

Australian Standard[®]

**Fine grained, weldable steel plates for
pressure equipment**



This Australian Standard® was prepared by Committee ME-001, Pressure Equipment. It was approved on behalf of the Council of Standards Australia on 31 March 2008. This Standard was published on 5 May 2008.

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Fine grained, weldable steel plates for pressure equipment

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME-001, Pressure Equipment and supersedes AS 1548—1995, *Steel plates for pressure equipment*.

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

For a summary of the major changes introduced in this edition of the Standard, refer to the Foreword.

The objective of this Standard is to specify requirements for hot-rolled fully killed carbon-manganese steel plates to a maximum thickness of 150 mm for use in the construction of pressure equipment.

Statements expressed in mandatory terms in notes to tables and figures are deemed to be requirements of this Standard.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

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FOREWORD

The following is a summary of the changes from AS 1548—1995:

- (a) The '5' and '7' designations have been replaced by 'PT', which partially aligns with the ISO and EN designations. 'P' is for pressure equipment and 'T' is for tensile strength designation as opposed to the yield strength designation used by the ISO and EN Standards. Essentially, the property requirements have not changed from the previous edition.
- (b) The 'R' and 'A' designations have been combined into a new normalized rolled 'NR' designation. This aligns the former 'R' and 'A' interchangeability clause with ISO and EN. The definition of normalized rolling aligns with EN 10028 except that the EN Standard allows it be designated as an 'N' grade. It was thought that this would create confusion in the Australian industry and hence the 'NR' designation was formed.

The designation 'NRA' has been added to allow for the ordering of NR grades with simulated normalized test results.

- (c) All grades are to be Charpy tested to exhibit some level of toughness, in line with the ISO and EN Standards. The former 'base' grades were expected to meet a certain toughness level in the pressure vessel design Standard AS 1210, based upon the performance of BlueScope Steel's grades but without any explicit requirements in AS 1548.
- (d) The Charpy energy values have been changed to align with those expected in AS 1210, and with those in the ISO and EN Standards.
- (e) With the removal of the '5' and '7' designations, it was decided to retain the strength requirements of the former 5-490 grade but allow NR and T to be supplied in addition to the original N. This is in line with the ISO and EN Standards.
- (f) The elevated temperature tensile test values (in Table 5) have been changed to align with the ISO and EN Standards. They now represent a lower 2 standard deviation yield stress value and are not a pass/fail criteria, but are more like design values. In case of disputes, the minimum acceptable elevated temperature yield strength is set at 5% below the tabulated values. The expected removal of the safety factor penalty for non-tested elevated temperature grades from AS 1210 and AS 1228 may reduce the need for the H grade, but it is retained for purchasers who want a test result.

Elevated temperature tensile strength (R_{mT}) values have not been listed.

- (g) A new grade PT540T has been included, up to 40 mm thickness, which takes advantage of the strength levels that can be achieved from thermomechanical controlled rolling. Creep rupture properties for this grade have not been included, as data is not yet available.
- (h) A definition of fine grained steels has been included.
- (i) Guidance on the effect of excessive stress relieving has been added.
- (j) Changes to Appendices C, D and E have been made to accommodate the new designations.
- (k) References to continuous mill product have been removed from the standard.
- (l) C and CE limits are tighter but well within the capacity of the standard grades.
- (m) For grades L20 and below, the allowable Niobium level has increased from 0.025% to 0.030%.

STANDARDS AUSTRALIA

Australian Standard

Fine grained, weldable steel plates for pressure equipment

1 SCOPE

This Standard specifies requirements for hot-rolled, fine grained, fully killed carbon-manganese steel plates to a maximum thickness of 150 mm for use in the construction of pressure equipment.

NOTE: Guidelines to purchasers on requirements that should be specified by the purchaser and those that should be agreed to at the time of enquiry or order, or both, are given in Appendix A.

2 APPLICATION

This edition of AS 1548 supersedes all previous editions of the Standard, however this does not imply that material manufactured to previous editions is now invalid, nor that designs using previous grades are invalidated. It is intended that existing designs, procedures, specifications, materials etc. need not be altered in response to the publication of the new edition of this Standard. The equivalency of current and previous grades of steel to AS 1548, and the application of current grades to existing designs, specifications, procedures, etc. is described in Appendix B.

3 REFERENCED DOCUMENTS

The following documents are referred to in this Standard.

AS

- | | |
|--------|---|
| 1210 | Pressure vessels |
| 1391 | Metallic materials—Tensile testing at ambient temperature |
| 1544 | Methods for impact tests on metals |
| 1544.2 | Part 2: Charpy V-notch |
| 1710 | Non-destructive testing—Ultrasonic testing of carbon and low alloy steel plate and universal sections—Test methods and quality classification |
| 1733 | Methods for the determination of grain size in metals |
| 2291 | Metallic materials—Tensile testing at elevated temperatures |
| 2706 | Numerical values—Rounding and interpretation of limiting values |

AS/NZS

- | | |
|------|--|
| 1050 | Methods for the analysis of iron and steel (all parts) |
| 1365 | Tolerances for flat-rolled steel products |
| 3992 | Pressure equipment—Welding and brazing qualification |

ISO

- | | |
|--------|---|
| 2566 | Steel—Conversion of elongation values |
| 2566-1 | Part 1: Carbon and low alloy steels |
| 9328 | Steel flat products for pressure purposes—Technical delivery conditions |
| 9328-2 | Part 2: Non-alloy and alloy steels with specified elevated temperature properties |

EN

10028 Flat products made of steels for pressure purposes

10028-2 Part 2: Non-alloy and alloy steels with specified elevated temperature properties

10314 Method for the derivation of minimum values of proof strength of steel at elevated temperatures

4 DEFINITIONS

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

4.1 Cast analysis

Chemical analysis determined from a test sample taken during the casting of each heat lot (see Clause 7.2).

4.2 Edge conditions

4.2.1 *Trimmed edge*

Edge produced by the removal of material by mechanical means or gas cutting.

NOTE: Also referred to as sheared, slit or gas cut edge.

4.2.2 *Untrimmed edge*

Edge produced by rolling between horizontal rolls, with or without vertical edging rolls.

NOTE: Also referred to as mill or universal edge.

4.3 Fine grained steels

Fine grained steels are steels which have an austenitic grain size of number 6 or finer when tested in accordance with AS 1733. Generally steels are considered fine grained without the need for testing when the total aluminium content is greater than 0.020%, or when niobium $\geq 0.01\%$, titanium $\geq 0.01\%$ or vanadium $\geq 0.02\%$ are deliberately added as carbonitride formers.

NOTE: AS 1733 includes various recognized methods for grain size determination, including the McQuaid–Ehn method, and appropriate etching techniques.

4.4 Longitudinal direction

Direction of the greatest extension of the steel during rolling.

4.5 Normalizing rolling

A rolling process in which final deformation is carried out in a certain temperature range leading to a material condition equivalent to that obtained after normalizing so that the specified values of the mechanical properties are retained even after normalizing.

4.6 Plate

Hot-rolled product supplied flat with width equal to or greater than 600 mm and nominal thickness greater than 4.5 mm. Edges are either trimmed or untrimmed.

4.7 Plate as-produced

A plate rolled from a slab or rolled directly from an ingot, except that when the plate is normalized and is cut into pieces, the term refers to each individual piece of the original plate normalized separately or to a group of pieces normalized together.

4.8 Product analysis

Chemical analysis determined from a test sample of the finished material.

4.9 ‘Shall’ and ‘should’

The word ‘shall’ indicates that a statement is mandatory, and the word ‘should’ indicates a recommendation.

4.10 Testing

Mechanical tests, chemical analyses and non-destructive tests as required by this Standard or by the purchaser.

4.11 Test piece

Piece prepared for testing and made from a test specimen by some mechanical operation.

4.12 Test sample

Portion of material selected from the plate as produced or from a batch (see Clause 11.3) by sampling.

4.13 Test specimen

Portion or a single item taken from the test sample for the purpose of applying a particular test.

4.14 Thermomechanical controlled rolling (TMCR)

Rolling procedure in which significant deformation takes place at temperatures below the normalizing range permitting little, if any, recrystallization of austenite. This appropriately conditions the austenite and consequently refines the final microstructure, conferring beneficial properties on the material.

4.15 Transverse direction

Direction at right angles to the direction of the greatest extension of the steel during rolling.

5 DESIGNATION

All plate shall be designated in the following manner:

AS 1548-PTYDAHLXZX

where

AS 1548 = number of this Standard

P = pressure vessel steel

T = tensile strength specified

Y = grade of steel

= specified minimum tensile strength, in megapascals (430, 460, 490 or 540)

D = delivery condition, as follows:

N—see Clause 6.1

NR—see Clause 6.2

T—see Clause 6.3

(See Table 1 for various TYD combinations.)

A = Testing required in the simulated normalized condition. (only applies for the NR delivery condition)

H = elevated temperature tensile testing required

NOTES:

1 Where a tensile test at elevated temperature is not required, 'H' is omitted.

2 See Table 5 for minimum lower yield or 0.2% proof stress at temperatures available.

LX = low temperature (L) impact property required, together with test temperature (X) at or below 0°C, e.g. L50 for -50°C impact tests.

NOTES:

1 Where a particular low temperature impact property is not required, 'LX' is omitted.

2 See Table 4 for minimum impact energy at test temperature.

ZX = through-thickness tensile test required (Z) together with percentage reduction of area (X), e.g. Z25 for 25% minimum average reduction of area.

NOTES:

- 1 Where a through-thickness test is not required, 'ZX' is omitted.
- 2 See Table 6 for minimum reduction of area requirements.
- 3 Only supplied in thicknesses equal to or greater than 16 mm (see Clause 15.5).

Examples of designation:

- 1 AS 1548-PT490NL20 is a fully killed carbon-manganese steel having a tensile strength between 490 MPa and 610 MPa, supplied normalized, and having guaranteed impact properties at -20°C .
- 2 AS 1548-PT430NRH is a fully killed carbon-manganese steel having a tensile strength between 430 MPa and 550 MPa, supplied normalized rolled, and having a specified elevated temperature property.
- 3 AS 1548-PT460TZ25 is a fully killed carbon-manganese steel having a tensile strength between 460 MPa and 580 MPa, supplied in the TMCR condition having a specified minimum average reduction of area of 25% in a through-thickness direction.
- 4 AS 1548-PT460NRA is a fully killed carbon-manganese steel having a tensile strength between 460 MPa and 580 MPa, supplied in the normalized rolled condition, but tested in the simulated normalized condition.

6 DELIVERY CONDITION

6.1 'N' designation plate

Plates specified with an 'N' designation shall be normalized by the steel manufacturer, after final rolling, in the temperature range 870°C to 930°C .

Normalized 'N' grades may be replaced by the steel manufacturer, in consultation with the purchaser, with normalized rolled 'NR' grades.

6.2 'NR' designation plate

Plates specified with an 'NR' designation shall be supplied in the normalized rolled condition as defined in Clause 4.5. Plates may also be supplied in the normalised 'N' condition at the steel manufacturer's discretion.

NOTE: This condition replaces the 'R' and 'A' interchangeability clause of AS 1548—1995.

Where plates are specified with an 'NRA' designation testing shall be carried out using simulated normalized samples, at an agreed frequency, to verify compliance with the specified properties in the normalized condition.

NOTE: Simulated normalized testing is intended for applications where hot forming will be carried out during fabrication, to provide assurance that the steel alloy design is capable of achieving the required mechanical properties. Such testing does not provide proof that heat treatment processes used during actual fabrication have resulted in the specified properties being achieved in the fabricated item.

6.3 'T' designation plate

Plates specified with a 'T' designation shall be supplied as material produced by the TMCR process. This results in low temperature impact properties equivalent to those of normalized material and may be used as an alternative process to normalizing.

NOTE: 'T' designation plate should not be hot-formed above 620°C . If hot-forming operations are performed on a 'T' designation plate, there will be some reduction in the tensile properties of the plate and appropriate procedural tests will be needed to ensure specified properties are achieved (see Appendix C, Paragraph C1.3).

7 CHEMICAL COMPOSITION

7.1 General

The steel shall conform to the cast analysis as specified in Table 1.

NOTE: A product analysis is not required by this Standard and is performed only where specified by the purchaser (see Appendix A, Paragraph A1(k)). Details of the product analysis are specified in Table 1.

7.2 Sampling and testing

Samples of the steel shall be taken from each heat lot. Where it is impracticable to obtain samples from liquid steel, analysis on samples taken in accordance with the relevant requirements for sampling from solid metal in AS/NZS 1050.1 may be reported as the cast analysis.

The method of sampling for chemical analysis shall be in accordance with AS/NZS 1050.1. The chemical composition shall be determined by methods which are accurate to not less than those defined in the AS/NZS 1050 series.

7.3 Residual elements

Elements not referred to in Table 1 shall not be intentionally added to the steel without the agreement of the purchaser.

TABLE 1
CHEMICAL COMPOSITION

Designation	Analysis type (see Clause 7)	Analysis, percent (see Notes 1, 2, 5, 6 and 7)										Carbon equivalent max. percent (see Note 3)
		C	Mn		Si	P	S	Nb		Al	Ti	
		max.	min.	max.	max.	max.	max.	min.	max.	max.	max.	
PT430 NR, N or T	Cast/ Product	0.20	0.80 (Note 8)	1.60	0.50	0.040	0.030	*	0.010 (Note 4)	0.100	0.040	0.43
PT460 N, NR or T	Cast/ Product	0.20	0.90 (Note 8)	1.70	0.60	0.040	0.030	*	0.010 (Note 4)	0.100	0.040	0.43
PT490 NR, N, or T	Cast/ Product	0.20	0.90	1.70	0.60	0.040	0.030	0.010	0.050	0.100	0.040	0.46
PT540T	Cast/ Product	0.20	0.90	1.70	0.60	0.040	0.030	0.010	0.050	0.100	0.040	0.46

* No specified limit.

NOTES:

- 1 The following elements may be present to the limits stated below:

Copper 0.40%.

Nickel 0.50%.

Chromium 0.25%.

Molybdenum 0.10%.

Vanadium 0.030%.

Nitrogen 0.0100%.

- 2 The use of sulphide shape control elements for these grades is permitted.

- 3 Carbon equivalent (CE) is calculated according to IIW practice, using the equation:

$$CE = C + \frac{Mn}{6} + \frac{Ni + Cu}{15} + \frac{Cr + Mo + V}{5}$$

- 4 Niobium (up to 0.030%) may be added for L20, L40 and L50 designations.

- 5 If percent by mass of copper exceeds 0.2%, the percent by mass of nickel shall be at least half the percent by mass of copper.

- 6 Copper + chromium + molybdenum = 0.45% max.

- 7 A minimum total aluminium content of 0.020% applies to ensure a fine grain structure. This minimum aluminium content does not apply if nitrogen is additionally fixed by the addition of niobium (Nb ≥ 0.01%), titanium (Ti ≥ 0.01%) or vanadium (V ≥ 0.02%).

- 8 Value not applicable for thicknesses ≤ 8 mm.

8 STEELMAKING PROCESS

The steel shall be made by the basic oxygen process or an electric process at the steel manufacturer's option. The steel making process shall be shown on test certificates.

NOTES:

- 1 A basic oxygen process means the process of making steel in a basic converter blown with commercially pure oxygen.
- 2 Additional refining by vacuum-arc-remelt (VAR), electroslag-refining (ESR) or vacuum degassing is permitted.