

LV and MV polymeric insulated cables for use by distribution and generation utilities —

**Part 6: Specification for 0.6/1 kV and
1.9/3.3 kV power cables with special fire
performance for use in power
stations —**

**Section 6.3: Cables with thermosetting
insulation and non-halogenated sheath**

(Implementation of HD 604)

ICS 29.060.20

Committees responsible for this British Standard

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- Association of Consulting Engineers
- British Approvals Service for Cables
- British Cables Association
- British Plastics Federation
- ERA Technology Ltd.
- Electricity Association
- London Underground Ltd.
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Foreword

BS 7870 was prepared by Subcommittee GEL/20/2. It implements the nationally applicable parts of Harmonisation Documents HD 603, 604, 605, 620, 622, 626 and 627, published by the European Committee for Electrotechnical Standardization (CENELEC), in accordance with the decision of the CENELEC Technical Board.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**. Tags indicating changes to text carry the number of the amendment. For example, text altered by amendment No. 1 is indicated by **A1** **A1**.

BS 7870 applies to cables for fixed installations having a rated voltage U_o/U up to and including 1.9/3.3 kV, and is published as a series of separate parts and sections, as listed in the table in the foreword of Part 1.

This section of BS 7870 is to be read in conjunction with BS 7870-1 and BS 7870-2.

This section of BS 7870 implements Part 5E of HD 604 and HD 604 A1. The cable types included in this section are listed below:

- a) 2-, 3-, 4- and 5-core cables having copper conductor and steel wire armour;
- b) 2-, 3- and 4-core cables having solid aluminium conductors and aluminium wire armour;
- c) single-core cables having stranded copper, stranded aluminium, solid or sectoral aluminium conductors and aluminium wire armour;
- d) multicore auxiliary cables having stranded copper conductors and steel wire armour.

A "Guide to use" for the above cables is given in Annex A.

Annex A is informative.

Amendment No. 1:2004 implements the changes to the identification of cores by colours, in accordance with HD 308 S2. The principal identification colours are now:

- Single phase — Green-and-yellow (Earth); blue (Neutral); brown (Live).
- Three phase — Green-and-yellow (Earth); blue (Neutral); brown, black, grey (Live).

Users should ensure that any interconnection between cables with these new colours and those with the pre-existing ones is carried out safely. BS 7671, as amended in parallel with this standard, gives some guidance in this respect, but does not cover all installation conditions or cable uses.

The provisions introduced by amendment No. 1:2004 are effective from 1st April 2004. The original version of this standard remains current until 31st March 2006.

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.

WARNING. This British Standard calls for the use of substances and/or procedures that may 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.

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 iv, pages 1 to 39 and a back cover.

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1 Scope

This section of BS 7870 specifies requirements and dimensions of single- and multicore cables with thermosetting insulation and non-halogenated sheath having reduced fire propagation performance and having low emission of smoke when affected by fire.

The cables are designed for a maximum continuous conductor operating temperature of 90 °C and for a maximum short circuit temperature of 250 °C.

Two types of cable are covered by this section of BS 7870: Type 1 and Type 2. The basis for the two types is as follows.

Type 1: cable intended to satisfy the installation and operating conditions prevailing in a fossil-fuelled power station or equivalent location.

Type 2: cable intended to satisfy the installation and operating conditions prevailing in a PWR power station, but excluding locations in or around the containment area.

NOTE 1 The cable type should be selected which is appropriate to the application.

NOTE 2 The general construction requirements are the same for both types. However, Type 2 cables have the option of dual-layer oversheaths and, for some types, of employing TI Z insulation with associated increase in thickness of insulation, bedding and oversheath.

NOTE 3 The more onerous type testing of Type 2 cables acknowledges the limited size range and voltage of cables currently used in certain PWR projects.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

[A1] *Text deleted* **[A1]**

BS 6360, *Specification for conductors in insulated cables and cords*.

[A1] *Text deleted* **[A1]**

BS 7870-1:1996, *LV and MV polymeric insulated cables for use by distribution and generation utilities — Part 1: General*.

BS 7870-2:1999, *LV and MV polymeric insulated cables for use by distribution and generation utilities — Part 2: Methods of test*.

[A1] BS EN 50265-2-1:1999, *Common test methods for cables under fire conditions — Test for resistance to vertical flame propagation for a single insulated conductor or cable — Part 2-1: Procedures — 1 kW pre-mixed flame*.

BS EN 50268-2, *Common test methods for cables under fire conditions — Measurement of smoke density of cables burning under defined conditions — Part 2: Procedure*. **[A1]**

BS EN 60811-1.2, *Insulation and sheathing materials of electric cables — Part 1: Methods for test for general applications — Section 1.2: Thermal ageing methods*.

BS ISO 4589-2, *Plastics — Determination of burning behaviour by oxygen index — Part 2: Ambient temperature test*.

3 Voltage designation

Cables are designated by the voltage U_0 , U and U_m expressed in the form $U_0/U (U_m)$.

The voltage designations of cables in this standard are:

- 0.6/1 (1.2) kV;
- 1.9/3.3 (3.6) kV.

4 General requirements

4.1 Identification of cores

The cores of all cables shall be identified either by numbers or by colours in accordance with the following sequence:

 <i>Number of cores</i>	<i>Identification</i>
One	Brown or blue
Two	Brown, blue
Three	Brown, black, grey
Four	Blue, brown, black, grey
Five	Green-and-yellow, blue, brown, black, grey
Auxiliary cables	1, 2, 3, 4, 5, 6, 7 and upwards 

The height of individual numbers shall be not less than 1.5 mm and the interval between adjacent numbers shall not exceed 70 mm.

 NOTE The core colour blue now denotes the neutral conductor. 

4.2 Thickness of bedding

The minimum thickness of extruded bedding shall be not less than the specified value for each type and size of cable shown in the tables by an amount more than 20 % + 0.2 mm. Conformity shall be checked by the test given in BS 7870-2, 2.1.2.

4.3 Cable marking

The method of cable marking shall conform to the following requirements.

4.3.1 External marking

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

<i>Element</i>	<i>Example of marking</i>
a) Electric Cable	ELECTRIC CABLE
b) Voltage designation	600/1 000 V 600/1 000 V AUX 1 900/3 300V
c) Standard number	BS 7870-6.3 Type 1 (or Type 2)
d) Manufacturer's identification	XYZ
e) Number of cores, type and nominal area of conductor, e.g.	
1) Copper conductor cables: 4 × 50	
(4 × 50 indicates a 4-core cable with 50 mm ² copper conductors).	
2) Aluminium conductor cables: 4 × 50 AL	
(4 × 50 AL indicates a 4-core cable with 50 mm ² aluminium conductors).	
3) Copper conductor cables with reduced neutral: 3 × 50/25	
(3 × 50/25 indicates a 4-core cable with three 50 mm ² copper phase conductors and one 25mm ² copper neutral conductor).	

The marking of items a) to d) shall be by embossing or indenting on the oversheath or by other durable means agreed with the purchaser.

For cables with tabulated approximate overall diameters above 15 mm, items a), b) and c) shall appear, in any sequence that neither confuses nor conflicts, on two or more primary lines along the axis of the cable, approximately equally spaced around the circumference of the cable. Items d) and e) shall appear on at least one line, which may be one of the primary lines, or a secondary line or lines. They may appear in any sequence that neither confuses nor conflicts, and need not all be on the same line.

For cables with tabulated approximate overall diameters of 15 mm or smaller, the items shall be disposed as for cables above 15 mm except that the marking for items a), b) and c) shall appear on one or more primary lines.

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 of marking 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).

Conformity shall be checked by visual examination and measurement.

4.3.2 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. As an alternative internal marking, an identification thread may be used.

If the identification is by marking on the surface it shall conform to the requirements given for items d) and e) in 4.3.1 in respect of maximum distance between marks.

4.3.3 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.

If the mark is applied to the cable it shall be on the surface in the form of the symbol(s) specified by the approval organization, and shall conform to the requirements given for items d) and e) in 4.3.1 in respect of maximum distance between marks.

As an alternative to the mark of the approval organization, an identification thread may be incorporated into the cable, as specified by the approval organization.

4.3.4 Optional marking

The use of optional marking is permitted. Where such marking is made it shall be throughout the length of the cable, and may be on the external surface of the cable, or by means of a tape or thread within the cable, or by a 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 4.3.1, 4.3.2 and 4.3.3.

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

4.4 Additional routine tests

4.4.1 Voltage testing (Type 1 and Type 2)

Cables shall not fail during the application of the following voltages for 5 min when tested in accordance with BS 7870-2, 3.2.1.

Cable type	Rated Voltage (<i>U</i>) kV	Test voltage kV r.m.s.
Single-core	1.0	3.5
	3.3	7
Multicore	1.0	3.5
	3.3	11.25/6.5 ^a
^a Voltage applied between conductors and from conductors to earth respectively.		

4.4.2 Test on oversheath of single-core cables (Type 1 and Type 2)

If a single-core cable is provided with a semi-conducting coating applied, it shall be subjected to an applied voltage of 3 kV a.c. or 5 kV d.c. for 1 min, in accordance with BS 7870-2, 3.2.3.1 and the oversheath shall not break down.

4.4.3 Insulation resistance

4.4.3.1 Type 1 (on HEPR core)

When a sample of insulated core is tested in accordance with BS 7870-2, 3.3.1 the K value at 90 °C shall be not less than 3.67 MΩ·km.

4.4.3.2 Type 2

When tested in accordance with BS 7870-2, 3.3.2 the measured insulation resistance shall be not less than the following values for 1 km at 20 °C.

Nominal cross-sectional area of conductor mm ²	Insulation Resistance MΩ·km	
	600/1 000 V	1 900/3 300 V
1.5	10	—
2.5	9	—
4	8	—
6	7	—
10	7	—
16	6	—
25	5	—
35	5	—
50	5	—
70	5	—
95 and above	5	5

4.4.4 Spark test on oversheath (Type 1 and Type 2)

The sheath shall meet the requirements of BS 7870-2, 3.6.1.

4.5 Additional sample tests

4.5.1 Thickness measurement (Type 1 and Type 2)

Measurements of the thickness of insulation, extruded inner sheath and oversheath shall be taken in accordance with the schedule of test requirements (Table 3) on a sample taken from one end of each drum length of cable selected for the test, having discarded any portion which may have suffered damage.

If any of the thicknesses measured does not conform to 6.3.2, 6.3.4 and 6.3.6, then two further samples shall be checked for the non-conforming items. If both samples meet the specified requirements, the cable is deemed to conform. If either does not meet the requirements, the cable is deemed not to conform.

4.5.2 Flame propagation test on a single cable (Type 1 and Type 2)

 Cables shall be tested in accordance with BS EN 50265-2-1. The test shall be carried out on a sample of completed cable. After the test, the cable shall conform to the performance recommendations given in BS EN 50265-2-1:1999, Annex A. 

4.6 Additional type tests

4.6.1 Sample selection (Type 1)

For the compatibility test, abrasion test and oversheath resistance test select a cable having a tabulated diameter not exceeding 15 mm, and also a cable having a tabulated diameter between 26 mm and 40 mm.

The cable tested may have copper or aluminium conductors and steel or aluminium wire armour, and satisfactory performance will be acceptable to cover other conductor and armour materials. Similarly, the cable tested may be rated at either 0.6/1 kV or 1.9/3.3 kV. However, a test will only be accepted as covering the particular insulating material (XLPE or HEPR) used in the sample.

4.6.2 Sample selection (Type 2)

The following samples shall be tested.

For 1-core 1.9/3.3 kV	— test a $1 \times 300 \text{ mm}^2$	1.9/3.3 kV (or 0.6/1 kV as if it were a 1.9/3.3 kV cable)
For 3-core 1.9/3.3 kV	— test a $3 \times 120 \text{ mm}^2$	1.9/3.3 kV (or 0.6/1 kV as if it were a 1.9/3.3 kV cable)
For 1-core 0.6/1 kV	— test a $1 \times 400 \text{ mm}^2$	0.6/1 kV
For multicore 0.6/1 kV	— test a $2 \times 2.5 \text{ mm}^2$	0.6/1 kV
	— test a $2 \times 35 \text{ mm}^2$	0.6/1 kV
	— test a $4 \times 120 \text{ mm}^2$	0.6/1 kV

4.6.3 Compatibility test (Type 1 and Type 2)

When tested in accordance with BS 7870-2, 2.4.12.2, the sample being aged for seven days at $100 \pm 2 \text{ }^\circ\text{C}$, the values shall conform to Table 26.

4.6.4 Abrasion test

Type 1

When a sample of completed cable is tested in accordance with BS 7870-2, 2.4.5 the oversheath shall be deemed as satisfactory if, following the test, examination of the sample without magnification reveals no cracks or splits in the internal or external surfaces.

Type 2

When a sample of completed cable is tested in accordance with BS 7870-2, 2.4.5 the oversheath shall be deemed as satisfactory if, following the test, examination of the sample without magnification reveals no cracks or splits in the internal or external surfaces and when tested in accordance with 4.4.2 the cable shall not fail.

4.6.5 Oversheath resistance test (Type 1 and Type 2)

This shall be measured between the armour and the water as in BS 7870-2, 3.3.4, except that the nominal voltage shall be not less than 500 V d.c.

The measured oversheath resistance, when corrected to $20 \text{ }^\circ\text{C}$ and to 1 kilometre length of cable, shall be not less than 1 M Ω .

4.6.6 Impulse test (Type 2)

When tested in accordance with BS 7870-2, 3.2.4.1, no breakdown of the insulation shall occur when the sample is subjected to 10 positive and 10 negative pulses at the appropriate level set out in the table below. The test shall be applied with the cable at ambient temperature and for 3-core cables the 3 cores shall be tested in sequence.

Rated voltage of cable (U) kV	Impulse voltage kV
3.3	40

4.6.7 Special type tests on complete cable (Type 2)

The tests given in Table 1a) shall be undertaken either on a sample taken from the cable or on a sample of complete cable, as appropriate.

When shown in Table 1a), tests shall be undertaken on aged and unaged samples. Ageing shall be in accordance with BS 7870-2, 5.1.1.

Test requirements are given in Table 1A.

4.7 Additional fire performance tests

4.7.1 Sample selection (Type 1)

For the fire propagation tests, oxygen index test and smoke emission test select a cable having a tabulated diameter not exceeding 15 mm, and also a cable having a tabulated diameter between 26 mm and 40 mm with a conductor size greater than 25 mm².

The cable tested may have copper or aluminium conductors and steel or aluminium wire armour, and satisfactory performance will be acceptable to cover other conductor and armour materials. Similarly, the cable tested may be rated at either 0.6/1 kV or 1.9/3.3 kV. However, a test will only be accepted as covering the particular insulating material (XLPE or HEPR) used in the sample.

For the corrosive and acid gas test, select a sufficient number of samples to ensure that each material type to be used has been tested.

4.7.2 Sample selection (Type 2)

One each of the following samples shall be selected for fire performance tests:

- a) 4 × 120 mm² cable size;
- b) 2 × 2.5 mm² cable size.

For the corrosive and acid gas test, select a sufficient number of samples to ensure that each material type to be used has been tested.

4.7.3 Flame propagation test on bunched cable (Type 1 and Type 2)

The cable shall be subjected to the test specified in BS 7870-2, 4.1.4 using the cable arrangement for category 2 for sizes greater than 25 mm² and that for category 3 for sizes less than or equal to 25 mm².

The test shall be considered satisfactory if, after burning has ceased, or the flames have been extinguished:

- a) penetration to the conductor has been achieved on one third or more of the total number of cables; and
- b) when the cables have been wiped clean, the charred portion has not reached a height exceeding 2.5 m above the bottom edge of the burner, measured at the front and rear and, where applicable, between the cable assembly.

4.7.4 Oxygen index test (Type 1 and Type 2)

During the fire performance tests, the absolute oxygen index of samples of insulation, bedding and oversheath, taken from the complete cable, shall be determined using the test method given in BS ISO 4589-2. The values obtained shall be used to enable a nominal value, together with suitable tolerances for sample tests, to be agreed between the manufacturer and the purchaser.

For sample tests, the oxygen index of the insulation, bedding and oversheath shall be determined using the test method given in BS ISO 4589-2. The values obtained shall fall within the agreed tolerances on the nominal value.

Where the oxygen index of the insulation obtained during the fire performance type tests is less than a value of 21, there is no need to check the value during sample tests.

4.7.5 Smoke emission test

Type 1 and Type 2 (Sample test)

When tested in accordance with **BS EN 50268-2**, the minimum level of light transmittance throughout the test shall be greater than 70 %.

Type 2 (Type test)

When tested in accordance with BS 7870-2, 4.2.2, the test shall be considered satisfactory if A_o (OFF) does not exceed a value of 10.

4.7.6 Corrosive and acid gas emission test

Type 1 and Type 2 (Sample test)

When tested in accordance with BS 6425-1, the level of HCl in the material under test shall not be greater than 0.5 %.

Type 2 (Type test)

When tested in accordance with BS 7870-2, 4.3.1, the average pH, conductivity and chloride yield shall be:

- 3.8 < pH < 10;
- conductivity < 80 $\mu\text{S}/\text{cm}$;
- chloride yield < 0.5 mg/g.

5 Cables without metallic covering

Not applicable.

6 Cables with metallic covering

6.1 Code designation

(Under consideration by CENELEC TC 20).

6.2 Rated voltage

The rated voltages shall be 0.6/1.0 kV and 1.9/3.3 kV.

6.3 Construction

6.3.1 Conductor

The conductors shall be of the material and type detailed in Table 4 to Table 17 and shall conform to the requirements of BS 6360:

- Class 1 for solid conductors;
- Class 2 for stranded conductors.

Circular sectoral conductors are formed from four 90° segments without any insulation between them. These shall conform to the material requirements of BS 6360 and the resistance requirements of Table 19.

6.3.2 Insulation

The insulation shall be either cross-linked polyethylene (XLPE) or hard ethylene propylene rubber (HEPR) conforming to the requirements in Table 1.

Alternatively, for 0.6/1 kV Type 2 cables having 2 to 4 cores with copper conductors (Tables 6b), 8b) and 10b), the insulation shall be either a single extruded layer of thermosetting TI Z material conforming to the requirements of Table 1, or two bonded layers of extruded thermosetting material conforming, as a composite, to the requirements of TI Z given in Table 1.

The corrosive and acid gas emission of the insulation shall meet the requirements in 4.7.6.

The insulation thickness shall conform to the value specified in Table 4 to Table 17.

6.3.3 Assembly of cores

The cores of cables having two, three, four or five cores shall be laid-up with a right-hand or right- and left-hand alternating direction of lay. For multicore auxiliary cables the direction of lay shall alternate for each successive layer. Auxiliary cables having up to and including seven cores may be laid-up with a right-hand or left-hand or with a right- and left-hand alternating direction of lay. Where necessary, synthetic fillers, which may be applied integrally with the bedding, shall be used to form a compact and reasonably circular cable.

The corrosive and acid gas emission of fillers and binder tape shall meet the requirements in 4.7.6.

6.3.4 Bedding

The bedding shall consist of an extruded layer of synthetic material compatible with the operating temperature of the cable and shall conform to the requirements in Table 2 as follows:

ZB 1 compound for Type 1 cable;

ZB 2 compound for Type 2 cable.

The corrosive and acid gas emission of the bedding shall meet the requirements in 4.7.6.

The bedding thickness shall conform to the values specified in Table 4 to Table 17.

6.3.5 Armour

The armour shall consist of a single layer of wires having nominal dimensions as given in Table 4 to Table 17, as appropriate.

For single-core cables, the armour shall consist of aluminium wires.

For multicore cables with copper conductors, the armour shall consist of a layer of galvanized steel wires.

For multicore cables with solid aluminium conductors, the armour shall consist of a layer of aluminium wires.

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 that for cables which have been laid-up with alternating right- and left-hand lay the armour may be applied with either a right-hand or a left-hand lay.

Wire armour shall conform to the following as appropriate.

- a) The diameter of round armour wire shall fall within the minimum and maximum wire diameters specified in Table 18 when measured in accordance with BS 7870-2, 2.1.4.3.
- b) The mass of zinc coating of galvanized steel armour wire shall be not less than that given in Table 18 when measured in accordance with BS 7870-2, 2.5.1.1.
- c) The steel wire shall be subjected to the wrapping test specified in BS 7870-2, 2.3.2 and shall not break.
- d) The tensile strength of aluminium armour wires shall be not less than 125 N/mm² when measured in accordance with BS 7870-2, 2.3.1.1.
- e) The d.c. resistance of the armour of the complete cable measured and corrected to 20 °C shall not exceed the appropriate value given in Table 19, Table 20, Table 21 and Table 22 when measured in accordance with BS 7870-2, 3.1.2.

Joints in steel armour wire shall be brazed or welded and any surface irregularity shall be removed.

Joints in aluminium wires shall be made by cold pressure or fusion welding and all surface irregularities shall be removed.

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

Tapes may be applied under or over the armour wire but, if used, their corrosive and acid gas emission shall meet the requirements in 4.7.6.

6.3.6 Oversheath

The oversheath for Type 1 cables shall consist of an extruded layer of black compound conforming to the requirements of ZM1 given in Table 2.

The oversheath for Type 2 cables shall consist of either an extruded layer of black compound conforming to the requirements of ZM2 in Table 2, or a dual-extruded layer of compounds, one of which conforms to the requirements of ZM2 in Table 2. In the case of a dual-layer oversheath, the minimum thickness of each layer shall be not less than 0.8 mm nominal. The outer layer shall be black.

The corrosive and acid gas emission of the oversheath shall meet the requirements in 4.7.6.

The oversheath for single-core cables may have a suitable semi-conducting coating to enable the resistance of the oversheath to be determined after the cable has been installed. The coating shall be capable of withstanding the rigours of installation and shall adhere to the surface of the oversheath when the cable is operating at maximum conductor temperature.

The oversheath thickness shall conform to the specified value in Table 4 to Table 17.