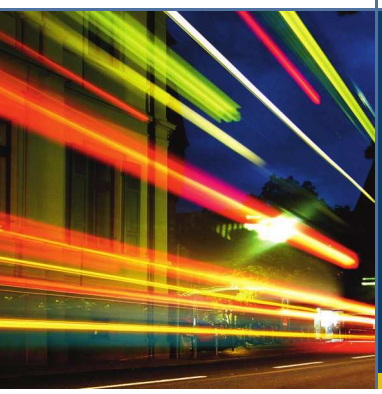
BS 3TA 100:2009



BSI British Standards

AEROSPACE SERIES

Procedure for inspection, testing and acceptance of wrought titanium and titanium alloys

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Contents

Summary of pages
This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 42, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI and came into effect on 30 November 2009. It was prepared by Panel ACE/61/-/49, *Titanium and its alloys*, 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This British Standard supersedes BS 2TA 100:1973, which is withdrawn.

Information about this document

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

Section **1**

a) Definitions have been amended.

b) Information to be supplied by purchaser has been added.

c) Information to be agreed by contracting parties has been added.

d) Method of melting has been amended.

e) Temperature control method has been amended.

f) Heat treatment temperature tolerances have been added.

g) Method for hydrogen determination has been added.

h) Rules for application of values have been added.

i) Tensile testing at ambient temperature to BS 4A 4 has been replaced by BS EN 2002-1.

j) Tensile testing at elevated temperature to BS 4A 4-1.2 has been replaced by BS EN 2002-2.

k) Creep and stress-rupture testing to BS 4A 4-1.3 has been replaced by BS EN 2002-005.

l) BS EN 2003-009, Method A, has been added as determination of surface contamination test method.

m) Protection and packaging requirements have been added.

n) Certification requirements have been added.

Section **2**

a) External defects requirements have been added.

b) Surface contamination requirements have been added.

Section **3**

a) External defects requirements have been added.

b) Surface contamination requirements have been added.

Section **4**

Completely re-written to reflect current methodology.

Section **5**

a) BS EN ISO 7438 has been added as single bend test method.

b) External defects requirements have been added.

c) Surface contamination requirements have been added.

d) Dimensional tolerances have been transferred from Appendix A.

Section **6**

a) External defects requirements have been added.

b) Surface contamination requirements have been added.

c) Dimensional tolerances have been transferred from Appendix A.

Section **7**

a) Test piece dimensions have been added by reference to BS EN 2002.

b) BS EN ISO 8493 has been added as drift test method and 74° added as conical mandrel angle.

c) BS EN ISO 8492 has been added as flattening test method.

d) External defects requirements have been added.

e) Surface contamination requirements have been added.

Section **8**

a) External defects requirements have been added.

b) Surface contamination requirements have been added.

Appendix A has been deleted – dimensional tolerances requirements transferred to Section **5** and Section **6**.

New Annex A has been added – rules for application of values for chemical composition and mechanical properties given in material specifications.

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 methods are expressed as a set of instructions, a description, or 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 inspection, testing and acceptance of wrought titanium and titanium alloys for aerospace purposes.

The standard is applicable to material specifications in the British Standard Aerospace TA series and also to other British Standard material specifications for wrought titanium and titanium alloys 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 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 2002-005, *Metallic materials – Test methods – Part 5: Uninterrupted creep and stress-rupture testing*

BS EN 2003-009:2007, *Test methods – Titanium and titanium alloys – Part 009: Determination of surface contamination*

BS EN 2003-010, *Titanium and titanium alloys – Test methods – Part 010: Sampling for determination of hydrogen content*

BS EN 3976, *Titanium and titanium alloys – Test method – Chemical analysis for the determination of hydrogen content*

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*

AMS 2750, *Pyrometry* [1)]

3 Terms and definitions

For the purposes of this British Standard the following terms and definitions apply.

3.1 α stabilized surface (α case)
surface zone enriched mainly by oxygen or less often by nitrogen or carbon, in which the α phase is stabilized

NOTE The α case results from elevated temperature exposure to environments containing these elements. α case is hard, brittle and considered detrimental.

1) Available from www.sae.org.

3.2 bar
wrought material of uniformly round, half round, square, rectangular, hexagonal, octagonal or regular polygonal solid section supplied in straight lengths

3.3 batch
material from the same ingot, manufactured by the same process, of the same nominal dimensions and, if heat treated, heat treated together

NOTE Where applicable, batch sizes for specific products are given in the relevant sections of this standard.

3.4 coil
length of a product wound into a cylindrical or annular form, without joint or seam

3.5 design authority
organization responsible for the detailed design of matériel and which has the responsibility of certifying designs and/or sealing drawings and specifications

3.6 edge straightness
deviation from straightness of the edge of a sheet, strip or plate when laid flat

3.7 extruded length
length produced from one cast extrusion ingot using a single or multihole die

3.8 extruded section
length of extruded material other than bar, wire or tube

3.9 forging
shape produced by hammering or pressing between open or closed dies, usually when hot

3.10 forging stock
wrought or cast material intended for the production of forgings

3.11 harmful defect
any defect prejudicial to the suitable and proper use of the material

3.12 hot work reduction ratio
ratio of ingot cross-section to product cross-section after hot working

3.13 ingot
product of one furnace charge

NOTE In this British Standard the terms ingot and cast are synonymous.

3.14 inspection schedule
details of inspection and test requirements specified by the purchaser

3.15 inspection stamp
unique stamp of the person approved by the manufacturer to carry out final inspection

3.16 lateral curvature
deviation from straightness of a plate, sheet or strip edge when the product is laid flat on a table with a calibrated surface

3.17 limiting ruling section
ruling section in which the specified properties can be guaranteed in the titanium alloy concerned by the specified heat treatment

NOTE Unless otherwise stipulated, it is a maximum.

3.18 manufacturer
organization that produces the material in the form and condition in which it is supplied to the purchaser

3.19 overheating
heating to a high temperature which results in a deleterious effect on the final properties and structure of the material

3.20 plate
rolled product of rectangular section and of uniform thickness over 6.0 mm supplied in flat form with sheared or sawn edges

3.21 pre-production forgings
forgings produced to a particular design to qualify the method of manufacture and equipment configuration and to demonstrate that the requirements of the purchaser can be met

3.22 procedure X
process control procedure for forgings in which test samples are machined from specified locations in forgings and tested to demonstrate that the forgings continue to conform to specified requirements

NOTE 1 The forgings from which the samples are taken are destroyed.

NOTE 2 This procedure is used in conjunction with procedures A, B or C.

3.23 purchaser
organization which orders and purchases the product

3.24 quality assurance authority
body responsible for authorizing the manufacturer or supplier to issue certification, when to certify means to attest as meeting a standard

3.25 ruling section
cross-sectional dimensions, at the time of heat treatment, of the product at the location which is most important from the point of view of mechanical properties

NOTE The ruling section is expressed as the diameter of the equivalent round bar.

3.26 seamless tube
tube in which there is no deliberate longitudinal bonding of two or more edges by pressure, fusion or mechanical means

3.27 section
extruded, rolled or formed product of uniform solid or hollow cross-section other than bar, wire, tube, sheet, strip or plate, generally supplied in straight lengths

3.28 sheet
flat rolled product of rectangular section and of uniform thickness from 0.2 mm up to and including 6.0 mm, supplied in straight lengths with slit, sawn or sheared edges

3.29 strip
flat rolled product of rectangular section and of uniform thickness from 0.2 mm up to and including 6.0 mm, supplied in coil form with slit edges

3.30 supplier
organization which has not necessarily made the product, but which supplies it to the purchaser

3.31 tube
extruded and/or drawn hollow product of uniform wall thickness, generally supplied in straight lengths

3.32 wire
solid product of round, square or regular polygonal section not more than 10 mm in diameter or width across flats, produced by drawing and usually supplied in coil form

4 General

This standard details the basic requirements for the inspection and testing of British Standard Aerospace TA series *wrought titanium and titanium alloys*.

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 purchaser and the manufacturer 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 [2] can be made and verified.

a) General:

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

2) if required, the minimum hot work reduction ratio (see **6.1.6**);

3) material condition if other than that specified by the material specification (see **6.1.7**);

4) if material is not to be descaled and etched or machined and etched prior to inspection (see **7.1**);

5) if required, the sequence and methods of descaling and cleaning (see **7.3**);

6) if heat treatment is to be carried out in other than in accordance with the material specification (see **8.1**);

7) the location and size of the sample for hydrogen determination if other than in accordance with BS EN 2003-010 (see **9.4**);

8) if required, the type of characters used and the nature and colour of any marking ink or similar medium (see **11.4**);

9) if a coating of corrosion preventative is not required (see **12.1**).

b) Forging stock:

1) ruling sections of the forging and test sample [see **23.2**c)].

c) Forgings:

1) the dimensional tolerances if other than those given in the material specification (see **30.2.1**);

2) any dimensions which require checking on each forging (see **30.2.2**);

3) where procedure X is invoked, the position, size and number of test pieces to be machined from each forging, the properties required and the frequency of testing (see **31.1** and **31.2** and Table 2);

4) for forgings subject to heat treatment after delivery and tested in accordance with procedure A, the number of the test samples required with each delivery (see **32.3**);

5) if a sampling procedure other than procedure A is to be used for batch acceptance tensile tests (see **33.1.1**);

6) for forgings tested in accordance with procedure C, the number, location, form and size of the test samples (see **33.2.2.1**);

[2] Marking a British Standard identifier (e.g. BS 3TA 1:2009) 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.

7) if, in the case of procedure C, separation of the test samples from the forgings before heat treatment is permitted (see **33.2.2.2**);

8) the location of the test samples to be machined from forgings in accordance with procedure D (see **33.2.3.2**);

9) the mechanical properties required from forgings tested in accordance with procedure C or procedure D, if other than in accordance with the material specification, or forgings tested in accordance with procedure X (see **33.4, 33.5** and **33.6**);

10) if grain flow examination and grain size measurement are required (see **35.1**); if so, the type of examination, and the sampling procedure as specified under procedure X (see **35.1**) and the required characteristics (see **35.2**);

11) the location and method of marking if not given in the material specification, and if other than at the discretion of the manufacturer (see **37.2**).

d) Wire:

1) required colour marking for bundles or coils if not specified in the material specification (see **72.2**).

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) the method of melting if other than multiple melted (see **6.1.1**);

b) acceptance standards for overheating for the various materials (see **6.1.5**);

c) the method of temperature control if other than AMS 2750 (see **8.2**);

d) the stage and frequency of hydrogen determination if other than after all manufacturing processes have been completed (see **9.4**);

e) if elements not listed in the material specification may be added (see **9.5**);

f) tolerances on descaled and pickled round, square and rectangular bar (see **16.3**);

g) tolerances on sections (see **16.4**);

h) dimensional tolerances of forging stock (see Clause **22**);

i) test sample preparation method (see **23.2**);

j) the number of forgings to be examined for overheating if other than each forging (see **36.1**);

[3)] Marking a British Standard identifier (e.g. BS 3TA 1:2009) 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.

k) details of the method of examination and, where necessary, the location of test samples (see **36.2**);

l) dimensional tolerances for material whose dimensions are outside those given in Table 5 or where special tolerances are required (see **39.1.2**);

m) if required, a standard of flatness for sheet and strip (see **39.5**);

n) direction of longitudinal axis of the test pieces cut from sheet over 200 mm wide if other than at right angles to the direction of final rolling (see **41.1.2** and **42.1.2**);

o) if required, a standard of flatness for plate (see **47.5**);

p) if internal examination of tubes is required (see Clause **61**);

q) dimensional tolerances for wire other than round wire (see **66.2**).

6 Manufacture and freedom from defects

6.1 Manufacture

6.1.1 Unless otherwise agreed between the manufacturer and the purchaser [see **5.2**a)], material shall be multiple melted. Melting cycle(s) prior to the final melting cycle shall be made using vacuum consumable electrode, non-consumable electrode, electron beam cold hearth, or plasma arc cold hearth melting practice. The final melting cycle shall be made under vacuum using vacuum arc remelting (VAR) practice with no alloy additions permitted.

6.1.2 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be argon and/or helium at an absolute pressure not higher than 1 000 mm of mercury.

6.1.3 The electrode tip for nonconsumable electrode melting shall be water-cooled copper.

6.1.4 During the manufacture of material, all processing shall be controlled so as to avoid overheating and to ensure adequate working at all stages.

6.1.5 Acceptance standards for overheating for the various materials shall be agreed between the manufacturer and the purchaser [see **5.2**b)].

6.1.6 If required by the purchaser, the minimum hot work reduction ratio shall be stated on the drawing, order or inspection schedule [see **5.1**a2)].

6.1.7 Unless otherwise specified by the purchaser, material shall be delivered in the condition specified in the material specification [see **5.1**a3)].

6.2 Freedom from defects

6.2.1 The material shall be free from harmful defects.

6.2.2 Notwithstanding prior acceptance of a material as conforming to this standard, any defect in the material which is found at a later stage, and which is likely to be detrimental to subsequent use, shall be a cause for rejection.

6.3 Local dressing

6.3.1 Surface defects on material in the delivery condition shall be removed by local dressing provided that such removal does not reduce the dimensions to below the minimum permitted. Dressed areas shall be blended smoothly into the surrounding material and the bottom radius of a dressed area shall be not less than three times the depth of the defect. Care shall be taken to avoid grinding abuse.

6.3.2 On completion of local dressing, the dressed areas shall be re-inspected using the same method as that which revealed the original defect.

7 Preparation for inspection

7.1 Unless otherwise stated on the drawing, order or inspection schedule [see **5.1**a4)], all wrought products shall be either descaled and etched or machined all over and etched to enable them to be inspected.

7.2 Sufficient material shall be removed to ensure freedom from any contaminated layer.

7.3 Unless otherwise stated on the drawing, order or inspection schedule [see **5.1**a5)], the sequence and methods of descaling and cleaning shall be at the option of the manufacturer.

8 Heat treatment

8.1 Heat treatment shall be carried out in accordance with the material specification or order [see **5.1**a6)].

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

8.3 If a specific temperature (value and tolerance) is given in the material specification, 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.

8.4 The total volume of the charge shall be maintained at the selected temperature subject to the following furnace tolerances, for the period stated in the material specification.

- Solution treatment: ±15 °C
- Annealing: ±15 °C
- Stress relieving: ±15 °C
- Precipitation treatment: ±10 °C

8.5 If no period or temperature is given in the material specification for a particular heat treatment, these and their tolerances shall be at the discretion of the manufacturer.

9 Chemical composition

9.1 The chemical composition shall conform to the material specification.

9.2 The chemical composition of each cast shall be determined. The samples selected for analysis shall be representative of the cast and, except as provided in **9.3**, shall be taken from the final remelted ingot.

9.3 The samples shall be chemically analysed for each of the specified elements except hydrogen. The method of analysis shall be at the discretion of the manufacturer. In case of dispute, the method of chemical analysis to be used shall be agreed between the purchaser and the manufacturer.

9.4 Unless otherwise agreed between the manufacturer and the purchaser [see **5.2**d)], the analysis for hydrogen shall be made on samples selected, after all manufacturing processes, including hot working, heat treatment and pickling, have been completed by the manufacturer, as follows.

a) Forgings: one sample taken from a forging in each batch.

b) Other wrought products: one sample from each batch.

Unless otherwise specified by the purchaser [see **5.1**a7)], the location and size of the sample shall be in accordance with BS EN 2003-010.

The hydrogen content shall be determined in accordance with BS EN 3976.

9.5 Elements not listed in the material specification shall not be added without the agreement of the purchaser [see **5.2**e)].

9.6 Overall control of the chemical composition, the use of scrap, and the method of analytical control shall be such that the chemical composition of the final product conforms to the material specification.

9.7 If in the course of routine analysis the presence of elements other than those named in the material specification is detected, the amounts of these other elements and/or their total shall not exceed the limits given in the material specification.

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

10 Testing

10.1 General

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

a) the material specification; or

b) the relevant section of this standard; or

c) the order or inspection schedule.

*NOTE See Clause **5**.*

10.1.2 The frequency of sampling shall be as given in the relevant section of this standard.

10.2 Selection and preparation of test samples

10.2.1 Test samples shall be selected and prepared in accordance with the relevant section of this standard, and shall be fully representative of the material in its delivery condition. Where test samples represent products in the final heat treatment condition specified in the material specification, they shall not be subjected to further heat treatment. Where test samples represent products to be delivered in a condition other than the condition of use, they shall be heat treated to the use condition in accordance with the material specification before testing.

10.2.2 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 and their orientation with respect to the product is clear.

10.2.3 Unless otherwise specified in the relevant section of this standard, test samples shall not be mechanically worked after removal from the products they represent.

10.3 Tensile test at ambient temperature

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

10.3.2 Unless otherwise specified in the relevant section of this standard, test pieces shall be to the dimensions of the largest practicable size of proportional round test piece specified in BS EN 2002-1.

10.3.3 The tensile test piece direction and location within the product shall be as specified in the relevant section of this standard.

10.4 Tensile test at elevated temperature

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

10.4.2 Unless otherwise specified in the relevant section of this standard, test pieces shall be to the dimensions of the largest practicable size of proportional round test piece specified in BS EN 2002-2.

10.4.3 The tensile test piece direction and location within the product shall be as specified in the relevant section of this standard.

10.5 Creep and stress-rupture test

10.5.1 Creep and stress-rupture testing shall be carried out in accordance with BS EN 2002-005.

10.5.2 Unless otherwise specified in the relevant section of this standard, test pieces shall be to the dimensions of the largest practicable size of proportional round test piece specified in BS EN 2002-005.

10.5.3 The creep and stress-rupture test piece direction and location within the product shall be as specified in the relevant section of this standard.

10.6 Surface contamination

10.6.1 Determination of surface contamination shall be carried out in accordance with BS EN 2003-009:2007, Method A.

10.6.2 Determination shall be carried out on one sample from each batch in the delivery condition.

10.7 Other tests

For those tests specific to a particular product form, the test procedure shall be as specified in the relevant section of this standard or material specification.

10.8 Retesting procedures

10.8.1 Mechanical testing

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, additional test samples shall be selected at twice the original sampling frequency, at least one of which shall be from the product or products on which the original results were obtained. If all retest results are satisfactory, the batch shall be accepted. If one or more retest results are unsatisfactory, the batch shall be:

a) rejected; or

b) every product tested, and the products conforming to the relevant requirement accepted; or

c) for heat treatable materials, reheat treated and tested as a new batch.

10.8.2 Other tests

For those tests specific to a particular product form, the retest procedure shall be as specified in the relevant section of this standard or the material specification.

10.9 Application of values

For the purpose of determining conformity to the limits specified in the material specification, excluding dimensions, an observed or a calculated value obtained from a test shall be rounded in accordance with Annex A.

11 Marking

11.1 Products shall be marked in accordance with the relevant section of this standard.

11.2 The material shall be kept identifiable as to its ingot (cast) and, if appropriate, its heat treatment test batch to enable final identification marking to be made.

11.3 In the case of products for which continuous or overall marking is specified, the direction of marking shall be parallel to the direction of final rolling, extrusion or drawing.

11.4 Unless specified on the order or inspection schedule, the type of characters used and the nature and colour of any marking ink or similar medium shall be at the discretion of the manufacturer [see **5.1**a8)].

11.5 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 The product shall be protected and/or packaged to prevent damage or corrosion during transport. Unless otherwise specified on the order, material shall be protected by an effective coating of corrosion preventative [see **5.1**a9)].

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 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.

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 [4)].

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

g) Quantity supplied.

[4)] Marking a British Standard identifier (e.g. BS 3TA 1:2009) 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.

h) Cast number(s) and batch number(s) or unique identification, including the ingot and the position within the ingot, where applicable.

i) Condition of the material as delivered.

j) Heat treatment details, including details of test sample heat treatment where appropriate.

k) Detail 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 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 hereon have been inspected and tested and, unless otherwise stated above, conform in all respects to the requirements of the contract and/or order."

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 **13.1**, as provided by the manufacturer, shall be supplied with each delivery.

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

Section 2: Bar and section for machining

14 General

This section covers the inspection and testing procedures for bar and section for machining and shall be used in conjunction with Section **1**.

15 Manufacture

Bar and section shall be manufactured from ingot conforming to Section **1**.

16 Dimensions and tolerances

16.1 The dimensions of the product shall be measured and shall fall within the tolerances given in Table 1. The frequency of measurement shall be at the discretion of the manufacturer.

Table 1 **Tolerances for bar and section**
Dimensions in millimetres

Nominal diameter (d)	Tolerance	
	Plus	Minus
$d \leqslant 15$	0.08	0.00
$15 < d \leqslant 25$	0.10	0.00
$25 < d \leqslant 40$	0.15	0.00
$40 < d \leqslant 60$	0.20	0.00
$60 < d \leqslant 100$	1% of d	0.00
$d > 100$	3% of d	0.00

In no portion of any bar shall the departure from straightness exceed 1 mm on any given length of 250 mm.

16.2 Tolerances on machined square and rectangular bar shall be:

- the width and thickness shall not vary from the nominal dimensions by more than +1.5 mm, –0.00 mm;
- in no portion of any bar shall the departure from straightness exceed 1 mm on any given length of 250 mm;
- the corner radii shall not exceed 1.0 mm.

16.3 Tolerances on descaled and pickled round, square and rectangular bar shall be agreed between the manufacturer and the purchaser [see **5.2**f)] and shall be stated on the drawing, order or inspection schedule.

16.4 Tolerances on sections shall be as agreed between the manufacturer and the purchaser [see **5.2**g)] and shall be stated on the drawing, order or inspection schedule.

17 Tensile, creep and stress-rupture tests

17.1 Sampling

One test sample shall be selected from each batch.

17.2 Test piece preparation

17.2.1 Except as provided in **17.2.2**, for bars and sections up to and including 30 mm diameter or minor sectional dimension, the test piece shall be machined coaxially from the test sample.

17.2.2 Bar and section not exceeding 10 mm diameter or major sectional dimension shall be tested in full section or, at the option of the manufacturer, on machined test pieces. For material tested in full section, the elongation shall be measured on a gauge length equal to five times the original diameter of the test piece or, for material of other than circular section, on a gauge length of 50 mm.

17.2.3 For bar and section over 30 mm and up to and including 75 mm diameter or minor sectional dimension, the longitudinal axis of the test piece shall be not less than 15 mm from the surface of the test sample.

17.2.4 For bar and section over 75 mm or minor sectional dimension, the test piece shall be prepared in accordance with **17.2.3** or, at the option of the manufacturer, shall be taken in the transverse direction.

17.3 Tensile testing at ambient temperature

Each test piece, prepared in accordance with **17.2**, shall be tested in accordance with **10.3** and the tensile properties shall conform to the material specification.

17.4 Tensile testing at elevated temperature

Each test piece, prepared in accordance with **17.2**, shall be tested in accordance with **10.4** and the tensile properties shall conform to the material specification.

17.5 Creep and stress-rupture testing

Each test piece, prepared in accordance with **17.2**, shall be tested in accordance with **10.5** and the creep and stress-rupture properties shall conform to the material specification.

18 External defects

Each product shall be visually examined and shall be free from harmful defects.

19 Surface contamination

19.1 Determination of surface contamination shall be carried out in accordance with **10.6**. The sample shall be free from any α stabilized surface (α case).

19.2 Determination is not required if the material is machined all over to depth of not less than 6 mm.

20 Marking

20.1 Products with a diameter or major sectional dimension $\geqslant$ 20 mm shall bear the following identification marking:

a) continuous marking in ink or similar medium, repeated at least every 0.5 m, giving the following information:
   1) number of the material specification [5)];
   2) delivery condition;
   3) manufacturer's identification and site identification;

b) end marking by hard stamping at one end of the product, giving the following information:
   1) batch number;
   2) inspection stamp.

20.2 Products with a diameter or major sectional dimension < 20 mm shall be wired together in bundles. Each bundle shall have attached a durable label indelibly marked with the information required by **20.1**.

[5)] Marking a British Standard identifier (e.g. BS 3TA 1:2009) 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 3: Forging stock

21 General

This section covers the inspection and testing procedures for forging stock and shall be used in conjunction with Section **1**.

22 Dimensions and tolerances

The dimensions of the product shall be measured and shall fall within the tolerances agreed between the manufacturer and the purchaser [see **5.2**h)] and shall be stated on the drawing, order or inspection schedule. The frequency of measurement shall be at the discretion of the manufacturer.

23 Tensile, creep and stress-rupture tests

23.1 Sampling

One test sample shall be selected from each batch.

23.2 Test sample preparation

Test samples shall be prepared in accordance with a), b) or c), as agreed between the manufacturer and purchaser [see **5.2**i)] and shall be heat treated.

a) A transverse slice not greater than 50 mm thick shall be upset in a direction at right angles to that of the previous working and drawn out in a diametral direction to a flat slab approximately 12.5 mm thick.

b) A transverse slice approximately 12.5 mm thick or a longitudinal sample shall be machined from the forging stock.

c) The test sample shall have a ruling section not less than that of the eventual forging at the time of heat treatment. The ruling sections of the forging and test sample shall be stated on the order [see **5.1**b1)].

NOTE *If the sample is of a larger section than the ruling section of the forging, it may be forged or machined to that ruling section before heat treatment.*

23.3 Test piece preparation

Test pieces shall be prepared from the test samples in accordance with **10.3.2**, **10.4.2** or **10.5.2**.

23.4 Tensile testing at ambient temperature

Each test piece, prepared in accordance with **23.3**, shall be tested in accordance with **10.3** and the tensile properties shall conform to the material specification.

23.5 Tensile testing at elevated temperature

Each test piece, prepared in accordance with **23.3**, shall be tested in accordance with **10.4** and the tensile properties shall conform to the material specification.

23.6 Creep and stress-rupture testing

Each test piece, prepared in accordance with **23.3**, shall be tested in accordance with **10.5** and the creep and stress-rupture properties shall conform to the material specification.

24 External defects

Each product shall be visually examined and shall be free from harmful defects.

25 Surface contamination

Determination of surface contamination shall be carried out in accordance with **10.6**. The sample shall be free from any α stabilized surface (α case).

26 Marking

26.1 Products with a diameter or major sectional dimension $\geqslant$ 20 mm shall bear the following identification marking:

a) continuous marking in ink or similar medium, repeated at least every 0.5 m, giving the following information:
   1) number of the material specification [6)];
   2) delivery condition;
   3) manufacturer's identification and site identification;

b) end marking by hard stamping at one end of the product, giving the following information:
   1) batch number;
   2) inspection stamp.

26.2 Products with a diameter or major sectional dimension < 20 mm shall be wired together in bundles. Each bundle shall have attached a durable label indelibly marked with the information required by **26.1**.

[6)] Marking a British Standard identifier (e.g. BS 3TA 1:2009) 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 4: Forgings

27 General

27.1 This section covers the inspection and testing procedures for forgings and shall be used in conjunction with Section **1**.

27.2 This section shall also apply to pre-production forgings intended for qualification of the method of manufacture, and inspection and testing.

28 Manufacture

28.1 Forgings shall be manufactured from forging stock conforming to Section **3**.

28.2 The method of manufacture of production forgings shall be the same as the method of manufacture of the pre-production forgings, except by agreement between the manufacturer and the purchaser and following written approval by the design authority including any requirement for re-qualification of the forgings.

29 Pre-production forgings

29.1 General

29.1.1 The following information to be supplied by the purchaser shall be fully documented on the order, drawing or inspection schedule:

a) the number of forgings to be selected from initial production for evaluation;

b) the location, size and form of any test pieces to be cut from the forgings and the test properties required at each location;

c) any other test requirements such as grain flow, macrostructure, microstructure, surface contamination;

d) the condition of the forgings on which the tests are to be carried out together with any requirements for machining prior to heat treatment;

e) those areas of the forgings which are critical and for which special finishing prior to inspection is required together with the standard of such finish;

f) whether an agreed method of manufacture is required.

If procedure X is required (see Clause **31**), this shall be documented and the location of the required test pieces shall be shown.

29.1.2 The inspection and testing of pre-production forgings shall be carried out, and the inspection and test conditions shall be recorded, to allow the definition of the optimum techniques to be used for production forgings.

29.1.3 The inspection and tests carried out on pre-production forgings shall include those which will be carried out on production forgings (see Clause **30**).

29.2 Inspection and testing report

In addition to any information required by Section **1**, the inspection and testing report on the pre-production forgings shall include all the technical information that has been obtained on these forgings, e.g. photographs taken during macroscopic and microscopic examination, results of dimensional measurements.

29.3 Acceptance of pre-production forgings

When all inspection and test results relating to pre-production forgings have been reported, and accepted as satisfactory by the purchaser, written agreement for series production shall be obtained from the design authority.

30 Production forgings

30.1 General

Inspection and testing carried out on production forgings shall be under the same conditions as those applied to the pre-production forgings (see **29.1.2** and **29.1.3**).

30.2 Dimensions and tolerances

30.2.1 The dimensions of the product shall be measured and shall fall within the tolerances given in the material specification, order or inspection schedule [see **5.1**c1)].

30.2.2 Designated dimensions, as indicated on the drawing or inspection schedule, shall be measured on each forging [see **5.1**c2)]. For other dimensions the frequency of measurement shall be at the discretion of the manufacturer.

31 Procedure X for process control testing

*NOTE Procedure X is a process control procedure used to ensure that forgings continue to conform to specified requirements (see **3.22**).*

31.1 Where procedure X is invoked, the testing requirements, including the position, size and number of test pieces to be machined from the forging and, where applicable, the properties required, shall be as stated on the order, drawing or inspection schedule [see **5.1**c3)].

31.2 Forgings selected for test in accordance with procedure X shall be to the frequency stated in the order, drawing or inspection schedule, but the number of forgings manufactured between the selection of the test samples shall not be more than that specified in Table 2 [see **5.1**c3)].

Table 2 **Maximum number of forgings to be manufactured between the collection of test samples**

Mass of forging kg		Number of forgings
Over	**Up to and including**	
—	5	600
5	10	300
10	50	150
50	—	As given on the order, drawing or inspection schedule

NOTE The number of test samples selected for grain flow examination may be less than that selected from the pre-production forgings as indicated by the drawing or inspection schedule.

32 Forgings subject to heat treatment after delivery

32.1 It shall be demonstrated that the forging stock has the capability to conform to the mechanical property requirements given in the material specification.

32.2 Each delivery of forgings, subject to solution treatment and/or ageing after delivery, shall be accompanied by representative test samples that reflect the heat treatment condition of the forgings as delivered.

NOTE Where forgings are supplied in the annealed condition, test samples in the "as forged" condition may be supplied.

32.3 For forgings tested in accordance with procedure A (see **33.1.1**) the number of test samples supplied with each delivery shall be as stated on the order [see **5.1**c4)]. If it is subsequently found that insufficient test samples from the same cast are available for heat treatment control purposes, the purchaser shall, with the agreement of the design authority, use control samples of material conforming to the same material specification.

32.4 For forgings tested in accordance with procedure C (see **33.1.1**), one integral test sample shall be removed from one forging from each cast.

33 Batch acceptance tensile, creep and stress-rupture tests

33.1 Sampling

33.1.1 The sampling procedure shall be one of the following as specified on the order [see **5.1**c5)]. It shall be permissible for procedure D to be used instead of procedure A provided that approval has been obtained from the quality assurance authority, and that it is stated on the certificate. Where no procedure is specified, procedure A shall be used.

a) Procedure A. Separate test samples shall be prepared from the same cast of forgings stock.

b) Procedure C. Integrally forged test samples shall be prepared.

c) Procedure D. Test samples shall be machined from selected locations on the forgings.

NOTE The forging is destroyed if Procedure D is used.

33.1.2 When separate or integrally forged test samples are used, it shall be permissible for them to be employed alone (procedure A or procedure C), or with additional test samples cut from the forgings in accordance with procedure X (procedure AX or procedure CX).

33.1.3 Procedure D shall only be used for forgings supplied in the fully heat treated condition.

33.1.4 Process control testing shall be employed when procedure AX or CX is specified on the order.

33.2 Test sample preparation

33.2.1 Procedure A: Separate test samples prepared from the same cast of forging stock

33.2.1.1 Representative test samples shall be taken from forging stock of the same form, dimensions and ingot as that used to make the forgings.

33.2.1.2 Test samples shall be prepared in accordance with a), b) or c):

a) machined from the full section of the forging stock from which they were taken;

b) forged or machined to the ruling section of the forging;

c) in the case of material to be used in the annealed condition, after forging to a nominal 30 mm diameter.

33.2.1.3 The heat treatment control test samples and the forgings they represent shall be heat treated together in accordance with the material specification and shall not be further heat treated or mechanically worked before being tested. Each batch of forgings heat treated shall be represented by at least one control sample.

33.2.2 Procedure C: Integrally forged test samples

33.2.2.1 One or more mechanical test samples shall be forged integrally with each forging. The number, location, form and size of the test samples shall be as stated on the order, drawing or inspection schedule [see **5.1**c6)].

33.2.2.2 In the case of forgings to be subjected to heat treatment, test samples shall not be separated from the forgings before heat treatment unless stated on the order, drawing or inspection schedule that this is permitted [see **5.1**c7)].

33.2.2.3 At least one integral test sample shall be used to represent each batch of heat treated forgings for mechanical test purposes.

33.2.2.4 The heat treatment control test samples and the forgings they represent shall be heat treated together in accordance with the material specification and shall not be further heat treated or mechanically worked before being tested.

33.2.3 Procedure D: Test samples machined from selected locations on the forgings

33.2.3.1 The forgings shall be heat treated in accordance with the material specification. One forging shall be selected for testing from each batch of forgings of the same pattern, made from the same cast and that have been heat treated together.

33.2.3.2 The location of the test samples shall be as stated on the drawing or inspection schedule [see **5.1**c8)], with a minimum of one longitudinal and, where appropriate, one transverse sample.

33.3 Test piece preparation

33.3.1 Except as provided in **33.3.2**, for forgings up to and including 30 mm diameter or minor sectional dimension, the test piece shall be machined coaxially from the test sample.

33.3.2 Forgings not exceeding 10 mm diameter or major sectional dimension shall be tested in full section or, at the option of the manufacturer, on machined test pieces. For material tested in full section, the elongation shall be measured on a gauge length equal to five times the original diameter of the test piece or, for material of other than circular section, on a gauge length of 50 mm.

33.3.3 For forgings over 30 mm and up to and including 75 mm diameter or minor sectional dimension, the longitudinal axis of the test piece shall be not less than 15 mm from the surface of the test sample.

33.3.4 For forgings over 75 mm or minor sectional dimension, the test piece shall be prepared in accordance with **33.3.3** or, at the option of the manufacturer, shall be taken in the transverse direction.

33.4 Tensile testing at ambient temperature

Each test piece, prepared in accordance with **33.3**, shall be tested in accordance with **10.3** and the tensile properties shall be in accordance with Table 3 [see **5.1**c9)].

33.5 Tensile testing at elevated temperature

Each test piece, prepared in accordance with **33.3**, shall be tested in accordance with **10.4** and the tensile properties shall be in accordance with Table 3 [see **5.1**c9)].

33.6 Creep and stress-rupture testing

Each test piece, prepared in accordance with **33.3**, shall be tested in accordance with **10.5** and the creep and stress-rupture properties shall be in accordance with Table 3 [see **5.1**c9)].

Table 3 **Tensile property requirements for forgings**

Procedure	Requirements
A	As specified in the material specification
C D	As specified in the material specification or as stated on the drawing or inspection schedule
X	As stated on the drawing or inspection schedule

34 External defects

Each forging shall be visually examined and shall be free from harmful defects.

35 Grain flow and grain size

35.1 If grain flow examination and grain size measurement are specified on the order or inspection schedule [see **5.1**c10)], macrographic and micrographic examination shall be carried out.

The type of examination shall be as specified on the order or inspection schedule and the sampling frequency shall be as specified on the order or inspection schedule under procedure X [see **5.1**c10)].

35.2 The grain flow and the grain size shall be the same as those obtained on the pre-production forgings and shall conform to the order or inspection schedule [see **5.1**c10)].

36 Examination for overheating

36.1 Each forging or, if agreed between the manufacturer and the purchaser [see **5.2**j)], not less than one forging from each batch, shall be examined in the heat treatment condition required by the material specification for the detection of overheating.

36.2 Details of the method of examination and, where necessary, the location of test samples shall be agreed between the manufacturer and the purchaser [see **5.2**k)], and shall be stated on the drawing, order or inspection schedule.

36.3 The forgings shall show no evidence of overheating.

36.4 If all the forgings in a batch have not been examined and any sample forging fails to conform to the requirement of **36.3**, all the remaining forgings in the batch shall be examined.

37 Marking

37.1 Forgings shall bear the following identification marking:

a) number of the material specification [7)];

b) part number or drawing number and, where required, serial number;

c) delivery condition;

d) manufacturer's identification;

e) batch number;

f) inspection stamp.

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7) Marking a British Standard identifier (e.g. BS 3TA 1:2009) 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.

37.2 Forgings with a large enough surface area to accommodate the markings specified in **37.1** shall be individually marked. The location and method of marking shall be as specified in the material specification or order [see **5.1**c11)]. If not specified in the material specification or order, the location and method of marking shall be at the discretion of the manufacturer.

37.3 Forgings with too small a surface area to accommodate the marking specified in **37.1** shall be packed in bags or bundles each of which shall have attached a durable label indelibly marked with the information required by **37.1**.

Section 5: Sheet and strip

38 General

This section covers the inspection and testing procedures for sheet and strip and shall be used in conjunction with Section **1**.

39 Dimensions and tolerances

39.1 General

39.1.1 The dimensions of the product shall be measured and, except as specified in **39.1.2**, shall conform to the appropriate requirements in **39.2** to **39.5**.

39.1.2 For material whose nominal dimensions are outside those given in the tables, or where special tolerances are required, the appropriate tolerances shall be agreed between the manufacturer and the purchaser [see **5.2**l)] and stated on the drawing, order or inspection schedule.

39.1.3 Where unilateral tolerances are specified on the order, the total permissible variation in the appropriate dimension shall be the sum of the plus and minus tolerances specified in the table.

39.2 Thickness

The thickness of sheet and strip shall conform to Table 4.

Table 4 **Tolerances on thickness of sheet and strip**
Dimensions in millimetres

Material	**Sheet finished by cold rolling**				**Sheet finished by hot rolling** [A)]	**Strip in coil**
Width (w)	**w ⩽ 600**		**600 < w ⩽ 1000**		**w ⩽ 1 000**	**w ⩽ 600**
Nominal thickness (a)	**Tolerances on thickness**					
	plus	minus	plus	minus	±	±
0.2 < a ⩽ 0.4	0.03	0.05	0.05	0.08	0.05	0.05
0.4 < a ⩽ 0.6	0.05	0.08	0.08	0.08	0.08	0.05
0.6 < a ⩽ 0.8	0.05	0.08	0.08	0.08	0.08	0.08
0.8 < a ⩽ 1.0	0.08	0.08	0.08	0.08	0.10	0.08
1.0 < a ⩽ 1.2	0.08	0.08	0.08	0.10	0.10	0.08
1.2 < a ⩽ 1.6	0.08	0.10	0.10	0.10	0.15	0.13
1.6 < a ⩽ 2.0	0.08	0.10	0.10	0.10	0.18	0.15
2.0 < a ⩽ 3.0	0.10	0.13	0.15	0.15	0.23	
3.0 < a ⩽ 4.0	0.13	0.13	0.18	0.18	0.35	
4.0 < a ⩽ 5.0	0.18	0.18	0.23	0.23	0.45	

[A)] and strip cut from sheet

39.3 Width and length

The width and length of sheet and strip shall conform to Table 5.

Table 5 **Shearing tolerances for sheet and strip**
Dimensions in millimetres

Material	**Sheet and strip cut from sheet**				**Strip in coil**
Width (w) or length (l)	**w or l ⩽ 600**	**600 < w or l ⩽ 1 200**	**1 200 < w or l ⩽ 2 400**	**2 400 ⩽ w or l ⩽ 3 600**	**w ⩽ 600**
Nominal thickness (a)	**Tolerances on width and length**				**Tolerances on width**
	±	±	±	±	±
a < 1	1.5	2.5	4.0	5.0	1.0
1 ⩽ a ⩽ 2	2.5	3.0	5.0	6.5	1.0
2 < a ⩽ 4	2.5	3.0	5.0	6.5	
4 < a ⩽ 5	3.0	4.0	6.5	8.0	

39.4 Edge straightness

No part of the edge of any sheet or coil of strip, when laid out flat, shall be distant from a 1 000 mm chord by more than 4.0 mm. If an edge is shorter than 1 000 mm, the distance shall be proportionate.

39.5 Flatness

If required, a standard of flatness for sheet and strip shall be agreed between the manufacturer and the purchaser [see **5.2**m)] and shall be stated on the drawing, order or inspection schedule.

40 Batch size

Sheets and strips shall be grouped in batches of not more than 25 sheets and of not more than 250 kg.

41 Tensile, creep and stress-rupture tests

41.1 Sampling

41.1.1 One test sample shall be selected from each batch.

41.1.2 Unless otherwise agreed between the manufacturer and the purchaser [see **5.2**n)], the test samples from material over 200 mm wide shall be cut so that the longitudinal axis of the test piece is in a direction at right angles to the direction of final rolling.

41.1.3 The test samples from material 200 mm wide and under shall be cut so that the longitudinal axis of the test piece is in a direction parallel to the direction of final rolling.

41.1.4 The position of the test sample axis within the sheet or strip shall be as detailed in Table 6.

Table 6 **Position of the test sample axis within the sheet or strip**

Orientation and test piece axis relative to rolling direction	Relative to thickness	Relative to width (*b*)
Longitudinal Long transverse	Full thickness	*b*/3

41.2 Test piece preparation

Flat tensile test piece dimensions shall be in accordance with BS EN 2002-1 for ambient temperature tensile testing, BS EN 2002-2 for elevated temperature tensile testing and BS EN 2002-005 for uninterrupted creep and stress-rupture testing.

41.3 Tensile testing at ambient temperature

41.3.1 Each test piece, prepared in accordance with **41.2**, shall be tested in accordance with **10.3** and the tensile properties shall conform to the material specification.

41.3.2 The proof stress and elongation shall be determined only on material having a nominal thickness of 0.5 mm and greater.

41.4 Tensile testing at elevated temperature

41.4.1 Each test piece, prepared in accordance with **41.2**, shall be tested in accordance with **10.4** and the tensile properties shall conform to the material specification.

41.4.2 The proof stress and elongation shall be determined only on material having a nominal thickness of 0.5 mm and greater.

41.5 Creep and stress-rupture testing

Each test piece, prepared in accordance with **41.2**, shall be tested in accordance with **10.5** and the creep and stress-rupture properties shall conform to the material specification.

42 Single bend test

42.1 Sampling

42.1.1 One test sample shall be selected from each batch.

42.1.2 Unless otherwise agreed between the manufacturer and the purchaser [see **5.2**n)], the test samples from material over 200 mm wide shall be cut so that the longitudinal axis of the test piece is in a direction at right angles to the direction of final rolling.

42.1.3 The test samples from material 200 mm wide and under shall be cut so that the longitudinal axis of the test piece is in a direction parallel to the direction of final rolling.

42.2 Single bend testing

42.2.1 The single bend test shall be carried out only on material having a nominal thickness of up to and including 3.0 mm.

42.2.2 Single bend testing shall be carried out in accordance with BS EN ISO 7438.

42.2.3 The bending factor (κ) and the angle of bend (α) shall be as specified in the material specification.

42.2.4 The test pieces shall not crack when bent once through the angle specified in the material specification.

42.2.5 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.

43 External defects

Each sheet and strip shall be visually examined and shall be free from harmful defects.

44 Surface contamination

Determination of surface contamination shall be carried out in accordance with **10.6**. The sample shall be free from any α stabilized surface (α case).

45 Marking

45.1 Sheet

Each sheet shall bear the following identification marking:

a) overall marking in ink or similar medium, giving the following information, all of which shall be visible on any separate piece 300 mm × 300 mm:
   1) number of the material specification [8];
   2) delivery condition;
   3) manufacturer's identification and site identification;

b) end marking in ink or by hard stamping on one face in one corner, giving the following information:
   1) batch number;
   2) inspection stamp.

45.2 Strip

Each coil of strip shall have attached a durable label indelibly marked with the information required by **45.1**.

[8] Marking a British Standard identifier (e.g. BS 3TA 1:2009) 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 6: Plate

46 General

This section covers the inspection and testing procedures for plate and shall be used in conjunction with Section **1**.

47 Dimensions and tolerances

47.1 General

The dimensions of the product shall be measured and shall conform to the appropriate requirements in **47.2** to **47.5**.

47.2 Thickness

The thickness of plate shall conform to Table 7.

Table 7 **Tolerances on thickness of plate**
Dimensions in millimetres

Nominal thickness (a)	Tolerances on thickness for widths $\leqslant$ 1 200 mm	
	plus	minus
$6.0 \leqslant a \leqslant 9.0$	1.2	0.25
$9.0 < a \leqslant 12.5$	1.3	0.25
$12.5 < a \leqslant 25.0$	1.5	0.25
$25.0 < a \leqslant 40.0$	2.0	0.25

47.3 Width and length

47.3.1 The width and length of plate shall conform to Table 8.

Table 8 **Tolerances on width and length of plate**
Dimensions in millimetres

Nominal thickness (a)	Tolerances on width and length for widths and lengths $\leqslant$ 3 000 mm	
	plus	minus
$6.0 < a \leqslant 12.5$	6.5	3.0
$12.5 < a \leqslant 25.0$	9.5	3.0
$25.0 < a \leqslant 40.0$	12.5	3.0

47.3.2 The tolerances specified in Table 8 shall apply when the appropriate dimension is measured at a temperature of 20 °C.

NOTE The effect of temperature on the length and/or width might be significant.

47.4 Edge straightness

No part of the edge of any plate shall be distant from a 1 000 mm chord by more than 4.0 mm. If an edge is shorter than 1 000 mm, the distance shall be proportionate.

47.5 Flatness

If required, a standard of flatness for plate shall be agreed between the manufacturer and the purchaser [see **5.2**o)] and shall be stated on the drawing, order or inspection schedule.

48 Batch size

Plates of the same nominal thickness shall be grouped in batches of not more than 500 kg. Where a plate exceeds 500 kg, it shall be regarded as a batch.

49 Tensile, creep and stress-rupture tests

49.1 Sampling

49.1.1 For plate up to and including 25 mm thick, sufficient material shall be selected to enable two test pieces to be machined as detailed.

a) Longitudinal: with the axis parallel to the direction of final rolling.

b) Transverse: with the axis at right angles to the direction of final rolling.

49.1.2 For plate thicker than 25 mm, sufficient material shall be selected to enable three test pieces to be machined as detailed.

a) Longitudinal: with the axis parallel to the direction of final rolling.

b) Transverse: with the axis at right angles to the direction of final rolling.

c) Short transverse: with the axis normal to the plate surface.

49.2 Test piece preparation

49.2.1 For plate of thickness of 8 mm and less, test pieces shall be to the dimensions of the largest practicable size of flat test piece specified in BS EN 2002-1 for ambient temperature tensile testing, BS EN 2002-2 for elevated temperature tensile testing and BS EN 2002-005 for uninterrupted creep and stress-rupture testing.

49.2.2 For plate of thickness over 8 mm, test pieces shall be to the dimensions of the largest practicable size of proportional round test piece specified in BS EN 2002-1 for ambient temperature tensile testing, BS EN 2002-2 for elevated temperature tensile testing and BS EN 2002-005 for uninterrupted creep and stress-rupture testing.

49.2.3 The position of the sample axis within the plate shall be as detailed in Table 9.

Table 9 **Position of the test sample axis within the plate**

Orientation and test piece axis relative to rolling direction	Relative to thickness (*a*)	Relative to width (*b*)
Longitudinal Long transverse	*a*/2	*b*/3
Short transverse	*a*/2 [A)]	

[A)] Mid-point of the gauge length.

49.3 Tensile testing at ambient temperature

Each test piece, prepared in accordance with **49.2**, shall be tested in accordance with **10.3** and the tensile properties shall conform to the material specification.

49.4 Tensile testing at elevated temperature

Each test piece, prepared in accordance with **49.2**, shall be tested in accordance with **10.4** and the tensile properties shall conform to the material specification.

49.5 Creep and stress-rupture testing

Each test piece, prepared in accordance with **49.2**, shall be tested in accordance with **10.5** and the creep and stress-rupture properties shall conform to the material specification.

50 External defects

Each plate shall be visually examined and shall be free from harmful defects.

51 Surface contamination

Determination of surface contamination shall be carried out in accordance with **10.6**. The sample shall be free from any α stabilized surface (α case).

52 Marking

Each plate shall bear the following identification marking:

a) overall marking, in ink or similar medium, giving the following information, all of which shall be visible on any separate piece 300 mm × 300 mm:

   1) number of material specification [9)];

   2) delivery condition;

[9)] Marking a British Standard identifier (e.g. BS 3TA 1:2009) 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.

3) manufacturer's identification and site identification;

4) thickness;

b) end marking in ink or similar medium or by hard stamping giving the following information:

1) on material less than 12 mm thick, on one face in a corner:

i) batch number or plate number;

ii) inspection stamp;

2) on material greater than 12 mm, on one edge:

i) plate number;

ii) inspection stamp;

c) material with a nominal thickness of 12 mm shall be end marked in accordance with **52**b1) or **52**b2).

Section 7: Tube

53 General

This section covers the inspection and testing procedures for tube and shall be used in conjunction with Section **1**.

54 Dimensions and tolerances

54.1 The dimensions of tube up to and including 25 mm nominal outside diameter shall conform to the following requirements.

a) Tolerance on nominal outside diameter including ovality: ±0.10 mm

b) Tolerance on nominal wall thickness: ±10%

54.2 The tube shall be free from kinks and the departure from straightness, in any selected straight length of 500 mm or more, shall not exceed one five-hundredth of the length measured.

55 Tensile, creep and stress-rupture tests

55.1 Sampling

One test sample shall be selected from each batch.

55.2 Test piece preparation

The test piece shall consist either of a length of tube or a longitudinal strip cut from the tube and having the full thickness of the wall of the tube, or of a test piece of circular cross-section machined from the wall of the tube.

Test piece dimensions shall be in accordance with BS EN 2002-1 for ambient temperature tensile testing, BS EN 2002-2 for elevated temperature tensile testing and BS EN 2002-005 for uninterrupted creep and stress-rupture testing.

55.3 Tensile testing at ambient temperature

Each test piece, prepared in accordance with **55.2**, shall be tested in accordance with **10.3** and the tensile properties shall conform to the material specification.

55.4 Tensile testing at elevated temperature

Each test piece, prepared in accordance with **55.2**, shall be tested in accordance with **10.4** and the tensile properties shall conform to the material specification.

55.5 Creep and stress-rupture testing

Each test piece, prepared in accordance with **55.2**, shall be tested in accordance with **10.5** and the creep and stress-rupture properties shall conform to the material specification.

56 Drifting test

56.1 Sampling

One test sample shall be selected per 30 m.

56.2 Drifting testing

Each end of the samples taken in accordance with **56.1** shall be drift-expanding tested in accordance with BS EN ISO 8493.

The angle (β) of the conical mandrel shall be (74 $\pm$1)°.

The expansion shall be 20%.

The expanded portion shall be free from cracks and non-uniform deformation.

If any tube fails the drift test, each end of every tube in the batch shall be tested. All tubes that fail the test shall be rejected.

57 Distension test

57.1 Sampling

One test sample shall be selected per 125 m.

57.2 Distension testing

57.2.1 The test piece shall be not less than 600 mm in length.

57.2.2 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 0.002 5 mm.

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

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

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

57.2.4 The permanent increase in the measured diameters of each sample shall not exceed the value given in the material specification.

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

58 Flattening test

58.1 Sampling

One test sample shall be selected per 30 m.

58.2 Flattening testing

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

The distance between platens measured under load in the direction of flattening shall be as specified in the material specification.

No cracks shall be visible without the use of magnifying aids. Slight cracking at the edges shall not be considered cause for rejection.

59 Pressure

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

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

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

The frequency of sampling for testing shall be in accordance with the material specification.

The results shall conform to the material specification.

60 Bore test

If required by the material specification, a bore test shall be carried out on each tube.

A bob or wire shall be passed through the bore of the tube. The diameter of the bob or wire shall be 80% of the nominal internal diameter of the tube. The length of the bob shall not be less than twice its diameter. The bob or wire shall pass through freely.

Alternatively, if the tube can be mounted to ensure full end-to-end visibility, it shall be examined visually and be free from constriction.

Any tube which fails to satisfy the test shall be rejected.

61 Internal examination

If agreed between the manufacturer and the purchaser [see **5.2**p)] and stated on the drawing, order or inspection schedule, a selected length of 600 mm from each 30 m of tube in each batch shall be slit along its length and opened out for internal examination.

The tube shall be free from harmful defects.

62 External defects

Each tube shall be visually examined and shall be free from harmful defects.

63 Surface contamination

Determination of surface contamination shall be carried out in accordance with **10.6**. The sample shall be free from any α stabilized surface (α case).

64 Marking

64.1 Tube with an outside diameter of 20 mm or greater shall bear continuous marking, in ink or similar medium, repeated every 0.5 m along the length, giving the following information:

a) number of the material specification [10];

b) delivery condition;

c) manufacturer's identification and site identification;

d) batch number;

e) inspection stamp.

64.2 Tube with an outside diameter less than 20 mm shall be wired together in bundles. Each bundle shall have attached a durable label indelibly marked with the information required by **64.1**.

[10] Marking a British Standard identifier (e.g. BS 3TA 1:2009) 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 8: Wire

65 General

This section covers the inspection and testing procedures for wire and shall be used in conjunction with Section **1**.

66 Dimensions and tolerances

66.1 The diameter of round wire shall be measured and shall fall within the tolerances given in Table 10 or Table 11 as required by the material specification. The frequency of measurement shall be at the discretion of the manufacturer.

Table 10 **Tolerances on diameter of wire for general purposes**
Dimensions in millimetres

Wire for general purposes, all	Tolerance
Centreless ground or oxidized wire	±0.025
Descaled and pickled wire	±0.050

Table 11 **Tolerances on diameter of wire for special purposes**
Dimensions in millimetres

Centreless ground wire for special purposes, nominal diameter, d	Tolerance
$d < 6$	+0.025
	–0.000
$6 \leqslant d \leqslant 10$	+0.025 0
	–0.000

66.2 Dimensional tolerances for wire other than round wire shall be agreed between the manufacturer and the purchaser [see **5.2**q)] and shall be stated on the drawing, order or inspection schedule.

67 Batch size

Wire shall be grouped in batches of not more than 150 kg.

68 Tensile, creep and stress-rupture tests

68.1 Sampling

One test sample shall be selected from each batch.

68.2 Test piece preparation

The test piece shall be tested in full section.

Test piece dimensions shall be in accordance with BS EN 2002-1 for ambient temperature tensile testing, BS EN 2002-2 for elevated temperature tensile testing and BS EN 2002-005 for uninterrupted creep and stress-rupture testing.

68.3 Tensile testing at ambient temperature

Each test piece, prepared in accordance with **68.2**, shall be tested in accordance with **10.3** and the tensile properties shall conform to the material specification.

68.4 Tensile testing at elevated temperature

Each test piece, prepared in accordance with **68.2**, shall be tested in accordance with **10.4** and the tensile properties shall conform to the material specification.

68.5 Creep and stress-rupture testing

Each test piece, prepared in accordance with **68.2**, shall be tested in accordance with **10.5** and the creep and stress-rupture properties shall conform to the material specification.

69 Torsion test

69.1 If the material specification specifies a torsion requirement, one sample of wire shall be taken from each batch and, if specified in the material specification, shall be heat treated before testing.

69.2 The test sample shall be gripped in two jaws 150 mm apart, one of which shall be free to rotate; the other shall not rotate but it is permissible for it to be free to move longitudinally during the test. The free end shall be turned the specified number of times through 360° and shall then be turned the specified number of times through 360° in the opposite direction.

69.3 The wire shall be examined visually and shall reveal no harmful defects.

70 External defects

Each coil of wire shall be visually examined and shall be free from harmful defects.

71 Surface contamination

Determination of surface contamination shall be carried out in accordance with **10.6**. The sample shall be free from any α stabilized surface (α case).

72 Marking

72.1 A durable label indelibly marked with the following information shall be attached to each coil or bundle:

a) number of the material specification [11];

b) delivery condition;

c) manufacturer's identification and site identification;

d) batch number or unique identification code;

e) inspection stamp.

72.2 Each bundle or coil shall be colour marked if required by the material specification or order [see **5.1**d1)].

[11] Marking a British Standard identifier (e.g. BS 3TA 1:2009) 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.

Annex A (normative) Rules for application of values for chemical composition and 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 five, the last figure to be retained shall remain unchanged;

   2) when the figure immediately after the last figure to be retained is greater than five, or equal to five 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 five and followed by zeros only, the last figure to be retained shall remain unchanged if even and be increased by one if odd.

Bibliography

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

BS 4A 4, *Test pieces and test methods for metallic materials for aircraft – Metric units* [12)]

BS 4A 4-1.2, *Specification for test pieces and test methods for metallic materials – Part 1: Tensile tests – Section 2: Tensile tests – elevated temperature – Metric units* [12)]

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[12)] Referred to in Foreword only.

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