

Electric cables — Fluid-filled, paper- and PPL-insulated, metal-sheathed cables and accessories for alternating voltages up to and including 400 kV ($U_m = 420$ kV) — Requirements and test methods

(Implementation of HD 633)

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Foreword

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

It implements the nationally applicable parts of Harmonization Document HD 633 published by the European Committee for Electrotechnical Standardization (CENELEC), in accordance with the decision of the CENELEC Technical Board.

BS 7922 applies to fluid-filled, paper- and PPL-insulated, metal-sheathed cables and accessories for alternating voltages up to and including 400 kV ($U_m = 420$ 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 to ii, pages 1 to 41 and a back cover.

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1 Scope

This British Standard specifies tests and requirements for radial field, fluid-filled, paper or polypropylene paper laminate (PPL) insulated metal-sheathed cables and their accessories, which operate with a minimum static pressure of between 20 kPa (0.2 bar) and 300 kPa (3.0 bar) inclusive, a maximum static pressure of not more than 800 kPa (8.0 bar) and a minimum transient pressure of not less than 20 kPa (0.2 bar)¹⁾.

NOTE The cables in this British Standard are specifically excluded from the scope of the Pressure Equipment Directive.

It also specifies tests for cables and accessories with maximum static pressures exceeding 800 kPa (8.0 bar).

This British Standard is applicable to cables and accessories intended for use in systems with nominal voltages not exceeding 400 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*.

BS 6346, *Specification for 600/1 000 V and 1 900/3 300 V armoured electric cables having PVC insulation*.

BS 6500:2000, *Electric cables — Flexible cords rated up to 300/500 V, for use with appliances and equipment intended for domestic, office and similar environments*.

BS 7912, *Power cables with XLPE insulation and metallic sheath, and their accessories, for rated voltages from 66 kV ($U_m = 72.5$ kV) to 132 kV ($U_m = 145$ kV) — Requirements and test methods*.

BS EN 50062, *Specification for ceramic pressurized hollow insulators for high-voltage switchgear and controlgear*.

BS EN 60068-2-1, *Environmental testing — Part 2: Test methods — Section 2-1: Tests A — Cold*.

BS EN 60068-2-2, *Environmental testing — Part 2: Test methods — Section 2-2: Tests B — Dry heat*.

IEC 60060-1, *High-voltage test techniques — Part 1: General definitions and test requirements*.²⁾

IEC 60060-2, *High-voltage test techniques — Part 2: Measuring systems*.

IEC 60228:1978, *Conductors of insulated cables*.³⁾

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*.⁴⁾

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

IEC 60554-2, *Specification for cellulose papers for electrical purposes — Part 2: Methods of test*.

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*.

¹⁾ These pressures are above atmospheric pressure.

²⁾ Published by BSI as BS 923-1.

³⁾ Published by BSI as BS 6360.

⁴⁾ Implemented by CENELEC as HD 48.

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

cables screened with carbon-black paper

cables where carbon-black paper is applied as a screen over the conductor and where the carbon-black paper is in contact with the insulation

3.2

cables not screened with carbon-black paper

cables where the screen over the conductor consists of any material other than carbon-black paper, or is such that carbon-black paper, if present, is not in contact with the insulation

NOTE For the purpose of this British Standard, cables with unscreened conductors are included in this group.

3.3

rated voltage U_0

nominal power-frequency voltage between conductor and core screen for which the cable and its accessories are suitable

3.4

rated voltage U

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

3.5

maximum voltage U_m

maximum value of the highest permissible system voltage for which the cable and its accessories are suitable

3.6

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 core screen U_0 and by the rated voltage between conductors U , both in kilovolts, e.g. 76/132 kV. Cables shall be operated in a system of the following categories.

a) **Category A** comprises those systems where earth faults are cleared as rapidly as possible by in any case within 1 min.

b) **Category B** comprises those systems which, under fault conditions, are operated for a short time with one phase earthed.

NOTE According to IEC 60183, this period should not exceed 1 h. For cables in this British Standard, a longer period not exceeding 8 h on any occasion can be tolerated. The total duration of earth faults per year should not exceed 125 h.

c) **Category C:** cables covered by BS 7922 are not intended for operating in category C systems. Where there is such a requirement, agreement on the design of cables and accessories shall be made between the purchaser and the manufacturer.

5 Characteristics of cables and accessories

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 core 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 bars⁵⁾;
 - 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.

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

- 1) maximum current rating in amperes (A) under the specified installation and operating conditions;
- 2) 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;
- 3) estimated inductance in henrys per kilometre (H/km) per phase of the completed cable under the specified installation conditions.

6 Test categories, frequency and conditions

6.1 Categories of tests

NOTE Tests 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.

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

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 not more than 10 % of the number of delivery lengths, on at least one length, unless otherwise specified by the purchaser at the time of enquiry.

6.2.2 Frequency of mechanical tests

Provided that the total length of cable supplied to the purchaser under a single contract exceeds 2 km of 3-core cable or 4 km of single core cable, tests shall be carried out in accordance with the number of samples specified in Table 1.

Table 1 — Number of samples for sample tests

Cable length				Number of samples
3-core cables		Single core cables		
Above km	Up to and including km	Above km	Up to and including km	
2	10	4	20	1
10	20	20	40	2
20	30	40	60	3
etc.	etc.	etc.	etc.	etc.

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 in a single contract.

7.1.2 For the tests specified in **7.3**, **7.4** and **7.5**, the cables shall be installed with suitable terminations and the fluid pressure at the highest position adjusted to a value not exceeding 200 kPa (2.0 bar) or the minimum static pressure [see Clause 5h)] plus 50 kPa (0.5 bar), whichever is the greater.

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 power frequency test voltage specified in **6.3.2**.

For paper-insulated cables up to and including 132 kV, the measurements shall be made at the rated voltages U_0 and $2U_0$. For paper-insulated cables for 275 kV and 400 kV, and for PPL-insulated cables, the measurements shall be made at the rated voltage U_0 and at $1.67U_0$.

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 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 2 and Table 3, or the declared values, whichever are the lower.

Table 2 — Tan δ measurement requirements for paper insulated cables

Rated voltage, U kV	Cables not screened with carbon-black paper					Cables screened with carbon-black paper				
	Maximum $\tan \delta \times 10^{-4}$			Maximum $\tan \delta$ difference ^a $\times 10^{-4}$		Maximum $\tan \delta \times 10^{-4}$			Maximum $\tan \delta$ difference ^a $\times 10^{-4}$	
	At U_0	At $1.67U_0$	At $2U_0$	$1.67U_0$ to U_0	$2U_0$ to U_0	At U_0	At $1.67U_0$	At $2U_0$	$1.67U_0$ to U_0	$2U_0$ to U_0
33	35	—	43	—	10	35	—	50	—	18
66	35	—	43	—	10	35	—	50	—	18
110	33	—	40	—	8	33	—	45	—	14
132	33	—	40	—	8	33	—	45	—	14
275	30	34	—	5	—	30	36	—	7	—
400	28	31	—	4	—	28	34	—	7	—

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

Table 3 — Tan δ measurement requirements for PPL insulated cables

Rated voltage, U_0 kV	Cables not screened with carbon-black paper			Cables screened with carbon-black paper		
	Maximum $\tan \delta \times 10^{-4}$		Maximum $\tan \delta$ difference ^a $\times 10^{-4}$	Maximum $\tan \delta \times 10^{-4}$		Maximum $\tan \delta$ difference ^a $\times 10^{-4}$
	At U_0	At $1.67U_0$	$1.67U_0$ to U_0	At U_0	At $1.67U_0$	$1.67U_0$ to U_0
275	14	16	4	14	19	6
400	14	16	4	14	19	6

^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 (see Table 4) shall be:

- $2U_0 + 10$ kV for cables with U_0 not exceeding 87 kV;
- $1.67U_0 + 10$ kV for cables with U_0 exceeding 87 kV.

NOTE 1 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 2.4 times the a.c. test voltage (see Table 4).

NOTE 2 See also IEC 60071 and IEC 60183.

7.5.2 Requirement

No breakdown of the insulation shall occur.

7.6 Test on corrosion-resistant coverings

When tested in accordance with IEC 60229, the corrosion-resistant coverings shall meet the requirements of IEC 60229.

Table 4 — Standard values of system voltages and test voltages recommended for cables to be used in 3-phase systems

System voltages ^a			Test voltages for cables ^b			
Nominal values (for information only)	Highest voltages for equipment, U_m	Rated voltage of cables, U_o	High-voltage test (routine test)	High-voltage test (routine test)	Dielectric security test	Test after installation ^c
kV	kV	kV	kV a.c.	kV d.c.	kV a.c.	kV d.c.
33	36	18	48	111	45	85
66	72.5	36	86	197	90	170
110	123	64	138	330	160	290
132	145	76	162	390	190	305
275	300	160	275	665	375	525
400	420	220	395	900	480	710

^a The system voltages are r.m.s. values.
^b The test voltages are rounded off to full kilovolt values for voltages up to and including 200 kV, and to 5 kV or 10 kV values, respectively, for voltages exceeding 200 kV.
^c See 15.1.

8 Sample tests on cables

8.1 Measurements 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.

8.1.2 Measurement of sheath thickness

Measurement of the sheath thickness shall be made on a representative sample of each drum length of cable.

The sample to be measured shall be taken not less than 300 mm from the end of a factory length and shall consist of a ring carefully cut from the cable.

The thickness of the sheath shall be determined at a sufficient number of points around the circumference of the ring sample to ensure that the minimum thickness is measured (see 8.1.3).

The measurements shall be made with a micrometer having either one flat nose and one ball nose or one flat nose and one flat rectangular nose 0.8 mm wide and 2.4 mm long. The ball nose or the flat rectangular nose shall be applied to the inside of the ring.

8.1.3 Measurement of the thickness of extruded polymeric oversheath

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

The measurement shall be made either by micrometer or by an optical method in which the error of determination shall not exceed 0.03 mm. In cases of dispute the optical method shall be used.

The measurements shall be made at six approximately equally spaced points around the periphery of the sample.

NOTE Care should be taken to ensure that the minimum thickness is measured.

The smallest measurement and the average of the measurements shall be recorded.

8.1.4 Re-test procedure

If any sample, when subjected to the tests specified in 8.1.1, 8.1.2 and 8.1.3, fails to conform to the manufacturer's specification [see Clause 5n)], two further samples shall be taken from the same batch and subjected to the same tests as those in which the original sample failed. If both additional test samples pass the tests, all the cables in the batch from which they were taken shall be deemed to conform to the specified requirements. If either fails, the batch of which the samples were representative shall be deemed not to conform.

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

8.2 Bending test

The bending test shall be carried out as described below unless otherwise agreed between the manufacturer and the purchaser.

The bending test shall be made on a sample of cable of sufficient length to provide at least one complete turn round the test cylinder. The test shall be made at ambient temperature, unless otherwise specified by the purchaser at the time of enquiry.

The test shall be carried out on 2 % of drum lengths on contracts with greater than 50 drums of one type of cable. If fewer than 50 drums are supplied, the number of samples shall be in accordance with Table 1.

The diameter of the test cylinder shall be not greater than the values specified in Table 5, with a tolerance of $\pm 5\%$.

Table 5 — Test cylinder diameters for bending test

Type of cable	Diameter of the test cylinder
Single core cables with lead, lead-alloy or corrugated aluminium sheaths	$25(D+d)$
3-core cables with lead, lead-alloy or corrugated aluminium sheaths	$20(D+d)$
All cables with plain aluminium sheaths	$36(D+d)^a$
Key D is the measured diameter over the pressure-retaining sheath or over crest of the corrugations of the corrugated aluminium sheath cable. d is the measured diameter of the conductor or, if a non-circular conductor is concerned, it is $1/3.14$ times the measured conductor perimeter.	
^a The fact that the diameter of the test cylinder is larger for these cables indicates that they have to be transported on larger diameter drums and installed with larger installation radii than reinforced lead or corrugated aluminium sheathed cables.	

The cable shall be laid out straight and level and one end shall be secured to the test cylinder.

A reference line shall be drawn along the top of the cable parallel to its longitudinal axis.

The cylinder shall be rotated steadily so that all the cable is taken up in a closely-wound coil. The cylinder shall then be rotated in either the opposite direction or the same direction so that the cable is unwound.

The cable shall then be rotated 180° about its longitudinal axis and the winding and unwinding process repeated with the same directions of test cylinder rotation as before.

Finally, either one of the two following procedures shall be carried out:

- a) the cable shall be rotated about its longitudinal axis by 180° to regain its initial position, i.e. reference line uppermost; or
- b) the direction of rotation of the test cylinder shall be reversed so that the cable is retained in the same position and alternates between the bottom and the top of the test cylinder.

The complete cycle of wind/unwind/cable rotation/wind/unwind/cable rotation shall be carried out three times on the cable sample.

8.3 Quality of insulation paper

When requested, the amount of water-soluble impurities present in the insulation paper before impregnation shall be determined in accordance with IEC 60554-2, using either the sample mass specified in IEC 60554-2 or a sample mass of 1 g at the discretion of the manufacturer.

The value obtained shall be calculated as a percentage of the dry paper mass.

9 Routine tests on accessories

9.1 General

The tests specified in 9.2, 9.3 and 9.4 shall be carried out on each accessory to be supplied to the purchaser.

9.2 Hydraulic test

9.2.1 Joint sleeves

9.2.1.1 Procedure

Each joint and sealing-end sub-assembly, e.g. porcelain, and sub-assembly having welded joints, shall be tested hydraulically at ambient temperature for 15 min at twice the maximum static design pressure [see Clause 5)] (but see Note).

NOTE If the design pressure exceeds 800 kPa (8.0 bar) by agreement between the manufacturer and the purchaser, the test pressure may be lower than twice the maximum static design pressure but in no case should it be less than 1 600 kPa (16 bar).

9.2.1.2 Requirement

At the conclusion at the test no leakage shall have occurred.

9.2.2 Porcelain assemblies

9.2.2.1 Procedure

The completed insulator shall be sealed with blanking plates and subjected to the appropriate internal pressure specified in Table 6.

Table 6 — Internal test pressure

Maximum design static pressure bar ^a	Test pressure bar
0 to 5.25	12
5.25 to 15	34
^a 1 bar = 10 ⁵ N/m ² = 10 ⁵ Pa.	

9.2.2.2 Requirement

The insulator shall withstand the test pressure without leakage for a period of not less than 15 min.

9.3 Pressure/feed tanks

9.3.1 Hydraulic test

9.3.1.1 Procedure

A hydraulic pressure equal to 1.1 times the maximum static design pressure of the tank shall be applied at ambient temperature to all tanks. This shall be done before the outer protection is applied, if it is deemed that the outer protection is likely to disguise to existence of a leak.

9.3.1.2 Requirement

No leaks shall be visible after the pressure has been applied for 8 h.

9.3.2 Pressure/volume test

9.3.2.1 Procedure

The pressure/volume test shall be carried out as follows.

- The tank shall be pumped up to the initial pressure shown in Table 7.
- The pressure shall be reduced in two successive steps to the appropriate pressure indicated in Table 7, and the volume of fluid drawn off shall be measured at each step.
- The volume so measured shall be corrected to a base temperature of 15 °C by multiplying by the factor:

$$\frac{288}{273 + T_a}$$

where T_a is the measured ambient temperature at the time of the test, in degrees Celsius (°C).

- The total corrected and integrated volumes corresponding to each step shall be compared with the volume obtained from Table 7 by multiplying the appropriate volume factor given therein by the nominal size of the pressure tank in litres.

No allowance shall be made for the pre-pressure ratio because this has already been allowed for in the volume factors.

Table 7 — Pressure/volume characteristics

Pre-pressure ratio	Initial pressure bar (gauge)	Step 1		Step 2	
		Pressure bar (gauge)	Volume factor	Pressure bar (gauge)	Volume factor
1	3.0	2.0	0.0838	1.25	0.195
1.5	4.4	3.25	0.0757	2.25	0.185
2	5.25	4.0	0.0807	3.0	0.181
2.25	5.25	4.0	0.0907	3.0	0.204
2.5	5.25	4.0	0.1008	3.0	0.227
3	5.25	4.0	0.1210	3.0	0.272
4	9.5	8.0	0.0642	6.0	0.192
5	12	9.5	0.0926	7.0	0.243

9.3.2.2 Requirement

The difference between the measured volume [see 9.3.2.1b)] and the theoretical volume [see 9.3.2.1d)] shall in no case exceed +10 % or be less than 5 % of the latter.

9.4 DC voltage test on joint sleeves and bonding lugs

When tested in accordance with IEC 60229:1982, 3.1, there shall be no breakdown.

10 Sample tests on accessories

10.1 Procedure

Watertight fittings and accessories shall be either:

- immersed in water to a depth of not less than 1 m at the highest point of the enclosure; or
- subjected to an external pressure of 10 kPa (100 mbar) for a period of 1 h.

The water used for the test shall be tap water at (20 ± 10) °C.

10.2 Requirement

After the test the fittings and accessories shall show no signs of damage or leakage.