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Procedure for inspection, testing and acceptance of seamless steel tubes and tubestock

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Contents

List of tables

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 28, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI and came into effect on 31 March 2010. It was prepared by Panel ACE/61/-/15, *Steels*, under the authority of Technical Committee ACE/61, *Metallic materials for aerospace purposes*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 4T 100:1997, which is withdrawn.

Information about this document

This is a full revision of BS T 100, and introduces the following principal changes.

Section **1**

a) Information and requirements to be agreed and documented amended.

b) Heat treatment details amended to add temperature tolerances and permit the use of polymer quenchants.

c) Tensile testing at ambient temperature to BS 4A4:1966, Part 1.1, replaced by BS EN 2002-1.

d) Tensile testing at elevated temperature to BS 4A4:1966, Part 1.2, replaced by BS EN 2002-2.

e) Hardness testing to BS 4A4:1966, Part 5, replaced by BS EN ISO 6506-1, BS EN ISO 6507-1 and BS EN ISO 6508-1.

f) Flattening test details replaced by reference to BS EN ISO 8492.

g) Drift-expanding test to BS 4A4:1966, Part 4, replaced by BS EN ISO 8493.

h) For the decarburization test, reference added to the micrographic method detailed in BS EN ISO 3887.

i) Reference to new Annex A (rules for application of values for mechanical properties given in material specifications) added.

j) Requirements for non-destructive and ultrasonic examinations of tube deleted.

Section **3**

k) For the susceptibility to intercrystalline corrosion test, reference to BS EN ISO 3651-2 added.

Section **5**

l) Bend test to BS 1639 replaced by BS EN ISO 7438.

Annex A

m) New Annex A (rules for application of values for mechanical properties given in material specifications) added.

Annex B

n) Former Annex A (dimensions and tolerances) re-identified as Annex B.

Hazard warnings

WARNING. This British Standard calls for the use of substances and/or procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Use of this document

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Section 1. General requirements

1 Scope

This British Standard specifies procedures for the inspection, testing and acceptance of seamless steel tube and tubestock for aerospace use. The standard is applicable to material specifications in the British Standard Aerospace T series and also to other British Standard material specifications for seamless steel tubes and tubestock which are suitable for aerospace use.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 1134-1, *Assessment of surface texture – Part 1: Methods and instrumentation*

BS 1134-2, *Assessment of surface texture – Part 2: Guidance and general information*

BS 7773, *Code of practice for cleaning and preparation of metal surfaces*

BS S 100, *Procedure for inspection, testing and acceptance of wrought steels (other than plate, sheet, strip and tube)*

BS EN 2002-1, *Metallic materials – Test methods – Part 1: Tensile testing at ambient temperature*

BS EN 2002-2, *Metallic materials – Test methods – Part 2: Tensile testing at elevated temperature*

BS EN ISO 3651-2, *Determination of resistance to intergranular corrosion of stainless steels – Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels – Corrosion test in media containing sulfuric acid*

BS EN ISO 3887, *Steels – Determination of depth of decarburization*

BS EN ISO 6506-1, *Metallic materials – Brinell hardness test – Part 1: Test method*

BS EN ISO 6507-1, *Metallic materials – Vickers hardness test – Part 1: Test method*

BS EN ISO 6508-1, *Metallic materials – Rockwell hardness test – Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

BS EN ISO 7438, *Metallic materials – Bend test*

BS EN ISO 8492, *Metallic materials – Tube – Flattening test.*

BS EN ISO 8493, *Metallic materials – Tube – Drift-expanding test*

EN 3718, *Test method for metallic materials – Ultrasonic inspection of tubes* [1)]

AMS 2750, *Pyrometry* [2)]

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1) Published as ASD Prestandard at the date of publication of this standard.

2) Available from www.sae.org.

3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in BS S 100 and the following apply.

3.1 extreme thickness
greatest (or least) thickness at any point

3.2 mean thickness
sum of the thicknesses measured at the ends of any two diameters at right angles, divided by four

3.3 tolerance on mean diameter
amount by which the sum of any two diameters at right angles, divided by two, may depart from the nominal diameter

3.4 total mean tolerance
algebraic sum of the tolerances on the mean diameter

3.5 tube
hollow product of uniform wall thickness and continuous periphery having a length greater than the outside diameter

3.6 tubestock
cast or wrought product which may be solid or pierced and which is designated for tube making

4 General

This standard details the basic requirements for the inspection and testing of British Standard Aerospace T series seamless steel tube and tubestock.

In addition to the definitive requirements, this standard also requires the items detailed in Clause **5** to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

If the purchaser wishes to specify an inspection, testing or acceptance procedure for any property of any product, which differs from that specified in this standard, this shall be agreed between the manufacturer and the purchaser and shall be fully documented on the order, drawing or inspection schedule, provided that the purchaser is also the quality assurance authority. If the purchaser is not also the quality assurance authority, deviations from the requirements of this standard shall only be agreed and documented after written approval has been obtained from the quality assurance authority.

5 Information and requirements to be agreed and to be documented

5.1 Information to be supplied by the purchaser

The following information to be supplied by the purchaser, which is specified in the clauses referred to, shall be fully documented on the order, drawing or inspection schedule, on which the number of this British Standard shall also be given.

Both the definitive requirements specified throughout the standard and the following documented items shall be satisfied before a claim of compliance with the standard [3] can be made and verified.

a) General:

1) the identity of the material specification with which this standard is to be used;

2) if sulfur printing and/or deep etching tests are also required on samples corresponding to the bottom of ingots (see **6.6**);

3) the required sampling frequency for sulfur printing and/or deep etching tests if different from the material specification and this standard (see **6.6**);

4) the condition of supply of tubestock if other than fully softened (see **6.9**);

5) if an alternative method of straightening tubes is required (see **7.3**);

6) the heat treatment condition in which the tubes are to be supplied if different from the material specification (see **7.4.1**);

7) the required heat treatment temperature (and tolerance) if different from the material specification (see **7.4.4**);

8) if the use of polymer quenching is to be precluded where it is not precluded by the material specification (see **7.4.7**);

9) if ultrasonic testing is required, in cases where this is not a requirement of the material specification (see **9.1**);

10) if overall ink marking is required where not specified in the material specification (see **11.3**);

11) if corrosion protection of tubes other than those made from corrosion-resisting steel is not required (see **12.1**);

b) Tubes delivered in the softened condition for use in the hardened and tempered condition:

1) if tests in the softened condition are required when not specified in the material specification (see **27.1**).

5.2 Items to be agreed between the contracting parties

The following items to be agreed between the contracting parties, which are specified in the clauses referred to, 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 [3] can be made and verified:

a) if non-destructive testing of tubestock is required, the nature of the tests, the stage at which the tests are to be applied, the method of testing and the acceptance standards (see **6.8.2**);

[3] Marking a British Standard identifier (e.g. BS T 80:1997) on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

b) the method of temperature control if other than AMS 2750 (see **7.4.3**);

c) if a particular limit for decarburization is required (see **8.9.4**);

d) if any tests other than those specified in the standard are required (see **8.10**);

e) methods for the examination of the bore of the tube where its diameter renders normal methods impractical (see **9.2**);

f) if non-destructive testing of tubes delivered in the final heat-treated condition is required, the nature of the tests, the stage at which the tests are to be applied, the method of testing and the acceptance standards (see Clause **18**);

g) if non-destructive testing of corrosion-resisting and heat-resisting austenitic steel tubes is required, the nature of the tests, the stage at which the tests are to be applied, the method of testing and the acceptance standards (see Clause **25**);

h) if non-destructive testing of tubes delivered in the softened condition for use in the hardened and tempered condition is required, the nature of the tests, the stage at which the tests are to be applied, the method of testing and the acceptance standards (see Clause **30**).

6 Tubestock manufacture, inspection and testing

6.1 Chemical composition

The chemical composition of the steel shall conform to the requirements of the relevant material specification and Section **1** of BS S 100.

Values for chemical composition given in the material specification shall be applied in accordance with Annex A.

6.2 Manufacture

The steel shall be manufactured in accordance with Section **1** of BS S 100.

6.3 Temporary identity up to cast approval stage

Temporary identification shall be maintained in accordance with Section **1** of BS S 100.

6.4 Surface dressing

Where surface dressing is required by the material specification or order, it shall be effected in accordance with Section **1** of BS S 100.

6.5 Freedom from defects

6.5.1 All material shall be free from any defect detrimental to the end use.

6.5.2 Notwithstanding the prior acceptance of a material as conforming to this standard, any defect in the material found at a

later stage, and which is likely to be detrimental to the subsequent use, shall be cause for rejection.

6.6 Sulfur printing and deep etching tests

Sulfur printing and deep etching tests shall be carried out in accordance with Section **1** of BS S 100 [see **5.1**a2) and **5.1**a3)]. This test shall not be applied to corrosion-resisting steels.

6.7 Cleanness

Unless otherwise specified in the material specification or order, the material shall conform to cleanness requirements specified in BS S 100. These requirements shall not be applied to corrosion-resisting steels.

6.8 Inspection of tubestock

6.8.1 Surface inspection

Tubestock shall be visually examined. The outer surface and, in the case of hollow tubestock, the inner surface shall be free from surface defects, detrimental to further processing of the material.

6.8.2 Non-destructive tests

If non-destructive tests, additional to visual examination for the detection of flaws in the tubestock, are required, they shall be agreed between the manufacturer and the purchaser and stated on the order. The manufacturer and the purchaser shall also agree the stage at which the tests are to be applied, the method of testing and the acceptance standards [see **5.2**a)].

For corrosion-resisting steel tubestock, an ultrasonic test shall be carried out to ensure that the presence of any primary pipe has been removed by cropping. This test shall be carried out during manufacture, after casting and prior to final finishing, and shall be reported on the release documentation.

6.9 Condition of supply

Tubestock shall be supplied in the condition required by the order [see **5.1**a4)]. If no condition is stated, the tubestock shall be supplied in the fully softened condition.

7 Tube manufacture, inspection and testing

7.1 Manufacture

Tubes shall be manufactured from tubestock conforming to Clause **6**.

7.2 Dimensions and tolerances

7.2.1 Tube dimensions shall be measured at a frequency sufficient to show conformance to the tolerances specified in Table B.1, Table B.2 and Table B.3. The tolerances shall meet the requirements of the tables unless otherwise stated in the material specification.

NOTE Tolerances other than those specified in Table B.1, Table B.2, and Table B.3 may be specified by agreement between the manufacturer and purchaser but these are outside the scope of this standard.

7.2.2 The tube sizes and tolerances shall be selected from those in Table B.1, Table B.2 and Table B.3 together with the note given in Annex B.

7.3 Straightness

Tubes shall be free from kinks and shall not depart from straightness in any selected length of 500 mm or more by an amount exceeding 1/600 of the length measured. Unless otherwise stated in the material specification or order [see **5.1**a5)], machine straightening shall be used.

7.4 Heat treatment

7.4.1 Tubes shall be supplied in the heat treatment condition specified in the material specification, drawing or order [see **5.1**a6)].

7.4.2 No tube shall be subjected to the specified final heat treatment more than three times.

7.4.3 Unless otherwise agreed between the manufacturer and the purchaser [see **5.2**b)], temperature control during heat treatment shall be in accordance with AMS 2750.

7.4.4 If a specific temperature (value and tolerance) is given in the material specification, drawing or order [see **5.1**a7)] that temperature shall be used. If a temperature range is given in the material specification, a temperature within that range, reduced by the furnace tolerance, shall be selected that will give the properties specified in the material specification.

7.4.5 The total volume of the charge shall be maintained at the selected temperature (θ), subject to the following furnace tolerances, for the period stated in the material specification:

a) $\theta < 750$ °C: ± 5 °C

b) 750 °C $\leqslant \theta \leqslant$ 1 250 °C: ± 10 °C

c) $\theta > 1\,250$ °C: ± 15 °C

7.4.6 If no period or temperature are given in the material specification, these shall be at the discretion of the manufacturer.

7.4.7 Unless specifically precluded by the material specification or order [see **5.1**a8)], where the material specification specifies the use of an oil quenchant, it is permissible for material to be quenched in a polymer quenchant.

7.4.8 When substituting a polymer quenchant for an existing oil quenchant, the polymer and concentration being substituted shall achieve cooling characteristics that are similar to the existing oil quenchant and the properties being produced shall be equivalent to those for oil quenched parts.

7.4.9 Heat treatment shall be carried out in such a manner as to minimize harmful defects, such as carburization and decarburization.

7.4.10 Any heat treatment applied after cold drawing or other bright finishing shall not form a scale of measurable thickness.

NOTE The surface of the tubes which have been reheated after cold drawing might be slightly dulled or discoloured.

8 Testing

8.1 General

The tests carried out and the test methods used shall conform to:

a) the material specification; or

b) the relevant section of this standard; or

c) the order or inspection schedule.

*NOTE See Clause **5**.*

8.2 Selection and preparation of test samples

8.2.1 Test samples shall be selected and prepared in accordance with the relevant requirements of this standard and the material specification, and shall be fully representative of the material in its delivery condition.

8.2.2 Test samples and associated test pieces shall be identified in such a manner that they are traceable to the batch from which they were taken.

8.2.3 Test samples shall not be mechanically worked after removal from the tubes they represent.

8.2.4 Test samples representing tubes in the final heat-treated condition specified in the material specification shall not be subjected to further heat treatment.

8.2.5 Test samples representing tubes to be delivered in a condition other than the condition of use shall be heat treated to the use condition in accordance with the material specification before testing.

8.3 Tensile test

8.3.1 One test sample shall be selected from each batch.

8.3.2 Tensile testing at ambient temperature shall be carried out in accordance with BS EN 2002-1.

8.3.3 Tensile testing at elevated temperature shall be carried out in accordance with BS EN 2002-2.

8.3.4 Test pieces for tensile testing shall conform to the dimensions of the largest practicable size test piece specified in BS EN 2002-1 or BS EN 2002-2, as appropriate.

8.3.5 The tensile properties obtained from the test pieces shall conform to the material specification.

8.4 Hardness test

8.4.1 If the material specification specifies a hardness value, hardness testing shall be carried out on every tensile test piece and one end of 10% of the tubes in each batch which shall be selected to represent the beginning, middle and end of a manufacturing sequence.

8.4.2 Hardness testing shall be carried out using one of the methods listed in **8.4.3**, **8.4.4** or **8.4.5** as specified in the material specification.

8.4.3 Brinell hardness testing shall be carried out in accordance with BS EN ISO 6506-1. If not specified in the material specification, the

ratio of F/D^2 shall be 30. Periodic checking of the testing machine by the user shall be carried out in accordance with, and at the frequency specified in, BS EN ISO 6506-1.

8.4.4 Vickers hardness testing shall be carried out in accordance with BS EN ISO 6507-1. Periodic checking of the testing machine by the user shall be carried out in accordance with, and at the frequency specified in, BS EN ISO 6507-1.

8.4.5 Rockwell hardness testing shall be carried out in accordance with BS EN ISO 6508-1. Periodic checking of the testing machine by the user shall be carried out in accordance with, and at the frequency specified in, BS EN ISO 6508-1.

8.4.6 All tests on the same batch (including test pieces, where applicable) shall be made by the same method and under the same conditions of loading.

8.4.7 The hardness shall conform to the material specification.

8.5 Flattening test

8.5.1 One test sample of not less than 50 mm length shall be selected from every 30 m, or part thereof, of tube in each batch for the flattening test.

8.5.2 Flattening testing shall be carried out in accordance with BS EN ISO 8492.

8.5.3 The distance between platens measured under load in the direction of flattening shall be as specified in the material specification plus twice the nominal wall thickness of the tube.

8.5.4 After flattening, the test pieces shall not show any cracking.

8.6 Drift-expanding test

8.6.1 One end of each tube shall be drift-expanding tested in accordance with BS EN ISO 8493.

8.6.2 The angle (β) of the conical mandrel shall be as specified in the material specification.

8.6.3 The maximum outside diameter of the expanded part of the test piece, D_u, or relative expansion as a percentage of the original diameter, D, shall be as specified in the material specification.

8.6.4 After drift-expanding, there shall be no evidence of cracking.

8.7 Hydraulic pressure test

8.7.1 Tubes shall be subjected to the hydraulic pressure test at the following frequencies.

a) For tubes delivered in the final heat-treated condition (excluding austenitic steels), each tube shall be tested.

b) For corrosion-resisting and heat-resisting austenitic steel tubes, 10% of each batch shall be tested.

8.7.2 The tube shall be subjected, for not less than 30 s, to the appropriate internal pressure specified in the material specification.

NOTE Care should be taken to ensure that all the air in a tube being tested is completely replaced by hydraulic fluid before the specified pressure is applied.

8.7.3 When subjected to the hydraulic pressure, or after release of the pressure, the tube shall show no defects such as leaks, cracks, pinholes or bulges.

8.8 Distension test

8.8.1 One test sample from each batch shall be selected for distension testing.

8.8.2 A test piece, not less than 600 mm in length, shall be cut from each sample tube. If the tubes are to be subjected to the hydraulic pressure test in accordance with **8.7**, the test piece shall be cut before the tube is tested.

8.8.3 The mean outside diameter shall be determined at the mid-point of the length of the test piece by measurement of two diameters at right angles with an instrument having a sensitivity of 0.0025 mm.

8.8.4 The test pressure shall be as specified in the material specification.

8.8.5 The test pressure shall be applied and maintained for not less than 30 s.

8.8.6 After release of the pressure, the mean outside diameter shall be determined by measurement of two diameters at right angles at the original position.

8.8.7 The permanent increase in the mean outside diameter shall not exceed the value specified in the material specification.

8.8.8 The test piece used for the test shall be discarded.

8.9 Decarburization test

8.9.1 One test sample from every 100 m, or part thereof, of tube shall be selected from each batch.

8.9.2 A transverse section shall be taken from the test sample and the depth of decarburization shall be determined in accordance with the micrographic method detailed in BS EN ISO 3887.

8.9.3 The section prepared from the test sample shall be examined with bright field illumination at a magnification of approximately ×200.

8.9.4 There shall be no identifiable decarburization greater than that specified in the material specification, or agreed between the manufacturer and the purchaser [see **5.2**c)], at any point on the inner or outer surface of the tube.

8.10 Other tests

Other tests shall be agreed between the manufacturer [see **5.2**d)] and the purchaser.

8.11 Retesting procedures

8.11.1 Tensile test

If the test procedure or test piece preparation is found to be faulty, testing shall be reapplied using the original sampling frequency after

identification of the cause of the failure. When failure cannot be attributed to faulty testing or test piece preparation, and any test piece fails to conform to **8.3.5**, one or both of the following procedures shall be adopted.

a) Two additional samples, one of which is from the tube from which the original test sample was taken, shall be selected from the same batch. The mechanical properties obtained from the test pieces prepared from both additional test samples shall conform to the material specification.

b) The batch shall be re-heat treated in accordance with **7.4** and re-subjected to all the tests required by the material specification.

8.11.2 Hardness test

If any tube fails to conform to the material specification (see **8.4.7**), all remaining tubes in the batch shall be tested, and one of the following retest procedures shall be applied.

a) Tubes outside the specified hardness range shall be tensile tested, the samples being taken from the minimum and maximum hardness test values found. If these tests conform to the specified tensile and ductility requirements, all the tubes represented shall be accepted.

b) Tubes found to be of incorrect hardness shall be re-heat treated or processed to conform to the material specification. Such tube shall be subjected to the full test requirements of the material specification.

8.11.3 Flattening test

If any test piece fails to conform to **8.5.4**, one or both of the following retest procedures shall be applied.

a) Twice the number of samples originally selected, half of which are from the tubes from which the original samples were taken, shall be selected from the same batch. The test pieces prepared from all these additional samples shall conform to **8.5.1**.

b) The batch shall be re-heat treated in accordance with **7.4** and re-subjected to all the tests required by the material specification.

8.11.4 Drift-expanding test

Tubes which fail to conform to **8.6.4** shall be re-heat treated in accordance with **7.4** and re-subjected to all the tests required by the material specification.

8.11.5 Hydraulic pressure test

If all the tubes in the batch have not been tested and any test sample fails to conform to **8.7.3**, all the remaining tubes in the batch shall be tested.

8.11.6 Distension test

If any test piece fails to conform to **8.8.7**, two additional samples from the same batch shall be selected for test, one of which shall be the

tube from which the test piece was taken, unless that tube has been withdrawn by the manufacturer. The test pieces cut from both these additional test samples shall conform to **8.8.2**.

8.11.7 Decarburization test

If any test sample fails to conform to **8.9.4**, twice the number of samples originally selected shall be selected for test from the same batch, half of which shall be from the tubes from which the original samples were taken. The sections prepared from all these additional samples shall conform to **8.9.2**.

8.12 Application of values

The values for mechanical properties given in the material specification shall be applied in accordance with Annex A.

9 Defects

9.1 Internal defects

If specified in the material specification, order or inspection schedule [see **5.1**a9)], tubes shall be ultrasonically tested in accordance with EN 3718. The material shall conform to the material specification, order or inspection schedule.

9.2 External defects

9.2.1 The tube shall be visually examined for defects and the inner and outer surfaces of the finished tube shall conform to the material specification. If the dimensions of the tube render impractical the effective visual examination of the bore, alternative methods shall be agreed between the manufacturer and the purchaser [see **5.2**e)].

9.2.2 To enable the surfaces to be inspected, heat-treated tubes shall, if necessary, be descaled in accordance with BS 7773. Cathodic acid pickling shall not be used. Acid pickling shall not be used for tubes having a specified maximum tensile strength greater than 1 450 MPa (or a specified minimum tensile strength greater than 1 400 MPa where the steel specification specifies only a minimum tensile strength).

10 Maintenance of identity

10.1 The material shall retain its cast and batch identity, to enable final identification to be made in accordance with Clause **11**.

10.2 Each tube shall be checked immediately before despatch, using a qualitative test method, to ensure that it is of the correct material type. The test method used shall be at the discretion of the manufacturer.

NOTE Suitable methods of testing include a spark test, or use of a spectroscope or an electromagnetic sorting appliance. Hardness testing alone may suffice in some instances.

10.3 Test samples and test pieces shall be identifiable to the material they represent.

11 Final marking

11.1 Each tube over 20 mm in diameter shall be marked with an inspection stamp and the material specification number[4)].

11.2 Tubes equal to or less than 20 mm in diameter of the same nominal dimensions from the same batch shall be made into bundles each of which shall bear a durable label marked with the inspection stamp and such other marking as shall ensure full identification of the material.

11.3 If overall ink marking of each tube is required, such marking shall conform to the material specification or order [see **5.1**a10)].

11.4 If marking ink or a similar medium is used, this shall remain visible after handling and after contact with any corrosion preventative used. The ink shall be removable with cleaning products without leaving a residue which could affect further processing. Cleaning products and inks shall not give rise to corrosion.

12 Protection and packaging

12.1 Unless otherwise specified on the order [see **5.1**a11)], tubes other than those made from corrosion-resisting steel shall be protected before despatch by a corrosion preventative, selected and applied so that the purchaser receives the tube free from corrosion.

12.2 If the product is packaged, the outside of the package shall bear the following information:

a) the name of the purchaser;

b) the total mass of the package;

c) the order number and sufficient information to enable the package to be related to the order and other relevant documentation.

13 Certification

13.1 The manufacturer shall supply, to the purchaser, the necessary certification in respect of all material governed by this standard and all relevant material specifications.

13.2 If a batch of material consigned by the manufacturer is subdivided by a supplier before re-consignment, the supplier shall carry out any subsequent additional dimensional inspection or identification marking and shall certify accordingly.

13.3 The manufacturer shall supply with each delivery a certificate of conformity bearing the name and address of the manufacturer and a printed serial number, containing the following minimum information:

a) purchaser's name and address;

b) contract and/or order number,

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4) Marking a British Standard identifier (e.g. BS T 80:1997) on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

c) quality assurance authority under which the material is supplied and, where appropriate, the registration or approval number,

d) manufacturer's internal order number;

e) material designation, or the number of the material specification, and the number of this British Standard [5)];

f) description of the material supplied, including dimensions, drawing numbers and part numbers, if appropriate, and any other identification, together with number(s) of the inspection or manufacturing schedule, where applicable;

g) quantity supplied;

h) cast number(s) and batch number(s) or unique identification, including the ingot and the position within the ingot, or strand and position in the strand in the case of continuously cast material, where applicable;

i) condition of the material as delivered;

j) heat treatment details, including details of test sample heat treatment, where appropriate. For material supplied in the final heat-treated condition and subject to quenching, the type of quenchant used;

k) details of all the tests carried out, or the reference numbers of the relevant test reports, copies of which shall be attached;

l) inspection stamp;

m) a statement that "This material has been released in accordance with BS T 100", where appropriate;

n) a certification clause signed by a duly authorized employee of the manufacturer, in the following form unless otherwise required by the quality assurance authority:

"Certified that the whole of the supplies detailed herein have been inspected and tested and, unless otherwise stated above, conform in all respects to the requirements of the contract and/or order."

13.4 When certification of the material is issued by a supplier, who is not the manufacturer, the supplier shall hold equivalent certification issued by the manufacturer of the material. All the information required by **13.3**, as provided by the manufacturer, shall be supplied with each delivery.

5) Marking a British Standard identifier (e.g. BS T 80:1997) on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

Section 2. Tubes delivered in the final heat-treated condition (excluding austenitic steels)

14 General

This section covers the requirements for the inspection and testing of tubes delivered in the final heat-treated condition (excluding austenitic steels) and shall be used in conjunction with Section **1**.

15 Mechanical tests

Test pieces from test samples selected and prepared in accordance with Clause **8** shall be subjected to the mechanical tests listed in the material specification. Testing shall be in accordance with Clause **8**.

16 Hardness test

When required by the material specification, samples shall be selected and tested in accordance with **8.4**.

17 Decarburization test

When required by the material specification, samples shall be selected and tested in accordance with **8.9**.

18 Non-destructive tests

If non-destructive tests, additional to visual examination for the detection of flaws in tubes, are required by agreement between the manufacturer and the purchaser [see **5.2**f)], the manufacturer and the purchaser shall agree the stage at which the tests are to be applied, the method of testing and the acceptance standards.

Section 3. Corrosion-resisting and heat-resisting austenitic steel tubes (elevated temperature properties not verified)

19 General

This section covers the requirements for the inspection and testing of corrosion and heat-resisting austenitic steel tubes and shall be used in conjunction with Section **1**.

20 Mechanical tests

Test pieces from test samples selected and prepared in accordance with Clause **8** shall be subjected to the mechanical tests listed in the material specification. Testing shall be in accordance with Clause **8**.

21 Hardness test

When required by the material specification, samples shall be selected and tested in accordance with **8.4**.

22 Surface finish

22.1 Selection of test samples

When required by the material specification, one test sample from every 100 m, or part thereof, of tube in each batch shall be selected for the surface finish test.

22.2 Initial tests

The test sample shall be examined in accordance with the requirements of BS 1134-1 and BS 1134-2, and the R_a value (arithmetic mean variation) shall conform to the material specification.

22.3 Retests

If any test sample fails to conform to **22.2**, twice the number of samples originally selected shall be selected for test from the same batch, half of which shall be from the tubes from which the original samples were taken, unless those tubes have been withdrawn by the manufacturer. All these additional samples shall conform to **22.2**.

23 Freedom from surface contamination

23.1 Selection and preparation of test samples

23.1.1 When required by the material specification, one test sample from every 100 m, or part thereof, of tube in each batch shall be selected for microscopic examination for freedom from surface contamination.

23.1.2 The test sample shall be heated at a temperature of 650 °C for 30 min, unless otherwise stated in the material specification, and cooled in air. A transverse section shall be taken from the sample and shall be mounted in such a manner that the edges are adequately supported, polished and etched electrolytically in an aqueous solution of 10% oxalic acid or 10% chromic acid.

23.2 Initial tests

23.2.1 The section prepared from the test sample shall be microscopically examined, at the magnification specified in the material specification, for evidence of carburization, oxide penetration, oxidation and other surface or sub-surface contamination.

23.2.2 The extent of any contamination shall not exceed that permitted by the material specification.

23.3 Retests

If any test sample fails to conform to **23.2.2** all the remaining tubes in the batch shall be tested.

24 Susceptibility to intercrystalline corrosion

24.1 Selection and preparation of test samples

24.1.1 When required by the material specification, and unless the material specification requires one sample to be taken from each tube, one test sample from every 100 m, or part thereof, of tube in each batch shall be selected for the intercrystalline corrosion tests.

24.1.2 A flattening test piece, prepared in accordance with BS EN ISO 3651-2, shall be sensitized for 30 min at (650 $\pm$10) °C and cooled in air. It shall then be subjected to intercrystalline corrosion testing in accordance with BS EN ISO 3651-2, Method A or Method B, appropriate to the type of steel.

24.1.3 A length of approximately 13 mm shall be cut from the sample and flattened as described in BS EN ISO 3651-2.

24.1.4 The remainder of the sample shall be either:

a) split longitudinally into two equal pieces which shall be flattened as required by the material specification, care being taken to avoid reverse bending and damage to the surface of the bore; or

b) cut transversely to leave approximately 10% of the circumference and then bent back to an angle of 90° to disclose the bore.

24.2 Initial tests

24.2.1 The outer surface of the sample treated in accordance with **24.1.3** and the inner surface of the sample treated in accordance with **24.1.4** shall be examined at a magnification of not less than ×10.

24.2.2 If fissuring or crazing of either of the surfaces is observed, the extent of the intergranular attack resulting from the treatment in **24.1.2** shall be verified, by sectioning and microscopic examination at a magnification of approximately ×200, and shall conform to the material specification.

24.3 Retests

If any test sample fails to conform to **24.2.2**, all the remaining tubes in the batch shall be tested.

25 Non-destructive tests

If non-destructive tests, additional to visual examination for the detection of flaws in the tubes are required they shall be agreed between the manufacturer and the purchaser and stated on the order. The manufacturer and the purchaser shall also agree the stage at which the tests are to be applied, the method of testing and the acceptance standards [see **5.2**g)].

Section 4. Tubes delivered in the softened condition for use in the hardened and tempered condition

26 General

This section specifies requirements for the inspection and testing of tubes delivered in the softened condition for use in the hardened and tempered condition and shall be used in conjunction with Section **1**.

27 Selection of mechanical test samples

27.1 When tests in the softened condition are required by the material specification or order [see **5.1**b1)], one test sample from every 100 m, or part thereof, of tube shall be selected from each batch.

27.2 To demonstrate that the material will respond to the hardening and tempering treatment, one tensile test sample from each batch shall be selected, and shall be heat treated in accordance with the material specification.

28 Mechanical tests

Test pieces from test samples selected and prepared in accordance with Clause **27** shall be subjected to the mechanical tests listed in the material specification. Testing shall be in accordance with Clause **8**.

29 Decarburization test

When required by the material specification, samples shall be selected and tested in accordance with **8.9**.

30 Non-destructive tests

If non-destructive tests, additional to visual examination for the detection of flaws in the tubes are required they shall be agreed between the manufacturer and the purchaser and stated on the order. The manufacturer and the purchaser shall also agree the stage at which the tests are to be applied, the method of testing and the acceptance standards [see **5.2**h)].

Section 5. Modified requirements for the acceptance of small quantities of tubes and tubestock

31 General

This section specifies the modified requirements applicable to the acceptance of small quantities of tubes and tubestock and shall be used in conjunction with Section **1**.

32 General requirements

If a small quantity of tube or tubestock conforming to this standard is required, the use of a portion of a cast already made, but for which it has not been proved that:

a) at some stage, or stages, in the manufacture of the product, adequate discard has been removed from the portions corresponding to the top and the bottom of each ingot or the beginning and end of each strand;

b) there is conformance to **6.1**, **6.2** and **6.4** of this standard;

shall be acceptable provided that the following conditions are met.

1) The consent in writing of the quality assurance authority is obtained.

2) The steel has been manufactured and supplied by a company, or companies, whose quality assurance system has been approved by the quality assurance authority.

3) A steelmaker's certificate stating the process by which the steel was made is provided as proof of conformity to the manufacturing requirements of Section **1** of BS S 100.

4) The steelmaker's certificate of analysis is provided as proof of conformity to the chemical composition requirements of Section **1** of BS S 100.

5) Each of the pieces of steel concerned is identifiable as to its cast, and adequate documentary evidence is available to secure correlation with the steelmaker's certificates (see items 3 and 4).

6) Visual examination and the tests detailed in Clause **33** and Clause **34** do not reveal any harmful defects.

7) The steel conforms to all other requirements of this standard and the material specification.

33 Micro-cleanness assessment

An examination of one or more samples shall be carried out to verify that the material conforms to the micro-cleanness requirements of BS S 100.

34 Other tests

34.1 General

The steel shall be examined at a suitable stage to verify freedom from harmful defects, as specified in **34.2**, **34.3**, **34.4** and **34.5**.

34.2 Selection of samples

Samples shall be selected as follows.

a) For billets in pieces up to 50 kg each, one sample shall be selected from each piece.

b) For billets in pieces over 50 kg each, one sample shall be selected from each 50 kg, or part thereof.

c) For tube over 15 mm outside diameter, one sample shall be selected from each 100 m, or part thereof, of tubes of the same nominal dimensions produced from the same cast and, if heat treated, that have been heat treated together;

d) For tube not over 15 mm outside diameter, one sample shall be selected from each 50 m, or part thereof, of tubes of the same nominal dimensions produced from the same cast and, if heat treated, that have been heat treated together.

34.3 Billets

The samples from billets shall be sulfur printed or deep etched as required by **6.6**.

34.4 Tubes

34.4.1 Tubes over 3 mm wall thickness

The samples shall be submitted to one of the following tests:

a) sulfur printing as required by **6.6**;

b) metallographic examination;

c) pickling test as described in **34.5**.

34.4.2 Tubes equal to or less than 3 mm wall thickness

A transverse strip shall be cut from each sample tube and fractured by reverse bending in accordance with BS EN ISO 7438. The fractured edge shall be free from harmful defects. In cases of dispute, the test shall be carried out with testing machines or presses equipped with a bending device with two supports and a former as specified in BS EN ISO 7438.

The test piece shall be bent into the form of a U over a mandrel of radius approximately three times the nominal thickness of the tube, the bore of the tube being inside the bend. The test piece shall show no evidence of crack or flaw.

34.5 Pickling test

34.5.1 A sample approximately 75 mm long, slit longitudinally to facilitate examination of the internal surface, shall be immersed for 10 min in a solution of equal volumes of concentrated hydrochloric acid (d = 1.16 to 1.18) and water maintained at a temperature of not less than 85°C and then removed from the solution and washed and dried.

NOTE The pickling test may conveniently be employed for examination for both soundness and surface condition, provided that one end of the sample is machined square with the longitudinal axis.

34.5.2 The pickled surface shall not reveal any harmful defects.

Annex A (normative)

Rules for application of values for mechanical properties given in material specifications

For the purpose of determining conformity to the limits specified in the material specification, an observed or a calculated value obtained from a test shall be rounded in one step to the same number of figures used to express the specified limit in the material specification in accordance with the following procedures.

a) For units of stress:

   tensile strength and proof stress values shall be rounded as follows:

   1) stresses up to 250 MPa: to the nearest even number;

   2) stresses over 250 MPa up to and including 1 000 MPa: to the nearest multiple of five;

   3) stresses over 1 000 MPa: to the nearest multiple of 10.

b) For numerical values and other units:

   1) when the figure immediately after the last figure to be retained is less than 5, the last figure to be retained shall remain unchanged;

   2) when the figure immediately after the last figure to be retained is greater than 5, or equal to 5 and followed by at least one figure other than zero, the last figure to be retained shall be increased by one;

   3) when the figure immediately after the last figure to be retained is equal to 5 and followed by zeros only, the last figure to be retained shall remain unchanged if even and be increased by one if odd.

Annex B (normative) Dimensions and tolerances

B.1 General

In Table B.1, Table B.2 and Table B.3, the tolerances enclosed in parentheses are those for nominal outside diameters and thicknesses selected from the preferred R 10 series specified in BS M 46.

B.2 Tolerances

The limits given in Table B.1, Table B.2 and Table B.3 are derived as follows where D is the nominal outside diameter, T is the nominal thickness and M is the total mean tolerance.

a) Tolerance on mean inside or outside diameter:

1) $D \leqslant 38$ mm: ± 0.08 mm;

2) $D > 38$ mm: ± 0.025 mm for each 12.5 mm of diameter or part thereof.

b) Tolerance on extreme outside diameter:

$\pm(M + 0.04)$ mm or as derived from the formula in 1), 2) or 3) below, as appropriate, whichever is the greater, each limit taken to the nearest 0.02 mm under the calculated value.

1) Cold drawn and tempered tubes:

$$\pm\left[0.254 + \frac{1.2D^3}{(1\,000T)^2} - \frac{M}{4}\right]$$

2) Annealed, normalized or hardened and tempered tubes:

$$\pm\left[0.254 + \frac{2D^3}{(1\,000T)^2} - \frac{M}{4}\right]$$

3) Corrosion-resisting and heat-resisting tubes:

$$\pm\left[0.254 + \frac{3D^3}{(1\,000T)^2} - \frac{M}{4}\right]$$

NOTE The limits on extreme outside diameter are based on the mean diameter and indicate the maximum out of round permissible.

c) Tolerance on mean thickness:

1) $T \leqslant 0.6$ mm: ± 0.04 mm;

2) $0.6 \text{ mm} < T \leqslant 1.4$ mm: ± 0.05 mm;

3) $T > 1.4$ mm: $\pm 4\%$.

d) Tolerance on extreme thickness:

1) Maximum thickness: 1.1 × actual mean thickness;

2) Minimum thickness: 0.9 × actual mean thickness.

B.3 Eccentricity

At any one section, the variation in thickness shall be not greater than 10% of the actual mean thickness.

Table B.1 **Tolerances on dimensions of cold drawn and tempered steel tubes**
Dimensions in mm

Nominal thickness	0.6		0.8		1.0		1.2		1.6		2.0	
Mean thickness	0.56 to 0.64		0.75 to 0.85		0.95 to 1.05		1.15 to 1.25		1.54 to 1.66		1.92 to 2.08	
Extreme thickness	Actual mean thickness ±10%		Actual mean thickness ±10%		Actual mean thickness ±10%		Actual mean thickness ±10%		Actual mean thickness ±10%		Actual mean thickness ±10%	
Nominal diameter	Mean diameter	Total out of round	Mean diameter	Total out of round	Mean diameter	Total out of round	Mean diameter	Total out of round	Mean diameter	Total out of round	Mean diameter	Total out of round
	±		±		±		±		±		±	
5	(0.08)	(0.20)	(0.08)	(0.20)	—	—	—	—	—	—	—	—
6	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	—	—	—	—	—	—
8	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	—	—	—	—	—	—
10	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	—	—
12	(0.08)	(0.22)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	—	—
14	0.08	0.22	0.08	0.20	0.08	0.20	0.08	0.20	0.08	0.20	—	—
16	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	—	—
18	0.08	0.22	0.08	0.22	0.08	0.22	0.08	0.20	0.08	0.20	—	—
20	(0.08)	(0.24)	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.20)	(0.08)	(0.20)
22	0.08	0.24	0.08	0.22	0.08	0.22	0.08	0.22	0.08	0.20	—	—
25	(0.08)	(0.26)	(0.08)	(0.24)	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.20)
28	0.08	0.28	0.08	0.24	0.08	0.24	0.08	0.22	0.08	0.22	—	—
32	(0.08)	(0.32)	(0.08)	(0.26)	(0.08)	(0.24)	(0.08)	(0.24)	(0.08)	(0.22)	(0.08)	(0.22)
36	0.08	0.36	0.08	0.30	0.08	0.26	0.08	0.24	0.08	0.22	—	—
40	(0.10)	(0.40)	(0.10)	(0.32)	(0.10)	(0.28)	(0.10)	(0.24)	(0.10)	(0.22)	(0.10)	(0.26)
45	0.10	0.50	0.10	0.36	0.10	0.30	0.10	0.26	0.10	0.24	—	—
50	0.10	0.62	(0.10)	(0.42)	(0.10)	(0.34)	(0.10)	(0.30)	(0.10)	(0.26)	(0.10)	(0.24)
56	0.125	0.76	0.125	0.52	0.125	0.40	0.125	0.34	0.125	0.26	0.125	0.24
63	—	—	(0.125)	(0.66)	(0.125)	(0.48)	(0.125)	(0.38)	(0.125)	(0.30)	(0.125)	(0.26)
71	—	—	0.15	0.84	0.15	0.60	0.15	0.46	0.15	0.34	0.15	0.28
80	—	—	—	—	(0.175)	(0.78)	(0.175)	(0.58)	(0.175)	(0.40)	(0.175)	(0.32)

Table B.2 **Tolerances on dimensions of annealed, normalized or hardened and tempered steel tubes**
Dimensions in mm

Nominal thickness	0.6		0.8		1.0		1.2		1.6		2.0	
Mean thickness	0.56 to 0.64		0.75 to 0.85		0.95 to 1.05		1.15 to 1.25		1.54 to 1.66		1.92 to 2.08	
Extreme thickness	Actual mean thickness ±10%		Actual mean thickness ±10%		Actual mean thickness ±10%		Actual mean thickness ±10%		Actual mean thickness ±10%		Actual mean thickness ±10%	
Nominal diameter	Mean diameter	Total out of round	Mean diameter	Total out of round	Mean diameter	Total out of round	Mean diameter	Total out of round	Mean diameter	Total out of round	Mean diameter	Total out of round
	±		±		±		±		±		±	
5	(0.08)	(0.20)	(0.08)	(0.20)	—	—	—	—	—	—	—	—
6	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	—	—	—	—	—	—
8	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	—	—	—	—	—	—
10	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	—	—
12	(0.08)	(0.22)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	—	—
14	0.08	0.22	0.08	0.22	0.08	0.20	0.08	0.20	0.08	0.20	—	—
16	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.20)	(0.08)	(0.20)	—	—
18	0.08	0.24	0.08	0.22	0.08	0.22	0.08	0.22	0.08	0.20	—	—
20	(0.08)	(0.24)	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.20)
22	0.08	0.26	0.08	0.24	0.08	0.22	0.08	0.22	0.08	0.22	—	—
25	(0.08)	(0.30)	(0.08)	(0.26)	(0.08)	(0.24)	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.22)
28	0.08	0.32	0.08	0.28	0.08	0.24	0.08	0.24	0.08	0.22	—	—
32	(0.08)	(0.38)	(0.08)	(0.30)	(0.08)	(0.26)	(0.08)	(0.24)	(0.08)	(0.22)	(0.08)	(0.22)
36	0.08	0.46	0.08	0.34	0.08	0.30	0.08	0.26	0.08	0.24	—	—
40	(0.10)	(0.54)	(0.10)	(0.40)	(0.10)	(0.32)	(0.10)	(0.28)	(0.10)	(0.24)	(0.10)	(0.22)
45	0.10	0.70	0.10	0.48	0.10	0.38	0.10	0.32	0.10	0.26	—	—
50	0.10	0.88	(0.10)	(0.58)	(0.10)	(0.44)	(0.10)	(0.36)	(0.10)	(0.30)	(0.10)	(0.26)
56	0.125	1.16	0.125	0.72	0.125	0.54	0.125	0.42	0.125	0.32	0.125	0.26
63	—	—	(0.125)	(0.96)	(0.125)	(0.68)	(0.125)	(0.52)	(0.125)	(0.38)	(0.125)	(0.30)
71	—	—	0.15	1.28	0.15	0.88	0.15	0.66	0.15	0.44	0.15	0.34
80	—	—	—	—	(0.175)	(1.18)	(0.175)	(0.86)	(0.175)	(0.56)	(0.175)	(0.42)

NOTE The tolerances on the inside diameter of tubes ordered by outside diameter and thickness and the tolerances on the outside diameter of tubes ordered by inside diameter and thickness will not necessarily be those given in the table.

Table B.3 **Tolerances on dimensions of austenitic corrosion-resisting and heat-resisting steel tubes**
Dimensions in mm

Nominal thickness	0.3		0.4		0.5		0.6		0.8		1.0		1.2		1.6	
Mean thickness	0.26 to 0.34		0.36 to 0.44		0.46 to 0.54		0.56 to 0.64		0.75 to 0.85		0.95 to 1.05		1.15 to 1.25		1.54 to 1.66	
Extreme thickness	Actual mean thickness ±10%		Actual mean thickness ±10%		Actual mean thickness ±10%		Actual mean thickness ±10%		Actual mean thickness ±10%		Actual mean thickness ±10%		Actual mean thickness ±10%		Actual mean thickness ±10%	
Nominal diameter	Mean diameter	Total out of round	Mean diameter	Total out of round	Mean diameter	Total out of round	Mean diameter	Total out of round	Mean diameter	Total out of round	Mean diameter	Total out of round	Mean diameter	Total out of round	Mean diameter	Total out of round
	±		±		±		±		±		±		±		±	
3.2	0.08	0.20	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	0.08	0.20	—	—	—	—	—	—
4	0.08	0.20	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	—	—	—	—	—	—
5	0.08	0.20	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	—	—	—	—
6	0.08	0.22	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)	—	—	—	—
8	0.08	0.22	(0.08)	(0.20)	(0.08)	(0.22)	(0.08)	(0.20)	(0.08)	(0.22)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	—
10	0.08	0.24	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	0.20	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)
12	0.08	0.26	0.08	0.24	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.20)	(0.08)	(0.20)	(0.08)	(0.20)
14	0.08	0.30	0.08	0.26	0.08	0.24	0.08	0.22	0.08	0.22	0.08	0.22	0.08	0.20	0.08	0.20
16	0.08	0.34	0.08	0.28	(0.08)	(0.26)	(0.08)	(0.24)	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.22)
18	—	—	0.08	0.32	0.08	0.28	0.08	0.26	0.08	0.24	0.08	0.22	0.08	0.22	0.08	0.22
20	—	—	0.08	0.36	(0.08)	(0.30)	(0.08)	(0.28)	(0.08)	(0.24)	(0.08)	(0.22)	(0.08)	(0.22)	(0.08)	(0.22)
22	—	—	—	—	0.08	0.34	0.08	0.30	0.08	0.26	0.08	0.24	0.08	0.22	0.08	0.22
25	—	—	—	—	(0.08)	(0.40)	(0.08)	(0.34)	(0.08)	(0.28)	(0.08)	(0.26)	(0.08)	(0.24)	(0.08)	(0.22)
28	—	—	—	—	0.08	0.46	0.08	0.38	0.08	0.30	0.08	0.26	0.08	0.24	0.08	0.22
32	—	—	—	—	(0.08)	(0.60)	(0.08)	(0.48)	(0.08)	(0.36)	(0.08)	(0.30)	(0.08)	(0.28)	(0.08)	(0.24)
36	—	—	—	—	—	—	(0.08)	(0.48)	0.08	0.42	0.08	0.34	0.08	0.30	0.08	0.26
40	—	—	—	—	—	—	(0.10)	(0.72)	(0.10)	(0.50)	(0.10)	(0.38)	(0.10)	(0.32)	(0.10)	(0.26)
45	—	—	—	—	—	—	0.10	0.96	0.10	0.62	0.10	0.46	0.10	0.38	0.10	0.30
50	—	—	—	—	—	—	(0.10)	(1.24)	(0.10)	(0.78)	(0.10)	(0.56)	(0.10)	(0.46)	(0.10)	(0.34)
56	—	—	—	—	—	—	0.125	1.64	0.125	1.00	0.125	0.70	0.125	0.54	0.125	0.34
63	—	—	—	—	—	—	—	—	(0.125)	(1.36)	(0.125)	(0.94)	(0.125)	(0.07)	(0.125)	(0.42)
71	—	—	—	—	—	—	—	—	0.15	1.84	0.15	1.24	0.15	0.92	0.15	0.58
80	—	—	—	—	—	—	—	—	—	—	(0.175)	(1.70)	(0.175)	(1.22)	(0.175)	(0.68)

NOTE The tolerances on the inside diameter of tubes ordered by outside diameter and thickness and the tolerances on the outside diameter of tubes ordered by inside diameter and thickness will not necessarily be those given in the table.

Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 1639, *Methods for bend testing of metals* [6)]

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BS M 46, *Specification for outside diameters and thicknesses of tubing*

[6)] Referred to in the foreword only.

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