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AEROSPACE SERIES

Procedure for inspection, testing and acceptance of iron, nickel, copper, cobalt and refractory metal base alloy castings

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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 36, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI and came into effect on 31 January 2010. It was prepared by Panel ACE/61/-/15, *Steels*, and Panel ACE/61/-/48, *Heat resisting 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This standard supersedes BS HC 100:1972, which is withdrawn.

Information about this document

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

Section 1: General requirements

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) Qualification of foundry technique requirements has been added.

e) Reference to AMS 2750 has been added for heat treatment temperature control.

f) Heat treatment temperature tolerances have been added.

g) Tensile testing at ambient temperature to BS 4A 4 has been replaced by BS EN 2002-1.

h) Tensile testing at elevated temperature to BS 4A 4-1.2 has been replaced by BS EN 2002-2.

i) Creep and stress-rupture testing to BS 4A 4-1.3 has been replaced by BS EN 2002-005.

j) Impact testing to BS 4A 4 has been replaced by BS 131 and BS EN 10045.

k) Brinell hardness testing to BS 240 has been replaced by BS EN ISO 6506-1.

l) Vickers hardness testing to BS 427 has been replaced by BS EN ISO 6507-1.

m) Rockwell hardness testing to BS 891 has been replaced by BS EN ISO 6508-1.

n) Bend testing to BS 4A 4 has been replaced by BS EN ISO 7438.

o) Depth of case test method BS EN ISO 2639 has been added.

p) Intercrystalline corrosion test method BS EN ISO 3651-2 has been added.

q) Rules for application of values have been added.

r) Penetrant flaw detection test method EN 2002-16 has been added.

s) Penetrant dye sensitivity requirements have been added.

t) Magnetic particle flaw detection test method BS EN ISO 9934 has been added.

u) Radiological examination test method EN 2002-021 has been added.

v) Reference to ASTM E192 has been added for defect acceptance standards.

w) Protection and packaging requirements have been added.

x) Certification requirements have been amended.

Section 2: Re-melting stock

Internal and external defects requirements have been added.

Section 3: Precision castings

Internal and external defects requirements have been added.

Section 4: Sand castings

Internal and external defects requirements have been added.

Section 5: Centrifugal castings

Internal and external defects requirements have been added.

New Annex A 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 iron, nickel, copper, cobalt and refractory metal base alloy castings for aerospace purposes.

The standard is applicable to material specifications in the British Standard Aerospace HC series and also to other British Standard material specifications for iron, nickel, copper, cobalt and refractory metal base alloy castings 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 131-1, *Methods for notched bar tests – Part 1: The Izod impact test on metals*

BS 131-4, *Methods for notched bar tests – Part 4: Calibration of Izod pendulum impact testing machines for metals*

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 2103-3, *Steel, nickel base and cobalt base alloy remelting stock and castings – Technical specification – Part 3: Pre-production and production castings*

BS EN 4179, *Qualification and approval of personnel for non-destructive testing*

BS EN 10045-1, *Charpy impact test on metallic materials – Part 1: Test method (V- and U-notches)*

BS EN ISO 148-2, *Metallic materials – Charpy pendulum impact test – Part 2: Verification of testing machines*

BS EN ISO 2639, *Steels – Determination and verification of the depth of carburized and hardened cases*

BS EN ISO 3452-2, *Non-destructive testing – Penetrant testing – Part 2: Testing of penetrant materials*

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

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

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

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

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

BS EN ISO 9934 (all parts), *Non-destructive testing – Magnetic particle testing*

EN 2002-16, *Metallic materials – Test methods – Part 16: Non-destructive testing –Penetrant testing* [1)]

EN 2002-021, *Metallic materials – Test methods – Part 21: Radiographic testing of castings* [1)]

AMS 2750, *Pyrometry* [2)]

ASTM E192, *Standard Reference Radiographs of Investment Steel Castings for Aerospace Applications* [3)]

3 Terms and definitions

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

3.1 batch
batch of ingots for re-melting or castings, each of which is:

a) castings of similar dimensions, (see Note 1), produced from the same melt and, if heat treated, heat treated together; or

b) precision castings of similar dimensions (see Note 2), poured from a melt made up of re-melt stock or re-melt stock plus the same amount of alloying additions [see **30.1**a), **30.1**b) and **30.2**] and, if heat treated, heat treated together

NOTE 1 For centrifugal castings, similar dimensions only apply to the cross-section dimension, i.e. length can be ignored.

NOTE 2 If mechanical test samples are cut from actual castings, a batch comprises castings to the same pattern. Castings to the left-hand and right-hand version of any pattern are considered as being to the same pattern.

3.2 cast
product of a single furnace charge, or more than one furnace charge mixed prior to pouring, used to produce re-melting stock

3.3 centrifugal castings
process in which a mould in metal or sand rotates around the pouring axis

3.4 designated area
highly stressed or otherwise important region of a casting, the location of which is determined by the design authority and stated on the drawing or associated documents

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

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

2) Available from www.sae.org.

3) Available from www.astm.org.

3.6 melt
product of a single furnace charge, or more than one furnace charge mixed prior to pouring, used to produce castings

3.7 precision castings
process involving a ceramic mould formed around a disposable pattern (e.g. lost wax process)

3.8 pre-production castings
castings produced to a particular design which qualify the method of manufacture and mould configuration and demonstrate that the purchaser's requirements can be met

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

3.10 re-melting stock
metal, supplied in cast or wrought form, the chemical composition of which has been established by analysis

NOTE This is also known as "master melt" in connection with investment castings.

3.11 sand castings
process involving the moulding of a re-usable pattern with a bonded sand (excluding castings made by the centrifugal process)

3.12 undesignated area
all regions within a casting which have not been designated

3.13 vacuum melting
practice of melting and casting under vacuum

4 General

This standard details the basic requirements for the inspection and testing of British Standard Aerospace HC series, wrought heat-resisting 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 [4)] can be made and verified.

a) General:

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

2) the heat treatment required if different from that specified in the material specification (see **9.1**);

3) if the use of polymer quenching is to be precluded where it is not precluded by the material specification (see **9.7**);

4) when test samples are cut from castings, the number of castings to be tested in each batch (see **12.2.2**);

5) for castings supplied in other than the finally heat treated condition, the number of additional test samples required [see **12.3.2**a) and **12.3.2**b)];

6) the technique for magnetic particle flaw detection (see Clause **16**);

7) the technique for radiological examination (see **17.1**);

8) the nature and colour of the marking ink and type of characters if other than at the discretion of the manufacturer (see **19.1**);

9) if the product is not to be protected by a coating of corrosion preventative (see **20.1**);

b) Re-melting stock:

1) the manufacturing method if other than by the use of pure materials, added elements and approved scrap (see Clause **23**);

2) if mechanical tests are required where this is not specified by the material specification (see **27.1**);

3) the mechanical properties where they are not specified in, or are different from, those specified in the material specification (see **28.2**);

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4) Marking a British Standard identifier (e.g. BS HC 202:1973) on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

c) Precision castings:

1) the required frequency of chemical analysis for melts produced in accordance with **30.1**a) or **30.1**b) where this is not specified by the material specification or is not to be determined by the quality assurance authority (see **32.2.1**);

2) the required properties if other than in accordance with the material specification (see **36.1** and **36.2**);

d) Sand castings:

1) the required properties if other than in accordance with the material specification (see **47.1** and **47.2**).

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 [5)] can be made and verified.

a) The method of temperature control if other than AMS 2750 (see **9.2**).

b) The form, mass, dimensions and tolerances of re-melting stock (see **11.1**).

c) The method of selection and preparation of test samples if not specified elsewhere in the standard (see **12.2.1**).

d) For precision castings, if cast-to-size test pieces may be used (see **12.2.3**).

e) If flaw detection using non-fluorescent penetrants is permitted (see Clause **15**).

f) The acceptance criteria for castings with a wall thickness greater than 25 mm (see **17.4**).

g) For re-melting stock, the test methods and acceptance criteria for internal defects if not at the manufacturer's option (see Clause **25**).

h) For re-melting stock, the method of casting the test samples if not at the manufacturer's option (see **27.2**).

i) The condition of the castings if not in accordance with the material specification (see Clause **31**, Clause **42** and Clause **53**).

j) If all castings are not required to be examined for internal defects (see **33.2**, **44.2** and **55.2**).

k) The acceptance standard for other than cracks and crack-like defects (see **34.3**, **45.3** and **56.3**).

l) For centrifugal castings, the method of obtaining the test samples (see **57.2**).

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5) Marking a British Standard identifier (e.g. BS HC 202:1973) 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.

6 Pre-production castings – qualification of foundry technique

6.1 Prior to commencing series production of a design, pre-production castings shall be produced in order to optimize and qualify the method of manufacture and mould configuration and to demonstrate that the design authority's requirements can be met.

NOTE It is strongly recommended that the technical representative of the founder should be given the opportunity to examine the casting drawing at the initial stages of design and to advise on the optimum design which will enable acceptable castings to be produced consistently.

The following requirements shall be specified on the order, drawing and/or inspection schedule:

a) number of pre-production castings to be produced for evaluation/qualification;

b) heat treatment condition of the pre-production castings including any requirements for machining prior to heat treatment;

c) any areas on the castings which are critical and for which a high internal and/or external defect standard is required;

d) type, number and locations of tests/inspections necessary to evaluate and qualify the method of manufacture such as dimensions, mechanical properties, microstructure, macrostructure, etc;

e) whether the method of manufacture needs to be agreed with the design authority or is at the founder's discretion;

f) who is to perform the evaluation/qualification.

6.2 Qualification of the pre-production castings shall be carried out and include those inspections and tests which will be performed on production castings. All manufacturing parameters shall be recorded with the following foundry techniques in particular being noted:

a) position of runners and risers;

b) position and nature of chills;

c) type of moulding material and details of mould manufacturing parameters;

d) mould temperature;

e) maximum amount of approved scrap which may be added to the melt (at the founder's discretion);

f) casting temperature range;

g) heat treatment details;

h) method of surface finishing.

6.3 Unless otherwise agreed with the design authority, it shall be demonstrated that the casting procedure developed is capable of consistently producing castings fully conforming to drawing requirements, without the need for weld repair.

6.4 When all inspection and test results relating to pre-production castings have been reported and are considered as satisfactory by the design authority, the founder shall compile a manufacturing schedule defining the foundry technique and inspection requirements, including any radiographic techniques to be used. This shall be made available to and/or be subject to written agreement with the design authority as

required. Series production shall commence when written agreement or an order has been received from the design authority or purchaser.

7 Manufacture of production castings

7.1 General

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

7.2 Correction of distortion

Correction of distortion shall be carried out only by agreement between the founder and design authority. The founder shall be responsible for specifying the conditions under which such correction shall be carried out, subject to any requirements of the design authority. The method agreed shall be incorporated in the manufacturing schedule. After correction of distortion, all castings so treated shall be examined by magnetic or penetrant flaw detection, as applicable (see Clause **15**).

7.3 Repair of castings

7.3.1 Castings shall be repaired only as permitted by the design authority. Unless the design authority stipulates a particular method of repair, the founder shall submit the proposed method to the design authority. All repairs shall be carried out before impregnation and/or sealing.

7.3.2 Prior to weld repair, defects shall be completely dressed out. Each weld preparation area shall be subject to magnetic or penetrant flaw detection, as applicable (see Clause **15** and Clause **16**) to ensure that defects have been completely removed.

7.3.3 If castings are pre-heated prior to weld repair, the pre-heating shall be carried out in such a manner that the mechanical properties of the finally heat treated castings are not adversely affected.

7.3.4 Weld repair of castings shall be carried out by a welder whose competence has been satisfactorily demonstrated. The founder shall devise a scheme for demonstrating the competence of the welder and, if required by the order, specification or associated document, shall submit details of the scheme and the results of any competence tests to the design authority for approval.

8 Re-qualification requirements

At the discretion of the design authority, re-qualification of serial production castings shall be required in the following instances:

a) modification to the drawing;

b) use of re-melt stock from a different source;

c) modifications to the approved casting route;

d) use of a new casting founder;

e) when a significant time interval (usually several years) has elapsed between casting campaigns for a specific part;

f) if new tooling is used;

g) when required by the design authority for any other reason.

Re-qualification testing requirements, especially location/type of test samples, shall be identical to those used for the initial qualification of the pre-production castings unless otherwise specified on the order, drawing or inspection schedule.

9 Heat treatment

9.1 Heat treatment shall be carried out in accordance with the material specification or order [see **5.1**a2)].

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

9.3 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 gives the properties specified in the material specification.

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

a) $\theta < 750$ °C: ± 5 °C.

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

c) $\theta >$ 1 250 °C: ± 15 °C.

9.5 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.

9.6 No castings shall be subjected to the specified final heat treatment (other than tempering) more than three times.

9.7 Unless specifically precluded by the material specification or order [see **5.1**a3)], where the material specification specifies the use of an oil quenchant, it is permissible for material to be quenched in a polymer quenchant.

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

10 Chemical composition

10.1 The chemical composition shall conform to the material specification.

10.2 The frequency of chemical analysis shall be as specified in the relevant section of this standard. The samples taken for analysis shall be representative of the cast. 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.

10.3 Elements not listed in the material specification shall not be added for any purpose other than fluxing, degassing or grain refining.

10.4 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.

10.5 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.

10.6 The values specified in the material specification shall be applied in accordance with Annex A.

11 Dimensions and tolerances

11.1 Re-melting stock

The form, mass, dimensions and tolerances of re-melting stock shall be agreed between the manufacturer and purchaser [see **5.2**b)].

The frequency of measurement shall be at the discretion of the manufacturer.

11.2 Castings

11.2.1 The dimensions of the casting shall be measured and shall fall within the tolerances specified on the drawing.

11.2.2 Designated dimensions, as indicated on the drawing or inspection schedule, shall be measured on each casting. For other dimensions the frequency of measurement shall be at the discretion of the manufacturer.

11.2.3 The datum points to be used for dimensional inspection, machining or jigging shall be as stated on the drawing.

12 Testing

12.1 General

12.1.1 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.

(See Clause **5**.)

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

12.2 Selection and preparation of test samples

12.2.1 Unless otherwise specified in the relevant section of this standard, test samples shall be selected and prepared by one or more of the following methods as agreed between the founder and the purchaser [see **5.2**c)]:

a) test samples cut from castings;

b) test samples cast integrally with or gated to castings;

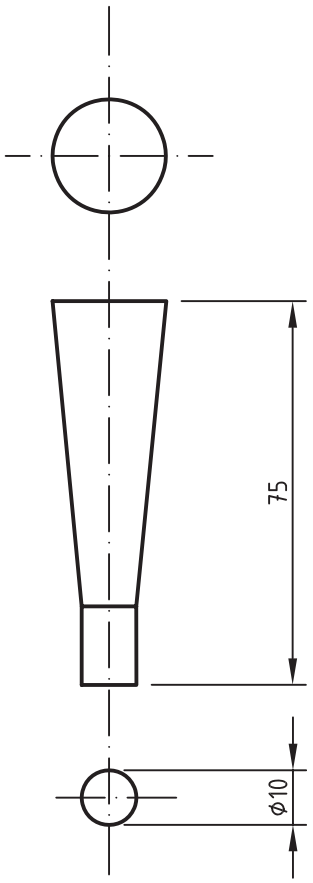
c) test samples cast under similar conditions to the castings they represent but cast in a separate mould from the same melt.

12.2.2 When the test samples are taken as described in **12.2.1**a), the design authority shall specify the number of castings to be tested in each batch [see **5.1**a4)], and shall define on the casting drawing the location from which the test samples are to be taken.

12.2.3 Test samples for precision castings shall conform to one of the forms illustrated in Figure 1. Alternatively, if agreed with the design authority [see **5.2**d)], cast-to-size test pieces, including a grinding allowance if required, shall be used.

Figure 1 **Test samples for precision castings**

All dimensions in millimetres

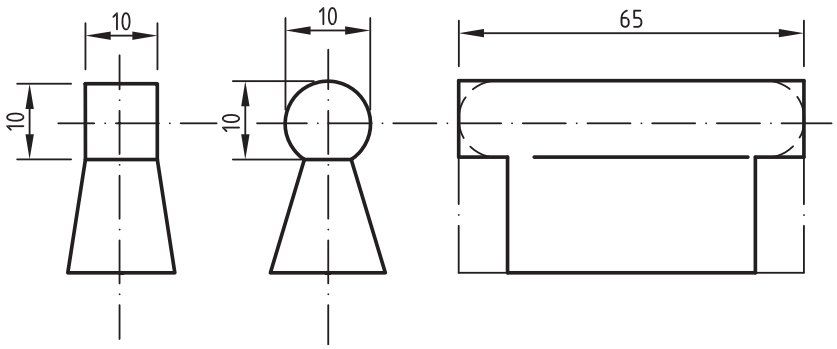


a) Carrot test sample

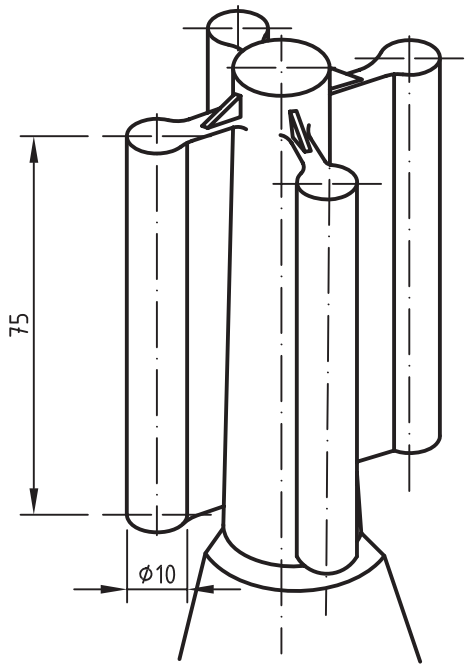
NOTE All dimensions given are minimum values.

Figure 1 **Test samples for precision castings** *(continued)*

All dimensions in millimetres



b) Keel block test sample (circular or square section)



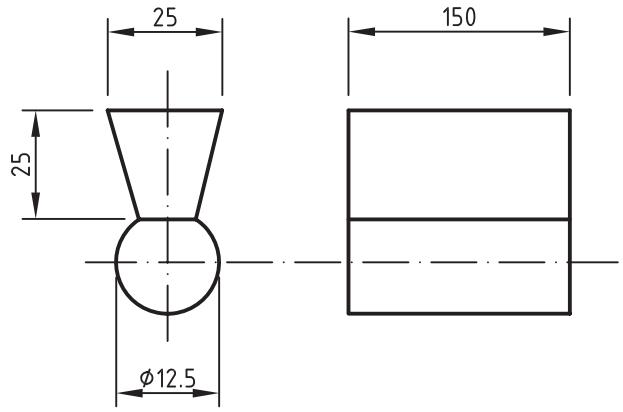
c) Clover leaf test sample

NOTE All dimensions given are minimum values.

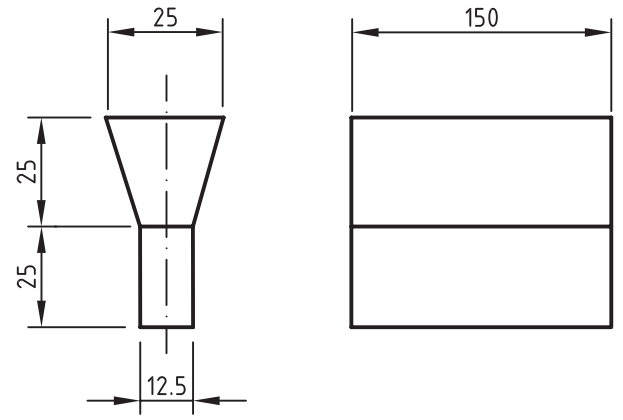
12.2.4 Test samples for sand castings shall conform to one of the forms illustrated in Figure 2.

Figure 2 **Test samples for sand castings**

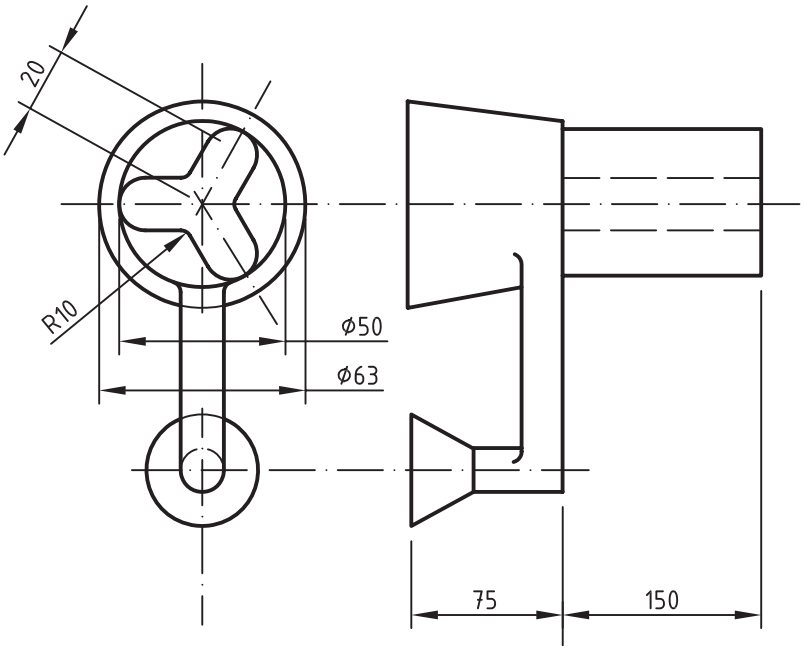
All dimensions in millimetres



a) Wedge fed test bar sample



b) Wedge fed test plate sample

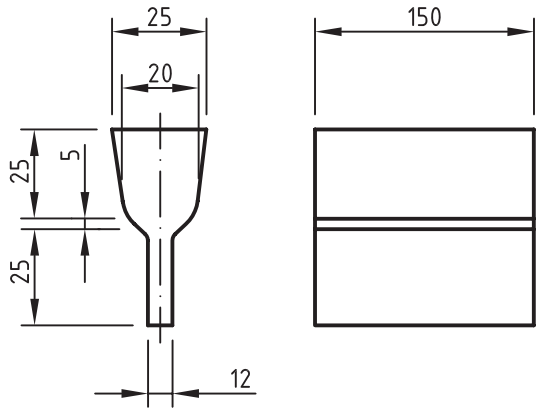


c) Triple test bar sample

NOTE All dimensions given are minimum values.

Figure 2 **Test samples for sand castings** *(continued)*

All dimensions in millimetres



d) Single test bar sample

NOTE All dimensions given are minimum values.

12.2.5 The test samples shall be fully representative of the material in its delivery condition.

12.2.6 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.

12.2.7 Alternatively to **12.2.6**, except for cast-to-size test pieces, mechanical test samples, for which the specified minimum tensile strength is $\geqslant$1 300 MPa, shall be machined to test piece size plus, if required, a grinding allowance, and heat treated in that size or, in the case of maraging or precipitation hardening materials, the test sample shall be machined to test piece size plus, if required, a grinding allowance after solution treatment.

12.2.8 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.

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

12.3 Provision of test samples

12.3.1 Castings supplied in the finally heat treated condition or for use without subsequent heat treatment

The founder shall select a minimum of three test samples per batch for each of the tests specified. If appropriate, the samples shall be heat treated with the batch of castings they represent in accordance with the material specification.

12.3.2 Castings supplied in other than the finally heat treated condition

a) Alloys other than carburizing or nitriding steels.

The founder shall select a minimum of three test samples per batch for each of the tests specified in order to prove the batch. In addition, the founder shall provide the purchaser with sufficient additional samples to accompany each subsequent heat treatment batch through final heat treatment. The purchaser shall state on the order the number of additional test samples required [see **5.1**a5)].

All samples shall accompany the batch through such intermediate heat treatment operations as are required by the specification or order.

The samples required to prove the batch shall be finally heat treated in accordance with the material specification.

b) Carburizing or nitriding steels.

The founder shall select a minimum of three test samples per batch for each of the tests specified in order to prove the batch. In addition, the founder shall provide the purchaser with sufficient additional samples to accompany each subsequent heat treatment batch through final heat treatment.

These shall include samples for depth of case measurement for nitriding and carburizing steels (see **12.3.3**) and sufficient impact samples for nitriding steels to provide an impact test for the proving test and each nitriding batch. The purchaser shall state on the order the number of additional test samples required [see **5.1**a5)].

Samples shall accompany the batch through such intermediate heat treatment operations as are required by the specification or order.

If the castings are to be nitrided, at least one of the additional impact test samples required shall additionally be heat treated at a temperature of (500 $\pm$10) °C for not less than 60 h.

12.3.3 Depth of case test samples

Test samples for depth of case determination shall be provided as detailed.

a) Carburizing steels: at least one test sample shall be included with each carburizing batch.

b) Nitriding steels: at least one test sample shall be included with each nitriding batch. The test sample shall accompany the castings it represents throughout all the heat treatment process to which the castings are subject prior to nitriding.

12.4 Tensile test

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

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

12.4.3 The test pieces shall be prepared from the test samples (see **12.2**) and shall be to the dimensions of the largest practicable size test piece specified in BS EN 2002-1 or BS EN 2002-2, as appropriate.

12.5 Creep and creep-rupture test

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

12.5.2 The test pieces shall be prepared from the test samples (see **12.2**) and shall be to the dimensions of the largest practicable size of proportional round test piece specified in BS EN 2002-005.

12.6 Impact test

12.6.1 Test piece preparation

12.6.1.1 The test piece(s) shall be prepared from the test sample (see **12.2**) to the dimensions of the appropriate type of test piece (Izod, Charpy V-notch or Charpy U-notch as specified in the material specification). Conversions from one type of impact test result to another shall not be permitted.

12.6.1.2 The test shall be carried out on a minimum of two notches.

12.6.1.3 If the test sample is machined to test piece size prior to heat treatment (see **12.2**), the notches shall be machined after heat treatment, or partly machined before heat treatment, in such a manner that at least 0.2 mm of material remains to be removed from the radius of the root of each notch after heat treatment.

12.6.2 Izod impact test

Izod impact testing shall be carried out in accordance with BS 131-1 except that the machining tolerances shall be those quoted for non-ferrous metals.

The machines used shall be calibrated in accordance with BS 131-4.

12.6.3 Charpy impact test

Charpy U- and V-notch impact testing shall be carried out in accordance with BS EN 10045-1.

The machines used shall be calibrated in accordance with BS EN ISO 148-2.

12.7 Hardness test

12.7.1 Hardness testing shall be carried out using one of the methods listed in **12.7.2** to **12.7.4** as specified in the material specification.

12.7.2 Brinell hardness testing shall be carried out in accordance with BS EN ISO 6506-1. If not specified in the material specification, the ratio of F/D^2 shall be 10 for copper and copper based alloys and 30 for all other alloys. Periodic checking of the testing machine by the user shall be carried out in accordance with, and at the frequency specified in, BS EN ISO 6506-1.

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

12.7.4 Rockwell hardness testing shall be carried out in accordance with BS EN ISO 6508-1. Periodic checking of the testing machine by

the user shall be carried out in accordance with, and at the frequency specified in, BS EN ISO 6508-1.

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

12.8 Bend test

12.8.1 Bend testing shall be carried out in accordance with BS EN ISO 7438.

12.8.2 Bend testing shall be carried out on:

a) a round test piece machined to the largest practicable size, subject to a maximum diameter of 10 mm, that can be prepared from the test sample; or

b) the full section of the test sample subject to a diameter or minor sectional dimension of 10 mm maximum.

The angle of bend and the bending radius shall be as specified in the material specification.

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.

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

12.9 Depth of case test

12.9.1 Carburizing steels

The depth of case of test samples shall be determined by:

a) hardness testing in accordance with BS EN ISO 2639, with the case depth being the depth at which the hardness is 550 HV;

b) examination of a prepared section;

c) examination of a fractured test piece.

12.9.2 Nitriding steels

The depth of case of test samples shall be determined by:

a) hardness testing in accordance with BS EN ISO 2639, with the case depth being the depth at which the hardness is equal to 75% of the specified minimum case hardness;

b) examination of a prepared section;

c) examination of a fractured test piece.

12.10 Susceptibility to intercrystalline corrosion

A bend test piece, prepared in accordance with BS EN ISO 3651-2, shall be sensitized for 30 min at (650 ±10) °C and cooled in air. It shall then be subjected to intercrystalline corrosion testing in accordance with BS EN ISO 3651-2, Method A or Method B, appropriate to the type of steel. The angle of bend and the bending radius shall be as specified in the material specification.

13 Retesting procedures

13.1 Tensile, creep, creep-rupture, impact, bend and intercrystalline corrosion test

If the test procedure or test piece preparation is found to be faulty, testing shall be reapplied using the original sampling frequency after identification of the cause of the failure. When failure cannot be attributed to faulty testing or test piece preparation, additional test samples shall be selected at twice the original sampling frequency. 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) for heat treatable materials, re-heat treated (see **9.6**) and tested as a new batch.

13.2 Hardness test

13.2.1 If any casting tested from a batch which has not been tested at 100% fails to conform to the material specification, one of the following procedures shall be adopted.

a) The complete batch shall be re-tempered or re-heat treated (see **9.6**) as appropriate, in accordance with the material specification and tested as a new batch.

b) All castings in the batch not previously hardness tested shall be tested and the re-test procedure given in **13.2.2** shall be applied.

13.2.2 If any casting tested from a batch which has been tested at 100% fails to conform to the material specification, one or more of the following procedures shall be adopted.

a) For castings with hardness below the minimum value specified, the softest casting in the batch shall be submitted to the mechanical tests specified in the material specification. If the results of these tests conform to the mechanical property requirements of the material specification, all the castings in the batch shall be accepted.

b) For castings with hardness above the maximum value specified, the hardest casting in the batch shall be submitted to the mechanical tests specified in the material specification. If the results of these tests conform to the mechanical property requirements of the material specification, all the castings in the batch shall be accepted.

c) Castings of incorrect hardness, or the complete batch, shall be re-tempered or re-heat treated (see **9.6**) as appropriate, in accordance with the material specification, and tested as a new batch.

14 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.

15 Penetrant flaw detection

Penetrant flaw detection shall be carried out in accordance with EN 2002-16. Unless otherwise agreed with the design authority and stated on the drawing or inspection schedule, flaw detection shall be carried using fluorescent penetrants [see **5.2**e)].

Fluorescent penetrants to be used for machined and unmachined castings shall have a sensitivity corresponding to at least sensitivity level 2 of BS EN ISO 3452-2.

Where the use of colour contrast penetrants is permitted, colour contrast penetrants to be used for machined and unmachined castings shall have a sensitivity corresponding to at least sensitivity level 1 of BS EN ISO 3452-2.

16 Magnetic particle flaw detection

Magnetic particle flaw detection shall be carried out in accordance with BS EN ISO 9934 to a technique stated on the drawing, order or inspection schedule [see **5.1**a6)]. The technique for each pattern of casting shall be agreed with the design authority. Personnel carrying out non-destructive testing to this standard shall satisfy the competency requirements of BS EN 4179.

17 Radiological examination

17.1 Radiological examination shall be carried out in accordance with EN 2002-021 to a technique stated on the drawing, order or inspection schedule [see **5.1**a7)]. The technique for each pattern of casting shall be agreed with the design authority.

17.2 The radiographs shall be suitably identified with the castings they represent and shall be supplied to the design authority with the castings.

17.3 Radiographic indications shall be identified in terms of the defects listed in BS EN 2103-3.

17.4 For castings with a wall thickness equal to or less than 25 mm, acceptance shall be made in accordance with the defect level stated on the drawing, order or associated document. If no level is specified, level B shall apply to all radiographed areas of a casting. The castings shall conform to the appropriate acceptance levels for all the defects listed in BS EN 2103-3. The acceptance levels given shall apply to each 50 mm × 50 mm area of the casting as defined in ASTM E192.

For castings with a wall thickness greater than 25 mm, acceptance criteria shall be agreed between the manufacturer and the purchaser and stated on the drawing, order or inspection schedule [see **5.2**f)].

Despite conformance to the appropriate acceptance standard for individual defects, the following shall apply to each 50 mm × 50 mm area.

a) No more than one type of defect shall be permitted at the minimum acceptance level.

b) If two types of defect are present, both shall be at least one level better than the minimum acceptance level.

c) Irrespective of level, not more than two types of defect shall be permitted in one area.

d) Defects associated with an edge or extremity shall not be permitted.

18 Identification

18.1 Re-melting stock and castings shall be kept identifiable as to their melt and cast, and, if appropriate, the heat treatment batch, to enable final identification marking to be made in accordance with Clause **19**.

18.2 Test and analytical samples shall be kept identifiable with the re-melting stock or castings they represent.

19 Marking

19.1 General

19.1.1 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)].

19.1.2 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.

19.2 Re-melting stock

All products shall bear the following identification marking:

a) material specification number [6)];

b) melt number;

c) identification of the manufacturer and plant;

d) inspection stamp;

e) such other marking as will ensure full identification.

19.3 Castings

Each casting shall be marked with:

a) part number;

b) batch number;

c) material specification number [6)];

d) inspection stamp;

e) such other marking as will ensure full identification of the casting.

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6) Marking a British Standard identifier (e.g. BS HC 202:1973) 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.

The location and method of marking shall be indicated on the drawing and shall not be detrimental to the casting.

NOTE If shape or dimension does not permit all of the above markings, the amount of marking may be reduced provided traceability to the required information is maintained.

Alternatively, the castings shall be packed in bags or bundles each of which shall carry a durable label bearing the required information.

20 Protection and packaging

20.1 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)].

20.2 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.

21 Certification

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 [7)].

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.

h) Cast number(s) and batch number(s) or unique identification.

i) Moulding process used.

j) Condition of the material as delivered.

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7) Marking a British Standard identifier (e.g. BS HC 202:1973) 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) Heat treatment details, including details of test sample heat treatment where appropriate.

l) Detail of all the tests carried out, or the reference numbers of the relevant test reports, copies of which shall be attached.

m) Inspection stamp.

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

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

Section 2: Re-melting stock

22 General

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

23 Manufacture

Re-melting stock shall be manufactured from a melt consisting of:

a) pure materials and added elements; or

b) pure materials, added elements plus a defined and constant percentage of approved scrap; or

c) pure materials, added elements and approved scrap. Their proportion per melt shall be at the option of the manufacturer.

Unless otherwise specified on the order [see **5.1**b1)] or manufacturing schedule, manufacturing method c) shall be applied.

24 Chemical composition

The chemical composition of each cast of re-melting stock shall be determined in accordance with Clause **10**.

25 Internal defects

Re-melting stock shall not contain defects prejudicial to its intended use. Unless otherwise agreed between the manufacturer and the purchaser and stated on the order or in the inspection schedule [see **5.2**g)], test methods and acceptance criteria shall be at the option of the manufacturer.

The frequency of examination adopted shall be sufficient to permit the manufacturer to certify compliance with the requirements.

26 External defects

Re-melting stock shall be visually examined and shall be free from corrosion, scale, slag, grease or any other foreign matter including paint, other than that approved for marking.

The frequency of examination adopted shall be sufficient to permit the manufacturer to certify compliance with the requirements.

27 Selection and preparation of mechanical test samples

27.1 If mechanical tests are required by the material specification or order [see **5.1**b2)], sufficient test samples shall be prepared from every cast to provide for each of the tests required.

27.2 Unless otherwise agreed with the purchaser and stated on the order or in the inspection schedule [see **5.2**h)], the method of casting the test samples shall be at the option of the manufacturer.

27.3 If appropriate, the test sample(s) shall be heat treated in accordance with the material specification.

28 Mechanical tests

28.1 Test pieces from test samples selected and prepared in accordance with Clause **27** shall be subjected to the mechanical tests listed in the material specification. Testing shall be in accordance with Clause **12**.

28.2 The properties shall conform to the material specification or order [see **5.1**b3)].

Section 3: Precision castings

29 General

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

30 Manufacture

30.1 Castings shall be poured from a melt, made by one of the three following methods:

a) made up from one cast of re-melting stock or from two casts of re-melting stock blended in constant and fixed proportions to which no additions of scrap or alloying additions other than deoxidants have been made. The re-melting stock shall conform to Section **2**.

b) made up from one cast of re-melting stock that conforms to Section **2**, to which a fixed amount of alloying additions has been made and to which no scrap has been added.

c) made up directly from scrap and/or the appropriate constituents.

30.2 When castings are poured in accordance with **30.1**a) or **30.1**b), the quality assurance authority shall determine the number of melts that can be grouped into one batch.

31 Condition

Unless otherwise agreed between the manufacturer and the purchaser and stated on the order [see **5.2**i)], the castings shall be supplied in the condition required by the material specification.

32 Chemical composition

32.1 Sampling

From each melt, produced in accordance with **30.1**, a representative analytical sample shall be cast and suitably marked to ensure identification.

32.2 Frequency of analysis

32.2.1 Unless otherwise required by the order [see **5.1**c1)] or material specification, the frequency of analysis of melts made in accordance with **30.1**a) and **30.1**b) shall be determined by the quality assurance authority. At least one analysis shall be carried out on melts produced from one cast of re-melting stock. When carbon arc melting is employed, each melt shall be analysed for carbon content.

32.2.2 The chemical composition of all melts made in accordance with **30.1**c) shall be determined.

32.2.3 The chemical composition shall be determined in accordance with Clause **10**.

33 Internal defects

33.1 Castings shall be radiologically examined in accordance with Clause **17**.

33.2 Unless otherwise agreed between the manufacturer and the purchaser and stated on the order or inspection schedule, [see **5.2**j)], all castings shall be examined.

34 External defects

34.1 Castings shall be suitably fettled, dressed, cleaned and if appropriate, etched and passivated, to enable inspection to be carried out in a satisfactory manner.

34.2 Each casting shall be examined for surface defects by visual inspection and penetrant flaw detection in accordance with Clause **15** or magnetic particle examination in accordance with Clause **16**, appropriate to the type of material after all specified heat treatment and pressure tests have been completed.

34.3 Castings shall be free from cracks and crack like indications. The acceptance standard for other defects shall be agreed between the founder and the purchaser [see **5.2**k)] and stated on the drawing, order or inspection schedule.

35 Selection and preparation of mechanical test samples

Test samples for the tests required by the material specification shall be selected and prepared in accordance with **12.2** and **12.3**.

36 Batch acceptance tests

36.1 Castings not subject to carburizing or nitriding

Test samples shall be finally heat treated with each batch of castings in accordance with the material specification. Test pieces prepared from the samples shall be tested in accordance with Clause **37**, Clause **38** and, if necessary, Clause **39** and shall conform to the material specification, order or drawing [see **5.1**c2)].

36.2 Carburized and hardened castings

Test samples shall accompany each batch through the carburizing operation and shall be finally heat treated in accordance with the material specification.

Except for the sample to be used for the determination of case depth as required by **12.3.3**, samples shall be protected to prevent the absorption of carbon.

Test pieces prepared from the test samples shall be tested in accordance with **12.9.1**, Clause **37**, Clause **38** and, if applicable, Clause **39**, and shall conform to the material specification, order or drawing [see **5.1**c2)]. The depth of case of the test samples shall include a stated grinding allowance.

36.3 Nitrided castings

Test samples to be used for impact testing and for the determination of case depth shall accompany each batch of castings through the nitriding operation.

The impact test samples shall be protected against the absorption of nitrogen and shall accompany the castings they represent through any stabilizing heat treatment operations given to the casting prior to nitriding.

Test pieces prepared from the samples shall be impact tested in accordance with **12.6** and subjected to depth of case determination in accordance with **12.9**.

The impact strength shall conform to the material specification.

The depth of case shall conform to drawing requirements, including a stated grinding allowance.

37 Mechanical tests

Test pieces from test samples selected and prepared in accordance with Clause **35** shall be subjected to the mechanical tests listed in the material specification. Testing shall be in accordance with Clause **12**.

38 Hardness tests

38.1 Non-carburized or non-nitrided castings

If the material specification includes a hardness requirement, each batch of castings shall be tested in accordance with **12.7** as detailed.

a) For hardened and tempered or precipitation hardened castings, the frequency of testing for batches of up to 100 castings shall be 40 castings or 100% per batch, whichever is the less, and for batches of over 100 castings shall be $4\sqrt{N}$ castings per batch, where N is the number of castings in the batch.

b) For "as cast", annealed or normalized castings or castings to be tested at an intermediate stage of heat treatment, the frequency of testing for batches of up to 100 castings shall be 20 castings or 100% per batch, whichever is the less, and for batches of over 100 castings shall be $2\sqrt{N}$ castings per batch, where N is the number of castings in the batch.

c) The hardness shall conform to the material specification or drawing and the positions of hardness testing, if considered necessary, shall be indicated on the drawing.

38.2 Carburized or nitrided castings

For castings that are subsequently carburized or nitrided, at least one hardness test shall be carried out in accordance with **12.7** on the hardened case of each casting.

The hardness shall conform to the drawing and the positions of hardness testing, if considered necessary, shall be indicated on the drawing.

39 Susceptibility to intercrystalline corrosion

Intercrystalline corrosion testing shall be carried out in accordance with **12.10** on a test piece taken from a test sample provided as specified in **12.2** from each batch of casting. After corrosion testing, a bend test shall be carried out in accordance with the material specification. There shall be no evidence of cracking in the test piece.

Section 4: Sand castings

40 General

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

41 Manufacture

Castings shall be poured from a melt made up directly from the appropriate constituents and/or scrap and/or re-melting stock.

42 Condition

Unless otherwise agreed between the manufacturer and the purchaser and stated on the order [see **5.2**i)], the castings shall be supplied in the condition required by the material specification.

43 Chemical composition

43.1 Sampling

From each melt, produced in accordance with Clause **41**, a representative analytical sample shall be cast and suitably marked to ensure identification.

43.2 Frequency of analysis

The chemical composition of each melt shall be determined in accordance with Clause **10**.

44 Internal defects

44.1 Castings shall be radiologically examined in accordance with Clause **17**.

44.2 Unless otherwise agreed between the manufacturer and the purchaser and stated on the order or inspection schedule, [see **5.2**j)], all castings shall be examined.

45 External defects

45.1 Castings shall be suitably fettled, dressed, cleaned and if appropriate, etched and passivated, to enable inspection to be carried out in a satisfactory manner.

45.2 Each casting shall be examined for surface defects by visual inspection and penetrant flaw detection in accordance with Clause **15** or magnetic particle examination in accordance with Clause **16**, appropriate to the type of material after all specified heat treatment and pressure tests have been completed.

45.3 Castings shall be free from cracks and crack like indications. The acceptance standard for other defects shall be agreed between the founder and the purchaser [see **5.2**k)] and stated on the drawing, order or inspection schedule.

46 Selection and preparation of mechanical test samples

Test samples for the tests required by the material specification shall be selected and prepared in accordance with **12.2** and **12.3**.

47 Batch acceptance tests

47.1 Castings not subject to carburizing or nitriding

Samples shall be finally heat treated with each batch of castings as required by the material specification. Test pieces prepared from the samples shall be tested in accordance with Clause **48**, Clause **49** and, if applicable, Clause **50** and shall conform to the material specification, order or drawing [see **5.1**d1)].

47.2 Carburized and hardened castings

Test samples shall accompany each batch through the carburizing operation and shall be finally heat treated as required by the material specification.

Except for the sample to be used for the determination of case depth, samples shall be protected to prevent the absorption of carbon.

Test pieces prepared from the test samples shall be tested in accordance with **12.9.1**, Clause **48**, Clause **49** and, if applicable, Clause **50**, and shall conform to the material specification, order or drawing [see **5.1**d1)]. The depth of case of the test samples shall include a stated grinding allowance.

47.3 Nitrided castings

Test samples to be used for impact testing and for the determination of case depth shall accompany each batch of castings through the nitriding operation.

The impact test samples shall be protected against the absorption of nitrogen and shall accompany the castings they represent through any stabilizing heat treatment operations given to the casting prior to nitriding.

Test pieces prepared from the samples shall be impact tested in accordance with **12.6** and subjected to depth of case determination in accordance with **12.9**.

The impact strength shall conform to the material specification.

The depth of case shall conform to drawing requirements, including a stated grinding allowance.

48 Mechanical tests

Test pieces from test samples selected and prepared in accordance with Clause **46** shall be subjected to the mechanical tests listed in the material specification. Testing shall be in accordance with Clause **12**.

49 Hardness tests

49.1 Non-carburized or non-nitrided castings

If the material specification states a hardness value or values, all castings and their representative mechanical test samples shall be hardness tested in accordance with **12.7**.

The hardness shall conform to the material specification or drawing and the positions of hardness testing, if considered necessary, shall be indicated on the drawing.

49.2 Carburized or nitrided castings

For castings that are subsequently carburized or nitrided, at least one hardness test shall be carried out in accordance with **12.7** on the hardened case of each casting.

The hardness shall conform to the drawing and the positions of hardness testing, if considered necessary, shall be indicated on the drawing.

50 Susceptibility to intercrystalline corrosion

Intercrystalline corrosion testing shall be carried out in accordance with **12.10** on a test piece taken from a test sample provided as specified in **12.2** from each batch of casting. After corrosion testing, a bend test shall be carried out in accordance with the material specification. There shall be no evidence of cracking in the test piece.

Section 5: Centrifugal castings

51 General

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

52 Manufacture

Castings shall be poured from a melt made up directly from the appropriate constituents and/or scrap and/or re-melted stock.

53 Condition

Unless otherwise agreed between the manufacturer and the purchaser and stated on the order [see **5.2**i)], the castings shall be supplied in the condition required by the material specification.

54 Chemical composition

54.1 Sampling

From each melt, produced in accordance with Clause **52**, a representative analytical sample shall be cast and suitably marked to ensure identification.

54.2 Frequency of analysis

The chemical composition of each melt shall be determined in accordance with Clause **10**.

55 Internal defects

55.1 Castings shall be radiologically examined in accordance with Clause **17**.

55.2 Unless otherwise agreed between the manufacturer and the purchaser and stated on the order or inspection schedule, [see **5.2**j)], all castings shall be examined.

56 External defects

56.1 Castings shall be suitably fettled, dressed, cleaned and if appropriate, etched and passivated, to enable inspection to be carried out in a satisfactory manner.

56.2 Each casting shall be examined for surface defects by visual inspection and penetrant flaw detection in accordance with Clause **15** or magnetic particle examination in accordance with Clause **16**, appropriate to the type of material after all specified heat treatment and pressure tests have been completed.

56.3 Castings shall be free from cracks and crack like indications. The acceptance standard for other defects shall be agreed between the founder and the purchaser [see **5.2**k)] and stated on the drawing, order or inspection schedule.

57 Selection and preparation of test samples

57.1 Except as specified in **57.2**, test samples for the tests required by the material specification shall be selected and prepared in accordance with **12.2** and **12.3**.

57.2 Test samples for the tests required by the material specification shall be obtained by one or more of the following methods as agreed between the founder and the purchaser [see **5.2**l)] and stated on the drawing, order or inspection schedule.

a) Test samples cut from castings.

b) Test samples cut from a separate centrifugally cast test pot, but cast under similar conditions to the castings represented from the same melt.

c) Test samples cut from separate statically cast keel blocks made in either metal dies or sand moulds as appropriate to the castings they represent, and poured from the same melt.

57.3 If the test samples are taken as in **57.2**a), the design authority shall specify the number of castings in each batch to be tested and if considered necessary, shall define on the casting drawing the agreed locations from which the test samples are to be taken.

57.4 If provided as in **57.2**b), the test samples for all mechanical tests shall be cut longitudinally or transversely from the wall of the test pot as specified by the design authority on the order or drawing.

57.5 If provided as in **57.2**c), correlation between the properties of the test samples and the castings they represent shall be established to the satisfaction of the design authority.

58 Batch acceptance tests

Samples shall be finally heat treated with each batch of castings as required by the material specification. Test pieces prepared from the samples shall be tested in accordance with Clause **59**, Clause **60** and, if applicable, Clause **61**, and shall conform to the material specification.

NOTE A relaxation may be permitted if agreed between the heat treater, the purchaser and the quality assurance authority, as follows.

If castings from any melt are split into smaller batches and mixed with castings from other melts, subject to the same heat treatment, to make a heat treatment load, a test sample representing each melt is to be included in the furnace load. Only one sample from each heat treatment load need be tested to prove the heat treatment, provided at least one sample from each melt is tested, irrespective of how many heat treatment loads have contained castings from that melt.

59 Mechanical tests

Test pieces from test samples selected and prepared in accordance with Clause **57** shall be subjected to the mechanical tests listed in the material specification. Testing shall be in accordance with Clause **12**.

60 Hardness tests

If the material specification states a hardness value or values, all castings and their representative mechanical test samples shall be hardness tested in accordance with **12.7**.

The hardness shall conform to the material specification or drawing and the positions of hardness testing, if considered necessary, shall be indicated on the drawing.

61 Susceptibility to intercrystalline corrosion

Intercrystalline corrosion testing shall be carried out in accordance with **12.10** on a test piece taken from a test sample provided as specified in **12.2** from each batch of casting. After corrosion testing, a bend test shall be carried out in accordance with the material specification. There shall be no evidence of cracking in the test piece.

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;

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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*[8)]

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*[8)]

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[8)] Referred to in Foreword only.

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