

Electric cables — Internal gas-pressure cables and accessories for alternating voltages up to and including 275 kV ($U_m = 300$ kV) — Requirements and test methods

(Implementation of HD 634)

ICS 29.060.20

Confirmed
December 2009

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee GEL/20, Electric cables, to Subcommittee GEL/20/16, Medium/high voltage cables, upon which the following bodies were represented:

- British Approvals Service for Cables
- British Cables Association
- British Plastics Federation
- Energy Networks Associations
- ERA Technology Ltd.
- Co-opted members

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 4 August 2004

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The following BSI references relate to the work on this British Standard:
Committee reference GEL/20/16
Draft for comment 95/215973 DC

Amendments issued since publication

Amd. No.	Date	Comments

ISBN 0 580 38567 1

Contents

	Page
Foreword	ii
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Voltage designation	1
5 Characteristics	2
6 Test categories, frequency and conditions	3
7 Routine tests on cables	4
8 Sample tests on cables	5
9 Routine tests on accessories	7
10 Sample tests on accessories	8
11 Type tests on cables and accessories	8
12 Non-electrical type tests on cables	15
13 Non-electrical type tests on accessories	18
14 Tests after installation	20
Bibliography	25
Table 1 — Tan δ measurement requirements	5
Table 2 — High voltage test values	5
Table 3 — Diameter of the test cylinder	6
Table 4 — Waveshape	13
Table 5 — Voltage levels	13
Table 6 — Lightning impulse test voltage levels	14
Table 7 — Impulse voltage level requirements	19
Table 8 — Test voltages for salt fog test	19
Table 9 — High voltage test levels	20

Foreword

This British Standard has been prepared by Subcommittee GEL/20/16.

It implements the nationally applicable parts of Harmonization Document HD 634 published by the European Committee for Electrotechnical Standardization (CENELEC), in accordance with the decision of the CENELEC Technical Board.

BS 7923 applies to internal gas-pressure cables and accessories for alternating voltages up to and including 275 kV ($U_m = 300$ kV).

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 25 and a back cover.

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1 Scope

This British Standard specifies tests and requirements for radial-field impregnated-paper-insulated cables and accessories in which, during normal operation, a gas pressure exceeding 1.2 MPa (12 bar) gauge is applied internally, i.e. with the gas in direct contact with the insulation.

It also specifies tests for cables and accessories intended for use in systems with a nominal voltage not exceeding 275 kV between phases.

2 Normative references

The following referenced documents are indispensable for 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 228:1994, *Specification for short-pitch transmission precision roller chains and chain wheels*.

BS 4727-2:Group 08, *Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms — Part 2: Terms particular to power engineering — Group 08: Electric cables*.

IEC 60060-1, *High-voltage testing techniques — Part 1: General definitions and test requirements*.¹⁾

IEC 60228:1978, *Conductors of insulated cables*.²⁾

IEC 60229:1982, *Tests on cable oversheaths which have a special protective function and are applied by extrusion*.

IEC 60230, *Impulse tests on cables and their accessories*.³⁾

IEC 60507:1991, *Artificial pollution tests for high-voltage insulators to be used on a.c. systems*.

IEC/TS 60859, *Cable connections for gas-insulated metal-enclosed switchgear for rated voltages of 72,5 kV and above — Fluid-filled and extruded insulation cables — Fluid-filled and dry type cable-terminations*.

3 Terms and definitions

For the purposes of this British Standard the definitions given in BS 4727-2:Group 08 and the following apply.

3.1

rated voltage U_0

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

3.2

rated voltage U

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

3.3

maximum voltage U_m

maximum sustained voltage between phase conductors for which the cable and its accessories are suitable

3.4

peak voltage U_p

peak value of the impulse withstand voltage for which the cable and its accessories are suitable

4 Voltage designation

Cables and accessories shall be designated by the rated voltage between conductor and screen U_0 and by the rated voltage between conductors U , both in kilovolts, e.g. 76/132 kV.

NOTE See IEC 60183.

¹⁾ Published by BSI as BS 923-1.

²⁾ Published by BSI as BS 6360.

³⁾ Implemented by CENELEC as HD 48.

5 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) rated voltage U_0 , in kilovolts (kV);
- b) lightning impulse withstand voltage U_p , in kilovolts (kV);
- NOTE 1 The lightning impulse withstand voltage U_p specified above for each particular cable should be selected in accordance with IEC 60071-1.
- c) type of conductor, material, nominal cross-sectional area of the conductors in square millimetres (mm^2), and conductor resistance (for conductor resistances, see 7.2);
- d) conductor resistance, if the nominal cross-sectional area is not in accordance with the values given in IEC 60228;
- e) number of cores;
- f) capacitance between each conductor and screen, in microfarads per kilometre ($\mu\text{F}/\text{km}$);
- g) maximum permissible conductor temperature, in degrees Celsius ($^{\circ}\text{C}$), for continuous operation under the specified ambient and installation conditions;
- h) minimum and maximum permissible static fluid pressure, in kilopascals (kPa) or bars⁴⁾;
- i) type and material of the metallic sheath and the construction of the sheath reinforcement, if any;
- j) thermal resistance between conductor(s) and metallic sheath, in kelvin metres per watt ($\text{K}\cdot\text{m}/\text{W}$);

NOTE 2 The thermal resistance should be calculated using the formulae given in IEC 60287-2-1.

- k) cable design stress, in kilovolts per millimetre (kV/mm);
- l) maximum design pressures of accessories, in kilopascals (kPa) (see Clause 9);
- m) type of conductor screen (with or without carbon-black paper);
- n) specified minimum thickness of insulation, nominal thickness of the metallic sheath and anti-corrosion covering, in millimetres (mm);
- o) nominal outside diameter of the cable and conductor, in millimetres (mm);
- p) type and material of the corrosion-resistant covering over the metallic sheath;
- q) cable thermal resistance.

The following additional characteristics shall be stated by the manufacturer when requested by the purchaser:

- 1) details of construction, e.g. shaped or circular conductor, screened or unscreened conductor, types of joint and sealing end, etc.;
- 2) insulation thickness of the cable, in millimetres (mm), and maximum voltage gradient in the cable insulation at U_0 , in kilovolts per millimetre (kV/mm), neglecting any stranding effect;
- 3) maximum current rating, in amperes (A), under the specified installation and operating conditions;
- 4) estimated effective (a.c.) resistance, in ohms per kilometre (Ω/km), of the cable at the maximum operating temperature and under the specified installation conditions;
- 5) estimated inductance, in henrys per kilometre (H/km), per phase of the completed cable under the specified installation conditions.

⁴⁾ 1 bar = $10^5 \text{ N}/\text{m}^2 = 10^5 \text{ Pa}$.

6 Test categories, frequency and conditions

6.1 Categories of tests

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

6.1.1 Routine tests

Tests made on all production cable lengths and accessories to demonstrate their integrity.

6.1.2 Sample tests

Test made on samples of completed cable or accessories, or components taken from a completed cable or accessory, adequate to verify whether the finished product meets the design specifications.

6.1.3 Type tests

Test required to be made before supplying a type of cable or accessory covered by this standard on a general commercial basis in order to demonstrate satisfactory performance characteristics to meet the intended application. These tests are of such a nature that, after they have been made, they need not be repeated unless changes are made in the cable materials, design or type of manufacturing process, which might change the performance characteristics.

6.1.4 Tests after installation

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

6.2 Frequency of tests

6.2.1 Frequency of measurements of dimensions

This test shall be carried out on each drum length.

6.2.2 Frequency of bend tests

Provided that the total length of cable supplied to the purchaser under a single contract exceeds 50 drums of one type of cable, the test shall be carried out on 2 % of drum lengths.

6.3 Test conditions

6.3.1 Ambient temperature

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

6.3.2 Frequency of 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.

6.3.3 Waveform of impulse test voltage

In accordance with IEC 60230, the impulse wave shall have a virtual front time between 1 μs and 5 μs and a nominal time to half the peak value between 40 μs and 60 μs . In other respects the impulse wave shall be in accordance with IEC 60060-1.

7 Routine tests on cables

7.1 General

7.1.1 The tests specified in **7.2**, **7.3**, **7.4**, **7.5** and **7.6** shall be carried out as routine tests (see **6.1.1**) on all completed cables under a single contract.

7.1.2 For the tests specified in **7.3**, **7.4** and **7.4**, the cables shall be suitably terminated and the tests shall be carried out at atmospheric pressure, except for not-fully-impregnated insulation, for which either atmospheric pressure or an internal gas pressure not exceeding 200 kPa (2.0 bar) shall be used.

7.2 Conductor resistance test

7.2.1 Procedure

The d.c. resistance of conductors in the finished cable shall be measured.

The measured value of resistance shall be corrected to a temperature of 20 °C and a length of 1 km. The correction for temperature and length shall be made in accordance with IEC 60228.

The cable shall be maintained at a reasonably constant temperature for at least 12 h before the test. If there is any doubt as to whether the conductor temperature is the same as the ambient temperature, this period shall be extended to 24 h.

7.2.2 Requirements

7.2.2.1 The measured value of resistance for 3-core cables (with a nominal cross-sectional area not exceeding 400 mm²) and for single core cables (with a nominal cross-sectional area not exceeding 2 000 mm²), when corrected, shall not exceed the value specified for class 2 conductors in columns 8 and 9 (for copper conductors) or column 10 (for aluminium conductors) of IEC 60228:1978, Table II.

7.2.2.2 For cables with a nominal cross-sectional area greater than those specified in **7.2.2.1** or not included in IEC 60228:1978, Table II, the d.c. resistance shall meet the value stated by the manufacturer.

7.3 Capacitance test

7.3.1 Procedure

The capacitance shall be measured at power frequency by means of an a.c. bridge.

7.3.2 Requirement

The capacitance of each core shall be not greater than 8 % above the declared value [see Clause 5f)].

7.4 Tan δ measurement test

7.4.1 Procedure

The tan δ measurement of the insulation shall be made at ambient temperature between each conductor and core screen, employing the following power-frequency test voltages.

a) For cables with fully-impregnated insulation, the test voltage shall be increased from $0.25U_0$ to U_0 in steps of $0.25U_0$. The tan δ at $0.5U_0$ shall not exceed 0.005 and the increase in tan δ between $0.25U_0$ and U_0 shall be not more than 0.001 per step of $0.25U_0$, the total increase between $0.25U_0$ and U_0 being not greater than 0.002.

b) For cables having not-fully-impregnated insulation, the test voltage shall be increased from $0.25U_0$ to $0.5U_0$. The tan δ at $0.25U_0$ shall not exceed 0.005 and the increase in tan δ between $0.25U_0$ and $0.5U_0$ shall not exceed 0.001.

If the measurements are made at a temperature below 20 °C, the results shall be corrected to 20 °C, either by subtracting from the measured value 2 % of this value per degree Celsius (°C) of the difference between the test temperature and 20 °C, or by the use of a correction curve appropriate to the insulation if agreement on such a curve has been reached between the purchaser and the manufacturer. No correction shall be made if the test temperature is 20 °C or higher.

7.4.2 Requirement

The $\tan \delta$ and the $\tan \delta$ difference shall not exceed the appropriate values given in Table 1, or the declared values, whichever are the lower.

Table 1 — Tan δ measurement requirements

Rated voltage, U_0 kV	Maximum $\tan \delta \times 10^{-4}$		Maximum $\tan \delta$ difference ^a 10^{-4}
	At $0.25 U_0$	At $0.5 U_0$	$0.5 U_0$ to $0.25 U_0$
33	47	150	—
66	47	67	24
132	47	67	24

^a The $\tan \delta$ difference is the maximum variation in value between the two test voltages.

7.5 High-voltage test

7.5.1 Procedure

The high-voltage test shall be made at ambient temperature, and the test voltage, which shall be either a.c. or d.c., shall be applied for 15 min between each conductor and core screen. The voltage shall be gradually increased to the specified value.

The value of the test voltage shall be as follows.

- a) If an a.c. test voltage is used, the value of the test voltage shall be as specified in Table 2.

NOTE The a.c. test may be made in conjunction with the measurement of $\tan \delta$ (see 7.4).

- b) If a d.c. test voltage is used, the value of the test voltage shall be:

- 1) for fully-impregnated cables, $5U_0$;
- 2) for not-fully-impregnated cables, $4U_0$.

Table 2 — High voltage test values

Rated voltage, U_0 kV	Test voltage kV
33	12.5
66	25
132	50

7.5.2 Requirement

No breakdown of the insulation shall occur.

7.6 Test on oversheath

When the oversheath is tested in accordance with IEC 60229:1982, Clause 3, no breakdown shall occur.

8 Sample tests on cables

8.1 Measurement of thickness

8.1.1 Measurement of insulation thickness

Measurement of the insulation thickness shall be made on a representative sample of each drum length of cable. The sample shall be not less than 300 mm in length and taken not less than 300 mm from the end of a factory length.

The insulation thickness shall be derived by taking half the difference of diameter tape measurements over the (screened) conductor and over the insulation after the insulation screen has been removed.