

Australian Standard™

Cast steels

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- Australian Building Codes Board
- Australian Foundry Institute
- Australian Industry Group
- Australian Institute of Steel Construction
- Bureau of Steel Manufacturers of Australia
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Australian Standard™

Cast steels

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PREFACE

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee MT-001, Iron and Steel, to supersede AS 2074—1982.

After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian, rather than an Australian/New Zealand Standard.

The objective of this Standard is to specify the steel specifications, heat treatment and test requirements for cast steels.

AS 2074—1982 specified additional requirements, including fettling and dressing, freedom from defects, rectification of defects and certification. These additional requirements are now specified in AS 4738. This edition of the Standard is a material's standard.

Cognizance was taken of the following International (ISO) Standards available on the subject:

ISO

4990:1986	Steel castings—General technical delivery requirements
4991:1994	Steel castings for pressure purposes
8062:1994	Castings—System of dimensional tolerances and machining allowances
11972:1998	Corrosion-resistant cast steels for general applications
11973:1999	Heat-resistant cast steels and alloys for general applications
13521:1999	Austenitic manganese steel castings

The term 'informative' has been used in this Standard to define the application of the appendix to which it applies. An 'informative' appendix is only for information and guidance.

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STANDARDS AUSTRALIA

Australian Standard Cast steels

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE AND APPLICATION

1.1.1 Scope

This Standard specifies requirements for carbon, low alloy and high alloy cast steels.

NOTES:

- 1 Advice and recommendations on information for optional test requirements to be supplied by the purchaser at the time of enquiry or order are contained in Appendix A.
- 2 A summary of chemical composition and tensile properties of steels included in this Standard is given in Appendix B, which also provides guidance on the selection of grades for specific applications.
- 3 AS 2074 only specifies materials. AS 4738 specifies the other additional requirements of the casting (See Preface).

1.1.2 Application

Castings shall comply with the general requirements of Section 1 and with the specific requirements of Sections 2, 3 and 4, as follows:

- (a) Carbon steel.....Section 2.
- (b) Low alloy steel Section 3.
- (c) High alloy steel.....Section 4.

1.1.3 Other requirements

The castings shall comply with AS 4738.

NOTE: The purchaser should specify AS 2074 and AS 4738 on the purchase order.

1.2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

1391	Methods for tensile testing of metals
1544	Methods for impact tests on metals
1544.2	Part 2: Charpy V-notch
1816	Metallic materials — Brinell hardness test
1816.1	Part 1: Test method (ISO 6506-1:1999, MOD)
1988	Welding of steel castings
2038	Methods for detecting the susceptibility of austenitic stainless steels to intergranular corrosion
2291	Methods for tensile testing of metals at elevated temperatures
2706	Numerical values — Rounding and interpretation of limiting values

AS

- 3507 Non-destructive testing
- 3507.1 Part 1: Guide to radiography for ferrous castings
- 3507.2 Part 2: Radiographic determination of quality of ferrous castings
- 4738 Metal castings—Ferrous sand moulded

AS/NZS

- 1050 Methods for the analysis of iron and steel
- 1050.1 Part 1: Sampling iron and steel for chemical analysis

ISO/TR

- 7468 Summary of average stress rupture properties of wrought steels for boilers and pressure vessels

ASTM

- E562 Test method for determining volume fraction by systematic manual point count
- G48 Test methods for pitting and crevice corrosion resistance of stainless steels and related alloys by use of ferric chloride solution

BS

- 5884 Magnetic materials—Methods for the determination of the relative magnetic permeability of feebly magnetic materials

BS EN

- 60404 Magnetic materials
- 60404-4 Part 4: Methods of measurement of d.c. magnetic properties of iron and steel

NACE

- MR-0175 Standard material requirements—Sulfide stress cracking resistant metallic materials for oilfield equipment

1.3 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

1.3.1 Certified material for elevated temperature properties

Material for which elevated temperature properties are specified in the relevant material specification in Section 2, 3 or 4 and supplied as having these properties in accordance with Clause 1.11.2.

1.3.2 Elevated temperature tested material

Material supplied as complying with the requirements of the material specification in Section 2, 3 or 4, and for which representative elevated temperature tests have been made at the temperature specified by the purchaser in accordance with Clause 1.11.2.

1.3.3 Mass effect

The effect of thickness, size and shape in causing a variation in properties from the surface inwards, due to differences in the rate of cooling during heat treatment.

NOTE: These variations in properties are particularly noticeable in low alloy steels which are hardened and tempered.

1.3.4 Ruling section

That combination of dimensions of a casting which has the greatest influence on the rate of cooling of the casting from the heat treatment temperature and hence on the mechanical properties induced by heat treatment. That diameter of round bar which will cool at the same rate is known as the 'equivalent section'.

1.3.5 Test bar

A bar poured from the same cast of steel as the casting it represents, and either—

- (a) separately cast; or
- (b) cast integral with the casting.

1.3.6 Test piece

A prepared piece for testing, made from a test bar by some mechanical operation.

1.4 DESIGNATION OF GRADE

The steel castings shall be given an appropriate grade designation as shown in Sections 2, 3 and 4, and shall be in accordance with the following sequence, wherein the elements of Items (a), (b) and (c) are always present in the designation and the elements of Items (d), (e), (f), (g), (h) and (i) are added as required:

- (a) The number of this Australian Standard, followed by a solidus, i.e. AS 2074/.
- (b) A letter denoting the level of alloys in the steel, as follows:
 - C —plain carbon steel.
 - L —low alloy steel.
 - H —high alloy steel.
- (c) A number from 1 to 10 indicating categories of general mechanical characteristics (for Sections 2 and 3) or general mechanical characteristics and suitability for type of service conditions (for Section 4).
- (d) A letter to distinguish between steels having different characteristics within a category (see Item (c)), e.g. A, B and C.
- (e) A number, 1 or 2, preceded by a dash (or the word 'Type') to distinguish between steels of similar chemical composition but with different mechanical properties.
- (f) The letter 'M' to indicate a free-machining steel.
- (g) The letter 'E' to indicate a material requiring elevated temperature properties.
- (h) The letters 'LT' followed by a number representing the temperature below zero, in degrees Celsius, to indicate impact properties at low temperature.
- (i) The letter 'U' to indicate that no tensile or impact testing is required on the allowed grades.

Examples of designation:

Grade designation	Interpretation
AS 2074/C1	The first of the plain carbon steels listed (see Section 2).
AS 2074/C4-1	Two plain carbon steels of similar chemical composition but differing in mechanical properties, as indicated by the suffix numbers 1 and 2.
AS 2074/C4-2	
AS 2074/C7A-1E	Plain carbon steel used for pressure purposes requiring elevated temperature properties.
AS 2074/C7A-1LT40	Plain carbon steel requiring impact properties at temperature -40°C .
AS 2074/L2A, L2B	Two low alloy steels for resistance to abrasion but of slightly different chemical compositions, as indicated by the suffix letters A and B.
AS 2074/H3AM	The free-machining version of the high alloy steel Grade H3A.

1.5 CHEMICAL COMPOSITION

1.5.1 Cast sampling and analysis

Where practicable, a chill-cast sample for chemical analysis shall be taken from the liquid steel. The method of sampling shall be in accordance with the procedure for sampling liquid metal specified in AS/NZS 1050.1.

Chemical composition shall be determined by procedures that are at least as accurate as those in the AS/NZS 1050 series of Standards, and shall be reported as the chemical compositioning.

Chemical composition (cast analysis) shall comply with the limits specified in Section 2, 3, or 4 for the grade being tested.

1.5.2 Product sampling and analysis

Where it is impracticable to sample in accordance with Clause 1.5.1, a product sample shall be taken from the solidified metal. The sampling location shall be selected by the manufacturer. The method of sampling shall be in accordance with the procedure for sampling solid metal specified in AS/NZS 1050.1.

Chemical composition shall be determined by procedures that are at least as accurate as those in the AS/NZS 1050 series of Standards, and shall be reported as chemical composition product analysis.

Chemical composition (product analysis) shall comply with the limits specified in Clause 1.5.1, after applying the permissible deviations specified in Table 1.5.

NOTE: If chemical composition (cast analysis) complies with Clause 1.5.1 then Clause 1.5.2 is not applicable.

TABLE 1.5.2
PERMITTED DEVIATIONS OF THE PRODUCT ANALYSIS
OUTSIDE THE SPECIFIED LIMITS FOR THE CAST ANALYSIS

Element	Range (% m/m) ¹	Permitted deviation ^{2,3,4}
Carbon	Up to 0.75 Over 0.75 up to 2.00	$0.04 \times C_L + 0.01$ 0.04
Silicon	Up to 1.00 Over 1.00 up to 3.00	$0.08 \times Si_L$ 0.10
Manganese	Up to 2.00 Over 2.00 up to 20.0	$0.04 \times Mn_L + 0.01$ $0.03 \times Mn_L + 0.09$
Phosphorus	All	$0.04 \times P_L + 0.002$
Sulfur	All	$0.04 \times S_L + 0.002$
Chromium	Up to 2.00 Over 2.00 up to 30.00	$0.02 \times Cr_L + 0.01$ $0.01 \times Cr_L + 0.05$
Molybdenum	Up to 1.00 Over 1.00 up to 5.00	$0.04 \times Mo_L + 0.01$ $0.01 \times Mo_L + 0.05$
Nickel	Up to 2.00 Over 1.00 up to 5.00	$0.02 \times Ni_L + 0.01$ $0.01 \times Ni_L + 0.05$
Niobium	Up to 1.00	$0.04 \times Nb_L + 0.01$
Copper	Up to 1.0 Over 1.0 up to 4.0	$0.03 \times Cu_L + 0.02$ $0.01 \times Cu_L + 0.05$
Vanadium	Up to 1.00	$0.04 \times V_L + 0.015$
Nitrogen ⁵	Up to 0.005 Over 0.005 up to 0.40	0.01 $0.04 \times N_L + 0.01$
Aluminium	Up to 0.10	0.01

¹ Range contains the value of the cast analysis limit with which the product analysis is in conflict.

² The subscript _L denotes that the cast analysis limit, upper or lower whichever is relevant, is to be inserted in the equation.

³ The calculated value of the permitted deviation is to be rounded down (towards zero) to the same number of decimal places shown for the cast analysis limit to which it refers. The rounded value is then subtracted from the cast analysis minimum value or added to the cast analysis maximum value to give the product analysis limit.

⁴ To illustrate the computation, consider a cast analysis limit of Manganese 1.60 maximum. This limit falls within the range 'Up to 2.00'. The permitted deviation on product analysis then is $(0.04 \times 1.60 + 0.01) = 0.074$. This is rounded down to 0.07 then added to the 1.60 giving a product analysis manganese maximum limit of 1.67.

⁵ Applies only to high alloy corrosion resistant grades.

1.6 HEAT TREATMENT

Castings shall be heat treated as required by Section 2, 3 or 4, as applicable. When required, castings may contain annealing lugs.

NOTE: Information on annealing lugs is given in Appendix A, Paragraph A2.5.

1.7 MASS EFFECT

The chemical composition used for grades AS 2074/L6, AS 2074/L6A, AS 2074/L6B and AS 2074/L6C shall take account of mass effect and shall be such as will give adequate hardening through the limiting ruling section of the casting (see Clauses 1.3.3 and 1.3.4).

NOTES:

- 1 There are numerous combinations of chemical compositions and heat treatments that will provide the specified properties in these grades in sections up to (and beyond) 300 mm ruling section.
- 2 If full section properties are required to be validated by the purchaser (not a requirement of AS 2074), the purchaser may reach an agreement with the manufacturer to test full-section test bars, integral appendages, trepanned specimens, or any other agreed method which the purchaser is satisfied will provide the required test data. See also Appendix A, Clause A2.3.

1.8 MECHANICAL PROPERTIES

The mechanical properties shall be determined from test bars cast either separately from, or attached to, the castings which they refer, and shall comply with the requirements of Section 2, 3 or 4 as applicable.

NOTE: Except for hardness tests carried out on castings, the test values represent the quality of the steel from which the castings have been poured, and not necessarily the properties of the castings (see Appendix A and AS 4738).

1.9 PROVISION AND PREPARATION OF TEST BARS**1.9.1 General**

At least one set of tests, as required by the relevant specification in Section 2, 3 or 4, shall be made per cast.

The manufacturer shall cast sufficient test bars to comply with the requirements of Clause 1.11 and Section 2, 3 or 4. In the event of test samples not being available, the manufacturer has the option of submitting one or more finished castings to an agreed destructive test, or the castings may be sectioned for mechanical test at agreed locations.

NOTE: Further information about test bars is given in Appendix A, and AS 4738.

Tests to establish the hardness values of castings shall be performed on a representative number of castings from each cast or heat treatment batch. (See also Paragraph A1.1 of Appendix A.)

1.9.2 Heat treatment of separate test bars

Where separate test bars are used, they shall be cast from the same cast of steel as the castings they represent and shall be submitted to the same heat treatment subject to allowance for mass effect, but not necessarily at the same time. (See Appendix A.)

1.9.3 Heat treatment of attached test bars

Attached test bars shall be heat treated with the castings they represent, and unless otherwise agreed, shall not be detached from the castings until—

- (a) heat treatment of the castings has been completed by the manufacturer; and
- (b) where so ordered, they have been stamped by the purchaser or the purchaser's representative.

1.10 PREPARATION OF TEST PIECES**1.10.1 General**

A test piece which shows defective machining, or develops flaws, shall be discarded and another test piece submitted for test (see Clause 1.12).

1.10.2 Tensile test piece

Where required by the ordered grade, one proportional test piece for tensile testing shall be prepared in accordance with AS 1391 from a representative test bar.

1.10.3 Elevated temperature tensile test piece

Where required by the ordered grade, one test piece for elevated temperature tensile testing shall be prepared in accordance with AS 2291 from a representative test bar.

1.10.4 Charpy V-notch impact test piece

Where required by the ordered grade, three Charpy V-notch impact test pieces shall be prepared in accordance with AS 1544.2, from representative test bars.

1.10.5 Intergranular corrosion test piece

Where required by the ordered grade, one test piece for intergranular corrosion testing shall be prepared in accordance with AS 2038 from a representative test bar.

Test pieces shall be submitted to a sensitizing heat treatment in accordance with AS 2038.

1.10.6 Ferrite content test piece

Where required by the ordered grade, one test piece for ferrite content testing shall be prepared in accordance with ASTM E562 from a representative test bar.

1.10.7 Pitting corrosion test piece

Where required by the ordered grade, one test piece for pitting corrosion testing shall be prepared in accordance with ASTM G48 from a representative test bar.

1.11 TEST REQUIREMENTS

1.11.1 Tensile test

The tensile test shall be carried out in accordance with AS 1391. The yield strength, tensile strength, percent elongation and reduction of area of a test piece, as appropriate for the grade, shall comply with Section 2, 3 or 4, as applicable.

1.11.2 Elevated temperature tensile test

Tensile properties at elevated temperatures shall be determined in accordance with AS 2291, at the temperature specified in Section 2, 3 or 4 for the relevant grade.

1.11.3 Charpy V-notch impact test

The Charpy V-notch impact test shall be carried out in accordance with AS 1544.2 at the temperature specified for the relevant grade.

The average absorbed energy of three test pieces shall be not less than the value specified, and no single value of absorbed energy shall be less than the minimum individual value specified for the ordered grade.

1.11.4 Hardness tests

Where required, hardness shall be determined in accordance with AS 1816.1, and values shall comply with Section 2, 3 or 4 for the relevant grade.

The surface of the castings shall be prepared by grinding or other appropriate method, and sufficient material shall be removed to ensure freedom from decarburization.

NOTE: Where the Brinell hardness test is impracticable, an alternative procedure may be used (see Appendix A, Paragraph A1.1).

1.11.5 Magnetic property tests

Where required, the magnetic properties of a casting shall be determined in accordance with BS 5884 or BS EN 60404-4. The properties shall comply with the specific requirements of Section 2 or Section 4.

NOTE: Information on magnetic property tests is given in Appendix A.

1.11.6 Intergranular corrosion test

Where required, the susceptibility of the steel to intergranular corrosion shall be determined in accordance with AS 2038, using the acidified copper sulfate exposure test.

NOTE: Information on intergranular corrosion testing is given in Appendix A.

1.11.7 Ferrite content test

Where required, the volume percent of ferrite contained in the microstructure of austenitic or duplex stainless steels shall be determined in accordance with ASTM E562, or by magnetic response measuring equipment approved by the purchaser.

NOTE: Magnetic response measurement is an advanced technique which now provides an attractive alternative to the slow and cumbersome manual point count method. Further information on ferrite testing is given in Appendix A.

1.11.8 Pitting corrosion test

Where required, the resistance of an alloy to pitting corrosion shall be determined in accordance with ASTM G48, using Method A.

NOTES:

- 1 Information on pitting corrosion testing is given in Appendix A.
- 2 Where referenced in this Standard, the Pitting Resistance Equivalent number (PREn) of an austenitic or duplex stainless steel is calculated from the expression:

$$\text{PREn} = \text{Cr}\% + (3.3 \times \text{Mo}\%) + (16 \times \text{N}\%)$$

1.12 RETESTS

1.12.1 General

Should the results of any mechanical test performed in accordance with Clause 1.8 fail to conform to the requirements of Section 2, 3 or 4, as applicable, the manufacturer may adopt one of the procedures given in Clauses 1.12.2, 1.12.3 and 1.12.4.

If any test piece shows obvious signs of casting defects, the results of the test shall be discarded, and a further test made using a test piece originating from the same cast. The results obtained shall be substituted for those of the defective test piece.

If the percentage elongation of any tensile test piece is less than that specified for the particular grade, and any part of the fracture is more than a distance of $2d$ from the centre of the gauge length, where d is the original diameter, a retest shall be allowed.

1.12.2 Failure of mechanical tests

The manufacturer may carry out duplicates of the mechanical test, including the intergranular corrosion test, under which failure occurred, on two additional test pieces. In the event of either of these duplicate test pieces failing to comply with the relevant requirements specified in Section 2, 3 or 4, the manufacturer may then follow the procedure given in Clause 1.12.4.

1.12.3 Failure of low temperature impact test

For low temperature impact tests, if the average level attained from the three tests fails to comply with the specified value, or if any of the individual values fails to comply with the minimum specified value, the manufacturer may test two additional test pieces from a test bar from the same cast or heat-treatment batch, add the results to those previously obtained and calculate a new average. Provided that this new average complies with the average value specified, the material represented shall be deemed to comply with this Standard. In the event of the new average value or any of the new individual values failing to comply with the relevant requirements specified in Section 2, 3 or 4, the manufacturer may then follow the procedure given in Clause 1.12.4.

1.12.4 Re-heat treatment

Where the manufacturer submits the castings, together with the test bars, to further heat treatment, the test bars shall be submitted to all mechanical tests, including the intergranular corrosion test, if appropriate, required by the relevant material specification in Section 2, 3 or 4.

In no instance shall the castings and test bar be subjected to more than a further two fully austenitizing additional heat treatments (excluding tempering and stress relieving) (see Paragraph A2.1).

1.12.5 Acceptance

The castings shall be deemed to comply with this Standard if the results obtained from the retests are satisfactory. If the results obtained from the retests fail to comply with the relevant requirements specified in Section 2, 3 or 4, the castings represented by these results shall be deemed not to comply with this Standard.

1.13 ROUNDING OF TEST RESULT VALUES

1.13.1 General

With the exception of tensile test results, the observed or calculated values shall be rounded to the same number of figures as in the specified values and then compared with the specified values. For example, for specified maximum or minimum values of 2.5, 2.50 and 2.500, the observed or calculated value would be rounded to the nearest 0.1, 0.01 and 0.001 respectively (see also AS 2706).

1.13.2 Tensile test results

The determined value of tensile strength shall be rounded to the nearest 10 MPa, the determined value of the yield strength or the 0.2% proof stress shall be rounded to the nearest 5 MPa, and the determined value of elevated temperature yield strength shall be rounded to the nearest 2 MPa.

SECTION 2 REQUIREMENTS FOR CARBON STEEL CASTINGS

2.1 CARBON STEEL CASTINGS FOR CASE HARDENING — GRADE C1

2.1.1 Chemical composition

The cast analysis of the steel shall be within the limits given in Table 2.1.1 (see Clause 1.5).

TABLE 2.1.1
CHEMICAL COMPOSITION

Element	Grade AS 2074/C1, Cast analysis, percent	
	Min.	Max.
Carbon	0.10	0.18
Silicon	—	0.60
Manganese	0.60	1.00
Phosphorus	—	0.050
Sulfur	—	0.050
Chromium*	—	0.25
Molybdenum*	—	0.15
Nickel*	—	0.40
Copper*	—	0.3

* Residual elements: total not to exceed 0.80 percent.

2.1.2 Heat treatment

2.1.2.1 Castings

Castings shall be supplied in the as cast, annealed, normalized or normalized and tempered condition.

2.1.2.2 Test piece

Test bars shall be machined to a diameter of 30 mm, and the test pieces there from shall be given the following heat treatment:

- Blank carburize in the range 880°C to 930°C.
- Refine in the range 870°C to 920°C, cool in air, oil or water.
- Harden in water from the range 760°C to 930°C.

NOTE: The tests may be performed on test pieces from which the blank carburizing treatment has been omitted, or modified to a short heating period (see Paragraph A2.4 of Appendix A).

2.1.3 Mechanical properties

The mechanical properties obtained from test pieces prepared as specified in Clause 2.1.2.2 and selected and tested in accordance with the requirements of Section 1 shall comply with Table 2.1.3.