BRITISH STANDARD

BS 3100:1991

Incorporating
Amendment No. 1

Specification for

Steel castings for general engineering purposes

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Iron and Steel Standards Policy Committee (ISM/-) to Technical Committee ISM/6, upon which the following bodies were represented:

Associated Offices Technical Committee
BEAMA Ltd.
British Gas plc
British Railways Board
British Steel Industry
British Valve and Actuator Manufacturers' Association
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
Institute of British Foundrymen
Institution of Mechanical Engineers
Lloyds Register of Shipping
Ministry of Defence
Nickel Development Institute
Process Plant Association
Steel Castings Research and Trade Association
Coopted member

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Contents

Foreword

This British Standard has been prepared under the direction of the Iron and Steel Standards Policy Committee and is a revision of BS 3100:1976 which is withdrawn.

This revision includes seven additional steels and ten steels have been deleted.

The designation system for carbon and alloy steels used in this standard consists of one or two letters followed by a number. The first letter consists of one of the following:

A for carbon and carbon manganese steels
B for low alloy steels

The second letter (if appropriate) consists of one of the following:

No letter for general purpose use
L for low temperature toughness
W for wear resistance
T with higher tensile strength (low alloy steels only)
M with specified magnetic properties (carbon steels only)

These letters are followed by a number which is arbitrary.

For corrosion resisting, heat resisting and high alloy steel castings, wherever possible the first three digits correspond to the AISI stainless steel designation. The letter C as the fourth character denotes casting and the last two digits are arbitrary.

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 14, 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 Scope

This British Standard specifies chemical composition, heat treatment and mechanical properties for steel castings intended for general engineering purposes. A number of steels are given to cover elevated temperature, low temperature, abrasive and corrosive service conditions.

Appendix A gives requirements for information to be supplied by the purchaser.

Appendix B lists additional options which may be specified by the purchaser.

Appendix C gives test procedures for sampling and testing.

NOTE 1 While steel castings complying with this standard may be used for pressure containing parts, reference should be made to BS 1504, for steels with elevated temperature properties.

NOTE 2 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

2.1
ruling section

that combination of dimensions of a casting which has the greatest influence on the rate of cooling and hence on the mechanical properties developed in the casting

2.2
melt

one melting furnace charge of steel

2.3
cast

a ladle of liquid steel consisting of one or more melts

3 Information to be supplied by the purchaser

3.1 General

Information to be supplied by the purchaser is given in appendix A.

3.2 Options

A number of options are specified in appendix B. In the event that the purchaser does not indicate his wish to implement any of these options and specify his requirements at the time of enquiry and order, the manufacturer shall supply the purchaser with steel castings in accordance with the base specification.

4 Chemical composition

4.1 Composition ranges

The chemical composition of the steel shall be determined by cast analysis and shall comply with Table 1 or Table 2. Deviations on check analysis are given in Table 3 and Table 4. The deviations, other than where maxima only are specified, apply either above or below the specified limits of the range but not both above and below for the same element from different samples for the same cast. If a product analysis is required see option **B.1**.

For steels 302C25, 304C12, 304C15, 347C17, 316C12, 316C16, 317C16 and 318C17, a free cutting steel may be specified (see option **B.2**). In this case, the properties given for these steels in Table 4 shall not apply.

4.2 Residual elements

Elements designated as residual elements in the individual specifications shall not be intentionally added to the steel. See also option **B.3**.

5 Mechanical properties

NOTE The mechanical properties given in Table 5 and Table 6 apply to separately cast or attached test blocks and not to the castings themselves. See also option **B.4**.

5.1 Tensile properties

Tensile properties of test pieces, when prepared and tested in accordance with appendix C, shall comply with Table 5 or Table 6.

5.2 Impact properties

Impact properties of test pieces, when prepared and tested in accordance with appendix C, shall comply with Table 5 orTable 6.

5.3 Bending

The bend test piece shall comply with Table 5 when prepared and tested in accordance with appendix C. The test piece shall have no cracks or other open defects exceeding 3 mm in any direction on the convex surface after bending.

NOTE For steels A1, A2, B1, B2, B3, B4 and B5, a bend test is carried out unless the purchaser specifies an impact test in which case a bend test is not carried out. See appendix A.

5.4 Hardness

Where hardness properties are given in the material specification the hardness of the casting shall comply with Table 5 or Table 6 when tested in accordance with appendix C. For steels A4, A5, A6, B2, B3, B4, BS, B6, 410C21, 420C28, 420C29, 425C12 and 425C11, see option **B.5**.

Table 1 — Chemical composition limits[a] for the cast analysis of carbon, carbon manganese and low alloy steel castings

Steel	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Nb	Sn	V	Total residuals max.
	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)
Carbon and carbon-manganese steels													
A1[b]	0.25	0.60	0.90	0.050	0.050	0.30[c]	0.15[c]	0.40[c]	0.30[c]	—	—	—	0.80
A2[b]	0.35	0.60	1.0	0.050	0.050	—	—	—	—	—	—	—	—
A3[b]	0.45	0.60	1.0	0.050	0.050	—	—	—	—	—	—	—	—
A4	0.18 to 0.25	0.60	1.2 to 1.6	0.050	0.050	—	—	—	—	—	—	—	—
A5	0.25 to 0.33	0.60	1.2 to 1.6	0.050	0.050	—	—	—	—	—	—	—	—
A6	0.25 to 0.33	0.60	1.2 to 1.6	0.050	0.050	—	—	—	—	—	—	—	—
For use at low temperatures													
AL1[d]	0.20	0.60	1.1	0.040	0.040	0.30[c]	0.15[c]	0.40[c]	0.30[c]	—	—	—	0.80
AL2[e]	0.25	0.60	1.2	0.040	0.040	0.30[c]	0.15[c]	0.40[c]	0.30[c]	—	—	—	0.80
AL3[e]	0.25	0.60	1.2	0.040	0.040	0.30[c]	0.15[c]	0.40[c]	0.30[c]	—	—	—	0.80
BL2	0.12	0.60	0.80	0.030	0.030	—	—	3.0 to 4.0	—	—	—	—	—
High magnetic permeability													
AM1	0.15	0.60	0.50	0.050	0.050	0.30[c]	0.15[c]	0.40[c]	0.30[c]	—	—	—	0.80
AM2	0.25	0.60	0.50	0.050	0.050	0.30[c]	0.15[c]	0.40[c]	0.30[c]	—	—	—	0.80
For case hardening													
AW1	0.10 to 0.18	0.60	0.60 to 1.0	0.050	0.050	0.30[c]	0.15[c]	0.40[c]	0.30[c]	—	—	—	0.80
Resistance to wear and for surface hardening													
AW2	0.40 to 0.50	0.60	1.0	0.050	0.050	0.30[c]	0.15[c]	0.40[c]	0.30[c]	—	—	—	0.80
AW3	0.50 to 0.60	0.60	1.0	0.050	0.050	0.30[c]	0.15[c]	0.40[c]	0.30[c]	—	—	—	0.80

Table 1 — Chemical composition limits[a] for the cast analysis of carbon, carbon manganese and low alloy steel castings

Steel	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Nb	Sn	V	Total residuals max.
	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)
For use at elevated temperatures													
B1	0.20	0.20 to 0.60	0.40 to 1.0	0.040	0.040	0.30[c]	0.45 to 0.65	0.40[c]	0.30[c]	—	—	—	0.80
B2	0.20	0.60	0.50 to 0.80	0.040	0.040	1.0 to 1.5	0.45 to 0.65	0.40[c]	0.30[c]	—	—	—	—
B3	0.18	0.60	0.40 to 0.70	0.040	0.040	2.0 to 2.75	0.90 to 1.20	0.40[c]	0.30[c]	—	—	—	—
B4	0.25	0.75	0.30 to 0.70	0.040	0.040	2.50 to 3.50	0.35 to 0.60	0.40[c]	0.30[c]	—	—	—	—
B5	0.20	0.75	0.40 to 0.70	0.040	0.040	4.0 to 6.0	0.45 to 0.65	0.40[c]	0.30[c]	—	—	—	—
B6	0.20	1.0	0.30 to 0.70	0.040	0.040	8.0 to 10.0	0.90 to 1.20	0.40[c]	0.30[c]	—	—	—	—
B7	0.10 to 0.15	0.45	0.40 to 0.70	0.030	0.030	0.30 to 0.50	0.40 to 0.60	0.30[c]	0.30[c]	—	0.025[c]	0.22 to 0.30	—
Higher tensile strengths													
BT1[f]	—	—	—	0.040	0.040	—	—	—	—	—	—	—	—
BT2[f]	—	—	—	0.040	0.040	—	—	—	—	—	—	—	—
BT3[f]	—	—	—	0.030	0.030	—	—	—	—	—	—	—	—
For resistance to abrasion													
BW2	0.45 to 0.60	0.75	0.50 to 1.0	0.040	0.040	0.80 to 1.5	0.40	—	—	—	—	—	—
BW3	0.45 to 0.60	0.75	0.50 to 1.0	0.040	0.040	0.80 to 1.5	0.40	—	—	—	—	—	—
BW4	0.45 to 0.60	0.75	0.50 to 1.0	0.040	0.040	0.80 to 1.5	0.40	—	—	—	—	—	—
For resistance to wear involving impact													
BW10	1.0 to 1.35	1.0	11.0 min.	0.050	0.050	—	—	—	—	—	—	—	—

[a] Composition in percentage mass by mass maximum unless shown as a range or as a minimum.
[b] For each reduction of 0.01 % C below the maximum specified an increase of 0.04 % Mn above the maximum specified shall be permitted up to a maximum of 1.1 % Mn.
[c] Residual elements.
[d] Manganese/carbon ratio shall exceed 3 : 1.
[e] For each reduction of 0.01 % % C below the maximum specified, an increase of 0.04 % Mn above the maximum specified shall be permitted up to a maximum of 1.4 % Mn.
[f] The composition range for these steels shall be such as to give adequate hardenability through the maximum section thickness of the casting.

Table 2 — Chemical composition limits[a] for the cast analysis of corrosion resisting, heat resisting and high alloy steel castings

Steel	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Nb	Sn	V	N_2
	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)
410C21	0.15	1.0	1.0	0.040	0.040	11.5 to 13.5	—	1.0	0.30[b]	—	—	—	—
420C28	0.20	1.0	1.0	0.040	0.040	11.5 to 13.5	—	1.0	0.30[b]	—	—	—	—
420C29	0.20	1.0	1.0	0.040	0.040	11.5 to 13.5	—	1.0	0.30[b]	—	—	—	—
425C12	0.06	1.0	1.0	0.040	0.030	11.5 to 14.0	0.40 to 1.0	3.5 to 4.5	—	—	—	—	—
425C11	0.10	1.0	1.0	0.040	0.030	11.5 to 13.5	0.60	3.4 to 4.2	—	—	—	—	—
302C25[c]	0.12	1.5	2.0	0.040	0.040	17.0 to 21.0	—	8.0 min.	—	—	—	—	—
304C12[c]	0.03	1.5	2.0	0.040	0.040	17.0 to 21.0	—	8.0 to 12.0	—	—	—	—	—
304C12LT196	0.03	1.5	2.0	0.040	0.040	17.0 to 21.0	—	8.0 to 12.0	—	—	—	—	—
304C15[c]	0.08	1.5	2.0	0.040	0.040	18.0 to 21.0	—	8.0 to 11.0	—	—	—	—	—
304C15LT196	0.08	1.5	2.0	0.040	0.040	18.0 to 21.0	—	8.0 to 11.0	—	—	—	—	—
347C17[c]	0.08	1.5	2.0	0.040	0.040	18.0 to 21.0	—	9.0 to 12.0	—	8 × C to 1.0[d]	—	—	—
316C12[c]	0.03	1.5	2.0	0.040	0.040	17.0 to 21.0	2.0 to 3.0	9.0 min.	—	—	—	—	—
316C12LT196	0.03	1.5	2.0	0.040	0.040	17.0 to 21.0	2.0 to 3.0	9.0 min.	—	—	—	—	—
316C16[c]	0.08	1.5	2.0	0.040	0.040	17.0 to 21.0	2.0 to 3.0	9.0 min.	—	—	—	—	—
316C16LT196	0.08	1.5	2.0	0.040	0.040	17.0 to 21.0	2.0 to 3.0	9.0 min.	—	—	—	—	—
317C16[c]	0.08	1.5	2.0	0.040	0.040	17.0 to 21.0	3.0 to 4.0	9.0 min.	—	—	—	—	—
318C17[c]	0.08	1.5	2.0	0.040	0.040	17.0 to 21.0	2.0 to 3.0	9.0 min.	—	8 × C to 1.0[d]	—	—	—
332C11	0.07	1.5	1.5	0.040	0.040	19.0 to 22.0	2.0 to 3.0	27.5 to 30.5	3.0 to 4.0	—	—	—	—
332C13	0.04	1.0	1.0	0.040	0.040	24.5 to 26.5	1.75 to 2.25	4.75 to 6.0	2.75 to 3.25	—	—	—	—
332C15	0.08	1.5	1.5	0.040	0.040	21.0 to 27.0	1.75 to 3.0	4.0 to 7.0	—	—	—	—	0.10 to 0.25
For use at high temperatures													
420C24	0.25	2.0	1.0	0.050	0.050	12.0 to 16.0	—	—	—	—	—	—	—
452C11	1.0	2.0	1.0	0.050	0.050	25.0 to 30.0	1.5	4.0	—	—	—	—	—

Table 2 — Chemical composition limits[a] for the cast analysis of corrosion resisting, heat resisting and high alloy steel castings

Steel	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Nb	Sn	V	N_2
	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)
452C12	1.0 to 2.0	2.0	1.0	0.050	0.050	25.0 to 30.0	1.5	4.0	—	—	—	—	—
302C35	0.2 to 0.4	2.0	2.0	0.050	0.050	17.0 to 22.0	1.5	6.0 to 10.0	—	—	—	—	—.
309C30	0.5	2.5	2.0	0.050	0.050	22.0 to 27.0	1.5	10.0 to 14.0	—	—	—	—	—
309C40	0.5	2.0	2.0	0.050	0.050	25.0 to 30.0	1.5	8.0 to 12.0	—	—	—	—	—
310C45	0.5	3.0	2.0	0.050	0.050	22.0 to 27.0	1.5	17.0 to 22.0	—	—	—	—	—
311C11	0.5	3.0	2.0	0.050	0.050	17.0 to 23.0	1.5	23.0 to 28.0	—	—	—	—	—
330C12	0.75	3.0	2.0	0.050	0.050	13.0 to 20.0	1.5	30.0 to 40.0	—	—	—	—	—
331C60	0.75	3.0	2.0	0.050	0.050	15.0 to 25.0	1.5	36.0 to 46.0	—	—	—	—	—
334C11	0.75	3.0	2.0	0.050	0.050	10.0 to 20.0	1.5	55.0 to 65.0	—	—	—	—	—
309C32[c]	0.20 to 0.45	1.5	2.5	0.040	0.040	24.0 to 28.0	1.5	11.0 to 14.0	—	—	—	—	0.2
309C35	0.20 to 0.50	1.5	2.0	0.040	0.040	24.0 to 28.0	1.5	11.0 to 14.0	—	—	—	—	—
310C40[c]	0.30 to 0.50	1.5	2.0	0.040	0.040	24.0 to 27.0	1.5	19.0 to 22.0	—	—	—	—	—
330C11	0.35 to 0.55	1.5	2.0	0.040	0.040	13.0 to 17.0	1.5	33.0 to 37.0	—	—	—	—	—
331C40	0.35 to 0.55	1.5	2.0	0.040	0.040	17.0 to 21.0	1.5	37.0 to 41.0	—	—	—	—	—

[a] Composition in percentage mass by mass maximum unless shown as a range or a minimum.
[b] Residual elements.
[c] These steels can be appreciably magnetic.
[d] C is the carbon content.

Table 3 — Permissible deviation from the specified composition for carbon, carbon manganese and low alloy steel castings

Element	Maximum of specification range	Permissible deviation from the specified range
	%(*m*/*m*)	%(*m*/*m*)
Carbon	≤ 0.35	± 0.03
	> 0.35	± 0.04
Silicon	1.0	± 0.05
Manganese	≤ 2.0	± 0.10
	≥ 10.0	± 0.15
Phosphorus	≤ 0.050	+ 0.005
Sulphur	≤ 0.050	+ 0.005
Chromium	≤ 10.0	± 0.10
Molybdenum	≤ 0.35	± 0.04
	> 0.35 ≤ 1.2	± 0.05
Nickel	≤ 5.0	± 0.07
Vanadium	≤ 0.30	+ 0.03

Table 4 — Permissible deviation from the specified composition for corrosion resisting, heat resisting and high alloy steel castings

Element	Maximum of specification range	Permissible deviation from the specified range
	%(*m*/*m*)	%(*m*/*m*)
Carbon	≤ 0.03	± 0.005
	> 0.03 ≤ 0.25	± 0.01
	> 0.25	± 0.03
Silicon	≤ 1.0	± 0.05
	> 1.0 ≤ 2.0	± 0.06
Manganese	≤ 1.0	+ 0.04
	> 1.0 ≤ 2.0	+ 0.05
Phosphorus	≤ 0.030	+ 0.003
	> 0.030 ≤ 0.050	+ 0.004
Sulphur	≤ 0.030	+ 0.003
	> 0.030 ≤ 0.050	+ 0.004
Chromium	≤ 10.0	± 0.10
	> 10.0 ≤ 15.0	± 0.15
	> 15.0 ≤ 20.0	± 0.20
	> 20.0	± 0.25
Molybdenum	≤ 1.0	+ 0.04
	> 1.0 ≤ 2.0	± 0.05
	> 2.0 ≤ 4.0	± 0.08
Nickel	≤ 1.0	± 0.03
	> 1.0 ≤ 2.0	± 0.05
	> 2.0 ≤ 5.0	± 0.07
	> 5.0 ≤ 10.0	± 0.10
	> 10.0 ≤ 20.0	± 0.15
	> 20.0	± 0.20
Copper	≥ 2.0 ≤ 5.0	± 0.07
Niobium	≤ 1.0	± 0.05
Nitrogen	≤ 0.25	± 0.01

6 Magnetic properties

Where magnetic properties are required for AM1 or AM2, see option **B.6**. Where austenitic stainless steels are required in the non-magnetic condition see option **B.7**.

7 Intercrystalline corrosion testing

Where intercrystalline corrosion testing is required for 302C25, 304C12, 304C15, 347C17, 316C12, 316C16, 317C16 or 318C17, see option **B.8**.

8 Heat treatment

The castings shall be heat-treated in compliance with Table 5 or Table 6.

NOTE Steels 420C24, 452C11, 452C12, 302C35, 309C30, 309C40, 310C45, 311C11, 330C12, 331C60, 334C11, 309C32, 309C35, 310C40, 330C11 and 331C40 are supplied in the as-cast condition.

9 Fettling and dressing

All castings shall be fettled and dressed and all surfaces shall be prepared for inspection purposes.

10 Rectification by welding

Rectification by welding shall be carried out in compliance with BS 4570. See also option **B.9** and **B.10**.

11 Surface quality and further inspection

11.1 Surface quality

All accessible surfaces shall be visually inspected.

NOTE Acceptance criteria should be agreed at the time of enquiry and order.

11.2 Further inspection

No further inspection shall be carried out by the manufacturer.

The castings shall be deemed not to comply with this British Standard in the event of subsequent manufacturing operations revealing discontinuities, in castings accepted in the unmachined condition, which are capable of detection by the agreed inspection techniques prior to dispatch from the foundry and of a severity level greater than the acceptance criteria agreed between the manufacturer and purchaser.

The castings shall be deemed to comply with this British Standard if the discontinuities revealed by further manufacturing operations, in castings accepted in the unmachined condition, are not capable of detection by the agreed inspection technique and are found to be of a severity level greater than the agreed acceptance criteria, or are capable of detection by the agreed inspection technique and are of a severity level less than the agreed acceptance criteria. See also option **B.11**.

12 Marking

Each casting shall be either of the following:

a) marked with cast or stamped symbols representing the steel; or

b) for small castings, packaged and labelled with symbols representing the steel.

13 Manufacturer's certificate and traceability

Where a manufacturer's certificate is required, see option **B.13**.

Where full traceability is required, see option **B.14**.

14 Delivery condition

Castings shall be delivered in the unmachined condition with the heads and gates removed, fettled and dressed. Accessible surfaces shall be free from adhering sand and heat treatment scale. Where castings are required in the machined condition, see option **B.12**.

Table 5 — Mechanical properties and heat treatment processes of carbon, carbon manganese and low alloy steel castings

Steel	Lower yield stress R_{eL} or 0.2 % proof stress $R_{p0.2}$ min.	Tensile strength R_m min.	Elongation A % min. ($L_o = 5.65\sqrt{S_o}$)	Charpy V-notch		Angle of bend	Radius of bend	Brinell hardness	Final heat treatment[a]
				energy	temp.				
	N/mm^2	N/mm^2	%	J	°C	°	mm	HB	
A1[bc]	230	430	22	27	20	120	$1.5t^d$	—	A or N
A2[bc]	260	490	18	20	20	90	$1.5t^d$	—	or N + T or OQ + T or WQ + T
A3[b]	295	540	14	18	20	—	—	—	or N + T or OQ + T or WQ + T
A4	320	540 to 690	16	30	20	—	—	—	N or N + T or OQ + T or WQ + T
A5	370	620 to 770	13	25	20	—	—	—	(up to 100 mm thickness) N or N + T or OQ + T or WQ + T
A6	495	690 to 850	13	25	20	—	—	—	(up to 63 mm thickness) OQ + T or WQ + T
AL1[b]	230	430	22	20	– 40	—	—	—	N or N + T or OQ + T or WQ + T
AL2[b]	275	485 to 655	22	20	– 46	—	—	—	
AL3[e]	275	485 to 655	22	27	– 46	—	—	—	
AM1	185	340 to 430	22	—	—	120	$1.5t^d$	—	A or N
AM2	215	400 to 490	22	—	—	120	$1.5t^d$	—	
AW1[f]		460 min.	12	25	20	—	—	—	As-cast
AW2	325	620 min.	12	—	—	—	—	—	A or N or N + T
AW3	370	690	8	—	—	—	—	—	A or N or N + T
B1[c]	260	460	18	20	20	120	$1.5t^d$		N + T or OQ + T or WQ + T (T 680 °C max.)
B2[c]	280	480	17	30	20	120	$1.5t^d$	—	N + T or OQ + T or WQ + T (T 700 °C max.)
B3[c]	325	540	17	25	20	120	$3.0t^d$	—	N + T or OQ + T or WQ + T (T 720 °C max.)
B4[c]	370	620	13	25	20	120	$3.0t^d$	—	
B5[c]	420	620	13	25	20	90	$3.0t^d$	—	
B6	420	620	13	—	—	—		—	
B7	295	510	17	—	—	120	$3.0t^d$	—	N + T (N 950 °C to 1 000 °C, T 720 °C max.)

Table 5 — Mechanical properties and heat treatment processes of carbon, carbon manganese and low alloy steel castings

Steel	Lower yield stress R_{eL} or 0.2 % proof stress $R_{p0.2}$ min.	Tensile strength R_m min.	Elongation A % min. ($L_o = 5.65\sqrt{S_o}$)	Charpy V-notch		Angle of bend	Radius of bend	Brinell hardness	Final heat treatment[a]
				energy	temp.				
	N/mm^2	N/mm^2	%	J	°C	°	mm	HB	
BL2	280	460	20	20	– 60	—	—	—	N + T or OQ + T or WQ + T
BT1[g]	495	690	11	35	20	—	—	201 to 279	AH + T or OQ + T or WQ + T
BT2[g]	585	850	8	25	20	—	—	248 to 327	AH + T or OQ + T or WQ + T
BT3[g]	695	1 000	6	20	20	—	—	293 to 362	
BW2	—	—	—	—	—	—	—	201 to 255[h]	A or AH + T or OQ + T or WQ + T
BW3	—	—	—	—	—	—	—	293 min.[h]	
BW4	—	—	—	—	—	—	—	341 min.[h]	
BW10	—	—	—	—	—	—	—	—	ST (1 000 °C min.)

[a] Heat treatment designations are as follows.

A for anneal by heating to a temperature above the AC_3 and cool in the furnace.

N for normalize by heating to a temperature above AC_3 and cool in still air.

OQ for quench into oil from a temperature above AC_3.

WQ for quench into water from a temperature above AC_3.

AH for air harden by heating to a temperature above AC_3 and cool in air at a rate fast enough to produce a hardened microstructure.

T for temper by heating to a temperature below AC_1.

ST for solution treat by heating to a temperature high enough to dissolve carbides and any intermetallic phases followed by a rapid cool.

[b] If attached test blocks are used, the mechanical properties can only be expected in those cases where the maximum section thickness of the casting is less than 500 mm. Where castings include sections of greater thickness the purchaser should agree, with the manufacturer, the mechanical properties to be obtained from such test blocks.

[c] Where the purchaser requires an impact test for these grades, a bend test is not performed.

[d] t is the thickness of the test piece.

[e] Steel AL3 is only suitable for small section castings.

[f] For steel AW1, test pieces are blank carburized for 8 h at 880 °C to 930 °C, refined at 870 °C to 920 °C, cooled in air, oil or water then WQ from 760 °C to 780 °C.

[g] Where, due to the mass or design, it is not practicable to liquid quench the castings, it may not be possible to achieve the specified impact properties. In such cases the values to be obtained should be agreed between the manufacturer and purchaser at the time of enquiry or order.

[h] The Brinell hardness values for BW2, BW3 and BW4 are not applicable when castings are supplied in the annealed condition.

Table 6 — Mechanical properties and heat treatment processes for corrosion-resisting and heat resisting and high alloy steel castings

Steel	Lower yield stress R_{eL} or 0.2 % proof stress $R_{p0.2}$ min.	Tensile strength R_m min.	Elongation A % min. ($L_o = 5.65\sqrt{S_o}$)	Charpy V-notch		Angle of bend	Radius of bend	Brinell hardness	Final heat treatment[a]
				energy	temp.				
	N/mm^2	N/mm^2	%	J	°C	°	mm	HB	
410C21	370	540	15	—	—	—	—	—	AH + T or OQ + T (T at 750 °C max.)
420C28	450	620	13	—	—	—	—	—	
420C29	465	690	11	—	—	—	—	—	
425C12	550	755	15	—	—	—	—	—	AH or OQ (from 950 °C to 1 050 °C) and T (590 °C to 650 °C) or AH or OQ (from 950 °C to 1 050 °C), T (660 °C to 700 °C) and cool in air to below 95 °C and T (590 °C to 620 °C)
425C11	620	770	12	30	20	—	—	—	AH or OQ (from 950 °C to 1 050 °C) and T (590 °C to 650 °C)
	1 % proof stress $R_p1.0$ min.								
302C25	240	480	26	—	—	—	—	—	ST (1 000 °C to 1 100 °C)
304C12	215	430	26	—	—	—	—	—	
304C15	215	480	26	—	—	—	—	—	
347C17	215	480	22	—	—	—	—	—	
304C12LT196	215	430	26	41	– 196	—	—	—	
304C15LT196	215	480	26	41	– 196	—	—	—	
316C12	215	430	26	—	—	—	—	—	ST (1 050 °C to 1 150 °C)
316C12LT196	215	430	26	41	– 196	—	—	—	
316C16	240	480	26	—	—	—	—	—	

Table 6 — Mechanical properties and heat treatment processes for corrosion-resisting and heat resisting and high alloy steel castings

Steel	1 % proof stress R_P 1.0 min.	Tensile strength R_m min.	Elongation A % min. ($L_o = 5.65\sqrt{S_o}$)	Charpy V-notch		Angle of bend	Radius of bend	Brinell hardness	Final heat treatment[a]
				energy	temp.				
	N/mm^2	N/mm^2	%	J	°C	°	mm	HB	
316C16LT196	240	480	26	41	– 196	—	—	—	ST (1 050 °C to 1 150 °C)
317C16	240	480	22	—	—	—	—	—	
318C17	240	480	18	—	—	—	—	—	
332C11	170	425	34	—	—	—	—	—	ST (1 120 °C min.)
332C13	485	690	16	25	20	—	—	—	ST (1 050 °C min.)
332C15	430	640	30	25	20	—	—	—	ST (1 110 °C min.)
309C32[b]	—	560	3	—	—	—	—	—	As cast
309C35	—	510	7	—	—	—	—	—	As cast
310C40	—	450	7	—	—	—	—	—	As cast
330C11	—	450	3	—	—	—	—	—	As cast
331C40	—	450	3	—	—	—	—	—	As cast

[a] Heat treatment designations are as follows.

OQ for quench into oil form a temperature above AC_3.

AH for air harden by heating to a temperature above AC_3 and cool in air at a rate fast enough to produce a hardened microstructure.

T for temper by heating to a temperature below AC_1.

ST for solution treat by heating to a temperature high enough to dissolve carbides and any intermetallic phases followed by a rapid cool.

[b] For steel 309C32, test pieces are heat treated for 24 h at 760 °C ± 15 °C and cooled in air.

Appendix A Information to be supplied by the purchaser

The following information should be supplied by the purchaser to the manufacturer at the time of enquiry and order.

a) A description of the casting(s) by pattern number and/or drawing. When a pattern is supplied, a description of the pattern equipment should be included.

NOTE Where no drawing is supplied, the casting is purchased on the basis of "as per pattern" and the foundry is not responsible for the dimensions of the part, unless they result from inadequate foundry practice.

b) Dimensional tolerances, including machining allowances. The datum points for machining and measuring should be included in the drawing.

c) The complete designation of the steel, e.g. BS 3100:1990 steel A1.

d) Whether an impact test should be carried out instead of a bend test for steels A1, A2, B1, B2, B3, B4 or B5.

e) Details of options required.

Appendix B Options

B.1 Product analysis

The casting shall be subjected to product analysis to verify that it complies with the requirements of the purchaser (see clause **4**).

B.2 Free cutting steels

Free-cutting steel to be supplied by the manufacturer, if specified in the purchase order, shall be identified by the suffix F, e.g. 302C25F.

Chemical composition and mechanical properties shall be agreed between the purchaser and manufacturer.

B.3 Residual elements

Analysis of residual elements given in Table 1 or Table 2 shall be supplied.

B.4 Mechanical testing

The steel shall not be subjected to mechanical testing.

B.5 Hardness

Hardness tests shall be carried out on areas of the surface of the casting to be agreed between purchaser and manufacturer. The results shall comply with Table 7.

B.6 Magnetic properties

Magnetic properties of the steel shall be determined in accordance with BS 6404-4. Magnetic properties for steels AM1 and AM2 are given in Table 8 for information only.

B.7 Non-magnetic austenitic stainless steels

If the purchaser specifies that an austenitic stainless steel is to be non-magnetic, the chemical composition, mechanical properties and test method shall be agreed between the purchaser and manufacturer.

B.8 Intercrystalline corrosion test

A special bend test shall be performed on test pieces representing the castings in accordance with BS 5903:1980. The test pieces from steels 302C25 and 304C15 shall not be submitted to the sensitizing heat treatment at 650 °C.

Table 7 — Hardness values for castings

Steel	Brinell hardness
	HB
A4	152 to 207
A5	179 to 229
A6	201 to 255
B2	140 to 212
B3	156 to 235
B4	179 to 255
B5	179 to 255
B6	179 to 255
410C21	152 to 207
420C28	179 to 235
420C29	201 to 255
425C12	262 max.
425C11	321 max.

Table 8 — Magnetic properties for steels AM1 and AM2

AM1		AM2	
Magnetic field strength *H*	Minimum magnetic flux density *B*	Magnetic field strength *H*	Minimum magnetic flux density *B*
A/m	T	A/m	T
640	1.0	800	1.0
1 600	1.4	2 240	1.4
2 400	1.5	3 200	1.5
6 800	1.7	8 800	1.7
18 800	1.9	—	—

B.9 Rectification by welding

The purchaser shall be informed that the casting is to be rectified by welding before any repair is carried out.

B.10 Weld procedure documentation

Weld procedure documentation shall be supplied to the purchaser together with any details of post-weld heat treatment.

B.11 Non-destructive examination

Acceptance criteria and a method of examination should be agreed between purchaser and manufacturer at the time of enquiry and order.

Following any rectification by welding, castings shall be re-examined in the area of the repair by the method and to the acceptance criteria specified on the order.

NOTE Methods include BS 4080:1966, BS 4080-1 and BS 4080-2, and BS 6208.

B.12 Machined castings

Where castings are required in the machined condition, requirements should be agreed at the time of enquiry and order.

B.13 Test certificate

The manufacturer shall supply the test certificate selected by the purchaser from prEN 10204.

B.14 Traceability

Full traceability shall be maintained.

B.15 Representative test blocks

Test blocks with ruling sections equivalent to those of the castings they represent shall be provided, the dimensions of the test block shall be agreed between purchaser and manufacturer but shall be not less than 28 min.

B.16 Cast-on test blocks

Test blocks shall be cast-on to the casting. They shall not be detached until the heat treatment given in Table 5 or Table 6 has been completed.

B.17 Heat treatment of test blocks

Separately cast test blocks shall accompany the castings they represent during the heat treatment given in Table 5 or Table 6.

B.18 Purchaser's representation

Testing and inspection shall be carried out in the presence of the purchaser's representative.

Appendix C Sampling and testing

C.1 Sampling

At least one set of test blocks shall be cast separately from the castings to which they refer. The ruling section of the test blocks shall be a minimum of 28 mm.

The test blocks shall be poured from the same cast of steel as the castings they represent and shall be marked to maintain their identity throughout processing.

See options **B.15** and **B.16**.

C.2 Heat treatment of test blocks

Test blocks shall be submitted to the same heat treatment, but not necessarily at the same time, as the castings they represent.

See option **B.17**.

C.3 Mechanical testing

See option **B.18**.

C.3.1 *Tensile testing*

One tensile test shall be performed in accordance with BS 18.

C.3.2 *Bend test*

One bend test shall be performed in accordance with BS 1639.

The test piece shall be smooth machined to 25 mm diameter, or to a rectangular section 25 mm wide × 20 mm thick, or in the same proportion for small castings.

NOTE The corners of rectangular test pieces may be slightly rounded to a radius not exceeding 1.5 mm.

C.3.3 *Impact tests*

Three impact tests shall be performed at the specified temperature in accordance with BS 131-2. The average value from the three test pieces shall be not less than the specified value. It is permissible for one individual value to be below the average specified value but it shall be not less than 70 % of that value.

C.3.4 *Hardness tests*

Hardness tests in accordance with BS 240 shall be performed on a representative number (a minimum of 5 %) of castings from each cast or heat treatment batch. The surface shall be prepared by grinding and sufficient material shall be removed to ensure freedom from decarburization.

NOTE The location of tests should be agreed between the manufacturer and the purchaser.

C.4 Retests

C.4.1 *Tensile and bend test*

If any test piece falls to comply with the requirements of Table 5 or Table 6 as a result of incorrect test procedure, faulty equipment or a defective test piece the test results shall be discarded and a further test piece shall be tested.

If test pieces fail to comply with Table 5 or Table 6 for any other reason, two further test pieces shall be tested.

If properties obtained from these further test pieces comply with Table 5 or Table 6 the material represented shall be deemed to comply with this British Standard. Should any retest piece fail, the manufacturer has the option of subjecting the castings and test blocks to further heat treatment in accordance with **C.5**.

C.4.2 *Impact test*

If the average of three impact values is lower than the value given in Table 3 or Table 4 or if any one value is lower than 70 % of that value, three additional test pieces shall be taken from the same test block and tested. If the average value of the six test pieces is higher than the value given in Table 3 or Table 4 and not more than two individual values are less than that value and not more than one is less than 70 % of that value, the material represented shall be deemed to comply with this British Standard.

If the six test pieces do not meet these requirements it is permissible for the manufacturer to subject the castings and test blocks to further heat treatment in accordance with **C.5**.

C.5 Re-heat treatment

Where the material has failed to meet the requirements of Table 5 or Table 6, the manufacturer shall submit the castings and test blocks to further heat treatment after which test pieces from the test blocks shall be submitted to all the tests previously performed.

If the test pieces fail these additional tests, it is permissible for the manufacturer to submit the castings and test blocks to one further heat treatment after which test pieces from the test blocks shall be submitted to all the tests previously performed.

In no instance shall the castings and test blocks be subjected to more than two additional heat treatments (excluding tempering).

The castings shall be deemed to comply with this British Standard if the results obtained from the retests meet the requirements given in Table 5 or Table 6. If the results of the retests fail to meet these requirements, the castings represented shall be deemed, not to comply with this British Standard.

Publication(s) referred to

BS 18, *Method for tensile testing of metals (including aerospace materials).*

BS 131, *Methods for notched bar test.*

BS 131-2*, The Charpy V-notch impact test on metals.*

BS 240, *Method for Brinell hardness test and for verification of Brinell hardness testing machines.*

BS 1504, *Specification for steel castings for pressure purposes.*

BS 1639, *Methods for bend testing of metals.*

BS 4080:1966, *Methods for non-destructive testing of steel castings.*

BS 4080, *Specification for severity levels for discontinuities in steel castings.*

BS 4080-1*, Surface discontinuities revealed by magnetic particle flaw detection;*

BS 4080-2*, Surface discontinuities revealed by penetrant flaw detection.*

BS 4570, *Specification for fusion welding of steel castings.*

BS 5903, *Method for determination of resistance to intergranular corrosion of austenitic stainless steels: copper sulphate-sulphuric acid method (Moneypenny Strauss test).*

BS 6208, *Method for ultrasonic testing of ferritic steel castings including quality levels.*

BS 6404, *Magnetic materials.*

BS 6404-4*, Methods of measurement of the d.c. magnetic properties of solid steels.*

prEN 10 204, *Steel and iron and steel products. Inspection documents.*

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