

BS 7889:2012



BSI Standards Publication

# Electric cables – Thermosetting insulated, non-armoured cables with a voltage of 600/1 000 V, for fixed installations

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## Contents

Foreword *ii*

1	Scope	1
2	Normative references	1
3	Terms and definitions	2
4	Rated voltage	3
5	Conductors	3
6	Insulation	3
7	Identification of cores	4
8	Laying up	5
9	Extruded optional inner covering	5
10	Sheath	6
11	Cable marking and additional information	6
12	Schedule of tests	8
13	Test conditions	9
14	Routine tests	10
15	Sample tests	10
16	Type tests	11

### Annexes

Annex A (informative)	Guide to use	16
Annex B (normative)	Compatibility test	19
Annex C (normative)	Abrasion test	20
Annex D (informative)	Notes on type tests	21
Annex E (normative)	Green-and-yellow measurement for shaped conductors	22

Bibliography 24

### List of figures

Figure 1	– An example of the marking as used on the outer sheath of the cable	7
Figure E.1	– Measurement of green-and-yellow for shaped conductors	23

### List of tables

Table 1	– Schedule of tests	9
Table 2	– Single-core 600/1 000 V cables with circular stranded copper conductor	12
Table 3	– Two-core 600/1 000 V cables with stranded copper conductors	13
Table 4	– Three-core 600/1 000 V cables with stranded copper conductors	14
Table 5	– Four-core 600/1 000 V cables with stranded copper conductors	15
Table 6	– Five-core 600/1 000 V cables with stranded copper conductors	15
Table A.1	– Minimum installation radius	18
Table B.1	– Compatibility requirements	20
Table C.1	– Vertical load requirements	20

### Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 24, an inside back cover and a back cover.

## Foreword

### Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 October 2012. 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 these committees can be obtained on request to their secretary.

### Supersession

This British Standard supersedes BS 7889:1997, which is withdrawn.

### Relationship with other publications

BS 7889 is related to but not equivalent to IEC 60502-1.

### 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 to include cables with two to five cores.
- b) The marking arrangements are updated and clarified.
- c) Test methods are updated to reflect the latest CENELEC harmonization.

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 50395 (replacing Annex E of BS 7889:1997) on electrical tests;
- BS EN 50396 (replacing Annex D of BS 7889:1997) on thickness measurement;
- BS EN 60332-1-2 (replacing BS EN 50265-2-1);
- BS EN 62230 (replacing BS EN 50356) on spark testing;
- IEC 60050-461 (replacing BS 4727-2-08).

In the preparation of BS 7889, GEL/20/17 has requested that references to other standards for which the committee is responsible are undated, even if referring to a specific clause. It is the committee's intention not to amend the fundamentals (e.g. clause numbers, material type designation) in any of these standards and so the latest edition applies.

**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 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 of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is “shall”.

*Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.*

**Contractual and legal considerations**

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

**Compliance with a British Standard cannot confer immunity from legal obligations.**



## 1 Scope

This British Standard specifies requirements and test methods for the construction and performance of non-armoured cables with thermosetting insulation of rated voltages 600/1 000 V. Cables specified in this British Standard are intended for use in fixed installations in industrial areas, buildings and similar applications but not for burial in the ground, either directly or in ducts.

The cables specified in the standard are all stranded copper conductor, thermosetting insulated, PVC sheathed types. There are single-core types, and multi-core types (2-, 3-, 4- and 5-core).

The insulation and other components are suitable to permit operation of the cables at a maximum sustained conductor temperature of 90 °C and for a maximum short-circuit conductor temperature of 250 °C (for a maximum period of 5 s).

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

*NOTE 2 In installations that include wiring accessories, junction boxes and consumer units, etc., the performance of these accessories should be taken into account in deciding the maximum operating temperature of the cable.*

*NOTE 3 Annex A gives guidance on the use of these cables, Annex B gives the compatibility test, Annex C gives the abrasion test, Annex D gives notes on type tests and Annex E gives green-and-yellow measurement for shaped conductors.*

## 2 Normative references

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

BS 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 7655-4.2, *Specification for insulating and sheathing materials for cables – Part 4: PVC sheathing compounds – Section 4.2: General application*

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

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

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

BS EN 60228, *Conductors of insulated cables*

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

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

BS EN 60811-401, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 401: Miscellaneous tests – Thermal ageing methods – Ageing in an air oven*

BS EN 60811-501, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds*

BS EN 60811-502, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 502: Mechanical tests – Shrinkage test for insulation*

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

IEC 60050-461, *International Electrotechnical Vocabulary – Part 461: Electric cables*

### 3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in IEC 60050-461 and the following apply.

#### 3.1 cable manufacturer

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

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

#### 3.2 length of lay

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

#### 3.3 routine tests, R

tests made on all production cable lengths to demonstrate their integrity

#### 3.4 sample tests, S

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

#### 3.5 type tests, T

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

*NOTE* 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 materials, design or type of manufacturing process, which might change the performance characteristics.

#### 3.6 values

##### 3.6.1 approximate value

value which is only indicative

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

##### 3.6.2 nominal value

value by which a quantity is designated

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



### 3.7 voltages

#### 3.7.1 maximum voltage, $U_m$

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

#### 3.7.2 rated voltage, $U_0$

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

#### 3.7.3 rated voltage, $U$

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

## 4 Rated voltage

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

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

The maximum designated voltage ( $U_m$ ) for the purposes of this standard for 600/1 000 V cable shall be 1 200 V.

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

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

## 5 Conductors

The conductors shall be annealed copper as given in Table 2 to Table 6 inclusive, and shall conform to the requirements of BS EN 60228, Class 2.

*NOTE The category of test for this requirement, and for all others in this standard, is shown in Table 1, "Schedule of tests".*

## 6 Insulation

### 6.1 Type of insulation

The insulation shall be type GP 8 conforming to BS 7655-1.3, or type GP 6 conforming to BS 7655-1.2, or type EI 5 conforming to BS EN 50363-5.

### 6.2 Application

The insulation shall be applied by an 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, the complete insulation shall be tested as though it were a single layer.

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

The manufacturer shall have the option to apply a tape or tapes over the conductor or insulation. These tapes shall not be included as part of the insulation.

It shall be possible to remove the insulation easily without damage to the insulation itself or to the conductor.

### 6.3 Thickness of insulation

The mean value of the radial thickness of the insulation, when measured in accordance with BS EN 50396, 4.1, shall be not less than the value given in Table 2 to Table 6. The smallest value measured,  $t_m$ , shall not fall below 90% of the value given in Table 2 to Table 6 by more than 0.1 mm, i.e.:

$$t_m \geq 0.9t_n - 0.1$$

where:

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

$t_n$  is the tabulated radial thickness, in millimetres (mm).

## 7 Identification of cores

### 7.1 General

The cores of all cables shall be identified by colour. 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 Alternatively, green-and-yellow, blue, brown
Four-core	Blue, brown, black, grey Alternatively, green-and-yellow, brown, black, grey
Five-core	Green-and-yellow, blue, brown, black, grey

*NOTE* Depending on their intended use, the cables might be subject to the core colour requirements specified in BS 7671 or other standards, or in statutory requirements.

The colour shall be applied throughout either the insulation or the outer cohesive layer, and shall be applied as part of the extrusion process.

The insulation of the coloured cores, irrespective of the method of colouring, shall be tested as a complete single layer (see 6.2).

Conformity shall be checked by visual examination.

### 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 not less than 30% and at most 70% of the surface of the core, while the other colour shall cover the remainder of the surface. Conformity shall be checked by measurement.

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

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

### 7.3 Clarity and durability

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

## 8 Laying up

The cores of cables having two, three, four or five cores shall be laid up with a right-hand or right-hand-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.

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

Conformity shall be checked by the test method given in 15.4.

If necessary, the formation of a compact and reasonably circular cable shall be achieved by one of the following methods.

- a) The application of synthetic fillers or binder tape(s).
- b) The optional inner covering (see Clause 9).
- c) The sheath (see Clause 10) provided it effectively fills the interstices.
- d) Any combination of the above.

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

Conformity shall be checked visually.

## 9 Extruded optional inner covering

*NOTE 1 The manufacturer has the option to include or not include an inner covering.*

The optional inner covering, where used, shall consist of an extruded layer of synthetic polymeric material compatible with the operating temperature of the cable. It shall surround the single core and the laid-up two, three, four or five cores, giving the assembly a practically circular shape. The inner covering shall not adhere to the cores.

*NOTE 2 For information, an approximate value of thickness of the inner covering is given in Table 2 to Table 6.*

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

*NOTE 3 The manufacturer may apply a tape or tapes over the optional extruded inner covering.*

## 10 Sheath

### 10.1 General

The sheath shall be an extruded layer of PVC material conforming to the requirements for Type 9 specified in BS 7655-4.2.

*NOTE Sheaths are normally black and, when properly formulated and compounded, this provides good resistance to deterioration from outdoor exposure to light. Sheaths where the black is only in an outer cohesive layer, or sheaths with colours other than black, can be provided by agreement between the manufacturer and the purchaser but, unless such sheaths also include additives to protect the cable from UV, the cables are not suitable for all exposure conditions.*

### 10.2 Application

The sheath shall be applied in a single layer:

- a) to the core of the single core cables and inner covering (if any);
- b) to the assembly of cores with inner covering;
- c) to the assembly of cores without inner covering.

The sheath shall be capable of being removed without damage to the core(s).

Conformity shall be checked visually.

### 10.3 Thickness of sheath

When measured in accordance with BS EN 50396, 4.2, the smallest value,  $t_m$ , of the radial thickness of the sheath shall not fall below 85% of the value given in Table 2 to Table 6 by more than 0.1 mm, i.e.:

$$t_m \geq 0.85t_n - 0.1$$

where:

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

$t_n$  is the tabulated radial thickness, in millimetres (mm).

## 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	600/1 000 V

- d) British Standard number                      BS 7889 <sup>1)</sup>  
 e) Number of cores and nominal area of conductor    4 × 70 <sup>2)</sup>  
 f) Year of manufacture                              ZZZZ

*NOTE 4* The year of manufacture may take the form of the actual year (e.g. 2013) or a coded year identifier assigned by the manufacturer.

- g) Standard core colour identifier                H

*NOTE 5* See 11.2.

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

For cables with overall diameters greater than 15 mm, items a) to d) inclusive 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 e), f) and g) shall appear on either one of the primary lines, or on a secondary line or lines, in any sequence that is deemed neither to confuse nor conflict.

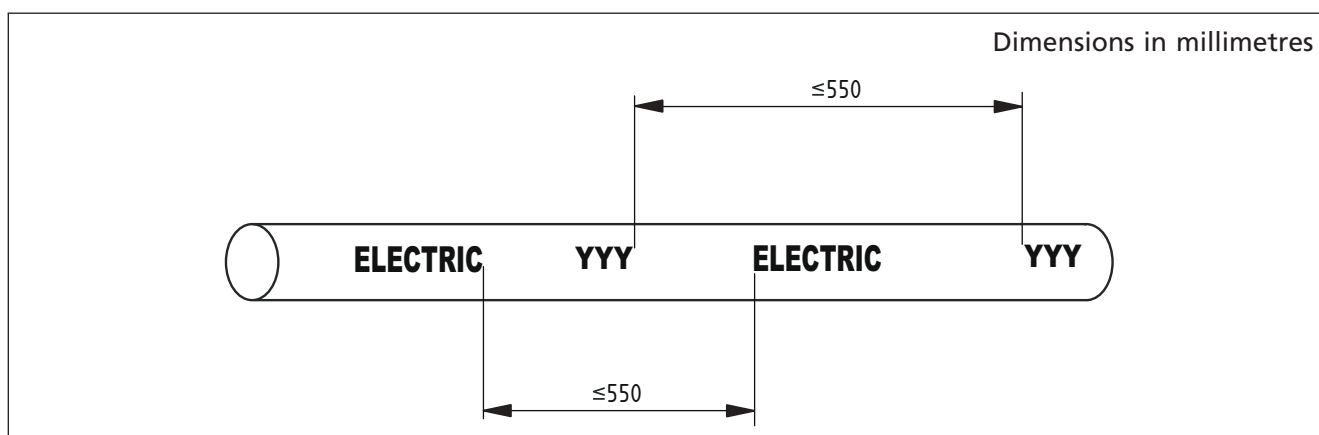
For cables with overall diameters up to and including 15 mm, items a) to g) inclusive shall appear, in any sequence that is deemed neither to confuse nor conflict, on one or more primary lines along the axis of the cables. Where more than one line is used, they shall be approximately equally spaced around the circumference of the cable.

*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 this subclause.

The letters and figures shall consist of upright block characters.

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



<sup>1)</sup> Marking BS 7889 or BS 7889:2012 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.

<sup>2)</sup> 4 × 70 indicates a four-core cable with 70 mm<sup>2</sup> conductors.

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 7.1, 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 or indented 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.

### 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.

Where the information is applied by printing, it shall be durable so that it cannot be removed when tested in accordance with BS EN 50396, 5.1.

## 12 Schedule of tests

The tests to be performed on cables specified in this British Standard shall be as scheduled in Table 1, 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).

Table 1 Schedule of tests

Test	Requirements given in clause	Test method	Test category
Conductor construction	Clause 5	BS EN 60228	S
Insulation:			
• material	6.1	BS 7655-1.3 or BS 7655-1.2 or BS EN 50363-5	T
• application	6.2	Visual examination	S
• thickness	6.3	BS EN 50396, 4.1	S
Core identification:			
• colours	7.1, 7.2	Visual examination	S
• clarity and durability	7.3	BS EN 60396, 5.1	S
Laying-up:			
• direction and sequence of lay	Clause 8	Visual examination	S
• length of lay of assembled cores	Clause 8	15.4	S
• fillers and binders	Clause 8	Visual examination	S
Inner covering application (if present)	Clause 9	Visual examination	S
Sheath:			
• material	10.1	BS 7655-4.2	T
• application	10.2	Visual examination	S
• thickness	10.3	BS EN 50396, 4.2	S
Cable marking	Clause 11	Visual examination and measurement	S
Durability of printed information	11.4	BS EN 50396, 5.1	T
Conductor resistance	14.2	BS EN 60228	R
Check the absence of faults on the insulation:			
• single core	14.3.1	BS EN 62230, BS 5099	R
• multi-core	14.3.2	BS EN 50395	R
Flame propagation on single cable	15.2	BS EN 60332-1-2	S
Ovality	15.3	BS EN 50396	S
Compatibility	16.2	Annex B	T
Shrinkage test on insulation	16.3	BS EN 60811-502	T
Abrasion	16.4	Annex C	T

NOTE 1 Tests classified as sample (S) or 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.

## 13 Test conditions

### 13.1 Temperature

Tests shall be performed at a temperature of  $(20 \pm 15)$  °C unless otherwise specified in the details for the particular test.

### 13.2 Frequency and waveform of power frequency test voltages

The frequency of the alternating test voltages shall be in the range of 49 Hz to 61 Hz, unless otherwise specified in the particular test. The waveform shall be substantially sinusoidal.

## 14 Routine tests

*COMMENTARY ON Clause 14*

*In some tests, the preparation and presentation of the test sample can have a critical effect on the result of the tests, so test samples should always be prepared carefully.*

### 14.1 General

Routine tests shall be performed in accordance with Table 1 as indicated by the symbol "R" in Column 4.

*NOTE The requirements for routine testing which are not fully covered by earlier clauses are detailed in 14.2 and 14.3.*

### 14.2 Conductor resistance

The d.c. resistance of each conductor shall conform to BS EN 60228 when measured in accordance with BS EN 60228 and corrected to 20 °C. The measurement shall be made on a complete drum length or on a 1 m sample taken from the drum.

### 14.3 Test to check the absence of faults on the insulation

#### 14.3.1 Test for single core cable

The completed single core cable shall be tested in accordance with the a.c. or d.c. test method in BS EN 62230 at the test voltage stated in BS 5099, 5.3 (insulation and sheath combined) and there shall be no breakdown of the insulation or sheath.

#### 14.3.2 Test for multi-core cable

The completed multi-core cable shall be tested in accordance with BS EN 50395, 10.3, having a test voltage of 3 500 V a.c. r.m.s. for 5 min, and there shall be no breakdown of the insulation.

## 15 Sample tests

*COMMENTARY ON Clause 15*

*In some tests, the preparation and presentation of the test sample can have a critical effect on the result of the tests, so test samples should always be prepared carefully.*

### 15.1 General

Sample tests shall be performed in accordance with Table 1, as indicated by the symbol "S" in Column 4.

*NOTE The requirements for sample testing which are not fully covered by earlier clauses are detailed in 15.2, 15.3 and 15.4.*

### 15.2 Flame propagation on single cable

When tested in accordance with BS EN 60332-1-2, the sample of completed cable shall conform to BS EN 60332-1-2:2004, Annex A.



### 15.3 Ovality

The difference between any two values of the overall diameter of circular sheathed cables at the same cross-section shall not exceed 15% of the mean of the six diameter values obtained when tested in accordance with BS EN 50396, 4.4.

A test sample shall be taken from a cable from three places, separated by at least 1 m.

Two measurements shall be taken at the same cross-section of the cable, covering the maximum and minimum values.

### 15.4 Length of lay

The length of lay shall be determined by measuring the length of two pitches of a sample and dividing this length by 2. If the cores of the cable have been laid up using the right-hand-left-hand alternating direction method, only the right-hand or left-hand portion of the laid-up cores shall be used (i.e. not the transition between directions of lay). The result shall be taken as the length of lay of the laid-up cores.

## 16 Type tests

### COMMENTARY ON Clause 16

*In some tests, the preparation and presentation of the test sample can have a critical effect on the result of the tests, so test samples should always be prepared carefully.*

### 16.1 General

Type tests shall be performed in accordance with Table 1, as indicated by the symbol "T" in Column 4. (See also Annex D.)

*NOTE The requirements for type testing which are not fully covered by earlier clauses are detailed in 16.2 to 16.4.*

### 16.2 Compatibility

When a sample of complete cable is tested in accordance with Annex B, the insulation and sheath shall conform to the requirements given in Table B.1. In addition, at the end of the test period in the oven, the blotting paper shall be free of stains.

### 16.3 Shrinkage of insulation

When a 200 mm sample of core is tested at  $(130 \pm 2)$  °C for 1 h in accordance with BS EN 60811-502, the shrinkage of the insulation shall not exceed 4%.

The test shall be performed on all cables. Each core in a cable shall be tested.

### 16.4 Abrasion resistance

When a sample of the complete cable is tested in accordance with Annex C, the sheath shall be deemed to be satisfactory provided that, following the test, examination of the sample without magnification reveals no cracks or splits in the internal and external surfaces.

Table 2 Single-core 600/1 000 V cables with circular stranded copper conductor

Nominal cross-sectional area of conductor <sup>A)</sup> mm <sup>2</sup>	Radial thickness of insulation mm	Approximate thickness of inner covering mm	Radial thickness of sheath mm
1.5	0.7	0.4	1.4
2.5	0.7	0.4	1.4
4	0.7	0.4	1.4
6	0.7	0.4	1.4
10	0.7	0.4	1.4
16	0.7	0.4	1.4
25	0.9	0.4	1.4
35	0.9	0.4	1.4
50	1.0	0.6	1.4
70	1.1	0.6	1.4
95	1.1	0.6	1.5
120	1.2	0.8	1.5
150	1.4	0.8	1.6
185	1.6	0.8	1.6
240	1.7	1.0	1.7
300	1.8	1.0	1.8
400	2.0	1.2	1.9
500	2.2	1.2	2.0
630	2.4	1.4	2.2
800	2.6	1.6	2.3
1 000	2.8	1.6	2.4

<sup>A)</sup> Circular or compacted circular stranded conductor (Class 2).

Table 3 Two-core 600/1 000 V cables with stranded copper conductors

Nominal cross-sectional area of conductor mm <sup>2</sup>	Radial thickness of insulation mm	Approximate thickness of inner covering mm	Radial thickness of sheath mm
1.5 <sup>A)</sup>	0.7	0.4	1.8
2.5 <sup>A)</sup>	0.7	0.4	1.8
4 <sup>A)</sup>	0.7	0.4	1.8
6 <sup>A)</sup>	0.7	0.4	1.8
10 <sup>A)</sup>	0.7	0.6	1.8
16 <sup>A)</sup>	0.7	0.6	1.8
25 <sup>A)</sup>	0.9	0.8	1.8
35 <sup>A)</sup>	0.9	0.8	1.8
50 <sup>A)</sup>	1.0	1.0	1.8
70 <sup>A)</sup>	1.1	1.0	1.8
95 <sup>A)</sup>	1.1	1.2	1.9
120 <sup>A)</sup>	1.2	1.2	2.0
25 <sup>B)</sup>	0.9	0.6	1.8
35 <sup>B)</sup>	0.9	0.6	1.8
50 <sup>B)</sup>	1.0	0.8	1.8
70 <sup>B)</sup>	1.1	0.8	1.8
95 <sup>B)</sup>	1.1	1.0	1.9
120 <sup>B)</sup>	1.2	1.0	2.0

<sup>A)</sup> Circular or compacted circular stranded conductor (Class 2).

<sup>B)</sup> Shaped stranded conductor (Class 2).

Table 4 Three-core 600/1 000 V cables with stranded copper conductors

Nominal cross-sectional area of conductor mm <sup>2</sup>	Radial thickness of insulation mm	Approximate thickness of inner covering mm	Radial thickness of sheath mm
1.5 <sup>A)</sup>	0.7	0.4	1.8
2.5 <sup>A)</sup>	0.7	0.4	1.8
4 <sup>A)</sup>	0.7	0.4	1.8
6 <sup>A)</sup>	0.7	0.4	1.8
10 <sup>A)</sup>	0.7	0.6	1.8
16 <sup>A)</sup>	0.7	0.6	1.8
25 <sup>A)</sup>	0.9	0.8	1.8
35 <sup>A)</sup>	0.9	0.8	1.8
50 <sup>A)</sup>	1.0	1.0	1.8
70 <sup>A)</sup>	1.1	1.2	1.9
95 <sup>A)</sup>	1.1	1.2	2.0
120 <sup>A)</sup>	1.2	1.2	2.1
25 <sup>B)</sup>	0.9	0.6	1.8
35 <sup>B)</sup>	0.9	0.8	1.8
50 <sup>B)</sup>	1.0	0.8	1.8
70 <sup>B)</sup>	1.1	1.0	1.9
95 <sup>B)</sup>	1.1	1.2	2.0
120 <sup>B)</sup>	1.2	1.2	2.1

<sup>A)</sup> Circular or compacted circular stranded conductor (Class 2).

<sup>B)</sup> Shaped stranded conductor (Class 2).

Table 5 Four-core 600/1 000 V cables with stranded copper conductors

Nominal cross-sectional area of conductor mm <sup>2</sup>	Radial thickness of insulation mm	Approximate thickness of inner covering mm	Radial thickness of sheath mm
1.5 <sup>A)</sup>	0.7	0.4	1.8
2.5 <sup>A)</sup>	0.7	0.4	1.8
4 <sup>A)</sup>	0.7	0.4	1.8
6 <sup>A)</sup>	0.7	0.6	1.8
10 <sup>A)</sup>	0.7	0.6	1.8
16 <sup>A)</sup>	0.7	0.6	1.8
25 <sup>A)</sup>	0.9	0.8	1.8
35 <sup>A)</sup>	0.9	1.0	1.8
50 <sup>A)</sup>	1.0	1.0	1.8
70 <sup>A)</sup>	1.1	1.2	2.0
95 <sup>A)</sup>	1.1	1.2	2.1
120 <sup>A)</sup>	1.2	1.2	2.3
25 <sup>B)</sup>	0.9	0.8	1.8
35 <sup>B)</sup>	0.9	0.8	1.8
50 <sup>B)</sup>	1.0	1.0	1.8
70 <sup>B)</sup>	1.1	1.2	2.0
95 <sup>B)</sup>	1.1	1.2	2.1
120 <sup>B)</sup>	1.2	1.2	2.3

<sup>A)</sup> Circular or compacted circular stranded conductor (Class 2).

<sup>B)</sup> Shaped stranded conductor (Class 2).

Table 6 Five-core 600/1 000 V cables with stranded copper conductors

Nominal cross-sectional area of conductor <sup>A)</sup> mm <sup>2</sup>	Radial thickness of insulation mm	Approximate thickness of inner covering mm	Radial thickness of sheath mm
1.5	0.7	0.4	1.8
2.5	0.7	0.4	1.8
4	0.7	0.6	1.8
6	0.7	0.6	1.8
10	0.7	0.6	1.8
16	0.7	0.8	1.8
25	0.9	1.0	1.8
35	0.9	1.0	1.8
50	1.0	1.2	1.9
70	1.1	1.2	2.1
95	1.1	1.4	2.2
120	1.2	1.4	2.4

<sup>A)</sup> Circular or compacted circular stranded conductor (Class 2).

**Annex A  
(informative)****Guide to use**

*NOTE* The details given in this annex are intended only as general technical guidance and not as interpretation of any UK statutory regulations.

**A.1 Aim**

The aim of this annex is to inform users of characteristics and limitations of electric cables and thereby to minimize their misuse.

It is assumed that the design of installations and the specification, purchase and installation of cables specified in this British Standard is entrusted to suitably skilled and competent people.

In cases of doubt as to the suitability of cables for a particular use, further specific information should be obtained from the manufacturer.

**A.2 General**

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

*NOTE 1* 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 2002 [1], as appropriate.

*NOTE 2* Attention is drawn to the fact that in countries outside the UK, corresponding national regulations might apply.

In special environments, the appropriate regulations and codes of practice should be observed.

Cables supplied in accordance with this British Standard are intended for installation in air (which includes installation in conduit or other closed system). The cables are not suitable for either direct burial in the ground or installation within cable ducts that are buried in the ground. When cables are to be installed in any other environment, reference should be made to the cable manufacturer.

**A.3 Maximum operating, short circuit and overload temperatures**

The cables are suitable for use where the combination of ambient temperature and temperature rise due to load results in a conductor temperature not exceeding 90 °C. In the case of short circuit, the maximum allowable time is 5 s and the maximum conductor temperature should not exceed 250 °C. In the case of overload, the maximum allowable time is 4 h and the maximum conductor temperature should not exceed 156 °C. Repeated short circuits and overloads can potentially damage the cable and lead to premature failure.

The operating, short-circuit and overload temperatures are based on the intrinsic properties of the insulating material.

The accessories that are used in the cable system with mechanical and/or soldered connections should be:

- a) suitable for the temperature adopted for the cable; and
- b) able to accommodate a cable conductor operating temperature of 90 °C.

## A.4 Voltage ratings

The rated voltage of the cable for a given application should be suitable for the operating conditions in the system in which the cable is used. To facilitate the selection of the cable, systems are divided into three categories as follows.

- Category A, which comprises those systems in which any phase conductor that comes in contact with earth, or an earth conductor, is disconnected from the system within 1 min.
- Category B, which comprises those systems that, under fault conditions, are operated for a short time with one phase earthed. This period, according to IEC 60183, should not exceed 1 h. For cables specified in this British Standard, a longer period, not exceeding 8 h on any occasion, can be tolerated. The total duration of earth faults in any year should not exceed 125 h.
- Category C, which comprises all systems that do not fall into categories A and B.

*NOTE* In a system where an earth fault is not automatically and promptly isolated, the extra stresses on the insulation of cables during the earth fault reduce the life of the cables to a certain degree. If the system is expected to be operated fairly often with a permanent earth fault, it might be advisable to classify the system into a higher category.

For system categories A, B or C, the cables in this specification are suitable for the following nominal and maximum system voltages. The nominal system voltage,  $U$ , is 1 000 V and is the nominal voltage between phases. The maximum sustained system voltage,  $U_m$ , is 1 200 V and is the highest voltage between phases that can be sustained under normal operating conditions at any time and at any point in the system. It excludes transient voltage variations, due, for example, to lightning impulses, fault conditions and rapid disconnection of loads.

These cables are suitable for operation for d.c. systems operating at a maximum of 900 V to earth and a maximum of 1 800 V between conductors. However, consideration should be given to the peak value when determining the voltage of a d.c. system derived from rectifiers, bearing in mind that smoothing does not modify the peak value when the rectifiers are operating on an open circuit.

## A.5 Cable selection and system design

**A.5.1** The products specified in this British Standard are intended for fixed installations and to be used for the supply of electrical energy up to the rated voltage indicated on the cable. Subclause **A.4** classifies the voltage ratings of cables manufactured in accordance with this specification. These ratings should not be exceeded.

**A.5.2** These cables are intended for use within a nominal power frequency range of 49 Hz to 61 Hz.

**A.5.3** For current ratings of cables installed in and around buildings, reference should be made to BS 7671.

**A.5.4** In addition to the current ratings, due regard should be given to:

- a) the capability of the cable to withstand the worst anticipated fault and overload condition of the system;
- b) the earth loop impedance;
- c) the operating characteristics of the connected equipment;
- d) the voltage drop requirements during normal load or motor starting conditions.

**A.5.5** The possible effects of transient over-voltages should be recognized as they can be detrimental to cables.

**A.5.6** If selected in place of an armoured cable, the system designer should take into account the electromagnetic compatibility requirements of his system.

## **A.6 Environment and application**

**A.6.1** Reasonable protection against mechanical damage, appropriate to the choice of cable and the installation conditions, should be provided.

**A.6.2** Cables could be harmed by exposure to corrosive products or solvent substances, especially petroleum-based chemicals or their vapours.

**A.6.3** Special precautions are required when cables are to be installed in areas classified as hazardous, e.g. potentially explosive gas atmospheres. Reference should be made to BS EN 60079-14.

**A.6.4** If cables in accordance with this specification are exposed to localized heat, solar radiation or high temperature ambient conditions, the current carrying capacity will be reduced.

**A.6.5** The standard sheathing compounds supplied on these cables do not provide protection against damage by rodents, termites, etc.

**A.6.6** Care should be taken as loaded cables have surface temperatures which require protection against accidental contact.

## **A.7 Installation**

### **A.7.1 General**

Cables specified in this British Standard are designed for use in fixed installations in industrial areas, buildings and similar applications. The cables are not suitable for either direct burial in the ground or installation within cable ducts that are buried in the ground. They are designed for fixed installations only, i.e. they are not to be used where they are subject to flexing.

### **A.7.2 Minimum temperature during installation**

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

### **A.7.3 Minimum installation radius**

None of the cables specified in this standard should be bent during installation to a radius smaller than that given in Table A.1.

Table A.1 **Minimum installation radius**

<b>Construction (cables with)</b>	<b>Minimum internal radius of bend</b>
Circular copper conductors (overall cable diameter less than or equal to 25 mm)	4D
Circular copper conductors (overall cable diameter greater than 25 mm)	6D
Shaped copper conductors	8D

**NOTE** *D is the measured overall diameter of the cable.*

Wherever possible, larger installation radii should be used.



#### A.7.4 Preventing damage to cables

Precautions should be taken to avoid mechanical damage to the cables before and during installation.

Exceeding the manufacturer's recommended maximum pulling tensions could result in damage to the cable.

The cable support system should be such as to avoid damage or danger under normal or fault conditions with fixings conforming to BS EN 61914 or ties conforming to BS EN 62275.

#### A.7.5 Selection of cable glands, accessories and associated tools

The selection of cable glands, accessories and any associated tools should take account of all aspects of intended use.

*NOTE The cables are not suitable for either direct burial in the ground or installation within cable ducts that are buried in the ground.*

Cable glands, when used, should conform to BS EN 50262.

Cable joints, when used, should conform to BS EN 50393.

#### A.7.6 Preventing premature failure of the cable

Care should be taken as repeated voltage testing after installation can lead to premature failure of the cable.

#### A.8 Storage and handling of drums

**A.8.1** Cable drums should be regularly inspected during storage to assess their physical condition.

**A.8.2** Battens, where applied, should not be removed from drums until the cable is about to be installed.

**A.8.3** When handling drums, reasonable precautions should be taken to avoid injury. Due regard should be paid to the weight, method and direction of rolling, lifting, protruding nails and splinters.

**A.8.4** Care should be taken to avoid deterioration of drums or their becoming a hazard to the general public.

*NOTE A detailed guide to the safe handling of cable drums is given in BS 8512.*

#### A.9 Waste and scrap cable

Waste and scrap cable should be recycled. This should be carried out by contractors with appropriate waste licenses issued by the authorizing agencies (e.g. Environment Agency, Scottish Environmental Protection Agency, etc).

### Annex B (normative)

## Compatibility test

### B.1 General

This test determines whether the insulation and sheath are likely to deteriorate due to contact with the other components in the cable.

### B.2 Procedure

**B.2.1** Prepare a test sample by ageing it in an air oven in accordance with BS EN 60811-401, 4.2.3.4, for 7 days at  $(100 \pm 2)$  °C. A sheet of clean white blotting paper shall be placed under each test sample in the oven during the ageing to detect any exudation that might drip from the cable.

**B.2.2** After completion of the ageing test, the tensile strength and the elongation at break for insulation and sheath shall conform to the requirements stated in Table B.1 when measured in accordance with BS EN 60811-501.

Table B.1 Compatibility requirements

Component	Test	Requirement			
		GP 8	GP 6	EI 5	Type 9
Insulation	Minimum tensile strength (N/mm <sup>2</sup> )	12.5	8.5	—	—
	Minimum percentage elongation at break	200	200	—	—
	Maximum percentage variation <sup>A)</sup> of tensile strength	±25	±30	±30	—
	Maximum percentage variation <sup>A)</sup> of elongation at break	±25	±30	±30	—
Sheath	Minimum tensile strength (N/mm <sup>2</sup> )	—	—	—	12.5
	Minimum percentage elongation at break	—	—	—	150
	Maximum percentage variation <sup>A)</sup> of tensile strength	—	—	—	±25
	Maximum percentage variation <sup>A)</sup> of elongation at break	—	—	—	±25

<sup>A)</sup> The variation is the difference between the respective values obtained prior to and after heat treatment, expressed as a percentage of the former.

## Annex C (normative)

### Abrasion test

#### C.1 General

This test shall demonstrate the abrasion resistance of the complete cable.

#### C.2 Test method

A sample of the complete cable shall be tested in accordance with BS EN 60229, 4.1.2.1, at the vertical load stated in Table C.1.

Table C.1 Vertical load requirements

Overall measured diameter of cable		Force
Greater than or equal to mm	Less than mm	N
—	10	10
10	20	15
20	30	35
30	40	65
40	50	105
50	60	155
60	70	210
70	80	270

## Annex D (informative)

### Notes on type tests

#### D.1 General

Type tests, after they have been completed, need not be repeated unless changes have been made that affect conformity to the test requirements. This means that type tests should not normally be required on cables for any individual contracts provided that such type tests have already been successfully performed by the manufacturer.

Subclauses **D.2**, **D.3** and **D.4** give guidance as to the amount of type testing that might reasonably be required.

#### D.2 Sample selection for type tests

For the type tests on finished cable, conformity to the requirements should be confirmed for the complete range of cables in this standard by selecting samples for test as follows:

- for single-core cables, the smallest and largest conductor size should be tested;
- for multi-core cable, the smallest conductor size with the smallest number of cores, and the largest conductor size with the largest number of cores should be tested.

In addition, where manufacturers wish to demonstrate conformity to this British Standard, the cable samples should be subjected to full dimensional checks and to all other sample (S) and routine (R) tests given in Table 1.

#### D.3 Type tests

##### D.3.1 Insulation material test (see 6.1)

One test should be performed for each grade of insulation material on any one cable from the range of cables selected.

##### D.3.2 Sheath material test (see 10.1)

One test should be performed on each size of cable selected.

##### D.3.3 Compatibility test (see 16.2)

One test should be performed on each size of cable selected.

##### D.3.4 Shrinkage test on insulation (see 16.3)

One test should be performed on each size of cable selected.

##### D.3.5 Length of lay (see 15.4)

*NOTE This test is classified as a sample test. The guidance given below applies to type testing.*

One test should be performed on each size of cable selected.

##### D.3.6 Abrasion test (see 16.4)

One test should be performed on each cable selected.

#### D.4 Change of material

The tests referred to in **D.3** assume that the materials are consistent throughout the range of cables for which conformity is to be confirmed. Where a change occurs, additional testing should be included to ensure that such changes are adequately examined.

## D.5 Evidence of type testing

When evidence of type testing is required, this should be stated at the enquiry stage. Because of the possible variations in cable designs, it should not be assumed that full type test information will be available for the size and type of cable of a particular enquiry.

A certificate of type test signed by the representative of a competent witnessing body, or a properly authorized report by the manufacturer giving the test results, should be acceptable.

### Annex E (normative)

## Green-and-yellow measurement for shaped conductors

### E.1 Procedure

Two samples of the green-and-yellow core, each approximately 100 mm in length, shall be taken at least 2 m one from the other.

Measure a 15 mm length from each of the samples and cut three sections of insulation perpendicular to the longitudinal axis of the conductor from each 15 mm test piece length, one from each end and one from the centre.

Place each cross-section into a video camera projection system and measure the following:

- a) the perimeter of the cross section,  $p$  (to the nearest mm);
- b) the length of all portions of the green colour at the surface of the insulation,  $p_n$ , where, in this example,  $p_n = p_1 + p_2 + p_3$  (to the nearest mm).

*NOTE* Figure E.1 shows the above for a closed cross-section and an open cross-section.

Use the following calculations to determine the percentage proportions of green ( $G$ ) and yellow ( $Y$ ).

$$G = [(p_n)/p] \times 100\%$$

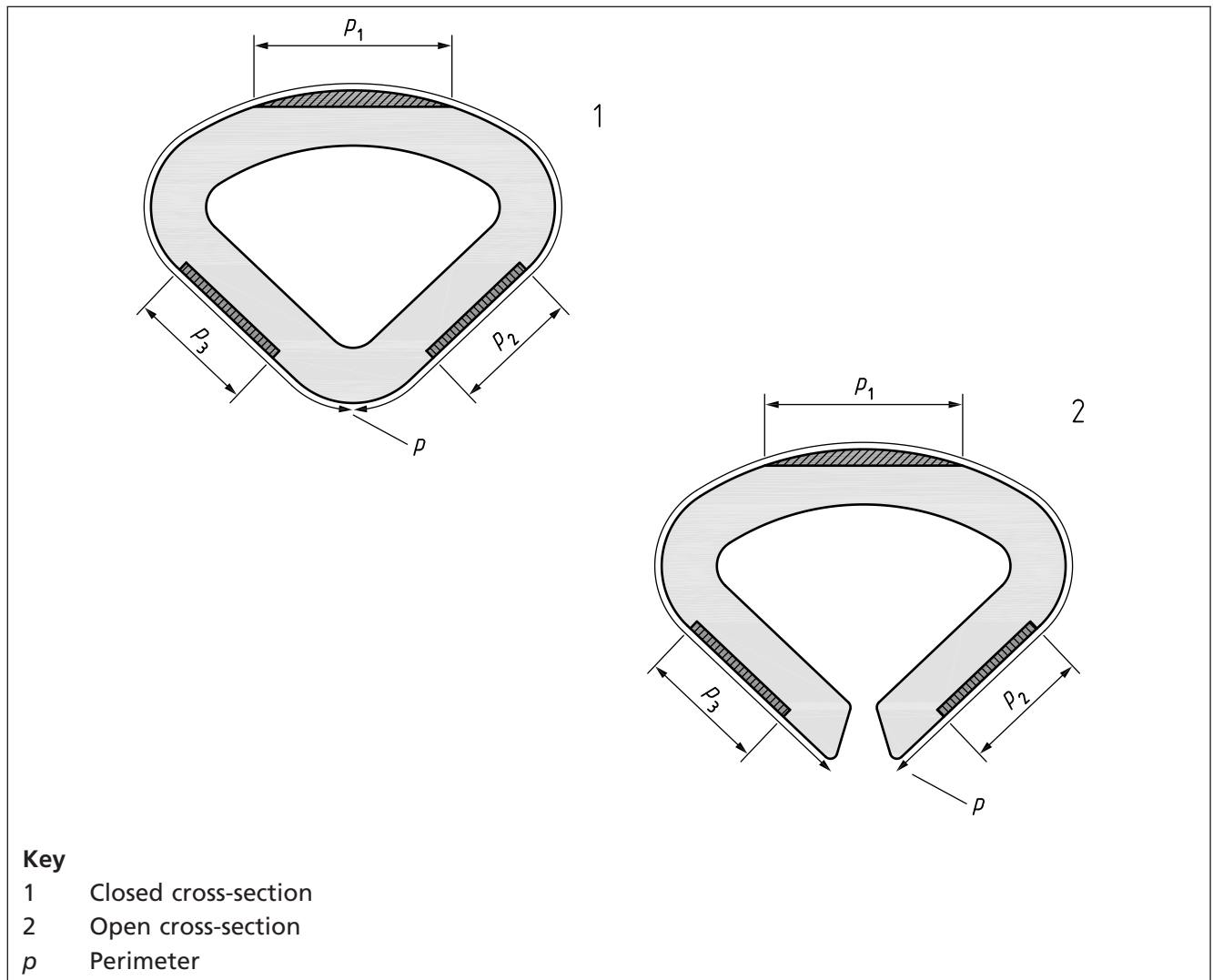
$$Y = (100 - G)\%$$

### E.2 Evaluation of results

Calculate the mean of the six measurements and round to the nearest integer.

The result shall be compared to the requirements specified in 7.2.

Figure E.1 Measurement of green-and-yellow for shaped conductors



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

BS 8512, *Electric cables – Code of practice for the storage, handling, installation and disposal of cables on wooden drums*

BS EN 50262, *Cable glands for electrical installations*

BS EN 50393, *Test methods and requirements for accessories for use on distribution cables of rated voltage 0,6/1,0 (1,2) kV*

BS EN 60079-14, *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*

BS EN 61914, *Cable cleats for electrical installations*

BS EN 62275, *Cable management systems – Cable ties for electrical installations*

IEC 60183, *Guide to the selection of high-voltage cables*

IEC 60502-1, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV ( $U_m = 1,2$  kV) up to 30 kV ( $U_m = 36$  kV) – Part 1: Cables for rated voltages of 1 kV ( $U_m = 1,2$  kV) and 3 kV ( $U_m = 3,6$  kV)*

### Other publications

[1] GREAT BRITAIN. The Electricity Safety, Quality and Continuity Regulations 2002. London: The Stationery Office.



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