

Inspection and testing procedure for iron, nickel, copper, cobalt and refractory metal base alloy castings

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Foreword

This British Standard covers the general inspection and testing requirements for iron, nickel, copper, cobalt and refractory metal base alloy castings. The procedure defined is primarily for use in conjunction with related material specifications in the HC series of British Standards and the Ministry of Defence DTD series. It may also be used in conjunction with firms own casting specifications.

In this standard wherever agreement between the manufacturer and the purchaser is required, the onus is on the purchaser to obtain the concurrence of the parent design firm to such agreement; if such concurrence is mandatory the word “purchaser” is marked with an asterisk (*).

This standard makes reference to the latest issues of the following British Standards:

BS A4, *Test pieces and test methods for metallic materials for aircraft.*

BS 240, *Method of Brinell hardness test — Part 1: Testing of metals.*

BS 427, *Method for Vickers hardness test — Part 1: Testing of metals.*

BS 891, *Method for Rockwell hardness test — Part 1: Testing of metals.*

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 13 and a back cover.

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

Amendments issued since publication

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1 General requirements

1.1 Foundry approval

1.1.1 At the initiative of the Design Authority, foundries producing castings for critical applications shall be required to demonstrate their ability to produce castings of a high standard of uniformity of properties, in addition to the basic quality assurance requirements.

1.1.2 To obtain approval against this requirement, the foundry shall produce evidence of the uniformity of mechanical properties and shall nominate a metallurgist to be responsible for process and metallurgical control, to the satisfaction of the Design and Quality Assurance Authorities.

1.2 Definitions

For the purposes of this British Standard the following definitions apply:

1.2.1

batch

unless otherwise agreed by the Quality Assurance Authority, either:

- 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 **3.1.1 1)**, **3.1.1 2)** and **3.1.2)** 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.

1.2.2

cast

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

1.2.3

centrifugal castings

castings made by a process involving centrifugal casting in either metal dies or sand moulds rotating about the major axis of the casting

1.2.4

melt

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

1.2.5

precision castings

those products produced by an investment process, the Shaw process or any similar process as agreed by the Quality Assurance Authority

1.2.6

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.

1.2.7

sand castings

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

1.2.8

vacuum melting

the practice of melting and casting under vacuum

1.2.9

quality assurance authority

the authority stated in the contract or the accredited representative of that authority

1.2.10

design authority

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

1.3 Control of material

1.3.1 All raw materials, including scrap, used directly for the production of melts shall be carefully stored to prevent mixing and contamination with harmful materials.

1.3.2 The method of melting employed for the production of re-melting stock and castings shall be as required by the material specification or as required by the Approved Metallurgist and recorded in the foundry technique.

1.4 Chemical composition

1.4.1 The chemical composition of re-melt stock and castings shall comply with the requirements of the material specification.

1.4.2 Elements not quoted in the material specification shall not be intentionally added to the alloy without the agreement of the purchaser, except for the purpose of finishing the heat; reasonable precautions shall be taken to prevent their inclusion during manufacture. For special applications the purchaser, by agreement with the manufacturer, may set a limit to the amount of one or more such elements and may require the amount of such elements to be stated on the certificate of analysis.

NOTE Care is to be taken to prevent contamination of the metal from preceding casts or melts of different composition melted in the same furnace.

1.4.3 No further additions shall be made to a cast or melt after the final analytical sample has been selected.

1.5 Heat treatment temperatures

If a temperature with a tolerance is stated in a material specification, order or drawing, that temperature shall be mandatory, if a temperature range is stated, a temperature within that range shall be selected to give the required properties.

1.6 Mechanical tests

1.6.1 Tensile, stress rupture, creep strain and impact tests. Except as provided for in **1.6.2** all test samples shall be machined in the finally heat treated condition to the dimensions of the appropriate largest size of proportional round test piece shown in BS A4 that can be prepared from the test samples. An impact test shall comprise a minimum of two notches.

1.6.2 Alternatively to **1.6.1**, except for cast to size test pieces, mechanical test samples, for which the specified minimum tensile strength is 1 300 N/mm² or greater, 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.

1.6.3 Bend test. Bend test samples shall be machined to the largest practicable round test piece, subject to a maximum diameter of 10 mm, that can be prepared from the test sample. Alternatively, the bend test may be carried out on the full section of the test sample subject to a diameter or minor sectional dimension of 10 mm maximum.

1.7 Methods of testing

1.7.1 Mechanical tests. The test pieces shall be tested in accordance with the requirements of BS A4.

1.7.2 Hardness tests. Hardness tests shall be carried out in accordance with the requirements of BS 240, Part 1, using an F/D^2 ratio of 10 for copper and copper based alloys and 30 for all other alloys, unless otherwise stated in the material specification, or BS 427, Part 1, or BS 891, Part 1, as required by the material specification.

1.7.3 Depth of case tests. The depth of case of test samples shall be determined by fracturing, metallographic examination, taper grinding and hardness testing, or other examination to the satisfaction of the Inspector.

1.7.4 Intercrystalline corrosion test

1.7.4.1 If required by the material specification a bend test piece, prepared in accordance with the requirements of **1.6.3**, shall be sensitized for 30 min at 650 ± 10 °C and cooled in air. It shall then be immersed either:

1) for 72 h in a boiling solution having the following composition:

111 g of copper sulphate crystals
(CuSO₄·5H₂O) 98 g of concentrated sulphuric acid
(s.g. 1.84) made up to one litre with distilled water; or

2) for 24 h in a boiling solution of the composition given in 1) to which 50 g of copper turnings or filings are added before the test, and the test piece shall be in contact with this copper. The test solution may be used only once.

Precautions shall be taken during boiling to prevent concentration by evaporation.

1.7.4.2 If required by the material specification, a bend test piece, prepared in accordance with the requirements of **1.6.3**, shall be tested in accordance with the requirements of **1.7.4.1**, except that the sensitizing treatment shall be omitted.

1.8 Freedom from defects

1.8.1 Re-melting stock shall be free from rust, scale, slag, grease, paint and other foreign matter.

1.8.2 Vacuum re-melting stock shall be capable of producing vacuum melts which are essentially free from dross or foreign matter on the melt surface, if required, a standard shall be agreed between the manufacturer and the purchaser.

1.8.3 All castings shall be suitably fettled, dressed and cleaned for surface inspection purposes.

1.8.4 Each casting shall be examined for surface defects by a non-destructive method to the satisfaction of the Quality Assurance Authority. Flaw detection shall be carried out by the founder unless otherwise agreed by the purchaser. Any casting subsequently subjected to heat treatment or to a proof loading test shall be re-examined.