BS 6899 : 1991

Specification for

Rubber insulation and sheath of electric cables

Enveloppes isolantes et gaines en caoutchouc des câbles électriques — Spécifications

Isolierung und Mantel aus Gummi von Elektrokabeln

BSI British Standards

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 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
Telecommunications Cables Group of Bcmc

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 28 February 1991

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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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Amendment No. 1
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to BS 6899 : 1991

Specification for rubber insulation and sheath of electric cables

Revised text

AMD 6937
April 1992

Contents

Under 'Specification', after the entry for clause 9, insert the following.

'**10** Covering material for welding cables'

Under 'Tables', after the entry for table 8, insert the following.

'**9** Test requirements of covering material for welding cables'

AMD 6937
April 1992

Foreword

After paragraph 5, insert the following.

'This standard was amended to incorporate technical changes to include covering material for welding cables as detailed in Amendment 6 of HD 22.1 S2.'

AMD 6937
April 1992

Table 1. Types of compound, designation, maximum operating temperature and general application

After the entry for 'EI 2', at the bottom of table 1, insert the following.

'EM 5[5)]	–	–	–	10	9'

At the end of the table insert the following footnote.

'[5)] Covering material for welding cables in accordance with BS 638 : Part 4'.

AMD 6937
April 1992

New clause 10.

'10 Covering material for welding cables

10.1 Type of covering material

The covering material, as specified in BS 638 : Part 4, shall be type EM 5 and shall be a rubber compound in which the characteristic constituent is a synthetic chlorinated rubber, e.g. polychloroprene (PCP), chlorosulphonated polyethylene (CSP) or chlorinated polyethylene (CPE). When vulcanized it shall comply with the performance requirements of this standard.

10.2 Test requirements for physical properties

When tested as described in the methods given in appendix B the properties of the covering material shall be in accordance with the requirements given in table 9.'

AMD 6937
April 1992

New table 9.

Insert the following new table 9.

Table 9. Test requirements of covering material for welding cables[1)]

Test	Requirements for covering type EM 5
Tensile properties of unaged test pieces	
Minimum tensile strength, N/mm^2	10.0
Minimum elongation at break, %	300
Tensile properties after accelerated ageing in air oven for 14 days *at* 100 ± 2 °C	
Maximum variation in tensile strength from unaged value, %	–30[2)]
Maximum variation in elongation at break from unaged value, %	–40[2)]
Tensile properties after ageing in oil, 24 h *at* 100 ± 2 °C	
Tensile strength, minimum percentage of value for unaged sample	60
Elongation at break, minimum percentage of value for unaged sample	60
Hot set test at 200 ± 2 °C, *stress on test piece* 0.2 N/mm^2	
Maximum elongation, %	100
Maximum permanent elongation, %	25

[1)] As specified in BS 638 : Part 4.
[2)] An increase in value after ageing is permitted without limit.

AMD 6937
April 1992

Publication(s) referred to

Above the entry for 'BS 903', insert the following.

'BS 638 Arc welding power sources, equipment and accessories
Part 4 Specification for welding cables'

Contents

Foreword

This new edition of BS 6899 has been prepared under the direction of the Cables and Insulation Standards Policy Committee and it supersedes BS 6899 : 1984, which is withdrawn.

This edition incorporates technical changes to bring the standard up-to-date but it does not reflect a full review of the standard, which will be undertaken in due course. Differences in the text between this edition and BS 6899 : 1984 are indicated by a line in the margin.

The previous edition introduced a range of 90 °C rubber insulations that included requirements for cross-linked polyethylene (XLPE) insulation and hard ethylene propylene (HEPR) insulation (designated as type GP6) formerly specified in BS 5468 and BS 5469 respectively. Alignment of the standard with the test methods described in BS 6469 meant that it had not been necessary to include some of the methods contained in the previous edition of this standard.

The following designations were introduced for the compounds not previously codified:

Compound	New designation
Heavy duty sheath	RS1
Heavy duty O and FR	RS2
HOFR sheath	RS3
Heavy duty HOFR	RS4
GP3	RS5 rated at 90 °C

This edition incorporates technical changes to align with Amendments 2, 4 and 5 of CENELEC[1)] Harmonization Document HD 22.1 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 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 manufactuered under a BASEC licence can carry marks acceptable to other signatory countries (CENELEC 'Common marking').

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

[1)] European Committee for Electrotechnical Standardization.

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

Specification

1 Scope

This British Standard specifies the physical and electrical requirements for the types of rubber 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. XLPE compound (designated as type GP8) has been included.

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, together with those given in BS 1755, BS 3558 and BS 4727.

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 60 °C insulation

3.1 60 °C insulation, type EI 1

The insulation shall consist of a vulcanized rubber compound in which the characteristic constituent is a natural or synthetic rubber, or a mixture of the two, formulated and vulcanized so as to comply with the performance requirements of this standard.

3.2 Test requirements for physical and electrical properties

3.2.1 *Tensile properties before and after ageing*

3.2.1.1 *General*

When tested as described in the methods given in appendix A the properties of the insulation shall comply with **3.2.1.2** and **3.2.1.3** and, as appropriate, **3.2.1.4** and **3.2.1.5**.

3.2.1.2 *Tensile properties of unaged material*

The tensile strength and elongation at break shall be not less than the values given in table 2.

3.2.1.3 *Tensile properties after* 10 days *in air at* 70 ± 1 °C

3.2.1.3.1 The tensile strength and elongation at break shall be not less than the values given in table 2.

3.2.1.3.2 If the median value of the tensile strength after this ageing test is equal to or greater than 5.0 N/mm^2 (e_1 in figure 1), the median values of the tensile strength and elongation at break shall not differ from the median values obtained without ageing by more than 40 % of the median values without ageing, and in addition the material shall comply with **3.2.1.4**.

3.2.1.3.3 If the median value of the tensile strength after this ageing test is lower than 5.0 N/mm^2, but not less than 4.2 N/mm^2 (e_2 in figure 1), the material shall in addition comply with **3.2.1.5**.

3.2.1.4 *Tensile properties after* 4 days *in oxygen at* 70 ± 1 °C

3.2.1.4.1 The tensile strength and elongation at break shall be not less than the values given in table 2.

3.2.1.4.2 If the median value of the tensile strength after this ageing test is equal to or higher than 5.0 N/mm^2 and if the change in tensile strength or elongation at break after the ageing test in air (**3.2.1.3**) does not exceed 25 % (f_1 in figure 1), the median value after ageing in the oxygen bomb shall not differ from that obtained without ageing by more than:

(a) 40 % of the median value without ageing, in the case of tensile strength, and

(b) 30 % of the median value without ageing, in the case of elongation at break.

3.2.1.4.3 If the median value of the tensile strength after this ageing test is equal to or greater than 5.0 N/mm^2 and if the change in tensile strength or elongation at break after the ageing test in air (**3.2.1.3**) exceeds 25 % (f_2 in figure 1), the median value after ageing in the oxygen bomb shall not differ from that obtained without ageing by more than:

(a) 25 % of the median value without ageing, in the case of tensile strength, and

(b) 35 % of the median value without ageing, in the case of elongation at break.

3.2.1.4.4 If the median value of the tensile strength after the ageing test in the oxygen bomb for 4 days is less than 5.0 N/mm^2, but not less than 4.2 N/mm^2 (f_3 in figure 1), the material shall in addition comply with **3.2.1.5**.

3.2.1.5 *Tensile properties after* 7 days *in oxygen at* 70 ± 1 °C

The tensile strength and elongation at break shall be not less than the values given in table 2. The maximum variation shall be as given in table 2.

3.2.2 *Retests of tensile properties before ageing*

If the tensile tests carried out in accordance with **3.2.1** were not conducted at an ambient temperature of 20 ± 5 °C and any maximum variation specified in **3.2.1** between tensile properties before and after ageing is exceeded, a single retest shall be carried out using the procedure described in **A.2**(a) at exactly the same temperature as that at which the tensile test after ageing was carried out.

Table 1. Types of compounds, designation, maximum operating temperature and general application

Compound type	Operating temperature, max.	General application		Clause reference	Table number
		Insulation	Sheath		
	°C				
EI 1	60	Ordinary duty		3	2
EM1	60		Ordinary duty	4	3
EM2	60		Ordinary duty oil-resisting and flame retardant		
RS1	60		Heavy duty		
RS2	60		Heavy duty oil-resisting and flame retardant		
GP1[1)]	85	Ordinary duty		5	4
GP2[1)]	85	Ordinary duty			
FR1[1)]	85	Flame retardant composite			
FR2[1)]	85	Flame retardant composite			
OR1	85	Oil-resisting and flame retardant			
RS3[2)]	85		Ordinary duty oil-resisting and flame retardant	6	5
RS4[2)]	85		Heavy duty oil-resisting and flame retardant		
RS5	90		Ordinary duty	7	6
GP4[1)]	90	Ordinary duty			
GP5[1)]	90	Ordinary duty			
GP6[1)]	90	Ordinary duty			
GP7[1)]	90	Ordinary duty[3)]			
GP8	90	Ordinary duty XLPE		7	6
EI 3	110	Ordinary duty EVA rubber or equivalent	Ordinary duty EVA rubber or equivalent	8	7
EI 2[4)]	150	Ordinary duty silicone rubber	Ordinary duty silicone rubber	9	8

[1)] The voltage designation of the cable may have a bearing on the type of compound selected for a particular application.

[2)] RS3 and RS4 sheaths are suitable for use over cables operating at a maximum conductor temperature of 90 °C.

[3)] GP7, complying with EPR requirements in IEC 502.

[4)] The operating temperature may be increased to 180 °C if there are no limits imposed by environmental conditions.

Table 2. Test requirements for 60 °C insulation

Test	Requirements					
	Tensile strength		Elongation at break		Elongation, max.	Permanent elongation, max.
	Min.	Variation, max.	Min.	Variation, max.		
	N/mm^2	%	%	%	%	%
Tensile properties of unaged test pieces	5.0	—	250	—	—	—
Tensile properties after accelerated ageing in air oven 10 days *at* 70 ± 1 °C	4.2	see clause **3**	250	see clause **3**	—	—
Tensile properties after accelerated ageing in oxygen bomb 4 days *at* 70 ± 1 °C	4.2	see clause **3**	250	see clause **3**	—	—
Tensile properties after accelerated ageing in oxygen bomb 7 days *at* 70 ± 1 °C	4.2	25	250	35	—	—
Hot set test at 200 ± 2 °C, *stress on test piece* 0.2 N/mm^2	—	—	—	—	100	25

NOTE. A dash (—) denotes test not applicable.

3.2.3 *Hot set test requirements*

When samples of the insulation or sheath are taken, prepared and tested as described in **3.3** of BS 6469 : 1990, the conditions of temperature and stress being those given in table 2, the tensile properties of the samples shall be as given in table 2.

4 60 °C sheath

4.1 Types of sheath

4.1.1 *Ordinary duty sheath type EM1, and heavy duty sheath type RS1*

The sheath shall consist of a vulcanized compound in which the characteristic constituent is a natural or synthetic rubber or a mixture of the two, formulated and vulcanized so as to comply with the performance requirements of this standard.

4.1.2 *Ordinary duty oil-resisting and flame retardant sheath type EM2, and heavy duty oil-resisting and flame retardant sheath type RS2*

The sheath shall consist of a vulcanized compound in which the characteristic constituent is polychloroprene rubber or equivalent material, formulated and vulcanized so as to comply with the performance requirements of this standard.

NOTE 1. Sheaths of the types specified in **4.1.2** do not normally support combustion, but this property is affected by other components of the cable and hence any test requirements for flame retardance are given in the British Standard for the particular finished cable.

NOTE 2. A cable employing sheath complying with the ageing in oil test requirement in **4.2** is not necessarily suitable for continuous use in oil.

4.2 Test requirements for physical and electrical properties

When tested as described in appendix B the properties of the sheath shall be in accordance with the requirements given in table 3 for the particular type of material.

5 85 °C insulation

5.1 Types of insulation

5.1.1 *Ordinary duty, types GP1 and GP2*

The insulation shall consist of a compound based on a synthetic rubber, formulated and vulcanized so as to comply with the performance requirements of this standard.

5.1.2 *Flame retardant composite, types FR1 and FR2*

The insulation shall consist of an inner layer of type GP1 or GP2 and a closely adherent outer layer complying with the physical requirements of type OR1, (see **5.1.3**), formulated and vulcanized so as to comply with the performance requirements of this standard.

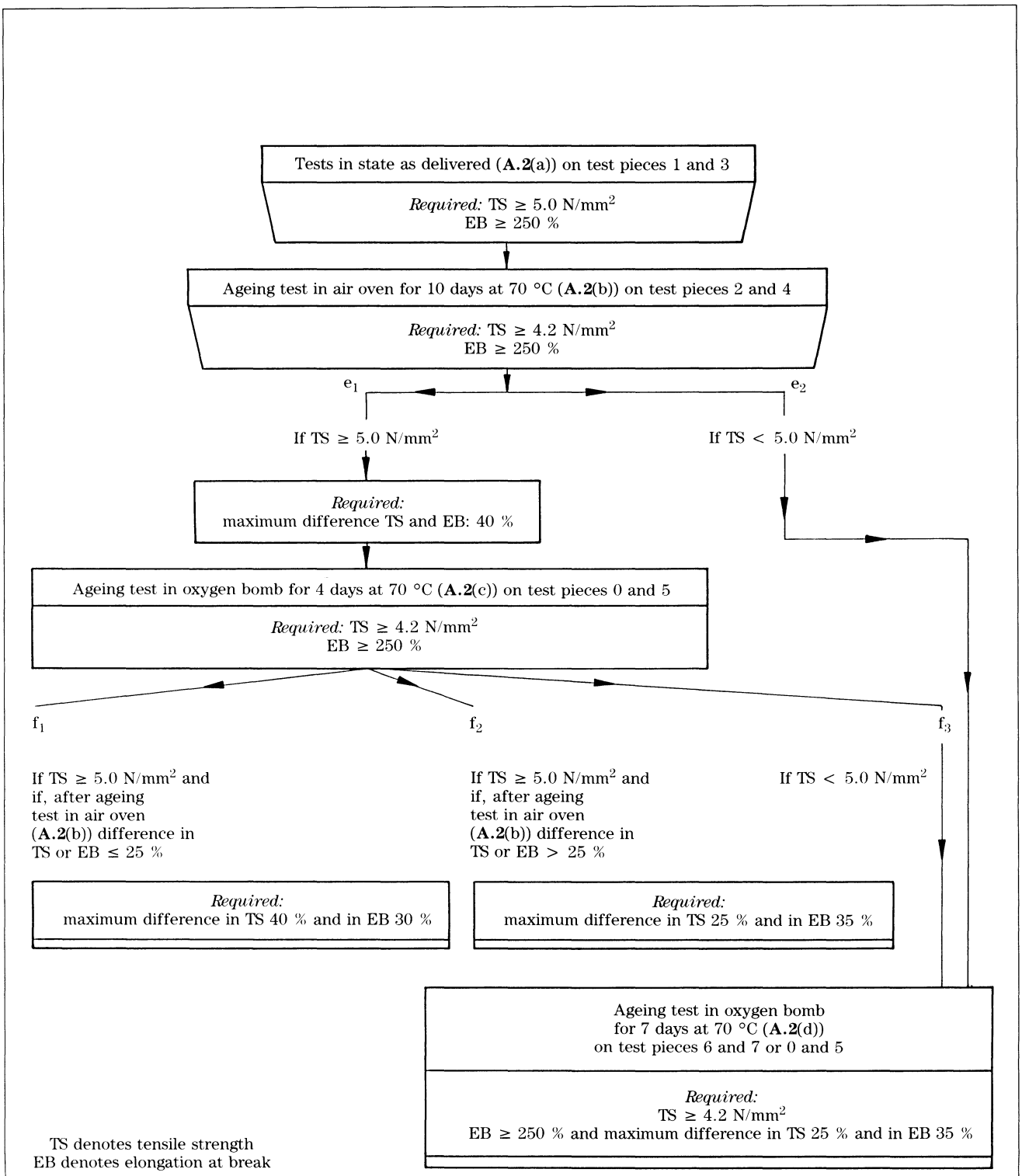

Figure 1. Synopsis of tests for the mechanical properties of insulation consisting of compound type El 1

Table 3. Test requirements for 60 °C sheath

Test	Requirements			
	Ordinary Duty		Heavy duty	
	EM1	EM2	RS1	RS2
Tensile properties of unaged test pieces				
Minimum tensile strength, N/mm^2	7.0	10.0	12.0	11.0
Minimum elongation at break, %	300	300	300	250
Tensile properties after accelerated ageing in air oven for 10 days *at* 70 ± 1 °C				
Maximum variation in tensile strength, %	20	15[1)]	20	15[1)]
Elongation at break:				
median value, minimum, %	250	250	250	200
maximum variation, %	20	25[1)]	20	25[1)]
Tensile properties after ageing in oil for 24 h *at* 100 ± 2 °C				
Maximum variation in tensile strength from unaged value, %	—	40	—	40
Maximum variation in elongation at break from unaged value, %	—	40	—	40
Tear resistance				
Minimum value, N/mm	—	—	—	5
Hot set test at 200 ± 2 °C, *stress on test piece* 0.2 N/mm^2				
Maximum elongation, %	100	100	100	100
Maximum permanent elongation, %	25	25	25	25
Bending test at low temperature				
Test temperature (°C)	—	−35	—	—
Requirement	—	No cracks	—	—
Elongation test at low temperature				
Test temperature (°C)	—	−35	—	—
Minimum elongation without break (%)	—	30	—	—

[1)] There is no limit on the increase in value after ageing.

NOTE. A dash (—) denotes test not applicable.

5.1.3 *Oil-resisting and flame retardant, type OR1*

The insulation shall consist of a compound based on chlorosulphonated polyethylene or equivalent, formulated and vulcanized so as to comply with the performance requirements of this standard.

NOTE 1. Insulation of the types specified in **5.1.2** and **5.1.3** do not normally support combustion, but this property is affected by other components of the cable and hence any test requirements for flame retardance are given in the British Standard for the particular cable.

NOTE 2. A cable employing insulation complying with the ageing in oil test requirements in **5.2** is not necessarily suitable for continuous use in oil.

5.2 Test requirements for physical and electrical properties

5.2.1 The insulation shall comply with **5.2.2** and with the prolonged ageing test requirements of **5.2.3**.

5.2.2 When tested as described in the methods given in appendix B, the properties of the insulation shall be in accordance with the requirements given in table 4 for the particular type of material. For FR1 and FR2 compounds having insulation thickness greater than 2.5 mm, the inner layer shall after separation comply with the requirements for types GP1 and GP2, for the tensile properties of unaged test pieces and for test pieces aged in an air bomb, and the outer layer with the requirements for type OR1 for the tensile properties of unaged test pieces and for test pieces aged in an air bomb and in oil.

5.2.3 When the insulation is tested as described in appendix B, the tensile properties after prolonged ageing in an air oven shall be in accordance with the following.

(a) After ageing for 28 days the median value of elongation at break shall be not less than 120 %.

(b) After ageing for 28 days the median value of the tensile strength shall be not less than 50 % of the tensile strength without ageing.

(c) The difference in the elongation at break after ageing for 14 days and 28 days respectively shall be not more than 20 % of the elongation at break without ageing.

6 85 °C sheath

6.1 Types of sheath

The sheath shall be one of the following types:

(a) ordinary duty oil-resisting and flame retardant type RS3; or

(b) heavy duty oil-resisting and flame retardant, type RS4.

For each type, the sheath shall consist of a compound based on a synthetic rubber, formulated and vulcanized so as to comply with the performance requirements of this standard. The colour of the compounds shall be black unless otherwise specified in the British Standard for the particular cable.

NOTE 1. Sheaths of the types given in **6.1** do not normally support combustion, but this property is affected by other components of the cable and hence requirements for flame retardance, where relevant, are given in British Standards for finished cables.

NOTE 2. A cable employing sheath complying with the ageing in oil test requirement in **6.2** is not necessarily suitable for continuous use in oil.

6.2 Test requirements for physical and electrical properties

When tested as described in the methods given in appendix B the properties of the sheath shall be in accordance with the requirements given in table 5 for the particular type of material.

7 90 °C insulation and sheath

7.1 Types of compound

7.1.1 *Ordinary duty, type GP4, GP5, GP6 and GP7*

The insulation shall be based on ethylene propylene rubber which when vulcanized complies with the performance requirements of this standard.

7.1.2 *Ordinary duty, type GP8*

The insulation shall be a thermoset material formed by the cross-linking of thermoplastic polyethylene compound either by chemical or by irradiation methods, so as to comply with the performance requirements of this standard.

7.1.3 *Ordinary duty, type RS5*

The sheath shall be based on ethylene propylene rubber which when vulcanized complies with the performance requirements of this standard.

NOTE. The colour of the material should be grey.

7.2 Test requirements for physical and electrical properties

When tested as described in the methods given in appendix B the properties of the insulation or sheath shall be in accordance with the requirements given in table 6 for the particular type of material.

Table 4. Test requirements for 85 °C insulation

Test	Requirements for insulation type:				
	GP1	GP2	FR1	FR2	OR1
Tensile properties of unaged test pieces					
Minimum tensile strength, N/mm^2	4.2	4.2	5.5[1]	5.5[1]	7.0
Minimum elongation at break, %	200	200	200[1]	200[1]	200
Tensile properties after accelerated ageing in air bomb, 42 h *at* 127 ± 1 °C					
Tensile strength: minimum percentage of value for unaged samples %	60	60	50[1]	50[1]	50
Elongation at break: minimum percentage of value for unaged samples %	60	60	50[1]	50[1]	50
Tensile properties after prolonged ageing (type test)[2]	As specified in **5.2.3**				
Ozone resistance test at ozone concentration					
0.025 % *to* 0.030 %					
Test duration, h	—	3	—	3	—
Power factor and permittivity test					
Maximum power factor at 20 °C	—	0.035	—	0.035	—
Maximum permittivity at 20 °C	—	4.5	—	5.5	—
Water absorption[2]					
Maximum increase in capacitance:					
1 to 14 days, %	10	6	15	10	15[3]
7 to 14 days, %	3	2.5	5	3	5[3]
Insulation resistance constant test[2]					
Minimum K value at 20 °C, MΩ·km	2400	4800	1900	3700	10
Tensile properties after ageing in oil, 24 h *at* 100 ± 2 °C					
Tensile strength: minimum percentage of value for unaged samples, %	—	—	—	—	60
Elongation at break: minimum percentage of value for unaged samples, %	—	—	—	—	60

[1] These requirements are applicable only to FR1 and FR2 compounds having insulation thickness up to and including 2.5 mm. See **5.2.2** and **B2**.

[2] These tests are carried out only when requested by the purchaser. It is essential therefore for the purchaser to state at the time of enquiry or order he wishes this testing to be done.

[3] These are additional requirements for type OR1 which apply only if the purchaser specifies at the time of ordering that the cable is to be used in a wet location.

NOTE. A dash (—) denotes test not applicable.

Table 5. Test requirements for 85 °C sheath

Test	Requirements for sheath type:	
	RS3	**RS4**
Tensile properties of unaged test pieces		
Minimum tensile strength, N/mm^2	8.0	11.0
Minimum elongation at break, %	250	250
Tensile properties after ageing in air bomb, 42 h *at* 127 ± 1 °C		
Tensile strength: minimum percentage of value for unaged sample	50	50
Elongation at break: minimum percentage of value for unaged sample	50	50
Prolonged ageing test[1)] (type test)	As **5.2.3**	As **5.2.3**
Tensile properties after ageing in oil, 24 h *at* 100 ± 2 °C		
Tensile strength: minimum percentage of value for unaged sample %	60	60
Elongation at break: minimum percentage of value for unaged sample %	60	60
Tear resistance		
Minimum value, N/mm	—	5.0
Hot set test at 200 ± 2 °C *stress on test piece* 0.2 N/mm^2		
Maximum elongation %	175	175
Maximum permanent elongation, %	25	25

[1)] This test is carried out only when requested by the purchaser. It is essential therefore for the purchaser to state at the time of enquiry or order he wishes this testing to be done.

NOTE. A dash (—) denotes test not applicable.

Table 6. Test requirements for 90 °C rubber insulation and sheath

Test	Requirements for insulation or sheath type:					
	GP4	GP5	GP6	GP7	GP8	RS5
Tensile properties of unaged test pieces						
Minimum tensile strength, N/mm^2	6.5	6.5	8.5	4.2	12.5	6.0
Minimum elongation at break, %	200	200	200	200	200	200
Tensile properties after accelerated ageing in air oven for 7 days *at* 135 ± 3 °C						
Tensile strength: maximum variation from unaged value, %	30	30	30	30	25	30
Elongation at break: maximum variation from unaged value, %	30	30	30	30	25	30
Tensile properties after ageing in air bomb for 40 h *at* 127 ± 1 °C						
Tensile strength: maximum variation from unaged value, %	30	30	30	30	—	30
Elongation at break: maximum variation from unaged value, %	30	30	30	30	—	30
Ozone resistance at ozone concentration 0.025 % *to* 0.030 %						
Test duration, h	—	3	30	30	—	—
Hot set test, stress on test piece 0.2 N/mm^2 *at temperature,* °C	200 ± 2	200 ± 2	250 ± 3	250 ± 3	200 ± 2	200 ± 2
Maximum elongation, %	100	100	100	100	175	100
Maximum permanent elongation, %	25	25	25	25	15	25
Determination of hardness						
Minimum hardness, IRHD	—	—	80	—	—	—
Water absorption						
Maximum increase in capacitance:						
1 to 14 days, %	10	6	—	—	—	—
7 to 14 days, %	3	2.5	—	—	—	—
Water absorption (gravimetric) 14 days *at* 85 ± 2 °C						
Maximum variation in mass, mg/cm^2	—	—	5	5	1	—
Insulation resistance constant						
Minimum *K* value at 20 °C, MΩ·km	2400	4800	—	—	—	—
Minimum *K* value at 90 °C, MΩ·km	—	—	3.67	3.67	3.67	—
Shrinkage test, 1 h *at* 130 ± 3 °C						
Maximum shrinkage, %	—	—	—	—	4	—
Power factor and permittivity test						
Maximum power factor at 20 °C	—	0.035	—	[1]	[1]	—
Maximum permittivity at 20 °C	—	4.5	—	[1]	[1]	—

[1] Tests on cables should be carried out in accordance with the appropriate cable standards.

NOTE. A dash (—) denotes test not applicable.

8 110 °C insulation or sheath

8.1 110 °C insulation or sheath, type EI 3

The insulation or sheath shall consist of a vulcanized compound in which the characteristic constituent is ethylene vinyl acetate or equivalent, formulated so as to comply with the performance requirements of this standard.

8.2 Test requirements for physical and electrical properties

When tested as described in the methods given in appendix B the properties of the insulation or sheath shall be in accordance with the requirements given in table 7.

Table 7. Test requirements for 110 °C insulation or sheath type EI 3

Test	Requirement
Tensile properties of unaged test pieces	
Minimum tensile strength, N/mm^2	6.5
Minimum elongation at break, %	200
Tensile properties after accelerated ageing in air oven for 10 days *at* 150 ± 2 °C	
Tensile strength: maximum variation from unaged value, %	30
Elongation at break: maximum variation from unaged value, %	30
Tensile properties after accelerated ageing in air bomb for 7 days *at* 150 ± 2 °C	
Minimum strength, N/mm^2	6.0
Elongation at break: maximum variation from unaged value, %	−30
Hot set test at 200 ± 2 °C, *stress on test piece* 0.2 N/mm^2	
Maximum elongation, %	100
Maximum permanent elongation, %	25
Hot pressure test: 0.5 h *at* 150 ± 2 °C	
K value	1.0
Maximum penetration, %	50

9 150 °C insulation or sheath

9.1 150 °C insulation or sheath, type EI 2

The insulation or sheath shall consist of a vulcanized compound in which the characteristic constituent is a silicone rubber, formulated so as to comply with the performance requirements of this standard.

9.2 Test requirements for physical and electrical properties

When tested as described in the methods given in appendix B the properties of the insulation or sheath shall be in accordance with the requirements given in table 8.

Table 8. Test requirements for 150 °C insulation or sheath type EI 2

Test	Requirement
Tensile properties of unaged test pieces	
Minimum tensile strength, N/mm^2	5.0
Minimum elongation at break, %	150
Tensile properties after accelerated ageing in air for 10 days *at* 200 ± 2 °C	
Minimum tensile strength, N/mm^2	4.0
Minimum elongation at break, %	120
Hot set test at 250 ± 3 °C, *stress on test piece* 0.2 N/mm^2	
Maximum elongation, %	100
Maximum permanent elongation, %	25

Appendices

Appendix A. Test methods for 60 °C insulation types EI 1

A.1 Sampling and numbering of test pieces

Take samples from each core if the cable has one, two or three cores and from three cores (or different colours, if any) if the cable has more than three cores.

Take three samples from each of the requisite number of cores, each sample not less than 1 m from the other two, and of sufficient size to provide six or eight (see note) test pieces as described in **2.2.1.3** of BS 6469 : 1990. Reject any samples that show signs of mechanical damage. Number the test pieces obtained from each sample consecutively 0 to 5 (or 0 to 7).

NOTE. Two additional test pieces are required where ageing in oxygen for 7 days proves necessary.

A.2 Test procedures

Determine the cross-sectional area of each of the test pieces in accordance with BS 6469 and then proceed as follows.

(a) Subject test pieces 1 and 3 to the conditioning and to the tensile test in accordance with **2.2** and **2.3** of BS 6469 : 1990, in the state as delivered. Obtain the median values of tensile strength and elongation at break.

(b) Subject test pieces 2 and 4 to ageing in an air oven for 10 days at 70 ± 1 °C and subsequently to the conditioning and to the tensile test in accordance with **2.2** and **2.3** of BS 6469 : 1990. Obtain the median values of tensile strength and elongation at break.

If the median value of the tensile strength obtained in (b) is equal to or greater than 5.0 N/mm^2 and the variation in the values of tensile strength and elongation at break between (a) and (b) is not more than 40 %, proceed with (c) with an ageing period of 4 days.

If the median value of the tensile strength obtained in (b) is less than 5.0 N/mm^2 but not less than 4.2 N/mm^2, proceed with (c) with an ageing period of 7 days.

(c) Subject test pieces 0 to 5 to ageing in an oxygen bomb for 4 days or 7 days at 70 ± 1 °C in accordance with **2.3** of BS 6469 : 1990 and subsequently to the conditioning and to the tensile test in accordance with **2.2** of BS 6469 : 1990. Obtain the median values of tensile strength and elongation at break.

If the median value of the tensile strength obtained in (c) after 4 days ageing at 70 °C is less than 5.0 N/mm^2 but not less than 4.2 N/mm^2, proceed with (d).

(d) Subject test pieces 6 and 7 to ageing in an oxygen bomb for 7 days at 70 ± 1 °C in accordance with **2.3** of BS 6469 : 1990 and subsequently to the conditioning and to the tensile test in accordance with **2.2** of BS 6469 : 1990. Obtain the median values of tensile strength and elongation at break.

NOTE. A synopsis of the test for the mechanical properties of type EI 1 insulation is given in figure 1.

Appendix B. Test methods for compounds other than type EI 1

B.1 Sampling

Take insulation and sheath samples as described in BS 6469.

B.2 Test procedures

B.2.1 *General*

Carry out in accordance with the following methods the applicable tests given in italic type in tables 3 to 8, as appropriate, under the conditions of temperature, test duration, etc. given in those tables.

Test	Method
Tensile properties: tensile strength and elongation at break	**2.2** of BS 6469 : 1990
Accelerated ageing	**2.3** of BS 6469 : 1990
Shrinkage test	**2.5** of BS 6469 : 1990
Gravimetric water absorption test	**2.6** of BS 6469 : 1990
Ageing of insulation and sheath in oil	**3.1** of BS 6469 : 1990
Ozone resistance of insulation	**3.2** of BS 6469 : 1990
Hot set test	**3.3** of BS 6469 : 1990
Tear resistance of sheath	**3.4** of BS 6469 : 1990
Water absorption of insulation	**B.2.2**
Insulation resistance constant (K value)	**B.2.3**

Determination of hardness	Method CM of BS 903 : Part A26 : 1969
Power factor and permittivity	**B.2.4**
Prolonged ageing test	**B.2.5**
Hot pressure tests	**4.2** of BS 6469 : 1990
Low temperature tests	**4.3** of BS 6469 : 1990

NOTE. For thicknesses of FR1 and FR2 compound greater than 2.5 mm, the layers of insulation require separating, e.g. by grinding, and testing individually for compliance with **5.2.2**.

B.2.2 *Method for water absorption of insulation*

B.2.2.1 *Preparation of test specimen*

Take a sample of the core about 4.5 m long, after vulcanization but before the application of any covering except tape applied before vulcanization. Wherever possible remove any tape before the test. Prepare the test specimen from the sample not less than 48 h after vulcanization, by drying for 24 h in air at 70 ± 5 °C. Allow the test specimen to cool to approximately 50 °C before immersion in the water.

B.2.2.2 *Immersion of specimen*

Place the test specimen in a water tank so that its middle portion for a length of 3 m is immersed, whilst each end is above the water level for a length of 0.75 m. Maintain the water at a temperature of 50 ± 1 °C for 14 days. Place a tightly fitting cover directly above the water surface with suitable watertight bushings for the ends of the test specimen and keep the water level constant.

B.2.2.3 *Electrical measurements*

Carry out the test with one of the following voltages:

(a) an average stress at any frequency from 40 Hz to 62 Hz inclusive, of:

800 V/mm for types GP1, FR1, OR1 and GP4,

2500 V/mm for type FR2,

3200 V/mm for types GP2 and GP5.

(b) a low voltage at any frequency from 800 Hz to 1000 Hz inclusive.

Measure the capacitance after continuous immersion for 1, 7 and 14 days checking that the water is at the same temperature for all measurements.

Express the increase in capacitance from 1 day to 14 days and from 7 days to 14 days as percentages of the 1-day and the 7-day values respectively.

B.2.3 *Method for insulation resistance constant (K value)*

Remove the sheath and any other covering or filling from a length of at least 5 m, taking care not to damage the insulation. Immerse the core for at least 12 h in water at the specified temperature, a length of about 250 mm at each end of the core projecting above the water. Maintain the temperature of the water at 20 ± 1 °C or 90 ± 2 °C, as appropriate, for the 30 min immediately preceding the test. Apply a direct current voltage between 300 V and 500 V 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:

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

where

D is the diameter (in mm) over insulation;

d is the diameter (in mm) over conductor;

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

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

B.2.4 *Method for power factor and permittivity*

Take samples of core of length not less than 5 m, from the complete cable and immerse them in water for 24 h at room temperature with a length of about 250 mm at each end of the core projecting above the water. Measure the power factor and capacitance of the insulation between the conductor and the water with suitable equipment at any convenient frequency between 40 Hz and 62 Hz, at the rated voltage to earth, U_0, of the cable and at a temperature of 20 ± 1 °C.

Calculate the permittivity from the equation:

$$\epsilon = \frac{41.4C\log_{10} (D/d)}{l}$$

where

ϵ is the permittivity of the insulation;

C is the measured capacitance (in nF) of the sample;

D is the diameter (in mm) over insulation;

d is the diameter (in mm) over conductor;

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

B.2.5 ***Method for prolonged ageing***[1)]

Carry out the test by the method described in BS 6469 for accelerated ageing by the air oven method using ten test pieces. Place the test pieces in the dark in the air oven maintained at a temperature of 110 ± 1 °C.

After a period of 14 days remove five of the test pieces from the oven, allow them to cool down and keep them at room temperature, avoiding direct sunlight, for at least 16 h. Subject these test pieces to the tensile testing specified for insulation and sheath.

After a period of 28 days from the commencement of ageing remove the remaining test pieces from the oven and subject them to the same procedure as the first test pieces.

[1)] This is a type test to be carried out by a manufacturer before he supplies cable on a general commercial basis. The test need not be repeated unless changes are made which might affect compliance with the test requirements.

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Publication(s) referred to

BS 903	Methods of testing vulcanized rubber Part A26 Determination of hardness
BS 1755[1)]	Glossary of terms used in the plastics industry
BS 3558[1)]	Glossary of rubber terms
BS 4727[1)]	Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms
BS 6469	Methods of test for insulation and sheaths of electric cables
IEC 502	Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV

[1)]Referred to in the foreword only.

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