

Electric cables — PVC insulated, armoured cables for voltages of 600/1 000 V and 1 900/3 300 V

ICS 29.060.20

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee GEL/20, Electric cables, upon which the following bodies were represented:

- Association of Consulting Engineers
- Association of Manufacturers of Domestic Electrical Appliances
- BEAMA Electrical Cable and Conductor Accessory Manufacturers' Association
- British Approvals Service for Cables
- British Cables Association
- British Iron and Steel Producers' Association
- British Plastics Federation
- Department of Trade and Industry (Consumer Safety Unit, CA Division)
- Electricity Association
- London Transport

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- Association of Manufacturers Allied to the Electrical and Electronic Industry (BEAMA Ltd.)
- Chartered Institution of Building Services Engineers
- ERA Technology Ltd.
- Electrical Installation Equipment Manufacturers Association (BEAMA Ltd.)
- Engineering Industries Association
- Institution of Incorporated Executive Engineers
- London Underground Ltd.
- National Association of Lift Makers
- Portable Electric Tool Manufacturers' Association
- Transmission and Distribution Association (BEAMA Ltd.)

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Foreword

This British Standard has been prepared by Technical Committee GEL/20. It constitutes a major revision of the 1989 edition which is now withdrawn. BS 6346 is related to but not equivalent to IEC 60502-1:1998.

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 in the text by **A1** **A1**.

This edition makes changes to the scope so as to reflect those cable types in common use in the construction and industrial sector. Five-core cables have been introduced and the range of multicore auxiliary cables modified to include only the preferred number of cores up to 48-cores.

Unarmoured cable designs have been removed, but XLPE-insulated unarmoured types are specified in BS 7889.

The opportunity has also been taken to refer to BS 7655 for details of requirements for materials.

Further changes have been made to update and improve this standard in line with the corresponding revisions of BS 6724 and BS 5467.

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 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.

Product certification/inspection/testing. Users of this British Standard are advised to consider the desirability of third-party certification/inspection/testing of product conformity with 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.

WARNING This 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 and a back cover.

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1 Scope

This British Standard specifies requirements for construction and describes methods of test for armoured cable with PVC insulation of rated voltages 600/1 000 V and 1 900/3 300 V. Cables specified in this standard are intended for use in fixed installations in industrial areas, buildings and similar applications.

The insulation and other components are suitable to permit operation of the cables at a maximum sustained conductor temperature of 70 °C and for a maximum short-circuit conductor temperature of 160 °C for conductor sizes up to and including 300 mm² and 140 °C for conductor sizes greater than 300 mm².

The cables specified in this standard are as follows:

- a) 600/1 000 V cables, either wire or aluminium strip armoured and oversheathed having:
 - single-core stranded copper conductor;
 - single-core solid aluminium conductor;
 - two-, three-, four- and five-core stranded copper conductor;
 - two-, three-, and four-core solid aluminium conductor;
 - multicore auxiliary stranded copper conductor.
- b) 1 900/3 300 V cables, wire armoured and oversheathed having:
 - single-core stranded copper conductor;
 - single-core solid aluminium conductor;
 - three-core stranded copper conductor;
 - three-core solid aluminium conductor.

Annex A gives recommendations for the selection and operation of cables while recommendations for the installation of cables are given in Annex B. Annex C lists the information that should be given with an enquiry or order.

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.

[A1] *Text deleted [A1]*

BS 4727-2-0.8:1994, *Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms — Part 2: Terms particular to power engineering — Group 08: Electric cables.*

BS 5099:1992, *Specification for spark testing of electric cables.*

BS 6360:1991, *Specification for conductors in insulated cables and cords.*

BS 7655-3.1:1993, *Specification for insulating and sheathing materials for cables — Part 3: PVC insulating compound — Section 3.1: Harmonized types.*

BS 7655-4.1:1993, *Specification for insulating and sheathing materials for cables — Part 4: PVC sheathing compounds — Section 4.1: Harmonized types.*

BS EN 10002-1:1990, *Tensile testing of metallic materials — Part 1: Method of test at ambient temperature.*

[A1] BS EN 10244-2, *Steel wire and wire products — Non-ferrous metallic coatings on steel wire — Part 2: Zinc or zinc alloy coatings on steel wire.*

BS EN 50265-2-1, *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 60811-1-1:1995, *Insulating and sheathing materials of electric cables — Common test methods — Part 1-1: General application — Measurement of thickness and overall dimensions — Tests for determining the mechanical properties.*

BS EN 60811-1-2:1995, *Insulating and sheathing materials of electric cables — Common test methods — Part 1-2: General application — Thermal ageing methods.*

3 Terms and definitions

For the purposes of this British Standard the definitions given in BS 727-2:Group 08 apply together with the following.

3.1

rated voltage U_0

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

3.2

rated voltage U

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

3.3

maximum voltage U_m

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

3.4

nominal value

the value by which a quantity is designated and which is often used in tables

NOTE In this standard, nominal values usually give rise to values to be checked by measurements taking into account specified tolerances.

3.5

approximate value

a value which is only indicative

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

3.6

type tests (symbol T)

tests required to be made before supplying a type of cable specified in this standard, on a general commercial basis, in order to demonstrate satisfactory performance characteristics to meet the intended application. These tests are of such a nature that, after they have been made, they need not be repeated unless changes are made in the cable material, design or type of manufacturing process which might change the performance characteristics

3.7

sample tests (symbol S)

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

3.8

routine tests (symbol R)

tests made on all production lengths to demonstrate their integrity

3.9

tests after installation

tests intended to demonstrate the integrity of the cable and its accessories as installed

4 Voltage designation

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

The rated voltages recognized for the purposes of this standard are 600/1 000 V and 1 900/3 300 V.

The maximum designated voltages (U_m) for the purposes of this standard for 600/1 000 V and 1 900/3 300 V cables are recognized as 1 200 V and 3 600 V respectively.

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

5 Conductors

The conductors shall be either annealed copper or solid aluminium, as given in Table 5 to Table 19 inclusive, and shall conform to the requirements detailed in Table 2 and to BS 6360.

Where the manufacturer deems it necessary to use tinned copper conductors, they shall conform to the requirements of BS 6360 for metal coated conductors.

The conductors shall be circular, circular sectoral or shaped solid (class 1), or circular, circular compacted or shaped stranded (class 2), as specified in Table 5 to Table 19 inclusive.

6 Insulation

6.1 General

The insulation shall be PVC compound TI 1 conforming to BS 7655-3.1. The insulation shall be applied by the extrusion process to form a compact and homogeneous layer.

6.2 Thickness of insulation

The thickness of insulation, when determined by taking the average of a number of measurements in accordance with Annex D, shall be not less than the value given in Table 5 to Table 19, as appropriate, and the smallest of the measured values shall not fall below the value given in Table 5 to Table 19, as appropriate, by more than $(10\% + 0.1 \text{ mm})$.

6.3 Spark testing of insulation

The core insulation shall conform to the requirements for spark testing specified in BS 5099 when tested in accordance with the a.c. or d.c. test methods specified in that standard.

7 Identification of cores

7.1 General

The cores of all cables shall be identified either by colour or by numbers. Numbers shall be marked sequentially starting with the number 1. Colour coding shall be in accordance with the following sequence.

Number of cores	Identification
Single-core	Brown or blue
Two-core	Brown, blue
Three-core	Brown, black, grey
Four-core	Blue, brown, black, grey
Five-core	Green-and-yellow, blue, brown, black, grey

The colour shall be applied either throughout the insulation or on its external surface.

Numbers on each core shall be printed in a colour contrasting with that of the insulation.

The height of the individual number shall be not less than 1.5 mm.

The spacing shall be such that each number is repeated at intervals not greater than 70 mm.

Conformity shall be checked by visual examination and measurement.

7.2 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 at least 30 % and at most 70 % of the surface of the core, while the other colour covers the remainder of the surface.

NOTE 1 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 Clause 8 of BS 6469-99.1:1992.

NOTE 2 It is understood that the colours green and yellow when they are combined as specified above are recognized as identifying exclusively the core intended for use as an earth connection or similar protection.

7.3 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 rubbed 10 times with a piece of cotton wool or cloth soaked in water.

8 Laying-up

8.1 General

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. Cores shall be laid-up in the sequence given in 7.1.

Conformity shall be checked by visual examination.

If necessary, the formation of a compact and reasonably circular cable shall be achieved either by the bedding (see 9.1), or by the application of synthetic fillers and binder tape.

It shall be possible to strip the fillers, if any, from the cable without damaging the insulation of the cores.

9 Bedding

9.1 General

For single core 600/1 000 V cables the bedding shall consist of an extruded layer of polymeric material compatible with the operating temperature of the cable. When tested in accordance with BS EN 60811-1-1 it shall have a tensile strength of not less than 4 N/mm² and elongation at break not less than 50 %.

For multicore 600/1 000 V cables the bedding shall be either:

- a) an extruded layer of polymeric material compatible with the operating temperature of the cable which, when tested in accordance with BS EN 60811-1-1, shall have a tensile strength of not less than 4 N/mm² and elongation at break not less than 50 %; or
- b) for cables having a nominal conductor area of 16 mm² and above, a taped bedding (as indicated in the relevant tables) comprising two or more layers of PVC tape or other synthetic tape applied so 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, as determined by measurement in accordance with 17.3.

The bedding of all 1 900/3 300 V cables shall consist of an extruded layer of polymeric material compatible with the operating temperature of the cable. When tested in accordance with BS EN 60811-1-1 it shall have a tensile strength of not less than 4 N/mm² and elongation at break not less than 50 %.

It shall be possible to remove the bedding without damaging the insulation of the core(s).

9.2 Thickness of bedding

The approximate thickness of the taped bedding shall be 0.8 mm.

The minimum thickness of extruded bedding, measured in accordance with Annex D, shall not fall below the value given in Table 5 to Table 19, as appropriate, by an amount more than (20 % + 0.2 mm).

10 Armour

10.1 General

The armour shall consist of a single layer of wires or aluminium strips having nominal dimensions as given in Table 5 to Table 19, 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 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.

The manufacturer shall, where necessary, apply a suitable binder tape over the armour.

10.2 Aluminium strip armour

The thickness and width of aluminium strip, determined in accordance with G.6 shall not differ from the values specified in the appropriate table by more than 10 %.

The tensile strength of aluminium strip when tested in accordance with G.4, shall not be less than 145 N/mm².

10.3 Wire armour

Wire armour for cables having two or more cores shall consist of a single layer of galvanized steel wires. Wire armour for single-core cables shall consist of a single layer of aluminium wires.

The armour wire shall conform to the following.

- When determined in accordance with G.1, the diameter of the round armour wires, whether of galvanized steel or plain aluminium, shall fall within the minimum and the maximum wire diameters given in Table 1.
- When determined in accordance with G.2, the mass of zinc coating of galvanized steel armour wire shall be not less than the value given in Table 1.
- When tested in accordance with G.3, the mechanical characteristics of galvanized armour wires shall be such that none of the wires shall break.
- When tested in accordance with G.4, the tensile strength of aluminium armour wires shall be not less than 125 N/mm².

Table 1 — 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	
0.9	0.85	0.95	112
1.25	1.18	1.32	150
1.6	1.51	1.69	172
2.0	1.90	2.10	180
2.5	2.37	2.63	195
3.15	2.99	3.31	206

10.4 Joints

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

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

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

10.5 Armour resistance

When measured and corrected to 20 °C in accordance with G.5, the d.c. resistance of the armour of the completed cable shall not exceed the appropriate value given in Table H.1, Table H.2, Table H.3, Table H.4 or Table H.5.

11 Oversheath

11.1 General

The oversheath shall be an extruded layer of PVC material conforming to the requirements for TM 1 material specified in BS 7655-4.1.

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

11.2 Thickness of oversheath

The minimum thickness of the oversheath, when measured in accordance with Annex D, shall not fall below the value given in Table 5 to Table 19, as appropriate, by an amount exceeding (20 % + 0.2 mm).

11.3 Spark testing of oversheath

The oversheath shall conform to the requirements for spark testing specified in BS 5099 when tested in accordance with the a.c. or d.c. test methods specified in that standard.

12 Cable marking

12.1 End marking

The ends of each factory length of cable having three or more cores of conductor size 25 mm² and above shall be marked red or green. The end at which the sequence of core colours, as specified in Clause 7, is clockwise shall be marked red and the other end shall be marked green.

12.2 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) Electric cable	ELECTRIC CABLE
b) Voltage designation	600/1 000 V 3 300 V 600/1 000 V AUX
c) British Standard number	BS 6346
d) Manufacturer's identification	XYZ
 e) Number of cores, type and nominal area of conductor	
1) Copper conductor cables	4 × 50
NOTE 1 4 × 50 indicates a four-core cable with 50 mm ² copper conductors.	
2) Aluminium conductor cables	4 × 50AL
NOTE 2 4 × 50AL indicates a four-core cable with 50 mm ² aluminium conductors. 	

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

For cables with tabulated approximate overall diameters greater than 15 mm, items a), b) and c) shall appear, in any sequence that is deemed neither to confuse nor conflict, on two or more primary lines along the axis of the cables, approximately equally spaced around the circumference of the cable.

Items d) and e) shall appear either on one of the primary lines, or on a secondary line or lines, in any sequence that is deemed neither to confuse nor conflict.

 NOTE 3  Items d) and e) need not both appear on the same line.

For cables with tabulated approximate overall diameters up to and including 15 mm, the elements of the marking shall be disposed as for cables of greater than 15 mm diameter 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 with a minimum height of 3 mm.