



BSI Standards Publication

**Electric cables –
Thermosetting insulated,
armoured, fire-resistant
cables of rated
voltage 600/1 000 V for
fixed installations, having
low emission of smoke and
corrosive gases when
affected by fire –
Specification**

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Summary of pages

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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 30 November 2015. It was prepared by 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This British Standard supersedes BS 7846:2009, which will be withdrawn on 1 December 2016.

Information about this document

This is a full revision of the standard, and introduces the following principal changes.

- a) Interlocked tape armour has been removed as it no longer has market relevance.
- b) 48 core auxiliary cables have been removed as they are no longer market relevant.
- c) The marking requirements have been updated and clarified.
- d) The guide to use given in Annex A has been updated to reflect modern installation practice and the recommendations in BS 8519:2010.
- e) Test methods have been updated in accordance with the latest BS EN standards.

The new edition takes account of:

- BS EN 50363 (replacing certain parts of BS 7655) on materials;
- BS EN 50395 (replacing Annex K of BS 7846:2009) on electrical tests;
- BS EN 50396 (replacing Annex D of BS 7846:2009) on thickness measurement;
- BS EN 60332-1-2 (replacing BS EN 50265-2-1);
- BS EN 60332-3-24 (replacing BS EN 50266-2-4);
- BS EN 62230 (replacing BS EN 50356 and BS 5099) on spark testing.

Product certification/inspection/testing

Users of this British Standard are advised to consider the desirability of third-party certification/inspection/testing of product conformity to this British Standard. Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association.

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 the 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 for construction and performance of thermosetting insulated, armoured, fire-resistant cables of rated voltage 600/1 000 V having low emission of smoke and corrosive gases when affected by fire.

This British Standard is applicable to cables for use in fixed installations in industrial areas, buildings or similar applications, where maintenance of power supply during a fire is required for a defined period of time.

This British Standard specifies requirements for the following types of cables:

- a) wire armoured and oversheathed cables with two-, three-, four- or five-cores, and with stranded copper conductor;
- b) multicore auxiliary cables, wire armoured and oversheathed, with stranded copper conductor.

This British Standard specifies four categories of cables based on their performance in tests which assess separately resistance to fire, resistance to fire with water spray and resistance to fire with mechanical shock (Category F2) and which assess resistance to fire with direct mechanical impact and water jet in combination (Categories F30, F60 and F120).

This British Standard is applicable to cables that are designed for a maximum sustained conductor temperature of 90 °C and for a maximum short-circuit conductor temperature of 250 °C (for a maximum of 5 s).

NOTE 1 Limitation on the temperature of the cables might be imposed in situations where they may be touched or where they could touch other materials.

NOTE 2 Annex A gives the guide to use, Annex B gives armour wire tests, Annex C gives compatibility test, Annex D gives abrasion test, Annex E gives insulation resistance constant test on oversheath, Annex F gives resistance of conductor and armour, Annex G gives gross cross-sectional area of armour, Annex H gives a test for shrinkage of oversheath, Annex I gives the fire resistance test for category F2 – additional provisions for cables with a diameter over 20 mm, and Annex J gives notes on type tests.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 6387, *Test method for resistance to fire of cables required to maintain circuit integrity under fire conditions*

BS 7655-1.2, *Specification for insulating and sheathing materials for cables – Part 1: Cross-linked elastomeric insulating compounds – Section 2: General 90°C application*

BS 7655-1.3, *Specification for insulating and sheathing materials for cables – Part 1: Elastomeric insulating compounds – Section 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 1: General application thermoplastic types*

BS 7671, *Requirements for electrical installations – IET Wiring Regulations – Seventeenth edition*

BS 8491, *Method for assessment of fire integrity of large diameter power cables for use as components for smoke and heat control systems and certain other active fire safety systems*

BS EN 10244-2:2009, *Steel wire and wire products – Non-ferrous metallic coatings on steel wire – Part 2: Zinc or zinc alloy coatings*

BS EN 50363-5, *Insulating, sheathing and covering materials for low voltage energy cables – Part 5: Halogen-free, cross-linked insulating compounds*

BS EN 50395, *Electrical test methods for low voltage energy cables*

BS EN 50396, *Non electrical test methods for low voltage electric cables*

BS EN 60228, *Conductors of insulated cables*

BS EN 60229, *Electric cables – Tests on extruded oversheaths with a special protective function*

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

BS EN 60332-3-24:2009, *Tests on electric and optical fibre cables under fire conditions – Part 3: Test for vertical flame spread of vertically-mounted bunched wires or cables – Category C*

BS EN 60754-1, *Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content*

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 60811-501, *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 61034-2, *Measurement of smoke density of cables burning under defined conditions – Part 2: Test procedure and requirements*

BS EN 62230, *Electric cables – Spark-test method*

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 cable manufacturer

organization that has the capability to both produce and control the conformity of cable made to this British Standard

NOTE See 12.1a) for information on marking the cable with the cable manufacturer's name and identifier.

3.2 length of lay

axial length of one complete turn of the helix formed by one cable component

3.3 routine tests, R

tests made on all production cable lengths to demonstrate their integrity

3.4 sample tests, S

tests made on samples of completed cable, or components taken from a completed cable, adequate to verify that the product meets the design specifications

3.5 type tests, T

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

NOTE Type 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.

3.6 values**3.6.1 approximate value**

value which is only indicative

NOTE Values described as "approximate" do not constitute requirements to be checked by measurement.

3.6.2 nominal value

value by which a quantity is designated

NOTE Nominal values usually give rise to values to be checked by measurements taking into account specified tolerances.

3.7 voltages**3.7.1 maximum voltage, U_m**

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

3.7.2 rated voltage, U_0

nominal power-frequency voltage between conductor(s) and earth for which the cable is suitable

3.7.3 rated voltage, U

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

3.8 fire resistance

ability of a cable to maintain circuit integrity under fire for a stated period of time and under defined conditions

NOTE The designation 'fire resistant' given to a cable implies that it fulfils the requirements of the relevant fire resistance test.

4 Voltage designation and fire resistance categories

4.1 Voltage designation

The cables shall be designated by the rated voltages U_0 and U , expressed in the form U_0/U .

The rated voltage recognized for the purpose of this standard shall be 600/1 000 V.

NOTE 1 The maximum permitted operating voltages of the system are stated in Table 1.

Table 1 Maximum permitted voltages against rated voltage of cable

Rated voltage of cable U_0/U	Maximum permitted operating voltage of the system			
	a.c.		d.c.	
	Conductor-earth, U_0 max	Conductor-conductor, U_m	Conductor-earth	Conductor-conductor
V	V	V	V	V
600/1 000	700	1 200	900	1 800

In an alternating current system, the rated voltage of the cable shall be at least equal to the nominal voltage of the system for which it is intended.

NOTE 2 Guidance on the selection of cables of appropriate voltage designations for particular systems is given in A.4.

4.2 Fire resistance categories

Cables shall be designated by category according to their fire resistance characteristics as follows:

- Category F2.** Resistance to fire, resistance to fire with water, resistance to fire with mechanical shock, assessed separately, when tested in accordance with 17.6.2;
- Category F30.** Resistance to fire with direct mechanical impact and water jet assessed in combination, when tested in accordance with BS 8491 for 30 min;
- Category F60.** Resistance to fire with direct mechanical impact and water jet assessed in combination, when tested in accordance with BS 8491 for 60 min;
- Category F120.** Resistance to fire with direct mechanical impact and water jet assessed in combination, when tested in accordance with BS 8491 for 120 min.

All cables shall conform to the requirements for category F2.

For cables with 2 cores, 3 cores, 4 cores, 5 cores or 7 cores, with a measured overall diameter of 20 mm or greater, if the manufacturer wishes to claim additional fire resistance the cable shall conform to the requirements for category F30, F60 or F120, as applicable, as specified in 17.6.

If a cable conforms to the requirements for category F60 it shall be deemed to conform to the requirements for category F30 as the tests are identical except for the test durations.

If a cable conforms to the requirements for category F120 it shall be deemed to conform to the requirements for categories F30 and F60 as the tests are identical except for the test durations.

NOTE 1 The test in BS 8491 is only applicable to cables of measured overall diameter of 20 mm or greater.

NOTE 2 Attention is drawn to the fact that the ability of a given cable to meet a particular category in this standard refers only to the test conditions stated, and the level of performance achieved in a particular installation can be influenced by actual installation conditions.

5 Conductors

The conductors shall be annealed copper as given in Table 4 to Table 8, and shall conform to the requirements of BS EN 60228, Class 2.

6 Insulation

6.1 Type of insulation

The insulation shall be type GP 8 conforming to BS 7655-1.3, type GP 6 conforming to BS 7655-1.2, or type EI 5 conforming to BS EN 50363-5, except for the requirement for corrosive and acid gas emissions, which shall only be in accordance with 18.2, and shall apply to all types of insulation. The manufacturer shall declare which insulation type the insulation meets.

6.2 Application

The insulation shall be applied by an extrusion process and cross-linked. The insulation shall be applied either in a single layer, or in a number of layers. Each individual layer shall be compact and homogeneous.

Where more than one layer is used, the complete insulation shall be tested as though it were a single layer.

NOTE 1 The manufacturer should demonstrate that all insulated cores are, as a continuous and on-going part of the manufacturing process, subject to spark testing in accordance with BS EN 62230, using only a.c. or d.c. methods.

NOTE 2 Insulation applied in more than one layer does not conform to the definition of "double insulation" given, for instance, in BS 7671.

The manufacturer shall have the option to apply a tape or tapes under and/or over the insulation. These tapes shall not be considered as part of the insulation for the purposes of testing or measurement.

It shall be possible to remove the insulation without damage to the insulation itself or to the conductor. This shall be checked by visual examination.

6.3 Thickness of insulation

The mean value of the radial thickness of the insulation, when measured in accordance with BS EN 50396, 4.1, shall be not less than the relevant value given in Table 4 to Table 8. The smallest value measured, t_m , shall not fall below 90% of the relevant value given in Table 4 to Table 8 by more than 0.1 mm, i.e.:

$$t_m \geq 0.9t_n - 0.1$$

where:

t_m is the smallest value measured, in millimetres (mm); and

t_n is the radial thickness given in Table 4 to Table 8, in millimetres (mm).

The thickness of any tape(s) over either the conductor or the insulation shall not be included in the measurement of the thickness of the insulation.

7 Identification of cores

7.1 General

The cores of all cables shall be identified either by:

- a) colours; or
- b) numbers

7.2 Coloured cores

Unless otherwise agreed between the manufacturer and the purchaser, the colour coding shall be in accordance with the following standard sequence:

- a) Two-core: brown, blue;
- b) Three-core: brown, black, grey;
- c) Four-core: blue, brown, black, grey;
- d) Five-core: green-and-yellow, blue, brown, black, grey.

It shall be permitted to use other identification colours subject to agreement with the manufacturer, taking into account the core colour requirements specified in BS 7671 or other standards. Where other identification colours are used, the marking requirement as stated in 12.5 does not apply.

NOTE Attention is drawn to BS 7671, Appendix 7 where other core colours that are still required outside the EU are given.

The colour shall be applied:

- a) throughout the insulation;
- b) throughout the outermost layer of insulations that comprise more than one layer; or
- c) via a dedicated colouring layer.

Conformity shall be checked by visual examination.

7.3 Numbered cores

Numbers shall be marked sequentially starting with the number 1.

All cores that are numbered shall be of the same insulation colour.

Numbers on each core shall be printed in a colour contrasting with that of the insulation and shall be legible. Each number shall be repeated at intervals not greater than 70 mm.

Conformity shall be checked by visual examination and measurement.

7.4 Bi-colour combination

On the core marked with the bi-colour combination green-and-yellow, the distribution of the colours shall be such that for every 15 mm length of core, one of these colours shall cover not less than 30% and at most 70% of the surface of the core, while the other colour shall cover the remainder of the surface. Conformity shall be checked by measurement.

NOTE 1 In the case of shaped cores one colour may be applied as one or more stripes, provided that both colours remain readily visible.

NOTE 2 In cases of dispute, and where appropriate to the method of colour marking of the insulation, a suitable test for checking conformity is given in BS EN 50396, 5.2, for circular cores, and in BS 8573:2012, Annex F for shaped cores.

7.5 Clarity and durability

The colour or the number used for core identification shall be clearly identifiable and durable such that it cannot be removed when tested in accordance with BS EN 50396, 5.1.

8 Laying-up

The cores of cables having two, three, four or five cores shall be laid up with a uni-directional lay or right-hand-left-hand alternating direction of lay. Where standard colour coding of cores given in 7.2 has been used, the cores shall be laid up in the sequence given in 7.2.

Auxiliary cables having up to and including seven cores shall be laid-up with a uni-directional lay or with a right-and-left-hand direction of lay.

For multicore auxiliary cables of greater than seven cores, the direction of lay shall alternate for each successive layer.

Numbered cores shall be laid-up in number sequence.

Conformity shall be checked by visual examination.

The maximum length of lay for cores with circular conductors shall not exceed 65 times the diameter of the laid-up cores, and the maximum length of lay for cores with shaped conductors shall not exceed 80 times the diameter of the laid-up cores.

Conformity shall be checked by the test method given in 17.2.

It shall be permitted for the manufacturer to apply synthetic fillers or binder tapes.

It shall be possible to remove the fillers and/or tape(s), if any, from the cable without damaging the insulation of the cores.

Conformity shall be checked by visual examination.

9 Bedding

9.1 General

The bedding shall consist of an extruded layer of polymeric material consistent with the operating temperature of the cable. When tested in accordance with BS EN 60811-501 it shall have a tensile strength of not less than 4 N/mm² and elongation at break of not less than 50%. It shall be possible to remove the bedding without damaging the insulation of the cores. This shall be checked by visual examination.

9.2 Thickness of bedding

When measured in accordance with BS EN 50396, 4.2, the smallest value, t_m , of the radial thickness of the bedding shall not fall below 80% of the relevant nominal value given in Table 4 to Table 8, as applicable, by more than 0.2 mm, i.e.:

$$t_m \geq 0.8t_n - 0.2$$

where:

t_m is the smallest value measured, in millimetres (mm); and

t_n is the nominal thickness given in Table 4 to Table 8, in millimetres (mm).

10 Armour

10.1 General

The armour shall consist of a single layer of galvanized steel wires having nominal dimensions as given in Table 4 to Table 8, as appropriate. The armour shall be applied helically with a left-hand lay for cables having up to and including five cores. For multicore auxiliary cables the armour shall be applied helically with a direction of lay opposite to that of the final layer of cores, except when the cores of the cable have been laid-up with alternating right-and-left-hand lay in which case the armour shall be applied with either a right-hand or a left-hand lay.

The manufacturer shall have the option to apply a tape or tapes under and/or over the armour.

The maximum length of lay for the armour wires of nominal wire diameter up to and including 1.6 mm shall not exceed 20 times the diameter over the armour.

The maximum length of lay for the armour wires of nominal wire diameter 2.0 mm and greater shall not exceed 15 times the diameter over the armour.

Conformity shall be checked by the test method given in 17.3.

10.2 Armour wire

The armour wire shall conform to the following.

- When determined in accordance with B.1, the diameter shall fall within the minimum and maximum wire diameters given in Table 2.
- When determined in accordance with B.2, the mass of zinc coating shall be not less than the relevant value given in Table 2.
- When tested in accordance with B.3, none of the wires shall break.

Table 2 Diameter of armour wire and mass of zinc coating

Nominal wire diameter mm	Wire diameter		Minimum mass of zinc coating g/m ²
	Minimum mm	Maximum mm	
0.90	0.85	0.95	112
1.25	1.18	1.32	150
1.60	1.51	1.69	172
2.00	1.90	2.10	180
2.50	2.37	2.63	195
3.15	2.99	3.31	206

10.3 Joints

Joints in the armour shall be brazed or welded and any surface irregularity shall be removed carefully.

A joint in any armour wire shall be not less than 1 m from the nearest joint in any other armour wire in the complete cable.

10.4 Armour resistance

When measured and corrected to 20 °C in accordance with B.4, the d.c. resistance of the armour of the completed cable shall not exceed the relevant value given in Table F.1 or Table F.2, as applicable.

NOTE For the purposes of calculating maximum fault current, it is also necessary to know the gross cross-sectional area of armour wires. Such information is given in Annex G.

11 Oversheath

11.1 General

The oversheath shall be an extruded layer of Type LTS 1 conforming to BS 7655-6.1.

NOTE Oversheaths are normally black and, when properly formulated and compounded, this provides good resistance to deterioration from outdoor exposure to light. Oversheaths with colours other than black can be provided by agreement between the manufacturer and the purchaser but, unless such oversheaths also include additives to protect the cable from UV, the cables are not suitable for all exposure conditions.

11.2 Application

The oversheath shall be applied in a single layer over the armour.

Conformity shall be checked by visual examination.

11.3 Thickness of oversheath

When measured in accordance with BS EN 50396, 4.2, the smallest value, t_m , of the radial thickness of oversheath shall not fall below 80% of the relevant nominal value given in Table 4 to Table 8 by more than 0.2 mm, i.e.:

$$t_m \geq 0.80 t_n - 0.2$$

where:

t_m is the smallest value measured, in millimetres (mm); and

t_n is the nominal thickness given in Table 4 to Table 8, in millimetres (mm).

11.4 Spark testing of oversheath

When tested in accordance with the a.c or d.c test methods and the test voltages specified in BS EN 62230, there shall be no breakdown of the oversheath.

12 Cable marking and additional information

12.1 External marking

The external surface of all cables conforming to this British Standard shall be legibly marked with the following elements.

Element	Example of marking
a) Cable manufacturer	Manufacturer's name and their unique factory identifier