

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

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

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This part of BS G 198 supersedes BS 3G 198-3:1994 which is withdrawn.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

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 45 and a back cover.

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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 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 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
<i>Shrink ratio 2:1</i>				
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
<i>Shrink ratio 3:1</i>				
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
<i>Shrink ratio 4:1</i>				
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
<i>Shrink ratio 4.1: Repair sleeve</i>				
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