AS/NZS 3678:2011

Australian/New Zealand Standard™

Structural steel—Hot-rolled plates, floorplates and slabs

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NOTES

Australian/New Zealand Standard™

Structural steel—Hot-rolled plates, floorplates and slabs

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee BD-023, Structural Steel, to supersede AS/NZS 3678:1996.

The objective of this Standard is to specify requirements for hot-rolled plates, floorplates and slabs for general structural and engineering applications.

This edition incorporates the following changes:

(a) R_{eH} and R_m have been added to Table 9.

(b) Steel making manufacturing process has been included.

(c) Layout and clause numbering have been changed.

(d) Referenced Standards have been updated.

Statements expressed in mandatory terms in notes to tables 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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Australian/New Zealand Standard
Structural steel—Hot-rolled plates, floorplates and slabs

1 SCOPE

This Standard specifies requirements for the production and supply of hot-rolled structural steel plates and floorplates for carbon and carbon-manganese mechanically-tested steels, fully-killed analysis-only steels, and low-alloy (weathering) mechanically-tested steels. This Standard also specifies requirements for the production and supply of wide slabs as fully-killed analysis-only steel.

For general structural and engineering applications, all grades specified in this Standard are suitable for—

(a) welding in accordance with AS/NZS 1554; or

(b) riveting and bolting as specified in AS/NZS 4600, AS 3990, AS 4100 and NZS 3404.1.

This Standard does not cover the following:

(i) Structural steel—Hot-rolled bars and sections (AS/NZS 3679.1), and welded I sections (AS/NZS 3679.2).

(ii) Steel plates for pressure equipment (AS 1548).

(iii) Structural steel hollow sections (AS/NZS 1163).

(iv) Hot-rolled steel flat products (AS 1594).

(v) Structural and pressure vessel steel—Quenched and tempered plate (AS 3597).

Means for demonstrating compliance with this Standard are specified in Appendix B.

NOTES:

1 Guidelines to purchasers on requirements that should be specified by the purchaser and those that should or may be agreed on at the time of enquiry and ordering are given in Appendix A.

2 Guidelines on cold-bending and hot-forming of plate during fabrication are given in Appendix C.

2 NORMATIVE REFERENCES

The following are the normative documents referenced in this Standard.

NOTE: References for information purposes are included in the Bibliography.

AS

1365 Tolerances for flat-rolled steel products

1391 Metallic materials—Tensile testing at ambient temperature

1544 Methods for impact tests on metals

1544.2 Part 2: Charpy V-notch

1733 Methods for the determination of grain size in metals

2706 Numerical values—Rounding and interpretation of limiting values

3990 Mechanical equipment—Steelwork

4100 Steel structures

AS/NZS
1050 Methods for the analysis of iron and steel
1050.1 Part 1: Sampling iron and steel for chemical analysis

1554 Structural steel welding
1554.1 Part 1: Welding of steel structures
1554.2 Part 2: Stud welding (steel studs to steel)

4600 Cold-formed steel structures

4855 Welding consumables—Covered electrodes for manual metal arc welding of non-alloy and fine grain steels—Classification

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2566 Steel—Conversion of elongation values
2566-1 Part 1: Carbon and low alloy steels

7966 Acceptance control charts

NZS
3404 Steel structures Standard
3404.1 Part 1: Materials, fabrication and construction

AISI
SAE J403 Chemical composition of carbon steels

3 DEFINITIONS

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

3.1 Analysis

3.1.1 *Cast analysis*

Chemical analysis determined from test samples taken from the ladle, tundish or mould during casting.

3.1.2 *Product analysis*

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

3.2 Batch

The tonnage of products to be accepted or rejected together, the basis of the tests to be carried out on sample products in accordance with the product conformity requirements (test unit).

3.3 Can

To imply a capability or possibility and refers to the ability of the user of the Standard, or to a possibility that is available or that might occur.

3.4 Crack

Narrow line of fracture on the surface.

3.5 Defects

Surface discontinuity including cracks, shell and seams with a depth or area, or both, greater than a specified limiting value.

3.6 Edge conditions

3.6.1 *Trimmed edge*

Edge produced by the removal of material by mechanical means or gas cutting—also referred to as sheared, slit or thermal-cut edge.

3.6.2 *Untrimmed edge*

Edge produced by the rolling between horizontal rolls, with or without vertical edging rolls—also referred to as mill, universal or rolled edge.

3.7 Fine grained steels

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 ≥0.01%, titanium ≥0.01% or vanadium ≥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.

3.8 Floorplate

Hot-rolled product supplied flat, having a rolled raised pattern at regular intervals on one surface, with width greater than or equal to 900 mm, with a nominal thickness greater than or equal to 4.50 mm. Edges are either trimmed or untrimmed.

3.9 Imperfection

Surface discontinuity other than cracks, shell and seams with a depth or area, or both, less than or equal to a specified limiting value.

3.10 Longitudinal direction

Direction of the greatest extension of the steel during rolling (X direction).

3.11 Manufacturer

The business operating the hot rolling process producing the steel product.

3.12 May

Indicates the existence of an option.

3.13 Normalized

Steel produced by heating to a suitable temperature above the transformation range (typically 870°C to 930°C) and then cooling in air to a temperature substantially below the transformation range.

3.14 Plate

Hot-rolled product supplied flat, with a width greater than or equal to 900 mm, with nominal thickness greater than or equal to 4.50 mm. Edges are either trimmed or untrimmed.

3.15 Seams

Seams are caused when imperfections in the semi-finished product are elongated and extended during rolling.

3.16 Shall

Indicates that a statement is mandatory.

3.17 Shell

Overlapping material partially connected with the base material.

3.18 Should

Indicates a recommendation.

3.19 Slab

A semi-finished rolled or continuously-cast product with a rectangular cross-section, with thickness greater than 100 mm and a width-to-thickness ratio of not less than 4:1.

3.20 Testing

Chemical analysis tests and mechanical tests as specified in Clauses 7 and 10, respectively.

3.21 Test piece

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

3.22 Test sample

Portion of material or product, or a group of items selected from a test batch or group by a sampling procedure.

3.23 Test specimen

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

3.24 Through-thickness direction

Direction perpendicular to the plate surface (Z direction).

3.25 Transverse direction

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

4 NOTATION

The symbols used in this Standard are listed in Table 1.

TABLE 1

NOTATION

Symbol	Unit	Description
a	mm	measurement of perpendicular diameters
b	mm	measurement of perpendicular diameters
d	mm	diameter of the test piece
J	J	absorbed energy
L_o	mm	gauge length
S	mm^2	cross-sectional area after fracture
S_o	mm^2	original cross-sectional area
t	mm	nominal thickness
Z	%	percentage reduction of the cross-sectional area after fracture
R_{eH}	MPa	Upper yield stress
R_{eL}	MPa	Lower yield stress
$R_{p0.2}$	MPa	Proof stress, 0.2% plastic extension. (0.2% proof stress)
$R_{t0.5}$	MPa	Proof stress, 0.5% total extension. (0.5% total extension)
R_m	MPa	Tensile strength

NOTE: 1 MPa = 1 N/mm^2

5 DESIGNATION

5.1 General

All grades shall be designated in accordance with the procedures specified in Clause 5.2 or Clause 5.4, as applicable. Additional modifications may be designated with the procedures specified in Clause 5.3, Clause 5.5 or Clause 5.6 as applicable. All designations shall include the number of this Australian/New Zealand Standard, i.e., AS/NZS 3678.

Grades designated with a WR prefix, offer enhanced atmospheric corrosion resistance over unalloyed grades.

5.2 Mechanically tested grades

Mechanically tested carbon and carbon-manganese grades and low alloy (weathering) grades shall be designated as follows:

Examples: AS/NZS 3678-250

AS/NZS 3678-WR350

where

AS/NZS 3678 = number of this Standard

250, 350 = grade designation

WR = weather-resistant

Grades to these designations shall meet the requirements for impact designation 'None' in Table 10.

5.3 Additional properties

In addition to Clause 5.2, the grade designation for the steel may also indicate mechanical testing in accordance with the following:

(a) *Through-thickness tensile properties* Where material has a specified minimum through-thickness tensile properties, this is indicated by the suffix 'Z' indicating that the material has been through thickness tested. This suffix is followed by the value of the guaranteed minimum reduction in area (see Clause 11.3).

Example: AS/NZS 3678-250Z25

(b) *Impact properties* Where material has specified minimum impact properties, this is indicated by the quality suffix 'L' or 'Y' indicating that the material has been impact tested and the minimum energy requirement. The suffix is followed by the value of a temperature equal to the actual impact test temperature that is at or below 0°C.

Examples: AS/NZS 3678-WR350L0

AS/NZS 3678-350L20

AS/NZS 3678-350Y40

NOTE: A grade designated at one impact test temperature is suitable for use at all higher impact test temperatures.

(c) Any combination of these additional properties is valid.

Example: AS/NZS 3678-350Y40Z35

(a) For New Zealand only, a seismic grade designation suffix S0 is available (see Appendix D).

Example: AS/NZS 3678-350S0

5.4 Analysis grades

The designation for analysis grades shall consist of a five-digit alphanumeric system in accordance with the following:

(a) First character, a letter indicating deoxidation practice, as follows:

(i) A = aluminium killed.

(ii) K = silicon killed, with or without aluminium additions.

(b) A four-digit series designation whereby the first two digits indicate the type of steel, as follows:

(i) 10xx.....plain carbon steels.

(ii) 15xx..... carbon-manganese steels.

The last two digits indicate the approximate mean of the specified carbon range based on corresponding AISI-SAE J403 grade.

Example: AS/NZS 3678-A1006

5.5 Modification symbol

Modification symbols may be added to the grade designation specified in Clause 5.3(a).

The prefix letter 'X' shall be used to indicate a major deviation in chemical composition of any grade from the corresponding AISI-SAE J403 grade.

Example: AS/NZS 3678-XK1016

5.6 Fine grained steels

A fine-grained modification symbol may be added to the grade designations specified in Clauses 5.2 and 5.3(d).

The suffix letter 'FG' shall be used to indicate that the material was produced using a fine grained steelmaking practice (Appendix A).

Examples: AS/NZS 3678-250FG

AS/NZS 3678-K1016FG

NOTE: Fine grained steelmaking practice is a steelmaking practice that is intended to produce killed steel that is capable of meeting the requirements for fine **austenitic** grain size after post rolling reheating. This may have no effect on the grain size of the as rolled steel. Typically used to control the **austenite** grain size when the as rolled steel is subsequently reheated in the normalizing temperature range (see Clause 11.4).

6 MANUFACTURING PROCESS

6.1 Steelmaking process

The steelmaking process shall be at the discretion of the manufacturer with the exclusion of the open hearth process. The steelmaking process shall be shown on test certificates and inspection documentation.

6.2 Delivery condition

Unless otherwise agreed at the time of enquiry and ordering, the delivery condition is at the manufacturer's discretion (see Appendix A). The delivery condition shall be shown on test certificates or inspection documentation.

7 CHEMICAL COMPOSITION

7.1 General

The method of sampling for chemical analysis shall be in accordance with AS/NZS 1050.1. Chemical composition shall be determined in accordance with AS/NZS 1050.1 or other procedures which achieve the same, or better, degree of accuracy.

7.2 Cast analysis

A cast analysis of the steel shall be made from each cast to determine the proportions of the specified elements. In cases where it is impracticable to obtain samples from the liquid steel, analysis on test samples taken in accordance with AS/NZS 1050.1 may be reported as cast analysis.

The cast analysis of the steel shall conform to the limits given in Tables 2 and 3 for the appropriate grade.

Inspection documents reporting cast analysis shall indicate values for all elements necessary to establish compliance with the appropriate grade.

7.3 Product analysis

The chemical analysis of the finished product is not a mandatory requirement of this Standard. If the steel is subjected to a product analysis, the analysis shall conform to the limits given in Table 2, Table 3 or Table 4, as appropriate.

7.4 Residual elements

Elements not given in Table 2 or Table 3 for the appropriate grade shall not be intentionally added to the steel without the agreement of the purchaser.

TABLE 2

CHEMICAL COMPOSITION—MECHANICAL PROPERTY GRADES

Grade designation (see Notes 1, 7 and 8)	Cast or product analysis %															
	C	Si		Mn	P	S	Cr (see Note 2)		Ni (see Note 2)	Cu (see Note 2)		Mo (see Note 2)	Al (see Note 3)	Ti	Micro-alloying elements	CE (see Note 4)
	Max.	Min.	Max.	Max.	Max.	Max.	Min.	Max.	Max.	Min.	Max.	Max.	Max.	Max.	Max.	Max.
200	0.15	—	0.35	0.60	0.030	0.030	—	0.25	0.50	—	0.40	0.10	0.100	0.040	(see Note 5)	0.25
250	0.22	—	0.55	1.70	0.040	0.030	—	0.25	0.50	—	0.40	0.10	0.100	0.040	(see Note 5)	0.44
300	0.22	—	0.55	1.70	0.040	0.030	—	0.25	0.50	—	0.40	0.10	0.100	0.040	(see Note 5)	0.44
350	0.22	—	0.55	1.70	0.040	0.030	—	0.25	0.50	—	0.40	0.35	0.100	0.040	(see Note 6)	0.48
400	0.22	—	0.55	1.70	0.040	0.030	—	0.25	0.50	—	0.40	0.35	0.100	0.040	(see Note 6)	0.48
450	0.22	—	0.55	1.80	0.040	0.030	—	0.25	0.50	—	0.60	0.35	0.100	0.040	(see Note 6)	0.48
WR350	0.14	0.15	0.75	1.70	0.160	0.030	0.35	1.05	0.55	0.15	0.50	0.10	0.100	0.040	(see Note 6)	—

— = no specified limit

NOTES:

1 The use of sulphide modification steelmaking techniques (such as Ca addition) is permitted for listed grades.

2 Except for grades 450, 450Lxx, 450Yxx, WR350 and WR350L0, a Cr + Ni + Cu + Mo = 1.00% maximum applies.

3 Limits specified are for both acid soluble and total aluminium.

4 Carbon equivalent (CE) is calculated from the following equation based on actual cast or product analysis:

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

5 Niobium plus vanadium: 0.06% maximum. Niobium: 0.020% maximum. Vanadium: 0.050% maximum.

6 Vanadium: 0.10% maximum. Niobium plus vanadium plus titanium: 0.15% maximum.

7 Where a grade is ordered as fine grained steelmaking practice (Appendix A) see Clause 3.7 for minimum limits.

8 Chemical composition requirements are the same for all impact tested and through thickness tensile tested variants, see Clause 5.3.

TABLE 3

CHEMICAL COMPOSITION—ANALYSIS GRADES

Grade (see Notes 1 and 3)	Cast analysis %											
	C		Si	Mn		P	S	Cr	Ni	Cu	A1 (see Notes 2 and 3)	Ti
	Min.	Max.	Max.	Min.	Max.	Max.	Max.	Max.	Max.	Max.	Max.	Max.
A1006	—	0.08	0.03	—	0.40	0.040	0.030	(see Note 4)	(see Note 4)	(see Note 4)	0.100	0.040
A1010	0.08	0.13	0.03	0.30	0.60	0.040	0.030	(see Note 4)	(see Note 4)	(see Note 4)	0.100	0.040
K1042	0.39	0.47	0.50	0.60	0.90	0.040	0.040	(see Note 4)	(see Note 4)	(see Note 4)	0.100	0.040
XK1016	0.12	0.18	0.50	0.80	1.20	0.040	0.040	(see Note 4)	(see Note 4)	(see Note 4)	0.100	0.040
XK1515	0.12	0.18	0.50	1.20	1.50	0.040	0.040	(see Note 4)	(see Note 4)	(see Note 4)	0.100	0.040

— = no specified limit

NOTES:

1 The use of sulphide modification steelmaking techniques (such as Ca addition) is permitted for listed grades.

2 Limits specified are for both acid soluble and total aluminium.

3 Where a grade is ordered as fine grained steelmaking practice (Appendix A) see Clause 3.7 for minimum limits.

4 The following elements may be present to the limits stated, subject to a total content of 1.00%:

(a) Copper: 0.40%.

(b) Nickel: 0.50%.

(c) Chromium: 0.25%.

(d) Molybdenum: 0.10%.

TABLE 4

PRODUCT ANALYSIS TOLERANCES FOR GRADES GIVEN IN TABLE 3

Element	Limit or maximum of specified range %	Tolerance %	
		Under minimum limit	Over maximum limit
Carbon	≤0.25	0.03	0.03
	>0.25 ≤0.50	0.03	0.04
Silicon	≤0.05	—	0.01
	>0.05 ≤0.50	—	0.05
Manganese	—	0.10	0.10
Phosphorus	—	—	0.010
Sulfur	—	—	0.010

— = no specified limit

8 MANUFACTURING TOLERANCES

Plates, floorplates and slabs supplied in accordance with this Standard shall comply with the dimensional tolerances specified in AS 1365.

9 FREEDOM FROM DEFECTS

9.1 General

Discontinuities visible to the naked eye and discontinuities of steelmaking and rolling origin are covered by this Clause. This Clause may also be applied to discontinuities originating during processing and despatching of product.

If the purchaser needs to be sure that all discontinuities visible to the naked eye have been identified, assessed and where necessary repaired before delivery, products shall be ordered descaled.

If the product is not ordered descaled, some of the discontinuities may be covered by scale and not visible to the naked eye.

The surface condition shall comply with Clauses 9.2 and 9.3.

The remaining thickness of the affected area under discontinuities and of repaired ground areas may be less than the minimum thickness as specified in AS 1365.

Repair by chipping or grinding, or both, followed by welding is permitted in compliance with Clause 9.3.

9.2 Requirements

9.2.1 *General*

Plates may have surface discontinuities, which are divided into categories depending on their nature, depth and number as specified in Clauses 9.2.2 and 9.2.3.

9.2.2 *Imperfections*

The following imperfections shall be considered:

(a) Discontinuities other than cracks, shell and seams (see Clause 9.2.3(c)) not exceeding the limits given in Table 5, are regarded as being inherent to the manufacturing process and are permissible irrespective of their number.

A surface area with a remaining thickness under the discontinuities less than the minimum thickness as specified in AS 1365, is permissible with a maximum of 15% of the inspected surface.

(b) Discontinuities other than cracks, shell and seams (see Clause 9.2.3(c)) with a depth exceeding the limits given in Table 5 but not exceeding the limits given in Table 6 and of which the sum of the affected areas does not exceed 5% of the inspected surface, may be left unrepaired.

A surface area with a remaining thickness under the discontinuities less than the minimum thickness as specified in AS 1365, is permissible with a maximum of 2% of the inspected surface.

NOTES:

1 Cracks are due mainly to material stresses which often develop during the cooling of the feed stock.

2 There is a preponderance of non-metallic inclusions or scale, or both, among the shell.

TABLE 5

MAXIMUM PERMISSIBLE DEPTH OF IMPERFECTIONS < 5% OF INSPECTED AREA

Nominal thickness of the product (t) mm	Maximum permissible depth of imperfections mm
$3 \le t < 8$	0.2
$8 \le t < 25$	0.3
$25 \le t < 40$	0.4
$40 \le t < 80$	0.5
$80 \le t < 150$	0.6
$150 \le t \le 250$	0.9

TABLE 6

MAXIMUM PERMISSIBLE DEPTH OF IMPERFECTIONS

Nominal thickness of the product (t) mm	Maximum permissible depth of imperfections mm
$3 \le t < 8$	0.4
$8 \le t < 25$	0.5
$25 \le t < 40$	0.6
$40 \le t < 80$	0.8
$80 \le t < 150$	0.9
$150 \le t \le 250$	1.2

9.2.3 *Defects*

The following defects shall be considered:

(a) Discontinuities with a depth exceeding the limits given in Table 5 but not exceeding the limits given in Table 6, and with an affected surface area of more than 5% of the inspected surface shall be repaired.

(b) Discontinuities with a depth exceeding the limits given in Table 6 shall be repaired irrespective of their number.

(c) Discontinuities such as cracks, shell and seams which are in general deep and sharp, and therefore impair the use of the products, shall be repaired irrespective of their depth and number.

9.3 Repair procedures

9.3.1 *Grinding*

The manufacturer shall be allowed to repair the entire surface by grinding to the minimum thickness as specified in AS 1365.

If a discontinuity has to be repaired, it shall be removed completely by grinding to its full depth. The ground areas shall have a smooth transition to the surrounding surface of the product.

Grinding of defects shall be carried out subject to the following conditions:

(a) The maximum permissible depth of ground areas below the minimum thickness as specified in AS 1365 is given in Table 7.

(b) For ground areas with a thickness under the minimum permissible thickness, as specified in AS 1365, the sum of all ground areas below the minimum permissible thickness on one side of the product shall be less than or equal to 2% of the surface area under inspection.

(c) For the remaining thickness of two ground areas lying opposite to each other on both sides of the product, Item (a) of this Clause applies.

TABLE 7

GRINDING ALLOWANCES FOR PLATES

Nominal thickness of the product (t) mm	Permitted grinding depth allowances below the minimum thickness as specified in AS 1365 mm
$3 \le t < 8$	0.3
$8 \le t < 15$	0.4
$15 \le t < 25$	0.5
$25 \le t < 40$	0.8
$40 \le t < 60$	1.0
$60 \le t < 80$	1.5
$80 \le t \le 250$	2.0

9.3.2 *Welding*

Repair by welding is at the discretion of the manufacturer unless agreed at the time of enquiry and ordering.

The following conditions apply for the repair by welding of defects that cannot be repaired by grinding as specified in Clause 9.3.1:

(a) Defects shall be completely eliminated before any weld repair is commenced. This procedure shall not reduce the thickness of the product to less than 80% of its nominal thickness.

(b) Prior to weld-repair of edges of flat products, the depth of the groove measured from the edge inward, shall not exceed the nominal thickness of the product or 30 mm, whichever is the lesser value.

(c) Welding used in the repair of surface defects shall be performed in accordance with AS/NZS 1554.1, using low-hydrogen consumables complying with AS/NZS 4855.

(d) The weld shall be free of any lack of fusion, undercutting cracks and other defects which may impair the use of the product.

(e) The deposited weld material shall project at least 1.5 mm above the rolled surface and shall subsequently be ground smooth and level with the product surface. After grinding, ordered product thickness tolerances shall apply to the ground area.

(f) A single welded area shall not exceed 0.125 m^2 and the sum of the welded areas shall not exceed 0.125 m^2 or 2% of the surface area under inspection, whichever is the greater.

(g) Ground and welded areas which are separated by a distance less than their average width shall be treated as a single area for the purpose of determining the limiting area.

10 TESTING

10.1 Selection of test samples

10.1.1 *General*

Samples for the preparation of test pieces for tensile, impact and through-thickness tensile tests shall be taken in accordance with Clause 10.2. Samples shall be tested in the same condition as the finished product. Samples shall be representative of the body of the product.

NOTE: Where the product is to be further heat-treated and separate heat treatment of test samples is appropriate, this should be specified at the time of enquiry and order (see Paragraph A2 of Appendix A).

10.1.2 *Sampling and testing*

Test samples shall be taken to represent finished steel of the same product form, treated in the same manner and from the same batch (Appendix B).

NOTE: Where the product is heat treated by normalizing a batch is each discrete piece loaded in to the heat treatment unit.

10.2 Position and orientation of test pieces

Test pieces shall be positioned and orientated as follows:

(a) Tensile, impact and through-thickness tensile tests shall be taken midway between the centre and one edge.

(b) Tensile tests shall be prepared with the major axis of the test piece in the transverse direction (see (a) in Figure 1).

(c) Impact tests shall be prepared with the major axis of the test piece in the longitudinal direction (see (b) in Figure 1).

(d) Through-thickness tensile tests shall be prepared with the major axis of the test piece perpendicular to the plate surface (see (c) in Figure 1).

10.3 Preparation of test pieces for mechanical testing

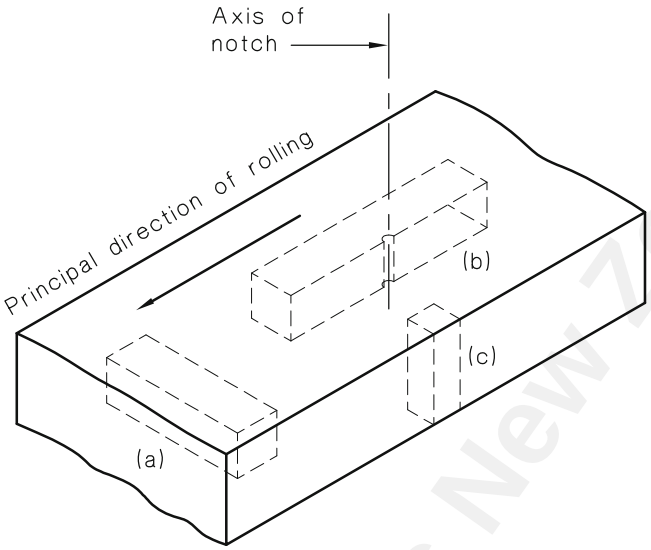
10.3.1 *General*

Test specimens may be straightened cold before preparation, in accordance with this Standard. A test piece which shows defective machining or develops flaws may be discarded and another test specimen may be submitted.

10.3.2 *Tensile test piece*

A test piece for tensile testing shall be prepared in accordance with AS 1391. For material less than or equal to 30 mm in thickness, a non-proportional test piece of full-product thickness shall be used.

For material greater than 30 mm in thickness, either a proportional cylindrical test piece from as close as possible to the quarter thickness position or a non-proportional test piece of full-product thickness shall be used.



NOTE: For explanation of (a), (b) and (c), see Clause 10.2.

FIGURE 1 ORIENTATION OF TEST PIECE

10.3.3 *Impact test piece*

The axis of the notch shall be perpendicular to the rolled surface of the plate. Test pieces shall be prepared in accordance with AS 1544.2 and with the following, as appropriate:

(a) *Plates of nominal thickness less than 8 mm* For plates of nominal thickness less than 8 mm, a 10 mm × full thickness test piece is to be used. In such a case, minimum absorbed energy values of 10 mm × 5 mm test pieces apply

NOTE: For nominal thicknesses less than 6 mm impact tests should not be required.

(b) *Plates of nominal thickness from 8 mm to 20 mm* For plates of nominal thickness from 8 mm to 20 mm, material within 1 mm from the surface shall not be included.

Where possible, machine standard 10 mm × 10 mm test pieces. If the material is too thin to permit the preparation of 10 mm × 10 mm test pieces, tests shall be carried out on 10 mm × 7.5 mm or 10 mm × 5 mm subsidiary test pieces as specified in AS 1544.2.

(c) *Plates of nominal thickness from 20 mm to 32 mm* Machine standard 10 mm × 10 mm test pieces. Material within 3 mm from the plate surface shall not be included.

(d) *Plates of nominal thickness greater than 32 mm* Machine standard 10 mm × 10 mm test pieces so that the major axis of the test piece is as close as possible to the quarter thickness position of the plate.

10.3.4 *Through-thickness tensile test*

A test piece of 10 mm diameter (S_o) for through-thickness tensile testing shall be prepared as follows:

(a) *Plates of nominal thickness less than or equal to 40 mm* A cylindrical test piece of full plate thickness shall be prepared by making welded extensions on the plate. Welding by suitable methods shall be carried out giving a strong bond without causing any marked alteration in the mechanical properties (see Note 1).

(b) *Plates of nominal thickness greater than 40 mm* A cylindrical test piece of full plate thickness shall be prepared without welded extensions provided that a minimum of 6 mm on either side is used for heads or other means of fastening the test piece in the tensile testing machine.

NOTES:

1 Friction welding, manual metal-arc welding using properly handled low hydrogen consumables, and stud welding in accordance with AS 1554.2 are preferred methods for attaching the extensions..

2 This Standard does not cover through-thickness tested grades with nominal thickness less than 16 mm.

3 When nominal plate thickness $t \leq 25$ mm and specimen geometry does not allow a valid test to be performed, a 6 mm diameter (S_o) test piece may be used in lieu of a 10 mm diameter test piece.

10.4 Mechanical testing

10.4.1 *Tensile test*

The tensile test shall be carried out in accordance with AS 1391. The rate of straining when approaching the yield stress shall be within the limits of the conventional straining rate as specified in AS 1391.

Elongation results shall be reported on a gauge length L_o equal to $5.65\sqrt{S_o}$ where S_o is the cross-sectional area of the test piece before testing. Conversion of results from a non-proportional gauge length shall be in accordance with ISO 2566-1.

For test pieces with a cross-sectional area greater than 1000 mm^2, the minimum elongation after conversion to the gauge length of $5.65\sqrt{S_o}$, shall be reduced by 2% from that given in Table 9.

10.4.2 *Charpy V-notch impact test*

The impact test shall be carried out in accordance with AS 1544.2.

10.4.3 *Through-thickness tensile test*

The rate of straining when approaching the yield stress shall be within the limits of the conventional straining rate as specified in AS 1391.

11 MECHANICAL PROPERTIES

11.1 Tensile tests

If determined in accordance with Clause 10.4.1, the yield stress, tensile strength and elongation of a test piece shall conform to the limits given in Table 9.

For the specified yield stress in Table 9, the upper yield stress (R_{eH}) shall be determined, or wherever this is not pronounced, either the 0.2% proof stress ($R_{p0.2}$) or the 0.5% total elongation proof stress ($R_{t0.5}$), may be used.

Where a pronounced lower yield stress (R_{eL}) is present, the value determined for R_{eL} may be used in place of R_{eH} where it complies to the R_{eH} requirements in Table 9.

11.2 Impact test

If determined in accordance with Clause 10.4.2, the absorbed energy of a test piece shall conform to the limits given in Table 10.

11.3 Through-thickness tensile test

The percentage reduction of the cross-sectional area after fracture (Z) shall be determined by the following equation:

$$Z = \left(\frac{S_o - S}{S_o} \right) 100 \quad \ldots 11.3(1)$$

where

S_o = original cross-sectional area of the test piece, in square millimetres

$$= \frac{\pi d^2}{4} \quad \ldots 11.3(2)$$

where

d = diameter of the test piece, in millimetres

S = cross-sectional area after fracture, in square millimetres

$$= \frac{\pi}{4} \left(\frac{a}{2} + \frac{b}{2} \right)^2 \quad \ldots 11.3(3)$$

where

a and b are the measurements of two perpendicular diameters, in millimetres; where the fracture is elliptical in shape, a and b correspond to the axes of the ellipse.

The percentage reduction of the cross-sectional area after fracture (Z) shall conform to the limits given in Table 8.

TABLE 8

MINIMUM REDUCTION IN AREA

Grade suffix	%
Z15	15
Z25	25
Z35	35

11.4 Heat treatment

If it is intended to reheat the grades defined in this Standard above 620°C, the purchaser shall discuss the application and the reheating treatment with the manufacturer.

NOTE: The mechanical properties of these grades can be affected by any reheating that may be applied for its end use.

TABLE 9

TENSILE TEST REQUIREMENTS FOR PLATE AND FLOOR PLATE

Grade designation (see Note 4)	Minimum yield stress, R_{eH} MPa							Minimum tensile strength, R_m MPa	Minimum elongation on a gauge length of $5.65\sqrt{S_o}$ (see Notes 1 and 5) %
	Thickness mm								
	≤8	>8 ≤12	>12 ≤20	>20 ≤32	>32 ≤50	>50 ≤80	>80 ≤150		
200	200	200	—	—	—	—	—	300	24
250 (see Note 2)	280	260	250	250	250	240	230	410	22
300	320	310	300	280	280	270	260	430	21
350	360	360	350	340	340	340	330	450	20
400	400	400	380	360	360	360	—	480	18
450	450	450	450	420	400	—	—	520 500	16 18
WR350	340	340	340	340	340	—	—	450	20

NOTES:

1 Elongation need not be determined for floorplate.

2 For grade designation 250, the minimum tensile strength requirement does not apply to material under 6 mm thick.

3 Recommendations for cold-bending and hot-forming of plates are given in Appendix C.

4 Tensile test requirements are the same for all impact tested, through thickness tensile tested and fine grained variants.

5 For test piece cross sectional area > 1000 mm^2, minimum elongation is reduced by 2%, see Clause 10.4.1.

TABLE 10

CHARPY V-NOTCH IMPACT TEST REQUIREMENTS

Grade designation	Impact designation (see Note 1)	Test temperature °C	Minimum absorbed energy, J					
			Size of test piece					
			10 mm × 10 mm		10 mm × 7.5 mm		10 mm × 5 mm	
			Average of 3 tests	Individual test	Average of 3 tests	Individual test	Average of 3 tests	Individual test
250	None	0	27	20	22	16	19	13
	L15	–15						
300	L20	–20						
350	L40	–40						
400	Y20	–20	40	30	32	24	28	21
450	Y40	–40						
WR350	L0	0	27	20	22	16	19	13

NOTES:

1 If any product is tested, for grades with no impact test designation (None), the absorbed energy shall meet these values.

2 Grades with impact designations with lower test temperatures are directly replaceable for grades with designations with higher test temperatures and/or lower minimum energies. For example, Grades with Y40 designation can be used in place of grades with Y20, L40, L20, L15 and None designations. Grades with L40 designations can be used in place of grades with L20, L15 and None designations.

12 IDENTIFICATION AND CERTIFICATION

12.1 Identification

All product supplied to this standard shall be clearly and legibly identified by suitable and durable methods, such as painting or stamping with the following:

(a) The manufacturer's name or mark, or both.

(b) The grade of steel (see Clause 5).

(c) The product to be identified with this Standard.

(d) A traceable plate or identification number (to include reference to serial and heat number).

Where identification is by means of die-stamping, low-stress stamps shall be used for impact tested grades.

NOTES:

1 Products not marked with the provisions specified in this Clause would be considered to be non-compliant with this Standard.

2 If the identified portion of the product is subsequently removed, then these identifications are to be transferred to each remaining portion of the product.

3 Manufacturers making a statement of compliance with this Standard on a product, packaging, test certification, inspection documentation or promotional material related to that product are advised to ensure that such compliance is capable of being verified.

12.2 Inspection documents and test certificates

12.2.1 *Qualifications on inspection documents and test certificates*

An inspection document or test certificate shall provide results in relation to the following:

(a) Tests performed by a laboratory accredited by signatories to the International Laboratory Accreditation Corporation (ILAC) through their Mutual Recognition Agreement (MRA), in the field and class of testing, on behalf of the manufacturer for the purpose of establishing compliance with this Standard. The appropriate logo or further details of the ILAC (MRA) signatory shall be noted on the document.

(b) Additional tests as agreed between the purchaser and manufacturer, see Appendix B.

NOTE: In Australia, ILAC (MRA) accredited bodies include National Association of Testing Authorities (NATA) and in New Zealand they include International Accreditation New Zealand (IANZ).

12.2.2 *Minimum requirements for inspection documents and test certificates*

In addition to Clause 12.2.1, any inspection document or test certificate shall be written in English alphanumeric characters, issued by the manufacturer and shall have the following:

(a) Steelmaker's, manufacturer's, supplier's, inspection and testing authority's company name.

(b) Test certificate number and test number.

(c) Date.

(d) Product, testing specification and grade, e.g. AS/NZS 3678-350L0 (see Clause 5).

(e) Product delivery condition (see Clause 6.2) and dimensions Width (mm) × Thickness (mm) × Length (mm), e.g. 2000.0 × 100.00 × 6000.

(f) Product steelmaking process, e.g. basic oxygen, slab cast (see Clause 6.1).

(g) Unique product identifiers for the tested units and other product that the inspection document or test certificate applies (see Clause 12.1(d)).

(h) Heat number (from steel feed melting and casting).

(i) Chemical analysis type, e.g. ladle or cast analysis 'L' or product 'P' (see Clauses 7.1, 7.2 and 7.3).

(j) Chemical composition of all elements listed in Table 2 or Table 3 as appropriate for the grade including elements mentioned in the notes and any other element intentionally added.

(k) Where relevant, mechanical testing information as noted below:

(i) Tensile tests to Clause 10.4.1, position and orientation (see Clause 10.2), batch or item test, and results, i.e., R_{eH} (or $R_{p0.2}$ or $R_{t0.5}$ or R_{eL}), in MPa, R_m, in MPa, gauge length and % elongation (see Clause 11.1).

(ii) Impact tests to Clause 10.4.2, position and orientation (see Clause 10.2), batch or item test, test piece dimensions, in mm, (see Clause 10.3.3), tested temperature in °C and results, i.e. individual and average energy, in J, (see Clause 11.2).

(iii) Through-thickness tensile tests to Clause 10.4.3: Position and orientation (see Clause 10.2), batch or item test and results, i.e. % reduction in area (see Clause 11.3).

(iv) Any additional heat treatment of the test piece (see Clause 10.1.1).

(l) Additional tests agreed between the purchaser and the manufacturer, see Appendix A.

(m) Statement acknowledging the chemistry and tested mechanical properties comply with this Standard.

(n) Signatory from manufacturer, supplier and certification authority attesting to Items (a) to (m) above.

NOTE: Test certificates may be requested by the end purchaser at the time of manufacture.

12.3 Independent tests

In the event of a dispute as to the compliance of the steel with the requirements of this Standard, the purchaser and the manufacturer, or the supplier, shall have referee testing carried out by independent laboratories accredited by signatories to ILAC (MRA).

13 ROUNDING OF NUMBERS

13.1 General

For the purpose of deciding whether a particular requirement of this Standard is complied with, the determined value, observed or calculated, shall be rounded off in accordance with AS 2706.

The number of significant places retained in the rounded-off value shall be the same as that of the specified value in the appropriate material standard.

13.2 Tensile properties

The determined value of tensile strength shall be rounded off to the nearest 10 MPa, and the determined value of yield stress shall be rounded off to the nearest 5 MPa.

14 SAMPLING AND TESTING TO DEMONSTRATE PRODUCT CONFORMITY

As a minimum, the sampling and testing procedures shall conform to Appendix B. Additional testing of product may be agreed between the manufacturer and the purchaser (see Appendix A).

APPENDIX A

PURCHASING GUIDELINES

(Informative)

A1 GENERAL

Australian/New Zealand Standards are intended to include the technical provisions necessary for the supply of materials referred to in the particular Standard, but do not purport to comprise all the necessary provisions of a contract. In a number of cases, the purchaser is asked to state the requirements or is given a choice of optional requirements. These are contractual matters to be agreed upon between the purchaser and the manufacturer, or the supplier.

This Appendix contains detailed explanations, advice and recommendations on the information to be supplied by the purchaser at the time of enquiry and order.

Its aims are to avoid misunderstandings and to result in the purchaser receiving satisfactory products and services.

A2 INFORMATION TO BE SUPPLIED BY THE PURCHASER

The purchaser should consider and supply the following information at the time of enquiry and order, after making due reference to the explanation, advice and recommendations contained in this Appendix:

(a) Product form required, i.e., plate, floorplate or slab (see Clauses 3.14, 3.8 and 3.19 respectively).

(b) Quantity and delivery instructions (dates, schedules, delivery point).

(c) Dimensions of section, e.g. thickness, width, length.

(d) Designation of grade and Standard number (see Clause 5).

(e) Type of edge required, i.e., trimmed or untrimmed edge (see Clause 3.6).

(f) Any limitations in respect of packaging, e.g. number or mass of plates per pack, packaging materials.

(g) Whether it is the intention of the purchaser to inspect the steel at the manufacturer's works (see Paragraph A5).

(h) Any information concerning processing or end-use that the purchaser considers would assist the manufacturer.

(i) Whether the steel is to be ultrasonically tested (see Paragraph A3).

(j) Whether a product analysis is required and the frequency of the analysis (see Clause 7.3).

(k) Whether special tolerances on dimensions are required.

(l) Allowing additions of residual elements (see Clause 7.4).

(m) Heat-treated condition of steel, i.e., as-rolled or normalized (see Clause 6.2).

(n) For as-rolled steel, the condition of test pieces, i.e., as-rolled or normalized (see Clause 10.1.1).

(o) If fine grained steelmaking practice is required on steels supplied (see Clause 5.6).

(p) If products are to be ordered descaled (see Clause 9.1).

(q) If repair by welding is not allowed (see Clause 9.3.2).

(r) If the product is for seismic and fracture critical applications to NZS 3404.1, (see Appendix D).

NOTE: Any special or supplementary requirements of this Standard are subject to agreement between the purchaser and the manufacturer, or the supplier at the time of enquiry and order, and should be stated on the order.

A3 ULTRASONIC TESTING

If ultrasonic testing is required by the purchaser, the method of test to be used and the limits of acceptance should be determined at the time of enquiry and order.

The test method and quality grade should be in accordance with AS 1710.

A4 INDEPENDENT TESTS

In the event of a dispute as to the compliance of the steel with this Standard, a referee testing should be carried out by an independent laboratory, and the results should be accepted as final.

A5 INSPECTION

If it is the purchaser's intention to undertake any of the following functions at the manufacturer's works, this should be notified at the time of enquiry and order, and should be accomplished in a manner which will not interfere with the operation of the works. The functions are as follows:

(a) Inspect the product during manufacture.

(b) Select and identify the test samples.

(c) Witness the tests being made.

The manufacturer should provide all reasonable facilities to enable the purchaser to be satisfied that the product complies with this Standard.

A6 HEAT TREATMENT

The mechanical properties of these grades can be affected by any reheating that may be applied for its end use.

If it is intended to reheat these grades above 620°C, the purchaser should discuss the application and the proposed reheating treatment with the manufacturer.

APPENDIX B

PRODUCT CONFORMITY

(Normative)

B1 SCOPE

This Appendix sets out the minimum sampling and testing plan for product conformity to this Standard, which shall be demonstrated by the plate, floorplate or slab manufacturer or supplier.

The product conformity requirements shall enable conformity assessment to be made by a manufacturer or supplier (first party), a user or purchaser (second party), or an independent body (third party), and shall not be dependent on a quality management system standard (e.g. AS/NZS ISO 9001, etc).

NOTE: These provisions are based on the following:

(a) ISO/IEC Directives, Part 2, *Rules for the structure and drafting of International Standards*, 5th Edition, 2004.

(b) ISO/IEC Directives, Supplement—Procedures specific to IEC, 4th Edition, 2009.

(c) IEC, Conformity Assessment Board (CAB/822/INF, 2009-05-27), Agenda item 7.2, ISO/IEC Directives, text concerning conformity assessment: current status.

B2 SAMPLING AND TESTING

B2.1 General

Sampling and testing shall be carried out by the manufacturer in accordance with Paragraphs B2.2 or B2.3, as appropriate. For every batch, the chemical composition shall be obtained in accordance with Clause 7.1, 7.2 or 7.3, as appropriate.

B2.2 Minimum batch sampling and testing

B2.2.1 *Test batch*

B2.2.1.1 *General*

A test batch is a group of rolled parent plates consisting of finished steel of the same yield stress gradation (see Table 9) and product form, treated in the same manner and from the same cast.

A sample product representative of the batch shall be selected and samples taken as follows:

(a) One sample for a batch not exceeding 70 tonnes.

(b) One additional sample for the balance of the batch.

If either batch includes steel of more than one thickness, a further sample shall be taken for each variation in thickness, above or below the thickness of the first test piece selected within each thickness range as set out in Table B1.

(c) If specified at the time of order, take a sample for each rolled parent plate.

(d) Where the product is heat treated by normalizing, one sample shall be taken from each discrete piece loaded in to the heat treatment unit.

TABLE B1

BATCH THICKNESS VARIATION RANGES

Nominal thickness of the product (t) mm	Nominal thickness variation mm
$3 \le t \le 25$	±5
$25 < t \le 250$	±25

B2.2.1.2 *Tensile test*

For the tensile test one tensile test piece shall be taken from the sample.

B2.2.1.3 *Impact test*

If impact testing is required for the grade, a set of three impact test samples shall be taken from the sample. (See Clause 10.3.3).

B2.2.1.4 *Through-thickness tensile test*

If through-thickness testing is required for the grade, take two test samples from a sample off either end of any one rolled parent plate in the batch. (See Clause 10.3.4).

B2.2.1.5 *Conformity*

Each test batch conforms to this Standard if all of the samples tested give results that are within the specified limits. If any of the properties of the tested samples give results outside the specified limits, the requirements of Paragraph B2.2.2 apply.

B2.2.1.6 *Invalidation of test results*

Test results that are affected by improper sampling and/or preparation of test pieces and/or tests being carried out improperly shall be considered invalid. The test shall be repeated with a new test piece.

B2.2.2 *Retests*

B2.2.2.1 *Tensile test*

Should a retest be carried out, one or more of the following procedures should be adopted:

(a) Take two additional tests on test pieces from samples taken from a position as near as practicable to the failed sample. The unit and batch comply with this Standard provided both additional test pieces comply with Clause 11.1.

(b) Take two test samples at random from the remainder of the test batch. If the results from the test pieces from both additional samples comply with Clause 11.1, this remainder complies with this Standard. If one of these additional samples fails to comply, the steel of the applicable test batch does not comply with this Standard.

(c) Take test samples from each rolled unit of steel and individually test in accordance with this Standard. If the results from the test piece from the additional sample complies with Clause 11.1, the rolled unit of steel complies with this Standard.

(d) Reprocess (e.g. heat-treat) the unit which failed and perform another complete set of tests in accordance with Paragraph B2.2.1. The unit complies with this Standard if the results from the reprocessed test pieces comply with Clause 11.1 and, if applicable, Clauses 11.2 and 11.3.

The remainder of the test batch complies with this Standard provided it is reprocessed in the same manner as the above reprocessed unit.

B2.2.2.2 *Impact tests*

Should a retest be carried out, one or more of the following procedures should be adopted:

(a) If the average value of the three impact test results is less than the specified minimum average, or if one value is less than the specified individual test value given in Table 10—

(i) test three additional test pieces from the original sample in accordance with Clause 11.2; and

(ii) add the results to those previously obtained and calculate a new average.

If the average value of the six tests is not less than the specified minimum average, and not more than one result of the six tests is below the specified individual test value, then the unit complies with this Standard.

(b) Take two further test samples at random from the same thickness plate in the remainder of the test batch. If the test pieces from both additional samples comply with Clause 11.2, then this remainder complies with this Standard. If one of these additional samples fails to comply, the steel of the applicable thickness range (see Paragraph B 2.2.1.1) does not comply with this Standard.

(c) Take test samples from each rolled unit of steel and individually test in accordance with this Standard. If the test piece from the additional sample complies with Clause 11.2, then the rolled unit of steel complies with this Standard.

(e) Reprocess (e.g. heat-treat) the units which failed and perform another complete set of tests in accordance with Paragraph B 2.2.1. If the reprocessed test pieces comply with Clauses 11.1, 11.2 and, if applicable, Clause 11.3, then the unit complies with this Standard.

The remainder of the test batch complies with this Standard provided it is reprocessed in the same manner as the above reprocessed unit.

B2.2.2.3 *Through-thickness tensile test*

Should a retest be carried out, one or more of the following procedures should be adopted:

(a) Take two additional tests on test pieces from samples taken from a position as near as practicable to the failed sample. If both additional test pieces comply with Clause 11.3, then the unit complies with this Standard.

(b) Sample two plates at random from the remainder of the test batch. If all of the four test pieces from both additional plates comply with Clause 11.3, then this remainder complies with this Standard. If one of these additional samples fails to comply, the steel of the applicable thickness range (see Paragraph B2.2.1.1) does not comply with this Standard.

(c) Take two test samples from each rolled unit of steel and individually test in accordance with this Standard. If both the test pieces from the plate comply with Clause 11.3, then the rolled unit of steel conforms to this Standard.

(d) Reprocess (e.g. heat-treat) the unit which failed and perform another complete set of tests in accordance with Paragraph B2.2.1. If the reprocessed test pieces comply with Clause 11.3 and, if applicable, Clauses 11.1 and 11.2, then the unit complies with this Standard.

The remainder of the test batch complies with this Standard provided it is reprocessed in the same manner as the above reprocessed unit.

B2.3 Statistical sampling

B2.3.1 *General*

Process verification by statistical sampling or alternate methods can be used to demonstrate product conformity where the conditions required by Paragraph B2.3 are met (see also Note 1).

Where it can be demonstrated that the type test (see Note 2) of any group of products (see Note 3) manufactured under the same conditions of steel grade and steel processing are distributed normally, then it shall be permissible to adopt statistical sampling to verify process acceptance for each product in accordance with ISO 7966.

For product conformance to this Standard via statistical sampling, the inputs of process acceptance verification, ongoing testing and statistical sampling must be demonstrated and, where applicable, also maintained. To ensure that the process being assessed is in control (see Note 1), a statistically significant number of samples must be obtained within a rationally determined time period which is reflective of typical manufacturing practice. Within a defined group, each type of test sample randomly selected shall not exceed a sampling period of three months.

Additionally, any sample or sampling that indicates a predicted proportion of non-conforming product in excess of an amount considered within the demonstrated statistical sampling method, shall cause the sampling for that combination of size, thickness and grade to revert to batch testing rules until it can be demonstrated that the conditions of statistical sampling are valid for that combination.

In the event of actual non-conforming test results, the retest provisions of normal batch testing shall also apply.

NOTES:

1 Statistical sampling is a procedure that enables decisions to be made about the quality and conformity of batches of items after inspecting or testing only a portion of those items. This procedure will only be valid if the sampling plan has been determined on a statistical basis and the following requirements are met:

(a) The sample is drawn randomly from a population of product of known history that enables verification that the product was made from known materials at essentially the same time by essentially the same processes and under essentially the same system of control.

(b) For each different situation, a suitable sampling plan is defined. A sampling plan for one manufacturer of given capability and product throughput may not be relevant to another manufacturer producing the same items.

In order for statistical sampling to be meaningful to the customer, the manufacturer or supplier needs to demonstrate how the above conditions have been satisfied. Sampling and the establishment of a sampling plan should be carried out in accordance with recognized Standards (e.g. AS 2490, AS 1199) and methods.

Under this approach, ongoing sampling and testing of product should be directed primarily at monitoring the process to ensure that product outcomes are acceptable, within characteristic ranges as well as stable and under control (e.g. normally distributed).

2 The type test is the measured parameter such as tensile testing, impact testing, etc. These are long-term testing plans based on initial testing undertaken to determine overall conformance and other required controls to be put into place (e.g. same steel supply, same manufacturing process) to ensure ongoing compliance.

3 To reduce sampling frequencies, a group of products can consist of an aggregation of batch data from a range of products if it can be demonstrated to be normally distributed.

B2.3.2 *Tensile tests*

B2.3.2.1 *General*

Testing to AS 1391 as noted in Clause 10.4.1 is only considered within this Clause for product conformance assessment to tensile testing requirements.

B2.3.2.2 *Sampling conditions*

In conjunction with the provisions of Paragraph B2.3.1, statistical sampling shall only be used for a combination of size, thickness and grade where the statistically predicted proportion of non-conforming product is less than 5% at a confidence level of 90%.

Changes in steel supplier, steel grade and significant changes in steel maker, steel grade or plate processing (e.g. mill) shall necessitate a re-evaluation of the conditions in this Paragraph (B2.3.2.2).

B2.3.3 *Impact tests*

B2.3.3.1 *General*

Testing to AS 1544.2 as noted in Clause 10.4.2 is only considered within this Clause for product conformance assessment to impact testing requirements.

B2.3.3.2 *Sampling conditions*

In conjunction with the provisions of Paragraph B2.3.1, statistical sampling shall only be used for a combination of size, thickness and grade where the statistically predicted proportion of non-conforming product is less than 5% at a confidence level of 90%.

B2.3.4 *Through-thickness tensile test*

B2.3.4.1 *General*

Testing as noted in Clause 10.4.3 is only considered within this Paragraph (B2.3.4) for product conformance assessment to through thickness tensile testing requirements.

B2.3.4.2 *Sampling conditions*

In conjunction with the provisions of Paragraph B2.3.1, statistical sampling shall only be used for a combination of size, thickness and grade where the statistically predicted proportion of non-conforming product is less than 5% at a confidence level of 90%.

APPENDIX C

COLD-BENDING AND HOT-FORMING OF PLATE DURING FABRICATION

(Informative)

C1 COLD-BENDING

For steel plates manufactured in accordance with this Standard, the minimum inside radii for cold-bending during fabrication should be in accordance with Table C1. The recommendations given in Table C1 assume that the plate edge has been conditioned prior to bending.

Guidelines for steel grade selection, where fracture toughness is important, are given in the Sections on brittle fracture in AS 4100 and NZS 3404.1.

TABLE C1

RECOMMENDED MINIMUM INSIDE RADIUS FOR COLD-BENDING OF MECHANICALLY TESTED PLATE DURING FABRICATION

Plate thickness (t) mm	Bend direction (see Notes 1 and 2)	Inside radius, mm			
		Grade designation			
		200	250 and 300	350 and 400	450 and WR350
≤6	Transverse	0.5t	1.0t	1.5t	1.5t
	Longitudinal	1.0t	1.5t	2.25t	2.25t
>6 ≤10	Transverse	1.0t	1.5t	2.0t	2.0t
	Longitudinal	1.5t	2.25t	3.0t	3.0t
>10 ≤20	Transverse	1.5t	2.0t	2.5t	3.0t
	Longitudinal	2.25t	3.0t	3.75t	4.5t
>20 ≤50	Transverse	—	4.0t	(see Note 3)	Hot-form
	Longitudinal	—	6.0t	(see Note 4)	Hot-form
>50 ≤150	Transverse	—	(see Note 4)	Hot-form	—
	Longitudinal	—	(see Note 4)	Hot-form	—

NOTES:

1 A transverse bend is one where the axis of the bend is at right angles to the direction of rolling.

2 A longitudinal bend is one where the axis of the bend is parallel to the direction of rolling.

3 Where radii in the approximate range of 3t to 10t is desired, bending should be carried out by hot-forming. Where large bend radii (greater than 10t) is desired, bending may be carried out by cold-forming. With plate thickness greater than 40 mm, slight warming to approximately 75°C is recommended before forming.

4 It is generally desirable to hot-form. If bend radii is large (greater than 15t) and the steel is preheated to approximately 75°C, cold-forming methods should be satisfactory.

5 The recommended minimum bending radii of floorplates are as above except that where the raised figures are in tension, more liberal radii should be used.

C2 HOT-FORMING

Where hot-forming is required, it should be carried out within the temperature ranges of 580°C to 620°C or 870°C to 930°C (see Paragraph A6 of Appendix A).

APPENDIX D

STEEL FOR SEISMIC AND FRACTURE CRITICAL APPLICATIONS (NEW ZEALAND ONLY)

(Normative)

D1 ADDITIONAL REQUIREMENTS FOR SEISMIC AND FRACTURE CRITICAL APPLICATIONS

Additional requirements for steel used for seismic and fracture critical applications are set out in the New Zealand Steel Structures Standard, NZS 3404.1. Where steel is required to be supplied for these applications, the steel shall comply with those additional requirements and as set out in this Appendix.

D2 DESIGNATION

Grades for seismic and fracture critical applications shall be designated in accordance with the procedures specified in Clause 5.2 and have a S0 suffix as specified in Clause 5.3. The fine grained requirement is as specified in Clause 5.6.

Example: AS/NZS 3678-350S0FG

D3 STEEL FOR SEISMIC APPLICATIONS

S0 grade shall be tensile tested according to Clauses 10.1, 10.2, 10.3.2. If determined in accordance with Clause 10.4.1, the yield stress and tensile strength of a test piece shall conform to the limits given in Table 9. The elongation, yield ratio and yield stress of a test piece shall also conform to the additional limits in items 1, 2 and 3 given in Table D1.

The lower yield stress R_{eL} shall be used for determining the limiting ratios in Table D1 for S0 grade seismic steels. The R_{eL} value used shall be either—

(a) the R_{eL} value determined in accordance with AS 1391 and reported on the mill test certificate; or

(b) the R_{eL} value calculated from the R_{eH} value reported on the mill test certificate. The steel manufacturer shall provide the difference in mean values of R_{eH} and R_{eL} for all S0 grades of steel with a 90% statistical confidence level. These values shall be published by the manufacturer and made freely available to the purchaser on request.

TABLE D1

LIMITING RATIO REQUIREMENTS FOR S0 GRADE SEISMIC STEELS

Item	Requirement	Ratio
1	Minimum percentage elongation after fracture (A) on a gauge length of $5.65\sqrt{S_o}$ (see Note2)	0.25
2	Maximum yield to tensile ratio (R_{eL}/R_m) (see Note 2)	0.8
3	Maximum yield stress R_{eL} (see Note2)	$<1.33f_y$ (see Note 1)
4	Minimum absorbed energy for a test piece of size 10 mm × 10mm tested at 0°C (see Notes 3, 4)	70 J average 50 J individual

NOTES:

1 f_y is the grade nominal yield stress for the steel 16 mm thick

2 The R_{eL}, R_m and A values are the actual values recorded on the plate or batch test certificate

3 Impact testing is only required for plates with a nominal thickness > 12 mm.

4 The absorbed energy vales are the actual absorbed energy values recoded on the plate or batch test certificate

D4 STEEL FOR FRACTURE CRITICAL MEMBERS

The following requirements apply:

(a) Steel shall be ordered with the fine grained steelmaking practice option (see Clause 5.6).

(b) No weld repairs shall be performed to the steel (see Clause 9.3.2).

(c) The removal of defects from a plate by grinding, or by chipping followed by grinding, shall not extend below the rolled surface by more than 0.5 mm for all thicknesses of material (see Clause 9.3.1).

(d) Conformity as outlined in Appendix B shall apply.

NOTE: Fracture critical members are typically fatigue sensitive members in bridges and other structures as defined in NZS 3404.1.

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NOTES

NOTES

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