

Australian/New Zealand Standard™

Welding of aluminium structures



AS/NZS 1665:2004

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RECONFIRMATION
OF
AS/NZS 1665:2004
Welding of aluminium structures

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NOTES

Australian/New Zealand Standard™

Welding of aluminium structures

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee WD-003, Welding of Structures, to supersede AS 1665—1992.

The objective of this Standard is to standardize the welding of aluminium structures and incorporate the latest techniques used in industry.

This is a major revision of the previous edition, including references to the latest materials being used.

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.

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

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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard Welding of aluminium structures

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies requirements for the welding of aluminium and its weldable alloys in structures, components and equipment complying with AS/NZS 1664.1 or AS/NZS 1664.2, by the following processes:

- (a) Gas tungsten-arc welding (GTAW).
- (b) Gas metal-arc welding (GMAW).
- (c) Pulsed-arc welding (GTAW or GMAW).
- (d) Plasma-arc welding (PAW).

The Standard can also be used for all welded constructions other than those excluded in Section 1.2.

NOTES:

- 1 Throughout this Standard, 'aluminium' is taken to refer to 'aluminium and its weldable alloys'.
- 2 Welded components may be made up of combinations of sheets, plates, extrusions or sections, including hollow sections, built-up sections, castings and forgings.

1.2 EXCLUSIONS

This Standard does not apply to resistance welding, brazing, soldering, or the welding of pressure vessels and pressure piping (which should comply with AS/NZS 1200).

NOTE: The welding of pressure vessels and pressure piping are covered in AS/NZS 1200.

1.3 INNOVATION

It is not intended to prevent the use of novel materials, welding processes, consumables, methods of construction or testing that do not comply with a specific requirement of this Standard or are not mentioned in it, but which give equivalent results to those specified. The Standard can be applied to other welding processes such as friction welding, including friction stir, laser welding and electron beam welding, provided all requirements of the Standard are met, as well as specific constraints of needs, demands and operation of the individual welding processes.

1.4 REFERENCED DOCUMENTS

The documents referred to in this Standard are listed in Appendix A

1.5 DEFINITIONS

For the purpose of this Standard, the symbols and definitions given in AS 1101.3 and AS 2812 and the definitions below apply.

1.5.1 Design throat thickness of a complete penetration butt weld

The thickness of the thinner joined part.

NOTE: No increase is permitted for weld reinforcement.

1.5.2 Design throat thickness of an incomplete penetration butt weld

The depth of a machined preparation.

1.5.3 Effective area of a weld

The product of the effective length and the design throat thickness.

1.5.4 Effective length of a weld

The length of the continuous full-size weld, as measured along the centre-line of the throat.

1.5.5 Size of a complete or incomplete penetration butt weld

The minimum depth to which the weld extends from its face into a joint, exclusive of reinforcement.

1.5.6 Size of a complete penetration butt weld for T-joints and corner joints

The thickness of the part of a T-joint butt weld or a corner joint butt weld, of which the end or edge butts against the face of the other part.

1.5.7 Size of a fillet weld

The lengths of the sides lying along the legs of a triangle inscribed within the cross-section of the weld (see Figure 3.4).

NOTES:

- 1 Where these lengths are equal, the size is given by a single dimension.
- 2 Where there is a root gap, the length of one side is decreased by the length of the root gap, measured in the direction of that side (see Figure 3.4(c)).

1.5.8 Fabricator

The person or organization responsible for the welding of a structure during its fabrication or erection.

1.5.9 Inspecting authority

The authority having statutory powers to control the design and erection of buildings and structures.

NOTE: Where a structure is not subject to statutory jurisdiction, the principal is deemed to be the inspecting authority.

1.5.10 Inspector

A person employed by or acceptable to the inspecting authority or principal for the purposes of inspecting welding in accordance with this Standard.

1.5.11 Principal

The purchaser, owner or nominated representative (e.g., designer or engineer) of a structure being fabricated or erected.

1.5.12 Shall

Indicates that a statement is mandatory.

1.5.13 Should

Indicates a recommendation.

1.5.14 May

Indicates the existence of an option.

1.6 WELD CATEGORIES

1.6.1 General

Butt welds shall be designated Weld Category A, B or C. All fillet welds shall be designated Category B. Each weld category is characterized by permissible levels of imperfection (see Section 6) so as to assist the designer in the selection of the weld quality most appropriate to the service conditions to which the weld will be subjected. Since individual welds in a structure will normally be subjected to different service requirements, the specification of weld category should normally be considered in respect of each weld. Where a member is subject to a combination of stress conditions, the highest appropriate weld category should be applied.

The principal, or nominated representative, who may be the designer, shall indicate on the drawing the weld category selected for all welds to be fabricated in accordance with Clause 1.7. This should be by means of an additional letter added to the standard symbols for welding specified in AS 1101.3, which would normally be used. The principal is also required to nominate the extent of non-destructive examination required for production welding (see Note 1).

Matters for resolution between the principal and the fabricator shall be as given in Appendix C.

NOTES:

- 1 Guidance on the selection and extent of non-destructive examination is given in Appendix B.
- 2 The selection of a better (i.e., higher) than necessary weld category for any joint is not considered desirable, partly because it will lead to additional fabrication and inspection costs, and also because there will likely be little or no improvement in weld performance.

1.6.2 Weld Category A

Weld Category A is intended for the more severe fatigue conditions in structures. It should be specified only for members with continuous full penetration, longitudinal or transverse, butt welds, with the reinforcement dressed flush with the surface, and the weld quality verified by higher level examination and testing as set out in this Standard.

Butt welds in members with continuous penetration longitudinal or transverse, shall be dressed flush by machining, finished in the direction of the applied stress.

The members shall have edges as extruded or carefully machined, or filed in the direction of stress.

NOTE: Examples of weld designs meeting these requirements are given in AS/NZS 1664.1 or AS/NZS 1664.2 (Clause 4.8 in each of the 1997 editions).

1.6.3 Weld Category B

Weld Category B is intended principally for those butt welds subject to a tensile stress approaching the maximum permissible under AS/NZS 1664.1 or AS/NZS 1664.2 and the less severe of the fatigue stress conditions. This weld category is also intended for all fillet welds. Weld Category B is applicable where joints carry static tensile stresses in excess of 80% of the maximum stress permitted by AS/NZS 1664.1 or AS/NZS 1664.2, or the joints are subject to low-to-moderate levels of fatigue loading.

Weld Category B is normally specified for structural (i.e., load-bearing) welds in general aluminium fabrication and construction. Members fabricated with such welds would normally be identified as having one or more of the following characteristics:

- (a) Full or partial penetration transverse butt welds made from both sides.
- (b) Full-penetration continuous longitudinal automatic butt welds.
- (c) Continuous longitudinal fillet welds.

- (d) Transverse butt welds made from both sides or made from one side with an underbead.
- (e) Transverse butt welds made on permanent backing strips, which may or may not be attached by full-length fillet welds.
- (f) Full or partial penetration transverse load-carrying fillet welds or cruciform welds.
- (g) Tee joints, with or without full penetration if made from both sides, but with full penetration if made from one side.

NOTE: Examples of weld designs meeting these requirements are given in AS/NZS 1664.1 or AS/NZS 1664.2 (Clause 4.8 in each of the 1997 editions).

1.6.4 Weld Category C

Weld Category C is appropriate for joints subject only to static compressive stresses or joints carrying static tensile stress less than 80% of the maximum permitted by AS/NZS 1664.1 or AS/NZS 1664.2, or discontinuous butt and fillet welds subject to fatigue. Members fabricated with such welds would normally be identified as having one or more of the following characteristics:

- (a) Discontinuous longitudinal fillet or butt welds.
- (b) Beams with intermittent web-to-flange welds.

NOTE: Examples of weld designs meeting these requirements are given in AS/NZS 1664.1 or AS/NZS 1664.2.

1.7 BASIS

The basis of this Standard is that a weld shall—

- (a) be made in accordance with a qualified welding procedure;
- (b) be carried out by a welder suitably qualified to carry out such a procedure;
- (c) be carried out under the supervision of a welding supervisor who is employed by or contracted to the fabricator; and
- (d) comply with the appropriate requirements of the Standard.

NOTE: Where fabrication activities require the approval of the principal or the inspecting authority, or where the fabrication of large, complex or critical structures is being undertaken, fabricators may find it useful to refer to AS/NZS ISO 3834 and its parts.

1.8 SAFETY

1.8.1 Safety equipment and procedures

Welding shall be carried out in accordance with the relevant requirements of AS 1470, AS 1674.1, AS 1674.2, AS/NZS 1336, AS/NZS 1337, AS/NZS 1338.1 and AS/NZS 2865.

1.8.2 Welding equipment

Welding plant and equipment shall comply with all relevant sections of appropriate regulations, and AS 1966.1, AS 1966.2, AS 2799, AS/NZS 1995 and IEC 60974-1.

1.8.3 Other hazards

The fabricator shall identify and manage other risks and hazards from welding aluminium not covered by Clauses 1.8.1 and 1.8.2. In particular, due consideration shall be given to—

- (a) appropriate protection against both direct and indirect arc radiation;
- (b) awareness that aluminium does not change colour when heated;
- (c) the risk of high-frequency leakage from GTAW and plasma equipment; and

- (d) protection against excess noise and fume levels.

NOTES:

- 1 Guidance on safety precautions when welding aluminium can be found in WTIA Technical Note 2. For general guidance on all aspects of health and safety in welding refer to WTIA Technical Notes 7 and 22.
- 2 Guidance on the management of risk is given in AS/NZS 4360.

SECTION 2 MATERIALS OF CONSTRUCTION

2.1 PARENT METAL

2.1.1 General

Parent metal includes sheet, plate, extruded sections, castings, forgings and fabrications prepared for welding. Aluminium materials are normally supplied in wrought (i.e., mechanically worked to their final shape) or cast form. Relevant Australian Standards covering these alloys include AS 1874, AS 2338, AS/NZS 1734, AS/NZS 1865, AS/NZS 1866 and AS/NZS 1867.

2.1.2 Wrought alloys

When wrought alloys are welded in accordance with this Standard, the suitability of the alloy for welding should be assessed by reference to information contained in AS/NZS 1664.1 or AS/NZS 1664.2 or WTIA Technical Note 2.

Advice on the welding of aluminium alloys not included in the above should be obtained from the manufacturer, and should only be used after the establishment of welding procedures to the satisfaction of the principal.

2.1.3 Casting alloys

Comparatively few of the large number of casting alloys available are suitable for welding. Where welding of a casting alloy is required to comply with this Standard, the suitability of the alloy should be assessed by reference to information contained in WTIA Technical Note 2.

Typical cast alloys suited to welding are given in Table 2.2. Advice on the welding of cast aluminium alloys not included in Table 2.2 should be obtained from the manufacturer, and should only be used after the establishment of welding procedures to the satisfaction of the principal.

2.2 FILLER METALS

The selection of filler metals for use with various parent metal combinations should be as listed in Tables 2.1, 2.2 and 2.3.

NOTE: AS 2717.2 specifies requirements for aluminium and aluminium alloy filler metals.

Filler metals shall be stored in their original packets or cartons, in a dry place adequately protected from the weather. Where the manufacturer recommends special protection during storage and use, filler metals shall be stored in accordance with the recommended conditions. They shall be kept dry, smooth and free from corrosion or matter that is deleterious to the weld metal or to the satisfactory operation of the welding equipment.

NOTE: Further guidance on the selection and care of filler metals can be obtained from WTIA Technical Note 2.

2.3 SHIELDING GASES

Gases used in the welding of aluminium are normally welding-grade argon, helium or argon-helium mixtures.

Any gas or gas mixture may be used, provided that satisfactory performance and material properties are obtained from procedure tests.

Gases for shielding shall comply with AS 4882.

Shielding gases shall be stored and delivered to the welding torch in such a way as to maintain their quality.

NOTE: Further guidance on shielding gases for welding aluminium can be obtained from WTIA Technical Note 2.

TABLE 2.1
FILLER METAL SELECTION CHART FOR THE WELDING OF WROUGHT
ALLOYS ^(1,2)

First alloy	Second alloy							
	7005	6005A 6060 6061 6063 6082 6101 6106 6351	5454	5083 5086 5383	5052 5251	5005	3004 3105	1050 1100 1200 1350 3003
1050 1100 1200 1350 3003	4043	4043 ⁽³⁾	4043 ⁽³⁾	5356 ⁽⁴⁾	4043 ⁽³⁾	4043 ⁽³⁾	4043 ⁽³⁾	1100 ⁽⁴⁾
3004 3105	5356 ⁽³⁾	4043 ⁽⁵⁾	5356 ⁽⁵⁾	5356 ⁽³⁾	4043 ⁽³⁾	4043 ⁽³⁾	4043 ⁽³⁾	
5005	5356 ⁽³⁾	4043 ⁽⁵⁾	5356 ⁽⁵⁾	5356 ⁽³⁾	4043 ⁽³⁾	4043 ^(3,6)		
5052 5251	5356 ⁽³⁾	5356 ^(4,5)	5356 ⁽⁵⁾	5356 ⁽³⁾	5356 ^(4,5,7)			
5083 5383	5183 ⁽³⁾	5356 ⁽³⁾	5356 ⁽³⁾	5183 ⁽³⁾				
5086	5356 ⁽³⁾	5356 ⁽³⁾	5356 ⁽³⁾	5356 ⁽³⁾				
5454	5356 ⁽⁵⁾	5356 ^(4,5)	5554 ^(3,4,8)					
6005A 6060 6061 6063 6082 6101 6106 6351	5356 ^(4,5)	4043 ^(5,9)						
7005	5356 ^(3,10)							

NOTES:

- 1 Service conditions such as immersion in fresh or salt water, exposure to specific chemicals, or a sustained high temperature of over 65°C may limit the choice of filler metals. Filler metals alloys 5356, 5183, 5556 and 5654 are not recommended for sustained elevated temperature service over 65°C.
- 2 Recommendations in the main body of this Table apply for most applications and are the preferred choice. Under special circumstances, for alternative filler alloys refer to WTIA Technical Note 2. These alternatives offer improvements to one or more of the characteristics resistance to weld metal cracking, weld strength, ductility, corrosion resistance, anodising colour match or high-temperature service characteristics.
- 3 Alloys 5183, 5356 or 5556 may be used.
- 4 Alloy 4043 may be used.
- 5 Alloys 5183, 5356, 5554, 5556 and 5654 may be used. Alloy 5554 is the only 5xxx series filler listed suitable for service temperatures over 65°C.
- 6 Filler metal with the same analysis as the base metal may be used.
- 7 Alloy 5654 is used for welding base metal alloys for low-temperature hydrogen peroxide service of less than 65°C.
- 8 Alloy 5554 is the only 5xxx series filler listed suitable for service temperatures above 65°C.
- 9 Where welding alloys 6061, 6063 and 6082, alloy 4043 filler is recommended, to minimise sensitivity to hot cracking. However, if higher weld strength is required, alloy filler metals 5183, 5356 or 5556 may be used.
- 10 Alloy 5039 is preferred but may not be readily available.

TABLE 2.2
FILLER METAL SELECTION CHART FOR WELDING CAST
TO WROUGHT ALLOYS ^(1,2,3)

Cast alloy	Wrought alloy							
	7005	6005A 6060 6061 6063 6082 6101 6106 6351	5454	5083 5086	5052 5251	5005	3004 3105	1050 1100 1200 1350 3003
AA303 AA305 AA309 AA311 AA317 AA319 BA323 BB325 CA327 AA337 AA339	4043 ^(4,5)	4043 ^(4,5)	4047 ⁽⁶⁾	4047 ⁽⁶⁾	4043 ⁽⁴⁾	4043 ⁽⁴⁾	4043 ⁽⁴⁾	4043 ^(4,5)
CB401 CA401 CC401 DA401 EA401	4043 ^(4,7)	5356 ^(4,6,8)	4043 ^(4,7)	5356 ^(4,6,8)	4043 ^(4,7)	4043 ⁽⁴⁾	4043 ⁽⁴⁾	4043 ⁽⁴⁾
AA601 AC601 CC601 DA601 AA603 AC603	4043 ^(4,7)	5356 ^(4,6,8)	4043 ^(4,7)	5356 ^(4,6,8)	4043 ^(4,7)	4043 ⁽⁴⁾	4043 ⁽⁴⁾	4043 ⁽⁴⁾
BA701	5356 ⁽⁸⁾	5356 ^(4,6,7)	5356 ⁽⁷⁾	5356 ⁽⁷⁾	5356 ⁽⁸⁾	5356 ⁽⁸⁾	5356 ⁽⁸⁾	4043 ⁽⁴⁾

NOTES:

- 1 Service conditions such as immersion in fresh or salt water, exposure to specific chemicals, or a sustained high temperature of over 65°C may limit the choice of filler metals. Filler metals alloys 5356, 5183, 5556 and 5654 are not recommended for sustained elevated temperature service over 65°C.
- 2 Recommendations in the main body of this table apply for most applications and are the preferred choice. Under special circumstances, for alternative filler metals refer to WTIA Technical Note 2. These alternatives offer improvements to one or more of the characteristics resistance to weld metal cracking, weld strength, ductility, corrosion resistance, anodising colour match or high-temperature service characteristics.
- 3 Equivalent cast alloy designations are listed in WTIA Technical Note 2.
- 4 Alloy 4047 may be used.
- 5 Alloy 4145 is preferred but may not be readily available.
- 6 Alloy 4043 may be used.
- 7 Alloys 5183, 5356, 5554, 5556 and 5654 may be used. Alloy 5554 is the only 5xxx series filler listed suitable for service temperatures over 65°C.
- 8 Alloys 5183, 5356 or 5556 may be used.

TABLE 2.3
FILLER METAL SELECTION CHART FOR
WELDING CAST-TO-CAST ALLOYS ^(1,2,3)

Cast alloy	Second alloy				
	CB401 CC401	AA601 AC601 DA601	AA603	AA303 AA309	BA701
AA303 AA309				4047 ⁽⁴⁾	4043 ⁽⁴⁾
CB401 CC401	4047 ⁽⁵⁾	4043 ⁽⁴⁾	4043 ⁽⁴⁾	4047 ^(6,7)	4043 ^(4,5)
AA601 AC601 DA601		4043 ⁽⁴⁾	4043 ⁽⁴⁾	4047 ^(6,7)	4043 ^(4,5)
AA603			4043 ⁽⁴⁾	4047 ^(6,7)	4043 ^(4,5)
BA701					5356 ⁽⁸⁾

NOTES:

- 1 Service conditions such as immersion in fresh or salt water, exposure to specific chemicals, or a sustained high temperature of over 65°C may limit the choice of filler metals. Filler metal alloys 5356, 5183, 5556 and 5654 are not recommended for sustained elevated temperature service over 65°C.
- 2 Recommendations in the main body of this table apply for most applications and are the preferred choice. Under special circumstances, for alternative filler metals refer to WTIA Technical Note 2. These alternatives offer improvements to one or more of the characteristics resistance to weld metal cracking, weld strength, ductility, corrosion resistance, anodising colour match or high-temperature service characteristics.
- 3 Equivalent cast alloy designations are listed in WTIA Technical Note 2.
- 4 Alloy 4047 may be used.
- 5 Alloys 5183, 5356, 5554, 5556 and 5654 may be used. Alloy 5554 is the only 5xxx series filler listed suitable for service temperatures over 65°C.
- 6 Alloy 4043 may be used.
- 7 Alloy 4145 is preferred but may not be readily available.
- 8 Alloys 5183, 5356 or 5556 may be used.

SECTION 3 DETAILS OF WELDED CONNECTIONS

3.1 GENERAL

Welded connections shall be designed in accordance with AS/NZS 1664.1 or AS/NZS 1664.2 and may be joined by butt, fillet, plug or slot welds, or a combination of these. Where drawings detail welded connections, they shall provide at least the following information:

- (a) Materials of construction.
- (b) Location and type of weld.
- (c) Dimensions (e.g., leg length, design throat thickness) and effective length of welds.
- (d) Weld category required (refer Clause 1.6).
- (e) Type and level of non-destructive examination required.
- (f) Whether welds are to be made in the shop or at the site.
- (g) Details of non-standard welds, and any special requirements that would affect welding operations.
- (h) Fabrication tolerances.

When welded joints are to be subjected to cyclic loads they shall comply with the fatigue design requirements of AS/NZS 1664.1 or AS/NZS 1664.2.

NOTE: Guidance on the effects of imperfections on weld properties is given in WTIA Technical Note 2.

3.2 EDGE PREPARATION

Typical butt joint preparations for GTAW and GMAW for use in the qualification of weld procedures (see Section 4) are shown in Figures 3.1 and 3.2.