BRITISH STANDARD

BS 6746:1990

Incorporating
Amendment No. 1

Specification for

PVC insulation and sheath of electric cables

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Cables and Insulation Standards Policy Committee (CIL/-) to Technical Committee CIL/20, upon which the following bodies were represented:

Aluminium Federation
Association of Consulting Engineers
Association of Manufacturers of Domestic Electrical Appliances
British Approvals Service for Electric Cables
British Cable Makers Confederation
British Plastics Federation
British Railways Board
British Steel Industry
British Telecommunications plc
Department of the Environment (Property Services Agency)
Department of Trade and Industry (Consumer Safety Unit, CA Division)
ERA Technology Ltd.
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
Institution of Electrical Engineers
London Regional Transport

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

Association of Supervisory and Executive Engineers
British Rubber Manufacturers' Association
GAMBICA (BEAMA Ltd.)
Queen Mary College Industrial Research

This British Standard, having been prepared under the direction of the Cables and Insulation Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on
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The following BSI references relate to the work on this standard:
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Amendments issued since publication

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Contents

Foreword

This new edition of BS 6746 has been prepared under the direction of the Cables and Insulation Standards Policy Committee and it supersedes BS 6746:1984, which is withdrawn.

This edition introduces technical changes but it does not reflect a full review or revision of the standard, which will be undertaken in due course.

This standard should be read in conjunction with BS 6469 which describes the test methods common to various electric cable materials and is referred to in British Standards for those materials.

The second edition of this standard was prepared to take account of CENELEC[1)] Harmonization Document HD 21. The third edition agreed with HD 21.S2 dated October 1982.

This edition incorporates amendments 1 and 2 (published September 1986 and February 1990) to BS 6746:1984 and introduces compound TI 4 which appears in amendment No. 4 (dated January 1989) to HD 21.1 S2. Differences in the text between this edition and BS 6746:1984 are indicated by a line in the margin.

Amendment No. 1 incorporates PVC type TI 3 compound to align with Amendment No. 2 to HD 21.1 S2.

The requirements for the various types of compound have been drafted such that compliance with them can be checked by testing samples taken from finished cables.

Attention is drawn to the certification services of the British Approvals Service for Electric Cables (BASEC)[2)]. These services include licensing manufacturers to use BASEC certification trade marks as independent assurance that cables or cords have been designed and manufactured to appropriate British Standards. BASEC is a subscriber to an agreement in CENELEC whereby cables or cords coming within Harmonized Code Designations and manufactured under a BASEC licence can carry marks acceptable to other signatory countries (CENELEC "Common marking").

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 6, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1) European Committee for Electrotechnical Standardization.

2) British Approvals Service for Electric Cables, Silbury Court, 360 Silbury Boulevard, Milton Keynes, Buckinghamshire MK9 2AF.

1 Scope

This British Standard specifies the physical and electrical requirements for the types of PVC insulation and sheath of electric cables given in Table 1. The relevant test methods for verification of compliance are given either in BS 6469 or in the appendices of this standard.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this British Standard the following definitions apply.

2.1
median value

when several test results have been obtained and ordered in an increasing or decreasing succession, the median value is the middle value if the number of available values is odd, and is the mean of the two middle values if the number is even

2.2
variation

the difference between the median value after ageing and the median value without ageing, expressed as a percentage of the latter

3 Composition

The insulation or sheath shall consist of a compound based on one of the following materials, suitably compounded and processed to comply with this standard:

a) polyvinyl chloride (PVC); or

b) a copolymer of vinyl chloride; or

c) a mixture of materials a) and b).

4 Colours

Opaque insulation and sheath shall be of a colour that reasonably matches one of the colours given in BS 6746C.

NOTE There is no requirement for the colour of transparent insulation and sheath.

5 Test requirements for physical and electrical properties

5.1 When tested by the methods specified in **5.2** and **5.3**, the properties of the insulation or sheath shall be in accordance with the requirements given in Table 2 or Table 3 for the particular type of material.

Table 1 — Types of insulation and sheath

Type	Maximum operating temperature	General application	
		Insulation	Sheath
	°C		
TI 1	70	General purpose	—
TM 1	70	—	For use over cables operating at a maximum conductor temperature of 80 °C
TI 2	70	Flexible (including transparent)	—
TM 2	70	—	General purpose flexible
TI 3	90	Heat resistant	—
TI 4	70	For installation at low temperatures	—
2	70	Hard	—
4	85	Flexible	Flexible
5	85	—	Hard
6	70	—	General purpose
7	70	—	Low temperature non-migratory for radio-frequency cables complying with BS 2316
8	70	—	Low temperature general purpose for radio-frequency cables complying with BS 2316
9	—	—	For use over cables operating at a maximum conductor temperature of 90 °C

Table 2 — Test requirements for compounds designated according to HD 21

Test	Requirements					
	Insulation				Sheath	
	TI 1	TI 2	TI 3	TI 4	TM 1	TM 2
Tensile properties of unaged test pieces						
Min. tensile strength, N/mm^2	12.5	10	15.0	12.5	12.5	10
Min. elongation at break, %	125	150	150	125	125	150
Low temperature bend test						
Temperature at which specimen shall not crack, °C	– 15 ± 2	– 15 ± 2	– 15 ± 2	– 40 ± 2	– 15 ± 2	– 15 ± 2
Low temperature elongation test						
Test temperature, °C	– 15 ± 2	– 15 ± 2	– 15 ± 2 [b]	– 40 ± 2	– 15 ± 2	– 15 ± 2
Min. elongation, %	20	20	20	20	20	20
Low temperature impact test						
Temperature at which specimen shall not crack, °C	– 15 ± 2	– 15 ± 2	—	– 40 ± 2	– 15 ± 2	– 15 ± 2
Accelerated ageing for specified period at specified temperature followed by loss of mass test						
Max. loss of mass, mg/cm^2, after ageing:						
7 days at 80 ± 2 °C	2.0	2.0	—	2.0	2.0	2.0
14 days at 115 ± 2 °C	—	—	1.5	—	—	—
Accelerated ageing for specified period at specified temperature followed by tensile strength and elongation at break test						
Number of days ageing	7	7	14	7	7	7
Ageing temperature, °C	80 ± 2	80 ± 2	135 ± 2	80 ± 2	80 ± 2	80 ± 2
Tensile strength after ageing:						
min. value, N/mm^2	12.5	10	15	12.5	12.5	10
max. variation, %	20	20	25	20	20	20
Elongation at break after ageing:						
min. value, %	125	150	150	125	125	150
max. variation, %	20	20	25	20	20	20
Pressure test at high temperature						
Test temperature, °C	80 ± 2	70 ± 2	90 ± 2	80 ± 2	80 ± 2	70 ± 2
Max. indentation, %[a]	50	50	50	50	50	50
Resistance to cracking						
Temperature at which specimen shall not crack, °C	150 ± 2	150 ± 2	150 ± 2	150 ± 2	150 ± 2	150 ± 2
Insulation resistance test						
Min. K value at 70 °C, MΩ·km	0.037	0.037	—	0.037	—	—
Min. K value at 90 °C, MΩ·km	—	—	0.037	—	—	—
Thermal stability test at 200 °C						
Min. value, minutes	—	—	240	—	—	—

NOTE A dash (—) indicates test not applicable.

[a] The value of 50 % is inseparable from the underlying principle of the formula and is the same for all materials. The severity of the test can be changed by variation of the factor k only (see BS 6469) without altering the value of 50 %.

[b] Currently only applicable to use of TI 3 on national types of cable with mean overall diameters exceeding 12.5 mm.

Table 3 — Test requirements for compounds designated according to this standard

Test	Requirements for insulation or sheath type:						
	2	4	5	6	7	8	9
Tensile strength and elongation at break test							
Min. tensile strength, N/mm^2	18.5	7.5	12.5	6	7.5	7.5	12.5
Min. elongation at break, %	125	150[a]	125	125	125	150	150
Low temperature bend test							
Temperature at which specimen shall not crack, °C	– 15 ± 2	– 20 ± 2	– 15 ± 2	– 15 ± 2	– 40 ± 2	– 40 ± 2	– 15 ± 2
Low temperature elongation test							
Test temperature, °C	– 15 ± 2	– 20 ± 2	– 15 ± 2	– 15 ± 2	– 40 ± 2	– 40 ± 2	– 15 ± 2
Min. elongation, %	20	20	20	20	20	20	20
Low temperature impact test							
Temperature at which specimen shall not crack, °C	—	—	—	—	–	—	– 15 ± 2
Accelerated ageing for specified period at specified temperature followed by loss of mass test							
Max. loss of mass, mg/cm^2, after ageing:							
7 days at 80 ± 2 °C	2.0	—	—	2.0	2.0	2.0	—
7 days at 100 ± 2 °C	—	—	—	—	—	—	1.5
10 days at 115 ± 2 °C	—	—	1.5	—	—	—	—
Accelerated ageing for specified period at specified temperature followed by tensile strength and elongation at break test							
Number of days ageing	—	7	10	—	—	—	7
Ageing temperature, °C	—	135 ± 2	135 ± 2	—	—	—	100 ± 2
Tensile strength after ageing:							
min. value, N/mm^2	—	—	12.5	—	—	—	12.5
max. variation. %	—	—	25	—	—	—	25
Elongation at break after ageing:							
min. percentage of unaged value, %	—	65	—	—	—	—	—
min. value, %	—	—	125	—	—	—	150
max. variation from unaged value, %	—	—	25	—	—	—	25
Pressure test at high temperature							
Test temperature, °C	80 ± 2	90 ± 2	95 ± 2	80 ± 2	60 ± 2	60 ± 2	90 ± 2
Max. indentation, %[b]	50	50	50	50	50	50	50

Table 3 — Test requirements for compounds designated according to this standard

Test	Requirements for insulation or sheath type:						
	2	4	5	6	7	8	9
Hot deformation test Max. deformation, %	30[c]	65[c]	30[c]	65[c]	65[c]	65[c]	40[c]
Resistance to cracking Temperature at which specimen shall not crack, °C	150 ± 2	150 ± 2	150 ± 2	150 ± 2	100 ± 2	120 ± 2	150 ± 2
Insulation resistance constant test Min. *K* value at 20 °C, MΩ km	350	0.35	180	0.0035	0.0035	0.0035	0.0035
Colour fastness to daylight[d]	The perceived colour change shall not be poorer than grey scale 4 of method AO2C of BS 1006.						
Bleeding and blooming of colour[d]	No appreciable staining of PVC film or filter paper						

NOTE A dash (—) denotes test not applicable.

[a] 125 % for specified radial thickness up to and including 0.4 mm.

[b] The value of 50 % is inseparable from the underlying principle of the formula and is the same for all materials. The severity of the test can be changed by variation of the factor *k* only (see BS 6469), without altering the value of 50 %.

[c] Applicable only for specified radial thickness less than 0.4 mm.

[d] These tests apply only when requested by the purchaser. It is essential therefore for the purchaser to state at the time of enquiry or order he requires this testing to be done.

5.2 The tests for insulation and sheath designated according to HD 21.S2 shall be those printed in italic type in Table 2; the tests for insulation and sheath designated according to this standard shall be those printed in italic type in Table 3; the conditions of temperature, test duration, etc. shall be as specified in the appropriate table and the methods of sampling and of testing shall be as described in the appropriate clause of BS 6469:1990 or appendix of this standard, as stated below.

Test	Method
Tensile properties: tensile strength and elongation at break	**2.2** of BS 6469:1990
Low temperature bend, elongation and impact tests	**4.3** of BS 6469:1990
Accelerated ageing	**2.3** of BS 6469:1990
Loss of mass	**4.1** of BS 6469:1990
Pressure test at high temperature	**4.2** of BS 6469:1990
Hot deformation test	**4.5** of BS 6469:1990
Resistance to cracking (Heat shock test)	**4.4** of BS 6469:1990
Insulation resistance constant (*K* value)	Appendix A of this standard
Colour fastness to daylight	Appendix B of this standard
Bleeding and blooming of colour	Appendix C of this standard
Thermal stability test	**4.6** of BS 6469:1990

NOTE Attention is drawn to the fact that additional test to those called up in this standard may be required by cable specifications.

5.3 Unless otherwise stated in the British Standard for the particular cable, the tests on insulation shall be made on samples from each core if the cable has one, two or three cores, and on samples from three cores (of different colours, if any) if the cable has more than three cores.

The tests shall be carried out not less than 16 h after extrusion.

Appendix A Method of test for insulation resistance constant (*K* value)

A.1 Test on core for compounds types TI 1, TI 2, TI 3 and TI 4

Remove the sheath and any other covering or filling from a length of 5 m, taking care not to damage the insulation. Immerse the core in water for 2 h at a temperature of 70 ± 2 °C, 90 ± 2 °C for TI 3 a length of about 250 mm at each end of the core projecting above the water. Apply a voltage between 300 V and 500 V d.c. between the conductor and the water. Measure the insulation resistance 1 min after the application of the voltage.

Calculate the insulation resistance constant (*K* value) from the equation:

$$K = \frac{lR}{1000 \log_{10} (D/d)} M\Omega \cdot Km$$

where

D is the diameter over insulation (in mm);

d is the diameter over conductor (in mm);

l is the immersed length of core (in m);

R is the insulation resistance of the length of core (in MΩ).

A.2 Test on core for compounds types 2 and 4

Proceed as described in **A.1**, except:

a) immerse the core for at least 12 h in water at a temperature of 20 ± 5 °C, and

b) maintain the water temperature at 20 ± 1 °C for the 30 min immediately preceeding the test.

Calculate the insulation resistance constant (*K* value) from the equation given in **A.1**.

A.3 Test on sheath

For the test piece use a sheet 1.00 ± 0.15 mm thick and large enough to accommodate the electrodes, moulded from the sheath at a temperature between 140 °C and 160 °C or obtained by milling the material at a suitable temperature between 130 °C and 160 °C for the minimum time required to form a continuous and homogeneous sheet.

Immerse the test piece in water for at least 12 h at a temperature of 20 ± 5 °C.

Measure the insulation resistance in air according to BS 2782: Method 230A at a temperature of 20 ± 1 °C.

Calculate the insulation resistance constant, *K*, from the equation:

$$K = \frac{3.66 \times 10^{-7} \times R \times A}{t} M\Omega \cdot Km$$

where

R is the measured resistance of sheet (in MΩ);

A is the area of electrode (in mm^2);

t is the thickness of sheet (in mm), taken to the nearest ± 0.05 mm.

Appendix B Method of test for colour fastness to daylight

Carry out the determination by the method described in BS 2782: Method 540A except that the flaps which form part of all exposure cases of the type standardized for testing flat PVC materials up to 1.6 mm thick, may need to be kept raised or to be removed during the test.

Use the standardized special support for exposing the standard colour patterns.

It is important that the purchaser defines the required exposure time.

NOTE Reference may be made to the table in **6.4.1** of BS 2782: Method 540A:1977. Stage 7/1 is approximately equal to 1 year's exposure to natural daylight in temperate climates.

Appendix C Method of test for bleeding and blooming of colour

C.1 Test assembly for cables up to 6 mm outside diameter

Prepare a test assembly consisting of a mandrel between 25 mm and 50 mm in diameter to which the following are applied in successive layers:

a) a sheet or lapped tape about 0.25 mm thick of transparent plasticized PVC film;

NOTE In cases of dispute the type and source of the PVC film should be agreed between the manufacturer and the purchaser at the time of enquiry and order.

b) a sample of the core or sheathed cable under test, wound helically under slight tension for at least six close turns and with the ends firmly secured to the mandrel;

c) a strip of double acid-washed, retentive, very low ash filter paper[3] covering about half the circumference of the cable turns;

[3] Suitable filter papers are Whatman No. 44, Barcham Green No. 88 and equivalent types.

d) a tape of PVC film as used for the first layer, wound under slight tension over the filter paper and turns of cable and secured to the mandrel to maintain tension.

If the sample under test has too rigid a conductor to maintain intimate contact between the cable and the film when wound on a mandrel, prepare the test assembly as described in **C.2**.

C.2 Test assembly for cables over 6 mm outside diameter

Prepare a test assembly by wrapping a sample of the core or sheathed cable approximately 300 mm long with a tape of PVC film specified in **C.1** a). Apply the tape with a slight tension over a length of 250 mm and an overlap of 30 % to 60 %. Bind the ends to the cable to maintain tension. For 80 mm of this length separate the film from the cable by a layer of filter paper as specified in **C.1** c).

C.3 Procedure

Store the test assembly described in **C.1** or **C.2** in an air oven at a temperature of 50 ± 1 °C for 72 h.

At the end of this period, strip down the assembly and compare the portions of film tape that have been in contact with the PVC with the adjacent portions. If the filter paper has not become coloured, rub its surface on the PVC using light hand pressure and examine it again for stains.

Publications referred to

BS 1006, *Methods of test for colour fastness of textiles and leather.*
BS 2316, *Radio-frequency cables.*
BS 2782, *Methods of testing plastics.*
BS 2782:*Method 230A, Volume resistivity.*
BS 2782:*Method 540A, Determination of resistance to change upon exposure under glass to daylight.*
BS 6469, *Methods of test for insulation and sheaths of electric cables.*
BS 6746C, *Colour chart for PVC insulation and sheath of electric cables.*

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