

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 6.1: PVC insulated and PVC
sheathed cables**

(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.
- UK Steel Association

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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 is indicated by **A1** **A1**.

BS 7870 applies to cables for fixed installations having a rated voltage U_0/U up to and including 19/33 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 3E of HD 604 and HD 604 A1. The cable types included in this section are listed below:

- a) 3- and 4-core cables having copper conductor and steel wire armour;
- b) 3- and 4-core cables having solid aluminium conductors and aluminium wire or strip armour;
- c) single-core cables having stranded copper or stranded aluminium conductor and aluminium wire armour;
- d) single-core cables having solid or sectoral aluminium conductors and aluminium wire or strip armour;
- e) multicore auxiliary cables having from 2 up to 48 cores with copper conductors and steel wire armour.

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

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.

Annex A is informative.

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 33 an inside back cover and a back cover.

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1 Scope

This section of BS 7870 specifies requirements and dimensions of single and multicore PVC insulated and sheathed cables having reduced fire propagation performance.

The cables are designed for a maximum continuous operating temperature of 70 °C and for a maximum short-circuit temperature of 160 °C for conductor sizes up to and including 300 mm² and 140 °C for larger conductor sizes.

2 References

2.1 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.*

BS 7870, *Specification for LV and MV polymeric insulated cables for use by distribution and generation utilities.*

[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.* **[A1]**

BS EN 60811-1-2, *Insulation and sheathing materials of electric cables — Part 1: Methods for test for general applications — Section 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 voltages 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>
[A1] 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 [A1]

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

[A1] NOTE The core colour blue now denotes the neutral conductor. **[A1]**

4.2 Thickness of bedding

The minimum thickness of extruded bedding shall not be less than the specified value for each type and size of cable shown in Table 3 to Table 14 by an amount more than 20 % + 0.2 mm. Compliance shall be checked by the test given in BS 7870-2, 2.1.2.

NOTE The thickness of lapped beddings need not be checked by measurement.

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 1 900/3 300 V
c) Standard number	BS 7870-6.1
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 25 mm ² copper neutral conductor).	

The marking of the items a) to d) shall be by embossing or indenting on the oversheath.

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 test requirements

4.4.1 Sampling for thickness measurement

Make the measurements of thickness of insulation, extruded bedding and oversheath listed in the schedule of test requirements (Table 2) 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 of this section, 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, but if either does not meet the requirements, the cable is deemed not to conform.

4.4.2 Voltage test

4.4.2.1 Test on oversheath of single-core cables

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

4.4.2.2 Test on complete cable

When the voltage test is carried out in accordance with BS 7870-2, 3.2.1, using the test voltage below for a duration of 5 min, the insulation shall not break down.

Cable type	Rated voltage (U) kV	Test voltage kV (r.m.s.)
Single-core	1.0	3.5
	3.3	7.0
Multicore	1.0	3.5
	3.3	11.25/6.5 ^a

^a Voltage applied between conductors and from conductors to earth, respectively.

4.4.3 Insulation resistance

When a sample of insulated core is tested in accordance with BS 7870-2, 3.3.1 the *K* value at 70 °C shall be not less than 0.037 MΩ·km.

When a complete cable is tested in accordance with BS 7870-2, 3.3.2 the measured insulation resistance shall be not less than the values given in Table 26.

4.4.4 Approval for tests related to fire conditions

4.4.4.1 Range of approval for single-core cables

Type approval for the complete range of single-core cables specified for this type or limited range of sizes is obtained by the successful completion of the tests given in BS 7870-2, 4.1.1 on one cable size.

The cable size selected for test from the range for which approval is sought shall be that which has the greatest ratio of sectional area, in mm², of non-metallic material to that of all the metallic components. Tests carried out on cables having aluminium conductors will also cover cables having copper conductors but tests on cables with copper conductors will not be valid for cables having aluminium conductors. Tests carried out on aluminium strip armour will also be valid for wire armour and tests on wire armour will also be valid for aluminium strip armour.

4.4.4.2 Range of approval for multicore cables

Type approval for the complete range of multicore cables specified for this type is obtained by carrying out the tests given in BS 7870-2, 4.1.1 on a cable having copper conductors not exceeding 16 mm² and also on a cable having aluminium conductors of 35 mm² or larger.

Limited approval of 16 mm² and below can be obtained by carrying out the tests in BS 7870-2, 4.1.1 on a cable having copper conductors not exceeding 16 mm². Limited approval for cables greater than 16 mm² can be obtained by carrying out the tests in BS 7870-2, 4.1.1 on a cable having aluminium conductors of 35 mm² or larger.

The cable sizes selected for test shall be those which have the greatest ratio of sectional area in mm² of non-metallic material to that of all the metallic components. Tests carried out on aluminium strip armour will also be valid for aluminium wire armour. Tests carried out on aluminium wire armour will also be valid for aluminium strip armour.

4.4.4.3 Test requirements

The test shall be considered satisfactory if, after burning has ceased, or the flames extinguished in accordance with BS 7870-2, 4.1.1:

- a) penetration to the conductor has been achieved on all the front row 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 upper burner, measured at the front, rear and where applicable between the cable assembly. Inspection shall be made of the internal surfaces of closely packed cable installations to ensure that the damage does not exceed the limits specified.

4.4.4.4 Oxygen index test

During type 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 manufacturer and purchaser.

For sample tests the value of 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 tolerance on the nominal value.

4.5 Compatibility test

When tested in accordance with BS 7870-2, 2.4.12.2, but using a temperature of $(80 \pm 2)^\circ\text{C}$, the material shall conform to Table 27.

4.6 Oversheath resistance test

The oversheath resistance measurement shall be made between the armour and the water in accordance with BS 7870-2:1999, 3.3.4, except that the test voltage shall be 500 V d.c.

The measured oversheath resistance, when corrected to 70 °C and to a 1 km length of cable, shall be not less than 1 MΩ.

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 either 0.6/1 kV or 1.9/3.3 kV.

6.3 Construction

6.3.1 Conductor

The conductors shall be of the material and type detailed in Table 3 to Table 14 and shall conform to the requirements of BS 6360:

Class 1 for solid conductors;

Class 2 for stranded conductors.

Circular sectoral conductors shall be 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 17 and Table 18.

6.3.2 Insulation

The insulation shall be polyvinyl chloride compound type TI 1 conforming to the non-electrical requirements given in Table 1 and the insulation resistance requirements given in 4.4.3.

The insulation thickness shall conform to the values specified in Table 3 to Table 14. However, the thickness at any one place may be less than the specified value provided that the difference does not exceed 0.1 mm + 10 % of the specified value.

6.3.3 Assembly of cores

The cores of cables having two, three or four cores shall be laid-up with a right-hand or a right and left-hand alternating direction of lay. For multicore auxiliary control cables the direction of lay shall alternate for each successive layer.

For auxiliary control cables having up to and including seven cores, it is permissible for cores to be laid-up with a right-hand or left-hand or with a right and left-hand alternating direction of lay.

6.3.4 Bedding

6.3.4.1 Single-core cables

The bedding shall consist of an extruded layer of polymeric compound type TB 1 conforming to the requirements in Table 1.

The thickness shall conform to the values specified in Table 3, Table 4 and Table 11. However, the thickness at any one place may be less than the specified value provided that the difference does not exceed 0.2 mm + 20 % of the specified value.

6.3.4.2 Multicore cables

Unless otherwise specified the bedding shall consist of an extruded layer of polymeric compound type TB 1 conforming to the requirements in Table 1.

For extruded beddings the thickness shall conform to the values specified in Table 5 to Table 14. However, the thickness at any one place may be less than the specified value provided that the difference does not exceed 0.2 mm + 20 % of the specified value.

It is permissible for 0.6/1 kV cables having a nominal conductor cross-sectional area of 16 mm² and above to have lapped bedding as indicated in Table 5 to Table 10 comprising two or more layers of PVC or other synthetic tape. The lapped bedding shall be approximately 0.8 mm thick.

When lapped bedding is used it shall be applied such that any gaps between adjacent edges of each tape are not coincident through the thickness of the bedding. If there is a gap between adjacent edges of each tape it shall not exceed 15 % of the tape width. The method of measurement of the gap between tapes is given in BS 7870-2, 2.1.8.

NOTE The thickness of lapped bedding need not be checked by measurement.

6.3.5 Armour

The armour shall consist of a single layer of wires or strips having nominal dimensions as given in Table 3 to Table 14, as appropriate. The armour shall be applied helically with a left-hand lay for cables having up to and including four 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.

For single-core cables having stranded copper or aluminium conductors the armour shall consist of aluminium wire. For single-core cables having solid or sectoral aluminium conductors the armour shall consist of aluminium wire or strip.

For multicore cables having solid aluminium conductors the armour shall consist of a single layer of aluminium wires or strips.

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

Wire or strip 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 15 when measured in accordance with BS 7870-2, **2.1.4.3**.
- b) The mass of zinc coating of galvanized steel armour wire shall not be less than that given in Table 16 when measured in accordance with BS 7870-2, **2.5.1.1**.
- c) The 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 not be less than 125 N/mm^2 when measured in accordance with BS 7870-2, **2.3.1.1**.
- e) The thickness and width of individual strips of aluminium armour shall not differ from the values specified in Table 4, Table 6, Table 8 or Table 13 of this section as appropriate, by more than 10 %. The method of measurement shall be in accordance with BS 7870-2, **2.1.4.3**.
- f) The tensile strength of individual strips of aluminium armour shall not be less than 145 N/mm^2 when measured in accordance with BS 7870-2, **2.3.1.1**.
- g) 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 17, Table 18, Table 19, Table 20 and Table 21 of this section 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 or strip shall be made by cold pressure or fusion welding and all surface irregularities shall be removed.

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

6.3.6 Oversheath

The oversheath shall be an extruded layer of black PVC compound Type TM 1 conforming to the requirements given in Table 1.

The oversheath thickness shall conform to the values specified in Table 3 to Table 14. However, the thickness at any one place may be less than the specified value provided that the difference does not exceed $0.2 \text{ mm} + 20\%$ of the specified value.

The oversheath for single-core cables may have a suitable semi-conducting coating to enable the integrity 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 sheath when the cable is operating at maximum conductor temperature.

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

6.4 Tests

Conformity to the requirements of **6.3** shall be checked by inspection and by the tests specified in Table 2.