

BRITISH STANDARD

Electric cables – Armoured cables with thermosetting insulation for rated voltages from 3.8/6.6 kV to 19/33 kV having low emission of smoke and corrosive gases when affected by fire – Requirements and test methods

ICS 29.060.20



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Foreword

Publishing information

This British Standard is published by BSI and came into effect on 30 November 2007. 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 this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 7835:2000, which is withdrawn.

Information about this document

This revision of BS 7835 has been prepared to bring the requirements up to date in accordance with current practice in the industry and to align with the methods used for calculating cable component dimensions given in IEC 60502-2.

This standard specifies requirements for cables in the rated voltage range from 3.8/6.6 kV up to 19/33 kV which are insulated with cross-linked polyethylene (XLPE) or ethylene propylene rubber compound (EPR), with improved performance under fire conditions compared to the cables specified in BS 6622.

Hazard warnings

WARNING. This British Standard calls for the use of substances and/or procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Use of this document

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.

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.

Contractual and legal considerations

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

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard specifies requirements and test methods for the construction, dimensions and mechanical and electrical properties of armoured cables with thermosetting insulation for rated voltages from 3.8/6.6 (7.2) kV up to 19/33 (36) kV inclusive which, when assessed by the specified tests, produce lower levels of smoke and corrosive gases on exposure to fire compared to the cables specified in BS 6622. It covers cables designed for a maximum continuous conductor operating temperature of 90 °C and for a maximum short circuit conductor temperature of 250 °C, for use in fixed installations such as networks or industrial installations.

This British Standard specifies single-core and three-core cables for voltages in the range 3.8/6.6 (7.2) kV up to 19/33 (36) kV, with:

- a stranded copper, stranded aluminium or solid aluminium conductor or conductors;
- cross-linked polyethylene or cross-linked ethylene propylene rubber insulation;
- a metallic screening layer of copper wire or copper tape and/or a metallic armour of aluminium or galvanized steel wire;
- a thermoplastic oversheath.

NOTE Guidance on the selection of cables is given in Annex A. Information to be supplied by the purchaser, and items to be agreed between the purchaser and the manufacturer, at the time of enquiry and/or order, are given in Annex B. Recommendations for the installation of cables are given in Annex C. Guidance on the use of cables is given in Annex D.

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 5099, *Electric cables – Voltage levels for spark testing*

BS 7655-1.2, *Specification for insulating and sheathing materials for cables – Part 1: Cross-linked elastomeric insulating compounds – Section 1.2: General 90 °C application*

BS 7655-1.3, *Specification for insulating and sheathing materials for cables – Part 1: Cross-linked elastomeric insulating compounds – Section 1.3: XLPE*

BS 7655-6.1, *Specification for insulating and sheathing materials for cables – Part 6: Thermoplastic sheathing compounds having low emission of corrosive gases and suitable for use in cables having low emission of smoke when affected by fire – Section 6.1: General application thermoplastic types*

BS EN 10002-1, *Metallic materials – Tensile testing – Part 1: Method of test at ambient temperature*

BS EN 10244-2, *Steel wire and wire products – Non-ferrous metallic coatings on steel wire – Part 2: Zinc or zinc alloy coatings*

BS EN 50266-2-4:2001, *Common test methods for cables under fire conditions – Test for vertical flame spread of vertically mounted bunched wires or cables – Part 2-4: Procedures – Category C*

BS EN 50267-2-1, *Common test methods for cables under fire conditions – Tests on gases evolved during combustion of materials from cables – Part 2-1: Procedures – Determination of amount of halogen acid gas*

BS EN 50356, *Method for spark testing of cables*

BS EN 60228, *Conductors of insulated cables*

BS EN 60230, *Impulse tests on cables and their accessories*

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 60811-1-1, *Insulating and sheathing materials of electric and optical cables – Common test methods – Part 1-1: General application – Measurement of thickness and overall dimensions – Tests for determining the mechanical properties*

BS EN 60811-1-2, *Common test methods for insulating and sheathing materials of electric and optical cables – Part 1-2: General application – Thermal ageing methods*

BS EN 60811-1-3, *Insulating and sheathing materials of electric and optical cables – Common test methods – Part 1-3: General application – Methods for determining the density – Water absorption tests – Shrinkage test*

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

BS EN 61034-2, *Measurement of smoke density of cables burning under defined conditions – Part 2: Test procedure and requirements*

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 and the following apply.

3.1 rated voltage

reference voltage for which the cable is designed

NOTE This is expressed as a combination of the values U_0 , U and U_m .

3.2 rated voltage U_0

nominal power-frequency voltage between any conductor and earth or metallic screen for which the cable is suitable

3.3 rated voltage U

nominal power-frequency voltage between phase conductors for which the cable is suitable

3.4 maximum voltage U_m

maximum sustained power-frequency voltage between phase conductors for which the cable is suitable

3.5 cross-linked polyethylene (XLPE)

thermosetting material formed by the cross-linking of thermoplastic polyethylene compound

3.6 ethylene propylene rubber compound (EPR)

thermosetting material comprising a cross-linked compound in which the elastomer is ethylene-propylene

3.7 nominal value

value, often used in tables, by which a quantity is designated

NOTE In this standard, actual values to be checked by measurement, and on which tolerances are given, are usually specified in relation to particular nominal values.

3.8 approximate value

value which is only indicative

NOTE In this standard, values described as “approximate” do not constitute requirements to be checked by measurements.

3.9 fictitious value

value calculated in accordance with the “fictitious method” described in Annex E [IEC 60502-2:2005, 3.1.4]

NOTE The fictitious values referred to in the present standard are “fictitious diameters”.

3.10 routine tests

tests performed by the manufacturer on each manufactured length of cable to check whether the whole of each length meets the specified requirements

3.11 sample tests

tests performed by the manufacturer on samples of completed cable, or components taken from a completed cable, at a specified frequency, to determine whether the finished product meets the specified requirements

3.12 type tests

tests made before supplying a particular type of cable on a general commercial basis, to determine whether the cable has satisfactory performance characteristics to be suitable for the intended application

NOTE Type tests are of such a nature that, after they have been performed, they need not be repeated unless changes are made in the cable materials or design or manufacturing process which might change the performance characteristics.

4 Voltage designation

Cables shall be designated by the voltages U_0 , U and U_m expressed in the form U_0/U (U_m).

NOTE The voltage designations of cables specified in this standard are as follows:

- 3.8/6.6 (7.2) kV;
- 6.35/11 (12) kV;
- 8.7/15 (17.5) kV;
- 12.7/22 (24) kV;
- 19/33 (36) kV.

5 Non-metallic materials

In addition to the particular requirements specified for each material, all non-metallic materials shall meet the performance requirement for corrosive and acid gas specified in **20.2**.

6 Conductors

Conductors shall be either plain annealed copper or aluminium, circular, and shall conform to BS EN 60228. Copper conductors shall be stranded (class 2) and aluminium conductors shall be either solid (class 1) or stranded (class 2). Conductors shall be compacted or uncompacted and be between 70 mm² and 1 000 mm² for copper or aluminium stranded conductors (class 2) and 70 mm² to 300 mm² for solid aluminium conductors (class 1).

7 Conductor screen

A conductor screen consisting of an extruded layer of a cross-linkable semi-conducting compound shall be applied over the conductor and shall cover the surface of the conductor completely.

NOTE A semi-conducting tape may be applied prior to the extruded layer, at the discretion of the manufacturer.

The conductor screen shall be applied in the same operation as the insulation and shall be fully bonded to the insulation.

8 Insulation

The insulation shall be either XLPE (type GP 8) conforming to BS 7655-1.3 or EPR (type GP 7) conforming to BS 7655-1.2.

The insulation shall be applied by extrusion and cross-linked to form a compact and homogeneous layer.

NOTE The colour of the insulation should be such that it is easily distinguishable from the screening materials.

The nominal thickness of the insulation shall be as specified in Table 1.

Table 1 Nominal thickness of insulation

Nominal cross-sectional area of conductor mm ²	Nominal thickness of insulation for cables of rated voltage U_0/U (U_m)				
	3.8/6.6 (7.2) kV	6.35/11 (12) kV	8.7/15 (17.5) kV	12.7/22 (24) kV	19/33 (36) kV
	mm	mm	mm	mm	mm
70 to 185	2.5	3.4	4.5	5.5	8.0
240	2.6	3.4	4.5	5.5	8.0
300	2.8	3.4	4.5	5.5	8.0
400	3.0	3.4	4.5	5.5	8.0
≥500	3.2	3.4	4.5	5.5	8.0

9 Insulation screen

9.1 General

An insulation screen shall be applied to all cables and shall consist of a cross-linkable extruded semi-conducting layer as specified in **9.2**, in combination with a metallic layer (see **10.3** and **10.4** and Clause **11**). This screen shall be in contact with the metallic layer either directly or through a semi-conducting layer.

9.2 Extruded semi-conducting layer

The extruded semi-conducting layer shall consist of a bonded or cold strippable semi-conducting compound capable of removal for jointing and terminating (see **C.4** and Annex B). It shall be applied in the same operation as the insulation, and shall cover the surface of the insulation completely.

NOTE At the discretion of the manufacturer, a semi-conducting tape may be applied over the extruded semi-conducting layer as a bedding for the metallic layer.

10 Assembly of three-core cables, including inner coverings and fillers

10.1 General

Three-core cables shall be constructed with conductor sizes up to a maximum of 400 mm². Assembly of three-core cables shall be as specified in **10.2**, **10.3** or **10.4**, as applicable.

10.2 Inner coverings and fillers

The inner covering shall be extruded or lapped.

For cables with circular cores, if a lapped inner covering is to be used the interstices between the cores shall be filled.

NOTE 1 Before application of an extruded inner covering, a binder may be applied to the cores, at the manufacturer's discretion.

NOTE 2 The approximate thickness of an extruded inner covering should be as given in Table 2.

Table 2 **Thickness of extruded inner covering**

Fictitious diameter over laid-up cores, D_f *		Approximate thickness of extruded inner covering
Above mm	Up to and including mm	mm
—	25	1.0
25	35	1.2
35	45	1.4
45	60	1.6
60	80	1.8
80	—	2.0

* Calculated in accordance with Annex E.

NOTE 3 The approximate thickness of a lapped inner covering should be 0.6 mm.

10.3 Cables with a collective metallic layer

Cables with a collective metallic layer shall have an inner covering, and fillers if applicable, conforming to **10.2**, over the laid-up cores. The inner covering and fillers shall be of non-hygroscopic material, except if the cable is to be made longitudinally watertight.

The inner covering shall be semi-conducting.

NOTE The fillers may also be semi-conducting.

10.4 Cables with a metallic layer over each individual core

In cables with a metallic layer over each individual core, the metallic layers over the individual cores shall be in contact with each other.

Cables which have an additional collective metallic layer of the same material as the underlying individual metallic layers shall have an inner covering, and fillers, if applicable, conforming to **10.2**, over the laid-up cores. The inner covering and fillers shall be of non-hygroscopic material except if the cable is to be made longitudinally watertight.

NOTE 1 The inner covering and fillers may be semi-conducting.

For cables which have an additional collective metallic layer of a different material to the underlying individual metallic layers, the two shall be separated by an extruded sheath of a material conforming to **20.8** which is compatible with other materials in the cable construction in accordance with **20.14**.

NOTE 2 For cables without a collective metallic layer, the inner covering and fillers may be omitted provided the outer shape of the cable is still approximately circular.

11 Metallic layer

11.1 General

The metallic layer shall be applied around each core and/or as a collective screen. For cables with rated voltages above 8.7/15 (17.5) kV, a metallic insulation screen shall be applied around each core.

The metallic layer applied to a single-core cable or to the individual cores of a three-core cable shall be non-magnetic.

NOTE 1 Measures may be taken to achieve longitudinal watertightness in the region of the metallic layer, for example by the use of water swellable tapes.

NOTE 2 When choosing the material for the metallic layer, special consideration should be given to the possibility of corrosion, not only with regard to mechanical safety but also with regard to electrical safety.

If a copper wire screen is used, the d.c. resistance of the screen shall be as specified in **18.4**.

11.2 Metallic screen on each core

A metallic screen applied directly over the core of single-core cables or each core in three-core cables, shall consist of either metallic tape(s) or a concentric layer of metallic wires or a combination of wires and tapes.

The metallic wires shall be spaced with a mean gap width not greater than 4 mm. No gap shall exceed 8 mm.

11.3 Collective metallic screen

Three-core cables not having a metallic screen over each individual core shall have a collective screen of steel wire armour conforming to Clause **12** applied after the cores have been laid up together and over the lapped inner covering.

12 Metallic armour

12.1 Construction

12.1.1 General

The armour shall consist of round wires. The nominal diameter of the armour wires shall be as given in Table 3.

Table 3 Nominal diameter of round armour wires

Fictitious diameter under the armour, D_A *		Nominal diameter of armour wires
Above mm	Up to and including mm	mm
—	25	1.6
25	35	2.0
35	60	2.5
60	—	3.15

* See Annex E.

NOTE An open helix consisting of galvanized steel tape with an approximate thickness of 0.3 mm may be applied over the armour.

12.1.2 Material

The wires shall be of galvanized steel, aluminium or aluminium alloy.

NOTE In those cases where the purchaser specifies a minimum conductance for the steel wire armour layer (see Annex B) it is permissible to include sufficient copper or tinned copper wires in the armour layer to ensure conformity.

Armour of single-core cables for use on a.c. systems, unless provision of an armour layer with a special construction which requires the armour to be made of magnetic material has been specified by the purchaser at the time of enquiry and/or order (see Annex B), shall consist of non-magnetic material.

12.1.3 Application of armour

12.1.3.1 Single-core cables

In the case of single-core cables with no metallic layer under the armour, aluminium wire armour shall be applied over an extruded or lapped semi-conducting inner covering.

NOTE The approximate thickness of the inner covering should be in accordance with **10.2** Note 2 or Note 3, as applicable.

12.1.3.2 Three-core cables

In the case of three-core cables, galvanized steel wire armour shall be applied over the inner covering specified in Clause **10**.

12.2 Separation sheath

12.2.1 In cables with a metallic layer under the armour, if the underlying metallic layer and the armour are of different materials, unless measures have been taken to achieve longitudinal watertightness in the region of these metallic layers they shall be separated by an extruded separation sheath comprising material conforming to **20.8** which is compatible with other materials in the cable construction in accordance with **20.14**.

The nominal thickness of the separation sheath, t_s , expressed in millimetres, shall be calculated by the following formula:

$$t_s = 0.02D_u + 0.6$$

Where D_u is the fictitious diameter under the sheath, in millimetres, calculated as described in Annex E.

12.2.2 The nominal thickness of the separation sheath shall be not less than 1.2 mm.

13 Oversheath

13.1 General

Cables shall have an extruded oversheath which shall be of thermoplastic material conforming to BS 7655-6.1, Type LTS 1.

NOTE Oversheaths are normally black, but colours other than black may be provided by agreement between the manufacturer and the purchaser (see Annex B), subject to their suitability for the particular conditions under which the cables are to be used.

13.2 Thickness of oversheath

13.2.1 Unless otherwise specified by the purchaser at the time of enquiry or order (see Annex B) the nominal thickness of the oversheath, t_s , in millimetres (mm), shall be calculated by the following formula, and rounded to the nearest 0.1 mm in accordance with Annex F:

$$t_s = 0.035D + 1.0$$

where:

D is the fictitious diameter immediately under the oversheath, in millimetres (mm) (see Annex E).

13.2.2 For cables with the oversheath not applied directly over the armour, the nominal thickness of the oversheath shall be not less than 1.4 mm for single-core cables and not less than 1.8 mm for three-core cables.

13.2.3 For cables with the oversheath applied directly over the armour, the nominal thickness of the oversheath shall be not less than 1.8 mm.

13.3 Semi-conducting layer

If the purchaser specifies at the time of enquiry and/or order that a d.c. voltage test is to be performed on the oversheath (see A.5 and Annex B), a semi-conducting layer shall be applied over the surface of the oversheath.

14 Marking

14.1 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	
3.8/6.6 (7.2) kV	6 600 V
6.35/11 (12) kV	11 000 V
8.7/15 (17.5) kV	15 000 V
12.7/22 (24) kV	22 000 V
19/33 (36) kV	33 000 V
c) British Standard number ¹⁾	BS 7835
d) Manufacturer's identification	XYZ
e) The number of cores, and type and nominal cross-sectional area of conductors e.g.	
single-core cable with a 70 mm ² copper conductor	1 × 70
three-core cable with 70 mm ² aluminium conductors	3 × 70 AL

¹⁾ Marking BS 7835 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.

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 They may be on one of the primary lines or on 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 minimum height of 3 mm.

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

14.2 Identification of year of manufacture

A means of identifying the year of manufacture of the cable shall be provided throughout the length of the cable, either internally or by marking on the surface of the cable.

If the identification is internal, the distance between the end of one mark and the beginning of the next mark shall be not greater than 550 mm.

NOTE An identification thread may be used as an alternative to internal marking.

If the identification is by marking on the surface, the maximum distance between marks shall be 1 100 mm.

14.3 The mark of an approval organization

If the mark of an approval organization is used it shall be provided throughout the length of the cable, either as a mark on the surface of the cable, or as an identification thread, as specified by the approval organization.

If the mark is applied to the surface of the cable, it shall be in the form of the symbol(s) specified by the approval organization and the distance between the end of one mark and the beginning of the next shall be not greater than 1 100 mm.

14.4 Additional marking

Where additional marking is made, it shall be throughout the length of the cable, either on the external surface of the cable, or by means of a tape or thread within the cable, or by combination of these methods. If the additional marking is applied to the surface of the cable, it shall not render illegible the marking specified in **14.1**, **14.2** and **14.3**.

The additional marking, however made, shall be repeated at intervals not exceeding 1 100 mm.

15 End sealing

Before despatch, the manufacturer shall cap the ends of all cable in order to form a seal to prevent the ingress of water during transportation and storage.

16 Schedule of tests

Testing shall be performed in accordance with the schedule of tests given in Table 4.

NOTE 1 Tests listed in Table 4 as routine tests or sample tests may be required as part of a type approval scheme.

NOTE 2 Guidance on type testing is given in Annex G.

NOTE 3 Unless otherwise stated for particular tests, the tests need not be carried out in any particular sequence.

Table 4 **Schedule of tests**

Test	Test method and requirements given in clause
<i>Routine tests</i> (see 3.10)	
Spark test on oversheath	18.2
Conductor resistance	18.3
Copper wire screen resistance	18.4
Partial discharge test	18.5
Voltage test on complete cable	18.6
Cable markings	18.7
D.C. voltage test on oversheath ^{A)}	18.8
<i>Sample tests</i> (see 3.11)	
Conductor material and construction	19.4
Conductor screen application	19.5
Insulation, hot set test	19.6
Insulation, thickness	19.7.1
Insulation, concentricity	19.7.2
Circularity of cores	19.8
Insulation screen	
• application	19.9.1
• cold strippability	19.9.2
Metallic screen, application	19.10
Assembly of three-core cables	19.11
Separation sheath, thickness	19.12
Semi-conducting lapped inner covering, application	19.13
Measurement of armour wires	19.14
Oversheath thickness	19.15
Flame propagation on single cable	19.16
Smoke emission test	19.17
Four-hour voltage test	19.18
^{A)} If requested by the purchaser at the time of enquiry and/or order (see Annex B).	

Table 4 Schedule of tests (continued)

Test	Test method and requirements given in clause
Type tests (see 3.12)	
<u>Material tests</u>	
Corrosive and acid gas	20.2
Conductor screen resistivity	20.3
Insulation material	20.4
Insulation screen resistivity	20.5
Insulation screen cold strippability	20.6
Semi-conducting lapped inner covering resistivity	20.7
Separation sheath material	20.8
Armour	
• galvanized steel wires	• mass of zinc coating 20.9
	• wrapping test 20.10
	• wet compatibility test 20.11
• aluminium wires	• tensile test 20.12
Oversheath material	20.13
Compatibility test	20.14
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Test for shrinkage of oversheath on cable	20.18
<u>Electrical tests</u>	
Sequential tests (see 21.1)	
• partial discharge test	21.2
• bending test	21.3
• $\tan \delta$ in relation to voltage	21.4
• $\tan \delta$ in relation to temperature	21.5
• heating cycle test	21.6
• impulse voltage test	21.7
• four-hour voltage test	21.8
Adherence of screens at short circuit temperature	21.9
Insulation resistance constant of oversheath	21.10

17 Test conditions

17.1 Ambient temperature

Unless otherwise specified for a particular test, tests shall be performed at an ambient temperature within the range 5 °C to 35 °C.

17.2 Tolerances on temperature values

Unless otherwise specified for a particular test, the tolerances on the temperature values given in the test methods shall be as specified in Table 5.

Table 5 Tolerances on temperature values

Specified temperature, t °C	Tolerance °C
$-40 \leq t \leq 0$	± 2
$0 < t \leq 50$	As specified for the particular test
$50 < t \leq 150$	± 2
$t > 150$	± 3

17.3 Frequency and waveform of power-frequency test voltages

Unless otherwise specified for a particular test, alternating test voltages shall have a frequency between 49 Hz and 61 Hz. The waveform shall be substantially sinusoidal.

18 Routine tests

18.1 General

Routine tests shall be as specified in Table 4.

18.2 Spark test on oversheath

The oversheath shall be tested in accordance with BS EN 50356 with the voltages specified in BS 5099. No breakdown of the oversheath shall occur.

18.3 Conductor resistance

When measured, and corrected to 20 °C, in accordance with BS EN 60228, the d.c. resistance of each conductor shall be no greater than the relevant value specified in BS EN 60228.