

# Sleeves for aircraft electric cables and equipment wires —

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

# Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Aerospace Standards Policy Committee (ACE/-) to Technical Committee ACE/6, upon which the following bodies were represented:

- British Airways
- British Cable Makers' Confederation
- British Rubber Manufacturers' Association
- Civil Aviation Authority (Airworthiness Division)
- Electronic Components Industries Federation
- Ministry of Defence
- Society of British Aerospace Companies Ltd.
- Association of Manufacturers Allied to the Electrical and Electronic Industry (BEAMA Ltd.)

This British Standard, having been prepared under the direction of the Aerospace Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 15 February 1994

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The following BSI references relate to the work on this standard:  
Committee reference ACE/6  
Draft for comment 91/72967 DC

ISBN 0 580 22126 1

## Amendments issued since publication

| Amd. No. | Date | Comments |
|----------|------|----------|
|          |      |          |
|          |      |          |
|          |      |          |
|          |      |          |

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## Foreword

This Part of BS G 198 has been prepared under the direction of the Aerospace Standards Policy Committee. It 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 4: Specification for semi-rigid high performance heat-shrinkable sleeving for binding and insulation;*
- *Part 5: Specification for heat-shrinkable moulded shapes<sup>1)</sup>.*

It is envisaged that there will be a further Part on heat-shrinkable dual wall sleeves.

This Part of BS G 198 supersedes BS 2G 198-3:1985 which is withdrawn.

This Part of BS G 198 specifies requirements for heat-shrinkable sleeving, in a range of diameters, lengths and materials, suitable 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 suitable for use in potentially explosive atmospheres. Application tools suitable for the installation of heat-shrinkable sleeving in these areas should be designed for Zone 2 areas as specified in BS 5345-2.

**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 material 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 and ii, pages 1 to 42, an inside back cover and a back cover.

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

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<sup>1)</sup> In preparation.

## 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. These sleeves are suitable for binding, insulation and identification purposes. Routine and quality tests are specified.

When specified, sleeves used with bonding adhesives and/or heat-shrinkable moulded shapes are required to meet the compatibility test requirements detailed in Part 5<sup>2)</sup>.

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 Guidance 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 References

### 2.1 Normative references

This British Standard incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on page 42. Subsequent amendments to, or revisions of, any of these publications apply to this standard only when incorporated in it by updating or revision.

### 2.2 Informative references

This British Standard refers to other publications that provide information. Editions of these publications current at the time of issue of this standard are listed on page 43, but reference should be made to the latest editions.

**Table 1 — Types of heat-shrinkable sleeving**

| Type | Guide to temperature range<br>°C | Exposure temperature °C |                |                | Recommended minimum shrink temperature <sup>d</sup> and shrink ratio<br>°C |                     | Guide to stiffness | Other main properties                   |
|------|----------------------------------|-------------------------|----------------|----------------|----------------------------------------------------------------------------|---------------------|--------------------|-----------------------------------------|
|      |                                  | a <sup>a</sup>          | b <sup>b</sup> | c <sup>c</sup> |                                                                            |                     |                    |                                         |
| 10A  | – 75 to 120                      | 120                     | 150            | 215            | 150                                                                        | 2 : 1               | Very flexible      | Flame retarded and oil resistant        |
| 10B  | – 75 to 120                      | 120                     | 150            | 215            | 120                                                                        | 2 : 1               | Flexible           | Flame retarded                          |
| 11A  | – 55 to 135                      | 135                     | 175            | 225            | 100                                                                        | 2 : 1               | Very flexible      | Flame retarded                          |
| 11B  | – 55 to 135                      | 135                     | 175            | 225            | 120                                                                        | 2 : 1, 3 : 1, 4 : 1 | Flexible           | Flame retarded                          |
| 11C  | – 55 to 135                      | 135                     | 175            | 225            | 120                                                                        | 2 : 1               | Semi-rigid         | Flame retarded                          |
| 11D  | – 55 to 120                      | 120                     | 150            | 200            | 130                                                                        | 2 : 1               | Flexible           | Clear and flame retarded                |
| 12A  | – 55 to 200                      | 200                     | 250            | 300            | 175                                                                        | 2 : 1               | Flexible           | Low electric strength                   |
| 12B  | – 55 to 200                      | 200                     | 250            | 300            | 175                                                                        | 2 : 1               | Flexible           | High electric strength                  |
| 13   | – 55 to 90                       | 90                      | 120            | 150            | 150                                                                        | 2 : 1               | Flexible           | General purpose flame retarded          |
| 14   | – 55 to 150                      | 150                     | 225            | 275            | 90                                                                         | 2 : 1               | Flexible           | Clear, flame retarded and oil resistant |
| 15   | – 30 to 105                      | 105                     | 135            | 175            | 135                                                                        | 2 : 1<br>3 : 1      | Flexible           | Limited fire hazard                     |

<sup>a</sup> Temperature a is for a minimum of 20,000 h when assessing in accordance with 1.1.22.

<sup>b</sup> Temperature b is for a minimum of 168 h when assessing in accordance with 1.1.15.

<sup>c</sup> Temperature c is for a minimum of 4 h when assessing in accordance with 1.1.19.

<sup>d</sup> The minimum shrink temperature is the minimum temperature at which full recovery can be guaranteed. Refer to the manufacturer/supplier for actual values.

<sup>2)</sup> In preparation.

### 3 Information to be supplied by the purchaser

The following information to be supplied by the purchaser shall be fully documented. Both the definitive requirements specified throughout the standard and the following documented items shall be satisfied before a claim of compliance with the standard can be made and verified.

- a) the number of this British Standard (i.e. BS 3G 198-3:1994);
- 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).

### 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 11.24 and 11.25.

### 5 Colour

**5.1** Sleeving shall be manufactured in the colours given in Table 3 for the appropriate type of sleeving. For coloured sleeving, the colours shall be recognizable as those given in BS 6746C:1969.

**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.

**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 suitable 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 suitable 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.                                                                                        |
| 11D  | Flexible transparent polyolefin | This sleeving is flexible, flame retarded and transparent. It is suitable for general purposes.                                                                                                                                                                                                                          |

| Type | Material                                                             | Characteristics                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------|----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12A  | Vinylidene fluoride co-polymer (low electric strength) <sup>a</sup>  | This sleeving has good flexibility, is flame retarded and has a thick wall for mechanical protection. 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 low electric strength. The standard colour is black.                                                                                                  |
| 12B  | Vinylidene fluoride co-polymer (high electric strength) <sup>a</sup> | 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.                                                                                                                                                                                                                                 |
| 14   | Flexible polyvinylidene fluoride co-polymer                          | This sleeving is flexible, thin walled, flame retarded and transparent. It is suitable for use where a transparent flame retarded material is required with a higher temperature range, and with better resistance to contamination by aircraft fuels and hydraulic fluids than types 11A and 11B.                                                                                                                              |
| 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 |

<sup>a</sup> Includes hexafluoropropylene or 1-hydropentafluoropropylene.

Table 3 — Standard colours and availability

| Type | Black | Red | Yellow | Blue | White | Green | Brown | Pink | Violet | Orange | Gray | 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                        |
| 11D  | —     | —   | —      | —    | —     | —     | —     | —    | —      | —      | —    | —                        | X                        |
| 12A  | X     | —   | —      | —    | —     | —     | —     | —    | —      | —      | —    | —                        | —                        |
| 12B  | X     | —   | —      | —    | —     | —     | —     | —    | —      | —      | —    | —                        | —                        |
| 13   | X     | —   | —      | —    | —     | —     | —     | —    | —      | —      | —    | —                        | —                        |
| 14   | —     | —   | —      | —    | —     | —     | —     | —    | —      | —      | —    | —                        | X                        |
| 15   | X     | X   | X      | X    | X     | X     | X     | —    | —      | —      | —    | —                        | —                        |

## Key

X signifies available

— signifies not available as standard. See clause 3.

## 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 Table 4 to Table 12.

**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 cut 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.

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

**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 types 11A and 11D 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 |
| <b><i>Shrink ratio 2 : 1</i></b>               |                          |                              |                        |                             |
| 1                                              | 1.2                      | 0.6                          | 0.45                   | ± 0.10                      |
| 2                                              | 1.6                      | 0.8                          | 0.45                   | ± 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                          | 0.5                    | ± 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                   | ± 0.20                      |
| 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                      |
| <b><i>Shrink ratio 3 : 1</i></b>               |                          |                              |                        |                             |
| 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                      |
| <b><i>Shrink ratio 4 : 1</i></b>               |                          |                              |                        |                             |
| 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                       |
| <b><i>Shrink ratio 4 : 1 Repair sleeve</i></b> |                          |                              |                        |                             |
| 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 11 — Dimensions of type 14 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                          | 0.25                   | ± 0.05                      |
| 2         | 1.6                      | 0.8                          | 0.25                   | ± 0.05                      |
| 3         | 2.4                      | 1.2                          | 0.25                   | ± 0.05                      |
| 4         | 3.2                      | 1.6                          | 0.25                   | ± 0.05                      |
| 5         | 4.8                      | 2.4                          | 0.25                   | ± 0.05                      |
| 6         | 6.4                      | 3.2                          | 0.30                   | ± 0.10                      |
| 7         | 9.5                      | 4.8                          | 0.30                   | ± 0.10                      |
| 8         | 12.7                     | 6.4                          | 0.30                   | ± 0.10                      |
| 9         | 19.0                     | 9.5                          | 0.48                   | ± 0.10                      |
| 10        | 25.4                     | 12.7                         | 0.48                   | ± 0.10                      |
| 11        | 38.0                     | 19.0                         | 0.55                   | ± 0.15                      |
| 12        | 50.8                     | 25.4                         | 0.55                   | ± 0.15                      |

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 12 — Dimensions of type 15 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 |
| <b>Shrink ratio 2 : 1</b> |                          |                              |                        |                             |
| 1                         | 3.0                      | 1.5                          | 0.70                   | ± 0.10                      |
| 2                         | 3.2                      | 1.6                          | 0.50                   | ± 0.10                      |
| 3                         | 3.2                      | 1.6                          | 0.70                   | ± 0.10                      |
| 4                         | 4.8                      | 2.4                          | 0.55                   | ± 0.10                      |
| 5                         | 4.8                      | 2.4                          | 0.85                   | ± 0.15                      |
| 6                         | 5.0                      | 2.5                          | 0.75                   | ± 0.12                      |
| 7                         | 6.4                      | 3.2                          | 0.65                   | ± 0.15                      |
| 8                         | 6.4                      | 3.2                          | 0.90                   | ± 0.15                      |
| 9                         | 8.0                      | 4.0                          | 1.80                   | ± 0.15                      |
| 10                        | 9.5                      | 4.8                          | 0.65                   | ± 0.15                      |
| 11                        | 9.5                      | 4.8                          | 1.00                   | ± 0.15                      |
| 12                        | 12.0                     | 6.0                          | 1.90                   | ± 0.15                      |
| 13                        | 12.7                     | 6.4                          | 0.65                   | ± 0.15                      |
| 14                        | 12.7                     | 6.4                          | 1.20                   | ± 0.18                      |
| 15                        | 18.0                     | 9.0                          | 1.00                   | ± 0.18                      |
| 16                        | 19.0                     | 9.5                          | 0.75                   | ± 0.15                      |
| 17                        | 19.0                     | 9.5                          | 1.40                   | ± 0.25                      |
| 18                        | 24.0                     | 12.0                         | 1.10                   | ± 0.20                      |
| 19                        | 25.4                     | 12.7                         | 0.90                   | ± 0.15                      |
| 20                        | 25.4                     | 12.7                         | 1.80                   | ± 0.30                      |
| 21                        | 38.0                     | 19.0                         | 1.00                   | ± 0.20                      |
| 22                        | 40.0                     | 20.0                         | 1.30                   | ± 0.23                      |
| 23                        | 50.8                     | 25.4                         | 1.15                   | ± 0.25                      |
| 24                        | 60.0                     | 30.0                         | 1.50                   | ± 0.28                      |
| <b>Shrink ratio 3 : 1</b> |                          |                              |                        |                             |
| 25                        | 3.0                      | 1.0                          | 0.55                   | ± 0.05                      |
| 26                        | 6.0                      | 2.0                          | 0.75                   | ± 0.10                      |
| 27                        | 9.0                      | 3.0                          | 0.90                   | ± 0.15                      |
| 28                        | 12.0                     | 4.0                          | 0.90                   | ± 0.15                      |
| 29                        | 18.0                     | 6.0                          | 1.00                   | ± 0.15                      |
| 30                        | 24.0                     | 8.0                          | 1.15                   | ± 0.15                      |
| 31                        | 39.0                     | 13.0                         | 1.30                   | ± 0.15                      |

Table 13 — 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<sup>3)</sup>, that sleeving supplied in accordance with this standard conforms to the tests listed in Table 14, 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 14. The smallest sleeving to be tested shall have a specified recovered internal diameter of not less than 2 mm.

<sup>3)</sup> 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 an organization nominated by the Ministry of Defence, Directorate of Standardisation, Kentigern House, 65 Brown Street, Glasgow G2 8EX.

**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** No changes shall be made to the declared material composition and agreed techniques used in the production of the sleeving without the prior written agreement of the type approving authority.

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

**9.1.5** Type approval is valid for a period of 5 years after which time the manufacturer or supplier shall apply for reapproval of the material.

**Table 14 — Type tests**

| Title                                    | Clause |
|------------------------------------------|--------|
| Finish                                   | 11.1   |
| Dimensions                               | 11.2   |
| Longitudinal change                      | 11.3   |
| Colour <sup>a</sup>                      | 11.4   |
| Colour stability <sup>a</sup>            | 11.5   |
| Transparency                             | 11.6   |
| Colour fastness to light <sup>a</sup>    | 11.7   |
| Density <sup>a</sup>                     | 11.8   |
| Resistance to mould growth <sup>a</sup>  | 11.9   |
| Copper mirror corrosion <sup>a</sup>     | 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 <sup>a</sup>            | 11.16  |
| Flammability <sup>a</sup>                | 11.17  |
| Resistance to fluids <sup>a</sup>        | 11.18  |
| Heat shock                               | 11.19  |
| Restricted shrinkage                     | 11.20  |
| Secant modulus at 2 % strain             | 11.21  |
| Thermal endurance <sup>a</sup>           | 11.22  |
| Oxygen index <sup>a</sup>                | 11.23  |
| Flammability temperature <sup>a</sup>    | 11.24  |
| Smoke index <sup>a</sup>                 | 11.25  |
| Combustion products index <sup>a</sup>   | 11.26  |
| Printed sleeves <sup>a</sup>             | 12     |

<sup>a</sup> Only one size of sleeving needs to be tested.

## 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  $(20 \pm 5) ^\circ\text{C}$ . In the event of a dispute, the tests shall be conducted at  $(23 \pm 2) ^\circ\text{C}$ .

**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 15.

### 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 16.

### 10.3 Batch

A batch of sleeving shall consist of that 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 15 — Production routine tests**

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

**Table 16 — Production quality tests**

| Title                                   | Clause       |
|-----------------------------------------|--------------|
| Colour stability <sup>a</sup>           | <b>11.5</b>  |
| Transparency                            | <b>11.6</b>  |
| Colour fastness to light <sup>a</sup>   | <b>11.7</b>  |
| Resistance to mould growth <sup>a</sup> | <b>11.9</b>  |
| Copper mirror corrosion <sup>a</sup>    | <b>11.10</b> |
| Volume resistivity after damp heat      | <b>11.13</b> |
| Low temperature flexibility             | <b>11.14</b> |
| Heat ageing                             | <b>11.15</b> |
| Water absorption <sup>a</sup>           | <b>11.16</b> |
| Flammability <sup>a</sup>               | <b>11.17</b> |
| Resistance to fluids <sup>a</sup>       | <b>11.18</b> |
| Restricted shrinkage                    | <b>11.20</b> |
| Thermal endurance <sup>a</sup>          | <b>11.22</b> |
| Oxygen index <sup>a</sup>               | <b>11.23</b> |
| Flammability temperature <sup>a</sup>   | <b>11.24</b> |
| Smoke index <sup>a</sup>                | <b>11.25</b> |
| Combustion products index <sup>a</sup>  | <b>11.26</b> |
| Printed sleeves only                    | <b>12</b>    |

<sup>a</sup> For the purpose of these tests, one size of sleeving may be taken as representative of other sizes of sleeving made from the same single mix.

## 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 | <p>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.</p> <p>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.</p> <p>Calculate the concentricity (in %) of each test piece of the sleeving by use of the following equation.</p> $\text{Concentricity} = \frac{\text{minimum wal thickness}}{\text{maximum wall thickness}} \times 100$ <p>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.</p> <p>In the case of dispute an optical method shall be used.</p> | <p>All test pieces shall conform to clause 7.</p> <p>Concentricity shall be not less than</p> <p>shrink ratio 2 : 1</p> <p>65 % as received</p> <p>85 % when recovered</p> <p>shrink ratio 3 : 1</p> <p>60 % as received</p> <p>85 % when recovered</p> <p>shrink ratio 4 : 1</p> <p>50 % as received</p> <p>85 % when recovered</p> |

| Clause | Title                 | Method                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Requirement |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
|--------|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------|-----------------|-----|---------|---|-----|---------|---|-----|---------|---|-----|---------|---|-----|---------|---|-----|---------|---|-----|---------|---|-----|---------|---|----|---------|----|----|---------|---|----|---------|---|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-----------------------|-----|------|-----|------|-----|-----------|-----|-----------|-----|-----------|-----|------|-----|------|-----|------|----|-----------|----|------|----|-----------|
| 11.3   | Longitudinal change   | <p>From the test pieces used in 11.2, select at least three test pieces of length approximately 150 mm.</p> <p>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 (<i>L1</i>) shall be measured to an accuracy of 0.5 mm.</p> <p>Shrink the test pieces as specified below.</p> <p>Re-measure the length between the gauge marks (<i>L2</i>) to an accuracy of 0.5 mm.</p> <p>Calculate the longitudinal change (<i>LC</i>) from the equation:</p> $LC = \frac{L2 - L1}{L1} \times 100$ <p>where<br/><i>L1</i> = original length<br/><i>L2</i> = length after unrestricted shrinkage<br/><i>LC</i> = longitudinal change (%)</p> <p>Carry out the unrestricted shrinkage as follows.</p> <p>Lay the 150 mm lengths of sleeving on a preheated tray<sup>a</sup> in an oven at the appropriate temperature and for the appropriate time, as follows.</p> <table><tr><th>Type</th><th>Temperature °C</th><th>Time (min.) 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>11D</td><td>150 ± 2</td><td>5</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>14</td><td>120 ± 2</td><td>5</td></tr><tr><td>15</td><td>150 ± 2</td><td>5</td></tr></table> <p>Remove the sleeving from the oven, and allow to cool naturally to the temperature specified in 9.2.</p> | Type        | Temperature °C | Time (min.) min | 10A | 200 ± 2 | 5 | 10B | 200 ± 2 | 5 | 11A | 200 ± 2 | 3 | 11B | 200 ± 2 | 3 | 11C | 200 ± 2 | 3 | 11D | 150 ± 2 | 5 | 12A | 200 ± 2 | 5 | 12B | 200 ± 2 | 5 | 13 | 150 ± 2 | 10 | 14 | 120 ± 2 | 5 | 15 | 150 ± 2 | 5 | <p>Report all results.</p> <p>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 25 to 31 which shall be + 5 % to – 15 %.</p> <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>11D</td><td>± 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>14</td><td>± 10</td></tr><tr><td>15</td><td>+ 5, – 10</td></tr></table> | Type | Longitudinal change % | 10A | ± 10 | 10B | ± 10 | 11A | + 5, – 10 | 11B | + 5, – 10 | 11C | + 5, – 10 | 11D | ± 10 | 12A | ± 20 | 12B | ± 10 | 13 | + 5, – 15 | 14 | ± 10 | 15 | + 5, – 10 |
| Type   | Temperature °C        | Time (min.) min                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 10A    | 200 ± 2               | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 10B    | 200 ± 2               | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 11A    | 200 ± 2               | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 11B    | 200 ± 2               | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 11C    | 200 ± 2               | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 11D    | 150 ± 2               | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 12A    | 200 ± 2               | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 12B    | 200 ± 2               | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 13     | 150 ± 2               | 10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 14     | 120 ± 2               | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 15     | 150 ± 2               | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| Type   | Longitudinal change % |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 10A    | ± 10                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 10B    | ± 10                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 11A    | + 5, – 10             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 11B    | + 5, – 10             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 11C    | + 5, – 10             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 11D    | ± 10                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 12A    | ± 20                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 12B    | ± 10                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 13     | + 5, – 15             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 14     | ± 10                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |
| 15     | + 5, – 10             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |                |                 |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |     |         |   |    |         |    |    |         |   |    |         |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                       |     |      |     |      |     |           |     |           |     |           |     |      |     |      |     |      |    |           |    |      |    |           |

<sup>a</sup> The tray should be polytetrafluoroethylene (PTFE) coated or dusted with talcum powder.