



Railway track materials, Part 20: Welding of steel rail

RiSSB
RAIL INDUSTRY SAFETY AND STANDARDS BOARD

Infrastructure Standard



This Australian Standard® AS 1085.20 Railway track materials, Part 20: Welding of steel rail was prepared by a Rail Industry Safety and Standards Board (RISSB) Development Group consisting of representatives from the following organisations:

ARTC	Aurizon Network	BHP Billiton
Goldschmidt	John Holland Group	LMATS
Monash Institute of Railway Technology	Pandrol	Queensland Rail
Rail Technology International	Rio Tinto	

The Standard was approved by the Development Group and the Infrastructure Standing Committee in June, 2020. On June 23, 2020 the RISSB Board approved the Standard for release.

This Standard was issued for public consultation.

Development of the Standard was undertaken in accordance with RISSB's accredited process. As part of the approval process, the Standing Committee verified that proper process was followed in developing the Standard

RISSB wishes to acknowledge the positive contribution of subject matter experts in the development of this Standard. Their efforts ranged from membership of the Development Group through to individuals providing comment on a draft of the Standard during the open review.

I commend this Standard to the Australasian rail industry as it represents industry good practice and has been developed through a rigorous process.



Deb Spring
Exec. Chair / CEO
Rail Industry Safety and Standards Board

Keeping Standards up-to-date

Australian Standards developed by RISSB are living documents that reflect progress in science, technology and systems. To maintain their currency, Australian Standards developed by RISSB are periodically reviewed, and new editions published when required. Between editions, amendments may be issued. Australian Standards developed by RISSB could also be withdrawn.

It is important that readers assure themselves they are using a current Australian Standard developed by RISSB, which should include any amendments that have been issued since the Standard was published. Information about Australian Standards developed by RISSB, including amendments, can be found by visiting www.rissb.com.au.

RISSB welcomes suggestions for improvements and asks readers to notify us immediately of any apparent inaccuracies or ambiguities. Members are encouraged to use the change request feature of the RISSB website at: <http://www.rissb.com.au/products/>. Otherwise, please contact us via email at info@rissb.com.au or write to Rail Industry Safety and Standards Board, PO Box 518 Spring Hill Qld 4004, Australia.

Notice to users

This RISSB product has been developed using input from rail experts from across the rail industry and represents good practice for the industry. The reliance upon or manner of use of this RISSB product is the sole responsibility of the user who is to assess whether it meets their organisation's operational environment and risk profile.

AS 1085.20:2020

Railway track materials, Part 20: Welding of steel rail

Document details

First published as: AS 1085.20:2020

ISBN 978-1-76072-891-5

Document history

Publication Version	Effective Date	Reason for and Extent of Change(s)
2020	June 23, 2020	First publication 1085.20:2020

Approval

Name	Date
Rail Industry Safety and Standards Board	June 23, 2020

Copyright

© RISSB

All rights are reserved. No part of this work can be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of RISSB, unless otherwise permitted under the Copyright Act 1968.

Published by SAI Global Limited under licence from the Rail Industry Safety and Standards Board, PO Box 518 Spring Hill Qld 4004, Australia

This Standard was prepared by the Rail Industry Safety and Standards Board (RISSB) Development Group AS 1085.20 Railway track materials, Part 20: Welding of steel rail. Membership of this Development Group consisted of representatives from the organisations listed on the inside cover of this document

This Standard supersedes previous versions of AS 1085.20 in whole.

Objective

The objective of this Standard is to provide owners and maintainers of railway track with specifications for and means of qualification of welding procedures for use with rail steel in railway track.

This Standard does not address the conditions under which the procedures that are described are to be used.

This Standard is not intended to cover welding of worn steel rails using flash butt or aluminothermic welds. However, the principles and procedures may be adapted for the joining of worn rails.

It is not intended to cover existing welds.

This Standard is Part 20 of the AS 1085 (Railway track material) series.

Changes in the 2020 version include:

- a) revised production tests.
- b) annual requalification tests.
- c) the introduction of additional magnetic particle inspections and phased array ultrasonic tests.
- d) clarifications on the microstructural requirements for flash butt welds.

Compliance

There are two types of control contained within Australian Standards developed by RISSB:

- 1. Requirements.
- 2. Recommendations.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard. Requirements are identified within the text by the term 'shall'.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred. Recommendations are identified within the text by the term 'should'.

Recommendations recognise that there could be limitations to the universal application of the control, i.e. the identified control is not able to be applied or other controls are more appropriate or better.

For compliance purposes, where a recommended control is not applied as written in the standard it could be incumbent on the adopter of the standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it could also be incumbent on an adopter of the standard to demonstrate their method of controlling the risk to contracting entities, or interfacing organisations where the risk may be shared.

Controls in RISSB standards address known railway hazards are addressed in an Appendix A.

Any existing aluminothermic welding or arc welding procedures evidenced to meet the testing requirements of AS 1085.15:1995, AS 1085.20: 2006 or AS 1085.20: 2012 will not need to be requalified unless requalification triggers specified in this Standard have occurred.

Contents

1	Scope and general	6
1.1	Scope	6
1.2	Normative references.....	6
1.3	Terms, definitions, and symbols.....	7
2	Basic requirements.....	10
2.1	General.....	10
2.2	Qualification of the welding procedure	10
2.3	Qualification of welding personnel.....	11
2.4	Documentation.....	11
2.5	Testing.....	11
2.6	Defects	12
3	Fixed plant flash butt welding.....	14
3.1	General.....	14
3.2	Description of the process.....	14
3.3	Qualifying flash butt welding set-up.....	14
3.4	Job document	15
3.5	Welding procedure.....	15
3.6	Maintenance of equipment.....	16
3.7	Inspection and testing of finished welds	16
3.8	Marking and records	18
4	Mobile flash butt welding	19
4.1	General.....	19
4.2	Description of the process.....	19
4.3	Qualifying flash butt welding set-up.....	20
4.4	Job document	20
4.5	Welding procedure.....	21
4.6	Maintenance of equipment.....	22
4.7	Inspection and testing of finished welds	22
4.8	Marking and records	23
5	Aluminothermic welding.....	25
5.1	General.....	25
5.2	Description of process	25
5.3	Qualifying the welding procedure	25
5.4	Job document	26
5.5	Welding procedure.....	26
5.6	Maintenance of equipment.....	27
5.7	Inspection and testing of finished welds	28
5.8	Marking and records	28
6	Aluminothermic rail head repair welding	30
6.1	General.....	30

6.2	Description of process	30
6.3	Qualifying the welding procedure	30
6.4	Job document	31
6.5	Welding procedure	31
6.6	Maintenance of equipment	32
6.7	Inspection and testing of finished welds	33
6.8	Marking and records	33
7	Electric arc rail head repair welding	35
7.1	General	35
7.2	Descriptions of welding methods	35
7.3	Qualifying the welding procedure	35
7.4	Job document	35
7.5	Welding procedure	36
7.6	Maintenance of equipment	37
7.7	Inspection and testing of finished weld	37
7.8	Markings and records	38

Appendix Contents

Appendix A	Hazard register	39
Appendix B	Guidance on this Standard	40
Appendix C	Information to be supplied by purchaser	42
Appendix D	Qualification of welding personnel	43
Appendix E	Visual inspection and alignment	45
Appendix F	Non-destructive testing	51
Appendix G	Hardness tests	62
Appendix H	Macroscopic tests	69
Appendix I	Microscopic test	72
Appendix J	Chemical analysis	76
Appendix K	Slow bend test	77
Appendix L	Fatigue tests	79
Appendix M	Qualification of a flash butt welding procedure	87
Appendix N	Qualification of an aluminothermic welding procedure	91
Appendix O	Qualification of an arc welding procedure	104
Appendix P	Air quenching of flash butt welds	106
Appendix Q	Conventional and phased array ultrasonic testing procedure	111
Appendix R	Bibliography	117

1 Scope and general

1.1 Scope

This Standard specifies requirements for the qualification of welds in steel rail manufactured in accordance with AS 1085.1 or rails that are shown to be metallurgically compatible for use in railway track. The following welding processes are covered:

- (a) Joining of rails by flash butt welding or aluminothermic fusion welding.
- (b) Repair of the railhead by arc welding or aluminothermic fusion welding.

The Standard does not provide strength properties of welds for use in design, apply to the aluminothermic or flash butt welding of tri-metal steel assemblies, or cover the welding of austenitic manganese steels.

NOTES:

1. This Standard is only intended for steel rails used in railway tracks and does not apply to any other applications.
2. Rail produced to specifications other than AS 1085.1 will require a separate qualification process. Appropriate testing and acceptance requirements will also need to be determined.
3. Other welding processes may be used if the welds produced meet all requirements identified in this Standard and are accepted by the rail infrastructure manager.
4. Additional guidance on this Standard is given in Appendix B.

1.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

- AS 1003 Engineers' straightedges (metric units)
- AS 1085.1 Railway track materials, Part 1: Steel rails
- AS 1816.1 Metallic materials—Brinell hardness test, Part 1: Test method (ISO 6506-1:2005, MOD)
- AS 1817.1 Metallic materials—Vickers hardness test, Part 1: Test methods (ISO 6507-1:1997, MOD)
- AS 2083 Calibration blocks and their methods of use in ultrasonic testing
- AS 2193 Calibration and classification of force-measuring systems
- AS 2205.5.1 Methods for destructive testing of welds in metal, Method 5.1: Macro metallographic tests for cross-section examination
- AS 2205.6.1 Methods for destructive testing of welds in metal, Method 6.1: Weld joint hardness test
- AS 2207 Non-destructive testing—Ultrasonic testing of fusion welded joints in carbon and low alloy steel
- ISO 9712 Non-destructive testing—Qualification and certification of NDT personnel

NOTE: Documents for informative purposes are listed in a Bibliography at the back of the Standard as Appendix R.

1.3 Terms, definitions, and symbols

1.3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in RISSB Glossary:

<https://www.rissb.com.au/products/glossary/> and the following apply:

- (a) **aluminothermic welding**
a welding process in which an aluminothermic reaction takes place within a crucible and the resultant molten metal flows into a weld joint contained by a mould

NOTE: The by-product, aluminium oxide slag, is contained in a side receptacle.
- (b) **as-rolled**
type of rail that is cooled off the mill, without accelerated cooling, and is not subsequently heat treated
- (c) **bond line**
vertical centre-line of a flash butt weld
- (d) **closure**
a short length of rail to replace a piece of rail in tracks, also called a plug

NOTE: A minimum length of a closure or plug should be specified by the track owner.
- (e) **consumables**
material consumed in the performance of a weld
- (f) **flash butt welding**
electrical welding process that produces a weld at the mating surfaces of a butt joint by heating due to high electric current followed by the application of pressure between the two ends of the rail
- (g) **fusion zone**
area of weld metal revealed by etching cut sections

NOTE: This represents the area of molten metal consisting of a mixture of parent metal and weld metal (where applicable) that has solidified to form the weld metal as revealed in the etched cross-section during testing.
- (h) **rail grade**
rail with different metallurgical properties
- (i) **head-hardened**
type of rail in which the head has a hardened zone extending inwards from its top and side surfaces

NOTE: For the purpose of this Standard, head-hardened rail has been treated by accelerated cooling of the head to produce a fine pearlitic structure.
- (j) **heat-affected zone**
section of the parent rail outside the fusion zone that has mechanical properties altered by the welding process
- (k) **heat-softened zone**
part of the heat-affected zone characterized by hardness below that of the parent rail

- (l) **job document**
document that describes the specific program of work and refers to the welding procedure to be used
- (m) **junction weld**
weld joining together two different rail profiles
NOTES:
1. For example a weld joining a 50 kg and 60 kg rail.
2. See also 'step weld' (Definition p)).
- (n) **short head**
insufficient weld metal head
NOTE: See also definition 1.3.1(w)
- (o) **slope angle**
angle subtended between a horizontal line along the top of the rail surface, and a sloping line along the surface of a rail weld
NOTE: The slope angle is normally measured over a distance of 100 mm along the rail surface and 50 mm either side of the weld centreline.
- (p) **step weld**
weld joining together rails of the same profile but of different heights due to wear
Note: see also 'junction weld' (Definition m)).
- (q) **upset**
the stage during flash butt welding, after heating, when the two rail ends are forged together. The upset distance is the distance of rail consumed during this process
- (r) **welding procedure**
the written detailed methods and practices involved in the making and testing of a rail weld
- (s) **welding procedure qualification record**
the written record of the tests undertaken, and the results obtained, to qualify the welding procedure in accordance with the requirements of this Standard
- (t) **visible heat-affected zone**
section of the parent rail either side of the fusion zone within which microstructure has been altered by the heat of the welding process
NOTE: It can be made visible by macro etching and is not to be confused with heat-affected zones identified by hardness variation.
- (u) **welding process**
a particular method of welding involving the application of certain metallurgical, electrical, physical, chemical, or mechanical principles
NOTE: Flash butt, aluminothermic fusion and arc welding are applicable examples.
- (v) **weld gap**
the distance between the ends of the rail prior to welding
- (w) **weld metal head**
weld metal remaining above the top of the rail profile after solidification

- (x) **weld collar**
the thickened area of weld reinforcement surrounding an aluminothermic weld

1.3.2 Notation

The symbols used in this Standard, including their definitions are listed below:

A	= a value used in calculating the variation of fatigue results $= \sum(i n_i)$
AB	= distance identified as the width of the heat-softened zone by a hardness traverse just below the rail top surface
AT	= Aluminothermic tolerance allowable variation in longitudinal alignment of the welded rail section in the vertical and horizontal directions, when measured using a calibrated measurement device
B	= a value used in calculating the variation of fatigue results $= \sum(i^2 n_i)$
D_1, D_2	= collar depth at location A
d	= constant stress increment of the staircase, in megapascals, taken as 20 MPa
d_1, d_2	= collar depth at location B
E	= eccentricity on the railhead
HBW	= Brinell hardness number with the test carried out using tungsten carbide ball
HV	= Vickers hardness number
I	= second moment of area of the rail section, in millimetres to the fourth power
i	= number assigned to indicate the test stress level (coded stress level) ($i = 0$ for S_0)
L	= test span, in millimetres
m	= mean fatigue strength, in megapascals
N	= total number of less frequent events $= \sum(n_i)$
n_i	= number of less frequent events at the i -th moment level above S_0
P	= test load, in newtons
R_f	= riser cross-section, at the rail foot
R_N	= riser cross-section, at the neutral axis
S_0	= lowest stress range at which tests with the less frequent result were conducted, in megapascals
s	= standard deviation
W	= weld collar width
X_f	= minimum width of fusion zone
X_{vhaz}	= width of visible heat-affected zone, measured at the running surface
y_{foot}	= distance of the extreme fibre in the foot from the neutral axis, in millimetres
σ	= outer fibre stress, in megapascals

2 Basic requirements

2.1 General

Welding shall:

- (a) be qualified by testing;
- (b) be performed by appropriately qualified personnel;
- (c) be performed in accordance with the job document that references the required welding procedure; and
- (d) comply with the requirements of this Standard, including testing, for one of the following welding processes:
 - i. Flash butt welding as given in Sections 3 and 4.
 - ii. Aluminothermic welding as given in Section 5.
 - iii. Aluminothermic rail head repair welding as given in Section 6.
 - iv. Arc rail head welding repairs as given in Section 7.

NOTE:

1. See Appendix C for information to be supplied by the Purchaser.
2. Manufacturers making a statement of compliance with this Australian Standard on product, packaging or promotional material related to that product should ensure that such compliance is capable of being verified.

2.2 Qualification of the welding procedure

2.2.1 Qualification

Welding procedures shall be qualified by testing in accordance with the appropriate Section of this Standard.

The results of all qualification tests carried out shall be recorded in the form of a welding procedure qualification record, together with the relevant welding procedure. This information shall include the welding program used for the qualification testing.

All records shall be kept and made available to those authorized to examine them.

Separate qualification is required for each rail grade and type. Where welding procedures apply to the aluminothermic or flash butt welding processes, separate qualification is also required for each rail profile.

2.2.2 Requalification

Requalification of welding procedures shall be required, and a new welding procedure qualification record produced if any of the following occur:

- (a) The rail type, profile or grade are changed, including welds at a combination of two different rail types and grades.
- (b) The rail section used in aluminothermic or flash butt welding is changed.
- (c) Any aspect of a prequalified procedure has been altered as defined in Sections 3.3, 4.3, 5.3, 6.3 and 7.3 for each welding process, as appropriate.

2.3 Qualification of welding personnel

Welds shall be made by personnel who are qualified according to the requirements of Appendix D.

2.4 Documentation

2.4.1 Job document

The whole of the work to be carried out, including safety precautions, shall be described in a job document. The job document shall make reference to the welding procedure to be used. It shall be readily accessible, held as a record, and available for examination.

NOTES:

1. Rail welding requires considerations other than the production of the weld itself. Some of these will depend on the situation of the weld and the needs of the organizations involved. For example, access to a part of a railway track will require permission from the rail infrastructure manager. The job document should set out how such permission is to be secured and any operating procedures for safety.
2. Safe working procedures that are suitable for the activities to be carried out should be established and included in the job document (see Safe Work Australia, Code of Practice: Welding processes).

2.4.2 Welding procedure

Welding procedures shall be documented, see Sections 3.5, 4.5, 5.5, 6.5 and 7.5. The welding procedure shall be available at the welding site and shall also be referenced in the job document.

2.5 Testing

Test methods for use in this Standard are given in Appendix E to L, and include:

- (a) visual inspection alignment and size ranges for imperfections;
- (b) non-destructive test;
- (c) weld metal hardness;
- (d) hardness traverse;
- (e) macroscopic test;
- (f) microscopic test;
- (g) chemical analysis;
- (h) slow bend test;
- (i) fatigue test.

2.6 Defects

Table 2-1 provides an overview of the type of defects that can occur during the different welding processes described in this Standard.

Table 2-1 – Defect types

Defect type	Description	Applicable welding process			
		Flash butt	Aluminothermic	Aluminothermic head repair	Arc head repair
Cold shut	Prematurely chilled regions of metal resulting in unfused discontinuities within the weld metal.	x	✓	✓	x
Fin	Thin projection of weld metal from the weld collar, typically formed as a result of backfilling of cracks in the mould material.	x	✓	✓	x
Flashing	Thin protrusion of metal extending from the collar of an aluminothermic weld along the joint line between the mould and rail caused by a poor fit between the rail and mould. NOTES: 1. This condition can also be referred to as 'cold lap'. 2. "Flashing" can also refer to the period in the flash butt welding process where active sparking is taking place, leading to overall metal loss at the butted surfaces.	x	✓	✓	x
Flat spot	A discontinuity present at the bond line of flash butt welds, which can be evident as a circular or elliptical shape but can be large and irregular, and generally have a localized smooth texture in a fracture surface after slow bend testing.	✓	x	x	x
Hot tear	Fracture in the weld caused by excessive tension during solidification of the molten weld metal.	✓*	✓	✓	x
Inclusions	Non-metallic matter entrapped during welding.	✓	✓	✓	✓

Table 2-1 (Continued)

Defect type	Description	Applicable welding process			
		Flash butt	Aluminothermic	Aluminothermic head repair	Arc head repair
Lack of bond	Area of incomplete fusion between the rails in flash butt welds, which can also appear as small scale cracks or voids.	✓	✗	✗	✗
Lack of fusion	Area of incomplete fusion between the weld metal and the rail section, which can also appear as small scale cracks or voids.	✓	✓	✓	✓
Porosity	Cavities formed by entrapped gas during the solidification of molten metal	✗	✓	✓	✓
Short head	Insufficient weld metal to adequately fill the head, due to leakage elsewhere in the mould. See definition (w).	✗	✓	✓	✗
Shrinkage crack	Local cavity in the weld metal occurring during solidification. It can be on the surface or in the body of the weld.	✓	✓	✓	✓*

Legend

✓ applies to the process

✗ does not apply to the process

✓* can be an issue in exceptional circumstances.

3 Fixed plant flash butt welding

3.1 General

This Section covers the joining of lengths of rail by flash butt welding at permanent installations. This Section does not cover mobile machines used at a fixed location. See Section 4 for mobile flash butt welding.

3.2 Description of the process

Flash butt welding is a resistance welding process that produces a weld at the mating surfaces of a butt joint by a flashing action and by the application of pressure after heating is substantially completed. The flashing action, caused by very high current densities at small contact points between the workpieces, forcibly expels the material from the joint as the workpieces are slowly moved together. The weld is completed by a rapid upsetting of the workpieces. Excess material resulting from the upset stage is then removed by shearing. See Figure 3-1.

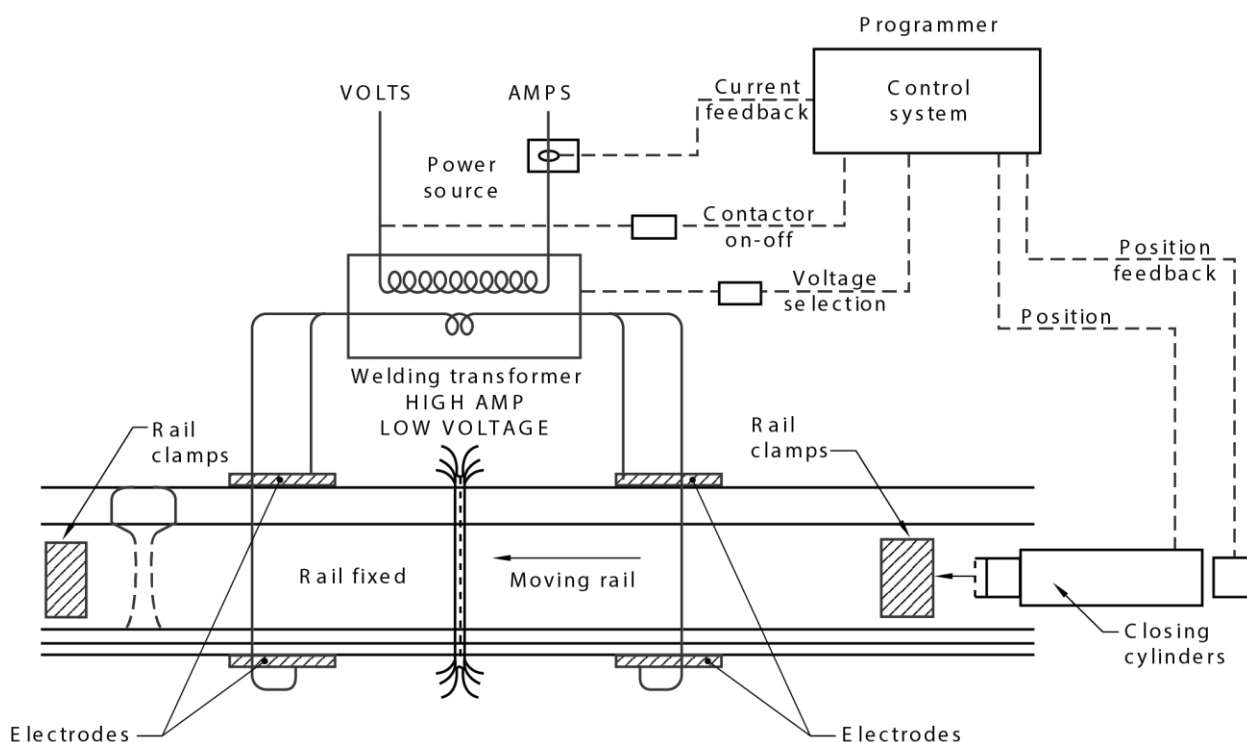


Figure 3-1 Typical fixed plant flash butt welding set-up

3.3 Qualifying flash butt welding set-up

A flash butt welding procedure shall be qualified in accordance with Appendix M.

Qualification shall be undertaken prior to the commencement of production welding for fixed plant welding equipment manufacturing long welded rail. This shall be performed on an annual basis, and/or if the flash butt welding equipment has not been used for more than six months.

Test welds prepared for qualification according to this Standard shall be manufactured in new rail.

Requalification of a flash butt welding procedure shall be carried out when either:

- (a) any change in any of the welding parameters (cycle time, duration of flashing, voltage, amps, and similar); or
- (b) the preheating is changed.

Following initial qualification of a flash butt welding procedure and commencement of production welding, for each rail grade and each rail profile, regular testing shall be carried out in accordance with Section 3.7. Additional tests may be undertaken in accordance with a quality assurance plan as agreed between the contracting parties. One routine slow bend test should be carried out every 1000 welds, unless otherwise specified by the rail infrastructure manager.

In addition to the requirements outlined above, additional slow bend testing (see Appendix K) shall be undertaken for fixed welding equipment following rectification of a welding machine malfunction and following equipment overhaul that could affect the welder's functionality, such as part replacements.

3.4 Job document

All flash butt welds shall have a job document prepared, which shall include the following:

- (a) Description of the work.
- (b) A reference to the qualified welding procedure to be used.
- (c) an arrangement for the protection of the equipment and the welded rail from adverse weather conditions during the process of welding and subsequent cooling.
- (d) Workplace health and safety (WHS) requirements.
- (e) Any preparatory tasks needed prior to welding (e.g. permission for access).

3.5 Welding procedure

This welding procedure shall include as a minimum:

- (a) Name of the procedure.
- (b) Welding personnel qualification — welding shall be performed by personnel qualified to the requirements of Appendix D.
- (c) Rail profile, type and grade — profile, type and grade shall be described (e.g. 60 kg head-hardened H370).
- (d) Diagrams of the process.
- (e) List of equipment.
- (f) The method used for removing the scale and rust at the ends to be welded as well as the electrical contact surfaces (typically head and foot of the rail for fixed welders). This method should ensure that these surfaces remove the oxide back to bare metal. The method used for qualification welds should be the same as that used for production welding.

- (g) Alignment of rails — Rails shall be aligned prior to welding, taking into account cooling and the specified tolerance of the finished weld. Alignment is required both vertically and horizontally.
- (h) Preheating (If applicable).
- (i) Welding parameters, which shall include identification of critical parameters of flash butt welding equipment. These include the preheating conditions, recording of flashing to ensure that this is not interrupted, upset load, current and upset (forging) distance. The record shall be available as a chart which includes the overall during of the welding cycle as well as recording when the shearing process was performed.
- (j) Post-weld heat treatment (If applicable).
- (k) Controlled cooling (If applicable).

NOTE: Cooling of the weld will need to be controlled to achieve the mechanical and microstructural properties. Additional requirements on controlled cooling are given in Appendix P.

- (l) Pressing of weld for alignment.
- (m) Dressing and grinding of welds — After welding, excess metal shall be removed and the running surface and both sides of the head finished by grinding. Final grinding shall be conducted in such a way that the temperature of the rail is not high enough to cause any metallurgical change.

NOTE: Additional grinding can be required of the other sheared surfaces such as the web, underside of the rail head or foot or the outer edges of the foot as specified by the purchaser.
- (n) Inspection and testing, post-weld inspection and testing shall be carried out as given in Section 3.7.
- (o) Marking and records, marking and records shall be in accordance with Section 3.8.

NOTES:

1. The ends of the welded string may be drilled with consideration given to the number and position of holes. Generally, holes are not allowed closer to the end than the position of the second hole in the 6-hole fishplate for that rail.
 2. Monitoring of the machine parameters (such as flashing time, current, hydraulic pressure, upset slippage and similar) can assist in control of the quality of the welds.
 3. A finished weld should be selected from normal production on a regular basis and tested in accordance with Appendix M, to ensure the welds continue to comply with this Standard.
- (p) Qualification to AS 1085.20 statement that the procedure has been qualified to this Standard.

3.6 Maintenance of equipment

The equipment shall be maintained and calibrated in accordance with a written procedure.

3.7 Inspection and testing of finished welds

Inspection and testing of all finished welds shall be carried out to ensure the weld satisfies the criteria given in Table 3-1 for weld collar tolerances, surface alignment (AT1, AT2 and AT3, as specified) and non-destructive testing.

Table 3-1 Inspection of finished flash butt welds

Test	Test Method (Appendix)	Description	Pass criteria		
Visual inspection	E	Visual inspection of all surfaces	No cracks, tears, gouges, shear drag, electrical contact burns, grinding burns		
Surface alignment tolerances	E	Alignment tolerance grade (Note 1,3)	Vertical	Horizontal	Maximum slope angle on top of rail
		AT1	0.0 mm to +0.3 mm	±0.5 mm	±7 milliradians (Note 2)
		AT2	0.0 mm to +0.5 mm	±0.5 mm	Limit to be specified by the purchaser
		AT3	Limit to be specified by the purchaser	Limit to be specified by the purchaser	Limit to be specified by the purchaser
Weld collar tolerances – Deviation from rail profile	E	At rail web and upper side of rail foot	0.0 mm to +2.0 mm		
		Underside of rail foot	0.0 mm to +1.0 mm		
		The maximum grinding deviation with respect to rail surface profile:			
		Top of railhead	0.0 mm to +0.15 mm		
		Side of railhead	0.0 mm to +0.3 mm		
Non-destructive test	F	Internal imperfections	Railway owners should determine the limits for internal imperfections. Suitable values are given in Appendix F.		
		Magnetic particle inspection (Note 4)	2 mm maximum linear indication.		
Slow bend test	K	Validation of welding equipment	Welding record confirms that welding equipment is operating as intended within the period of qualification (see Section 3.3).		

NOTES:

1. The grade is specified for the application. Selection of tolerance level will affect the loads experienced at the weld and thus the expected life of the joint for given track conditions and level of traffic.
2. Measured over a distance of 100 mm along the rail surface and 50 mm either side of the weld centre-line (Section 1.3.1, definition (o)).
3. An AT1 tolerance grade would be applicable for a high-speed passenger line. An AT2 tolerance grade would be generally applicable for passenger line and heavy haul freight line.
4. Where magnetic particle inspections are specified by the rail infrastructure manager.

3.8 Marking and records

3.8.1 Marking

Each weld shall have unique markings. Each marking shall remain legible for a minimum period of 12 months from the date on which the weld was made.

3.8.2 Records

A record of the procedure shall be kept, which shall include manufacturer's identification, weld number, date, rail string classification profile, type and grade, and post-welding treatments applicable to the weld, the rail number, welding parameters, (e.g. primary welding current, upset force, welding cycle time), inspection and testing.

Records should also be kept of the program used to make the welds during qualification trials so that it can be uniquely linked to that used for production welds.

3.8.3 Monitoring

Key parameters, as well as measurement of the overall heat input (i.e. combination of current and voltage input over the welding cycle), should be regularly monitored. These can indicate issues with rail surface preparation, current straps, machine cleanliness, cooling systems issues, etc.

4 Mobile flash butt welding

4.1 General

This Section covers the joining of lengths of rail by flash butt welding using portable equipment at a fixed location, in the field or on track.

4.2 Description of the process

Flash butt welding is a resistance welding process that produces a weld at the mating surfaces of a butt joint by a flashing action and by the application of pressure after heating is substantially completed. The flashing action, caused by very high current densities at small contact points between the workpieces, forcibly expels the material from the joint as the workpieces are slowly moved together. The weld is completed by a rapid upsetting of the workpieces. Excess material resulting from the upset stage is then removed by shearing. See Figure 4-1.

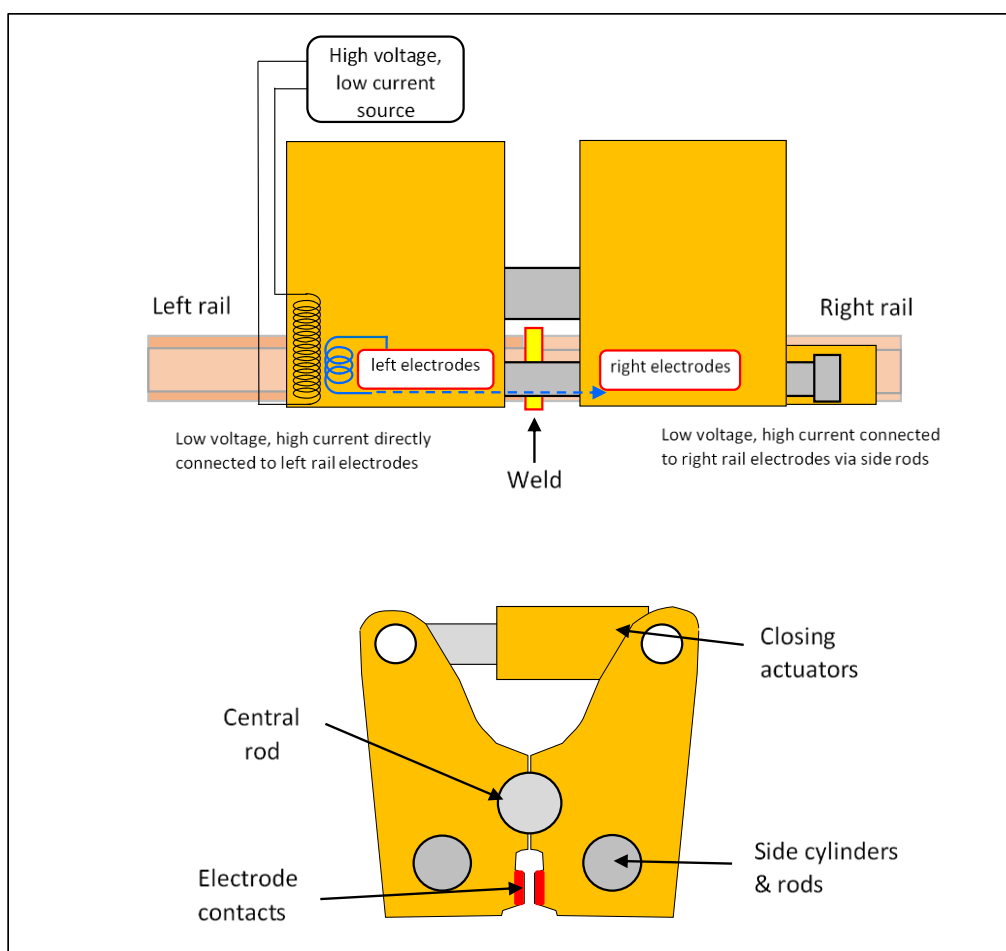


Figure 4-1 Typical flash butt welding set-up

4.3 Qualifying flash butt welding set-up

A flash butt welding procedure shall be qualified in accordance with Appendix M.

Qualification shall be undertaken prior to the commencement of production welding for mobile welding equipment operated as fixed plant for the manufacture of long welded rail or used in the field.

Subsequent requalification shall be carried out annually, unless otherwise specified by the rail infrastructure manager.

Test welds prepared for qualification according to this Standard shall be manufactured in new rail.

NOTE: Welding used rails in track can introduce variations to the process, such that additional qualification tests will be required if rails have high head loss or different rail grades.

Requalification of a flash butt welding procedure shall be carried out when any change in any of the welding program parameters:

- (a) will change the heat input into the weld; or
- (b) affect the hydraulic or mechanical system.

Following initial qualification of a flash butt welding procedure and commencement of production welding, for each rail grade and each rail profile, regular testing shall be carried out in accordance with Section 4.7. Additional tests may be undertaken in accordance with a quality assurance plan as agreed between the contracting parties.

One routine slow bend test should be performed every 500 welds for a mobile plant flash butt welder operating at a fixed location, unless otherwise specified by the rail infrastructure manager.

For mobile welders operating in the field one routine slow bend tests should be performed every 500 welds or every three months, whichever occurs first.

In addition to the requirements outlined above, additional slow bend testing (see Appendix K) shall be undertaken for mobile welding equipment following rectification of a welding machine malfunction and following equipment overhaul that could affect the welder's functionality, such as part replacements.

4.4 Job document

All flash butt welds shall have a job document prepared, which shall include the following:

- (a) Description of the work.
- (b) A reference to the qualified welding procedure to be used.
- (c) An arrangement for the protection of the equipment and the welded rail from adverse weather conditions during the process of welding and subsequent cooling.
- (d) Workplace health and safety (WHS) requirements.
- (e) Any preparatory tasks needed prior to welding (e.g. permission for access).
- (f) The use of rail tensioning equipment, where required.

4.5 Welding procedure

This welding procedure shall include as a minimum:

- (a) Name of the procedure.
- (b) Welding personnel qualification — Welding shall be performed by personnel qualified to the requirements of Appendix D.
- (c) Rail profile, type and grade — rail profile, type and grade shall be described (e.g. 60 kg head-hardened H370).
- (d) Overall rail head loss, and mismatch in rail head loss from one rail to the other.
- (e) Diagrams of the process.
- (f) List of equipment.
- (g) Weather conditions — Limits on weather conditions where welding is to be carried out in the open.

NOTE: Unless special controls and approvals are in place, welding should not be performed:

- 1. where fire restrictions are in place;
- 2. in extreme temperatures;
- 3. during high winds; and
- 4. during heavy rain.

- (h) Proximity of boltholes and other welds — The welding procedure shall define the proximity of boltholes and the minimum distance to other flash butt or aluminothermic welds.
- (i) End and web preparation — The grinding methods used for removing the scale and rust at the ends to be welded as well as the methods used to prepare the electrode contact surface on the rail web. The web grinding needs to remove any raised brand in the rail and include the entire area where the electrodes will make contact. The preparation method used for qualification welds should be the same as that used for production welding.

NOTE: Clamp surfaces can also require preparation where there are not combined with the electrodes.

- (j) Alignment of rails — Rails shall be aligned prior to welding, taking into account cooling and the specified tolerance of the finished weld. Correct alignment is required both vertically and horizontally.
- (k) Track lifting procedure for track lifting and removal of plastic components (e.g. rail pads). (For in-track welding only.)
- (l) Welding parameters — which shall include identification of critical parameters of flash butt welding equipment. These include the preheating conditions, recording of flashing to ensure that this is continuous, upset load, current and upset (forging) distance. The record shall be available as a chart which includes the overall during of the welding cycle as well as recording when the shearing process was performed.
- (m) Post-weld heat treatment (If applicable).
- (n) Controlled cooling (If applicable).

NOTE: Cooling of the weld will need to be controlled to achieve the mechanical and microstructural properties. Additional requirements on controlled cooling are given in Appendix P.

- (o) Dressing and grinding of welds — After welding, excess metal shall be removed and the running surface and both sides of the head finished by grinding. Final grinding shall be conducted in such a way that the temperature of the rail is not high enough to cause any metallurgical change. A hand held grinder shall not be used on the running surface or side of the rail.

NOTE: Additional grinding can be required of the other sheared surfaces such as the web, underside of the rail head or foot or the outer edges of the foot.

- (p) Inspection and testing, post-weld inspection and testing shall be carried out as given in Section 4.7.
- (q) Marking and records, marking and records shall be in accordance with Section 4.8.

NOTES:

1. The ends of the welded string may be drilled with consideration given to the number and position of holes. Generally, holes are not allowed closer to the end than the position of the second hole in the 6-hole fishplate for that rail.
 2. Monitoring of the machine parameters (such as flashing time, current, hydraulic pressure, upset slippage and similar) will assist in control of the quality of the welds.
 3. It is recommended that a finished weld be selected from normal production on a regular basis and tested in accordance with Appendix M, to ensure the welds continue to comply with this Standard.
- (r) Qualification to AS 1085.20 statement that the procedure has been qualified to this Standard.

4.6 Maintenance of equipment

The equipment shall be maintained and calibrated in accordance with a written procedure.

4.7 Inspection and testing of finished welds

Inspection and testing of all finished welds shall be carried out to ensure the weld satisfies the criteria given in Table 4-1 for weld collar tolerances, surface alignment (AT1, AT2 and AT3, as specified) and non-destructive testing.

Table 4-1 Inspection of finished flash butt welds

Test	Test Method (Appendix)	Description	Pass criteria		
Visual inspection	E	Visual inspection of all surfaces	No cracks, tears, gouges, shear drag, electrical contact burns, grinding burns		
Surface alignment tolerances	E	Alignment tolerance grade (Note 1,3)	Vertical	Horizontal	Maximum slope angle on top of rail
		AT1	0.0 mm to +0.3 mm	±0.5 mm	±7 milliradians (Note 2)

Test	Test Method (Appendix)	Description	Pass criteria
		AT2	0.0 mm to +0.5 mm ±0.5 mm Limit to be specified by the purchaser
		AT3	Limit to be specified by the purchaser Limit to be specified by the purchaser Limit to be specified by the purchaser
Weld collar tolerances – Deviation from rail profile	E	At rail web and upper side of rail foot	0.0 mm to +2.0 mm
		Underside of rail foot	0.0 mm to +2.0 mm
		The maximum grinding deviation with respect to rail surface profile:	
		Top of railhead	-0.0 mm to +0.15 mm
		Side of railhead	-0.0 mm to +0.3 mm
Non-destructive test	F	Internal imperfections	Railway owners should determine the limits for internal imperfections. Suitable values are given in Appendix F.
		Magnetic particle inspection (Note 4)	2 mm maximum linear indication
Slow bend test	K	Validation of welding equipment	Welding record confirms that welding equipment is operating as intended within the period of qualification. (see Section 4.3).

NOTES:

1. The grade is specified for the application. Selection of tolerance level will affect the loads experienced at the weld and thus the expected life of the joint for given track conditions and level of traffic.
2. Measured over a distance of 100 mm along the rail surface and 50 mm either side of the weld centre-line (Section 1.3.1, definition (o)).
3. An AT1 tolerance grade would be applicable for a high-speed passenger line. An AT2 tolerance grade would be generally applicable for passenger line and heavy haul freight line.
4. Where magnetic particle inspections are specified by the rail infrastructure manager.

4.8 Marking and records

4.8.1 Marking

Each weld shall have unique markings. Each marking shall remain legible for a minimum period of 12 months from the date on which the weld was made.

4.8.2 Records

A record of the procedure shall be kept, which shall include manufacturer's identification, weld number, date, rail string classification profile, type and grade, and post-welding treatments applicable to the weld, the rail number, welding parameters, (e.g. primary welding current, upset force, welding cycle time), inspection and testing.

Records should also be kept of the program used to make the welds during qualification trials so that it can be uniquely linked to that used for production welds.

4.8.3 Monitoring

Key parameters, as well as measurement of the overall heat input (i.e. combination of current and voltage input over the welding cycle), should be regularly monitored. These can indicate issues with rail surface preparation, current straps, machine cleanliness, cooling systems issues, etc.

5 Aluminothermic welding

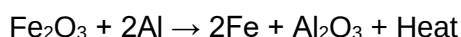
5.1 General

This Section covers the joining of lengths of rail by aluminothermic welding. Aluminothermic welding is usually carried out on the track.

NOTE: Use of aluminothermic welding for head repair welds is covered in Section 6.

5.2 Description of process

Aluminothermic welding is a process in which an aluminothermic reaction takes place within a crucible, from the following chemical reaction between iron oxide and aluminium:



The resultant molten metal flows into a weld joint contained by a mould and the rail ends. The joint is formed by the fusion of the weld metal and the rail. See Figure 5-1

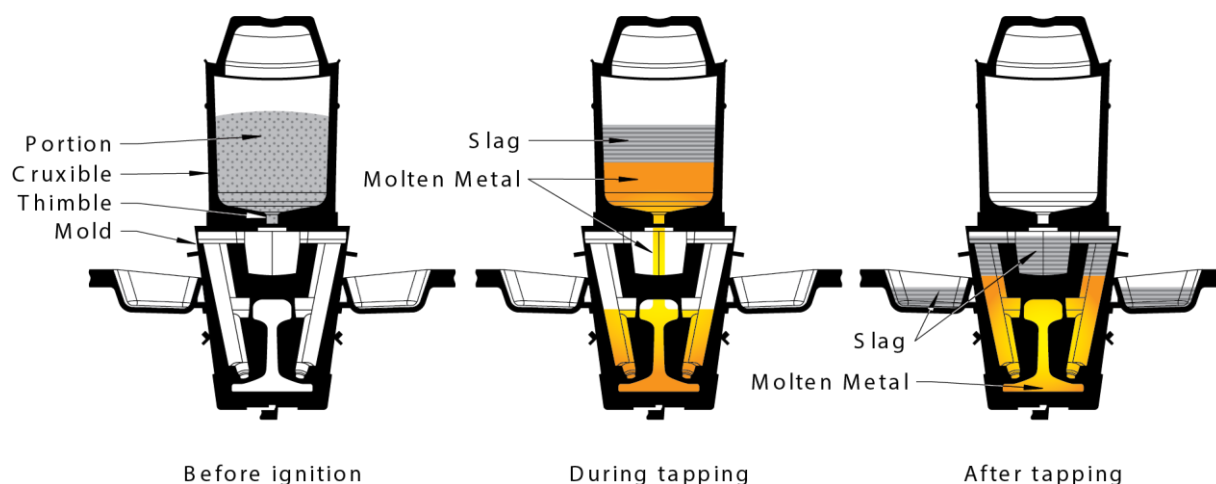


Figure 5-1 Typical aluminothermic welding process

NOTES:

1. Crucibles can be either single use or reusable.
2. Single use crucible illustrated above

5.3 Qualifying the welding procedure

An aluminothermic welding procedure shall be qualified in accordance with Appendix N.

Test welds prepared for qualification according to this Standard shall be manufactured in new rail.

Requalification of aluminothermic welding shall be carried out when a change in the welding parameters exceeds the range set out in Section N4, Appendix N.

Following initial qualification of an aluminothermic welding procedure, testing of individual batches of consumables shall be carried out on a regular basis for quality control purposes.

5.4 Job document

All aluminothermic welds shall have a job document prepared.

The job document should include the following:

- (a) Description of the work.
- (b) Selection of the welding procedure, taking into account the following:
 - i. Profile, type and grade of rail.
 - ii. Weld of same profile or junction or step weld.
 - iii. Size of gap.
 - iv. Length of preheat.
 - v. Control of fume (for enclosed spaces).
 - vi. The impact of the weld on rail adjustment in the area.
- (c) A reference to the qualified welding procedure to be used.
- (d) An arrangement for the protection of the equipment and the welded rail from adverse weather conditions during the process of welding and subsequent cooling.
- (e) Workplace health and safety (WHS) requirements.
- (f) Storage and transport of materials.
- (g) Any preparatory tasks needed prior to welding (e.g. permission for access).
- (h) The use of rail tensioning equipment, where required.
- (i) Time or temperature at which traffic can be allowed to pass.
- (j) Maximum time before inspection and testing is carried out.

5.5 Welding procedure

This welding procedure shall include as a minimum:

- (a) Name of the procedure.
- (b) Welding personnel qualification — welding shall be performed by personnel qualified to the requirements of Appendix D.
- (c) Rail profile, type and grade.
- (d) Manufacturer's instructions — the procedure shall include relevant information provided by the manufacturer of the consumables, including diagrams.

NOTE: trains should not pass over a newly cast weld until the time period or temperature specified by the manufacturer has been met.
- (e) List of equipment.
- (f) Weather conditions — limits on weather conditions where welding is to be carried out in the open.

NOTE: Unless special controls and approvals are in place, welding should not be performed:

1. where fire restrictions are in place;
2. in extreme temperatures;

3. during high winds; and
 4. during heavy rain.
- (g) Proximity of boltholes and other welds — The welding procedure shall state the proximity of boltholes, the distance to other flash butt or aluminothermic welds and, for closure welds, the minimum time between adjacent welds in the same rail.
- NOTE: The rail infrastructure manager can have additional requirements.
- (h) Rail end preparation — The welding procedure shall define the procedure for cutting of the rail and tolerances for the squareness and surface finish of the cut ends.
- (i) Track lifting procedure for track lifting and removal of plastic components (e.g. rail pads).
- (j) Alignment of rails — Rails shall be aligned prior to welding, taking into account cooling and the specified tolerance of the finished weld. Alignment is required both vertically and horizontally.
- (k) Preheating fuel type and pressure, oxygen pressure, and duration as prescribed by the manufacturer.
- (l) Welding parameters — Welding parameters shall include identification of critical parameters of aluminothermic welding equipment.
- (m) Post-weld heat treatment (If applicable).
- (n) Mould removal process timings from end of reaction to start of mould removal, including:
- i. removal of crucible,
 - ii. stripping of the mould, and
 - iii. commencement of shearing.
- (o) Dressing and grinding of head repair weld — After welding, excess metal shall be removed, and the running surface finished by grinding. All grinding shall be conducted in such a way that the temperature of the rail is not high enough to cause any metallurgical changes and the finished surface is free of sharp edges. A hand held grinder shall not be used on the running surface or side of the rail. All excess mould material shall be removed.
- (p) Inspection and testing post-weld inspection and testing shall be carried out as given in Section 5.7.
- (q) Marking and records marking and records shall be in accordance with Section 5.8.
- (r) Qualification to AS 1085.20, statement that the procedure has been qualified to this Standard.

5.6 Maintenance of equipment

The equipment shall be maintained and calibrated in accordance with a written procedure.

5.7 Inspection and testing of finished welds

Inspection and testing of all finished welds shall be carried out to ensure the weld satisfies the requirements given in Table 5-1 for surface finish, surface alignment (AT1, AT2 and AT3, as specified) and non-destructive testing.

Table 5-1 Test limits for finished aluminothermic welding

Test	Test method (appendix)	Description	Pass criteria		
Surface finish tolerances	E	Visual inspection of all surfaces	Satisfactory external appearance and shape; no gouges, cracks, tears, porosity, weld protrusion, shear drag or evidence of a short head.		
Surface alignment	E	Alignment tolerance grade (Note 1,3)	Vertical	Horizontal	Maximum slope angle on top of rail
		AT1	0.0 mm to +0.3 mm	±0.5 mm	±7 milliradians (Note 2)
		AT2	0.0 mm to +0.5 mm	±0.5 mm	Limit to be specified by purchaser
		AT3	Limit to be specified by purchaser	Limit to be specified by purchaser	Limit to be specified by purchaser
Non-destructive test	F	Internal imperfections	Railway owners should determine the limits for internal imperfections. Suitable values are given in Appendix F.		
		Magnetic particle inspection (Note 5)	2 mm maximum linear indication (Note 4)		

NOTES:

1. The grade is specified for the application. Selection of tolerance level will affect the loads experienced at the weld and thus the expected life of the joint for given track conditions and level of traffic.
2. Measured over a distance of 100 mm along the rail surface and 50 mm either side of the weld centre-line (Section 1.3.1, definition (o)).
3. An AT1 tolerance grade would be applicable for a high-speed passenger line. An AT2 tolerance grade would be generally applicable for passenger line and heavy haul freight line.
4. MPI should only be carried out on the top and side of the head, after grinding.
5. Where magnetic particle inspections are specified by the rail infrastructure manager.

5.8 Marking and records

5.8.1 Marking

Each weld shall have unique markings. Each marking shall remain legible for a minimum period of 12 months from the date on which the weld was made.

5.8.2 Records

A record of the procedure (weld return) shall be kept, which shall include the weld identification, date, location, welding information (e.g. preheat time, weld gap, tapping time, time to first train), identification of the welder, inspection and testing, consumable manufacturer, process type and portion batch number.

6 Aluminothermic rail head repair welding

6.1 General

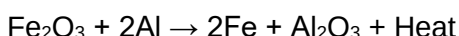
This Section covers the repair of head defects in rail by aluminothermic head repair welding.

Aluminothermic rail head repair welding is usually carried out on the track.

NOTE: Use of aluminothermic welding for joining rails is covered in Section 5 of this document.

6.2 Description of process

Aluminothermic welding is a process in which an aluminothermic reaction takes place within a crucible, from the following chemical reaction between iron oxide and aluminium:



and the resultant molten metal flows into a weld joint contained by a mould and the rail head. See Figure 6-1.

In head repair welding the defect is first mapped ultrasonically to ensure that it fits within the confines of the mould. The defect is then removed by an appropriate method. The refractory moulds are then fitted around the ground area and sealed. The rail head is preheated and then the aluminothermic reaction initiated to produce molten steel which pours into the mould fusing to the rail, replacing the removed metal.

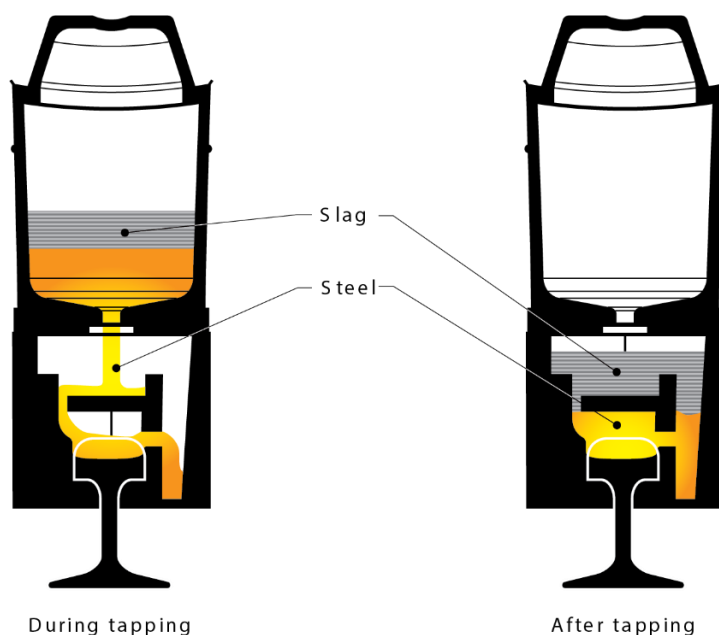


Figure 6-1 Typical aluminothermic head repair welding process

6.3 Qualifying the welding procedure

An aluminothermic head repair welding procedure shall be qualified in accordance with Appendix N.

Requalification of aluminothermic head repair welding shall be carried out when a change in the welding parameters exceeds the range set out in Section N4, Appendix N.

6.4 Job document

All aluminothermic head repair welds shall have a job document prepared, which shall include the following:

- (a) Description of the work to be performed including the portion of the railhead to be repaired.
- (b) Selection of the head repair welding procedure, taking into account the following:
 - i. Rail profile, type and grade.
 - ii. Speed of process (quick or slow, that is, short or long pre-heat).
 - iii. Control of fume (for enclosed spaces).
- (c) A reference to the qualified welding procedure to be used.
- (d) An arrangement for the protection of the equipment and the welded rail from adverse weather conditions during the process of welding and subsequent cooling.
- (e) Workplace health and safety (WHS) requirements.
- (f) Storage and transport of materials.
- (g) Any preparatory tasks needed prior to welding (e.g. permission for access).
- (h) Time or temperature at which traffic can be allowed to pass.
- (i) Maximum time before inspection and testing is carried out.

6.5 Welding procedure

This welding procedure shall include as a minimum:

- (a) Name of the procedure.
- (b) Welding personnel qualification welding shall be performed by personnel qualified the requirements of Appendix D.
- (c) Rail profile, type and grade.
- (d) Manufacturer's instructions — the procedure shall include relevant information provided by the manufacturer of the consumables, including diagrams.
- (e) List of equipment.
- (f) Weather conditions — limits on weather conditions where welding is to be carried out in the open.

NOTE: Unless special controls and approvals are in place welding should not be performed:

- 1. Where fire restrictions are in place.
 - 2. In extreme temperatures.
 - 3. During high winds; and
 - 4. In heavy rain.
- (g) Proximity of boltholes and other welds — the welding procedure shall define the allowable proximity of boltholes and the distance to other flash butt or aluminothermic welds.

NOTE: Head repairs should not be made above existing aluminothermic welds where train axle loads are equal to or greater than 20 tonnes.

- (h) Preparation of head defect to be welded — the welding procedure shall include the procedure for the removal of the rail defect, the required surface condition of the dressed defect removal area, and the maximum allowable depth of defect that can be repaired using this method.
- (i) Non-destructive testing — magnetic particle/dye penetrant tests shall be performed to check extent of cracking before and after grinding. All cracks shall be removed before welding commences.
- (j) Track lifting — a procedure shall be specified for peaking of the rail in the area where the defect is being removed and any required removal of plastic components (e.g. rail pads).
- (k) Alignment of rails — rails shall be aligned prior to welding, taking into account cooling and the specified tolerance of the finished weld. Alignment is required both vertically and horizontally.
- (l) Preheating — fuel type and pressure, oxygen pressure, and duration as prescribed by the manufacturer.
- (m) Welding parameters — welding parameters shall include identification of critical parameters of aluminothermic welding equipment.
- (n) Post-weld heat treatment (If applicable).
- (o) Mould removal process — process timings from end of reaction to start of mould removal, including:
 - i. removal of crucible,
 - ii. stripping of the mould, and
 - iii. commencement of shearing.
- (p) Dressing and grinding of head repair weld — After welding, excess metal shall be removed, and the running surface finished by grinding. All grinding shall be conducted in such a way that the temperature of the rail is not high enough to cause any changes in the metallurgical structure of the rail and the finished surface is free of sharp edges. A hand held grinder shall not be used on the running surface or side of the rail. All excess mould material shall be removed.
- (q) Inspection and testing, post-weld inspection and testing shall be carried out as given in Section 7.7.
- (r) Marking and records shall be in accordance with Section 7.8.
- (s) Qualification to AS 1085.20 statement that the procedure has been qualified to this Standard.

6.6 Maintenance of equipment

The equipment shall be maintained and calibrated in accordance with a written procedure.

6.7 Inspection and testing of finished welds

Inspection and testing of all finished head repair welds shall be carried out to ensure the weld satisfies the requirements given in Table 6-1. for surface finish, surface alignment (AT1, AT2 and AT3, as specified) and non-destructive testing.

Table 6-1 Test limits for finished aluminothermic head repair welds

Test	Test method (appendix)	Description	Pass criteria		
Surface finish tolerances	E	Visual inspection of all surfaces	Satisfactory external appearance and shape; no gouges, cracks, tears, porosity, weld protrusion, shear drag, undercut or evidence of a short head		
Surface alignment tolerances	E	Alignment tolerance grade (Note 1, 3)	Vertical	Horizontal	Maximum slope angle on top of rail
		AT1	0.0 mm to ± 0.3 mm	± 0.5 mm	± 7 milliradians (Note 2)
		AT2	0.0 mm to $+0.5$ mm	± 0.5 mm	Limit to be specified by the purchaser
		AT3	Limit to be specified by the purchaser	Limit to be specified by the purchaser	Limit to be specified by the purchaser
Non-destructive test	F	Internal imperfections	Railway owners should determine the limits for internal imperfections. Suitable values are given in Appendix F.		
		Magnetic particle inspection (Note 5)	2 mm maximum linear indication (Note 4)		

NOTES:

1. The grade is specified for the application. Selection of tolerance level will affect the loads experienced at the weld and thus the expected life of the joint for given track conditions and level of traffic.
2. Measured over a distance of 100 mm along the rail surface and 50 mm either side of the weld centre-line (Section 1.3.1, definition (o)).
3. An AT1 tolerance grade would be applicable for a high-speed passenger line. An AT2 tolerance grade would be generally applicable for passenger line and heavy haul freight line.
4. MPI should only be carried out on the top and side of the head, after grinding.
5. Where magnetic particle inspections are specified by the rail infrastructure manager.

6.8 Marking and records

6.8.1 Marking

Each weld shall have unique markings. Each marking shall remain legible for a minimum period of 12 months from the date on which the weld was made.

6.8.2 Records

A record of the procedure (weld report) shall be kept, which shall include the weld identification, date, location, welding information (e.g. pre-heat time, weld gap, tapping time, time to first train), identification of the welder, inspection and testing, consumable manufacturer, process type and portion batch number.

7 Electric arc rail head repair welding

7.1 General

This Section covers the repair of head defects in rail by electric arc welding. The methods described may be used for the repair of rail head surface defects, and switch and crossing components such as switch blades and wing rails.

NOTE: It is not intended to cover the joining of rails by arc welding.

7.2 Descriptions of welding methods

7.2.1 Manual metal arc welding

Manual metal arc welding is a process of arc welding with a covered electrode manually applied by the welder, without automatic or semi-automatic replacement of the electrode. Shielding is provided only by decomposition of the electrode covering.

7.2.2 Flux-cored arc welding

Flux-cored arc welding is a process that uses a consumable continuous flux cored electrode, which provides the filler metal.

Self shielded flux-cored arc welding uses continuous tubular wire filled with flux that provides shielding of molten pool.

Gas shielded flux-cored arc welding is using externally supplied gas or gas mixtures in order to shield molten metal against oxidation.

7.2.3 Gas metal arc welding

Metal inert gas welding is a gas metal arc welding process of arc welding with a bare wire electrode. Gas metal arc welding uses active shielding provided from an externally supplied gas or gas mixture. This process is unsuitable for welding on track due to wind disturbing the shielding gas but can be used indoors where air movement is not an issue.

7.3 Qualifying the welding procedure

An arc welding procedure shall be qualified in accordance with Appendix O.

Requalification of an arc welding procedure shall be carried out when a change in the welding parameters exceeds the range set out in Appendix O.

7.4 Job document

All arc welds shall have a job document prepared, which shall include the following:

- (a) Description of the work to be performed including the portion of the railhead to be repaired.
- (b) A reference to the qualified welding procedure to be used.
- (c) An arrangement for the protection of the equipment and the welded rail from adverse weather conditions during the process of welding and subsequent cooling.
- (d) Workplace health and safety (WHS) requirements.