AS/NZS 1665:2004
Reconfirmed 2016

Australian/New Zealand Standard™

Welding of aluminium structures

STANDARDS AUSTRALIA

STANDARDS NEW ZEALAND
Paerewa Aotearoa

AS/NZS 1665:2004

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee WD-003, Welding of Steel Structures. It was approved on behalf of the Council of Standards Australia on 16 December 2003 and on behalf of the Council of Standards New Zealand on 5 March 2004. It was published on 22 March 2004.

The following are represented on Committee WD-003:

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Australian Industry Group
AUSTROADS
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Electricity Supply Association of Australia
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New Zealand Heavy Engineering Research Association
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This Standard was issued in draft form for comment as DR 02451.

STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

RECONFIRMATION

OF

AS/NZS 1665:2004

Welding of aluminium structures

RECONFIRMATION NOTICE

Technical Committee WD-003 has reviewed the content of this publication and in accordance with Standards Australia procedures for reconfirmation, it has been determined that the publication is still valid and does not require change.

Certain documents referenced in the publication may have been amended since the original date of publication. Users are advised to ensure that they are using the latest versions of such documents as appropriate, unless advised otherwise in this Reconfirmation Notice.

Approved for reconfirmation in accordance with Standards Australia procedures for reconfirmation on 25 September 2015.

Approved for reconfirmation in New Zealand on behalf of the Standards Council of New Zealand on 4 November 2016.

The following are represented on Technical Committee WD-003:

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New Zealand Non-Destructive Testing Association
Steel Reinforcement Institute of Australia
The University of Sydney
Welding Technology Institute of Australia

NOTES

Australian/New Zealand Standard™

Welding of aluminium structures

Originated as AS 1665—1976.
Previous edition AS 1665—1992.
Jointly revised and designated AS/NZS 1665:2004.

Jointly published by Standards Australia International Ltd, GPO Box 5420, Sydney, NSW 2001 and Standards New Zealand, Private Bag 2439, Wellington 6020

ISBN 0 7337 5736 7

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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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 in 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.

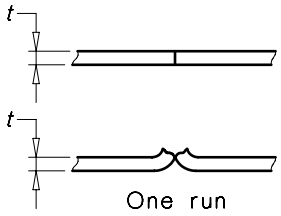
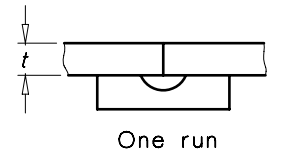
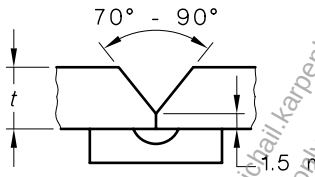
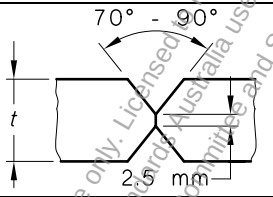
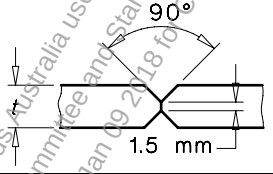
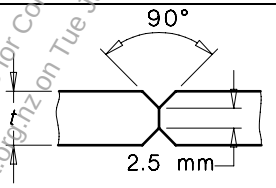
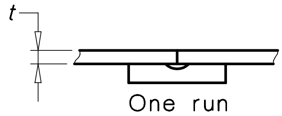
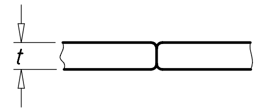
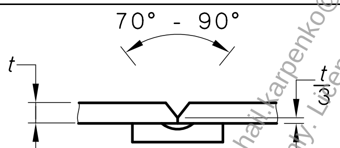
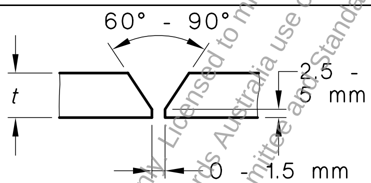
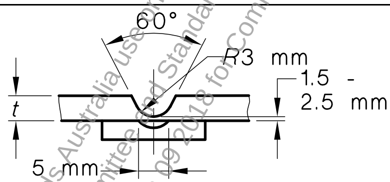
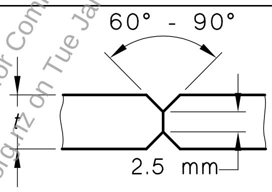
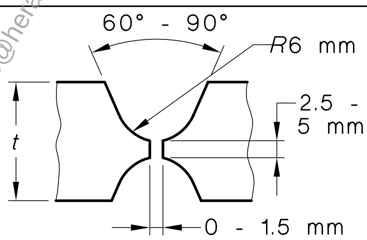
Figure	Joint type	Joint form (sectional view)	Recommended thickness *t*, mm	Application and Notes
a	Single-welded square or flanged butt joint		2 max. 1.5 max.	Flanging would be used only where square-edge close butt welds are impracticable
b	Single-welded square butt joint with backing bar		2 to 5	Where a backing bar cannot be used, welding from both sides is recommended
c	Single-welded single V butt joint with backing bar (or with sealing run, i.e., double-welded)		6 to 10	Where no backing bar is used, it is good practice to chip back to sound metal and add sealing run
d	Double-welded double V butt joint		5 to 12	Chip back first run to sound metal before welding underside Preheating may be necessary
e	Double-welded double V butt joint		5 to 6	Vertical butt welds by the double operator technique
f	Double-welded double V butt joint		6 to 12	

FIGURE 3.1 SOME TYPICAL JOINT PREPARATIONS FOR GTA WELDING

Figure	Joint type	Joint form (sectional view) (see Note)	Recommended thickness *t*, mm	Application and Notes
a	Single-welded square butt with backing bar		1.5 to 5	—
b	Double-welded square butt		6 to 10	Weld from both sides, slight chamfer recommended. 6 mm is maximum material thickness for positional welding
c	Single-welded single V butt joint with backing bar		5 to 12	Weld in one run. Suitable also for positional welding, when welded from both sides
d	Single-welded single V butt joint		6 to 12	One or more runs from each side. Back chipping recommended after first run
e	Single-welded single U butt joint with backing bar		6 to 20	One or more runs from one side, depending on thickness. Suitable also for position welding
f	Double-welded double V butt joint		12 to 25	Up to 1.5 mm root gap. One or more runs from each side. Back chipping recommended after first run
g	Double-welded double U butt joint		12 to 25	—

NOTE: The use of minimum angle should be associated with maximum radius or gap; conversely the minimum radius or gap should be associated with the maximum angle.

FIGURE 3.2 SOME TYPICAL JOINT PREPARATIONS FOR GMA WELDING

3.3 BUTT WELDS

3.3.1 Effective length

The ends of butt joints shall be welded so as to provide the full design throat thickness. This may be effected by the use of extension pieces, cross-runs, or other means approved by the principal.

3.3.2 Transition of thickness or width

Butt-welded joints between parts of different thicknesses or unequal widths that are subject to tension shall have a smooth transition between surfaces or edges. The transition shall be made by chamfering the thicker part or by sloping the weld surfaces or by any combination of these, as shown in Figure 3.3.

For static loads, the transition slope between the parts shall not exceed 1:1. For joints subject to fatigue loading, or where impulse loads may be experienced, design codes may require a lesser slope than this or a curved transition between the parts, or may require the weld to be placed away from the transition.

3.4 FILLET WELDS

3.4.1 Size of weld

As general rule, the minimum size of a fillet weld, including the first run of a multi-run fillet but not a fillet weld used to reinforce a butt weld, shall comply with Table 3.1.

TABLE 3.1

MINIMUM SIZE OF FILLET WELD

millimetres

Thickness of thinnest part, t	Size of fillet weld, S
<6	3
≥6 to <12	5
≥12 to <19	6
≥19	8

NOTE: Where it is desired to optimize the design, the size of the weld (S) may be determined using the following formula, subject to a minimum size of 3 mm:

$$S = 0.42t$$

where,

t = thickness

3.4.2 Weld contour

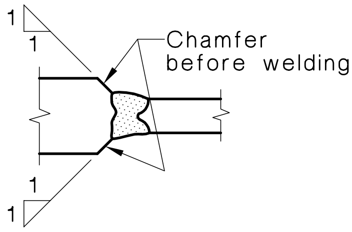
Reinforcement and penetration

The geometry of the weld shall comply with Table 6.1.

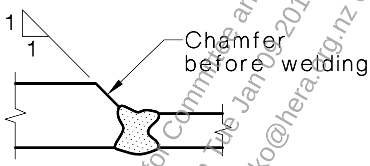
Design throat thickness

The design throat thickness for use in stress calculations shall not exceed that given in Table 3.2.

For fillet welds connecting parts, the fusion faces of which form an angle of more than 120° or less than 60°, should not be relied upon to transmit calculated loads at the full allowable working stresses.

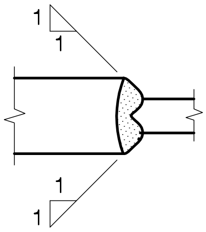


(A) Centre-line alignment (particularly applicable to web plates)

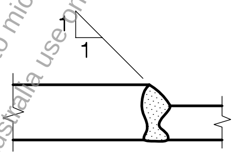


(B) Offset alignment (particularly applicable to flange plates)

(i) Transition by chamfering thicker part

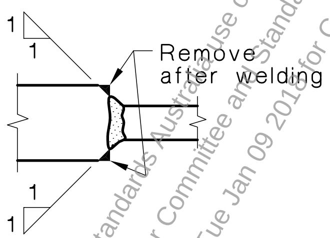


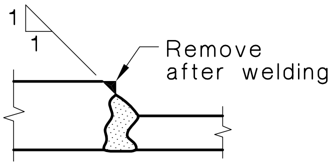
(A) Centre-line alignment



(B) Offset alignment

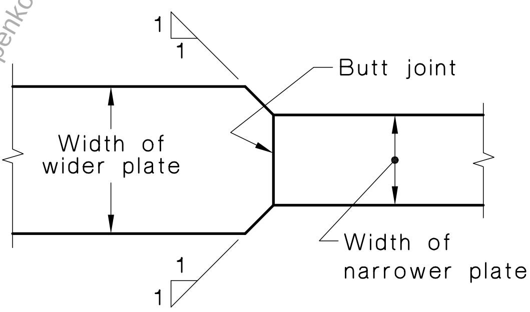
(ii) Transition by sloping weld surface





(iii) Transition by sloping weld surface and chamfering

(a) Transition of butt joints in parts of unequal thickness



(b) Transition of butt joints in parts of unequal width, transition by chamfering wider part

NOTE: Transition slopes shown in (a) and (b) are the maximum permitted.

FIGURE 3.3 TRANSITION OF THICKNESS OR WIDTHS FOR BUTT WELDS SUBJECT TO STATIC LOADING

TABLE 3.2

MAXIMUM DESIGN THROAT THICKNESSES OF FILLET WELDS

Angle θ between surfaces joined (see Figure 3.4)		Maximum design throat thickness of fillet weld
Over	Up to and including	
60°	90°	$0.70 \times S$ or S_2
90°	100°	$0.65 \times S$ or S_2
100°	107°	$0.60 \times S$ or S_2
107°	114°	$0.55 \times S$ or S_2
114°	120°	$0.50 \times S$ or S_2

LEGEND:
S = size of equal leg fillet weld
S_2 = size of shorter leg of unequal leg fillet weld (see Figure 3.4)

3.4.3 Lap joints

The overlap of parts at stress-carrying lap joints shall be not less than five times the thickness of the thinner part. Unless buckling or opening of the parts is prevented, they shall be connected by at least two transverse lines of fillet, plug or slot welds, or by two or more longitudinal fillet or slot joints.

3.4.4 T-joints and corner joints

Fillet welds may be used to join a part to a surface at angles from 60° to 90°. Fillet welds shall be provided on both sides of the joint, unless adequate provision is made to prevent bending about the axis of the weld.

NOTE: An example is shown in Figure 3.5(a).

For angles less than 60°, an arrangement that prevents bending about the axis of the weld shall be used.

NOTE: A typical acceptable detail is shown in Figure 3.5(b).

3.4.5 Intermittent fillet welds

Intermittent fillet welds may be used to transfer calculated stress across a joint or faying surfaces. The overall length of each intermittent fillet weld shall be at least four times the design leg length of the weld.

Design details shall comply with AS/NZS 1664.1 or AS/NZS 1664.2.

3.5 PLUG AND SLOT WELDS

3.5.1 Plug welds

Where plug welds are used to transmit shear in a lap joint or to prevent the buckling or separation of lapped parts, they shall—

(a) be made with fillet welds and not filled in except as permitted by the principal;

(b) have a minimum diameter of (t +10 mm), where t is the thickness of the part containing the plug weld;

(c) have a distance from the centre of the hole to the adjacent edge of the part containing it of not less than 1.75 times the diameter of the hole;

(d) have a distance from the edge of the hole to the adjacent edge of the part of not more than 10 times the thickness of the part containing the plug weld; and

(e) have a minimum centre-to-centre spacing of four times the diameter of the hole.

3.5.2 Slot welds

Where slot welds are used to transmit shear in a lap joint or to prevent the buckling or separation of lapped parts, they shall—

(a) be made with fillet welds and not filled in, except as permitted by the principal;

(b) have a width of slot of not less than the diameter of the hole specified in Clause 3.5.1(b);

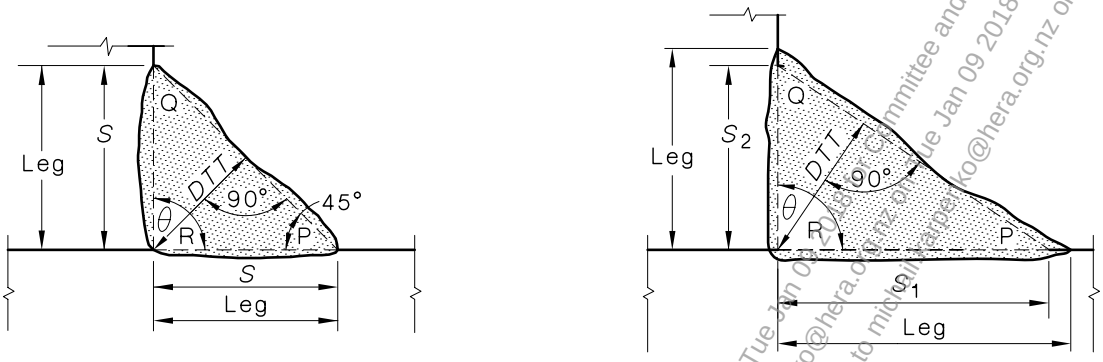
(c) have a distance from the centre of the slot to the adjacent edge of the part not less than 1.75 times the width of the slot;

(d) have a distance from the edge of the slot to the adjacent edge of the part of not more than 10 times the thickness of the part containing the slot weld;

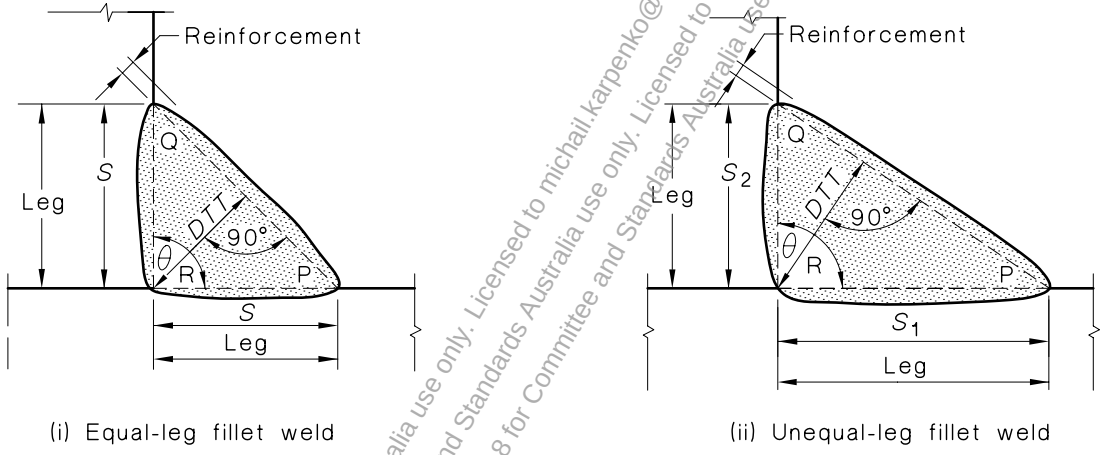
(e) have a centre-to-centre spacing in a longitudinal direction on any line of not less than the greater of twice the length of the slot or four times the width of the slot;

(f) have a length of slot of not more than 10 times the width of the slot; and

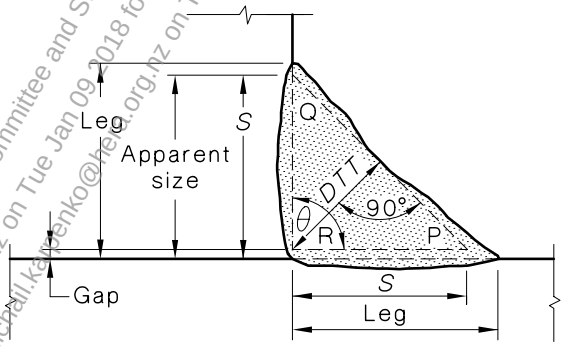
(g) have ends of the slot semicircular or rounded, to a radius of not less than the thickness of the part containing the slot.



(a) Concave fillet welds



(b) Convex fillet welds



(c) Fillet weld with root gap

LEGEND:
PQR = triangle inscribed within the cross-section of weld
S, S_1, S_2 = size of fillet welds
DTT = design throat thickness

FIGURE 3.4 FILLET WELDS

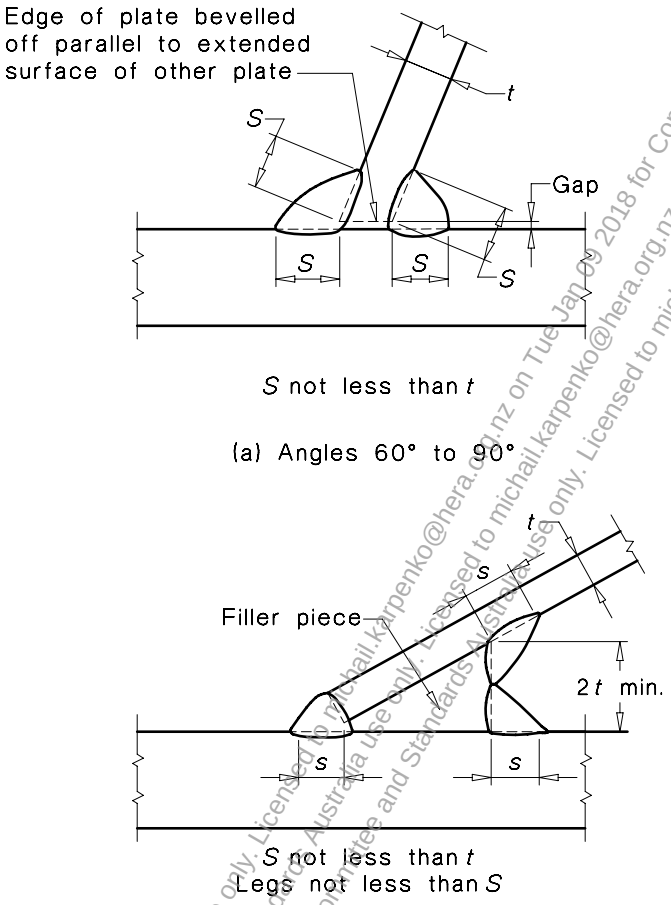


FIGURE 3.5 FILLET WELDS FOR T-JOINTS

SECTION 4 QUALIFICATION OF PROCEDURES AND PERSONNEL

4.1 WELDING PROCEDURES

4.1.1 General

The welding procedure (i.e., the weld preparation, the welding consumables and the welding parameters) shall be qualified before commencing to weld the structure or the component. The fabricator shall establish a welding procedure and list all applicable parameters in a document known as the welding procedure qualification record (PQR or also WPQR), which shall be held as a record of the welding and shall be available for examination.

A welding procedure specification shall be developed from the PQR, based on the limits of the essential variables of Clause 4.4, and made available to the welder during fabrication.

The welding procedures may be approved on the welding procedure sheets by a representative of the principal, who shall have, as a minimum, the qualification of a welding supervisor in accordance with Clause 5.2.1 or welding inspector (see Clause 7.2).

4.1.2 Methods for qualifying a welding procedure

A welding procedure shall be qualified by one of the following methods:

(a) Production of documentary evidence of relevant prior experience by the fabricator.

NOTE: A completed welding procedure sheet such as that shown in Appendix D, together with records of any tests carried out as required by the application Standard to which the procedure was qualified, constitutes documentary evidence of prior experience.

(b) Preparation of a standard test plate from which specimens are taken, such as shown in Figures 4.1 and 4.2. The plate shall simulate as closely as practicable the weld penetration, material type, material direction of rolling, material thickness, edge preparation, welding conditions, including welder access and conditions of restraint as used in production, and testing it in accordance with Clause 4.2.5.

(c) Production of a suitable length of test plate of the same joint type, material type, material thickness and edge preparation as the component upon which the procedures are to be applied. The test plate may be fabricated as a run-on or run-off piece during pre-production. Specimens taken shall be tested in accordance with Clause 4.2.5.

(d) Destructive testing of a prototype joint, structure or component. Such testing should be representative of the tests that would normally be required for a standard test plate, or by agreement between the principal and the fabricator. As far as possible, testing should comply with Clause 4.2.5.

4.1.3 Portability of qualified welding procedures

A welding procedure qualified by one fabricator shall be valid for use by a second fabricator, provided that—

(a) the original qualification tests were carried out in accordance with this Standard or other acceptable national or international Standards, and were fully documented;

(b) the second fabricator has adequate equipment and facilities and demonstrates successful welding of welder qualification tests or a production test plate (see Clause 4.3) using the procedure;

(c) the application of the welding procedure is acceptable to both fabricator and purchaser; and

(d) the welding procedure identifies the original and second fabricator.

4.2 QUALIFICATION OF WELDING PROCEDURE BY TESTING

4.2.1 General

Procedure test plates for butt welds and fillet welds shall be of the same parent metal and thickness as the procedure to be qualified. The same consumables and weld preparation shall be used, in the same position as the procedure to be qualified, using the same welding equipment, where practicable. The cleaning procedure for the test plates shall be the same as the procedure that is to be qualified and used in production.

NOTE: Where it is not practicable to comply with the above requirements, the principal and the fabricator should agree to follow the procedure test plate requirements and should simulate, as far as practicable, the procedures to be qualified.

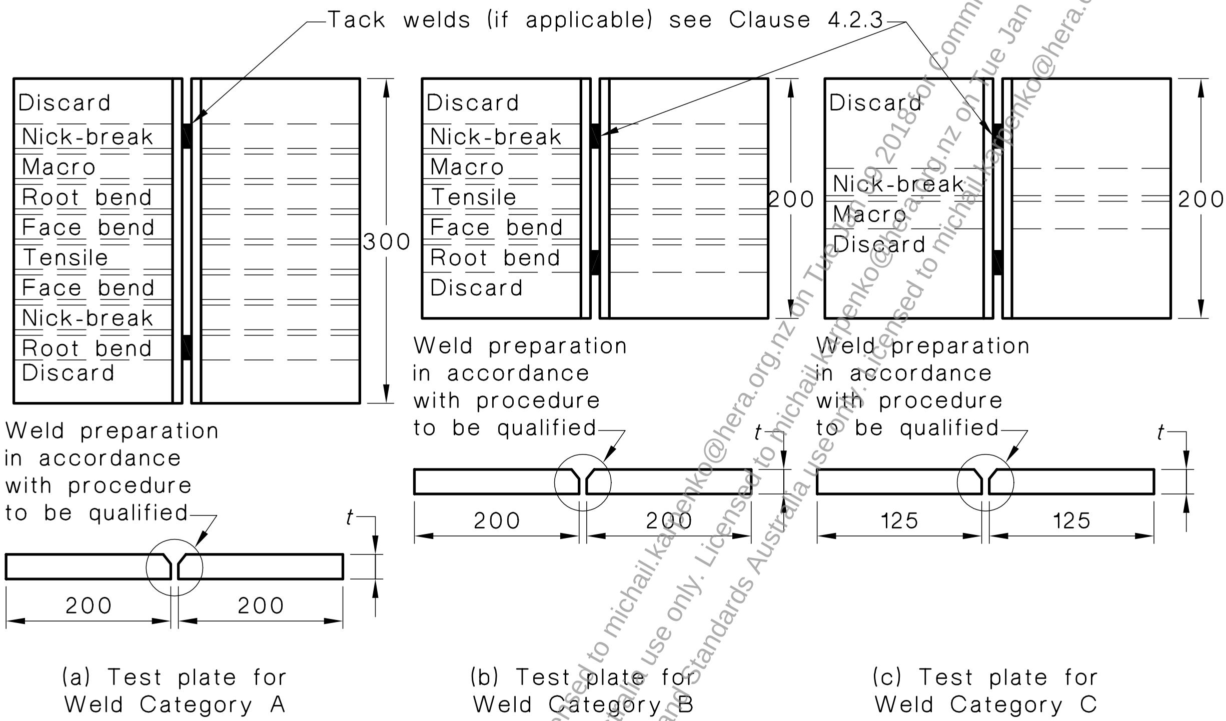
4.2.2 Tack welds

Where the welding procedure involves tack welding of the assembly, tack welds in the procedure test plate shall be located within the nick-break and root-bend specimens or in the nick-break specimen where no bend test is required, as shown in Figure 4.1.

4.2.3 Dimension of standard test plate

Where required, a standard test plate shall be prepared in accordance with Figure 4.1 or 4.2, of which the thickness of the test plate (t) shall be the same as that of the parent metal for which the qualification is being sought.

Under certain circumstances, such as an unusual joint configuration, it may be necessary to prepare multiple test plates. When preparing the test plate, good practice suggests that wherever possible run-on and run-off pieces (or tabs) should be used.



NOTES:

1 The width of specimens cut from the test piece shall not be not less than 20 mm.

2 Where double-sided preparations are used, a side-bend test may be substituted for each face-bend and root-bend test specimen.

3 For procedures involving the use of permanent backing bars, the root-bend test shall be replaced by an additional macro test.

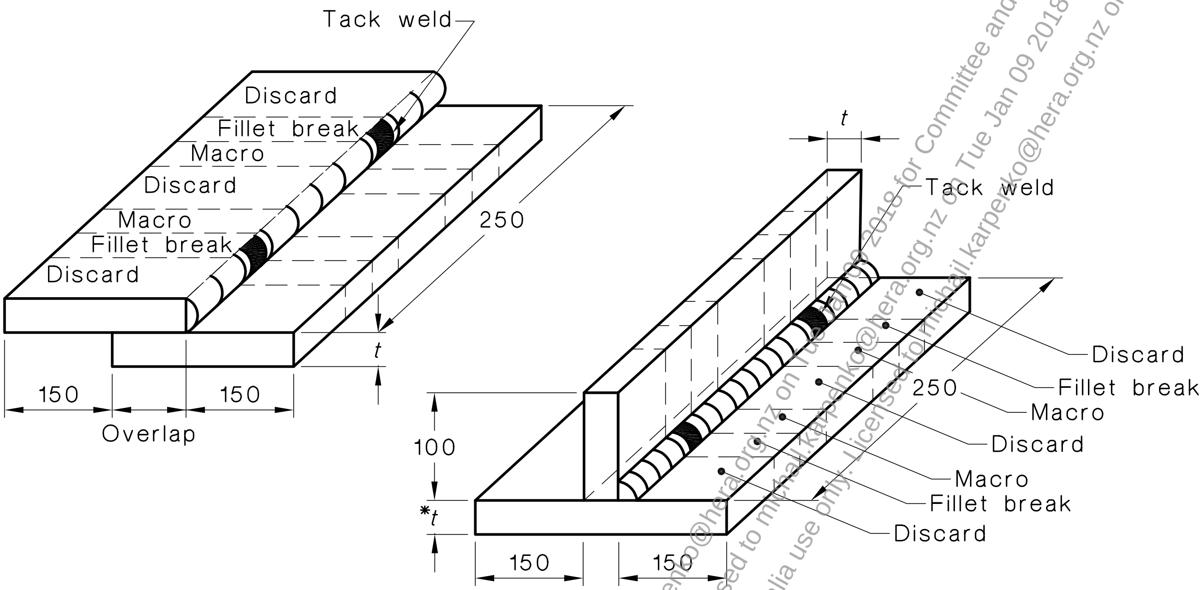
4 The width of the discards should be not less than 50 mm.

5 Plate dimensions are minimum.

6 *t* = plate thickness.

7 Test plate for Weld Category A may be used for Weld Category B and/or C. Test plate for Weld Category B may be used for Weld Category C, but not Weld Category A.

FIGURE 4.1 BUTT WELD TEST PLATES



LEGEND:
t = maximum thickness of metal at point of welding or 25 mm, whichever is smaller.

NOTES:

1 The width of specimens cut from the test piece shall not be less than 20 mm.

2 The width of the discards should be not less than 50 mm.

3 Plate dimensions are minimum.

4 Overlap should be representative of the joint configuration.

FIGURE 4.2 FILLET AND LAP WELD TEST PLATES

4.2.4 Dimension of other test plates

Where a standard test plate is not appropriate, other test plates representing the special configuration of the joint may be used. The dimensions shall be sufficient to simulate the conditions of restraint, heat flow and accessibility encountered in the actual joint and allow preparation of the required number of specimens for the tests.

4.2.5 Extent of testing

Visual examination shall be used as the first step of the assessment of all test plates. Other non-destructive tests may be used to complement visual examination prior to destructive testing. The extent of destructive testing of specimens taken from the test plates shall be as given in Tables 4.1 and 4.2.

TABLE 4.1

NUMBER OF BUTT WELD TEST SPECIMENS

	Number of test specimens		
	Weld category		
	A	B	C
Tensile	1	1	—
Face bend	2	1	—
Root bend	2	1	—
Nick-break	2	1	1
Macro	2	1	1

TABLE 4.2

NUMBER OF FILLET-WELD TEST SPECIMENS

Test	Number of test specimens
Fillet break	2
Macro	2

4.2.6 Requirements of non-destructive examination

Visual assessment and the results of other non-destructive testing shall be in accordance with the requirements of Table 6.1.

4.2.7 Transverse butt tensile test

The transverse butt tensile test shall be carried out in accordance with AS 2205.2.1, using the standard strain rate specified in AS 1391. The ultimate tensile strength of the specimen shall comply with the values given in Table 4.3. Where the specimen consists of two different parent metals, the lower of the values specified in Table 4.3 shall apply.

TABLE 4.3

TENSILE TEST REQUIREMENTS

Parent metal alloy	Minimum ultimate tensile strength of butt-welded joint (MPa)
1060	55
1350	55
1100	75
1200	75
3003	95
3105	95
3004	150
5005	96
5052	170
5251	170
5454	214
5086	240
5083	269
5383	290
6060	115
6063	115
6101	115
6106	115
6005A	165
6061	165
6082	165
6351	165
7005	256

4.2.8 Bend test

The bend test shall be carried out in accordance with AS 2205.3.1 using a wraparound jig with a mandrel diameter complying with Table 4.4. On the completion of the test, the dimension of any cracks or other defects in the weld or the heat-affected zone shall be not greater than 1.5 mm measured across the specimen or 3 mm along the specimen. Cracks and tears propagating from the edge of the specimen or defects in the parent metal remote from the weldment shall not necessarily be considered as a cause for rejection.

TABLE 4.4

MANDREL DIAMETERS FOR WRAP AROUND BEND TEST

Parent metals (all tempers)	Test mandrel diameter
1XXX series	4 *t*
3XXX and 5XXXX series	6 *t*
6XXXX series	8 *t*
7005	8 *t*

LEGEND:
t = thickness of parent metal
X = any number in the alloy series

NOTE: Where bend testing specimens consisting of two different metal alloys, the test mandrel diameter is the greater of that specified for the individual parent metal alloys.

4.2.9 Nick-break and fillet-break tests

The nick-break or fillet-break test shall be carried out in accordance with the procedure described in AS 2205.4.1 or AS 2205.4.2, as appropriate. The fracture surface shall not exhibit imperfections in excess of those specified in Table 6.1 for the appropriate weld category. In addition, the root of a fillet weld shall be fused for at least 80% of its length.

4.2.10 Macro test

The macro test shall be carried out in accordance with AS 2205.5.1. The specimen shall comply with the requirements of Table 6.1. Unless it can be proved otherwise for the remainder of the test plate (e.g., by radiographic testing, ultrasonic testing or further macro testing), internal imperfections revealed by the test piece shall be assumed to run the full length of the weld and assessed in accordance with Table 6.1.

4.2.11 Retests

If the test plate fails to comply with any of the requirements for visual inspection or non-destructive testing (NDT), a new test plate shall be welded and subjected to the same examination. If this additional test piece does not comply with the relevant requirements, the procedure qualification record (PQR) shall be regarded as not complying with the requirements of this Standard without modification.

If any test specimen fails to comply with the relevant requirements of Clause 4.2, two further test specimens shall be tested for that which failed. These specimens shall be taken from the same test plate.

If either of these additional test specimens does not comply with the relevant requirements, the PQR shall be regarded as not capable of complying with the requirements of this Standard.

If any two specimens from the test plate fail to comply with the requirements of the Standard, the PQR shall be regarded as non-complying.

4.3 WELDED PRODUCTION TEST PLATES

4.3.1 General

Welded production test plates representative of the completed weld shall be prepared and tested to verify continuing reliability of the weld procedures.

4.3.2 Number of test plates

During production, a test plate shall be provided to assess the conformance of the welding procedure whenever any of the following apply:

(a) The length of the completed production weld exceeds 200 m for automatic welding, or 100 m for manual or semi-automatic welding.

(b) There has been a prolonged break (as agreed between the principal and the fabricator) in the use of a welding procedure.

(c) A procedure qualified by another fabricator is to be introduced into production.

A production test plate may also be required where there has been a change in consumable supply or a significant change to the welding equipment.

4.3.3 Test plate requirements

The test plate shall represent the production weldment and shall be produced under production conditions.

4.3.4 Test plate size

The size of the test plate shall be in accordance with Figure 4.1(c) for butt welds or Figure 4.2 for lap welds or fillet welds, as appropriate.

4.3.5 Testing

For each type of test plate prepared, one nick-break or fillet break specimen and one macro test specimen shall be tested. The testing methods and requirements shall comply with Clauses 4.2.8 or 4.2.9 as appropriate.

4.4 CHANGES IN QUALIFIED PROCEDURE

The following changes in welding procedures shall require the welding procedure to be requalified in accordance with the requirements of this Standard:

(a) A change from one welding process to another.

(b) A change in parent metal, outside the limits given in Table 4.7.

(c) A change in filler metal classification.

(d) An increase in filler metal diameter of more than 20%.

(e) A change in electrode type and diameter for GTAW.

(f) A change in joint preparation.

(g) A change in shielding gas classification.

(h) A change in cleaning procedure, unless otherwise approved by the principal.

(i) A change of more than ±7% of the specified arc voltage.

(j) An increase of 15% or more, or any decrease of the specified welding current.

(k) A change of more than ±5% of the specified travel speed for an automatic welding process.

(l) A change of more than ±10% of the specified travel speed for a manual or semi-automatic welding process.

(m) A change of more than ±20% in the specified number of welding runs.

(n) A change in parent metal thickness outside the limits given in Table 4.5.

(o) An increase of 20% or more, or a decrease of 10% or more in flow rate of shielding gas.

(p) A change in welding position to vertical down.

(q) A change in welding current from a.c. to d.c. and vice versa.

(r) A change in d.c. polarity.

(s) change in metal transfer mode across the arc.

(t) A change in electrode stickout of more than ±20%.

(u) A change to pulsed welding, or a change in pulse parameters

NOTE: A change in pulse parameters includes a change in pulse waveform and implies that the welding machine and machine program used to qualify the welding procedure be identified on the welding procedure and used to produce the qualified production welds unless it can be demonstrated that pulse parameters remain unchanged.

TABLE 4.5

RANGE OF APPROVAL FOR THICKNESS FOR PLATES AND PIPES

Dimensions in millimetres

Thickness of the test piece *t* (see Note)	Range of approval
$t \leq 3$	0.5 *t* to 2 *t*
$3 < t \leq 20$	3 to 2 *t*
$t > 20$	≥ 0.8 *t*

NOTE: For multi-process procedures, the deposited weld metal thickness for each welding process may be used as a basis for the range of approval for the individual welding process.

4.5 QUALIFICATION OF WELDING PERSONNEL

4.5.1 General

Welding and erection should be carried out under the general direction of personnel experienced in the fabrication and welding of aluminium.

4.5.2 Welding supervisor

Welding shall be carried out under the supervision of a welding supervisor employed by or contracted to the fabricator.

The welding supervisor shall ensure that all welding is carried out in accordance with the plans, the specifications, any other documents and the requirements of this Standard.

The welding supervisor shall have a minimum of three years experience in the fabrication of welded structures, including experience or knowledge on welding of aluminium structures, and shall comply with one or more of the following:

(a) Hold a Welding Supervisor's Certificate in accordance with AS 2214, AS 1796 Certificate No. 10, or a New Zealand Institute of Welding Supervisor's Certificate.

(b) Hold an International Institute of Welding qualification at the level of International Welding Specialist (IWS), International Welding Technologist (IWT) or International Welding Engineer (IWE) diploma.

(c) Hold a New Zealand Institute of Welding Certificate in welding engineering.

(d) Hold a postgraduate certificate, diploma or degree in welding engineering from a recognized university or an approved technical college.

(e) Have served an apprenticeship in an appropriate metal trade and, during or subsequent thereto, has had five years' experience in the fabrication of welded aluminium structures and is able to satisfy the principal of sufficient technical knowledge and suitability for the work under the conditions of employment.

(f) Has at least seven years' experience in the fabrication of welded aluminium structures and is able to satisfy the principal of sufficient technical knowledge and suitability for the work under the conditions of employment.

(g) Hold a diploma or a certificate in engineering or metallurgy from an approved technical college; or is a graduate in engineering or metallurgy of a recognized university and, is able to satisfy the principal of sufficient technical knowledge and suitability for the work under the conditions of employment.

(h) Has equivalent qualifications acceptable to the principal.

NOTE: Guidance on the minimum technical knowledge requirements for Items (e), (f), (g) and (h) is provided in AS 2214.

4.5.3 Welders

Welders shall be qualified for the process, weld position, weld type (butt, fillet or lap) and weld category for which they are to be employed. The welder who qualifies a welding procedure is automatically qualified to use that welding procedure.

The following requirements shall apply to the qualification of welders:

(a) Welders not already qualified for the process and position required by the welding procedure shall be required to demonstrate an ability to comply with the procedure by producing a test plate in accordance with Clause 4.1.2(b). This shall be assessed by means of a nick-break test or a fillet break test, as appropriate, and a macro test in accordance with Clauses 4.2.9 and 4.2.10, respectively.

(b) Welders using fully automatic equipment need not be qualified, but the fabricator shall satisfy the principal that the welder is competent to operate the equipment.

Qualifications established in any one position described by this Standard may be extended within the limits of Table 4.6.

TABLE 4.6

RANGE OF WELDER APPROVAL ACCORDING TO WELDING POSITION (see Note 1)

Welding position of approval test piece				Range of approval																			
				Plates (Note 4)										Pipes									
				Butt welds					Fillet welds					Butt welds					Fillet welds				
														Rotating	Fixed				Rotating	(Note 2)	Fixed		
														0°			90°	45°			0°		90°
				F	H	VD	VU	OH	F	HV	VD	VU	OH	F	VD	VU	H	6G–VU	F	HV	VD	VU	(3)
Plates (Note 4)	Butt welds		F	✓	—	—	—	—	X	X	—	—	—	X	—	—	—	—	X	X	—	—	—
			H	X	✓	—	—	—	X	X	—	—	—	X	—	—	X	—	X	X	—	—	—
			VD	—	—	✓	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—
			VU	X	—	—	✓	—	X	X	—	X	—	X	—	—	—	—	X	X	—	X	—
			OH (Note 3)	X	X	—	X	✓	X	X	—	X	X	X	—	—	—	—	X	X	—	X	X
	Fillet welds		F	—	—	—	—	—	✓	—	—	—	—	—	—	—	—	—	X	—	—	—	—
			HV	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	X	X	—	—	—
			VD	—	—	—	—	—	—	—	✓	—	—	—	—	—	—	—	—	—	—	—	—
			VU	—	—	—	—	—	X	X	—	✓	—	—	—	—	—	—	X	X	—	—	—
			OH (Note 3)	—	—	—	—	—	X	X	—	X	✓	—	—	—	—	—	X	X	—	—	X
Pipes	Butt welds	Rotating	0°	F	X	—	—	—	—	X	X	—	—	—	✓	—	—	—	—	X	X	—	—	—
		Fixed	0°	VD	—	—	X	—	—	—	—	X	—	—	—	✓	—	—	—	—	—	X	—	—
				VU	X	—	—	X	X	X	X	—	X	X	X	—	✓	—	—	X	X	—	X	X
			90°	H	X	X	—	—	—	X	X	—	—	—	X	—	—	✓	—	X	X	—	—	—
			45°	6G–VU	X	X	—	X	X	X	X	—	X	X	X	—	X	X	✓	X	X	—	X	X
	Fillet welds	Rotating	45°	F	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	✓	—	—	—	—
		(Note 2)		HV	—	—	—	—	—	X	X	—	—	—	—	—	—	—	—	X	✓	—	—	—
		Fixed	0°	VD	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	✓	—	—
				VU	—	—	—	—	—	X	X	—	X	X	—	—	—	—	—	X	X	—	✓	X

LEGEND:

✓ Indicates the welding position for which the welder is approved in the approval list.

X Indicates those welding positions for which the welder is also approved.

— Indicates those welding positions for which the welder is not approved.

NOTES:

1 The letters in the table refer to welding positions as defined as follows, except that for vertical welding directions D = down and U = up:
F=flat position; H=horizontal position; V=vertical position; OH=overhead position; HV= horizontal-vertical position for fillet welds (position 2F as defined in AS 3545); 6G= butt weld in pipe inclined at 45 degrees (see AS 3545).

2 Horizontal for pipes may be welded in two versions:

(a) Pipe: rotating, axis: horizontal, welds; vertical.

(b) Pipe: fixed, axis: vertical, weld: horizontal vertical.

3 OH, is an approved position and is covered by other related tests.

4 Plates include Sections other than pipe.

A change in parent metal requires requalification of the welder, except as allowed for in Table 4.7. Table 4.7 describes groups of aluminium alloys with similar weldability characteristics such that a welder qualified for one alloy within a group is deemed to be qualified for all alloys within that group. Welders qualified for any of the Group 2 alloys are automatically qualified for all of the Group 1 alloys, but the reverse does not apply.

Welders qualified for Category A welds are also qualified for Category B and C welds. Welders qualified for Category B welds are also qualified for Category C welds, but not fillet welds.

Welder qualifications shall remain valid for as long as it can be demonstrated that the welder has been operating the relevant welding procedure(s) with reasonable continuity within the last six months and has continued to produce welds that comply with the requirements of this Standard.

TABLE 4.7

GROUPING OF PARENT METALS WITH SIMILAR WELDABILITY

Group	Description	Typical alloys
1	Aluminium with up to 1% impurities or alloy content, aluminium-manganese alloys, or non-heat-treatable aluminium magnesium alloys with up to 5.5% magnesium	1050, 1100, 1200, 1350, 3003, 3004, 3105, 5005, 5052, 5083, 5251, 5383, 5454
2	Heat-treatable aluminium-magnesium-silicon and aluminium-zinc alloys	6005A, 6060, 6061, 6063, 6082, 6101, 6106, 6351, 7003, 7005

4.6 RECORD OF QUALIFICATIONS

The names of all welders qualified in accordance with Clause 4.5.2, together with particulars of any qualification tests undertaken by each welder, shall be recorded and made available to the principal for the duration of the work.

SECTION 5 WORKMANSHIP

5.1 METHODS OF PREPARATION AND CLEANNESS

5.1.1 Arc strikes

Arc strikes outside the area of permanent welds should be avoided on any parent metal. Cracks or blemishes resulting from arc strikes on members other than those that are essentially statically loaded shall be repair welded, if necessary, and ground to a smooth contour. Run-on and run-off tabs should be used where applicable.

5.1.2 Joint preparation and procedures

Jigging or tack welding may be used to hold parts in proper relationship and orientation. The use of jigs and similar fixtures is preferred wherever practicable.

Where tack welding is used, the tack welds shall be completed using a qualified procedure and qualified personnel. Tack welds to be incorporated into the finished weld shall be completed using filler metal of the same composition as used for the finished weld, and the ends of the tack welds shall be dressed to allow the weld bead to blend with the tack. Tack welds shall be cleaned (e.g., by wire brushing) prior to the deposition of further weld runs. Tack welds should be well penetrated. The length of tack welds shall be not less than four times the thickness of the thicker part or 40 mm, whichever is the lesser.

Temporary attachments that aid alignment of parts shall be permitted only with the approval of the principal. The welding of temporary attachments will in many cases affect the properties of the parent metal and should be avoided where the finished structure is subject to a fatigue loading where Weld Category A (refer Clause 1.6.2) has been specified. Any temporary attachments shall be welded using a qualified procedure and qualified personnel, and shall be removed in such a manner that the thickness of the parent metal section is not reduced and the surface is dressed smooth and is free of cracks.

Temporary backing bars should be of aluminium, austenitic stainless steel, ceramic or glass tap. Copper backing bars may cause weld contamination and should not be used. Permanent backing shall be aluminium, preferably of the same alloy as that of the weldment.

NOTE: Guidance on the use of backing bars is given in WTIA Technical Note 2.

Edge preparation may be carried out by shearing, sawing, plasma-arc cutting, chipping, planing, milling or routing. Grinding may be used provided that appropriate abrasive materials are used to avoid contamination. For heat-treatable aluminium alloys, 3 mm of material shall be removed from plasma-arc cut edges by machining. Where the cut area is separated from the immediate weld area and is not part of the welded joint, that plasma-arc cut edges of heat-treatable aluminium alloys may be used without machining,.

NOTE: Typical edge preparations and welding procedures are given in WTIA Technical Note 2.

5.1.3 Cleaning

All surfaces to be welded shall be smooth and free from oxide, paint, grease and moisture. The interval between cleaning and welding should be as short as possible. The interval shall not exceed 6 h. Where a joint is accidentally contaminated by dirt or moisture after it has been cleaned, it shall be re-cleaned before it is welded.

NOTES:

1 Where prepared surfaces are not smooth, clean and free of moisture, weld porosity and oxide inclusions may result.

2 Heavily oiled material should be degreased either chemically or by a solvent. As many workshops do not possess suitable chemical degreasing plant, degreasing by swabbing with a solvent is commonly employed, but chlorinated hydrocarbon degreasing agents should not be used for this purpose because of their highly toxic properties. Solvents such as petroleum ether, industrial alcohol, acetone or white spirit are satisfactory, but the flammability of these components should be recognized and appropriate safety precautions utilised.

3 Degreasing should be followed by oxide removal from the surface to be welded, to ensure that all heavy oxide that has formed on the aluminium during manufacture and storage is removed. This can be achieved by mechanical or chemical etch cleaning methods. In multi-run welds, scratch brushing is necessary to clean between runs.

4 For further guidance on cleaning prior to welding, refer to WTIA Technical Note 2.

5.2 PREHEATING

Preheating is rarely necessary for welding aluminium except for parent metal thicknesses greater than 12 mm. Preheating may be necessary to—

(c) avoid cold start defects when welding thick aluminium;

(d) improve fusion and penetration;

(e) achieve heat balance with dissimilar thicknesses; or

(f) remove moisture.

Appropriate preheat temperatures and times should be sought from the material supplier.

NOTE: Guidance on the use of preheat and also on post-weld heating is given in WTIA Technical Note 2.

5.3 CONTROL OF DISTORTION AND SHRINKAGE STRESSES

For assembling and joining parts of a structure or built-up members or for welding reinforcing parts to members, the procedure and sequence of welding shall be such as will minimize distortion and restraint. Before starting to weld a member that is likely to result in extensive shrinkage stresses or distortion, a complete program of welding sequences shall be established by the fabricator and recorded in the welding procedure sheet.

The method of correction of distortion in excess of that allowable by the design and/or fabrication documentation shall be determined prior to commencement of welding. If heating is to be used to correct distortion, advice should be sought from the principal (see Clause 5.2).

5.4 PROTECTION AGAINST WEATHER CONDITIONS

During inclement weather, especially during periods of high winds, the welder and the work should be effectively protected. Draughts may break the gas shield, resulting in porous or oxidized welds. Simple shields may be used close to the prepared surfaces. Under conditions of high humidity, precautions should be taken to avoid condensation in the inert-gas passages of the welding torch equipment, and to avoid porous welds. If the ambient environmental temperature is below 0°C, a heated structure or shelter that will maintain the temperature adjacent to the weldment at 0°C or higher shall be provided.

5.5 ASSEMBLY

5.5.1 General

The alignment of parts to be welded shall be made as carefully as possible, having regard to the normal tolerances associated with the fabrication and erection procedures.

5.5.2 Alignment of butt-welded joints

Ends or edges of parts to be joined by butt welds shall be carefully aligned, having regard to the procedure being employed. Surfaces of plates shall not be out of alignment by more than—

(a) for Weld Category A, 5% of the thickness of the thinner part, subject to a maximum of 1.5 mm; and

(b) for Weld Categories B and C, 10% of the thickness of the thinner part, subject to a maximum of 3 mm.

The method of correction of misalignment in excess of that allowable shall be determined prior to commencement of welding. If heating is to be used to correct misalignment, advice should be sought from the principal (see Clause 5.2).

Root openings shall be not less than that specified by the qualified procedure to be used. Where a root opening exceeds that specified by more than 50%, the procedure shall be requalified by a macro test using the largest expected root gap. Welding to correct root gaps should only be used if authorized by the principal.

5.5.3 Alignment of fillet welds and incomplete penetration butt welds

Parts to be joined by incomplete penetration butt welds shall be brought into as close a contact as practicable. The root gap (i.e., the separation between the members) should not exceed 20% of the thickness of the thinner part.

For fillet welds where the root gap exceeds the lesser of 20% of the thickness of the thinner part or 1 mm, the size of the fillet weld shall be increased by the amount of the separation.

SECTION 6 QUALITY OF WELDS

6.1 QUALITY LEVELS OF WELDED FABRICATIONS

The extent of weld imperfections that are permitted for each of the weld categories is given in Table 6.1.

Where the extent of these exceeds the value shown, the imperfections shall be classed as defects and shall not be used unless repaired.

NOTE: Guidance on the extent of non-destructive examination considered desirable for a structure fabricated to this Standard is given in Appendix B.

6.2 REPAIR WELDING

6.2.1 Procedure for repair welding

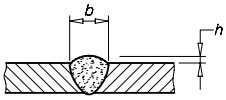
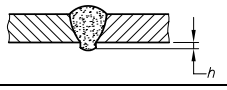
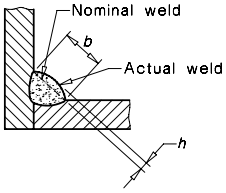
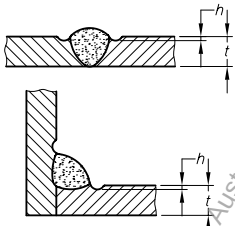
Welds that do not comply with the quality requirements as determined by Table 6.1 shall be repaired or rewelded in accordance with the requirements of this Standard. The principal shall be advised of such repairs (see Appendix C). At the discretion of the principal, it may be necessary to qualify the repair procedure. In preparation for repair welding, the defect shall be completely removed, so as to leave a smooth transition at the ends of the cut-out. The completed repair weld shall blend smoothly with the original material.

NOTE: Information on the nature and occurrence of defects in aluminium welds and recommended techniques for weld repair are given in Chapter 9 of WTIA Technical Note 2.

6.2.2 Inspection of repaired welds

Repaired welds shall be subjected to the same inspection and quality requirements as the original welds, in accordance with Clause 6.1.

TABLE 6.1
EXTENT OF WELD IMPERFECTIONS

Type of imperfection	Description of imperfection	Butt or groove welds			Fillet welds (equivalent to Category B)
		Weld category			
		Category A	Category B	Category C	
Cracks	All types of cracks in or adjacent to the weld	Not permitted			
Crater defects	Shrinkage cavity or tears	Not permitted		Total size ≤ 20% of weld width	Not permitted
Excess reinforcement (see Note 1)		$h \le 1$ mm (see Note 2)	$h \le (1.5 + 0.15b)$ and ≤ 3 mm	$h \le (1.5 + 0.2b)$ and ≤ 5 mm	
Excess penetration		$h \le 1$ mm (see Note 2)	$h \le 2$ mm	$h \le 3$ mm	
Excess convexity of reinforcement					$h \le (1.5 + 0.15b)$ and ≤ 3 mm
Undercut (see Notes 3 and 4)		Not Permitted	Continuous $h \le 0.05t$ and ≤ 1 mm	Continuous $h \le 0.07t$ and ≤ 2 mm	Continuous $h \le 0.05t$ and ≤ 1 mm
			Intermittent $h \le 0.1t$ and ≤ 1.5 mm	Intermittent $h \le 0.1t$ and ≤ 3 mm	Intermittent $h \le 0.1t$ and ≤ 1.5 mm
Exposed porosity	Refers to a single, isolated exposed pore	Not permitted	≤ 1 mm	≤ 1 mm	≤ 1 mm
Internal porosity, tungsten, and oxide inclusions	Isolated	3% loss of cross section (see Note 5)	5% loss of cross section (see Note 5)	7% loss of cross section (see Note 5)	5% loss of design throat thickness (Note 6)
	Clustered	3% loss of cross section (see Note 7)	5% loss of cross section (see Note 7)	7% loss of cross section (see Note 7)	5% loss of design throat thickness (see Note 6)
Lack of fusion and incomplete penetration	Fusion defects including lack of root, side-wall and inter-run fusion NOTE: Incomplete penetration is where the design depth of penetration is not achieved.	Not permitted	Continuous defect not permitted		
			Intermittent $h \le 0.1t$ and ≤ 1.5 mm (see Note 8)	Intermittent $h \le 0.75t$ and ≤ 3 mm (see Note 8)	Intermittent $h \le 0.05t$ and ≤ 1.5 mm (see Note 8)
Copper inclusions		Not permitted	Not permitted	Not permitted	Not permitted
Aggregate of all imperfections (see Note 9)		3% loss of cross section	5% loss of cross section	7% loss of cross section	5% loss of design throat thickness

LEGEND:
t = minimum thickness of parent metal at the weld, in millimetres
h = dimension (height or depth) of the imperfection, in millimetres
b = width of weld reinforcement, in millimetres

NOTES TO TABLE 6.1

1 For a double-sided weld, the allowable height of the reinforcement shall be considered independently for each side.

2 Reinforcement and excess penetration shall blend smoothly into the parent metal surface at the weld toes. Where the weld needs to be mechanically dressed to achieve the specified limit, the direction of dressing shall be parallel to the direction of major stress. The dressed weld shall have a maximum height above the parent metal of 1 mm at its centre. Care shall be taken that the dressing of the weld does not reduce the thickness of the parent material. Guidance on the dressing of welds is given in Chapter 10 of WTIA Technical Note 2.

3 The total length of undercut is the aggregate of both sides of the weld. A smooth transition to the adjacent material shall be provided.

4 One or more imperfections of the same type of total length greater than 25 mm in any 100 mm length of the weld, or a maximum of 25% of the weld for a weld shorter than 100 mm, shall be considered as continuous. Where the total length of the imperfection is less than these values, the imperfection shall be considered as intermittent. The length of an isolated imperfection in a weld is determined in accordance with Figure 6.1(a). Where two or more local imperfections occur in a weld, the effective total length is determined in accordance with Figure 6.1(b) or 6.1(c) as appropriate.

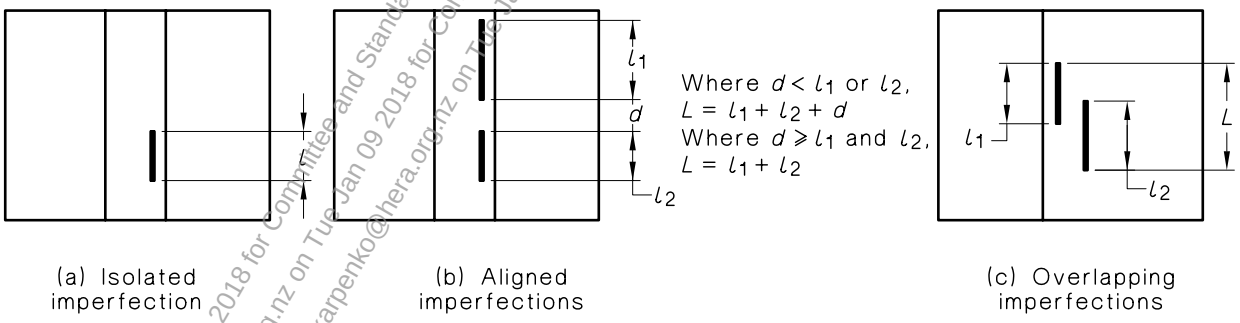
5 The cross-sectional area of the weld is calculated by multiplying the minimum parent material thickness by the average width of the weld reinforcement. Where there are adjacent vertical imperfections, the combined effect on the loss of cross-sectional area shall be determined in accordance with Figure 6.2.

6 The use of radiography for fillet welds is not always reliable, because of difficulties in interpretation. Porosity and inclusions can be evaluated from the fillet break test (see Clause 4.2.9).

7 Clustered porosity, as revealed by radiography, is considered to be a group of pores that fall within an inscribed circle of diameter equal to the width of the weld reinforcement. The total defect size is considered to be the sum of the areas of the individual pores in the cluster.

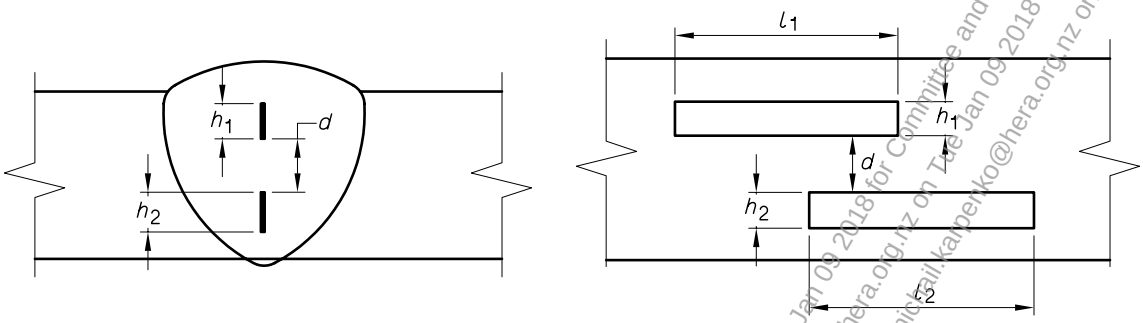
8 Where a lack of fusion or penetration defect is identified by radiography, further examination is required to determine the depth (height) of the defect. Where this is not possible for multi-pass welds, it may be assumed that the depth of the defect extends over the height of one weld run.

9 Total loss of cross-section is the sum of the contribution to the loss of cross-section of any defect listed in the table plus any other defects that may be observed, such as incompletely filled welds, root concavities, worm holes and misalignment of parent material.

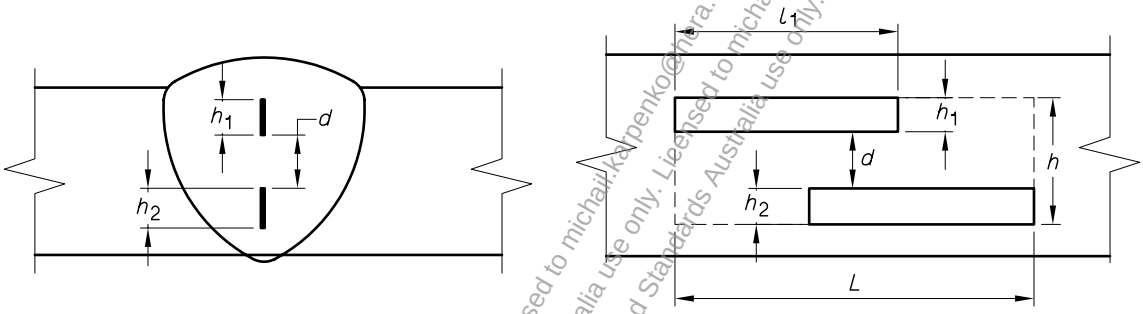


LEGEND:
ℓ = length of linear imperfections
L = effective aggregate length of imperfections

FIGURE 6.1 DETERMINATION OF EFFECTIVE TOTAL LENGTH OF IMPERFECTIONS



(a) Where $d > 5$ mm: Treat as separate defects, i.e. loss of cross-sectional area = $l_1 \times h_1 + l_2 \times h_2$



(b) Where $d \leqslant 5$ mm: Treat as separate defect, i.e. $h = h_1 + h_2 + d$ and loss of cross-sectional area = $L \times h$

FIGURE 6.2 ASSESSMENT OF ADJACENT IMPERFECTIONS IN THE CALCULATION OF THE LOSS OF CROSS-SECTIONAL AREA

SECTION 7 INSPECTION

7.1 GENERAL

This Section applies to the inspection of production welding by the inspecting authority or the principal. The inspector shall have access, at all reasonable times, to all relevant phases of the work, and shall be given reasonable notice in advance of the start of the welding operations. The inspector shall have the opportunity to witness all testing of welding procedures and welder qualification tests that are required.

7.2 QUALIFICATIONS OF INSPECTORS

The inspector shall have at least one of the following qualifications:

(a) A welding supervisor's certificate, plus significant experience in the fabrication and inspection of welded structures.

(b) A Welding Technology Institute of Australia certificate, either as a welding inspector or a welding/fabrication inspector.

(c) A Certification Board of Inspection Personnel (CBIP) New Zealand Welding Inspector Certificate.

The inspector should not be involved in the supervision of the welded fabrication.

7.3 VISUAL INSPECTION OF WORK

7.3.1 Inspection prior to and during welding

The inspector should inspect the set-up of the work and be satisfied that—

(a) the welded joints are in accordance with the approved design;

(b) the welding is being carried out with the specified material and suitable equipment;

(c) correct procedure conditions are being maintained; and

(d) the work is being performed in accordance with the provisions of this Standard.

If unacceptable defects consistently appear in the welds performed by any particular welder, further welding by that welder shall be discontinued, until additional tests are carried out by the welder and the welds so produced are considered satisfactory.

7.3.2 Inspection after welding

The inspector should verify that the type, size and location of all welds comply with the plans and specifications. A systematic check should be made to ensure that no weld called for on the drawings is omitted or that welding has been done where not required. Welds should be visually examined for surface defects, including contour, dimensions, undercut, lack of fusion, insufficient penetration, surface porosity, spatter, arc strikes and cracks in the weld or parent metal. The inspector should keep a record of the position and extent of all repairs that are required to be made and the procedure that has been approved to make the repairs.

7.3.3 Inspection after repair

The inspector should verify that all repairs required to be made have been carried out in the approved manner and the repaired welds comply, as far as practicable, with the plans and specifications. The repairs should be visually examined for surface defects, including contour, dimensions, undercut, lack of fusion, insufficient penetration, surface porosity, spatter, arc strikes and cracks in the weld or parent metal.

7.4 NON-DESTRUCTIVE EXAMINATION OTHER THAN VISUAL EXAMINATION

7.4.1 Extent of non-destructive examination

Where non-destructive examination is specified, the drawings or other documents shall state the methods to be used and the extent of testing to be carried out.

NOTE: Guidance on the selection of and extent of non-destructive examination is given in Appendix D.

7.4.2 Personnel and operator requirements

Personnel responsible for interpretation, evaluation and reporting of non-destructive examination shall have qualifications and experience acceptable to the inspecting authority and the principal. Personnel holding appropriate certification from the Australian Institute of Non-destructive Testing or the CBIP-NZ shall be deemed to be qualified.

APPENDIX A

LIST OF REFERENCED DOCUMENTS

(Normative)

AS	
1101	Graphical symbols for general engineering
1101.3	Part 3: Welding and non-destructive examination
1391	Methods for tensile testing of metals
1470	Health and safety at work—Principles and practices
1674	Safety in welding and allied processes
1674.1	Part 1: Fire precautions
1674.2	Part 2: Electrical
1796	Certification of welders and welding supervisors
1874	Aluminium and aluminium alloys—Ingots and castings
1966	Electric arc welding power sources
1966.1	Part 1: Transformer type
1966.2	Part 2: Rotary type
2205	Methods for destructive testing of welds in metal
2205.2.1	Method 2.1: Transverse butt tensile test
2205.3.1	Method 3.1: Transverse guided bend test
2205.4.1	Method 4.1: Nick-break test
2205.4.2	Method 4.2: Fillet break test
2205.5.1	Method 5.1: Macro metallographic test for cross-section examination
2214	Certification of welding supervisors—Structural steel welding
2338	Preferred dimensions of wrought metal products
2717	Welding—Electrodes—Gas metal arc
2717.2	Part 2: Aluminium and aluminium alloy
2799	Resistance welding equipment—Single-phase a.c. transformer type
2812	Welding, brazing and cutting of metals—Glossary of terms
3545	Welding positions
4882	Shielding gases for welding
AS/NZS	
1200	Pressure equipment
1336	Recommended practices for occupational eye protection
1337	Eye protectors for industrial applications
1338	Filters for eye protectors
1338.1	Part 1: Filters for protection against radiation generated in welding and allied operations
1664	Aluminium structures
1664.1	Part 1: Limit state design
1664.2	Part 2: Allowable stress design
1734	Aluminium and aluminium alloys—Flat sheet, coiled sheet and plate
1865	Aluminium and aluminium alloys—Drawn wire, rod, bar and strip
1866	Aluminium and aluminium alloys—Extruded rod, bar, solid and hollow shapes

AS/NZS

1867	Aluminium and aluminium alloys—Drawn tubes
1995	Welding cables
2865	Safe working in a confined space
4360	Risk Management

AS/NZS ISO

3834	Quality requirements for welding—Fusion welding for metallic material
3834-1	Part 1: Guidelines for selection and use
3834-2	Part 2: Comprehensive quality requirements
3834-3	Part 3: Standard quality requirements
3834-4	Part 4: Elementary quality requirements

IEC

60974	Arc welding equipment
60974-1	Part 1: Welding power sources

WTIA	[Welding Technology Institute of Australia]
Technical Note 2	Successful welding of aluminium
Technical Note 7	Health and safety in welding
Technical Note 22	Welding electrical safety

APPENDIX B

GUIDANCE ON THE SELECTION AND THE EXTENT OF NON-DESTRUCTIVE EXAMINATION

(Informative)

B1 GENERAL

The recommendations given in this Appendix are intended to apply to all aluminium structures welded in accordance with this Standard. Quality assurance procedures used for such structures may be divided into the following three categories:

(a) Procedure qualification and welder qualification, and visual examination in accordance with the requirements of the Standard.

(b) Proof (i.e., load) testing or leak testing of an agreed type.

(c) Radiographic examination or ultrasonic examination to an agreed extent.

NOTE: In general, the procedures identified in Paragraph B1(a) will provide adequate assurance for the types of structures usually welded in accordance with this Standard; however, the choice and extent of quality assurance procedures should ideally be related to the consequences of failure and possible modes of failure as detailed in Paragraphs B2 and B3.

B2 CONSEQUENCES OF FAILURE

The consequences of failure are grouped in the following four categories:

(a) *CF1*: Failure of the nominated weld resulting in total loss of structure function, danger to life or substantial financial consequences.

(b) *CF2*: Failure of the nominated weld resulting in total loss of structure function, no danger to life and moderate financial consequences.

(c) *CF3*: Failure of the nominated weld resulting in partial loss of function, total loss of function imminent.

(d) *CF4*: Failure of the nominated weld resulting in partial loss of function of structure, total loss of function being unlikely.

In some circumstances, it may be necessary to take into account that the failure of a nominated weld, while in itself having a minor (or low) consequence of failure, could lead to a more serious consequence of failure should further welds fail as a direct result. In such cases and where a single consequence of failure cannot be applied to the nominated weld, the higher (or more serious) consequence of failure should be considered.

B3 MODES OF FAILURE

Having identified the consequence of failure, it will also be necessary to consider the mechanism by which the potential failure of the nominated weld might occur. For the purposes of structures welded in accordance with this Standard, it is envisaged that the following three modes of failure should be considered:

(a) Fatigue of the structure, which is a result of the growth of a fatigue crack, which normally only applies to welds of Weld Category A or B.

(b) Lack of strength of the structure, which is the result of the application of excessive loads, which normally only applies to welds of Weld Category A or B.

(c) Leakage of the structure (e.g., tank, vessel, pipe), which is the result of a leakage of its contents, which normally only applies to welds of Weld Category B or C.

NOTE: A single mode of failure may not be applicable to a nominated weld. Instead, the weld may fail as a result of a combination of mechanisms. For example, lack of weld strength in a structure nominally subjected to static loading but experiencing minor fatigue loading may lead to local stress concentration, which could accelerate the propagation of a fatigue crack. Similarly, a weld that allows leakage in a tank or pipe may also have insufficient strength.

B4 RECOMMENDED QUALITY PROCEDURES

To achieve the required weld quality level, it is recommended that the quality assurance procedures take into account the differing consequences and modes of failure of nominated welds, as listed in Table B1.

TABLE B1
RECOMMENDED LEVELS OF QUALITY ASSURANCE

Mode of failure	Quality assurance requirements			
	Consequences of failure			
	CF1 (see Note)	CF2	CF3	CF4
Fatigue	PWQ and VE, plus RE or UE	PWQ and VE		
Lack of strength	PWQ and VE, plus RE or UE	PWQ and VE plus PT	PWQ and VE	
Leakage	PWQ and VE plus LT			

LEGEND:
PWQ = procedure and welder qualification
VE = visual examination
RE = radiographic examination
UE = ultrasonic examination
PT = proof (or load) testing
LT = leak testing

NOTE: For CF1, the amount of radiographic or ultrasonic examination normally considered appropriate is:

(a) For Weld Category A, 20 to 100%.

(b) For Weld Category B, 2 to 5%.

The percentages given may be taken over a total number of welds, or a total length of welding as considered appropriate.

APPENDIX C

MATTERS FOR RESOLUTION

(Normative)

The following matters of contractual nature shall be resolved:

(a) Nomination of weld categories (see Clause 1.6).

(b) Choice of parent metal and welding consumables (see Clauses 2.1 and 2.2).

(c) Types and details of welds (see Section 3).

(d) Approval of welding procedures (see Clause 4.1).

(e) Form of weld procedure specification sheet and procedure qualification record (see Appendix D).

(f) Method of qualification of welding procedures (see Clause 4.1.2).

(g) Requirement for production testing (see Clause 4.3).

(h) Qualification of welding supervisor (see Clause 4.5.2).

(i) Qualification of welders (see Clause 4.5.3).

(j) Details of joint preparation and set-up (see Clause 5.1.2).

(k) Details of cleaning in preparation for welding (see Clause 5.1.3).

(l) Allowances for pre-weld and/or post-weld heating and correction of distortion (see Clauses 5.2 and 5.5.2).

(m) Permissible levels of weld imperfections (see Clause 6.1).

(n) Requirements for weld repair (see Clause 6.2).

(o) Qualifications of inspectors (see Clause 7.2).

(p) Testing and inspection requirements (see Clauses 7.3 and 7.4 and Appendix B).

NOTES:

1 Further advice on these and other related matters to do with the successful welding of aluminium structures is given in WTIA Technical Note 2.

2 Where practicable, it is recommended that the principal resolve any problems with the fabricator before work is commenced.

APPENDIX D

TYPICAL FORMS FOR WELDING PROCEDURES

(Informative)

WELDING PROCEDURE QUALIFICATION RECORD (WPQR)

Procedure qualification record No.			**Date**	
WPS No.	**Process**	**1.**	**2.**	
		1.	**2.**	

Design sketch		**Welding sequence sketch**				
		Run No.	**Process No.**	**Amps**	**Volts**	**Travel speed, mm/min**
Parent metals						
Alloy and temper	To					
Thickness	To					
Wire/filler metals						
Classification						
Diameter						
Shielding gas						
Percent composition						
Flow rate						
Gas nozzle diameter						
Tungsten electrode (GTAW)						
Type						
Diameter						
Backing type						
Alloy						
Back gouging		Type of welding power source				
.....		.....				
Cleaning procedure initial		Single or multiple electrode				
Oxide removal method		Contact tip to work distance				
Degreasing agent		Welding current (a.c. or d.c.)				
Cleaning procedure interpass		Polarity				
Smut removal		Position of joint				
Dye penetrant removal		Welding progression				
		Stringer or weave bead				
		Preheat				
		Preheat temperature				
		Interpass temperature				

	Postweld heat treatment Original temper .... Final temper .... Temperature .... Time .... Quench ....

BUTT WELD TEST

Specimen no.	Width	Thickness	Area	Ultimate tensile load, kN	Ultimate tensile stress, MPa	Character of failure and location

GUIDED BEND TEST

Type of bend	Mandrel diameter	Results	Type of bend	Mandrel diameter	Results

Macro

Visual examination .... Pass .... Fail ....

Other NDT .... Pass .... Fail ....

Type and character of failure ....

FILLET WELD TEST

Fracture test .... Pass or fail	Root fusion .... Yes or no
Macro test: Weld size and contour .... (sat. or unsat.)	Penetration .... (sat. or unsat.)

Welder's name	Clock no. .... Stamp no.	
Tests conducted by		Laboratory
Test number		

	Signed .... (manufacturer)
Date	By ....
	Title ....

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Sections 4 and 6 of AS/NZS 1665, *Welding of aluminium structures*, Weld category ....

WELDING PROCEDURE SPECIFICATION SHEET (WPS)

Welding procedure specification No.	Date	Approved ....
Revisions	Date	Approved ....

Supporting PQR numbers	....	....	....	....

Weld category..

Weld joint Joint type .... Edge preparation method	**Wire/filler metal** Classification .... Diameter .... Other ....
Joint design sketch	**Shielding gas** Shielding gas .... Percent composition .... Flow rate .... Orifice or gas nozzle diameter .... Nozzle height above workpiece .... Other ....
Backing Type .... Permanent .... Removed .... Other (or sketch)	**Position** Position of joint .... Welding progression .... **Jigging or clamping details (or sketch)** ....
Parent metals Alloy and temper .... Thickness .... **welded to** Alloy and temper .... Thickness .... Thickness range qualified	**Tack welding details** .... **Run on and run off tabs** ....

	Run No.	Welding process	Amps	Volts	Travel speed, mm/min
Cleaning					
Initial cleaning oxide					
Initial cleaning oil and dirt					

Interpass cleaning					
Preheat					
Preheat temperature					
Interpass temperature					
Check method					
Postweld heat treatment					
Original temper					
Final temperature					
Temper					
Time					
Quench					
.....					
Processes					
Process ..... Type*					
Process ..... Type*					
Electrode (GTAW): Classification					
Diameter					
* Manual, automatic, polarity, pulse, transfer mode, etc.					
Technique	**Sketch of welding sequence**				
Stringer or weave bead					
Oscillation					
Contact tip to work distance					
Single pass or multipass					
(per slide)					
Tungsten extension					
Method of backgouging					
Other					
.....					
.....					

NOTES

NOTES

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ISBN 0 7337 5736 7

Printed in Australia