard are based on the assumption that the cables and accessories will be used on systems of Category A, as defined in [IEC 60183](#).

Table 1 — Test voltages

Rated voltage (between conductors)	Highest voltage for equipment (between conductors)	Value of U_0 (between conductor and screen) for determination of test voltages	Test voltage of voltage test: 9.3	Test voltage of partial discharge test: 9.2, 12.6 and 16.3	Maximum voltage of tan δ measurement: 12.7	Test voltage of tan δ measurement: 12.8	Load cycle voltage test: 12.9 and 16.4	Impulse voltage test: 12.10 and 16.5	Power frequency voltage test: 12.11 and 16.6
U	U_m	U_0	$2.5U_0$	$1.5U_0$	$2U_0$	U_0	$2U_0$	—	$3U_0$
kV	kV	kV	kV	kV	kV	kV	kV	kV	kV
66	72.5	36 ^{A)}	90	54	72	36	72	325	108
110	123	64	160	96	128	64	128	550	192
132	145	76	190	114	152	76	152	650	228

^{A)} Nominal service phase voltage is 38 kV. The tabulated value used as a test reference is in accordance with HD 632 S2:2008, Part 1, Table 4 [1].

4.2 Cable maximum temperatures

The maximum operating conductor temperatures upon which the specified conditions are based shall be as given in [Table 2](#).

Table 2 — *Cable maximum temperatures*

Insulating compound	Maximum conductor temperature	
	Normal operation	Short circuit
	°C	°C
Cross-linked polyethylene (XLPE)	90	250

4.3 Semi-conducting screens

Both the conductor and insulation semi-conducting screen shall be fully bonded to the XLPE insulation. Easy strip or cold strip types of screens shall not be used.

4.4 Metal cable sheathing materials and metal screen

The metal sheath material shall consist of lead, lead alloy or aluminium. The sheath shall be either a seamless extrusion or a longitudinally welded aluminium sheath or metal foil sheath. The latter two constructions shall, in addition to this British Standard, also conform to [BS 7970](#).

NOTE If necessary, in order to meet the short circuit rating, a layer of copper wires may be applied under the metal sheath.

No wires shall cross other wires.

A metal tape or wires shall be applied helically over, and in contact with, the layer of metal wires in order to equalize the current flowing in the individual wires forming the layer of wires.

4.5 Oversheath materials

COMMENTARY ON 4.5

Tests are specified in this British Standard for four types of oversheath material:

- ST_1 and ST_2 based on PVC;
- ST_3 and ST_7 based on polyethylene.

The choice of the type of sheath shall depend on the design of the cable and the mechanical and thermal properties during operation.

NOTE No temperature limits are given for sheaths in this British Standard.

4.6 Precautions against water penetration in cables

A1 The cable shall be designed to prevent longitudinal water penetration along internal interfaces i.e.:

- along the conductor;
- along the path between the outer surface of the insulation screen and the metal sheath.

When tested in accordance with [Clause 14](#), the resistance to longitudinal water penetration shall conform to [14.3](#).

NOTE If requested by the customer the cable should also be designed to prevent longitudinal water penetration along the interface between the oversheath and the metal sheath. **A1**

5 Marking of cables

5.1 External marking

The external surface of all cables shall be legibly marked with the following elements.

Element	Example of marking
a) Electric cable	ELECTRIC CABLE
b) Voltage designation	66 000 V or 110 000 V or 132 000 V
c) British Standard number	BS 7912 ¹⁾
d) Manufacturer's identification	XYZ
e) Number of cores and nominal area and type (CU or AL) of conductor, e.g. single-core cable with 300 mm ² copper conductor	1 × 300 CU

¹⁾ Marking BS 7912 or BS 7912:2012 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

The marking of elements a) to d) shall be by embossing or indenting on the oversheath.

The marking of element e) shall be by embossing, indenting or printing on the oversheath.

Elements a), b) and c) shall appear on two or more primary lines along the axis of the cable, approximately equally spaced around the circumference of the cable.

Elements d) and e) shall appear on at least one line.

NOTE Elements d) and e) may be on one of the primary lines or a secondary line or lines and need not be on the same line.

The letters and figures shall consist of upright block characters. The characters shall have a height of not less than 3 mm.

The distance between the end of the one element of marking and the beginning of the next identical element of marking shall be not greater than 550 mm for elements a), b) and c), and not greater than 1 100 mm for elements d) and e).

5.2 Identification of year and month of manufacture

A means of identifying the year and month of manufacture of the cable shall be provided throughout the length of the cable by marking on the surface of the cable.

The marking shall be by embossing or indenting on the oversheath. The characters shall have a height of not less than 3 mm and the distance between the end of the one element of marking and the beginning of the next identical element of marking shall be not greater than 1 100 mm.

5.3 Mark of an approval organization

If the mark of an approval organization is used, it shall be provided throughout the length of the cable.

6 Cable characteristics

For the purpose of carrying out and recording the tests described in this British Standard, the following characteristics shall be known or declared for each cable tested.

- a) The rated voltages; values shall be given for U , U_0 and U_m .

- b) The type of conductor, its material and cross-sectional area in square millimetres; presence (if any) and nature of measures taken to ensure that the cable is longitudinally watertight.
 - c) If the nominal cross-sectional area is not in accordance with [BS EN 60228](#), the d.c. conductor resistance shall be declared.
 - d) Material and nominal thickness of insulation.
 - e) Nominal thickness of conductor screen and insulation screen.
 - f) Presence (if any) and nature of measures in screening area to ensure that the cable is longitudinally watertight.
 - g) Nature and construction of metal sheath, and nature of any copper wires under the sheath.
 - h) Nature of non-metallic sheathing material.
 - i) Nominal diameter over conductor (d).
 - j) Nominal diameter over complete cable (D).
 - k) Nominal capacitance between conductor and metal screen/sheath.
-

7 Accessory characteristics

For the purposes of carrying out and recording the tests described in this British Standard, the following characteristics shall be known or declared for each accessory tested.

- a) For conductor connectors (supplied separately from the accessory) used within accessories:
 - assembly technique;
 - tooling and necessary setting;
 - preparation of contact surfaces;
 - type, reference number and any other identification of the connector.
 - b) For accessories:
 - name of manufacturer;
 - type, nominal bore diameter, designation, manufacturing date or date code;
 - rated voltage [see [Clause 6a](#)];
 - installation instructions (reference and date);
 - electrostatic screening measures in the region of the conductor connection;
 - details of any fluid filling medium (including chemical type, viscosity range, breakdown strength and any standard to which it conforms);
 - material types for resin and rubber components which form the main electrical insulation.
-

8 Test conditions

8.1 Ambient temperature

Unless otherwise specified in the details for the particular test, tests shall be made at an ambient temperature of $(20 \pm 15) ^\circ\text{C}$.

8.2 Frequency and waveform of power frequency test voltage

The frequency of the alternating test voltages shall be in the range 49 Hz to 61 Hz. The waveform shall be substantially sinusoidal.

NOTE The test voltage values quoted are r.m.s. values.

8.3 Waveform of impulse test voltage

In accordance with [BS EN 60230](#), the impulse wave shall have a virtual front time between 1 μ s and 5 μ s and a nominal time to half the peak value between 40 μ s and 60 μ s. In other respects, the impulse wave shall be in accordance with [BS EN 60060-1](#).

9 Routine tests on cables and on the main insulation of prefabricated accessories

9.1 General

The following tests shall be carried out on each manufactured length of cable:

- a) partial discharge test (see [9.2](#));
- b) voltage test (see [9.3](#));
- c) electrical test on oversheath of the cable, if required (see [9.4](#)).

NOTE 1 The order in which these tests are carried out is at the discretion of the manufacturer.

The main insulation of each prefabricated accessory shall undergo partial discharge (see [9.2](#)) and voltage routine tests (see [9.3](#)) according to either 1), 2) or 3) below:

- 1) on accessories installed on cable;
- 2) by using a host accessory into which a component of an accessory is substituted for test;
- 3) by using a simulated accessory rig in which the electrical stress environment of a main insulation component is reproduced.

In cases 2) and 3), the test voltage shall be selected so as to obtain electrical stresses at least the same as those on the component in a complete accessory when subjected to the test voltages specified in [9.2](#) and [9.3](#).

NOTE 2 The main insulation of prefabricated accessories consists of the components that come in direct contact with the cable insulation and are necessary to control the electric stress distribution in the accessory. Examples are premoulded or precast elastomer or filled epoxy resin insulating components that may be used singly or jointly to provide the necessary insulation or screening of accessories.

NOTE 3 Tests classified as sample or routine might be required as part of any type approval scheme.

9.2 Partial discharge test

The partial discharge test shall be carried out in accordance with [BS EN 60885-3](#) for cables, and the sensitivity as defined in [BS EN 60885-3](#) shall be 10 pC or better. Testing of accessories follows the same principles, but the sensitivity shall be 5 pC or better.

The test voltage shall be raised gradually to and held at $1.75 U_0$ for 10 s and then slowly reduced to $1.5 U_0$ (see [Table 1](#), column 5).

There shall be no detectable discharge exceeding the declared sensitivity from the test object at $1.5 U_0$.

9.3 Voltage test

The voltage test shall be made at ambient temperature using an alternating test voltage at power frequency.

The test voltage shall be raised gradually to $2.5 U_0$ (see [Table 1](#), column 4) and then be held for 30 min between the conductor and metal screen/sheath.

No breakdown of the insulation shall occur.

9.4 Electrical test on oversheath of the cable

When the test is required by the particular contract, the cable oversheath shall be subjected to the electrical test specified in [BS EN 60229:2008](#), Clause 3. A1

10 A1 Sample tests A1

10.1 A1 Cables A1

10.1.1 General

The following tests shall be made on samples taken to represent batches:

- a) volume resistivity of semi-conducting screens (see [10.1.4](#));
- b) hot set test for XLPE insulation (see [10.1.5](#));
- c) shrinkage test for XLPE insulation (see [10.1.6](#));
- d) insulation/screen moisture content determination (see [10.1.7](#));
- e) resistance test for semi-conducting tapes (see [10.1.8](#));
- f) confirmation of degassing of XLPE insulation by thermal history measurement (see [10.1.9](#));
- g) examination for contaminants in insulation (see [10.1.10](#));
- h) measurement of capacitance (see [10.1.11](#)).

NOTE Tests classified as sample or routine might be required as part of any type approval scheme.

10.1.2 Frequency of tests

Tests shall be carried out on numbers of samples, in accordance with [Table 3](#). Samples shall be taken from each batch (manufacturing series) of the same type and cross-section of cable.

Table 3 — Number of samples for sample tests

Cable length		Number of samples
Above	Up to and including	
km	km	
2	10	1
10	20	2
20	40	3
40	60	4
>60		Add 1 sample for each additional 20 km

10.1.3 Repetition of tests

If the samples from any length selected for the tests fail in any of the tests in this Clause, further samples shall be taken from two further lengths of the same batch and subjected to the same tests as those in which the original sample failed. If both additional cables pass the tests, the other cables in the batch from which they were taken shall be deemed to conform to the specified requirements. If either fails, this batch of cables shall be deemed not to conform.

NOTE Further re-sampling and testing should then become a matter for negotiation.

10.1.4 Volume resistivity of semi-conducting screens

10.1.4.1 Procedure

The resistivity of extruded semi-conducting screens applied over the conductor and over the insulation shall be determined by measurements on test pieces taken from the core of a sample of cable as made and a sample of cable which has been subjected to the ageing treatment to test the compatibility of component materials specified in [13.2](#).

The test procedure shall be in accordance with [BS 7870-2:2011](#), 3.9.3.

The measurements shall be made at a temperature within ± 2 °C of the rated maximum conductor temperature in normal operation for the design of cable.

10.1.4.2 Requirements

The resistivity, both without ageing and after ageing, shall not exceed the following values:

- conductor screen: 500 $\Omega \cdot m$;
- insulation screen: 500 $\Omega \cdot m$.

10.1.5 Hot set test for XLPE insulation

10.1.5.1 Procedure

The sampling and test procedure shall be in accordance with [BS EN 60811-507](#), employing the test conditions specified in [Table 4](#).

The test pieces shall be taken from the inner, middle or outer part of the insulation. The choice of test piece shall be such that it comes from the part of the insulation where, according to the method of processing, the cross-linking is lowest.

10.1.5.2 Requirements

The test results shall conform to the requirements specified in [Table 4](#).

Table 4 — Test conditions and requirements for particular characteristics of cable insulating materials

Test/condition	Units	Requirement
<i>Hot set test</i>		
Treatment:		
• air temperature	°C	200
• tolerance	°C	± 3
• time under load	min	15
• mechanical stress	N/cm ²	20
Maximum elongation under load	%	175
Maximum permanent elongation after cooling	%	15
<i>Shrinkage test</i>		
Distance between marks	mm	200
Temperature	°C	130
Tolerance	°C	± 3
Duration	h	6
Maximum permissible shrinkage	%	4.0

10.1.6 Shrinkage test for XLPE insulation

10.1.6.1 Procedure

The shrinkage test shall be carried out on XLPE insulation using the sampling test procedure specified in [BS EN 60811-502](#), and the conditions specified in [Table 4](#).

10.1.6.2 Requirement

The results of the test shall conform to the requirements specified in [Table 4](#).

10.1.7 Insulation moisture content determination

10.1.7.1 Sampling

Each cable length selected for the test shall be represented by a 300 mm piece of cable taken from the end of that length, after having discarded, if necessary, any portion which might have been contaminated. The sheath shall be removed and the sample sealed in a double polyethylene bag. Where it is not possible to test immediately, the sample shall remain sealed in the double polyethylene bag until ready for testing.

10.1.7.2 Procedure

The test shall be carried out on three separate test pieces taken from the 300 mm sample.

Each test piece shall comprise complete sections of insulation with the inner and outer semiconducting screens removed, taken from the cable sample. These shall be of a suitable size to fit the glass sample oven.

The glass oven containing the test pieces shall be maintained at 110 °C to 130 °C while the moisture determination is carried out.

Moisture shall be extracted by passing dry nitrogen over the test pieces contained in the glass oven. The effluent gas shall then be passed into a Karl Fischer titration equipment for measurement of the moisture contained in the gas.

The moisture content of each test piece shall be determined by dividing the total weight of moisture evolved during the test by the final weight of the test piece.

10.1.7.3 Requirement

The mean value of the moisture content for the three determinations shall be not greater than 150 parts per million (ppm) by weight. 

10.1.8 Resistance test for semi-conducting tapes

10.1.8.1 General

The following tests shall be carried out for those designs of cable where semi-conducting tapes are applied between the cable core and the metal sheath. These might be bedding tapes or water blocking tapes.

The resistance of the tape, which shall be taken from the raw material, shall be measured before it is applied to the cable.

10.1.8.2 Sampling

Prepare three samples of tape 150 mm × 10 mm.

10.1.8.3 Procedure

Samples shall be conditioned for 24 h in an environment of $(23 \pm 5)^\circ\text{C}$ and relative humidity of $(50 \pm 5)\%$.

While still in the environment, the tape samples shall be placed in a jig having two parallel electrical contact clamping bars with a separation distance between them of 100 mm. The resistance of each tape sample shall then be measured.

10.1.8.4 Requirement

The value of resistance of the tape in ohms per square shall be the average of the three values obtained, divided by 10. It shall not exceed $1\,500\ \Omega$ per square.

10.1.9 Confirmation of degassing of XLPE insulation by thermal history measurement**10.1.9.1 Principle**

Polymers which have crystallinity in the solid state undergo a transition to an amorphous phase on heating. This can be observed as an exothermic event in the Differential Scanning Calorimetry (DSC) experiment.

For a specimen which has been cooled from the melt, the exothermic peak observed will typically exhibit a slow onset on the low temperature side of the peak, which itself is usually sharp and has a relatively sharp tail and end. If, however, the specimen has undergone subsequent heating at a temperature within the envelope of the melting event, reorganization of the crystalline structure of the specimen will take place.

This is observable as a subsidiary peak.

Calibration with oven aged samples shows that these peaks are an accurate record of thermal history, but they can be erased by annealing at a higher temperature. Thus there might sometimes be a record of highest, next highest and second next highest temperature events if they occur in that order, but not in the opposite order.

10.1.9.2 Measurement**COMMENTARY ON 10.1.9.2**

Experience has shown that the measurement can be made using either a heat flux DSC or a power compensated DSC. The following experimental conditions are suitable.

<i>Pan:</i>	<i>Standard aluminium pan</i>
<i>Purge gas:</i>	<i>High Purity Nitrogen</i>
<i>Heat rate:</i>	<i>$10\ \text{K min}^{-1}$</i>
<i>Temperature range:</i>	<i>For cross-linked polyethylene, 30°C to 180°C is a suitable range. This can be varied for different polymers if necessary.</i>
<i>Baseline subtraction:</i>	<i>If necessary, run a baseline check with an empty pan and then use the data file generated for baseline subtraction in accordance with the instrument manufacturer's software instructions.</i>
<i>Sample size:</i>	<i>2.5 mg to 5 mg, weighed accurately, is suitable for power compensated DSC work but refer to the instrument manufacturer's guidelines for sample sizing.</i>

Samples of XLPE insulation shall be taken from close to the outer screen and close to the inner screen for separate DSC measurements.

For each sample, the experiment shall be run a first time using the above parameters, the DSC shall be allowed to slowly cool back to the start temperature so that the specimen can recrystallize fully, and then the experiment shall be run again with a new filename. The melting curves for the as-received specimen and for the recrystallized specimen shall be overlaid on screen.

NOTE The thermal history peak(s) can be found by inspection of the two curves (the recrystallized specimen curve is smooth on the low temperature side of the melting peak). Software (suitable software is usually supplied with DSC instruments) is used to determine the start and finish of the thermal history event.

10.1.9.3 Requirement

The inspection of the curves for both samples shall show evidence within the endothermic crystalline melting peak, in the range 60 °C to 80 °C consistent with the degassing operation carried out during cable manufacture.

NOTE As an alternative to this measurement, the manufacturer may carry out a direct measurement of methane content of the insulation to demonstrate that this has been reduced to a satisfactory and safe level. No standardized method is currently available for methane determination in XLPE insulation.

10.1.10 Examination for contaminants in insulation

10.1.10.1 Procedure

Five approximately 3 000 mm³ cross-sectional slices of insulation, each 1 mm thick, taken from a production length of the cable, shall be examined using a 50 × magnification transmission microscope. It shall be permissible for slices to be taken from one end of the cable length after elimination of any end effects. The dimensions of the largest five particles in each slice shall be recorded. The particle sizes shall be plotted in the form of a histogram for ease of comparison against the requirements specified in [10.1.10.2](#).

10.1.10.2 Requirements

The quality of the XLPE material and extrusion process shall be such that:

- there shall be no voids greater than 75 µm in diameter and the number of voids larger than 50 µm in diameter shall not exceed 20 per 15 000 mm³;
- there shall be no contaminant (any solid or liquid which is opaque or not homogeneous cross-linked polyethylene) larger than 150 µm in any dimension. The number of such contaminants between 50 µm and 150 µm shall not exceed 10 per 15 000 mm³.

10.1.11 Measurement of capacitance

The capacitance shall be measured between the conductor and metal screen/sheath. The measured value shall not exceed the nominal value specified by the manufacturer by more than 8%.

10.1.12 Dimensional checks

10.1.12.1 General

Measurement of the thickness of the insulation, semi-conducting screens, metal sheath and the oversheath shall be made on a sample from every production cable length of the same type and size of cable.

10.1.12.2 Measurement of thickness of insulation

10.1.12.2.1 Sampling

Each cable length shall be represented by a piece of cable, taken from the end of that length, after discarding, if necessary, any portion which might have suffered damage.