

British Standard Aerospace Series

Sleeves for aircraft electric cables and equipment wires

Part 4. Specification for semi-rigid high performance heat shrinkable sleeving for binding and insulation

Série Aérospatiale

Manchons pour câbles électriques et fils d'équipement pour avions

Partie 4. Manchon semi-rigide emmanchable à chaud de niveau de qualité élevé pour fixation et isolation — Spécifications

Luft- und Raumfahrt-Reihe

Manschetten für die elektrische Verkabelung in Flugzeugen

Teil 4. Halbstarre hochbelastbare Schrumpffolie für Bindung und Isolierung

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Foreword

This British Standard has been prepared under the direction of the Aerospace Standards Policy Committee at the request of the aircraft industry to provide a statement of the requirements for sleeves and sleeving for aircraft electric cables and insulated equipment wires. The standard is published in separate Parts: Part 1 relates to elastomeric sleeves, Part 2 to slip-on sleeves, Part 3 to heat shrinkable sleeving and Part 4 to semi-rigid high performance heat shrinkable sleeving.

This Part refers to the requirements for semi-rigid high performance heat shrinkable sleeving, in a range of

diameters, lengths and materials suitable for binding and insulation purposes on electric cables and insulated equipment wires in aircraft. Sleeves for identification purposes will be covered by a further Part of this standard to be published at a later date.

The various types of sleeving covered by this 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 this standard.

Sleeving should be installed in accordance with manufacturer'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 sleeve life may also be reduced.

It should be noted that the majority of heat guns available for the application of sleeving are not suitable for use in flammable atmospheres. Application tools suitable for the installation of heat shrinkable sleeving in these areas should be designed for Division 2 areas as given in CP 1003 : Part 3.

The importance of toxicity has been recognized, but no suitable test has been found to date which has proved acceptable for this standard. Pending the development of such a test, the materials from which the sleeving is manufactured should present the minimum hazard from toxic fumes and smoke emission.

WARNING NOTE. 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.

Particular attention is drawn to the following hazard although it is not necessarily exhaustive.

When heated above 260 °C, PTFE will begin to degrade and the rate of degradation will increase with increasing temperature. The gases produced during degradation will vary according to the temperature and other conditions but will invariably contain toxic components and good ventilation is therefore essential.

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

1 Scope

This Part of British Standard 2G 198 specifies the design, performance and quality assurance requirements and test procedures for the following types of semi-rigid high performance heat shrinkable sleeving suitable for binding and insulating purposes on electrical cables and insulated equipment wires in aircraft. Guidance for the storage of finished sleeves is given in appendix A, and appendix B describes a recommended ordering procedure.

Type 20. This sleeving, when fitted, is suitable for use in the temperature ranges:

- (a) -55 °C to 175 °C for at least 20 000 h;
- (b) up to 225 °C for at least 168 h;
- (c) up to 275 °C for one period of 5 min.

NOTE 1. The minimum shrink temperature is 175 °C and the shrink ratio (nominal) is 2:1.

These sleeves are basically transparent but may be tinted. These sleeves are semi-rigid, tough and abrasion resistant, and are suitable for use where strain relief and mechanical protection is required, or their transparent properties are used. They are not suitable for shrinkage on to surfaces having sharp changes in profile.

Type 21A. This sleeving, when fitted, is suitable for use in the temperature ranges:

- (a) -65 °C to 260 °C for at least 20 000 h;
- (b) up to 350 °C for at least 168 h;
- (c) up to 400 °C for one period of 5 min.

NOTE 2. The minimum shrink temperature is 330 °C and the shrink ratio (nominal) is 3:2.

These sleeves are milk white translucent. These sleeves are suitable for use where resistance to chemicals and high temperature performance are required. They are flame resistant, and have a low shrink ratio.

Type 21B. This sleeving when fitted, is suitable for use in the temperature ranges:

- (a) -65 °C to 260 °C for at least 20 000 h;
- (b) up to 350 °C for at least 168 h;
- (c) up to 400 °C for one period of 5 min.

NOTE 3. The minimum shrink temperature is 330 °C and the shrink ratio (nominal) is 4:1.

These sleeves are milk white translucent. These sleeves are suitable for use where resistance to chemicals and high temperature performance are required. They are flame resistant and have a high shrink ratio.

NOTE 4. The minimum shrink temperature is the minimum temperature at which full recovery can be achieved.

NOTE 5. 'Suitable for use in the temperature ranges' means the ability to withstand flexing without cracking after submission to the conditions specified in (a), (b) and (c).

NOTE 6. The flame and fluid resistance to materials types 20 and 21A/B are such that when subjected to the relevant tests described in British Standard 2G 198 : Part 3, the sleeving will not support combustion or be degraded, hence these tests are not considered necessary.

NOTE 7. Because of their relative inertness, types 20 and 21 A/B materials are not normally subjected to a copper mirror corrosion test. However, the approving authority may, at its option, specify this test if so desired. In this event, the test specified in 10.10 of British Standard 2G 198 : Part 3 : 1985 should be used and the test temperature should be specified by the approving authority.

NOTE 8. The titles of the publications referred to in this Part of British Standard 2G 198 are listed on the inside back page.

2 Materials

Sleeving shall be made from the following materials:

Type no.	Material
20	Polyvinylidene fluoride
21A	Polytetra-fluoroethylene (PTFE) (Low shrink ratio)
21B	Polytetra-fluoroethylene (PTFE) (High shrink ratio)

3 Finish

The sleeving, both before and after shrinkage, shall be free from bubbles, pinholes and other defects which may affect performance. After shrinkage, the sleeving surface shall be smooth.

4 Dimensions

The internal diameters and related wall thicknesses of the sleeving, both before and after unrestricted shrinkage, as applicable, shall comply with the requirements given in tables 1, 2 and 3.

Sleeves shall be supplied to lengths specified by the purchaser. They shall be cut to the tolerances specified in table 4. The normal maximum supplied length is 1.2 m.

5 Shelf life

The manufacturer shall declare the shelf life of the sleeving when stored under specified storage conditions. The declaration shall be based on the guaranteed minimum storage time that the sleeving retains the 'as supplied' internal diameter specified in this standard. Sleeving after storage shall also conform to the internal diameter, wall thickness and longitudinal change requirements of this standard following unrestricted shrinkage in accordance with 9.3.

6 Type testing

6.1 Type tests

The manufacturer shall produce evidence to the satisfaction of the approving authority* that sleeving supplied to this standard fulfils all the requirements of the tests listed in table 5, details of which are given in clause 9.

In the event of a failure of a specimen to comply with the requirements of any test, two additional sets of samples shall be taken and tested. Both sets shall comply with the appropriate test requirements, otherwise the sleeving shall be deemed not to comply with the requirements of this standard.

The manufacturer shall inform the approving authority if any changes are made to:

- (a) the material composition; and
- (b) production techniques which will affect the final performance of the sleeving.

NOTE. Following such changes, the approving authority may require a repetition of type testing.

Type tests shall be repeated every five years.

6.2 Test conditions

Unless otherwise specified in a particular test, the tests shall be carried out under normal atmospheric conditions, as follows.

- (a) At a temperature of $20 \pm 5^\circ\text{C}$. In the event of a dispute, between the manufacturer, the approving authority or the customer, the tests shall be conducted at $23 \pm 2^\circ\text{C}$.
- (b) At a relative humidity (r.h.) not greater than 65 %.

The heat shrink sleeving and measurement gauges (if used) shall be conditioned for at least 4 h under these conditions 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. A fan assisted circulating air oven shall be used for heating unless otherwise specified in a particular test.

7 Production and quality testing

7.1 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 6.

7.2 Production quality tests

The frequency of application of each production quality test shall be to 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 7.

7.3 Batch

A batch of sleeving shall consist of that sleeving of the same type, nominal internal diameter and colour produced by continuous extrusion from a single mix, provided that the cross linking conditions where relevant are maintained constant throughout. For continuous processing a 'single mix' and extrusion shall be agreed between the manufacturer and the approving authority.

NOTE. Continuous extrusion may not be applicable to types 21 A and 21B.

8 Packaging and identification

Each package shall be marked with the following information:

- (a) the number of this British Standard, i.e. BS 2G 198 : Part 4;
- (b) the type number;
- (c) the size;
- (d) the length and quantity of sleeving;
- (e) the manufacturer's name;
- (f) the batch number and year of manufacture;
- (g) use by date†.

NOTE. Packaging requirements will vary and should be specified by the purchaser in the order. For UK Government Services, these instructions will be based on Defence Standard 81-41/2 'Packaging of defence material', available from Directorate of Standardization, Kentigern House, 65 Brown Street, Glasgow G2 8EX.

* The approving authority for civil aircraft applications is the Civil Aviation Authority, Airworthiness Division or an organization approved by them, and for Ministry of Defence applications is the Procurement Executive, Ministry of Defence, DGDQA/TS Material Centre, Royal Arsenal East, London SE18 6TD.

† The 'use by date' will only apply when the storage conditions given in appendix A have been met.

9 Tests

Clause	Title	Description	Requirement																									
9.1	Finish	Inspect	All sleeving shall comply with the requirements of clause 3.																									
9.2	Dimensions	A minimum of three specimens shall be used for this test. Measure the specimens in the 'as supplied' condition and after unrestricted shrinkage. Determine unrestricted shrinkage as specified in 9.3. Determine the minimum and maximum wall thickness of a section taken at a single position along each specimen, and the concentricity as the ratio between the minimum and maximum values of wall thickness obtained, expressed as a percentage. Make the measurements of internal diameter to the nearest 0.05 mm and the wall thickness to the nearest 0.025 mm. In cases of dispute use an optical method of measurement, in which the error of determination does not exceed 0.025 mm. The measurements obtained by it shall be accepted as final.	All specimens shall comply with the requirements of clause 4. Concentricity for all specimens shall be not less than: <table><tr><th>Type</th><th>Concentricity</th></tr><tr><td></td><td>%</td></tr><tr><td>20</td><td>65</td></tr><tr><td>21A</td><td>65</td></tr><tr><td>21B</td><td>50</td></tr></table>	Type	Concentricity		%	20	65	21A	65	21B	50															
Type	Concentricity																											
	%																											
20	65																											
21A	65																											
21B	50																											
9.3	Longitudinal change	Cut three specimens, each approximately 150 mm in length, from the sleeving. The specimens shall be free from creases, kinks or other visible defects. 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 shall be measured to an accuracy of 0.5 mm (L_1). Place the specimens in an oven. The specimen may either be suspended from one end, or placed on a pre-heated tray* for the following temperatures and times: <table><tr><th>Type</th><th>Temperature</th><th>Time</th></tr><tr><td></td><td>°C</td><td>min</td></tr><tr><td>20</td><td>200 ± 2</td><td>5</td></tr><tr><td>21A</td><td>350 ± 5</td><td>10</td></tr><tr><td>21B</td><td>350 ± 5</td><td>10</td></tr></table> WARNING NOTE. See WARNING NOTE in the foreword. At the end of the heating period, remove the specimens from the oven and allow to cool naturally to room temperature. Re-measure the length (L_2) between the gauge mark to an accuracy of 0.5 mm. Calculate the longitudinal change (L_C) from the formula: $L_C = \frac{L_2 - L_1}{L_1} \times 100$ where L_1 = original length L_2 = length after unrestricted shrinkage L_C = longitudinal change (%) Report all values.	Type	Temperature	Time		°C	min	20	200 ± 2	5	21A	350 ± 5	10	21B	350 ± 5	10	No individual value shall exceed the following limits: <table><tr><th>Type</th><th>Longitudinal change</th></tr><tr><td></td><td>%</td></tr><tr><td>20</td><td>± 10</td></tr><tr><td>21A</td><td>± 20</td></tr><tr><td>21B</td><td>± 20</td></tr></table>	Type	Longitudinal change		%	20	± 10	21A	± 20	21B	± 20
Type	Temperature	Time																										
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* The tray should be PTFE coated or dusted with talc.

 Document Supply

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Clause	Title	Description	Requirement																				
9.4	Relative density	Conduct the test in accordance with method A of BS 903 : Part A1, on specimens shrunk in accordance with 9.3.	The relative density of type 20 material shall be initially established and declared to the approving authority during type testing, and shall not deviate from this value by more than ± 0.03 during subsequent production routine testing. For types 21A and 21B the relative density shall be not less than 2.10.																				
9.5	Elongation at break after contact with copper	Use cylindrical mandrels made from copper of at least 99 % purity that provide a snug fit for the recovered sleeving under test. When cylindrical mandrels are not available or are impractical to use, then copper plates of 99 % purity may be used. In order to minimize surface contamination, in all the following operations, handle the test specimens and test copper mandrels or plates using polyethylene gloves, medical fingercots or polypropylene forceps. Thoroughly scour the surface of the copper mandrels or plates using a pumice or rouge water slurry, e.g. pumice powder 30 mesh (500 µm), and distilled or deionized water applied with a cotton wool pad, until a matt surface is obtained. Rinse the copper initially with distilled or deionized water, then with acetone of analytical quality and finally allow to air dry. NOTE 1. Where prepared copper is not used immediately after cleaning, it may be stored up to a maximum of 24 h in a clean desiccator over dried silica gel prior to testing. Select sufficient length of sleeving to provide five samples 150 mm long after unrestricted shrinkage. Shrink the samples as specified in 9.3 and fit to the cleaned mandrels ensuring a snug fit is obtained. Place the prepared test assemblies in a uniformly heated air oven at the following temperature for 168⁺²₋₀ h. <table><tr><th>Type</th><th>Temperature</th></tr><tr><td></td><td>°C</td></tr><tr><td>20</td><td>175 ± 2</td></tr><tr><td>21A</td><td>260 ± 2</td></tr><tr><td>21B</td><td>260 ± 2</td></tr></table> NOTE 2. Care should be taken to ensure that the sleeving is not in contact with the oven walls or supports. After the period of test remove specimens together with the mandrels or plates from the oven and allow to cool naturally to the temperature specified in 6.2. Remove the specimens from contact with the copper and subject to the elongation at break test described in 9.6.	Type	Temperature		°C	20	175 ± 2	21A	260 ± 2	21B	260 ± 2	The elongation at break shall be not less than the following: <table><tr><th>Type</th><th>Elongation</th></tr><tr><td></td><td>%</td></tr><tr><td>20</td><td>50</td></tr><tr><td>21A</td><td>150</td></tr><tr><td>21B</td><td>150</td></tr></table> The test report shall state whether mandrels or plates were used for the test. When plates are used instead of mandrels the samples shall be slit lengthways, opened out, and clamped between two plates with sufficient pressure to ensure a minimum of 75 % of the inside surface is in contact with the plate.	Type	Elongation		%	20	50	21A	150	21B	150
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