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Specification for

Investment castings in metal —

**Part 2: Corrosion and heat resisting
steels, nickel and cobalt base alloys**

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British Cast Iron Research Association	Institution of Mechanical Engineers
British Constructional Steelwork Association	(Automobile Division)
British Ironfounders' Association	Institution of Production Engineers
British Mechanical Engineering Confederation	Institution of Structural Engineers
British Steel Industry*	Lloyd's Register of Shipping
Concrete Society	Ministry of Defence*
Council of Ironfoundry Associations	National Association of Drop Forgers
Department of Employment	and Stampers
Department of Industry (NPL)	Oil Companies Materials Association
Department of Trade (Marine Division)	Process Plant Association
Engineering Equipment Users' Association	Royal Institute of British Architects
Federation of Civil Engineering Contractors	Shipbuilders and Repairers'
Greater London Council	National Association
Institute of British Foundrymen*	Society of Motor Manufacturers and
Institute of Iron and Steel Wire Manufacturers	Traders Ltd.*
Institute of Marine Engineers	Steel Castings Research and Trade Association*
	Tin Research Institute

The Non-ferrous Metals Industry Standards Committee

Aluminium Federation	Institution of Production Engineers
Association of Bronze and Brass Founders*	Institution of Structural Engineers
British Electrical and Allied Manufacturers' Association	Lead Development Association
British Lead Manufacturers' Association	Light Metal Founders' Association*
British Non-ferrous Metals Federation	London Metal Exchange
British Non-ferrous Metals Technology Centre	Magnesium Industry Council
British Steel Industry*	Ministry of Defence*
Copper Development Association	National Brassfoundry Association
Department of Trade (Marine Division)	Non-ferrous Metal Stockists
Electric Cable Makers' Confederation	Post Office
Institute of British Foundrymen*	Royal Institute of British Architects
Institution of Mechanical Engineers	Society of Motor Manufacturers and
(Automobile Division)	Traders Ltd.*
Institution of Mining and Metallurgy	Tin Research Institute
	Zinc Development Association

The Government department and industrial organizations marked with an asterisk in the above lists, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard.

British Investment Casters' Technical Association.

Amendments issued since publication

Amd. No.	Date of issue	Comments
4767	March 1985	Indicated by a sideline in the margin

This British Standard, having been approved by the Iron and Steel and the Non-ferrous Metals Industry Standards Committees, was published under the authority of the Executive Board on 30 May 1975

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The following BSI references relate to the work on this standard:
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Foreword

This Part of this British Standard, which has been prepared under the authority of the Iron and Steel and the Non-ferrous Metals Industry Standards Committees, 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.

The scope of the new edition has been enlarged and it is now being published in 4 parts. The other parts which complete the series are as follows:

- *Part 1: Carbon and low alloy steel;*
- *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 are available.

Stress unit conversions are given in Appendix A.

Certification. Attention is drawn to the certification facilities described on the inside back cover of this standard.

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 to iv, pages 1 to 20, 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.

Section 1. General requirements

1 Scope

This Part of this British Standard specifies requirements for investment castings in corrosion and heat resisting steels and nickel and cobalt base alloys, complying with the general requirements of this section. and with the appropriate requirements of section 2.

2 References

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

3 Definitions

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

3.1

investment casting

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

3.2

remelting stock

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

3.3

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 having been added to the furnace or ladle (when a continuous process is employed) excluding deoxidants

3.4

heat treatment batch

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

the following heat treatment definitions apply

martensitic corrosion and heat resisting stainless steels

3.5

annealing

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

- a) inducing softness
- b) improving machinability
- c) obtaining a desired structure
- d) removing stresses

3.6

hardening

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

3.7

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

austenitic and precipitation hardening alloys

3.8

precipitation treatment (ageing)

the heat treatment of alloys to promote precipitation to produce optimum creep, or stress rupture and/or tensile characteristics. It may be accompanied by a change in hardness

3.9

solution treatment

the heat treatment of alloys normally intended for subsequent precipitation treatment, at a suitable temperature for sufficient time to ensure adequate solution of the precipitation phase(s), followed by cooling at a rate sufficient to retain the phase(s) in solution. The term is also associated with material in the softest condition

3.10

softening or annealing heat treatment

the heat treatment designed to give a soft, ductile product and normally associated with recrystallization of the material

NOTE 1 The terms are generally applied to alloys not subjected to precipitation treatment.

NOTE 2 A “softening” treatment is sometimes applied to alloys which are suitable for precipitation treatment in order to eliminate the effect of cold work. This treatment may effect an incomplete solution of the precipitated phase(s).

4 Information to be supplied by the purchaser

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

- a) The number of this British Standard together with the type number and grade (if applicable) given in section 2, e.g. BS 3146/2 ANC 1/A.
- b) The condition in which the castings are to be supplied. (See clause 10 and section 2.)
- c) Whether non-destructive testing is required and, if so, the details which have been agreed. (See clause 14.)
- d) Whether consultation is required before castings are rectified. (See clause 15.)
- e) Whether a certificate is required, giving details of analysis, mechanical testing and non-destructive testing, as appropriate. (See clause 17.)
- f) Whether the hardness of the castings is required for type ANC 1, type ANC 2 and type ANC 22.
- g) Any special requirements of the purchaser.

5 Method of manufacture

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

6 Freedom from contamination

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

7 Chemical composition

7.1 Remelting stock. The 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 the purpose of 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 the analysis for those elements specified. Care should be taken to prevent contamination of the metal from preceding casts or melts.

7.2 Castings. The chemical composition of the castings shall conform to the appropriate material specification given in section 2. 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. (See also clause 17.)

8 Tolerances

The castings shall be within the dimensional tolerances as specified on the casting drawing or order.

9 Freedom from defects

Castings shall be free from harmful defects. Notwithstanding previous acceptance as complying with the requirements of this standard, any casting which is later found to contain harmful defects shall be rejected. 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 clause 8.

10 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 should be taken to prevent excessive oxidation or decarburization during any heat treatment process.

11 Provision and preparation of test samples

Where required, test samples shall be provided as follows:

- a) from separately cast test bars from an identical charge and cast under similar conditions;
- b) from integrally cast test bars;
- c) cut from castings.

In the case of test bars provided as in a) and b) they shall conform to one of the types in Figure 1.

Unless otherwise agreed between the purchaser and the founder where or when castings are supplied in other than the finally heat treated condition, additional test pieces shall be supplied to accompany the castings through the final heat treatment. The number of additional samples required shall be stated on the order.

NOTE In alloys where mass effect becomes a factor during heat treatment, the ruling section of the test piece should be related to the ruling section of the casting.

12 Tests

12.1 General. Tensile, bend and impact test pieces shall be machined from test samples in fully heat treated condition to one of the standard test pieces shown in the appropriate British Standard.

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.

12.2 Tensile test. The tensile test shall be carried out in accordance with BS 18-2.

12.3 Bend test. The bend test shall be carried out in accordance with BS 1639.

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

12.5 Impact test. The impact test shall comprise a minimum of two notches and shall be carried out in accordance with the requirements of BS 131-1.