BS 8436:2011

BSI Standards Publication

Electric cables – Specification for 300/500 V screened electric cables having low emission of smoke and corrosive gases when affected by fire, for use in walls, partitions and building voids – Multicore cables

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Publishing and copyright information

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 20, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI and came into effect on 30 April 2011. It was prepared by Subcommittee GEL/20/17, *Low voltage cables*, under the authority of Technical Committee GEL/20, *Electric cables*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 8436:2004, which is withdrawn.

Relationship with other publications

The new edition takes account of:

- BS EN 60228 (replacing BS 6360) on conductors;
- BS EN 50363 (replacing certain parts of BS 7655) on materials;
- BS EN 60332-1-2 (replacing BS EN 50265-2-1) and BS EN 61034 (replacing BS EN 50268) on reaction to fire performance tests;
- BS EN 62230 (replacing BS EN 50356) on spark testing.

Information about this document

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

a) the range of cables specified is extended;

b) the marking arrangements are clarified;

c) the fundamental safety test relating to nail penetration is improved;

d) the relationship between the sizes and types of protective devices (circuit breakers) is clarified.

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.

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

Presentational conventions
The provisions in 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.

Attention is drawn to the following regulations:

The Electricity Safety, Quality and Continuity Regulations 2002 [1]

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1 Scope

- This British Standard specifies requirements and test methods for the construction and performance of cables that:
- have a thermosetting insulation of rated voltage 300/500 V;
- emit limited amounts of smoke (see **15.5**) and corrosive gases when subjected to relevant tests;
- are primarily intended for use in walls, partitions and building voids;
- have a screen that can carry the fault current required for a selected size and type of protective device, that operates within a given time if the cable is penetrated by a nail or similar fixing (see **16.4**).

To achieve a satisfactory safety performance of the cable when installed, both the selection of protective device and the maximum current rating is critical.

*NOTE 1 See Clause **12** for the requirements of the safe selection of protective devices and maximum current rating of cables.*

It is applicable to 2-core, 3-core and 4-core cables with an uninsulated, full-size circuit protective conductor and metallic screening.

NOTE 2 A guide to the use of the cables specified in this British Standard is given in Annex A.

2 Normative references

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

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

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

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

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

BS 7671:2008, *Requirements for electrical installations – IEE Wiring Regulations – Seventeenth edition*

BS EN 10230-1:2000, *Steel wire nails – Part 1: Loose nails for general applications*

BS EN 13603:2002, *Copper and copper alloys – Test methods for assessing protective tin coatings on drawn round copper wire for electrical purposes*

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

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

BS EN 60228, *Conductors of insulated cables*

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

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

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

BS EN 60898, *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations*

BS EN 61009-1, *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBO's) – Part 1: General rules*

BS EN 61034-1, *Measurement of smoke density of cables burning under defined conditions – Part 1: Test Apparatus*

BS EN 61034-2:2005, *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 standard

*NOTE See Clause **11.1**, a) for information on marking the cable with the cable manufacturer's name and identifier.*

3.2 let-through energy, I^2t
energy let-through value of a device, measured in amperes squared seconds (A^2s)

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 requirements

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

NOTE 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.

3.6 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
nominal power-frequency voltage between phase conductors for which the cable is suitable

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

4 Voltage designation

The cables shall be designated by the rated voltages U_o and U, expressed in the form U_o/U. The rated voltage recognized for the purpose of this British Standard shall be 300/500 V.

5 Conductors

The conductors shall conform to BS EN 60228, class 1, 2 or 5. The insulated conductors shall be plain or tinned annealed copper. The uninsulated circuit protective conductors shall be tinned annealed copper and shall be of the same nominal cross-sectional area as the insulated conductors.

Tinned coated wires shall conform to BS EN 13603:2002, Clause **5**.

The class of conductor shall be the same for all conductors in any single cable. The uninsulated circuit protective conductor shall be of the same class as the insulated conductors.

6 Insulation

6.1 Type

The insulation shall be one of the following types:

- EI 5, as specified in BS EN 50363-5;
- GP 4 or GP 6, as specified in BS 7655-1.2;
- GP 8, as specified in BS 7655-1.3.

*NOTE 1 BS EN 50363-5 specifies various requirements for assessing the insulation's corrosive and acid gas emission. To conform to this British Standard, it is only necessary to assess corrosive and acid gas emission in accordance with **6.5**, regardless of insulation types.*

NOTE 2 A tape or tapes can be applied over either the conductor or the insulation.

6.2 Application

The insulation shall be applied closely to the conductor or conductor taping by the extrusion process and cross-linked to form a compact and homogeneous layer.

NOTE 1 The insulation can be applied in a single layer or in a number of cohesive layers.

Where more than one layer is used, all testing specified in this British Standard shall be carried out on the complete insulation as though it were a single layer of the declared insulation type (see **6.1**).

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

When the application is tested by removing the insulation from the conductor, there shall be no damage to the insulation itself, the conductor or the tin coating (if any).

6.3 Thickness

The thickness of the insulation, when determined by taking the average of a number of measurements in accordance with Annex B, shall be not less than the value specified in Table 1, and the smallest of the measured values shall not fall below the value given in Table 1 by more than 0.1 mm + 10%.

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

Table 1 **Dimensions of cables**

Number of cores	**Nominal cross-sectional area of conductor** mm^2	**Radial thickness of insulation** mm	**Radial thickness of sheath** mm	**Approximate overall diameter** mm
2	1.0	0.6	0.9	8.0
	1.5	0.7	0.9	8.5
	2.5	0.7	1.0	10.5
	4.0	0.7	1.1	12.5
3	1.0	0.6	0.9	8.5
	1.5	0.7	0.9	9.5
	2.5	0.7	1.0	11.5
	4.0	0.7	1.1	13.5
4	1.0	0.6	1.0	9.0
	1.5	0.7	1.0	10.5
	2.5	0.7	1.1	12.0
	4.0	0.7	1.2	15.0

6.4 Spark test

When tested in accordance with BS EN 62230, using the test voltages specified in BS 5099, there shall be no breakdown of the insulation.

6.5 Corrosive and acid gas emission from insulation and tapes during combustion

When tested in accordance with BS EN 50267-2-1, the level of HCl shall be not greater than 0.5%.

7 Identification of cores

7.1 Colour coding

The cores of all cables shall be identified by colours in accordance with Table 2.

Table 2 **Identification of cores**

Number of cores	Core colours
2-core + uninsulated circuit protective conductor	Brown, blue or brown, brown
3-core + uninsulated circuit protective conductor	Brown, black, grey
4-core + uninsulated circuit protective conductor	Blue, brown, black, grey

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

Where surface colouring is applied, the surface colour shall be of essentially the same material as the underlying material and shall be applied as part of the extrusion process. The surface colour shall be inseparable from the underlying material.

7.2 Clarity and durability

The colours used for core identification shall be clearly identifiable. When the core is lightly rubbed ten times with a piece of cotton wool soaked in water, there shall be no degradation of the colour.

8 Laying up

8.1 Multicore cables

The cores of the 2-core, 3-core and 4-core cables shall be laid up using the sequence of colours specified in Clause **7**.

NOTE Non-hygroscopic binder tape(s) may be applied over the laid up cores.

An uninsulated circuit protective conductor shall be incorporated in the 2-core, 3-core and 4-core cables such that they conform to Clause **9**.

8.2 Corrosive and acid gas emission from tapes during combustion

When tested in accordance with BS EN 50267-2-1, the level of HCl of any binder tape(s) shall be not greater than 0.5%.

9 Screen

One or more metallic or laminated metallic tape(s) shall be applied, either longitudinally or helically or as a combination of both, with the metallic element in contact with the uninsulated circuit protective conductor.

If a tape is applied longitudinally, it shall have an overlap of not less than 1 mm. If a tape is applied helically, it shall have an overlap of not less than 20%.

The tapes shall be selected and applied in such a way that the completed cable conforms to the requirements specified in this British Standard.

10 Sheath

10.1 Type

The sheath shall be Type LTS 3 conforming to BS 7655-6.1.

10.2 Application

The sheath shall be applied by the extrusion process.

When the sheath is removed, there shall be no damage to the core insulation when visually checked.

10.3 Thickness

The thickness of the sheath, when measured in accordance with Annex B, shall be not less than the value given in Table 1 and the smallest of the measured values shall not fall below the value given in Table 1 by an amount greater than 0.1 mm + 15%.

10.4 Spark test

When tested in accordance with BS EN 62230, using the test voltages specified in BS 5099, there shall be no breakdown of the sheath.

10.5 Corrosive and acid gas emission from sheath during combustion

When tested in accordance with BS EN 50267-2-1, the level of HCl shall be not greater than 0.5%.

11 Cable marking and additional information

11.1 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

NOTE 1 A simplified version of the manufacturer's name, or a trading name of the manufacturer, may be used in place of the full name.
NOTE 2 Any suitable method may be used to unambiguously identify the manufacturer's factory.
NOTE 3 The manufacturer's own trademark or equivalent may be added but this cannot be used instead of the manufacturer's name or identifier.

b) Electric cable	ELECTRIC CABLE
c) Voltage designation	300/500 V
d) British Standard number	BS 8436 [1)]

[1)] Marking BS 8436 or BS 8436:2011 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

e) Number of cores and nominal area of conductor — 2 × 1.5 [2)]

f) Year of manufacture — YYYY

NOTE 4 The year of manufacture may take the form of the actual year (e.g. 2011) or a coded year identifier assigned by the manufacturer.

g) Standard core colour indicator — H

*NOTE 5 See **11.2**.*

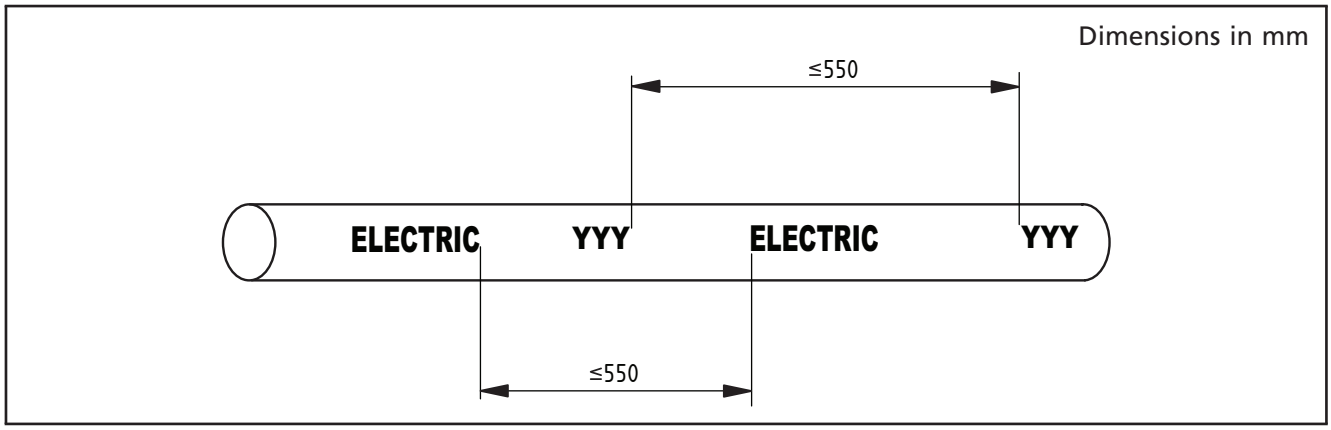
The marking of items a) to g) shall be by embossing, indenting or printing on the sheath. The markings shall appear along the axis of the cable in any sequence that is deemed to neither confuse nor conflict.

*NOTE 6 The order in which the elements of marking appear along the length of the external sheath is not prescribed, but it is preferred that they be in the order a) to g) as shown in **11.1**.*

The letters and figures shall consist of upright, block characters with a height of not less than 3 mm.

The distance between the end of one element of the marking and the beginning of the next identical element of the marking shall be not more than 550 mm in accordance with Figure 1.

Figure 1 **An example of the marking as used on the outer sheath of the cable**



Conformity of the marking shall be checked by visual examination and measurement of at least two sets of elements.

11.2 Standard core colour identifier

When the core colour combinations are used in accordance with Table 2, the letter "H" shall be included in the marking on the external sheath of the cable in accordance with **11.1**.

11.3 The mark of an approval organization

If the mark of an approval organization is used, it shall be embossed, indented or printed throughout the length of the external sheath of the cable.

The mark shall be in the form of symbol(s) specified by the approval organization, and the maximum distance between marks shall be not greater than 1 100 mm.

[2)] 2 x 1.5 indicates a two-core cable with 1.5 mm^2 conductors.

11.4 Additional information

Any additional information shall be embossed, indented or printed throughout the length of the external sheath of the cable.

The additional information shall be in one continuous string such that it does not conflict with, confuse nor render illegible the marking in **11.1**, **11.2** and **11.3**. The repeat interval shall not exceed 1 100 mm.

12 Requirements for safe selection of protective devices and maximum current rating of cables

The protective devices used for the cables covered by this British Standard shall be either a Type B circuit breaker conforming to BS EN 60898 or a Type B RCBO conforming to BS EN 61009-1. The protective devices shall have a maximum let-through energy (I^2t) of 42 000 A^2s when used with 1.0 mm^2 or 1.5 mm^2 cable, and 60 000 A^2s when used with 2.5 mm^2 or 4.0 mm^2 cable.

The maximum current rating used for cables to this British Standard shall be not greater than 16 A for the 1.0 mm^2 cable, 20 A for the 1.5 mm^2 cable, 32 A for the 2.5mm^2 cable (when used in a ring circuit) and 32 A for the 4.0 mm^2 cable.

NOTE 1 These stated maximum current ratings might need to be further reduced dependant on the precise installation conditions used for the cable; reference needs to be made to BS 7671 or the cable manufacturer for current ratings in various installation conditions.

NOTE 2 Circuit breakers have two areas of classification. One of these is how many times the rated current is required to operate in the time period 0.1 to 5 seconds (for a Type B breaker it is five times the rated current). The other is the I^2t of the device for time periods less than 0.1 seconds, which is stated by the manufacturer of the circuit breaker.

*NOTE 3 The designer of the circuit might consider additionally having supplementary protection by a residual current device in accordance with BS 7671:2008, **415.1.1**.*

13 Schedule of tests

The tests to be performed on cables specified in this standard shall be as scheduled in Table 3, which refers to the relevant clauses of the standard specifying the requirements and test methods as well as the category of each test which applies, i.e. T, S or R (as defined in Clause **3**) and which also indicates which tests relate to complete cable, and which relate to components.

14 Routine test for complete cables

14.1 General

The test specified in **14.2** shall be carried out under the test conditions specified in Annex C.

*NOTE Routine tests for components are covered in Clauses **5** to **10** and are identified in Table 3.*

14.2 Absence of faults on insulation

When the completed cable is tested in accordance with Annex D without immersion in water, there shall be no breakdown of the insulation.

Table 3 **Schedule of tests**

Parameter	Requirement	Test method	Test category
Component			
Conductor construction	Clause **5**	BS EN 60228	S
Insulation:			
– type	**6.1**	BS 7655-1.2 or BS 7655-1.3 BS EN 50363-5	T
– application	**6.2**	Visual examination and manual test	S
– thickness	**6.3**	Annex B	S
– spark test	**6.4**	BS EN 62230 and BS 5099	R
– corrosive and acid gas emission	**6.5**	BS EN 50267-2-1	T
Cores:			
– identification	Clause **7**	Visual examination	S
– laying up	**8.1**	Visual examination	S
– corrosive and acid gas emission on binder tape	**8.2**	BS EN 50267-2-1	T
Screen:			
– application	Clause **9**	Visual examination	S
Sheath:			
– type	**10.1**	BS 7655-6.1	T
– application	**10.2**	Visual examination and manual test	S
– thickness	**10.3**	Annex B	S
– spark test	**10.4**	BS EN 62230 and BS 5099	R
– corrosive and acid gas emission during combustion	**10.5**	BS EN 50267-2-1	T
Completed cable			
Marking	Clause **11**	Visual examination and measurement	R
Absence of faults on insulation	**14.2**	Annex D	R
Conductor resistance	**15.2**	BS EN 60228	S
Voltage withstand	**15.3**	Annex E	S
Performance under fire conditions:			
– flame propagation	**15.4**	BS EN 60332-1-2	S
– smoke emission	**15.5**	BS EN 61034-2	S
Bending characteristics	**16.2**	Annex F	T
Resistance to impact	**16.3**	Annex G	T
Nail penetration	**16.4**	Annex H	T
Shrinkage test on insulation	**16.5**	BS EN 60811-1-3	T

NOTE 1 Tests classified as sample (S) and routine (R) might be required as part of a type approval scheme.
NOTE 2 The order of the tests in this schedule does not imply a sequence of testing.

15 Sample tests for completed cables

15.1 General

The tests specified in this clause shall be carried out under the test conditions specified in Annex C, unless otherwise specified in the details of a particular test.

*NOTE Sample tests for components are covered in Clauses **5** to **10** and are identified in Table 3.*

15.2 Conductor resistance

When measured in accordance with BS EN 60228 and corrected to 20 °C, on a sample of cable not less than 1 m in length, the d.c. resistance of each conductor shall conform to BS EN 60228.

15.3 Voltage withstand

When tested in accordance with Annex E, there shall be no breakdown of the insulation or sheath.

15.4 Flame propagation

When tested in accordance with BS EN 60332-1-2, the completed cable shall conform to the flame propagation requirements specified in BS EN 60332-1-2:2004, Annex A.

15.5 Smoke emission

When tested in accordance with BS EN 61034-2, using the apparatus specified in BS EN 61034-1 and the number of cables specified in BS EN 61034-2:2005, **5.2.1.1**, as a flat horizontal unit, the smoke generated shall result in transmittance values of not less than 80%.

16 Type tests for completed cables

16.1 General

The tests specified in this clause shall be carried out under the test conditions specified in Annex C, unless otherwise specified in the details of a particular test.

*NOTE Sample tests for components are covered in Clauses **5** to **10** and are identified in Table 3.*

16.2 Bending characteristics

When tested in accordance with Annex F, the sheath shall be free from splits and there shall be no breakdown of the insulation.

16.3 Resistance to impact

When tested in accordance with Annex G, there shall be no breakdown of the insulation of any of the samples.

16.4 Nail penetration

Samples of completed cables shall be tested in accordance with Annex H until six valid test results are obtained. There shall be no failure of any of these six samples that have valid test results.

16.5 Shrinkage test on insulation

All grades of insulation shall be tested in accordance with BS EN 60811-1-3, Clause **10**, on a 200 mm sample of core tested at (130 ±2) °C for 1 h. The measured shrinkage shall not exceed 4%.

Annex A (informative) Recommendations for the selection, operation and installation of cables

IMPORTANT. This annex gives only general technical guidance and is not an interpretation of any UK statutory requirements, where these apply.

A.1 General

NOTE Attention is drawn to any nationally applicable regulations, which in the UK are those referenced in BS 7671.

The cables specified in this British Standard are intended for installation in air (which includes installation in trunking or other closed systems), and in thin partitions and building voids when connected to a suitably selected protective device (see Clause **12**). When cables are to be installed in any other environment, reference should be made to the cable manufacturer.

A.2 Temperature limitations

The cables specified in this British Standard are suitable for use, where the combination of ambient temperature and temperature rise due to load results in a conductor temperature not exceeding 70 °C and, in the case of a short circuit (maximum allowable time 5 s), the maximum conductor temperature does not exceed 250 °C. In the case of overload, the maximum allowable time is four hours and the maximum conductor temperature shall not exceed 156 °C.

However, when installed in an enclosure, subject to the sheath being terminated upon entry and the combination of ambient temperature and temperature rise due to load resulting in a conductor temperature not exceeding 70 °C outside the enclosure, the conductor temperature in the enclosure can be increased to a temperature not exceeding 90 °C.

NOTE The short-circuit temperature is based on the intrinsic properties of the insulating materials. It is essential that the accessories which are used in the cable system with mechanical and/or soldered connections are suitable for the temperature adopted for the cable.

A.3 Voltage ratings

The cables specified in this British Standard have a rated voltage (U_o/U) of 300/500 V.

The maximum sustained system voltage (U_m) is 550 V and is the highest voltage between phases which can be sustained under normal conditions at any time and at any point in the system. Transient voltage variations due, for example, to lightning impulses, fault conditions and rapid disconnection of loads are not taken into account.

The 300/500 V cables are suitable for d.c. systems up to 750 V between conductors. However, the peak value when determining the voltage of a d.c. system derived from rectifiers should be taken into account, bearing in mind that smoothing does not modify the peak value when the rectifiers are operating on an open circuit.

A.4 Minimum installation radius

During installation, the cables should not be bent to a radius smaller than six times the overall diameter of the cable.

A.5 Minimum temperature during installation

The cables should be installed either when both the cable temperature and the ambient temperature are above 0 °C and have been so for the previous 24 h, or where special precautions have been taken to maintain the cables above this temperature.

A.6 Installation practice

Cables should be installed and used in association with other equipment in accordance with BS 7671 as appropriate.

NOTE Attention is also drawn to any nationally applicable regulations, which in the UK are those referenced in BS 7671 and/or the Electricity Safety, Quality and Continuity Regulations [1], as appropriate.

A.7 Safe selection of protective devices and maximum current rating of cable

The requirements for the safe selection of protective devices and maximum current rating of cables are detailed in Clause **12**.

NOTE In countries outside the UK corresponding regulations might apply.

Annex B (normative) Measurement of insulation and sheath thickness

B.1 Sample

B.1.1 *Sample,* taken from one end of each length of cable selected for the test, having discarded any portion that has been damaged**.**

B.2 Procedure

Measure each component in accordance with BS EN 60811-1-1.

If the sheath adheres to the screen, remove the screen before measuring the thickness.

B.3 Expression of results

Calculate the average of all the values obtained from a sample to two decimal places and then round to obtain the mean value for both insulation and sheath thickness. If the calculation gives 5 or more for the second decimal figure, raise the first to the next number; thus, for example, 1.75 is rounded to 1.8 and 1.74 to 1.7.

Take the smallest of all the values obtained as the minimum thickness for both insulation and sheath at any place.

B.4 Interpretation of results

If any of the thicknesses measured do not conform to Table 1, check two further samples for the non-conforming items. If both of the further pieces meet the specified thickness, the cable conforms, but if either does not meet the requirements, the cable does not conform.

Annex C (normative) Test conditions

C.1 Ambient temperature

Test at an ambient temperature of (20 ±10) °C.

C.2 Frequency and waveform of power frequency test voltages

Test with:

- the frequency of the alternating test voltages in the range 49 Hz to 61 Hz;
- the waveform substantially sinusoidal; and
- the ratio peak value/r.m.s. value equal to $\sqrt{2}$ with a tolerance of ±7%.

Annex D (normative) Method of test for insulation faults

Carry out the test under the conditions in Annex C with a single phase a.c. supply of 2 000 V r.m.s. or with a direct current supply of 5 000 V on each drum length of cable.

Take:

a) each insulated conductor in turn;

b) all other insulated conductors, which are connected together and also connected to the circuit protective conductor, metallic layer and earth.

Gradually apply the test voltage between a) and b) and maintain this at full value for 1 min.

Annex E (normative) Method of test for voltage withstand

E.1 Sample

E.1.1 *Sample of completed cable*, not less than 20 m long.

E.2 Procedure

Immerse the sample in water at a temperature of (20 ±5) °C for a period of not less than 24 h. Ensure that the ends of the cable protrude above the water by a distance sufficient to prevent excessive surface leakage when the test voltage is applied between the conductor and the water.

Take:

a) each conductor in turn;

b) all other conductors, which are connected together and also connected to the water.

Gradually apply a test voltage of 2 000 V between a) and b) and maintain at full r.m.s. value for 15 min.

Repeat the test, but applying the voltage between all conductors connected together and the water.

In both cases earth the circuit protective conductor but do not include it in the conductors to be tested.

While the sample is still immersed, disconnect the circuit protective conductor or drain wire from the water and apply a voltage of 1 000 V a.c. for 5 min between this and the water.

Annex F (normative) Method of test for bending characteristics

F.1 Apparatus and sample

F.1.1 *Test mandrel*, having a diameter of 12*D* ±5%, where *D* is the external diameter of the completed cable.

F.1.2 *Sample of completed cable,* of a length at least five times the diameter of the test mandrel (**F.1.1**) and not less than 1 500 mm.

F.2 Preparation

Cool the sample and test mandrel for 2 h at 0 °C. Then immediately test in accordance with **F.3**.

F.3 Procedure

Mount the test mandrel on a horizontal or vertical axis about which it is free to rotate. Lay out the cable sample straight on a level surface and secure one cable end to the test mandrel through a swivel connection. Draw a reference line along the top of the cable parallel to its longitudinal axis.

Rotate the mandrel steadily so that all the cable is wound on in a closely wrapped coil, preventing the cable from twisting during the operation. Then rotate the mandrel in the opposite direction so that the cable is unwound and again laid straight on the level surface.

Rotate the cable through 180° around its longitudinal axis and repeat the winding and unwinding processes.

Take:

a) each conductor in turn;

b) all other conductors, which are connected together and also connected to the circuit protective conductor, metallic layer and earth.

Gradually apply a test voltage of 2 000 V a.c. between a) and b) and maintain at the full r.m.s. value for 1 min.

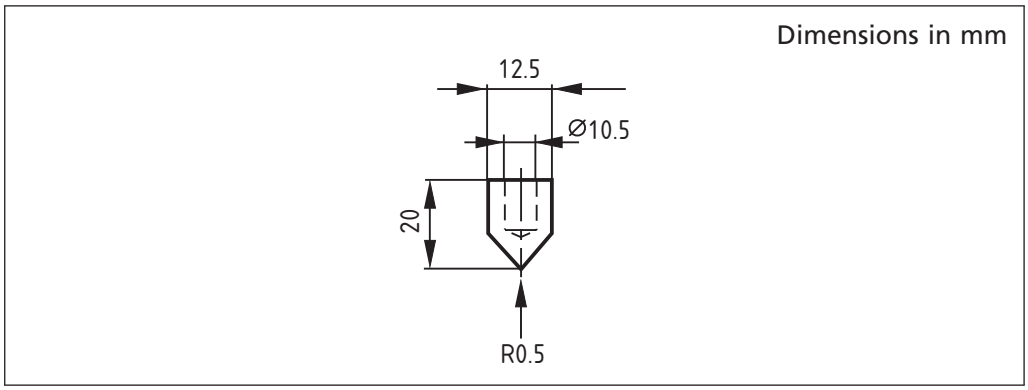
Annex G (normative) Method of test for resistance to impact

G.1 Apparatus and samples

G.1.1 *Impact test apparatus in accordance with BS EN 60811-1-4:1995, Figure 2*, with a chisel-edged intermediate piece (see Figure G.1) placed with its longitudinal axis at a right angle to that of the cable, and with a radiused intermediate piece.

G.1.2 *Six samples of cable*, each approximately 500 mm.

Figure G.1 **Chisel-edged intermediate piece for test for resistance to impact**



G.2 Procedure

Carry out the test at a temperature of (20 ±5) °C.

Stand the impact test apparatus on a firm base. Draw a reference line along the top of the cable parallel to its longitudinal axis prior to cutting the samples.

Remove 100 mm of sheath from the end of each sample to allow the cores to be separated. Place the samples successively in position on the impact test apparatus and allow the 500 g hammer to fall from a height of 250 mm, three samples being tested with the chisel-edged intermediate piece and three with the radiused intermediate piece. For each set of three samples, fix the impact position on each successive sample approximately 120° from the previous position.

For each sample of cable, take:

a) each conductor in turn;

b) all other conductors, which are connected together and also connected to the circuit protective conductor or drain wire and metallic layer.

Gradually apply a test voltage of 2 000 V a.c between a) and b) and maintain at the full r.m.s. value of 2 000 V for 1 min.

Annex H (normative)

Method of test for nail penetration

NOTE 1 The purpose of the nail penetration test is to determine whether the metallic screen will carry the fault current required for a selected type of protective device to operate within a given time if the cable is penetrated by a nail or similar fixing. The test assesses the performance of the cable against a specified test current, which is applied for 1 s. This test current should be taken into account when selecting a suitable protective device, and the device should be capable of operating at this specified current in a time not greater than 0.1 s.

NOTE 2 If a nail or similar object is driven into an unscreened cable and it only contacts a line conductor then the nail remains at line voltage. If a nail is driven into a metallic screened cable and it contacts a line conductor then the nail creates a fault path between that conductor and the screen. If the metallic screen is sufficiently robust then fault current will cause a suitably selected circuit protection to operate. Alternatively, the fault current could cause the screen to burn away from the nail before the protective device operates, and this would leave the nail at line voltage.

H.1 Test conditions

The tests shall be performed at ambient temperature using a supply with a nominal open-circuit voltage of 230 V. The supply voltage shall be alternating of approximately sine-wave form with a frequency in the range 49 Hz to 61 Hz. The ratio peak value/r.m.s. value shall be equal to $\sqrt{2}$ with a tolerance of ±7%.

The minimum test current shall be not less than that given in Table H.1 for the appropriate size of cable. If a higher test current than the minimum given in Table H.1 is used, it shall be declared.

H.2 Apparatus and sample

H.2.1 *Steel wire nail*, conforming to BS EN 10230-1 and shall have a diamond point, a plain circular shank with a nominal characteristic dimension of (1.6 ±0.045) mm in diameter.

H.2.2 *Test sample of completed cable*, which shall be at least 500 mm long. Remove 50 mm of sheath and metallic screen from each end to allow the cores to be separated.

Table H.1 **Minimum test current for nail penetration test**

Conductor cross sectional area mm²	**Minimum test current** [A)] A
1.0	80
1.5	100
2.5	160
4.0	160

[A)] The minimum test current (80 A at 1 s) for the 1.0 mm² cable is derived from BS 7671:2008, Appendix 3, Figure 3.4, and corresponds to a current that operates up to a 16 A Type B circuit breaker conforming to BS EN 60890 and Type B RCBOs conforming to BS EN 61009-1 in 0.1s. The device should also have a maximum I^2t not greater than 42 000 A²s and conform to the requirements stated in Clause **12**.
The minimum test current (100 A at 1s) for the 1.5 mm² cable is derived from BS 7671:2008, Appendix 3, Figure 3.4, and corresponds to a current that operates up to a 20 A Type B circuit breaker conforming to BS EN 60890 and Type B RCBOs conforming to BS EN 61009-1 in 0.1 s. The device should also have a maximum I^2t not greater than 42 000 A²s and conform to the requirements stated in Clause **12**.
The minimum test current (160 A at 1 s) for the 2.5 mm² cable is derived from BS 7671:2008, Appendix 3, Figure 3.4, and corresponds to a current that operates up to a 32 A Type B circuit breaker conforming to BS EN 60890 and Type B RCBOs conforming to BS EN 61009-1 in 0.1 s. The device should also have a maximum I^2t not greater than 60 000 A²s and conform to the requirements stated in Clause **12**.
The minimum test current (160 A at 1 s) for the 4.0 mm² cable is derived from BS 7671:2008, Appendix 3, Figure 3.4, and corresponds to a current that operates up to a 32 A Type B circuit breaker conforming to BS EN 60890 and Type B RCBOs conforming to BS EN 61009-1 in 0.1 s. The device should also have a maximum I^2t not greater than 60 000 A²s and conform to the requirements stated in Clause **12**.

H.3 The test circuit

The test circuit shall contain contactors and timers such that the prospective duration of the fault current can be set to at least 1 s. Series impedance shall be included in the test circuit to limit the fault current to the required value. Instrumentation shall be included in the test circuit to record the magnitude and duration of the fault current and the voltage on the nail during the test.

H.4 Procedure

The test sample shall be connected to the test circuit such that the fault current would flow through an insulated conductor and the metallic screen, via a nail, when a nail is driven into the cable. All of the insulated conductors shall be connected in parallel to increase the chance of hitting a live conductor with the nail. The uninsulated protective conductor shall be connected to the neutral of the test circuit. The foil screen shall only be connected to the test circuit via its contact with the uninsulated protective conductor. The nail shall only be connected to the recording instrumentation. The test sample shall be supported on a wooden base.

The timing circuit shall be so arranged as to achieve a fault duration of at least 1 s. The timing device shall be triggered at the initiation of the fault. The test circuit shall not include any overcurrent protection device that might interrupt the test current in less than 1 s.

A new 1.6 mm diameter steel nail shall be driven into the cable after the cable has been energized. The nail shall be driven into the cable by allowing a 900 g ±5% hammer to fall through a height of 400 mm ±5% on to an intermediate piece holding the nail.

NOTE The nail may be fitted in a chuck held in a sliding support above the cable sample.

The magnitude and duration of the current and the voltage between the nail and the uninsulated protective conductor shall be recorded.

On completion of the test, the sample shall be cut open and examined to determine whether the nail came into contact with the uninsulated protective conductor.

H.5 Results

The test results shall be classified according to the following criteria. Any test that is deemed to be invalid shall be discounted and the test repeated on a new sample of cable.

a) *Invalid*: the test shall be deemed to be invalid if any of the following occur:

- the nail misses the line conductor(s), hence no fault current flows;
- the nail hits a line conductor and the uninsulated protective conductor;

NOTE 1 In this event some of the fault current would flow directly to the protective conductor and it would not be a true test of the metallic screen.

- the fault current is interrupted in a period of less than 1 s and a voltage with a value of less than 25 V is measured on the nail.

NOTE 2 This would indicate that the point of the nail had burned away from the line conductor.

b) *Pass*: the sample shall be deemed to have passed the test for the selected current if the fault current is maintained for a period of not less than 1 s, and the value of voltage measured on the nail is less than 25 V.

c) *Fail*: the sample shall be deemed to have failed the test for the selected current if the fault current flows for a period of less than 1 s and the value of voltage measured on the nail is 25 V or greater.

NOTE 3 This would indicate that the metallic screen had burned away from the nail.

Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN 60811-1-4:1995, *Insulating and sheathing materials of electric cables – Common test methods – Part 1-4: General application – Tests at low temperature*

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