BRITISH STANDARD AEROSPACE SERIES

BS 4G
198-3:1999

Sleeves and moulded components for aircraft electric cables and equipment wires —

Part 3: Specification for heat-shrinkable sleeving for binding, insulation, and identification

ICS 49.060

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee ACE/6, Aerospace avionic, electrical and fibre optic technology, upon which the following bodies were represented:

British Airways
British Cable Makers' Confederation
British Rubber Manufacturers' Assocaition
Civil Aviation Authority (Airworthiness Division)
Federation of the Electronics Industry
Ministry of Defence
Society of British Aerospace Companies

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Contents

Foreword

This part of BS G 198 has been prepared by Technical Committee ACE/6 and specifies requirements for heat-shrinkable sleeves and sleeving for aircraft electric cables and insulated equipment wires. BS G 198 is published in the following separate parts.

— *Part 1: Specification for elastomeric sleeves for binding and identification*;

— *Part 2: Specification for slip-on sleeves for identification purposes*;

— *Part 3: Specification for heat-shrinkable sleeving for binding, insulation, and identification*;

— *Part 4: Specification for fluoropolymer heat-shrinkable sleeving for binding and insulation*;

— *Part 5: Specification for heat-shrinkable moulded shapes*.

It is envisaged that there will be a further part on heat-shrinkable dual wall sleeves. (This work has been transferred to IEC SC15C WG5.)

This part of BS G 198 supersedes BS 3G 198-3:1994 which is withdrawn.

This part of BS G 198 specifies requirements for heat-shrinkable sleeving, in a range of diameters, lengths and materials for binding, insulation and identification purposes on electric cables and insulated equipment wires in aircraft. Sleeves are available as uncoloured transparent and in a range of colours.

The various types of sleeving covered by this British Standard have been designated by the allocation of type numbers. These numbers have been adopted by the aircraft industry over a period of years and do not necessarily run consecutively through the parts of BS G 198.

Sleeving should be installed in accordance with the manufacturer's or the supplier's instructions and, in particular, it should be noted that when shrinkage is restricted some properties may be impaired, e.g. wall thickness will be reduced, and sleeving life may also be reduced.

It should be noted that the majority of heat guns available for the application of sleeving are not for use in potentially explosive atmospheres. Application tools for the installation of heat-shrinkable sleeving in these areas should be designed for Zone 2 areas in accordance with BS 5345-2.

This edition deletes types 11D and 14 and removes the requirement for a test for durability of marking.

WARNING NOTE 1 This standard calls for the use of substances and/or test procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and in no way absolves either the supplier or the user from statutory obligations relating to health and safety at any stage of manufacture or use.

WARNING NOTE 2 It should be clearly understood that the combustion characteristics tests detailed in this standard, i.e. flammability, oxygen index, flammability temperature, smoke index and combustion products index are in no way suitable for assessing a total fire hazard situation. They are solely for the purpose of specifying the basic quality requirements of the heat-shrinkable sleeving.

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

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1 Scope

This part of BS G 198 specifies the design, performance, quality assurance and methods of test for the types of heat-shrinkable sleeving shown in Table 1 and Table 2. These sleeves are for binding, insulation and identification purposes. Routine and quality tests are also specified.

These sleeves may be used in both aerospace and non-aerospace applications.

When specified, sleeves used with bonding adhesives and/or heat-shrinkable moulded shapes should conform to the compatibility test requirements detailed in part 5.

In addition to the definitive requirements, this standard also requires the items detailed in clause **3** to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

NOTE 1 Recommendations for the storage of finished sleeves is given in annex A.

NOTE 2 The latest revision of an Aerospace Series standard is indicated by a prefix number.

NOTE 3 Sleeving that has been shrunk is referred to as recovered.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 148:1999, *Specification for unused insulating oils for transformers and switchgear.*

BS 903, *Physical testing of rubber.*

BS 903-A1:1996, *Determination of density.*

BS 903-A2:1995, *Determination of tensile stress-strain properties.*

BS ISO 188:1998, *Rubber, vulcanized or thermoplastic — Accelerated ageing and heat resistance tests.*

BS 1595-1:1986, *Specification for propan-2-ol (isopropyl alcohol).*

BS 2011-2.1J:1999, *Environmental testing — Tests — Test J and guidance — Mould growth.*

BS ISO 4589-2:1996, *Plastics — Determination of burning behaviour by oxygen index — Ambient-temperature test.*

BS EN ISO 4589-3:1996, *Plastics — Determination of burning behaviour by oxygen index — Elevated temperature test.*

BS 2782-3: Methods 320A to 320F:1976, *Tensile strength, elongation and elastic modulus.*

BS 2782-4, *Chemical properties.*

BS 2782-4: Method 430A to 430D:1983, Method 430A, *Determination of water absorption at 23 °C.*

Method 430B, *Determination of water absorption at 23 °C with allowance for water-soluble matter.*

Method 430C, *Determination of boiling water absorption.*

Method 430D, *Determination of boiling water absorption with allowance for water-soluble matter.*

BS 2782-5: Method 540B:1982, *Methods of exposure to laboratory light sources, (xenon arc lamp, enclosed carbon arc lamp, open-flame carbon arc lamp, fluorescent tube lamps).*

BS 6401:1983, *Method for measurement, in the laboratory, of the specific optical density of smoke generated by materials.*

BS 2782-5: Methods 540D, E, F and G.

BS 650:1992 *Specification for corrosion inhibiting, engine cooling concentrate ("antifreeze").*

BS 6746C:1993, *Colour chart for insulation and sheath of electric cables.*

BS 3G 100, *Specification for general requirements for equipment and indicating instruments for aircraft.*

BS 3G 100-2, *All equipment.*

BS 3G 100-2-3, *Environmental conditions.*

BS 3G 100-2-3.12:1991, *Fluid contamination.*

IEC 60216, *Guide for the determination of thermal endurance properties of electrical insulating material.*

BS ISO 1817:1999 *Rubber, vulcanized — Determination of the effects of liquids.*

Table 1 — Types of heat-shrinkable sleeving

Type	Guide to temperature range °C	Exposure temperature °C			Recommended minimum shrink temperature[d] and shrink ratio	
		a[a]	b[b]	c[c]		
10A	−75 to 120	120	150	215	150	2:1
10B	−75 to 120	120	150	215	120	2:1
11A	−55 to 135	135	175	225	100	2:1
11B	−55 to 135	135	175	225	120	2:1, 3:1, 4:1
11C	−55 to 135	135	175	225	120	2:1
12A	−55 to 200	200	250	300	175	2:1
12B	−55 to 200	200	250	300	175	2:1
13	−55 to 90	90	120	150	150	2:1
15	−30 to 105	105	135	175	135	2:1, 3:1

[a] Temperature a is for a minimum of 10,000 h when assessing in accordance with **11.22**.

[b] Temperature b is for a minimum of 168 h when assessing in accordance with **11.15**.

[c] Temperature c is for a minimum of 4 h when assessing in accordance with **11.19**.

[d] The minimum shrink temperature is the minimum temperature at which full recovery occurs. Refer to the manufacturer/supplier for actual values.

Table 2 — Materials and characteristics

Type	Material	Characteristics
10A	Very flexible polymer	This sleeving has very good flexibility, is flame retarded and has a thick wall for mechanical protection. It is for use as cable protection in areas where wiring is subject to contamination by aircraft fuels and hydraulic fluids. The standard available colours are black or red.
10B	Flexible polymer	This sleeving has good flexiblity, is flame retarded and has a thick wall for mechanical protection. It is for use as cable protection in areas where wiring is subject to occasional contamination by aircraft fuels and hydraulic fluids. The standard colour is black.
11A	Very flexible polyolefin	This sleeving has good flexibility, is flame retarded and will shrink at low temperatures. It is suitable where sensitive components and delicate wiring need protection from excessive heat during shrinking. It is available in colours (see Table 3) and transparent. The transparent sleeving is not flame retarded.
11B	Flexible polyolefin	This sleeving is flexible and flame retarded. It is suitable for general purposes and is available with high shrink ratios (see Table 6). It is available in colours (see Table 3) and transparent. The transparent sleeving is not flame retarded.
11C	Semi-rigid polyolefin	This sleeving is semi-rigid and flame retarded. It is suitable where strain relief and mechanical support are required. It is available in colours (see Table 3) and transparent. The transparent sleeving is not flame retarded.
12A	Vinylidene fluoride co-polymer (low electric strength)[a]	This sleeving has good flexibility, is flame retarded and has a thick wall for mechanical protection. It is for use in areas subject to prolonged contamination by aircraft fuel and fluids with the exception of phosphate ester-based hydraulic fluids. It has low electric strength. The standard colour is black.

Table 2 — Materials and characteristics *(continued)*

Type	Material	Characteristics
12B	Vinylidene fluoride co-polymer (high electric strength)[a]	This sleeving has good flexibility, is flame retarded and has a thick wall for mechanical protection, but is generally thinner than type 12A. It is suitable for use in areas subject to prolonged contamination by aircraft fuel and fluids with the exception of phosphate ester-based hydraulic fluids. It has high electric strength. The standard colour is black.
13	Polychloroprene	This sleeving has good flexibility, is flame retarded and has a thick wall for mechanical protection. It is suitable for use as general purpose cable protection. The standard colour is black.
15	Limited fire hazard flexible polymer	This sleeving is flexible, flame retarded and emits minimum smoke, gases and corrosive by-products when exposed to fire. It is available with various wall thicknesses and also in a higher shrink ratio according to the application and degree of mechanical protection required. It is suitable for use (e.g. as cable protection) in areas where smoke, gases or corrosive by-products would constitute a particular hazard.

[a] Includes hexafluoropropylene or 1-hydropentafluoropropylene.

Table 3 — Standard colours and availability

Type	Black	Red	Yellow	Blue	White	Green	Brown	Pink	Violet	Orange	Grey	Green and yellow stripes	Available as transparent
10A	X	X	—	—	—	—	—	—	—	—	—	—	—
10B	X	—	—	—	—	—	—	—	—	—	—	—	—
11A	X	X	X	X	X	X	X	X	X	X	X	—	X
11B	X	X	X	X	X	X	X	X	X	X	X	X	X
11C	X	X	X	X	X	X	X	X	X	X	X	—	X
12A	X	—	—	—	—	—	—	—	—	—	—	—	—
12B	X	—	—	—	—	—	—	—	—	—	—	—	—
13	X	—	—	—	—	—	—	—	—	—	—	—	—
15	X	X	X	X	X	X	—	—	—	—	—	—	—

Key

X signifies available.

— signifies not available as standard. See clause **5**.

3 Information to be supplied by the purchaser

The following information to be supplied by the purchaser shall be fully documented. For compliance with the standard both the definitive requirements specified throughout the standard and the following documented items shall be satisfied.

a) the number of this British Standard (i.e. BS 4G 198- 3:1999);

b) the total quantity required;

c) cut length, if required, (see **7.2**) and tolerance on cut length, if the tolerance required is different from Table 13;

d) minimum continuous lengths on spools, if required (see note 1 of **7.2**);

e) whether the sleeving is to be tested in any further fluids in addition to those given in Table 17 (see **11.18**);

f) printing requirements (see clause **12**);

g) codified identification (see **13.1**);

h) packaging requirements (see **13.2**);

i) additional fluid resistance, if required, (see **11.18** and Table 16).

If sizes and/or tolerances other than those specified in this part of BS G 198 are required, full details of the requirements should be specified by the purchaser in the contract or order (see clause **3**).

4 Materials and characteristics

Sleeving shall be made from materials that ensure that the finished sleeving conforms to the appropriate requirements of clause **11**. After printing, sleeves shall conform to clause **12**.

NOTE 1 Materials known to meet the requirements of the tests specified in clause **11** will have the characteristics shown in Table 2.

NOTE 2 Printing on sleeves may affect properties.

NOTE 3 The tests specified in clause **11** are performed on finished sleeving, except for tests **11.23** and **11.24**.

5 Colour

5.1 Sleeving shall be manufactured in the colours specified in Table 3 for each type of sleeving. For coloured sleeving, the colours shall be recognizable as those specified in BS 6746C:1993.

5.2 The colour of sleeving shall be uniform and evenly dispersed.

5.3 For dual coloured sleeving, the percentage of either colour shall be not less than 30 % of the external surface area.

6 Finish

The sleeving, both before and after unrestricted shrinkage, shall be free from bubbles, pinholes, creases and other defects that may affect performance.

7 Dimensions

7.1 The internal diameters and related wall thicknesses of the sleeving, both before and after unrestricted shrinkage, shall conform to the requirements given in Tables 4 to 11.

7.2 Cut lengths of sleeving shall be cut to the tolerances specified in Table 13 unless otherwise agreed with the purchaser (see clause **3**).

NOTE 1 Sleeving supplied on a spool may not necessarily be in a continuous length. If a minimum length is required, the length should be stated by the purchaser in the contract or order (see clause **3**).

NOTE 2 The minimum continuous lengths will vary with size and material.

Table 4 — Dimensions of types 10A and 10B sleeving

All dimensions in millimetres

Size code	"As supplied"	After unrestricted shrinkage		
	Internal diameter (min.)	Internal diameter (max.)	Nominal wall thickness	Tolerance on wall thickness
1	3.2	1.6	0.8	±0.20
2	4.8	2.4	0.8	±0.20
3	6.4	3.2	0.9	±0.20
4	9.5	4.8	1.0	±0.20
5	12.7	6.4	1.2	±0.20
6	19.0	9.5	1.5	±0.30
7	25.4	12.7	1.8	±0.30
8	38.0	19.0	2.4	±0.40
9	50.8	25.4	2.8	±0.40
10	76.0	38.0	3.2	±0.50
11	102.0	51.0	3.6	±0.50

Table 5 — Dimensions of type 11A sleeving

All dimensions in millimetres

Size code	"As supplied"	After unrestricted shrinkage		
	Internal diameter (min.)	Internal diameter (max.)	Nominal wall thickness	Tolerance on wall thickness
1	1.2	0.6	0.45	±0.10
2	1.6	0.8	0.45	±0.10
3	2.4	1.2	0.50	±0.10
4	3.2	1.6	0.50	±0.10
5	4.8	2.4	0.50	±0.10
6	6.4	3.2	0.65	±0.15
7	9.5	4.8	0.65	±0.15
8	12.7	6.4	0.65	±0.15
9	19.0	9.5	0.75	±0.15
10	25.4	12.7	0.90	±0.15
11	38.0	19.0	1.00	±0.20
12	50.8	25.4	1.15	±0.25
13	76.0	38.0	1.25	±0.25
14	102.0	51.0	1.4	±0.25

Table 6 — Dimensions of type 11B sleeving

All dimensions in millimetres

Size code	"As supplied"	After unrestricted shrinkage		
	Internal diameter (min.)	Internal diameter (max.)	Nominal wall thickness	Tolerance on wall thickness
Shrink ratio 2:1				
1	1.2	0.6	0.45	±0.10
2	1.6	0.8	0.45	±0.10
3	2.4	1.2	0.50	±0.10
4	3.2	1.6	0.50	±0.10
5	4.8	2.4	0.50	±0.10
6	6.4	3.2	0.65	±0.15
7	9.5	4.8	0.65	±0.15
8	12.7	6.4	0.65	±0.15
9	19.0	9.5	0.75	±0.15
10	25.4	12.7	0.90	±0.15
11	31.0	16.0	0.95	±0.20
12	38.0	19.0	1.00	±0.25
13	50.8	25.4	1.15	±0.25
14	76.0	38.0	1.25	±0.25
15	102.0	51.0	1.40	±0.25
Shrink ratio 3:1				
16	1.5	0.5	0.45	±0.1
17	3.0	1.0	0.55	±0.1
18	6.0	2.0	0.65	±0.1
19	9.0	3.0	0.75	±0.12
20	12.0	4.0	0.75	±0.12
21	18.0	6.0	0.85	±0.12
22	24.0	8.0	1.0	±0.18
23	39.0	13.0	1.15	±0.20
Shrink ratio 4:1				
24	25.4	6.6	1.52	±0.2
25	38.1	9.5	1.52	±0.2
26	50.4	12.7	1.52	±0.2
27	76.2	19.1	1.52	±0.2
28	101.6	25.4	1.52	±0.2
Shrink ratio 4.1: Repair sleeve				
29	25.4	7.0	1.14	±0.18
30	50.8	14.0	1.14	±0.18
31	76.2	20.6	1.14	±0.18
32	101.6	26.7	1.14	±0.18

Table 7 — Dimensions of type 11C sleeving

All dimensions in millimetres

Size code	"As supplied"	After unrestricted shrinkage		
	Internal diameter (min.)	Internal diameter (max.)	Nominal wall thickness	Tolerance on wall thickness
1	1.2	0.6	0.5	±0.10
2	1.6	0.8	0.5	±0.10
3	2.4	1.2	0.5	±0.10
4	3.2	1.6	0.5	±0.10
5	4.8	2.4	0.65	±0.10
6	6.4	3.2	0.65	±0.10
7	9.5	4.8	0.75	±0.15
8	12.7	6.4	0.75	±0.15

Table 8 — Dimensions of type 12A sleeving

All dimensions in millimetres

Size code	"As supplied"	After unrestricted shrinkage		
	Internal diameter (min.)	Internal diameter (max.)	Nominal wall thickness	Tolerance on wall thickness
1	3.2	1.6	0.8	±0.15
2	4.8	2.4	0.8	±0.20
3	6.4	3.2	0.9	±0.30
4	9.5	4.8	1.0	±0.30
5	12.7	6.4	1.2	±0.40
6	19.0	9.5	1.4	±0.40
7	25.4	12.7	1.8	±0.50
8	38.0	19.0	2.4	±0.50
9	50.8	25.4	2.8	±0.50

Table 9 — Dimensions of type 12B sleeving

All dimensions in millimetres

Size code	"As supplied"	After unrestricted shrinkage		
	Internal diameter (min.)	Internal diameter (max.)	Nominal wall thickness	Tolerance on wall thickness
1	3.2	1.6	0.8	±0.20
2	4.8	2.4	0.9	±0.20
3	6.4	3.2	0.9	±0.30
4	9.5	4.8	0.9	±0.30
5	12.7	6.4	0.9	±0.30
6	15.9	7.9	1.1	±0.40
7	19.0	9.5	1.1	±0.40
8	22.2	11.1	1.4	±0.40
9	25.4	12.7	1.4	±0.50
10	31.8	15.9	1.5	±0.50
11	38.0	19.0	1.6	±0.50
12	50.8	25.4	1.6	±0.50

Table 10 — Dimensions of type 13 sleeving

All dimensions in millimetres

Size code	"As supplied"	After unrestricted shrinkage		
	Internal diameter (min.)	Internal diameter (max.)	Nominal wall thickness	Tolerance on wall thickness
1	3.2	1.8	0.8	±0.20
2	4.8	2.7	0.9	±0.30
3	6.4	3.7	0.9	±0.30
4	9.5	5.5	1.0	±0.30
5	12.7	7.3	1.2	±0.40
6	15.8	9.1	1.3	±0.40
7	19.0	10.9	1.5	±0.40
8	22.0	12.7	1.7	±0.40
9	25.4	14.5	1.8	±0.50
10	31.5	18.2	2.2	±0.50
11	38.0	22.0	2.4	±0.50
12	44.0	25.4	2.7	±0.50
13	50.8	29.0	2.8	±0.50
14	76.0	43.5	3.2	±0.50
15	100	58.0	3.6	±0.50

Table 11 — Dimensions of type 15 sleeving

All dimensions in millimetres

Thin wall shrink ratio 2:1				
Size code	"As supplied"	After unrestricted shrinkage		
	Internal diameter (min.)	Internal diameter (max.)	Nominal wall thickness	Tolerance on wall thickness
1	1.6	0.8	0.45	±0.10
2	2.4	1.2	0.50	±0.10
3	3.2	1.6	0.50	±0.10
4	4.8	2.4	0.50	±0.10
5	6.4	3.2	0.65	±0.15
6	9.5	4.8	0.65	±0.15
7	12.7	6.4	0.65	±0.15
8	19.0	9.5	0.75	±0.15
9	25.4	12.7	0.90	±0.15
10	38.0	19.0	1.00	±0.20
11	51.0	25.4	1.15	±0.25
12	76.0	38.0	1.25	±0.25
13	102.0	51.0	1.40	±0.25

Table 11 — Dimensions of type 15 sleeving *(continued)*

All dimensions in millimetres

Medium wall shrink ratio 2:1				
Size code	Expanded (min.)	Recovered (max.)	Nominal wall thickness	Tolerance on wall thickness
14	3.0	1.5	0.70	±0.10
15	5.0	2.5	0.75	±0.15
16	8.0	4.0	0.80	±0.15
17	12.0	6.0	0.90	±0.15
18	18.0	9.0	1.00	±0.20
19	24.0	12.0	1.10	±0.20
20	40.0	20.0	1.30	±0.25
21	60.0	30.0	1.50	±0.30
22	3.2	1.6	0.75	±0.15
23	4.8	2.4	0.85	±0.20
24	6.4	3.2	0.90	±0.20
25	9.5	4.8	1.00	±0.20
26	12.7	6.4	1.20	±0.30
27	19.0	9.5	1.45	±0.35
28	25.4	12.7	1.80	±0.45
29	38.0	19.0	2.40	±0.50
30	51.0	25.4	2.80	±0.50
31	3.0	1.0	0.60	±0.10
32	6.0	2.0	0.70	±0.10
33	9.0	3.0	0.80	±0.15
34	12.0	4.0	0.85	±0.15
35	18.0	6.0	1.00	±0.20
36	24.0	8.0	1.20	±0.20
37	40.0	13.0	1.25	±0.20

Table 11 — Dimensions of type 15 sleeving *(continued)*

All dimensions in millimetres

Thick wall shrink ratio 3:1				
Size code	**Expanded min.**	**Recovered max.**	**Nominal wall thickness**	**Tolerance on wall thickness**
38	12	3	2.3	±0.50
39	20	6	2.3	±0.50
40	34	10	2.4	±0.50
41	45	13	2.6	±0.50
42	54	18	2.7	±0.50
43	70	25	2.7	±0.50
44	90	30	2.8	±0.50
45	122	40	3.0	±0.50
46	170	58	3.0	±0.50

Table 12 — Standard cutting tolerances for cut lengths of sleeving

All dimensions in millimetres

Cut length	Standard cutting tolerance
0 to 9.9	±0.5
10 to 24.9	±1.0
25 to 49.9	±1.5
50 to 100	±3.0
101 to 150	±4.0
151 to 250	±5.0
251 to 1 200	±12.0
1 201 and over	±1 %

8 Shelf life

NOTE The use by date is the shelf life when stored under the conditions specified in annex A.

The use by date shall be the guaranteed minimum storage time for which the sleeving retains the "as supplied" internal diameter. Following unrestricted shrinkage in accordance with **11.3**, the sleeving shall conform to the internal diameter, wall thickness and longitudinal change requirements specified in this standard.

9 Type testing

9.1 Type tests

9.1.1 The manufacturer or supplier shall provide details of the following:

— material composition;

— agreed techniques;

— evidence, to the satisfaction of the type approving authority[1)], that sleeving in accordance with this standard conforms to the tests listed in Table 13, details of which are given in clauses **11** and **12**.

9.1.2 Type tests shall be performed on sizes taken from the top, middle and bottom of the manufacturer or supplier's range for each different material, unless otherwise indicated in Table 13. The smallest sleeving to be tested shall have a specified recovered internal diameter of not less than 2 mm.

9.1.3 In the event of a failure of the sleeving to conform to the requirements of a test, the batch shall be re-sampled and the test repeated using two further sets of test-pieces. Both sets shall conform to the appropriate test requirements, otherwise the sleeving shall be deemed not to conform to this standard.

9.1.4 Type approval is valid for a period of 5 years after which time the manufacturer or supplier shall apply for re-approval of the material.

[1)] The approving authority for civil aircraft applications is the Civil Aviation Authority, Airworthiness Division or an organization approved by them, and for defence applications is an organization nominated by project authority.

Table 13 — Type tests

Title	Clause
Finish	**11.1**
Dimensions	**11.2**
Longitudinal change	**11.3**
Colour[a b]	**11.4**
Colour stability[a b c]	**11.5**
Transparency test[d]	**11.6**
Colour fastness to light[a b c]	**11.7**
Density[a]	**11.8**
Resistance to mould growth[a c e]	**11.9**
Copper mirror corrosion[a]	**11.10**
Tensile strength and elongation at break	**11.11**
Dielectric strength	**11.12**
Volume resistivity after damp heat	**11.13**
Low temperature flexibility	**11.14**
Heat ageing	**11.15**
Water absorption[a]	**11.16**
Flammability[a]	**11.17**
Resistance to fluids[a]	**11.18**
Heat shock	**11.19**
Restricted shrinkage	**11.20**
Secant modulus at 2 % strain	**11.21**
Thermal endurance[a e]	**11.22**
Oxygen index[a]	**11.23**
Flammability temperature[a]	**11.24**
Smoke index[a]	**11.25**
Combustion products index[a]	**11.26**
Tests and requirements for identification sleeves[a]	**12**

[a] Only one size of sleeving needs to be tested.

[b] All colours are to be tested.

[c] If the manufacturer/supplier intends to supply printed sleeves, only printed sleeves shall be tested.

[d] Test the greatest wall thickness produced.

[e] The test only needs to be repeated if there is a significant change to composition or techniques.

9.2 Test conditions

9.2.1 Unless otherwise specified in a particular test, the tests shall be carried out under normal test conditions without control of humidity at a temperature of (20 ± 5) °C. In the event of a dispute, the tests shall be conducted at (23 ± 2) °C.

9.2.2 The heat-shrinkable sleeving and measurement gauges, if used, shall be conditioned for at least 4 h under the conditions specified in **9.2.1** prior to testing. When the sleeving is tested after heat-shrinking, conditioning of the sleeving shall take place after completion of the heat-shrinking procedure.

9.2.3 A fan-assisted air-oven shall be used for heating unless otherwise specified in a particular test.

10 Production routine and quality testing

10.1 Production routine tests

Production routine tests shall be applied to samples, taken at random, from every batch, and shall consist of the tests listed in Table 14.

10.2 Production quality tests

The frequency of application of each production quality test shall be in accordance with the requirements of the approving authority and will depend on the maintenance of the basic formulation of the sleeving material and the manufacturing conditions. Production quality tests shall be applied to samples taken at random from batches, and shall consist of the tests listed in Table 15.

10.3 Batch

A batch of sleeving shall consist of sleeving of the same type, dimensions and colour produced from a single mix at any one time, provided that the cross-linking conditions are maintained constant throughout. For continuous processing a single mix shall be defined by the manufacturer or supplier to the satisfaction of the approving authority.

Table 14 — Production routine tests

Title	Clause
Finish: printed/unprinted	**11.1**
Dimensions	**11.2**
Longitudinal change	**11.3**
Colour	**11.4**
Density	**11.8**
Tensile strength and elongation at break	**11.11**
Dielectric strength	**11.12**
Heat shock	**11.19**
Secant modulus at 2 % strain	**11.21**
Printed sleeves only	**12.1** (excluding **12.1.4** and **12.1.6**)

Table 15 — Production quality tests

Title	Clause
Colour stability[a] [b]	**11.5**
Transparency[c]	**11.6**
Colour fastness to light[a] [b]	**11.7**
Resistance to mould growth[a]	**11.9**
Copper mirror corrosion[a]	**11.10**
Volume resistivity after damp heat	**11.13**
Low temperature flexibility	**11.14**
Heat ageing	**11.15**
Water absorption[a]	**11.16**
Flammability[a]	**11.17**
Resistance to fluids[a]	**11.18**
Restricted shrinkage	**11.20**
Thermal endurance[a]	**11.22**
Oxygen index[a]	**11.23**
Flammability temperature[a]	**11.24**
Smoke index[a]	**11.25**
Combustion products index[a]	**11.26**
Tests and requirements for identification sleeves	**12**

[a] Only one size of sleeving needs to be tested.

[b] All colours are to be tested.

[c] Test the greatest wall thickness produced.

11 Tests and requirements for finished sleeving

Clause	Title	Method	Requirement
11.1	**Finish**	Inspect	All sleeving shall conform to clause **6**
11.2	**Dimensions**	A minimum of three test-pieces per batch shall be measured. Measure the test-pieces in the "as supplied" condition and after unrestricted shrinkage. Carry out unrestricted shrinkage under the conditions specified in **11.3**.	All test-pieces shall conform to clause **7**.
		Concentricity of the expanded and unrestricted recovered sleeving test-pieces shall be determined by means of a suitable number of measurements to locate the points on the wall corresponding to the minimum and maximum thickness at a given cross-section.	Concentricity shall be not less than: shrink ratio 2:1 65 % as received 85 % when recovered; shrink ratio 3:1 60 % as received 85 % when recovered; shrink ratio 4:1 50 % as received 85 % when recovered.
		Calculate the concentricity (in %) of each test-piece of the sleeving by use of the following equation. $\text{Concentricity} = \frac{\text{minimum wall thickness}}{\text{maximum wall thickness}} \times 100$	
		The methods of measurement can be mechanical, or optical. Wall thickness shall be measured to an accuracy of 0.025 mm and internal diameter to an accuracy of 0.05 mm.	
		In the case of dispute an optical method shall be used.	

<table>
<tr><th>Clause</th><th>Title</th><th>Method</th><th>Requirement</th></tr>
<tr><td>11.3</td><td>Longitudinal change</td><td>
From the test-pieces used in 11.2, select at least three test-pieces of length approximately 150 mm.

Make two gauge marks, nominally 100 mm apart, approximately centrally placed on the sample using a marking medium that is not detrimental to the material. The distance between gauge marks (L_1) shall be measured to an accuracy of 0.5 mm.

Shrink the test-pieces as specified below.

Re-measure the length between the gauge marks (L_2) to an accuracy of 0.5 mm.

Calculate the longitudinal change (L_C) from the equation:

$$L_C = \frac{L_2 - L_1}{L_1} \times 100$$
where
L_1 = original length;
L_2 = length after unrestricted shrinkage;
L_C = longitudinal change (%).

Carry out the unrestricted shrinkage as follows.

Lay the 150 mm lengths of sleeving on a preheated tray[a] in an oven at the appropriate temperature and for the appropriate time, as follows.
<table>
<tr><th>Type</th><th>Temperature
°C</th><th>Time
(min)</th></tr>
<tr><td>10A</td><td>200 ± 2</td><td>5</td></tr>
<tr><td>10B</td><td>200 ± 2</td><td>5</td></tr>
<tr><td>11A</td><td>200 ± 2</td><td>3</td></tr>
<tr><td>11B</td><td>200 ± 2</td><td>3</td></tr>
<tr><td>11C</td><td>200 ± 2</td><td>3</td></tr>
<tr><td>12A</td><td>200 ± 2</td><td>5</td></tr>
<tr><td>12B</td><td>200 ± 2</td><td>5</td></tr>
<tr><td>13</td><td>150 ± 2</td><td>10</td></tr>
<tr><td>15</td><td>150 ± 2</td><td>5</td></tr>
</table>
Remove the sleeving from the oven, and allow to cool naturally to the temperature specified in 9.2.
</td><td>
Report all results.

The longitudinal change shall not exceed the following limits with the exception of type 11B size codes 29 to 32 which shall be +5 % to −50 % and type 15 size codes 31 to 37 which shall be +5 % to −15 %.
<table>
<tr><th>Type</th><th>Longitudinal change
%</th></tr>
<tr><td>10A</td><td>±10</td></tr>
<tr><td>10B</td><td>±10</td></tr>
<tr><td>11A</td><td>+5, −10</td></tr>
<tr><td>11B</td><td>+5, −10</td></tr>
<tr><td>11C</td><td>+5, −10</td></tr>
<tr><td>12A</td><td>±20</td></tr>
<tr><td>12B</td><td>±10</td></tr>
<tr><td>13</td><td>+5, −15</td></tr>
<tr><td>15</td><td>+5, −10</td></tr>
</table>
</td></tr>
<tr><td colspan="4">[a] The tray should be polytetrafluoroethylene (PTFE) coated or dusted with talcum powder.</td></tr>
</table>

<table>
<tr><th>Clause</th><th>Title</th><th>Method</th><th>Requirement</th></tr>
<tr><td>11.4</td><td>Colour</td><td>Select a test-piece of each colour. Examine each test-piece visually for colour, both before and after unrestricted shrinkage.
Shrink each test-piece under the conditions specified in 11.3.</td><td>The colour of the test-piece shall be recognizable as the relevant colour specified in BS 6746C:1993 and shall be uniform and evenly dispersed throughout. For printed sleeving see also 12.1.6.</td></tr>
<tr><td>11.5</td><td>Colour stability</td><td>Shrink a test-piece of each colour, of 25 mm minimum length, under the conditions specified in 11.3 and place it in an air-circulating oven at the appropriate temperature and for the appropriate time as follows.
<table>
<tr><th>Type</th><th>Temperature
°C</th><th>Time
h</th></tr>
<tr><td>10A</td><td>150 ± 2</td><td>24 ± 0.25</td></tr>
<tr><td>10B</td><td>150 ± 2</td><td>24 ± 0.25</td></tr>
<tr><td>11A</td><td>175 ± 2</td><td>24 ± 0.25</td></tr>
<tr><td>11B</td><td>175 ± 2</td><td>24 ± 0.25</td></tr>
<tr><td>11C</td><td>175 ± 2</td><td>24 ± 0.25</td></tr>
<tr><td>12A</td><td>250 ± 2</td><td>24 ± 0.25</td></tr>
<tr><td>12B</td><td>250 ± 2</td><td>24 ± 0.25</td></tr>
<tr><td>13</td><td>120 ± 2</td><td>24 ± 0.25</td></tr>
<tr><td>15</td><td>135 ± 2</td><td>24 ± 0.25</td></tr>
</table>
After removal from the oven allow the test-piece to cool naturally to the temperature specified in 9.2, and examine visually for colour.</td><td>The colour of the test-piece shall be recognizable as the relevant colour given in BS 6746C:1993 and shall be uniform and evenly dispersed throughout. For printed sleeving see also 12.1.6.
Transparent sleeves shall conform to 11.6.</td></tr>
<tr><td>11.6</td><td>Transparency test</td><td>Shrink a test-piece, as specified in 11.3, of the greatest wall thickness produced. Place in an air-circulating oven at the temperature and time given in 11.5. After removal from the oven, open out and flatten between two plates of clear glass. Lay the test-piece, flattened by a piece of glass if necessary, on top of any text printed in 8 point Helvetica Medium type.</td><td>The text shall be legible using normal reading vision.</td></tr>
<tr><td>11.7</td><td>Colour fastness to light</td><td>Shrink a test-piece of each colour under the conditions specified in 11.3 and subject to the test for colour fastness given in annex B of BS 2782-5: Method 540B:1982, with the additional provisions:
a) no control of humidity shall be exercised;
b) any printing shall face the light source.
Observe and report the number of the wool standard where the first detectable fading corresponds with that of the test-piece.</td><td>The colour fastness to light shall not be less than standard No. 5. Any printing shall remain legible.
For printed sleeving see also 12.1.6.</td></tr>
</table>

Clause	Title	Method	Requirement
11.7 *(continued)*		For transparent sleeving, expose the test-piece to the blue wool standard No. 5. NOTE The test may be terminated after the appropriate blue wool standard has faded.	Transparent sleeving shall conform to **11.6**.
11.8	**Density**	Shrink the sleeving under the conditions specified in **11.3**. Conduct the test in accordance with method A of BS 903-A1:1996. NOTE Small bore sleeving may be cut longitudinally to avoid air entrapment.	The density of the material shall be initially established and declared during type testing, and shall not deviate from this value by more than ± 0.03 during subsequent production routine testing.
11.9	**Resistance to mould growth**	Shrink at least two lengths of sleeving, of approximately 25 mm length, under the conditions specified in **11.3** and subject to the 28 day test of BS 2011-2.1J:1999.	Mould growth shall not be greater than scale 2. For printed sleeving see also **12.1.6**.
11.10	**Copper mirror corrosion**	The copper glass mirrors[a] for this test shall be approximately 6 mm wide by 25 mm long and shall be of vacuum deposited copper, with a thickness giving (10 ± 5) % transmission of normal incident light of a wavelength of 500 nm (5 000 Å limit). The mirrors shall be stored in a desiccator in their original containers and shall be used only if no oxide film is present and the copper is not damaged or contaminated. Shrink the sleeving under the conditions specified in **11.3**. For sleeving with maximum internal diameter after unrestricted shrinkage of 3.2 mm and larger, cut two strips approximately 6.5 mm by 25 mm longitudinally from the shrunk sleeving. For sleeving with maximum internal diameter after unrestricted shrinkage smaller than 3.2 mm, use pieces of shrunk sleeving having a total outer surface area of approximately 150 mm^2 for each test sample. Place each strip or the pieces of shrunk sleeving in the bottom of clean, dry 13 mm by 300 mm test tubes. Suspend the mirrors with the lower edge 150 mm to 180 mm above the bottom of the test tubes. Support the mirrors by forming a single loop of fine clean copper wire, having a diameter not greater than 0.25 mm, around its upper end and attach the other end of the wire to a cork. Ensure that each mirror is vertical. Seal the test tubes with the corks wrapped in aluminium foil.	There shall be no further removal of the copper.

[a] For information on availability of mirrors write to the BSI Library, 389 Chiswick High Road, London W4 4AL.

<table>
<tr><th>Clause</th><th>Title</th><th>Method</th><th>Requirement</th></tr>
<tr><td>11.10
(continued)</td><td></td><td>Prepare a third test tube containing only a suspended mirror as a control.
Maintain the lower 50 mm, approximately, of the test tubes at the appropriate of the following temperatures for (16 ± 0.25) h.
<table><tr><th>Type</th><th>Temperature
°C</th></tr><tr><td>10A</td><td>150 ± 2</td></tr><tr><td>10B</td><td>150 ± 2</td></tr><tr><td>11A</td><td>175 ± 2</td></tr><tr><td>11B</td><td>175 ± 2</td></tr><tr><td>11C</td><td>175 ± 2</td></tr><tr><td>12A</td><td>200 ± 2</td></tr><tr><td>12B</td><td>200 ± 2</td></tr><tr><td>13</td><td>100 ± 2</td></tr><tr><td>15</td><td>150 ± 2</td></tr></table>Maintain the temperature of that portion of the test tubes containing the mirror below 60 °C.
Monitor this temperature using a thermocouple in the vicinity of the glass mirror in one of the test tubes containing a test sample.
After cooling, remove the mirrors and examine each one by placing it against a white background in good light. Any removal of copper from the mirror will be a sign of corrosion. Disregard, however, any removal of copper from the bottom of the mirror, provided the area does not exceed 8 % of the total area of the mirror, since condensation may cause this condition.
Discolouration of the copper film or reduction of its thickness shall not be considered as corrosion. Only the area over which the removal of copper has made the mirror transparent shall be considered as corrosion.
If the mirror in the control tube shows any sign of corrosion, the test shall be repeated.</td><td></td></tr>
</table>

<table>
<tr><th>Clause</th><th>Title</th><th>Method</th><th>Requirement</th></tr>
<tr><td>11.11</td><td>Tensile strength and elongation at break</td><td>Shrink sufficient sleeving under the conditions specified in 11.3 to carry out the following.
For sleeving of specified nominal recovered internal diameter less than 6 mm, cut five lengths of not less than 150 mm from the recovered sleeving.
For sleeving of specified nominal recovered internal diameter of 6 mm or over, cut five dumb-bell test pieces in accordance with type 2 of BS 903-A2:1995 from the recovered sleeving, with their lengths parallel to the extruded axis.
Conduct the tests for tensile strength and elongation at break in accordance with method 320A of BS 2782-3: Methods 320A to 320F:1976 except that test-pieces are as described above and the rate of grip separation used is (100 ± 10) mm/min.
The values of tensile strength and elongation at break shall be the median value of the results obtained.
Breaks at a bench mark or outside the gauge length shall be disregarded and further test-pieces shall be tested until five satisfactory breaks are obtained.</td><td>The tensile strength and elongation at break shall not be less than the following.
<table>
<tr><th>Type</th><th>Tensile strength
MPa</th><th>Elongation at break
%</th></tr>
<tr><td>10A</td><td>12</td><td>300</td></tr>
<tr><td>10B</td><td>12</td><td>300</td></tr>
<tr><td>11A</td><td>10</td><td>250</td></tr>
<tr><td>11B</td><td>10</td><td>250</td></tr>
<tr><td>11C</td><td>17</td><td>250</td></tr>
<tr><td>12A</td><td>10</td><td>250</td></tr>
<tr><td>12B</td><td>10</td><td>200</td></tr>
<tr><td>13</td><td>10</td><td>250</td></tr>
<tr><td>15</td><td>7</td><td>200</td></tr>
</table></td></tr>
<tr><td>11.12</td><td>Dielectric strength</td><td>Take three test-pieces of sleeving, not less than 200 mm long.
Provide a mandrel consisting of a straight clean metal wire, rod or tube of diameter equal to the maximum specified recovered internal diameter of the sleeving, protruding at least 25 mm beyond the ends of the sleeving.
Shrink the sleeving onto the mandrel in accordance with the temperatures specified in 11.3 until fully recovered onto the mandrel. Support the mandrel horizontally such that the sleeving is not in contact with the supports.</td><td>The dielectric strength of each test-piece shall be not less than the following values.
Types 10A and 10B:
a) wall thickness of 1.8 mm or less: 10 kV/mm;
b) wall thickness of over 1.8 mm: 8 kV/mm.
Types 11A, and 11B:
a) wall thickness of 0.9 mm or less: 20 kV/mm;
b) wall thickness of over 0.9 mm: 10 kV/mm.
Type 11C:
a) wall thickness of 0.9 mm or less: 20 kV/mm;
b) wall thickness of over 0.9 mm: 12 kV/mm.</td></tr>
</table>

Clause	Title	Method	Requirement
11.12 *(continued)*		Wrap a strip of aluminium foil, (100 ± 1) mm wide and not more than 0.025 mm thick, around the centre of the sleeving and secure it in position in such a manner that the foil is in intimate contact with the sleeving. Condition the prepared test assembly in accordance with **9.2** prior to testing. Test the conditioned test assembly in air or, if flash-over occurs below the required minimum dielectric strength, in oil conforming to BS 148:1999 using new test-pieces. Carry out the test under the conditions specified in **9.2**. Apply an alternating voltage with a nominal frequency of 50 Hz and a waveform approximately sinusoidal with a peak factor within limits of $\sqrt{2} \pm 7\ \%$ (that is 1.32 to 1.51) between the outer electrode and the mandrel. Apply the test voltage from zero at a uniform rate, such that breakdown or flash-over occurs between 10 s and 20 s. Calculate the dielectric strength by dividing the voltage at which breakdown or flash-over occurs by the recovered wall thickness of the sleeving on the mandrel. Express the result in kV/mm.	*Type 12A:* all wall thicknesses: 6 kV/mm. *Type 12B:* all wall thicknesses: 12 kV/mm. *Type 13:* a) wall thickness of 1.5 mm or less: 12 kV/mm; b) wall thickness of over 1.5 mm: 8 kV/mm. *Type 15:* all wall thicknesses: 15 kV/mm. For printed sleeves see also **12.1.4**.
11.13	**Volume resistivity after damp heat**	Shrink a test-piece of sleeving onto a mandrel of copper, aluminium or stainless steel wire, rod or tube, of the maximum specified recovered internal diameter of the sleeving under the temperature conditions given in **11.3** such that the test-piece is at least 100 mm long after unrestricted shrinkage. Wrap a strip of aluminium foil (25 ± 1) mm wide and not more than 0.025 mm thick round the centre of the sleeving and secure in position in such a manner that the foil is in intimate contact with the sleeving. Alternatively a 25 mm wide layer of high conductivity paint may be applied to the outside of the sleeving.	

<table>
<tr><th>Clause</th><th>Title</th><th>Method</th><th>Requirement</th></tr>
<tr><td>11.13
(continued)</td><td></td><td>Place the test-piece, with the foil in position, in a chamber provided with means of circulating damp air, and subject to damp heat treatment as follows.
a) Maintain the chamber for 16 h ± 5 min in such conditions that the temperature near the test piece is (55 ± 1) °C and the relative humidity is not less than 95 %.
b) Turn off the source of heat and allow the closed chamber to cool for at least 5 h with the damp air circulation maintained.
c) Turn on the source of heat so that at the end of 24 h ± 15 min from the beginning of the treatment the chamber conditions specified in a) are restored.
d) Repeat the cycle of operations described in a), b) and c).
e) Repeat the cycle of operations described in a) and b) except that between 4 h and 5 h after the source of heat has been turned off withdraw the test piece from the chamber, remove surface water and leave it to recover in normal atmospheric conditions.

Within 2 h of removal of the test piece from the chamber, measure its insulation resistance with a potential of approximately 500 V d.c. applied between the outer electrode and the mandrel. Make the measurement not less than 1 min and within 2 min after application of the voltage.

Calculate the volume resistivity as follows:
$\text{volume resistivity} = \frac{5\pi R}{\log_e \frac{D}{d}}$

where
R is the measured insulation resistance (in Ω);
D is the external diameter of sleeving (as fitted) (in mm);
d is the diameter of mandrel (in mm).</td><td>The minimum volume resistivity shall be as follows.<table><tr><th>Type</th><th>Minimum volume resistivity
Ω·cm</th></tr><tr><td>10A</td><td>1×10^{10}</td></tr><tr><td>10B</td><td>1×10^{10}</td></tr><tr><td>11A</td><td>1×10^{11}</td></tr><tr><td>11B</td><td>1×10^{13}</td></tr><tr><td>11C</td><td>1×10^{13}</td></tr><tr><td>12A</td><td>1×10^{11}</td></tr><tr><td>12B</td><td>1×10^{11}</td></tr><tr><td>13</td><td>1×10^{9}</td></tr><tr><td>15</td><td>1×10^{12}</td></tr></table></td></tr>
</table>

<table>
<tr><th>Clause</th><th>Title</th><th>Method</th><th>Requirement</th></tr>
<tr><td>11.14</td><td>Low temperature flexibility</td><td>Take three pieces of sufficient length to provide lengths of 300 mm after unrestricted shrinkage.
Shrink the test pieces under the conditions specified in 11.3.
For sleeving of specified nominal recovered internal diameter 6 mm or less, apply the test to cut lengths of that sleeving.
For sleeving of specified nominal recovered internal diameter greater than 6 mm, apply the test to strips of 6 mm wide, cut from the recovered sleeving, with their lengths parallel to the extruded axis.
Condition the test-pieces by freely suspending them in a refrigerated chamber maintained at the appropriate conditioning temperatures for a period of 4 h. Similarly condition a cylindrical mandrel of diameter equal to the thickness of the sleeving multiplied by any factor between 9 and 10.
For strips, the thickness is the measured wall thickness, and for tubular test-pieces, the thickness is the measured outside diameter.
<table>
<tr><th>Type</th><th>Conditioning temperature
°C</th></tr>
<tr><td>10A</td><td>−75 ± 2</td></tr>
<tr><td>10B</td><td>−75 ± 2</td></tr>
<tr><td>11A</td><td>−55 ± 2</td></tr>
<tr><td>11B</td><td>−55 ± 2</td></tr>
<tr><td>11C</td><td>−55 ± 2</td></tr>
<tr><td>12A</td><td>−55 ± 2</td></tr>
<tr><td>12B</td><td>−55 ± 2</td></tr>
<tr><td>13</td><td>−55 ± 2</td></tr>
<tr><td>15</td><td>−30 ± 2</td></tr>
</table>
At the end of the conditioning period, and while at the conditioning temperature, wrap each test-piece (taking not more than 10 s), 360° round the mandrel in a close helix, with the inside surface of the cut strips in contact with the mandrel. Inspect the test-piece whilst still on the mandrel.</td><td>There shall be no signs of cracking as seen by normal reading vision.</td></tr>
</table>

<table>
<tr><th>Clause</th><th>Title</th><th>Method</th><th>Requirement</th></tr>
<tr><td rowspan="4">11.15</td><td rowspan="4">Heat ageing</td><td>NOTE This repeats 11.11 but with aged specimens.

Age a number of test-pieces, as required for 11.11, in accordance with BS ISO 188:1998 for a period of (168 ± 2) h at the following temperatures as appropriate.</td><td>The minimum elongation at break shall be as follows.

<table><tr><th>Type</th><th>Elongation at break
°C</th></tr><tr><td>10A</td><td>200</td></tr><tr><td>10B</td><td>200</td></tr><tr><td>11A</td><td>150</td></tr><tr><td>11B</td><td>150</td></tr><tr><td>11C</td><td>170</td></tr><tr><td>12A</td><td>150</td></tr><tr><td>12B</td><td>150</td></tr><tr><td>13</td><td>150</td></tr><tr><td>15</td><td>150</td></tr></table></td></tr>
<tr><td><table><tr><th>Type</th><th>Temperature
°C</th></tr><tr><td>10A</td><td>150 ± 2</td></tr><tr><td>10B</td><td>150 ± 2</td></tr><tr><td>11A</td><td>175 ± 2</td></tr><tr><td>11B</td><td>175 ± 2</td></tr><tr><td>11C</td><td>175 ± 2</td></tr><tr><td>12A</td><td>250 ± 2</td></tr><tr><td>12B</td><td>250 ± 2</td></tr><tr><td>13</td><td>120 ± 2</td></tr><tr><td>14</td><td>225 ± 2</td></tr><tr><td>15</td><td>135 ± 2</td></tr></table></td><td rowspan="2">For printed sleeving see also 12.1.6.</td></tr>
<tr><td>After removal from the oven allow the test-pieces to cool naturally to the temperature specified in 9.2 and then test the specimens in accordance with the method given in 11.11.</td></tr>
</table>

<table>
<tr><th>Clause</th><th>Title</th><th>Method</th><th>Requirement</th></tr>
<tr><td>11.16</td><td>Water absorption</td><td>Conduct the test on recovered sleeving in accordance with method 430A of BS 2782-4: Methods 430A to 430D:1983 except that the test shall be conducted on suitable lengths of sleeving.

Choose a length of sleeving of a size which will have a specified nominal recovered internal diameter of 6 mm to 8 mm. Recover the sleeving as specified in 11.3.</td><td>The water absorption of the materials shall not exceed the following.

<table><tr><th>Type</th><th>Water absorption
%</th></tr><tr><td>10A</td><td>1.5</td></tr><tr><td>10B</td><td>1.5</td></tr><tr><td>11A</td><td>0.75</td></tr><tr><td>11B</td><td>0.5</td></tr><tr><td>11C</td><td>0.5</td></tr><tr><td>12A</td><td>1.0</td></tr><tr><td>12B</td><td>1.0</td></tr><tr><td>13</td><td>1.0</td></tr><tr><td>15</td><td>1.0</td></tr></table></td></tr>
<tr><td>11.17</td><td>Flammability</td><td>Use a three-walled sheet metal enclosure approximately 500 mm wide × 300 mm deep × 700 mm high, open at the top and equipped with two parallel horizontal metal rods 410 mm apart, with the lower rod approximately 50 mm apart, with the lower rod approximately 50 mm from the wall of the enclosure. The rods shall be positioned such that when a wire is stretched in the perpendicular plane over the middle of both rods, it shall make an angle of 70° with the horizontal.

Use a length of bare steel wire, approximately 0.74 mm in diameter, for supporting test-pieces during the test.

Place a wire mesh screen beneath the test-piece on the floor of the enclosure with the upper face of the screen covered with wrapping tissue paper of grammage between 12 g/m^2 and 30 g/m^2.</td><td>No test-piece shall emit flaming or glowing droplets at any time during the test, such that they ignite the tissue paper on the floor of the enclosure.

The maximum duration of burning time after the extinction of the gas flame shall be 30 s for all test-pieces.

No test-piece shall be completely consumed.

All sleeve types shall conform to the above requirements, except non-flame-retarded transparent sleeves of types 11A, 11B and 11C.</td></tr>
</table>

Clause	Title	Method	Requirement
11.17 *(continued)*		Use a burner with 9.5 mm nominal bore with the tube of the burner approximately 90 mm long above the primary inlet. Mount the burner on a jig such that the burner is positioned as shown in Figure 1 with the base of the burner at an angle of 25° to the horizontal and offset at an angle of 30° during the period that the flame is applied to the test-piece. The flame shall impinge on the test-piece at an angle of 45°. Public utility or propane gas may be used. Use a sample of sleeving of specified nominal recovered internal diameter of 6 mm to 8 mm to test for itself and all other sizes. Cut five test-pieces approximately 600 mm in length and shrink the test-pieces under the conditions specified in **11.3**. Conduct the test with enclosure situated in a hood or cabinet free from draughts. Draw the test-piece onto the wire. Attach the test-piece and the wire at one end to the middle of the upper horizontal bar by kinking the sleeving and clamping so as to provide a closed end to the test-piece to prevent any chimney effects during the test. Pass the lower end of the wire protruding from the open end of the sleeving over the middle of the lower horizontal bar, and hold it taut against the bar by a weight of at least 500 g, attached to the free end of the wire. With the burner in a vertical position, adjust the height of the flame to give an inner cone of 40 mm. The overall height of the flame shall be approximately 130 mm. The distance between the end of the burner and the edge of the test-piece shall be 40 mm measured along the axis of the burner. After preliminary positioning of the burner and before lighting the burner preparatory to application of the flame to the sleeving, pivot the burner away from the flame area. Ignite the burner in an upright position and drop into testing position at the instant that a timer is started. Apply the flame to the test-piece for 15 s and then extinguish it by turning off the gas supply. Determine the duration of burning of the test-piece from the time of extinction of the gas flame.	

<table>
<tr><th>Clause</th><th>Title</th><th>Method</th><th>Requirement</th></tr>
<tr><td>11.17
(continued)</td><td></td><td>Repeat the test on the other four test-pieces.
WARNING. Care should be exercised during this test as toxic fumes may be given off during combustion. It is recommended that the test chamber should be placed in a fume cabinet which will allow evacuation of gaseous products of combustion.</td><td></td></tr>
<tr><td>11.18</td><td>Resistance to fluids</td><td>Shrink a length of sleeving, with a recovered internal diameter of 6 mm to 8 mm, as specified in 11.3 for each of the fluids listed in Table 16[a] (excluding those sleevings listed as not applicable). Cut five dumb-bell test-pieces from each length as specified in 11.11.
Totally immerse the test pieces in the fluid for 24 h at the tempreature given in Table 16. The volume of the fluid shall be not less than 20 times that of the test-pieces. Remove the test-pieces from the fluid, lightly wipe and then condition for (45 ± 15) min under the conditions specified in 9.2. Examine the test-pieces using normal reading vision.
If the test-pieces are found to be acceptable on visual examination, test them for tensile strength and elongation at break in accordance with the method given in 11.11.</td><td>The sleeving shall not show any marked change of colour, except as given in note 2, nor any signs of crumbling, splitting or blistering.
The minimum tensile strength and elongation shall be as follows.
<table>
<tr><th>Type</th><th>Tensile strength
MPa</th><th>Elongation at break
%</th></tr>
<tr><td>10A</td><td>8</td><td>200</td></tr>
<tr><td>10B</td><td>5</td><td>200</td></tr>
<tr><td>11A</td><td>5</td><td>200</td></tr>
<tr><td>11B</td><td>5</td><td>150</td></tr>
<tr><td>11C</td><td>8</td><td>100</td></tr>
<tr><td>12A</td><td>8</td><td>200</td></tr>
<tr><td>12B</td><td>8</td><td>150</td></tr>
<tr><td>13</td><td>5</td><td>150</td></tr>
<tr><td>15</td><td>4</td><td>100</td></tr>
</table>
NOTE 1 It should be recognized that the figures in the above table apply to sleeving tested after 45 min conditioning. Results immediately after immersion may be significantly different.
NOTE 2 Commercial fluids of the types represented by test fluids (c), (d) and (r) in Table 16 will stain subjected sleeving. Sleevings should not be used purely as colour identifiers in areas subject to contamination by these fluids.</td></tr>
<tr><td colspan="4">[a] The purchaser may require sleeving to be tested in further fluids in addition to those listed in Table 16, in which case the additional fluids should be discussed with the manufacturer or supplier, see clause 3.</td></tr>
</table>

<table>
<tr><th>Clause</th><th>Title</th><th>Method</th><th>Requirement</th></tr>
<tr><td>11.18
(continued)</td><td></td><td>Calculate the tensile strength of the test pieces based on the original cross-sectional areas, and the ultimate elongation based on the gauge lengths of the test-pieces after immersion.

WARNING. Some test fluids may have a flash-point close to or below the temperature of the test. Appropriate precautions should be taken during testing. Some test fluids may themselves, or in combination with the test-piece, be toxic.</td><td>As indicated by the “not applicable” column in Table 16, certain sleeve types are not suitable under the conditions of this test for extended contamination. These sleeves may be for occasional (Class A) or intermittent (Class B) use as given in BS 3G 100-2-3.12:1991. The manufacturer or supplier shall demonstrate conformance to the minimum requirements specified above if the sleeves are claimed to be suitable for exposure to the conditions for Class A or Class B contamination.

For printed sleeves see also 12.1.6.</td></tr>
<tr><td>11.19</td><td>Heat shock</td><td>Select at least three test-pieces of length approximately 150 mm for test.

For sleeving of specified nominal recovered internal diameter 6 mm or less, apply the test to cut lengths of that sleeving.

For sleeving of specified nominal recovered internal diameter greater than 6 mm, apply the test to strips 6 mm wide, cut from the unrecovered sleeving, with their lengths parallel to the extruded axis.

Suspend the test-pieces vertically in an oven at the appropriate of the following temperatures for a period of 4 h ± 10 min.

<table><tr><th>Type</th><th>Temperature
°C</th></tr><tr><td>10A</td><td>215 ± 2</td></tr><tr><td>10B</td><td>215 ± 2</td></tr><tr><td>11A</td><td>225 ± 2</td></tr><tr><td>11B</td><td>225 ± 2</td></tr><tr><td>11C</td><td>225 ± 2</td></tr><tr><td>12A</td><td>300 ± 5</td></tr><tr><td>12B</td><td>300 ± 5</td></tr><tr><td>13</td><td>150 ± 2</td></tr><tr><td>15</td><td>175 ± 2</td></tr></table></td><td>The sleeving shall show no sign of flowing, or dripping.

After bending through 360°, the sleeving shall show no sign of cracking except that side cracking of flattened sleeving shall not be cause for rejection.

Any change of colour shall be ignored.

For printed sleeving see also 12.1.6.</td></tr>
</table>

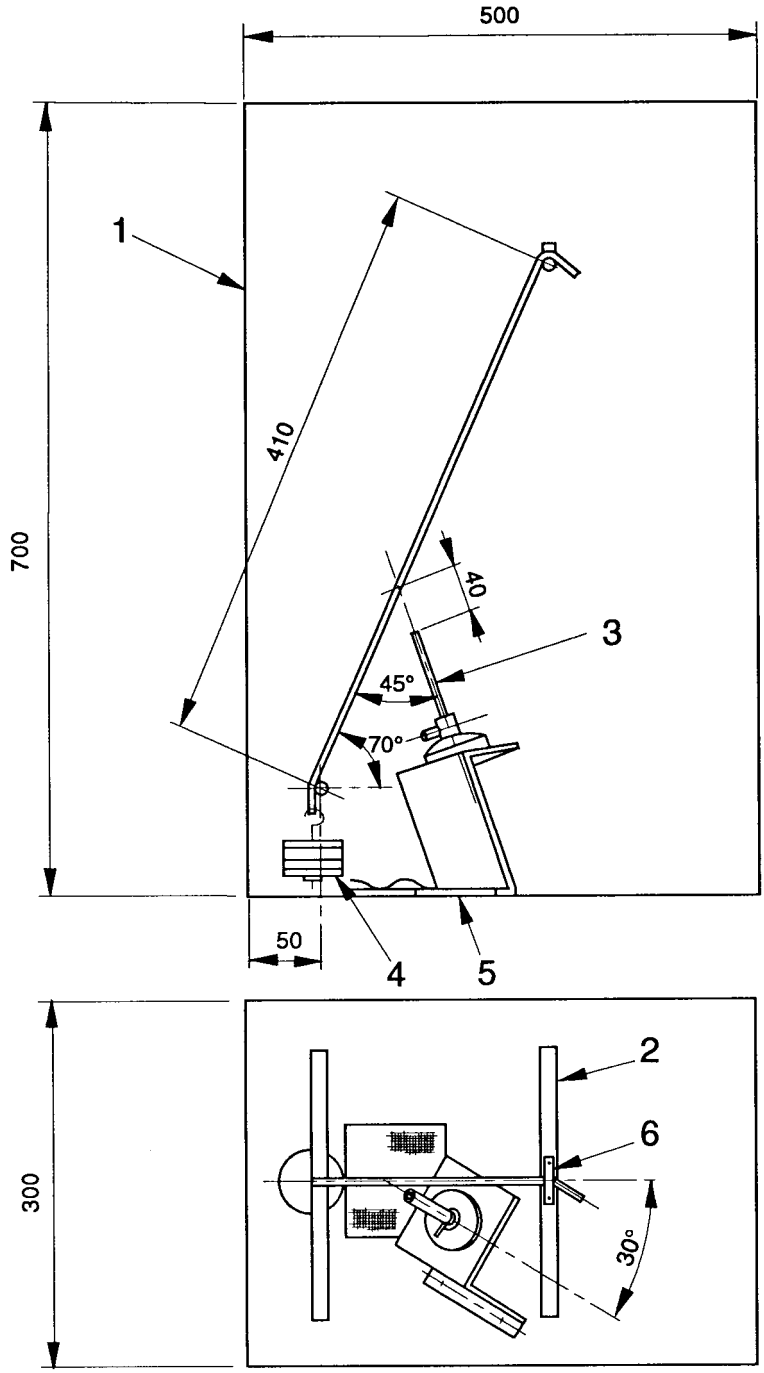
<table>
<tr><th>Clause</th><th>Title</th><th>Method</th><th>Requirement</th></tr>
<tr><td>11.19
(continued)</td><td></td><td>WARNING. Care should be exercised during this test as toxic fumes may be given off. It is recommended that the test should be conducted with fume extraction.
After removal from the oven, examine the specimens for evidence of flowing, or dripping.
Leave the test-pieces in the conditions specified in 9.2 for a period of 1 h ± 30 min and then wrap, in a close helix, 360° around a mandrel of diameter equal to the thickness of the sleeve multiplied by any factor between 9 and 10. Keep the inside surface of the cut strips in contact with the mandrel.
For strips, the thickness is the measured wall thickness and for tubular test-pieces the thickness is the measured outside diameter.
Examine the specimens using normal reading vision.</td><td></td></tr>
<tr><td>11.20</td><td>Restricted shrinkage</td><td>Prepare a metallic mandrel as shown in Figure 2 for each sleeving size. For type 11B size codes 29 to 32, the mandrel diameter for D shall be equal to D/2. The mandrels shall be free from burrs and sharp edges.
Select at least three test-pieces of each size, of sufficient length so that after shrinking onto the appropriate mandrel, each end of the mandrel is exposed for electrical connections. Place the sleeving over the appropriate cold mandrel and shrink it in an oven at the temperatures specified in 11.3 until fully recovered onto the mandrel.
Transfer the assembly to an oven maintained at the appropriate of the following temperatures for (30 ± 5) min.
<table>
<tr><th>Type</th><th>Temperature
°C</th></tr>
<tr><td>10A</td><td>150 ± 2</td></tr>
<tr><td>10B</td><td>150 ± 2</td></tr>
<tr><td>11A</td><td>175 ± 2</td></tr>
<tr><td>11B</td><td>175 ± 2</td></tr>
<tr><td>11C</td><td>175 ± 2</td></tr>
<tr><td>12A</td><td>250 ± 3</td></tr>
<tr><td>12B</td><td>250 ± 3</td></tr>
<tr><td>13</td><td>120 ± 2</td></tr>
<tr><td>15</td><td>135 ± 2</td></tr>
</table></td><td>The sleeving shall fit snugly over the mandrel without cracking. It shall withstand the voltage application specified.</td></tr>
</table>

<table>
<tr><th>Clause</th><th>Title</th><th>Method</th><th>Requirement</th></tr>
<tr><td>11.20
(continued)</td><td></td><td>WARNING. Care should be exercised when performing this test as toxic fumes may be given off. It is recommended that the test should be conducted with fume extraction.
Remove the test-piece from the oven and allow to cool naturally to the temperature specified in 9.2.
Subject the test-pieces to the following voltage test.
Paint the outer surface of the sleeving with a conductive material which has no detrimental effect on the sleeving. Allow sufficient sleeving area to remain unpainted at each end so that flash-over between the mandrel and the paint will not occur. Ensure that the conductive material extends for not less than 5 mm on either side of dimension Y in Figure 2. Apply a voltage of 2 000 V a.c. at the 50 Hz nominal frequency for 1 min between the painted surface and the mandrel.</td><td></td></tr>
<tr><td>11.21</td><td>Secant modulus at 2 % strain</td><td>Shrink three test-pieces as specified in 11.3 except that each length shall be sufficient to produce a gauge length of at least 100 mm. For sleeving of recovered internal diameter of less than 6 mm use lengths of recovered sleeving. For sleeving of specified nominal recovered internal diameter 6 mm or greater, use strips with a width to thickness ratio of not less than 8:1 cut parallel to the longitudinal axis of the sleeving.
The test-piece shall be mounted in a tensile strength machine in axial alignment in the direction of pull. The range of the tensile strength machine shall be such that the maximum load is between 15 % and 85 % of the maximum scale reading. Measure the extension by means of extensometer or by jaw separation to an accuracy of 2 %.</td><td>The secant modulus shall be as follows.
<table>
<tr><th>Type</th><th>Secant modulus
MPa</th></tr>
<tr><td>10A</td><td>50 max.</td></tr>
<tr><td>10B</td><td>100 max.</td></tr>
<tr><td>11A</td><td>100 max.</td></tr>
<tr><td>11B</td><td>170 max.</td></tr>
<tr><td>11C</td><td>200 min.</td></tr>
<tr><td>12A</td><td>100 max.</td></tr>
<tr><td>12B</td><td>100 max.</td></tr>
<tr><td>13</td><td>75 max.</td></tr>
<tr><td>15</td><td>130 max.</td></tr>
</table></td></tr>
</table>

Clause	Title	Method	Requirement
11.21 *(continued)*		The length of the test-piece between either the jaws or reference lines depending on the method of measurement chosen, shall be not less than 100 mm nor greater than 250 mm. The strain rate shall be (0.1 ± 0.03) mm per mm · min, e.g. for a distance between the jaws of 120 mm, the speed of the moving jaw shall be (0.1×120) mm = 12 mm per min. If an initial tensile force, F, is needed to straighten the test-piece this force shall not exceed 3 % of the final value. Record force F. Increase the force until the extension between the jaws or reference lines reaches 2 %. Record the force, F_1, required to produce this extension. Calculate the secant modulus from the determination of the tensile stress necessary to produce in the test-piece an extension of 2 % of the length between jaws or between reference lines as follows: $$2\,\%\ \text{secant modulus} = \frac{F_1 - F}{0.02A}$$ where A is the initial cross-sectional area of the test specimen (in mm^2); F_1 is the force required to produce a 2 % extension (in N); F is the force applied to produce the initial (straightening) stress (in N). Report all measured values. The result is the median value.	

<table>
<tr><th>Clause</th><th>Title</th><th>Method</th><th colspan="2">Requirement</th></tr>
<tr><td>11.22</td><td>Thermal endurance</td><td>Conduct the test in accordance with IEC 60216. Measure the ultimate elongation in accordance with 11.11. The end point for the ultimate elongation shall be 50 % absolute value. The colours to be tested shall be black and transparent (where appropriate) using sleeving of 6 mm to 10 mm recovered internal diameter.
NOTE It is recognized that other colours may give different results. The manufacturer/supplier may be required to provide evidence to the approval authority that other colours will meet the minimum temperature index, 10 000 h.</td><td colspan="2">The minimum temperature index shall be as follows.
<table><tr><th>Type</th><th>Temperature index
°C</th></tr><tr><td>10A</td><td>120</td></tr><tr><td>10B</td><td>120</td></tr><tr><td>11A</td><td>135</td></tr><tr><td>11B</td><td>135</td></tr><tr><td>11C</td><td>135</td></tr><tr><td>12A</td><td>200</td></tr><tr><td>12B</td><td>200</td></tr><tr><td>13</td><td>90</td></tr><tr><td>15</td><td>105</td></tr></table></td></tr>
<tr><td>11.23</td><td>Oxygen index</td><td>Conduct the test in accordance with BS ISO 4589-2:1996.
A 3 mm thick moulded sheet shall be prepared from the material from which the sleeving is fabricated. The sheet shall be cross-linked to the same degree as the sleeving.
The test-piece size shall be as type IV.</td><td colspan="2">Type 15 only
29 minimum</td></tr>
<tr><td>11.24</td><td>Flammability temperature</td><td>Test in accordance with method 143B of BS EN ISO 4589-2:1996.
A 3 mm thick moulded sheet shall be prepared from the material from which the sleeving is fabricated. The sheet shall be cross-linked to the same degree as the sleeving.
The test-piece size shall be as type IV.</td><td colspan="2">Type 15 only
250 minimum</td></tr>
<tr><td>11.25</td><td>Smoke index</td><td>Test in accordance with annex B.</td><td colspan="2">Type 15 only
20 maximum</td></tr>
<tr><td>11.26</td><td>Combustion products index</td><td>Test in accordance with annex C.</td><td colspan="2">Type 15 only
5 maximum
There shall be no detectable halogen gases.</td></tr>
</table>

Linear dimensions are in millimetres.



Key

1. Sheet metal enclosure with one side open for access.
2. Horizontal metal rods (2 off).
3. Burner 9.5 mm bore × 90 mm long.
4. Weights 500 g minimum.
5. Wire mesh screen covered with tissue paper of grammage between 12 g/m^2 and 30 g/m^2.
6. Clamp.

Figure 1 — Test configuration for flammability test

Table 16 — List of test fluids

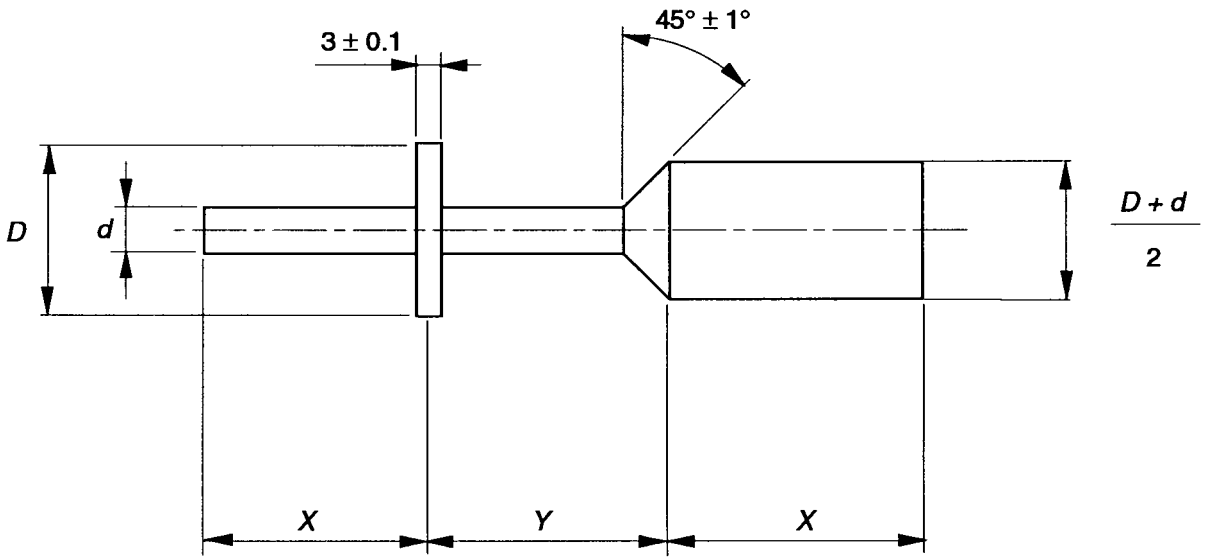
Test fluid reference	Test fluid	Immersion temperature °C[a]	Not applicable to sleeving types
See BS 3G 100-2-3.12:1991			
(b)	Aircraft fuel. Gasoline (piston engine). BS ISO 1817:1999 test liquid B	40 ± 2	
(c)	Hydraulic fluid. Mineral-based to NATO H-520 (OM-18)[b]	50 ± 2	10B, 11A, 15
(d)	Phosphate ester-based (synthetic). BS ISO 1817:1999. Test fluid 103	70 ± 2	10B, 12A, 12B
(e)	Silicone-based synthetic hydraulic fluid; dimethyl silicone 10 mm^2/s (cst) at 25 °C ZX42; NATO S1714	50 ± 2	
(g)	Lubricating oil. Ester-based (synthetic). ISO 1817:1999. Test liquid 101	100 ± 2	10B, 11A, 11B, 15
(h)	De-icing fluid; Propan-2-ol (isopropyl alcohol) to BS 1595-1:1986	23 ± 2	
(i)	Cleaning fluid[c]	23 ± 2	
(m)	De-icing fluid; inhibited ethylene glycol 50 % solution in water (*v*/*v*) BS 6580:1992	23 ± 2	
(r)	Sullage fluid; 4 ± 0.1 % formaldehyde plus 1 ± 0.1 % o-cresol (GPR) in water	23 ± 2	

[a] Or 10 000 h temperature of the sleeve if lower (see Table 1).

[b] NATO H515 may be used as an alternative.

[c] If a cleaning fluid is required then the test fluid shall be as agreed between the manufacturer/supplier and the purchaser. See clause **3**.

NOTE For information on the availability of the fluids given in this table, write to the BSI Library, 389 Chiswick High Road, London W4 4AL.



Key

d is the maximum internal diameter (+5, −0 %) of sleeving after unrestricted shrinkage in Tables 4 to 12.

D is the minimum internal diameter (+0, −5 %) of "as supplied" sleeving as specified in Tables 4 to 12.

Table 17 — Mandrel for restricted shrinkage test

All dimensions in millimetres

Specified maximum internal diameter of sleeving after unrestricted shrinkage	Mandrel section	
	X (min.)	*Y*
Less than 1.20[a]	13	6.4 ± 0.05
1.20 to 3.2	13	6.4 ± 0.05
3.21 to 9.5	25	12.7 ± 0.05
9.51 to 58.0	50	50.8 ± 0.05

[a] For sleeving sizes less than 1.20 mm specified maximum internal diameter after restricted shrinkage, a straight cylindrical mandrel shall be made with an outside diameter equal to *D*.

Figure 2 — Mandrel for restricted shrinkage test

12 Tests and requirements for identification sleeves

NOTE The information to be printed on sleeves should be stated by the purchaser in the contract or order (see clause **3**).

12.1 Printing on recovered identification sleeves

12.1.1 ***The printing shall be black or blue-black, except on sleeves that would not provide adequate contrast, where it shall be a light colour***

NOTE The term blue-black normally covers the range blue to black.

12.1.2 ***The printing shall be longitudinal on the sleeve, see Figure 3***

12.1.3 NOTE A transparent overlay may be used to protect the print if necessary.

Where an overlay is used, it shall be considered as part of the sleeve for the purposes of this standard.

12.1.4 Printed sleeving shall conform to **11.12**.

12.1.5 Printing shall be legible with normal reading vision.

12.1.6 Printing shall be legible after 25 strokes of dry tissue paper on completion of the final conditioning period for each of the following tests and for each printing technique, for example, laser, thermal transfer and daisy wheel.

a) colour (**11.4**);

b) colour stability test (**11.5**);

c) colour fastness test (**11.7**);

d) resistance to mould growth test (**11.9**);

e) heat ageing test (**11.15**);

f) resistance to fluids test (**11.18**);

g) heat shock test (**11.19**).

12.1.7 The production test on recovered identification sleeving shall be 25 strokes of tissue paper impregnated with isopropyl alcohol (IPA) after which the printing shall be legible with normal reading vision.

12.2 Sleeve printing systems for customers

Where a manufacturer supplies a customer with a sleeve printing system it shall be capable of producing results that conform to clause **12**.

12.3 Single characters

12.3.1 On the recovered sleeve the characters shall be clearly printed and of uniform density. Any characters capable of being misinterpreted shall be underlined or followed by a dot,
e.g. M. M W. W 6. 6 9. 9.

12.3.2 For sleeves with nominal internal diameter, "as supplied", up to and including 25 mm, the size of characters on the recovered sleeve and the number of times they are printed on each sleeve shall be as specified in Table 18 unless otherwise agreed with the customer.

12.3.3 For sleeves with nominal internal diameter, "as supplied", above 25 mm the requirements for height and number of times printed around the circumference shall be agreed between the customer and manufacturer or supplier.

12.3.4 The characters shall be of a height such that the total number of upper case characters shall cover at least 25 % of the circumference. Lower case characters shall be the same point size as the upper case characters.

12.3.5 When sleeves are marked more than once, the printing shall be approximately equally spaced around the sleeve.

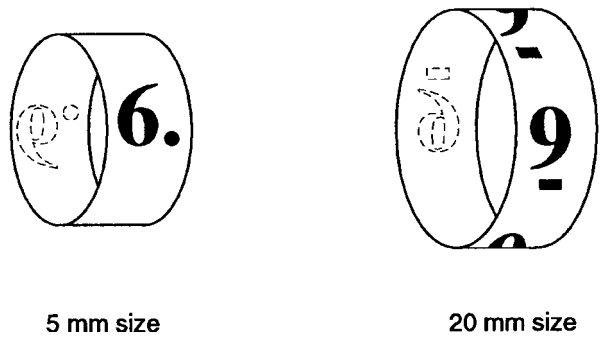


Figure 3 — Disposition of characters on identification sleeving

Table 18 — Size and repetition of characters

Nominal internal diameter of sleeve "as supplied" mm	Nominal height of characters (see **12.3**) mm	Number of times printed around circumference
0.5 to 1.6	1.6 to 2.0[2)]	1
1.61 to 4.0	2.5	2
4.1 to 10.0	4.5	2
10.1 to 25.0	6.0	4

12.4 Single numerals

Single numerals shall be related to the sleeve colour, as shown in Table 19.

Table 19 — Allocation of numerals to sleeve colours

Colour of sleeve	Printed number	Colour code
Black	0	0
Brown	1	1
Red	2	2
Orange	3	3
Yellow	4	4
Green	5	5
Blue	6. or $\underline{6}$	6. or $\underline{6}$
Violet	7	7
Grey	8	8
White	9. or $\underline{9}$	9. or $\underline{9}$
Pink	none	2L
Green/yellow	54	
Clear	none	X

NOTE The numeral/colour relationship is given in BS EN 60062:1994.

13 Marking and packaging

13.1 Each package of sleeves/sleeving shall be marked with the following information:

a) the number and date of this British Standard, i.e. BS 4G 198-3:1999[3)];

b) the type number;

c) the size code if relevant;

d) the length and quantity of sleeves/sleeving;

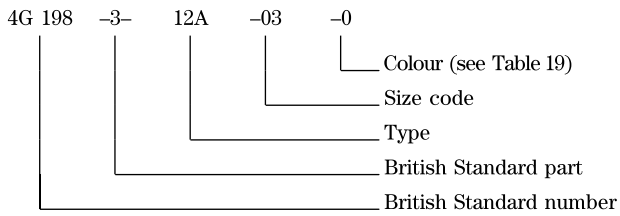
e) the manufacturer or supplier's name or recognized mark;

f) the batch number;

g) the use by date[4)];

h) the characters/legend printed on the sleeves.

NOTE 1 The number of this British Standard, including the part number, the type and the size code may be codified as in the following example.



In the example shown, type 12A sleeving, of 3.2 mm nominal internal diameter after recovery, colour black, conforming to this standard would be supplied.

NOTE 2 The purchaser should use this code to identify sleeving in the contract or order (see clause **3**).

13.2 If packed in non-transparent packages, the outside of the container shall be marked to show the colour of the sleeving.

NOTE 1 Packaging requirements will vary and should be specified by the purchaser in the contract or order (see clause **3**).

NOTE 2 For UK Government Services, these instructions will be based on Defence Standard 81-41/3 *Packaging of defence materiel* [1].

13.3 Where printing is made permanent by the heat shrink process, the packaging shall carry a caution about handling the item in the "as supplied" state.

[2)] Depending on the supplied diameter.

[3)] Marking BS 4G 198-3:1999 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, which may also be desirable.

[4)] The use by date is only applicable when the storage conditions given in annex A have been met.

Annex A (informative)

Storage recommendations

The following recommendations are intended to assist the prevention of sleeving degradation caused by conditions existing in the storage area:

a) for shelf life conditions, see BS 3F 68;

b) no sleeving should be stored in direct sunlight;

c) sleeving should not be stored within 2 m of a direct ultraviolet (e.g. fluorescent) light source;

d) sleeving delivered in packages should remain packaged until required;

e) material used in packaging should preferably be of an opaque material;

f) packages which are opened for removal of part of their contents should be adequately resealed;

g) unpackaged sleeving should be stored in dust-excluding containers;

h) periodically, at a frequency dependent on conditions and local quality control agreements, containers should be emptied and cleaned if they contain unpackaged sleeving;

i) artificial conditions, such as high ambient temperatures, dry humidities, and chemical vapours, should be avoided.

Annex B (normative)

Method for the determination of smoke index

B.1 Definition

For the purposes of this test method the definitions given in BS 6401:1983 apply, together with the following.

smoke index

the numerical summation of the rates of change in the specific optical density of the smoke produced from the start of the test to light transmittance values of 70 %, 40 %, 10 % and the minimum light transmittance value as applicable

B.2 Principle

Cut strips from a recovered sample sleeve and expose them to specified thermal conditions of pyrolysis and combustion in a continuous procedure. Record the change in optical density of the smoke produced when dispersed within a fixed volume of air is recorded throughout the period of the test. Use the resulting density/time curve to calculate the smoke index.

B.3 Apparatus

The apparatus shall conform to BS 6401:1983 with the following modifications:

B.3.1 *Small mixing fan*, positioned centrally near the top of the chamber to ensure complete dispersion of the smoke homogeneously throughout the chamber. This fan shall consist of four radially mounted blades with a dimension across the opposing blade tips of 250 mm and a maximum blade width of 70 mm. The fan shall rotate at a speed of between 60 r.p.m. and 120 r.p.m.

B.3.2 *Auxiliary heater*, to reduce the time required to bring the chamber walls to (33 ± 4) °C. This may take the form of either a small black heater positioned centrally in the chamber, or heater panels attached to the external walls of the chamber. Other means of heating the chamber walls may also be used. In all cases the method chosen shall not affect the value of the smoke index of the material under test.

B.3.3 *Burner*

B.3.3.1 *multi-jet burner*, constructed as shown in Figure B.1 used with premixed air/propane gas fuel. The burner shall be centred in front of the test-piece holder, level with the bottom edge of the test-piece and 10 mm away from it. Meter the air and propane gas using calibrated rotameters, the rate being such that a blue flame is obtained which touches the test-piece over at least 90 % of its width at a height approximately 5 mm above its bottom edge.

B.3.3.2 *ignition system*, such that the burner can be ignited remotely without opening the chamber. Platinum glow wire, piezo-electric crystal or pilot flame ignition systems have been found suitable. The system used shall have no effect on the value of the smoke index of the material under test.

B.4 *Test-pieces*

B.4.1 Choose a length of sleeving of a size which will have a recovered internal diameter of 6 mm to 8 mm, and shrink it fully.

B.4.2 Cut sufficient strips of material each 75 mm long to completely cover the face area of the test-piece holder. Slit each strip and open out the sleeving.

B.4.3 Use the 6 mm to 8 mm recovered internal diameter size to test for all sizes of the same material.

B.5 Conditioning

Prior to mounting the strips in the test-piece holder, condition them at (23 ± 2) °C and (50 ± 5) % relative humidity for at least 24 h.

B.6 Mounting of test-pieces

B.6.1 To prevent excessive buckling and distortion of the test-piece during test, use a wire mesh, manufactured from 1.5 mm diameter stainless steel wire with a spacing of 12.5 mm and a square mesh configuration to support the strips.

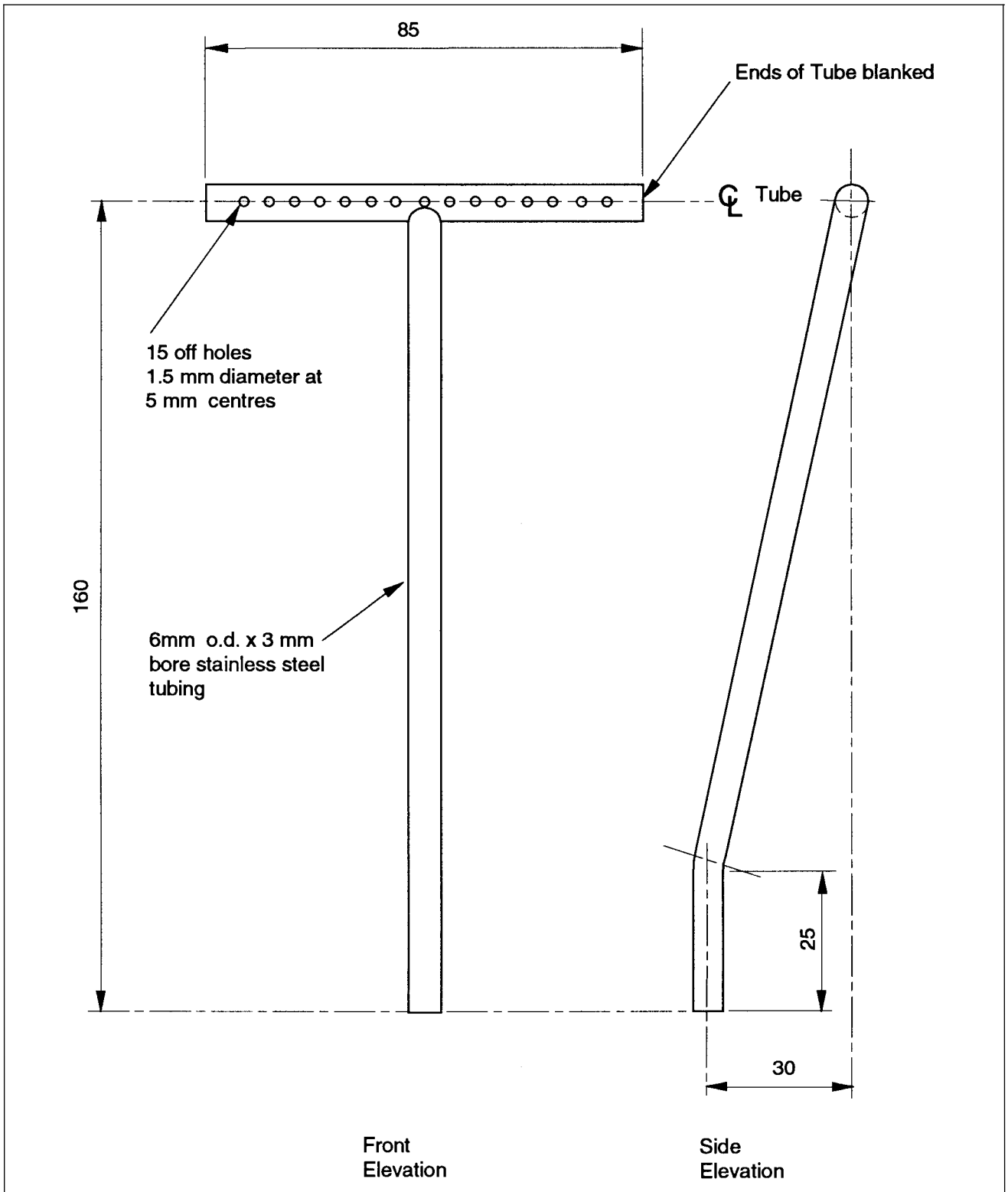


Figure B.1 — Schematic details of burner for smoke index test

B.6.2 Place the test-piece holder, face down, onto a flat surface and insert the wire mesh. Position each strip in the holder in a parallel arrangement, ensuring that spaces are not left between the strips without overlapping, so that when the holder is in the test position the strips are vertical. Completely wrap the insulating block in heavy duty aluminium foil, approximately 0.04 mm thick, and place it over the arranged strips in the test-piece holder. Position the tensioning spring and secure with the locking pin.

NOTE See Figure B.2 for the front view of the smoke index test-piece holder, showing the vertically mounted strips.

B.7 Safety

During the following test there is a danger that flammable and/or toxic fumes will be evolved from the test-piece, and operators should take precautions to avoid possible exposure to the evolved fumes.

B.8 Procedure

B.8.1 Set up the test chamber and carry out all necessary checks and calibration as required by BS 6401:1983, and in accordance with the manufacturer's instructions.

B.8.2 Turn on the propane and air supplies to the burner and ignite them. With a blank test-piece holder in position in front of the furnace, adjust the gas flow rates to obtain the correct flame height as specified in **B.3.3.1**. Note the settings of the rotameters and turn off the gases.

B.8.3 Clean the optical windows of the chamber and switch on the auxiliary heating system. Allow the apparatus to stabilize with the vents open, until the chamber wall temperature is within the range (33 ± 4) °C. Close the inlet vent.

B.8.4 Stabilize the output of the furnace at 2.5 W/cm^2 and close the exhaust vent. Set the zero and 200 % levels of the amplifier and the recorder respectively. Start the recorder at a minimum speed of 10 mm/min.

B.8.5 Place the test-piece holder containing the material to be tested in its position in front of the furnace and mark this point on the recorder as the start of the test. Simultaneously start the timing device.

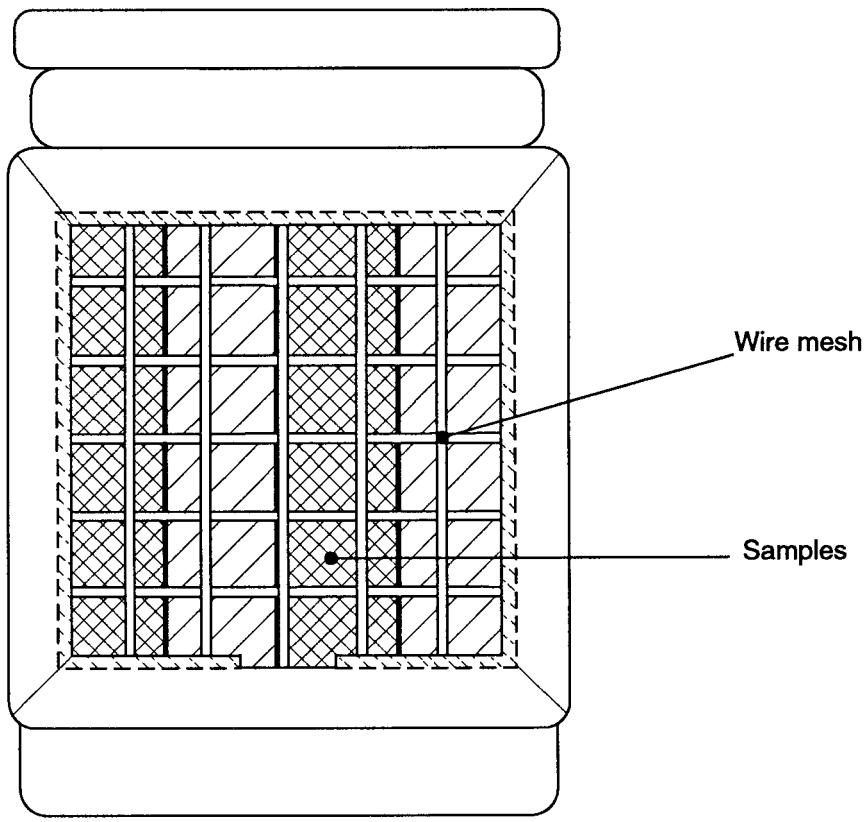


Figure B.2 — Schematic front view of smoke test piece holder, showing vertically mounted sleeving samples

B.8.6 After an interval of 300^{+10}_{0} s from the start of the test, turn on the gas supplies and ignite the burner, immediately adjusting the gas flow rates to those previously noted in **B.8.2**.

B.8.7 Expose the material simultaneously to the output from the furnace and the burner for a further 15 min $\pm$ 5 s. Record the percentage light transmission continuously and observe the burning characteristics of the material throughout this period. If the test-piece shows unusual burning behaviour, such as delamination, sagging, shrinkage, melting or collapse, report this in the test report together with the time at which the particular behaviour was observed. If the light transmission falls below 0.01 %, cover the observation window in the chamber door and withdraw the range extension filter from the light path.

B.8.8 At the end of the test, and without opening the chamber, turn off the gases to the burner and move the test-piece holder from in front of the furnace using the attenuator arm. Maintain the current to the furnace and the recorder. Evacuate the chamber according to the manufacturer's instructions. Continue to record the percentage light transmission with time until a steady value is obtained. This is the clear beam value (T_c).

B.8.9 Throughout the test period, adjust the ranging of the photo-detector amplifier system to maintain the level of the readings recorded for the percentage light transmission at a minimum of 10 % of the full scale value.

B.8.10 At the end of the test, ensure that the inside of the chamber, the auxiliary apparatus and the supporting framework are clean.

B.8.11 Repeat the test on two further test-pieces prepared from the sample sleeve.

NOTE Provided no adjustments to the test apparatus have been made that would affect the calibration or the flame condition, the same settings may be used for the repeat tests.

B.9 Calculation of results

B.9.1 *General*

The progressive build-up of deposits on the optical windows during the test run artificially depresses the recorded transmittance values. It may be necessary, therefore, to apply a correction to the recorded values by constructing a new plot of the transmittance/time relationship in accordance with **B.9.2** before calculating the smoke index.

B.9.2 *Correction of transmittance values*

B.9.2.1 Using the plot obtained from the recorder identify the following values:

a) T_c, the clear beam transmittance at the end of the test run;

b) $T_{\text{min.}}$ the minimum transmittance obtained during the test run.

B.9.2.2 Convert T_c and $T_{\text{min.}}$ to the equivalent specific optical densities, D_{sc} and $D_{s\text{max}}$

where

D_{sc} is the specific optical density for clear beam transmittance;

$D_{s\text{max.}}$ is the specific optical density for minimum transmittance.

The conversion of percentage transmittance to specific optical density, D_s, for the chamber is given by:

$$D_s = F \times \log_{10} \frac{100}{T}$$

where

T is the percentage transmittance;

F is the chamber factor.

NOTE 1 The chamber factor is 130.5 for the Stanton Redcroft (Trade Mark) smoke chamber.

NOTE 2 The chamber factor is given by $\frac{V}{AL}$ where V is the volume, A is the exposed area of the test-piece and L is the length of the light path.

B.9.2.3 If D_{sc} is 3 % or less of $D_{s\text{max.}}$ no further correction to the recorded plot need be made.

B.9.2.4 Subtract D_{sc} from $D_{s\text{max.}}$ to obtain the corrected maximum specific density $D_{s\text{max.}c}$. Convert $D_{s\text{max.c.}}$ to percentage transmittance and plot this value on the recorded chart as the corrected minimum transmittance, $T_{\text{min.}c}$, at the same time interval.

B.9.2.5 If D_{sc} is more than 3 % of $D_{s\text{max.}}$ and where $T_{\text{min.}c}$ is less than 70 %, produce a new plot from the recorder trace as follows.

Convert the percentage transmittance to specific optical density as in **B.9.2.2** and correct these values using the formula given below:

$$D_c = D_s - \frac{D_{sc} \times D_s}{D_{s\text{max.}}}$$

where

D_c is the corrected value of specific optical density;

D_s is the uncorrected value of specific optical density;

D_{sc} and $D_{s\text{max.}}$ are as defined in **B.9.2.2**.

B.9.2.6 For example, to obtain the corrected specific optical density at 70 % transmittance (where D_s = 20):

$$D_{20C} = D_{ST70} = \frac{D_{sc} \times 20}{D_{s\max.}}$$

Similarly, corrected values for specific optical density at 40 % transmittance (D_{ST40}) and 10 % transmittance (D_{ST10}) may be calculated.

B.9.2.7 Convert the corrected values for specific optical density obtained in **9.2.6** back to percentage transmission. Construct a new curve of transmittance against time from the corrected values plotted at the same time interval as the original uncorrected values.

Read from the graph the corrected times (in minutes) from the start of the test to reach 70 %, 40 % and 10 % transmittance.

B.9.3 ***Calculation of the smoke index***

B.9.3.1 Where the corrected minimum transmittance value is not less than 70 %, calculate the smoke index from the original plot as follows:

$$\text{smoke index} = \frac{D_{ST\min.c}}{t_{\min.}}$$

where

$D_{ST\min.c}$ is the specific optical density corresponding to the corrected minimum light transmittance value from the corrected curve;

$t_{\min.}$ is the time in minutes at which the minimum light transmittance value is recorded.

B.9.3.2 Where the corrected minimum transmittance value is less than 70 %, calculate the smoke index from the corrected curve as follows:

$$\text{smoke index} = \left(\frac{D_{ST70}}{t_{70}} + \frac{D_{ST40}}{t_{40}} + \frac{D_{ST10}}{t_{10}} + \frac{D_{ST\min.c}}{t_{\min.}}\right) \times \left(\frac{X - T_{\min.c}}{X - Y}\right)$$

where

D_{ST70} is the specific optical density corresponding to 70 % light transmittance, (20.0);

D_{ST40} is the specific optical density corresponding to 40 % light transmittance, (51.9);

D_{ST10} is the specific optical density corresponding to 10 % light transmittance, (130.5);

t_{70} is the corrected time, in minutes, from the start of the test to reach 70 % light transmittance;

t_{40} is the corrected time, in minutes, from the start of the test to reach 40 % light transmittance;

t_{10} is the corrected time, in minutes, from the start of the test to reach 10 % light transmittance;

$D_{ST\min.c}$ is the specific optical density corresponding to the minimum light transmittance value from the corrected curve;

$t_{\min.}$ is the time, in minutes, from the start of the test at which the minimum light transmittance occurs;

X is the lowest reference transmittance value reached during the test, that is 70 %, 40 % or 10 %;

Y is the lowest reference value reached during the test, that is 40 %, 10 % or 0 %.

$T_{\min.c}$ is the minimum light transmittance value from the corrected curve.

B.10 Test report

Include the following details in the test report:

a) the mean value of the smoke index for the repeat tests (a minimum of three) to the first decimal place;

b) a description of the burning behaviour (see **B.8.7**);

c) the wall thickness of the sleeving;

d) include the following statement:

"This test result alone does not assess the fire hazard of the material or a product made from this material under actual fire conditions. Consequently the results of this test alone shall not be quoted in support of claims with respect to the fire hazard of the material or product under actual fire conditions. The results, when used alone, should only be used for research and development, quality control and material specification".

Annex C (normative)
Method for the determination of combustion products index

C.1 Apparatus

C.1.1 *General*

As far as is practicable, all surfaces and all items of equipment within the test chamber shall be constructed from, or coated with, a non-metallic material which is inert to the gases evolved from the material during the test and which minimizes their adsorption.

NOTE Polypropylene is suitable for lining the chamber and polycarbonate sheet is suitable for lining the window.

C.1.2 *Test chamber*

A test chamber comprising:

a) an airtight enclosure of at least 0.7 m^3 lined with an opaque plastics material and having a hinged or sliding door fitted with a transparent plastics window;

b) a forced air extraction system which can be closed at the exit from the chamber when required during the test;

c) a mixing fan installed horizontally and centrally at roof level within the chamber. The fan shall have a minimum diameter of 200 mm and shall consist of six axially mounted blades rotating at between 1 200 r.p.m. and 1 500 r.p.m.;

d) a means for switching the fan on and off from outside the chamber.

C.1.3 *Burner*

A bunsen type burner with the following features:

a) able to operate on natural gas (methane) having a gross calorific value of approximately 30 MJ/m^3;

b) an air-supply external to the chamber;

c) a modified collar to prevent oxygen depletion and the consequential extinguishing of the flame or reduction of the flame temperature;

d) capable of producing a flame approximately 100 mm in height and having a temperature of (1 150 $\pm$ 50) °C at its hottest point;

NOTE A bunsen burner of 125 mm in height, 11 mm bore burner tube and 5 mm bore gas and air-inlet tubes is recommended for gas and air-flow rates of approximately 10 l/min and 15 l/min.

e) means for igniting and extinguishing the burner from outside the chamber.

C.1.4 *Test-piece support*

An annulus, cut from 2 mm to 4 mm thick non-combustible material, of (100 $\pm$ 1) mm outside diameter and (75 $\pm$ 1) mm internal diameter, over which a wire mesh is stretched. The mesh consists of temperature resistant wires approximately 10 mm apart in the form of a square lattice.

C.1.5 *Timing device*

A timing device capable of measuring intervals of 5 min with an accuracy of $\pm$1 s.

C.1.6 *Gas sampling and analytical equipment*

C.1.6.1 *Gas sampling equipment*

To minimize losses of the products of combustion through adsorption or condensation prior to measurement, all sampling lines shall be as short as is practicable. Sampling ports fitted to the chamber shall be such that they do not interfere with the air-tightness of the chamber.

C.1.6.2 *Analytical equipment*

The equipment used for the analysis of gases from the combustion of the test sample shall be such as to allow rapid detection and measurement of those gases specified in **C.7**. The use of colorimetric gas reaction tubes is acceptable. Where these are used they shall be positioned within the chamber itself.

C.2 Test-pieces

C.2.1 Fully re-cover a length of sleeving of 6 mm to 8 mm recovered internal diameter from which to prepare test-pieces to test for this and all other sizes of the same material.

C.2.2 Cut the test-piece to a size and shape such that during the test it is entirely engulfed in the flame. The mass of the specimen is chosen to provide optimum analytical precision, dependent on the nature of the combustion products and sensitivity of the analytical procedure.

C.3 Conditioning

After preparation, condition the test-piece at (23 $\pm$ 2) °C and (50 $\pm$ 5) % relative humidity for at least 24 h.

C.4 Safety

During the following test, there is a danger that flammable and/or toxic fumes will be evolved from the test-piece and operators should take precautions to avoid exposure to the evolved fumes.

C.5 Procedure

C.5.1 *Analysis*

In order to eliminate the unnecessary analysis for gases that are not produced during the combustion of the material under test, a preliminary qualitative elemental analysis may be performed, e.g. sodium fusion. Where it can be shown that no halogens are present in the material, the quantitative analysis for halogen-containing gases may be omitted. Similarly, where nitrogen is shown to be absent, quantitative analysis for nitrogen-containing gases is not required.

C.5.2 ***Determination of background correction factor***

C.5.2.1 Position the burner in the centre of the test chamber floor. Close the chamber and all inlet and outlet vents to the chamber. Ignite the burner and adjust the gas and air-flow rates to achieve the flame condition described in **C.1.3**d). Record or otherwise control these reference level flow rates in order that the flame condition may be re-established as rapidly as practicable when required during the test. Extinguish the burner and ventilate the chamber allowing sufficient time for any fumes produced to disperse.

C.5.2.2 Prepare the chamber for the analysis of carbon monoxide, carbon dioxide and oxides of nitrogen and close all sampling ports other than those required for the analysis of these gases. Where the method of analysis is to be by the use of colorimetric tubes, place these within the chamber.

C.5.2.3 Close the chamber and all inlet and outlet vents. Ignite the burner and simultaneously start the timing device. Maintain the flame condition at the reference level of gas and air-flow rates for 1 min $\pm$ 1 s. Extinguish the flame and start the mixing fan. After (30 $\pm$ 1) s stop the fan and sample the atmosphere within the chamber. Determine the concentration of carbon monoxide, carbon dioxide and oxides of nitrogen.

C.5.2.4 Forcibly extract all fumes from the chamber with it open to the free passage of air for 3 min. Repeat the procedure in **C.5.2.2** and **C.5.2.3**, but maintain the burning time for 2 min $\pm$ 1 s and 3 min $\pm$ 1 s in separate determinations.

C.5.2.5 Plot curves of the concentration of carbon monoxide, carbon dioxide and oxides of nitrogen against time of burning to show the rate of build up of the gases due to the burner alone. Zero time is at a level of 0.03 % for carbon dioxide, and 0.00% for carbon monoxide and oxides of nitrogen.

C.5.3 ***Determination of evolved gases***

C.5.3.1 Forcibly extract all fumes from the chamber with it open to the free-passage of air for at least 3 min.

C.5.3.2 Weigh a test-piece to the nearest milligram and place it on the support in the centre of the chamber at a height above the burner such that the test-piece will be sited within the flame boundary and subjected to a flame temperature of (1 150 $\pm$ *50)* °C. For materials that are liable to melt and drip, place a thin bed of glass wool on the wire mesh support to prevent sample-loss during combustion.

C.5.3.3 Prepare the chamber for the analysis of the evolved gases. Close all sampling ports other than those required for the analysis. Where the method of analysis is to be by the use of colorimetric tubes place these within the chamber.

C.5.3.4 Close the chamber and all inlet and outlet vents. Ignite the burner and simultaneously start the timing device. Maintain the flame condition at the reference level of gas and air-flow rates until complete combustion of the test-piece has occurred and record this time. Extinguish the burner and start the mixing fan. After (30 $\pm$ 1) s stop the fan and immediately begin sampling the atmosphere within the chamber. Determine the concentration of the gases evolved from the combustion of the test-piece.

Where the presence of halogen acids is suspected, determine the concentration of these first in order to reduce losses through adsorption or condensation.

C.5.3.5 After the analysis is complete, forcibly extract the remaining fumes from the chamber for at least 3 min with it open to the free passage of air.

C.5.3.6 Examine the residue of the test-piece for signs of incomplete combustion. If any part of the test-piece remains, or appears to remain incompletely burnt, repeat the test using a new test-piece.

C.5.3.7 Repeat the test using further test-pieces until the analyses of three complete combustions are obtained.

C.6 Calculation of combustion products index

C.6.1 Calculate the concentration of each of the gases produced when 100 g of material is fully burnt and the products of combustion are diffused in air in a volume of 1 m^3, C_0 in p.p.m., from the following equation:

$$C_0 = \frac{C \times 100 \times V}{m}$$

where

C is the concentration of gas in the test chamber (in p.p.m.);

m is the mass of the test-piece (in g);

V is the volume of the test chamber (in m^3).

In the cases of carbon monoxide, carbon dioxide and the oxides of nitrogen the values of C_0 shall be corrected by subtracting the value for the background gas concentration, obtained from the plots for the burner alone, at the time of complete combustion of the test-piece recorded in **C.5.2.4**.

C.6.2 Using the mean values of C calculated from the three tests for each gas, calculate the combustion products index as follows:

$$\frac{C_{0,1}}{C_{f,1}} + \frac{C_{0,2}}{C_{f,2}} + \frac{C_{0,3}}{C_{f,3}} + \frac{C_{0,4}}{C_{f,4}} + ... \frac{C_{0,n}}{C_{f,n}}$$

where

$C_{0,1}$, $C_{0,2}$, $C_{0,3}$, $C_{0,4}$, ... $C_{0,n}$	represent the calculated concentration of each gas produced from 100 g of material;
$C_{f,1}$, $C_{f,2}$, $C_{f,3}$, $C_{f,4}$ .... $C_{f,n}$	are the concentration factors (see **C.8**) for each gas in p.p.m.

C.7 Combustion products

NOTE 1 This may be determined by classical chemical techniques or colorimetric change (see **C.5.3.3**).

NOTE 2 The following is not intended to be a complete list of all possible gases that can be found in the products of combustion, but it does represent those most commonly produced.

The analysis of the products of combustion of the test-piece shall include the quantitative determination of the following gases:

a) acrylonitrile (CH_2CHCN);
b) ammonia (NH_3);
c) carbon dioxide (CO_2);
d) carbon monoxide (CO);
e) formaldehyde (HCHO);
f) hydrogen bromide (HBr);
g) hydrogen chloride (HC1);
h) hydrogen cyanide (HCN);
i) hydrogen fluoride (HF);
j) hydrogen sulfide (H_2S);
k) nitrogen oxides ($NO + NO_2$);
l) phenol (C_6H_5OH);
m) phosgene ($COCI_2$);
n) sulfur dioxide (SO_2).

C.8 Concentration factors of combustion products

For the purposes of this method the following values of concentration factors, C_f, are used to calculate the combustion products index:

a) acrylonitrile	400;
b) ammonia	750;
c) carbon dioxide	100 000;
d) carbon monoxide	4 000;
e) formaldehyde	500;
f) hydrogen bromide	150;
g) hydrogen chloride	500;
h) hydrogen cyanide	150;
i) hydrogen fluoride	100;
j) hydrogen sulfide	750;
k) nitrogen oxides	250;
l) phenol	250;
m) phosgene	25;
n) sulfur dioxide	400.

C.9 Test report

Include the following details in the test report:

a) a full description of the material tested, e.g. the type of sleeving;
b) the combustion products index;
c) a reference to this method of test;
d) a list of the gases detected during the test;
e) include the following statement.

"This test result alone does not assess the fire hazard of the material, or a product made from this material, under actual fire conditions. Consequently, the results of this test alone are not to be quoted in support of claims with respect to the fire hazard of the material or product under actual fire conditions. The results when used alone are only to be used for research and development, quality control and material specifications."

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[5)] Referred to in the foreword only.

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