

BS 3TA 100:2009



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AEROSPACE SERIES

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

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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This British Standard supersedes BS 2TA 100:1973, which is withdrawn.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- i) Tensile testing at ambient temperature to BS 4A 4 has been replaced by BS EN 2002-1.
- j) Tensile testing at elevated temperature to BS 4A 4-1.2 has been replaced by BS EN 2002-2.
- k) Creep and stress-rupture testing to BS 4A 4-1.3 has been replaced by BS EN 2002-005.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 standard²⁾ 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 23.2c)].

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 standard³⁾ 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 5.2a)], 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 5.2b)].

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 5.1a2)].

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

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 5.1a4)], 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 5.1a5)], 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 5.1a6)].

8.2 Unless otherwise agreed between the manufacturer and the purchaser [see 5.2c)], 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: $\pm 15^{\circ}\text{C}$
- Annealing: $\pm 15^{\circ}\text{C}$
- Stress relieving: $\pm 15^{\circ}\text{C}$
- Precipitation treatment: $\pm 10^{\circ}\text{C}$

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 5.2d)], 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 5.1a7)], 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 5.2e)].

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.