

CONFIRMED
OCTOBER 1984

Specification for

Investment castings in metal —

Part 1: Carbon and low alloy steels

UDC 669 – 145 + 669.14 – 145 + 669.15 – 194.2 – 145

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British Ironfounders' Association	Institution of Structural Engineers
British Mechanical Engineering Confederation	Lloyd's Register of Shipping
British Steel Industry*	Ministry of Defence
Concrete Society	Ministry of Defence (Army Department)*
Council of Iron Producers	National Association of Drop Forgers and Stampers
Council of Ironfoundry Associations	Oil Companies Materials Association
Department of Employment	Process Plant Association
Department of Trade and Industry (Marine Division)	Royal Institute of British Architects
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The Government department and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard.

Association of Bronze and Brass Founders	Light Metal Founders' Association
British Investment Casters' Technical Association	Ministry of Defence (Aviation Supply)

This British Standard having been approved by the Iron and Steel Industry Standards Committee, was published under the authority of the Executive Board on 30 September 1974

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First published September 1959
First revision September 1974

The following BSI references relate to the work on this standard:
Committee reference ISE/60
Draft for comment 71/42874

ISBN 0 580 08176 1

Amendments issued since publication

Amd. No.	Date of issue	Comments

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Foreword

This British Standard, which has been prepared under the authority of the Iron and Steel Industry Standards Committee, has been revised to meet the needs of industry in the rapidly growing field of investment castings. The advantages of investment castings of the type described in this standard are the complexity of the shapes that can be cast, and the accurate approach to final form that can be obtained without a large amount of machining which may be difficult. These advantages apply particularly to material that is extremely hard or tough.

The scope of the new edition has been enlarged and it is now being published in four parts. The other parts which complete the series are as follows:

- *Part 2: High alloy steels, nickel and cobalt alloys;*
- *Part 3: Vacuum melted alloys;*
- *Part 4: Non-ferrous alloys.*

It is intended that the Izod impact values given in Section 2 of this Part will be replaced by, Charpy V-notch impact values when sufficient data is available.

Stress unit conversions are given in Appendix B.

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.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 18, an inside back cover 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.

1 General requirements

1.1 Scope

This Part of this British Standard specifies requirements for carbon and low alloy steel investment castings complying with the general requirements of this Section and with the appropriate requirements of Section 2.

NOTE The titles of the British Standards referred to in this standard are listed on the inside back cover.

1.2 Definitions

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

1.2.1

investment castings

the production of castings by a process which involves the investment of an expendable pattern with a refractory slurry

1.2.2

remelting stock

metal supplied in cast or wrought form, the chemical composition of which has been established by analysis

1.2.3

melt

the product of a single furnace charge used to produce castings, or the amount of metal tapped from the furnace without any further addition of metal excluding deoxidants to the furnace or ladle (when a continuous process is employed)

1.2.4

heat treatment batch

castings of similar mass and dimensions produced from melts conforming to the same material specifications and heat treated together

1.2.5 Heat treatment definitions

1.2.5.1

annealing

heating to and holding at a suitable temperature, followed by cooling at a suitable rate, for such purposes as:

- 1) inducing softness
- 2) improving machinability
- 3) improving cold working properties
- 4) obtaining a desired structure
- 5) removing stresses.

NOTE When applicable, the more specific terms, i.e. full annealing, isothermal annealing, sub-critical annealing or stress relieving should be used.

Full annealing. Heating to and holding at some temperature above the austenite transformation range, followed by cooling slowly through the transformation range.

Isothermal annealing. Heating to and holding at some temperature above the austenite transformation range, then cooling to and holding at a suitable temperature until the austenite to pearlite transformation is complete, and finally cooling to room temperature.

Sub-critical annealing. Heating to and holding at some temperature below the austenite transformation range, followed by cooling at a suitable rate.

Stress relieving. Heating to and, if necessary, holding at some temperature generally below the austenite transformation range, usually followed by slow cooling, for the sole purpose of relieving internal stresses.

1.2.5.2

normalizing

heating to and, if necessary, holding at a suitable temperature above the austenite transformation range, followed by cooling in air, in order to modify the grain size, render the structure more uniform, and usually to improve the mechanical properties

1.2.5.3

hardening

increasing the hardness of steel by quenching from a temperature within or above the austenite transformation range

1.2.5.4

tempering

heating hardened or normalized steel to some temperature below the austenite transformation range, and holding for a suitable time at that temperature, followed by cooling at a suitable rate. This process is usually applied for the purpose of producing a desired combination of mechanical properties

1.2.5.5

blank carburizing

the carburizing heating cycle applied to a test bar but conducted without the carburizing medium

1.2.5.6

grain refining

heating from some temperature below the austenite transformation range to a suitable temperature above that range, followed by cooling at a suitable rate

1.3 Information to be supplied by the purchaser

The following information shall be stated on the enquiry and order. A drawing of the part to be made should be supplied in appropriate cases.

- 1) The number of this British Standard together with the type number and grade (if applicable) given in Section 2, e.g. BS 3146-1. CLA 1/A.
- 2) The condition in which the castings are to be supplied (see 1.9 and the relevant material specification in Section 2).
- 3) Whether non-destructive testing is required and, if so, which of the types specified in 1.13.
- 4) Whether consultation is required before castings are rectified.
- 5) Whether a certificate is required giving details of analysis, mechanical testing and non-destructive testing as appropriate.
- 6) Any special requirements of the purchaser.

1.4 Method of manufacture

The method and control of the manufacture of remelting stock shall be at the discretion of the melting stock manufacturer unless otherwise agreed between the founder and the melting stock manufacturer.

The method and control of the manufacture of castings shall be at the discretion of the founder unless otherwise agreed between the founder and the purchaser.

1.5 Freedom from contamination

All reasonable precautions shall be taken to prevent contamination during storage of materials used for the production of melts.

1.6 Chemical composition

1.6.1 Remelting stock. The chemical composition of stock for remelting shall be within the limits of the relevant material specification, unless otherwise stated on the founder's order. Residual elements and other elements not listed in the relevant material specification shall not be added deliberately, except for finishing the cast. No further additions shall be made to the cast or melt after the final analysis sample has been taken. The melting stock manufacturer shall supply to the founder the results of analysis for those elements specified. Care shall be taken to prevent contamination of the metal from preceding casts or melts.

1.6.2 Castings. The chemical composition of the castings shall conform to the relevant material specification. Residual elements and others not listed in the relevant material specification shall not be added deliberately except for the purpose of finishing the melt. All reasonable precautions shall be taken to prevent the addition of such elements arising from scrap or other materials used in the manufacture of the metal, and the purchaser by agreement with the founder may set a limit to one or more residual elements.

An analysis for residual elements is not normally carried out unless there is reason to suspect the presence of such elements in excessive amounts.

Care shall be taken to ensure that contamination of the metal does not occur from preceding heats.

If so stated on the enquiry and order, the founder shall supply a certificate of the chemical analysis on a basis agreed between the founder and the purchaser.

1.7 Tolerances

The castings shall conform to the tolerances as specified on the casting or drawing.

1.8 Freedom from defects

Castings shall be free from harmful defects. In the event of material proving defective during subsequent manufacturing operations, such material shall be deemed not to comply with the requirements of this standard, notwithstanding any previous certificate of satisfactory testing, provided the material has not been improperly treated after delivery. Surface or superficial imperfections may be removed, providing such rectification does not materially affect the strength, appearance or use for which the casting is intended. Any castings which have been subjected to rectification shall conform to such tolerances as are specified in 1.7.

1.9 Heat treatment

In the case of alloys which may be supplied in either the “as-cast” or heat treated condition, the condition required at the time of delivery shall be stated on the enquiry and/or order. In Section 2, if a temperature range is stated, a suitable temperature within that range shall be selected to give the required properties. Care shall be taken to prevent excessive oxidation or decarburization during any heat treatment process.

1.10 Provision and preparation of mechanical test samples

Test samples shall be provided by one of the following methods:

- 1) from separately cast test bars from an identical charge and cast under similar conditions;
- 2) from integrally cast test bars;
- 3) cut from castings.

In the case of test bars provided as required in 1) and 2), they shall conform to one of the types in Figure 1. The “carrot” type test sample is to be preferred.

NOTE 1 The properties obtained do not necessarily represent the properties of the castings themselves.

Unless otherwise agreed between the purchaser and the founder, where the material specification states that it is suitable for carburizing or nitriding, additional test samples shall be supplied to accompany castings through final heat treatment. The number of additional samples required shall be stated on the order.

NOTE 2 In alloys where mass effect becomes a factor during heat treatment, the ruling section of the test sample should be considered in relation to the ruling section of the casting.

1.11 Mechanical tests

1.11.1 General. Where the specified properties are dependent on heat treatment and unless otherwise agreed between the purchaser and the founder, one full set of tests per heat treatment batch shall be carried out. The test bars shall be heat treated with the castings they represent.

In all other cases, the type of tests and the frequency of testing shall be agreed between the purchaser and the founder.

1.11.2 Tensile test. The tensile test shall be carried out in accordance with BS 18-2. Test pieces shall be machined from test samples in the finally heat treated condition.

1.11.3 Hardness test. The hardness test shall be carried out in accordance with the requirements of BS 240-1, unless the Brinell test is considered unsuitable when other methods may be used. Considerable caution should be exercised when converting other hardness scales to Brinell (see BS 860).

1.11.4 Case depth and hardness test. Where the founder is required to carry out nitriding or carburizing, test samples shall be provided in accordance with the requirements of **1.10**.

For nitriding steels, at least one test sample shall be included with each nitriding batch. The sample shall have accompanied the castings it represents throughout all the heat treatment processes to which the castings are subject prior to nitriding.

For carburizing steels, at least one test sample shall be carburized with each batch of castings.

The depth of case of the nitrided or carburized test samples shall comply with drawing requirements, including a stated grinding allowance. At least one hardness test shall be carried out on the hardened case of each test sample. Hardness tests shall be carried out on the hardened case of castings at frequency agreed between the purchaser and the founder.

1.11.5 Impact test. The impact test shall comprise of a minimum of two notches and shall be carried out in accordance with the requirements of BS 131-1. Test pieces shall be machined from test samples in the finally heat treated condition.